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Dear Bob:

Enclosed is a copy of the rainbow MS. Will appreciate your comments.

I've had my nose to the grindstone on this thing since Nov and didn't have time to send out any X mas cards but I got yours and thanks.

Anyway I hope you all had a beautiful Christmas and have a good new year.

All best regards.

Bob

RAINBOW TROUT

The rainbow trout, oncorhyncus mykiss as the species is now known to the scientific community, is an extremely wide ranging and diverse group of salmonoid fishes. Under the broad specific umbrella are included all of the rainbow-like trout of the Pacific slope from the Tropic of Cancer in Mexico to the Arctic Circle in Alaska and the enclosed drainage basins of the high desert in eastern Oregon. Across the Bering Sea in Asia they occur on the Kamchatkan Peninsula, drainages to the Okhotsk Sea basin and in the Commander Islands. In addition to these native populations rainbows of hatchery origin have been introduced world wide. In this chapter we are concerned only with North American resident rainbows; the anadromous forms, "steelheads" and the golden trout of the High Sierras are being covered elsewhere in this volume.

Classification

The scientific classification of rainbow trout has had a long and turbulent history. Since the latter half of the last century and on to the present there has been much uncertainty and some controversy regarding the designation and validity of species and geographical races or subspecies. The number of

recognized species has varied from one to over fifteen and now we are back to one again.

Johann Walbaum, a Swede, formally described the first rainbow trout in 1792, naming it Salmo mykiss (from salmo "to leap" and mykiss, the native name for the fish). This was an Asian fish from Kamchatka and given the state of communications at the time was largely unknown or ignored in North America. Over forty years later Dr. Meredith Gairdner, a naturalist in the employ of the Hudson Bay Company, collected a rainbow specimen from the lower Columbia River and sent it to the renowned British naturalist Sir John Richardson in London who, in 1836, named the fish Salmo gairdneri after its donor. This specimen is now thought to have been a redband "steelhead" since this race of anadromous rainbows dominates the steelhead runs of the Columbia, but for over two decades gairdneri was the accepted name for all known North American rainbows. Then in the latter half of the 19th century came a spate of western explorations and natural history surveys in which a host of new species of both plants and animals were described and named. David Starr Jordan, the eminent ichthyologist of that period and early 20th century, along with his cohorts were the leaders in describing and naming new species and races of fishes including over fifteen rainbow trout as full species and one redband rainbow described as a cutthroat.

Among these were two races that would have later significance in taxonomy, S. irideus and S. newberryi, both described in 1858 by Gibbons and Girard respectively. Most of the species named during this period have since proved to be invalid, synonymous with others, or merely subspecies, but they had general acceptance at the time and were published in the Report of the U. S. Commissioner of Fisheries for the fiscal year 1928. During this time S. gairdneri generally referred to anadromous rainbows while S. irideus was used for resident rainbows.

In those early less critical days a description of a species was based largely on how it differed from others by outward appearance--phenotypic characters and linear measurements. If it looked different or had different body proportions, it was named a separate species. Now, with more stringent criteria, new and improved techniques and vastly more studies producing new information taxonomists evaluate the meristic or morphological characters, biochemical genetic data and chromosomal numbers as well as phenotypic, linear and zoogeographic information.

With this advanced approach it has now been shown that all of the western North American native trout formerly in the genus Salmo and Pacific salmon of the genus Oncorhynchus evolved from one ancestral line and are closer related to

each other than to the Atlantic salmon and the brown trout of the genus Salmo. Hence rainbows are now classified in the genus Oncorhynchus. It has also been shown that the Kamchatkan trout, described in 1792, is conspecific or identical to the Alaskan rainbows. Therefore, to conform with the international rules of nomenclature which state that the first named used has priority, the specific name gairdneri has been changed to mykiss, the name bestowed by Walbaum to the Kamchatkan trout almost two hundred years ago. So we now have Oncorhynchus mykiss as the approved scientific name for all rainbows and will be listed as such in the 1990 check list of the American Fisheries Society. Old time students of trout and anglers who grew up with the name Salmo gairdneri or irideus may object to this uneuphonious appellation but it does have biological reality and conforms to the rules.

Under the broad specific umbrella of mykiss, as all rainbows are now classified, are two greatly differentiated groups, the fine scaled highly colorful redbands and the coarse scaled much less colorful coastal rainbows. It is the redband group, particularly, that has caused the confusion and controversy among taxonomists from the time of their first description in 1858 on up to the present. They have been variously described as cutthroats, subspecies of rainbow, a link between cutthroats and rainbows or new species alto-

gether. In an attempt to resolve this dilemma, Behnke in his 1979 monograph tentatively proposed placing the redbands in a separate species, newberryi, after the first one described from Oregon's Upper Klamath Lake in 1858. Meristically, phenotypically and in chromosomal values this proposal has biological reality and would simplify the subspeciation of the group into logical divisions. Electrophoretic studies, however, charting biochemical genetic data have failed to find any significant difference between the two groups at any gene locus so far examined and therein lies the basis of the controversy.

The sequence of events leading to the differentiation between coastal rainbows and redbands began millions of years ago. According to the model accepted by most ichthyologists the rainbow tribe diverged from the ancestral line leading to the cutthroats possibly as early as the Pliocene epoch. Later on this rainbow branch diverged again leading to the ancestral stocks of coastal rainbows and redbands essentially as we know them today. During the colonization of Pacific watersheds by western trout from the sea the cutthroats came first, penetrating the intermountain west to the continental divide and even beyond. The redbands came next but were stopped by barriers in the upper Columbia system that were absent when the cutthroats went through but below the barriers

Wenatchee R.

they almost entirely replaced the cutthroats. In fact the only waters known where they have co existed without massive hybridization are headwater tributaries of the John Day River in Oregon as Smith pointed out in his 1984 publication.

The last to invade the Pacific watersheds were the coastal rainbows and they in turn replaced the redbands where they came in contact. The coastal rainbows did not penetrate as far inland as the redbands were able to do, however, and as a result we still have redbands in the closed drainage basins of eastern Oregon, the mid Columbia basin below the barriers, the Frazer River system above Hells Gate, the upper Klamath tributaries and the upper Sacramento River system. It is noteworthy that these four rivers are the only ones in the region that have cut through the Cascade Mountain barrier and that all known populations of redbands lie east of the Cascades.

Sac. McCloud

Where the ranges of the two groups overlapped there was undoubtedly some introgression and to compound the problem we have a hundred year history of massive introductions of hatchery fish whose origins are mostly of coastal rainbows. Consequently there are some "grey areas" where it is difficult to identify one from the other. Fortunately many of the domesticated strains of hatchery fish could not survive the rigors of a stream environment and failed to completely

contaminate the native stock.

At the present time only three subspecies of rainbows have some degree of acceptance--not all ichthyologists are in accord on this. These subspecies are classified as O. ~~M.~~ irideus, the coastal rainbow; redband or interior rainbows, O. ~~M.~~ gairdneri; and the Eagle Lake rainbow, O. ~~M.~~ aquilarum. The Kamloops rainbow although falling within the redband group is regarded by some ichthyologists as a valid subspecies. These will be discussed in greater detail along with other distinctive populations that may in the future receive subspecific recognition.

only Col.

Description

Due to the great diversity exhibited within the resident or non migratory rainbow group only a few generalized descriptive characters can be listed that apply to the species as a whole. All are soft rayed streamlined fishes with caudal fins noticeably forked in juveniles becoming almost truncate in large adults; all show the red or pink rainbow stripe at least when in spawning condition and lake dwelling fish are less colorful, more silvery than riverine populations. In general there are two broad categories of coloration and spotting patterns between the redband group and coastal rainbows and these are described in

redband steelhead
Col - Fraser

8/Smith

detail.

The redbands, except the lacustrine populations as noted above, are the most flamboyant of the rainbows and some of the most colorful races could be compared to golden trout. They show varying intensities of yellow and orange on the lower sides, have eight to thirteen large dark elliptical parr marks in a horizontal row which are bisected by the lateral line and a brick red to purplish "rainbow stripe" which usually terminates just above the anal fin. Above, below and sometimes slightly in between the elliptical parr marks are smaller round supplementary parr marks and except in mature lake fish the parr marks are retained into adulthood. The back, as in most other species of trout, varies from olive green to grey or tannish while the belly varies from white to dusky or yellowish. The cheeks are rose to carmine with a dark spot or blotch behind the eye similar to those found on cutthroats. The lower fins are usually dusky or may show an orange tint, the pelvic and anal fins white tipped and the dorsal fin white or yellow tipped. The adipose fin is usually black bordered or may have a few small black spots while the dorsal and caudal fins are profusely spotted. One usually constant character is the cutthroatlike slash marks under the lower jaw--it may be faint or very prominent--brassy to orange but is usually present.

The spotting pattern on the body may vary in different populations; in some the spots are confined to the area above the lateral line and on the caudal peduncle while others are also spotted on the lower sides and belly. The spots are generally small to medium size and in different populations may vary in shape from round to irregular.

There are other characteristics of the redband group not readily apparent in a casual examination but of importance to ichthyologists and taxonomists, such as, vestigial basibranchial teeth (minute teeth on the back of the tongue); a chromosome number of 58 as compared to 58--64 in coastal rainbows; finer scales, fewer pyloric caeca (spaghetti-like protuberances attached to the posterior end of the stomach) and fewer gill rakers (comb-like appendages attached to the first gill arch) than in coastal rainbows.

Many of these attributes of the redbands are considered to be primitive traits and are shared to some extent with the Apache and Gila trout, the Mexican golden trout and the golden trout of the High Sierras.

Compared with the colorful garb of the redbands coastal rainbows show up as dark cousins. They do not show the yellow and orange body shades; the rainbow stripe and the cheeks are much paler, more pink than red; the parr marks are not as dark and are round rather than elliptical; they lack the white

tipped dorsal fin, the cutthroat-like slash marks and cheek blotch. The black spots are typically irregular in shape, sometimes X or crescent shaped, and may be restricted to the area above the lateral line or extend to the belly. The background colors of the back vary from olive green to grey to bluish with a silvery sheen on the sides grading to a white belly. The fins are usually dusky, the dorsal and caudal heavily spotted and the pelvics and anal fins may or may not be white tipped. Lake fish may appear entirely silvery, the black spots and pink stripe being muted by deposits of guanine secreted by internal organs. When in spawning condition all fish become darker, the spots more prominent and the pink cheeks and lateral stripe become more intense, in males more so than the females, and large old males tend to develop a kype or hooked lower jaw.

Of all the different characteristics between the two groups of rainbows the relative size of the scales, determined by lateral counts from cheek to tail and number of scale rows counted vertically, seem to be the determining factor as to how the fish is classified, the "bottom line" so to speak. If it is fine scaled, it is considered a redband; coarse scaled, a coastal rainbow. Confusing combinations of other characters clouding identification are thought to be due to ancient introgression

between the two groups or hybridization with introduced hatchery rainbows.

Distribution

Rainbow trout have the second greatest latitudinal native distribution of any North American salmonid, spanning a north-south range of about 38 degrees of latitude or slightly over 2600 miles. This is exceeded only by the Arctic charr of the eastern seaboard. The rainbows, however, hold the record for the most southerly occurrence of North American salmonids at 24° N. latitude or almost to the Tropic of Cancer while at the north end of their range they crowd the Arctic Circle. They also span a considerable east-west distance, from 162° W. longitude in Alaska to 106° in Mexico, a spread of 56°. For the most part this range is relatively narrow, drained by short coastal streams heading up in the Coast Range, the Sierra-Cascade mountain chain and the high cordillera fronting the British Columbian and Alaskan coast lines. A few of the larger rivers, however, have pierced these mountain barriers and through these rainbows have colonized some of the inter-montane valleys and interior plateaus to the continental divide and even slightly beyond.

To be more specific, the northern limit of native rainbow distribution is the Kuskokwim River in southwestern Alaska

where they occupy its southern tributaries in the lower third of its course as far up as the Aniak and even stray up the main stem as far as the mouth of the Holitna at about 62° N. latitude. From the Kuskokwim south they are resident in every suitable drainage entering the Bering Sea and extend west on the Alaska Peninsula to near Port Moeller.

South of the peninsula rainbows occur as both anadromous and resident fish in all suitable streams entering the Pacific to the Mexican boundary. Along the Alaskan south coast and the panhandle they reached the interior through the Susitna, Copper, Alsek, Taku and Stikine Rivers. Southward along the British Columbia coast rainbows reached the broad interior plateaus through the Skeena and Fraser Rivers penetrating all the way to the continental divide and from the upper Frazer they crossed the divide into the headwaters of the Peace and Athabaska Rivers thus entering the upper MacKenzie system. The larger offshore islands from the Alaska Peninsula to Puget Sound also host rainbows, the largest and most important being Kodiak, the Queen Charlottes and Vancouver Islands.

The streams entering Puget Sound in the state of Washington and south on the Pacific to the mouth of the Columbia are all short drainages having their origins in the Cascades or Olympic mountains. The Columbia, however, one of the major rivers of the continent, drains an immense area and through this system

rainbows colonized the Columbia Plateau below impassable fish barriers in eastern Washington, eastern Oregon, northern Nevada and southeastern Idaho as far as Shoshone Falls on the Snake. Through an ancient Columbia connection ~~five~~ six of the closed desert basins in eastern ~~origin~~ Oregon were occupied by rainbows which have persisted there in a few small desert streams since the basins desiccated during the warming trend after the close of the Pleistocene.

Below the mouth of the Columbia all of the Oregon coastal drainages have their source in the Coast Range or adjoining Klamath mountains and are therefore short rivers excepting the Umpqua and the Rogue which cut through the coastal barrier and head in the Cascades. This is also the case in northern California as far as the Klamath which cut through the coastal and Cascade ranges allowing rainbows to invade the interior valleys and plateaus east of the Cascade crest.

South of the Klamath there are numerous short drainages along the coast to San Francisco Bay and the mouth of the Sacramento, California's largest river system. The Sacramento, with its southern tributary the San Joaquin, pick up all the west flowing streams from the Sierra Nevada entering the 400 mile long Central Valley while its northeasterly tributaries, the McCloud and Pit Rivers, pierced the Cascade barrier giving rainbows access to the interior plateaus as far as

the Warner Mountains near the Nevada border. It is through the headwaters of the Pit that rainbows are thought to have gained access to Eagle Lake, a western extension of the Lahontan Basin.

South of San Francisco Bay the climate becomes progressively drier, the coastal drainages fewer and none cut the coast range barrier. Probably the last viable native rainbow habitat in California is the San Luis Rey River just north of ~~Ensenada~~ Escondido draining the slopes of Mt. Palomar.

On Mexico's Pacific coast only three disjunct drainages contain rainbow trout and these are all resident fish. The most northerly stream is the Rio Santo Domingo draining the west slope of the Sierra San Pedro Martir, Baja California's highest mountain range and the only stream on the peninsula to contain trout. On the mainland coast the seven major drainages flowing off the west slope of the Sierra Madre Occidental north of the Tropic of Cancer contain trout but only the two most southerly have trout considered to be rainbows, these being the Rio San Lorenzo and the Rio del Presidio. Due to their proximity to the tropics and consequent high temperatures these trout are restricted to their high altitude headwaters.

The distribution of rainbow trout described above is the original or pre-Columbian range of the species in North America

and includes all native rainbow populations regardless of subspecies or racial groups. To delineate the boundary between the two principal subspecies, O M irideus the coastal rainbow and O M gairdneri the redband rainbow Behnke has proposed the crest of the Cascades as the boundary separating the lower reaches of the Frazer, Columbia, Klamath and Sacramento Rivers from their interior drainage basins above. With this segregation all rainbows above that point on the four river systems mentioned are considered to be redbands--all those below and in all other coastal drainages from Mexico to Alaska are considered coastal rainbows. In practical application this segregation works out very well even though there were no actual barriers to fish passage at any of these boundaries except on the McCloud and the Pit, the northeasterly tributaries of the Sacramento. There are some "grey areas", however, where it is difficult to positively identify one race from the other, probably due to introgression between the two forms, but this is a common phenomenon encountered on any boundary where there may be overlap between subspecies, whether fish, birds or mammals.

This pristine pattern of native distribution and racial segregation of rainbows was soon irreversibly altered with the settlement of the west. Beginning in the latter part of the 19th century and continuing to the present man has taken it

upon himself to improve upon nature by mass producing rainbow trout in hatcheries and planting them in waters where they did not occur naturally or to "beef up" native stocks already present. According to Mac Crimmon, who has documented the history and details of this ongoing operation, the first transfer of rainbows outside of their native waters occurred in 1874 in the form of eyed eggs from a small private egg collecting station and hatchery on California's McCloud River shipped to Seth Green at his hatchery in Caledonia, New York, and in 1876 rainbow fry, also from the McCloud, were introduced into the Au Sable River in Michigan. By 1879 the U. S. Fish Commission had taken over the McCloud operation and the distribution of rainbow trout eggs and fry got going at an accelerated pace as by 1880 twelve formerly rainbowless states had received McCloud River stock and these states soon began trading eggs and fry back and forth and exporting stock to other states. Probably the original stock from the McCloud was mostly of coastal rainbow origin, both resident and anadromous, with unknown amounts of the redband strain mixed in, but as hatchery production and stocking gained momentum other waters in California contributed different racial origins, some resident fish and some steelhead and stocks from Oregon, Washington and British Columbia added to the racial melting pot. Eventually these thoroughly mixed up rainbows had been

introduced in every state except Florida and became established in thirty-nine of these outside of their native range where they were also stocked extensively.

All of these introductions were made for the purpose of enhancing a dwindling trout fishery or to create a trout fishery where none was present before. Early attempts indicated that stocking with fry yielded poor returns to the angler so they began to be reared at the hatcheries to fingerlings or even to "catchable" size. This proved to be a more effective strategy but also a more expensive one. Consequently rainbows were selectively bred to produce a less expensive fish, such as selection for early maturity, rapid growth, resistance to disease and adaptation to life in a hatchery raceway, all but the disease resistant characteristic negative attributes for survival in a natural environment. So what we have today as brood stocks and their offspring dumped in waters by the millions are thoroughly domesticated fish poorly equipped to survive the rigors of life in the wild. Hatchery rainbows do, however, survive better and have a greater return to the angler's creel in lakes and reservoirs than in streams although many of these still-waters must be restocked annually.

The good side of all this long history of massive rainbow stocking is that there are now rainbow fisheries in all states except Mississippi, Louisiana and Florida, those in the south

made possible by the cold tailwaters at the outlets of the numerous reservoirs in the region, and now people living far from the Pacific coast can fish for rainbows close at hand. The other side of the coin lies in the western states where native indigenous trout have been hybridized out of existence over large areas of their range through the indiscriminate stocking of hatchery rainbows of dubious ancestry thereby destroying much of the genetic diversity originally present.

By no means was the introduction of hatchery rainbows confined to the United States. Ontario received fry from the Northville, Michigan hatchery in 1881 and in 1883 McCloud rainbows were stocked near Sault Ste. Marie. From those small beginnings rainbows were introduced in every Canadian province and the Yukon Territory where there are now self sustaining populations as well as some maintained by hatchery input. In Alberta a notable rainbow fishery has developed on the Bow River that attracts anglers from around the world.

N. Z. 1883

Mexico was another early recipient of rainbows, receiving the first shipments of eggs in 1888, 1889 and 1891. By 1937 one hatchery was in operation on the Almoloya River and another begun on the Lerma River, both for the propagation of rainbow trout. At the present time fifteen Mexican states and the Distrito Federal have naturalized rainbow populations.

This then concludes the distribution of rainbow trout in

North America, vastly expanded during the last hundred years. It should be noted that the successful establishment of rainbows in the low latitudes occurred at high elevations having cooler temperatures, the Sierra Madre ranges of Mexico both east and west and the high interior plateaus, many over 7000 feet at their minimum altitude.

Although outside the scope of this work it may be of interest to note that rainbows are now established in naturally reproducing populations on all the continents except Antarctica and sustain a number of world famous fisheries, as along the chain of the Andes in South America, in New Zealand and Australia. In addition to the sport fishing aspect rainbows are produced commercially on fish farms for the market, particularly in Europe and Japan. We even have some here in the United States, the source of the rainbows you see displayed with the meats at the super market.

Habitat

Throughout the extensive range of the rainbow trout in North America is a wide array of diverse climatic, topographic and ecological regions to which rainbows have successfully adapted. Yet within all this diversity they have quite a narrow range of tolerance where they find optimum conditions for growth and reproduction. Probably their overriding requirement, whether

lake dwelling or riverine populations, is relatively clear, cool, well oxygenated water slightly on the alkaline side. According to Moyle, who has studied the rainbows of California extensively, the optimum water temperatures for growth and reproduction are from 13° to 21° C although some populations can exist at temperatures from just above freezing to 28° C for short periods of time. At the low end of the scale they can get by with less oxygen, as low as 1.5 to 2 ppm re. Temp. but require amounts close to saturation as water temperatures approach the upper limits. For optimum growth slightly alkaline waters with pH values of 7 to 8 seem to be best although one subspecies, the Eagle Lake rainbow, thrives in a highly alkaline environment with PH values as high as 9.6. In acid waters, those with a pH reading of less than 6, rainbows do not reproduce.

Riverine rainbows prefer fast flowing streams with a high proportion of riffle areas to pools with adequate spawning areas of clean gravel, usually in the shallow tailout of pools or the tail of a riffle where the water velocity has slackened. There are some exceptions to this ideal habitat, however, as some populations are found in low gradient meadow or desert streams where riffle areas are few but they still require clean gravel areas with adequate flow for spawning.

Lacustrine or lake dwelling rainbows live out most of their

life cycle in still water, finding the preferred temperature ranges in high altitude lakes or in lakes or reservoirs deep enough to have cold water at depth during the warm months. In order to reproduce, however, they must have a stream environment, either inlet or outlet, in which to find proper spawning conditions. In lakes without these populations must be maintained entirely with the input of hatchery fish.

or springs?

In addition to water quality and temperature the bottom topography and nature of the substrate are important factors in determining the quality of rainbow habitat. As stated earlier, riverine rainbows prefer fast moving streams usually flowing over bedrock or a freestone bottom interspersed with gravel areas. This irregular and broken substrate provides a multitude of niches and crannies where invertebrates, the rainbows' primary food source, take shelter as well as providing small eddies or slack water behind ledges or boulders where trout can hold without expending energy breasting the current. Stream rainbows are territorial and require a site where drift food is readily available with a minimum of effort and a nearby place to hide in times of threat. Hence the more irregular and broken the substrate the more territories available resulting in more trout in the stream. On the other hand in the lower courses of many streams approaching base level water velocity slackens with accompanying accumulations of silt offering only marginal habitat

for rainbows or none at all.

In most natural lake habitats littoral shoal areas, reefs and other shallows combined with stable water levels provide sites where underwater vegetation can flourish, furnishing breeding places for invertebrates as well as cover for young fish. Lakes rich in nutrients, called eutrophic by ichthyologists, are some of the most productive insofar as the oxygen demand of algal blooms and decaying vegation does not deplete the amount necessary to sustain trout. Thus natural lakes are usually far more productive and provide better rainbow habitat than man made reservoirs, often merely steep sided depressions where water levels are drawn down annually during the growing season, obviating any possibility of aquatic plant growth.

Biology

Most resident wild rainbows are spring spawners, migrating in season to the same gravel spawning riffle on which they themselves hatched out as fry. The mechanics of this process are so similar to those of most other North American trout and described elsewhere in this volume that no details will be given here. Suffice to say that spawning is triggered by warming water temperatures after winter lows with eggs being successfully incubated at temperatures ranging from 5° C to 15° C. The timing of this is usually from February to June but due to the great

Firebote?

altitudinal range of the species, from near sea level to over 10,000 feet and the lineal spread in latitude, from arctic to tropics, spawning may begin earlier or be delayed until July or August. Eggs incubated at 10° C to 15° C hatch in three to four weeks, more time being required in colder water and the fry emerge from the gravel two to three weeks later upon absorption of the yolk sac. The number of eggs deposited by the female varies directly with her size; a five or six inch long fish will have less than two hundred eggs while the really big females will produce two thousand eggs per Kg of body weight. A small percentage of first time spawners survive to spawn again, sometimes several years in succession, or may skip a year altogether, but in some redband populations, as in Pacific salmon, none survive the first spawning.

Female rainbows are usually larger than males but the range in size at maturity boggles the mind--from five or six inches weighing a few ounces to well over forty inches and fifty-two pounds!

This vast range in size is due to a number of factors, some genetic and others environmental. The growth rate of rainbows slows down or becomes negligible after maturity. Consequently trout that are genetically programmed for maturity at seven or eight years have a much greater opportunity to attain a larger size than those programmed to mature at two or

three years. The amount and quality of food is, of course, controlled by the environment which puts an effective lid on the size trout may attain in any given water but in some lacustrine habitats rainbows have become adapted, over the millenia, to feed on forage fish with consequent rapid growth and large size at maturity and this trait is passed on from generation to generation. Where forage fish have been introduced in other waters where trout were not pre-adapted to this source of food the opposite result occurred, smaller trout due to increased competition for food.

Behavior

As the tiny rainbow fry emerge from their natal gravel they enter a hostile world. Beset by predators large and small, by floods and droughts, they begin life fraught by hazards on every hand. Of the many that struggle up through the gravel only a very small percentage will survive to maturity to start the process all over again.

Once free of the gravel the fry school in the relatively slow inshore waters or quiet eddies where they can feed on small zooplankton without being swept away by the current. After several weeks of this gregarious living they begin to show their aggressive nature toward one another, the school disperses and each fishlet must find a niche for itself. Stream rainbows are

territorial in a hierarchy related to size. Thus the largest fish defends the best and largest territories grading down in size to young of the year which must stake out a territory in what is left, move out or live in an exposed position usually with fatal results. Since rainbows are drift feeders, at least during the warm months, a desirable territory must include a site having suitable water depth and velocity where a fish can hold to intercept zooplankton, aquatic insect larvae and other insect life borne along on the current. There should also be a place to hide nearby when danger threatens, deeper water, an undercut bank or cover of any sort.

As Moyle has reported this territory must be defended against any other fish intruders, initially by an aggressive display of ridged swimming, flared cheeks and flared fins. If this display does not sufficiently impress the trespasser, the defender will charge and give a few nips at the tail. Regardless of the tactics, if the intruder is another trout, the outcome will be decided by size and the vanquished must seek out another territory with a smaller trout in residence. If the intruder is a sucker or other cyprinid, it will not respond to the show of aggression but will be evicted by repeated rushing and tail nipping.

There is usually little interspecific competition for living space as the water will be compartmentalized between the species by the selection of different microhabitats. For example, if

rainbows share the water with brown trout, the rainbows will seek the riffles and faster water while the browns will hold sway in the slower currents and deep pools. Eastern brook trout and cutthroats will seek out colder water higher in the stream than rainbows while the cyprinids will choose the warmer silty reaches lower down on the stream. Most of the competition, therefore, is between rainbows and the hierarchy is always in a state of flux due to natural predation and the removal of fish by angling.

The growth rate of rainbows in different streams varies, of course, with the available food supply. Moyle reports that in small California streams rainbows will reach 11 to 17 cm total length in their first year, from 14 to 21 cm in their second and from 20 to 23 cm in their third at which time many will be sexually mature. During the winter months growth slows perceptibly due to lower metabolism induced by colder water and what little food is taken consists of bottom organisms, there being little drift food available.

In lacustrine populations of rainbows the aggression and size hierarchy tends to break down. Since there is no current to bring their food to them they must cruise around as hunters either as individuals or in small schools. Growth is usually faster in lakes than in streams and in those populations that have adapted to feeding on a forage fish base a much greater

size can be attained than in those dependent on invertebrates.

Anglers usually rate rainbows as less wary than brown trout but more so than eastern brook trout or cutthroats. They take flies and lures readily and are extremely active when hooked, often leaping clear of the water. Consequently, they rate high as a game fish and are the favorites of many trout fishers.

Subspecies and Other Geographical Races

As previously noted only three subspecies are currently recognized by most ichthyologists in the entire rainbow complex: irideus, gairdneri and aquilarum. A provisional fourth subspecies, kamloops, is recognized by some. Yet within each subspecies, with the exception of aquilarum which is restricted to a single lake, is a diverse array of life history patterns, habitat requirements and other distinctive characters that deserve recognition even though the fish are all morphologically and genetically similar. That these differences are important in maintaining genetic diversity within a subspecies is now becoming increasingly apparent to fisheries managers and several states have designated some of these diverse groups as populations of special concern. Consequently each subspecies, again excepting aquilarum, will be broken down into geographical units sharing similar traits rather than lumping them all together.

Within the subspecies irideus, the coastal rainbow, there are four of these geographical entities spread over its extensive range. The most southerly of these lies in the headwaters of the Rio del Presidio and adjacent Rio San Lorenzo in the Mexican state of Durango. Here, on the broad top of the Sierra Madre Occidental, the topography is more plateau-like than mountainous with the headwaters wandering through gentle valleys and flats before falling into the deep gashes of the barrancas or sheer walled canyons that slice through the range. At an altitude varying between six and eight thousand feet the country supports a pine-oak forest and even though it lies almost at the Tropic of Cancer the small creeks remain cool enough to sustain trout. Very little is known about these fish and that mostly from the work of Needham and Gard published in 1959. Consequently they are only provisionally included in the coastal rainbow group. This study indicated that the trout in the two river systems differ from each other and both differ from all other rainbows in some respects. In coloration and body markings they resemble redbands, the Rio San Lorenzo fish more so than those from the Rio del Presidio. In addition the former has an extremely long adipose fin and a profusion of parr marks large and small while the latter is more silvery and has a greater number of vertebrae. Behnke has written that the ancestral line leading to these trout probably had a strong redband influence

and the specimens that I saw there during a 1983 fishing expedition would certainly bear this out.

Some ichthyologists are of the opinion that these trout were hatchery introductions but Needham and Gard reported that the native residents insisted that they had always been there and that E. W. Nelson, during one of his early faunal surveys, found them there in 1898. Furthermore, these Durango rainbows are quite different from any stocks of hatchery fish past or present.

Assuming then that these trout are actually natives an ocean origin is indicated at some time during the Pleistocene glacial period when the Pacific was cooler and trout could roam far south of where they now occur. Since this area was never glaciated they could have invaded during any one of the four major glacial advances and if an early one might account for the difference between the trout of the two drainages due to long isolation. There could have also been some introgression between the Rio San Lorenzo trout and the Mexican golden trout of the Rio Culiacan, the next drainage to the north, as some of their headwaters interdigitate on the high plateau making a headwater transfer a possibility.

The next geographical zone containing similar appearing rainbows begins with the Rio Santo Domingo drainage near the village of San Quintin on the northern Baja California coast and

continues north to at least the San Luis Rey River just north of Escondido, California. This area has a San Diegan type faunal zone, climate and vegetation and is backed by the same granitic batholith. The Rio Santo Domingo is unique on the Baja coast in being the only perennial stream to reach the sea at all seasons, the only one to contain trout and having its source on the highest range on the peninsula, the Sierra San Pedro Martir. The first specimens of this trout were collected in 1905 by E. W. Nelson, named as a full species in his honor, Salmo nelsoni, later relegated to subspecific status and now considered a coastal rainbow. Nelson reported it as occurring in a canyon reach above Rancho San Antonio to the base of a barrier falls at roughly 2000 feet elevation. In later years some were moved to the headwaters of the Santo Domingo and to a few other streams draining the west slope of the Sierra San Pedro Martir so the range now occupied is considerably greater than originally occurred.

The Santo Domingo trout also strongly resemble the redband group with their brick red band, white or yellow tipped fins, yellowish tinges on the lower sides and a cheek blotch. Needham and Gard even reported basibranchial teeth, a redband trait, in one specimen. They also reported greater than average body depth behind the head or a "nuchal hump". All the specimens I have seen had black spots on the iris at either side of the

pupil giving the impression of a horizontal black band across the eye, a trait shared with the Mexican golden trout, the Apache trout and some of the redbands.

The origin of this trout is obviously from the sea. There is no other route by which it could have colonized the Rio Santo Domingo. There is some conjecture, however, as to just when this happened. According to Needham and Gard the local residents reported that steelhead sometimes ascend the Santo Domingo during exceptionally high water conditions, probably from strays wandering down the coast from more northerly waters. Consequently some have proposed a recent origin for the resident fish. It seems to this writer, however, that these trout have too many distinctive characters to be derived from a recent coastal steelhead ancestor among which is a unique allele found in no other trout of the genus as reported by Berg in his doctoral thesis. Furthermore, Behnke has written that he had examined trout specimens from Pauma Creek, a tributary of the San Luis Rey River in California, that strongly resembled the Santo Domingo fish and suggested a strong redband influence in both populations probably from an early introgression in the ancestral stock. Therefore, these trout probably are remnants of an original ancient population of resident fish that were found in all suitable waters from the Rio Santo Domingo north along the coast, possibly as far as Point Conception.

Little is known of the life history of the rainbows of the Santo Domingo. Local residents report that they can survive exceptionally high water temperatures and due to the low latitude and mild climate are probably early spawners.

The next zone to the north is the most extensive--from Point Conception on the southern California coast to the southern edge of the Alaskan Peninsula. Within this range the coastal rainbows are both anadromous and resident fish, sharing the same waters with the steelheads being predominant except above barriers or in lakes tributary to the streams. These are the classical rainbows most everyone is familiar with, silvery profusely spotted fish with pink cheeks and body stripes and while there are variations in coloration and spotting pattern in different drainage systems the group as a whole is remarkably homogenous. This is especially true today after over one hundred years of indiscriminate introduction of hatchery fish. Whatever the original diversity might have been in pre-hatchery days is mostly gone now at least in our three coastal states and in southern British Columbia. Some of this diversity was originally found at opposite ends of California's Central Valley, 400 miles apart; in the McCloud River below the barriers at the north end and in the main stem of the Kern River at the south. Both of these populations were highly colored heavily spotted rainbows and

both were named as full species by the early taxonomists, Salmo shasta for the McCloud fish and Salmo gilberti for those of the Kern, the former thought to be the main contributor to the early stocks of hatchery fish. After years of hatchery introductions of various genetic strains in these waters the original identity of both forms has been pretty well masked and they are now considered to be coastal rainbows.

There are always exceptions, of course, as would be expected in such a huge range, one of which is the McKenzie River redside. The McKenzie, an upper Willamette River tributary heading in the high Cascades of Oregon is home to a brightly colored rainbow with a deep red lateral stripe--hence its local name. This would seem to indicate an ancient introgression with the redbands which the coastal rainbows displaced in the lower Columbia system. Another oddity of the Willamette drainage--there are no resident rainbows in its western tributaries. Another slightly divergent race of coastal rainbow was described in 1896 as Salmo beardslei from Crescent Lake on Washington's Olympic Peninsula but has since been shown to be a specialized lacustrine form of irideus.

In this zone there are no great deviations in life history patterns such as age at maturity, longevity or growth rates. According to McAfee the average age at maturity is three years with maximum age at six or seven years. Maximum size, depending

on the water and food base varies from about eight inches in small headwater streams to over ten pounds in lakes or reservoirs with an abundant supply of forage fish.

There are still large areas of wilderness in Northern British Columbia and the Alaskan Panhandle with difficult access where little work has been done on the fishery. When this area has been adequately studied it may be that some divergent strains of resident irideus will be found. Captain Beardslee of the U. S. Navy gave us some tantalizing intimations of this possibility during his residence at Sitka in 1879 and 1880 but for now we can only assume that the fish in this area fall into the general pattern described above.

The last of the four geographical zones of irideus, the most northerly and westerly, begins on the north side of the Alaska Peninsula and continues around the Bering Sea coast to the Kuskokwim River. This is primarily a tundra habitat and all of the rainbows in the numerous drainages are resident fish. They also grow to be exceptionally large old fish and are the primary attraction to the many anglers visiting the area each season. The Bristol Bay drainages receive the heaviest angler use and have therefore been most studied by the Alaska Department of Fish and Game, particularly the Lake Iliamna and Naknek drainages. Consequently I have relied heavily on the studies of Russell, Gwartney and Burger for the life history of the

rainbows of this area and on those of Alt for the fish of the Kuskokwim Bay drainages.

In many respects the life history patterns of rainbows in the two areas are similar; age at first maturity is 7 years with most spawners being 8, 9 and 10 years old. Maximum longevity so far recorded is 14 years but few survive to more than 11. In the most northerly drainages, the Kuskokwim tributaries and those flowing to Kuskokwim Bay, the populations are entirely riverine while to the south both riverine and lake populations are present and remain distinct even though the lake fish enter the rivers to spawn and to follow the salmon runs.

These rainbows are opportunistic feeders, taking insect life and other invertebrates including clams and snails, forage fish and even voles on occasion but rely almost exclusively on salmon eggs, fry and the flesh of dead salmon during the periods when the salmon are on their spawning runs and when their fry is available. According to Minard growth rates and reproductive capabilities, i. e. whether or not they will spawn in consecutive years, apparently depends upon the size of the salmon runs.

Spawning activity, as with other trout, depends upon water temperature with the timing varying from season to season from April to June. Growth rates in the young is initially slow but

once they reach sufficient size to feed on the salmon base their growth increases rapidly. All of the fish, whether riverine or lacustrine, attain a larger than average size but those of Lake Iliamna known as the "Talarik strain" are the largest and often exceed ten pounds.

The riverine rainbows are colorful profusely spotted fish and superficially resemble redbands, even to the white tipped fins and orange slash marks on the underside of the lower jaw. The lake populations acquire intense coloration only when in spawning condition. Fortunately there has been little or no introductions of hatchery rainbows in Alaska so that the native strains remain genetically undiluted.

only Col.-Fraser

We now enter the realm of the second major group of rainbows, the redbands, O. m. gairdneri. Here again this subspecies covers such a wide range of zoogeographic zones and habitats containing trout with diverse characteristics and life history patterns that separate treatment of each area with its unique trout populations will be necessary.

The first of these to be considered is the smallest-- a few tiny, often intermittent, headwaters of the McCloud River in northern California draining a heavily forested volcanic plateau just east of Mt. Shasta. The trout in these streams, numbering only in the hundreds, are relict populations isolated above barriers and believed to be absolutely pure strains

of the original trout to colonize the waters. Since this area was never glaciated they could have invaded very early in the Pleistocene, not just since the last push of the Wisconsin glaciation.

These unique fish were first brought to the notice of ichthyologists in 1939 when Wales reported "golden trout" from Tate Creek and an unnamed creek, probably Sheepheaven Creek. His identification is understandable as my first impression upon seeing these fish in 1972 was their close resemblance to the golden trout of the Kern plateau. The trout of Sheepheaven Creek have now been the most studied taxonomically of all the redbands and are considered by many ichthyologists to be the archtype of the redband group, the standard by which all others are judged as to purity. They are the most intensely colored and have distinctive morphological and genetic attributes, some of which are shared with the golden trout of the High Sierras.

Sheepheaven Creek may be the most "mini" of any trout microhabitat anywhere. It originates in a tiny spring and a few sidehill seeps, flows for about a quarter mile and then goes underground not to be seen again except during periods of spate. Its trout are micro as well, six or seven inches is about the maximum size attained. Yet they have survived in their minuscule, often harsh, environment for

many thousands of years--a tribute to their adaptability. But there is always the possibility that some natural catastrophe, such as, a forest fire or long standing drought could wipe them out so the California Department of Fish and Game has moved a few fish from Sheepheaven Creek to two other nearby McCloud tributaries.

Just north of the McCloud drainage is the upper Klamath watershed in Oregon--the Klamath River above its gorge and Upper Klamath Lake with its tributary streams. This drainage system lies mostly within the same forested volcanic region but some of the eastern tributaries reach out into the high sagebrush desert. It was from Upper Klamath Lake that the first redband was described in 1858 and named Salmo newberrii. These lake fish, having a forage fish food base, can be large fish and many have been taken weighing well over ten pounds with one reported to have weighed twenty-six pounds. Since the Klamath system is open to the sea coastal rainbow steelhead once ran into the upper river before being blocked by hydro-electric dams. Hence some fisheries workers believe that these big fish are merely landlocked steelhead. However, Behnke has written that the two subspecies, irideus and gairdneri, were sympatric in Upper Klamath Lake, i. e., did not hybridize, so it would seem that the present stock, still exhibiting strong redband characteristics, has maintained at least some

newberrii

of its genetic integrity despite massive introduction of hatchery fish.

The riverine populations of Klamath Basin redbands are largely restricted to the small headwater streams flowing from the southern Cascades, the isolated mountains farther to the east and to the main Klamath River in the gorge below the lake although the gorge is within the zone of overlap with the range of the coastal rainbow.

The next drainage to the north of the Klamath system is the Deschutes River, flowing north to the Columbia through a spectacular rimrock canyon along the east base of the Cascades. It is a big, fast river with a remarkably even flow at all seasons and supports both anadromous and resident rainbows, the latter known locally as "Deschutes redsides". Some ichthyologists question whether this resident fish is actually a redband at all but the Deschutes River lies within the redband range and its fish show many redband characteristics. In fact a specimen from the Columbia just below the mouth of the Deschutes named Salmo gibbsii by Suckley in 1858 was later found to be a redband and Jordan noted that this form was found in Columbia tributaries as far as Shoshone Falls on the Snake and was particularly common in the Deschutes. Since the Deschutes abuts against the range of the coastal rainbows it would seem that introgression between the two subspecies irideus and

gairdneri may have been greater here than deeper into redband territory which might account for the confusion as to just where the "redside" fits into the phylogenetic scheme of the rainbow tribe.

The Deschutes is rich in invertebrate life and its "redsides" grow to large size, three to five pounds being commonplace. Being stream dwellers they are colorful fish and show the prominent red stripe at all seasons. In recent years the sport fishery has attracted anglers from all over the country particularly during the period of the "salmon fly" hatch when these big stoneflies emerge in unbelievable numbers.

Other mid-Columbia tributaries are home to redbands, such as, the John Day, Umatilla, Yakima, Walla Walla and Snake Rivers. Even though these drainages have been heavily impacted by hatchery transplants their trout populations still show strong redband traits. I have taken redbands from the John Day headwaters and the Walla Walla and thought at the time that the amount of variability evident was probably due to varying degrees of hybridization, either ancient through contact with coastal rainbows or through hatchery implants.

In the upper Columbia system and the Frazer River of British Columbia above Hell's Gate there is a different type of redband known as the Kamloops trout. This fish was originally described from Kamloops Lake, a large lake in the Frazer

also in streams most distinct where isolated

system, by Jordan in 1892 and apparently Jordan thought it was a salmon for he originally named it Oncorhynchus kamloops. Since that time its taxonomic status has vacillated between specific and subspecific designations and some still consider it to be a valid subspecies. It is a fine scaled fish, however, and in riverine populations a very colorful one and definitely belongs in the redband group. A variation of this form was described by J. R. Dymond in 1931 and named Salmo gairdneri whitehousei, the mountain Kamloops. This fish has many of the same traits as the redbands of Sheepheaven Creek in California being a relict form found only above barriers, has finer scales, retains parr marks as adults, has more intense coloration and probably represents the original invaders before any introgression with coastal rainbows occurred.

Valid?

The original range of the Kamloops trout included all of the middle and upper Frazer basin and parts of the upper Columbia. It even gained access to the headwaters of the Athabaska and Peace Rivers east of the Continental Divide, probably through the proglacial lakes that abutted against the retreating ice. It is primarily a lake fish and known to most people as a bright silvery fish with subdued coloration except during the spawning season. There are riverine populations, however, and these are typically colorful redbands with brick red lateral stripes. The original range

has been considerably expanded in British Columbia by hatchery introductions into lakes barren of fish life but rich in food resources with some phenomenal results in growth rates. It has also been widely stocked in the United States with indifferent results except in Lake Pend Oreille in Idaho where it grew to exceptional size.

There are some outstanding differences in the life histories of some Kamloops trout populations of which the classic examples are the trout of Kootenay Lake in southern British Columbia. Here there are two separate and distinct strains of Kamloops trout living sympatrically in the same water. One strain is the "standard" Kamloops, living on an invertebrate food base and growing to an average size of three or four pounds and a maximum age of five or six years. The other, the "Gerrard" or"Lardeau" strain, living on a kokanee salmon food base, not maturing until six, seven or even eight years and attaining maximum weights of over fifty pounds--the largest trout in North America. No wonder Jordan first thought these fish to be salmon!

Raymond, reporting on Hartman's studies, notes that this Gerrard strain selects for large size on their spawning grounds thirty miles up the Lardeau River from Kootenay Lake. Here the Lardeau flows out of Trout Lake with slightly warmer water and stable levels allowing early maturation of the eggs and

faster growth of the alevins giving them a competitive advantage. The current is also very strong and swift so that only the very large fish are able to maintain their position over the spawning areas. This strong flow has also scoured the substrate so that only the largest females are able to dig redds in the coarse material left. All of these factors combined contribute to an ongoing selective process in which the breeding stock is annually selected for greater size and greater age at maturity.

The Gerrard strain has been widely stocked in an attempt to replicate the big fish of Kootenay Lake in other waters but with only limited success for without the kokanee food base the stocked fish can grow to only average size. The exceptions have produced some monsters, however, as at Jewel Lake in British Columbia with several fish taken of over forty pounds and at Lake Pend Oreille in Idaho that produced a fish weighing thirty-seven pounds. The largest authenticated weight from Kootenay Lake was fifty-two pounds, a female taken by an egg collecting crew at the spawning area. But these giant trout are a rarity with trout in the fifteen to twenty pound range being far more common.

The last of the zoogeographic zones of the redbands encompasses a large tract of the high desert country of eastern Oregon, southwestern Idaho, northern Nevada and northeastern California. A part of this area lies within the drainage

basins of the Snake and Sacramento River systems with the remainder a series of closed basins without outlets. Most of the vast area lies within the Columbia Plateau with a small part in the Basin and Range province but all areas share a similar environment with general aridity, extremes of temperature and low stream flows. The trout, too, have much in common particularly in adapting to the harsh conditions and in their life history patterns.

The closed basins of the Oregon high desert contained large lakes at the close of the Pleistocene glacial period but now only a few remnants remain, their former size and depth still evident as fossil shorelines on surrounding hills and slopes. The trout in these lakes had chubs as a food base amd were probably very large fish but as the lakes dessicated in the warming and drying trend following the retreat of the ice the survivors found refuge in the few small streams that drained into the basins from the surrounding mountains and of necessity became small stream dwellers. Many of these streams, particularly in their lower courses, were marginal trout habitat at best with low flows, high summer temperatures and with wide diurnal fluctuations but the trout adapted to these vastly changed conditions and we know them today as desert redbands.

There are seven of these basins, all closed system with no outlet to the sea except the Goose Lake Basin straddling

the Oregon-California border which has infrequently overflowed into the Pit River. One basin, the Alvord, contains cutthroats but the other six all have redbands. Most of these basins never overflowed even at the highest lake levels so their trout populations have been isolated from each other for many thousands of years. This long isolation together with an unknown degree of ancient introgression with coastal rainbows and more recent exposure to hatchery fish may account for the diversity in these redband populations for they all differ slightly from each other. They all look like redbands, however, and share a similar life history pattern which is unique among the rainbow group--none survive their first spawning. Hosford and Pribyl in their 1983 studies of the Malheur Basin redbands found that 97% of the fish in their sample were age 3 or younger, that most spawned at age 3 and that none had spawned twice--quite a contrast with the big, old, multiple spawners of Kootenay Lake!

The redbands in the tributaries of the middle Snake River in Idaho, Oregon and northern Nevada are very similar to those in the Oregon desert basins, all being small, highly colorful stream fish. Hosford reported that Wallace found these to have the same life history pattern as well--early maturity with none surviving their first spawning. The habitat is also similar--high desert, low stream flows and extremes of tempera-

ture. Behnke reports taking redbands on a fly from an intermittent headwater of the Owyhee River in Nevada that were active and full of spirit in water of 83° F, a lethal temperature for most races of trout.

While there has probably been some ancestral introgression between these desert redbands and coastal rainbows when they first came in contact, electrophoretic studies by Wishard et al in 1980 found no evidence of hybridization with hatchery rainbows in eight populations of Owyhee River tributaries and adjacent streams flowing into the Snake. They therefore assumed that stocks of hatchery origin did not survive in the harsh environments of these waters long enough to hybridize with the native fish. But another study by Leary et al in 1983, using a somewhat different technique, did find some evidence of hatchery influence and it seems logical to conclude that after years of hatchery introductions that some introgression has occurred throughout the range of the desert redbands even though the harsh environment selects against the domesticated hatchery fish.

In the small stream environments occupied by desert redbands the trout are generally small fish with few exceeding a length of ten inches. When introduced into man made reservoirs with a richer food supply such as forage fish, however, they grow to a fairly large size but still have a

short life span.

The last of the rainbow subspecies, the Eagle Lake rainbow, O. m aquilarum, described by J. O. Snyder, is native only to Eagle Lake in northeastern California, a large, highly alkaline natural lake lying on the western edge of the Lahontan Basin. The rainbow's occurrence there is an enigma to zoogeographers and ichthyologists as all other native trout in the Lahontan Basin are cutthroats and all the fish fauna in Eagle Lake except the rainbows are native endemic to the Lahontan Basin. This has led some to suspect that the rainbows were introduced there by early settlers but if this actually happened, the introduced fish would not have survived the high alkalinity which is lethal to all trout except the Eagle Lake rainbow. The only other alternative is an early headwater transfer from the Pit River into Eagle Lake's only tributary, Pine Creek, and that is probably how it happened. This would give the Eagle Lake rainbows a redband ancestry, many of which are preadapted to high alkalinity and then, too, Eagle Lake, having no natural outlet was probably less alkaline thousands of years ago when the transfer occurred and the trout adapted as the alkalinity slowly increased.

Eagle Lake rainbows have a long life span, eleven years being the oldest age recorded and grow to large size on a tui chub food base. They are highly colorful fish at spawn-

ing time, originally spawning in Pine Creek but now Pine Creek has become so degraded that this is no longer possible. Consequently, eggs are taken annually, propagated in hatcheries and restocked into the lake to maintain the population. Pure populations are also maintained in three lakes in the Caribou Wilderness area in Mt. Lassen National Park and have been stocked in other lakes in California.

There were two other rainbows also described by Snyder from nearby Lahontan waters: the royal silver trout, Salmo regalis, from Lake Tahoe and the emerald trout, Salmo smaragdus, from Pyramid Lake, Nevada. Both of these are now considered to be extinct and both were probably hatchery rainbows introduced by man.

How Mankind Has Affected the Rainbows

As a species the rainbows are now doing well. Through the efforts of man the range of rainbows has been expanded across the United States to include all states except Louisiana, Mississippi and Florida, all the Canadian provinces and fifteen Mexican states. In addition rainbow populations are now established worldwife, on every continent except Antarctica. There are undoubtedly more rainbows on earth today than at any previous time.

When we come to subspecies and discrete geographical

strains of rainbows it is a different story. Since domestic hatchery rainbows of polygenetic origins will hybridize freely with pure strains of native rainbows, our one hundred year history of indiscriminate hatchery introductions has severely compromised the genetic purity of the native races. This is particularly true in California, Oregon, Washington, Idaho and to some extent in southern British Columbia. In these areas some races have been completely hybridized out of existence and others hang on as pure strains in a few remote headwaters. As Behnke has pointed out what has been lost here is intraspecific diversity, the adaptive traits acquired by thousands of generations of rainbows to successfully cope with the individual demands of their habitats, such as, tolerance to high water temperatures, high alkalinity, low stream flows, ability to use a specialized food base and life history patterns governing age at maturity, maximum size and longevity. Once gone these genetic resources cannot be replaced, their loss is terminal--gone forever.

Along with this genetic swamping by introduced hatchery rainbows the natives have had to contend with environmental degradation of their habitats through poor land use practices, pollution, water diversions, dams and all the ills associated with urban developments and industrialization. In the western states the greatest impact has been overgrazing on riparian habitat

by livestock, clearcut logging, mining and water diversions for agriculture and though we are told we are in an enlightened period of resource management the evidence of this is not apparent.

And so today we have lots of rainbows, mostly mass produced factory fish ill adapted for life in the wild and a few remnants of the real thing, a tragic reminder of what we once had. The bright spots in this dismal picture are in Mexico, northern British Columbia and Alaska where native rainbow populations exist without being impacted by hatchery transplants.

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List of Common Names of Resident Rainbow Trout

Redside

Redband

Bow

Kamloops

Mountain Trout

Speckled Trout

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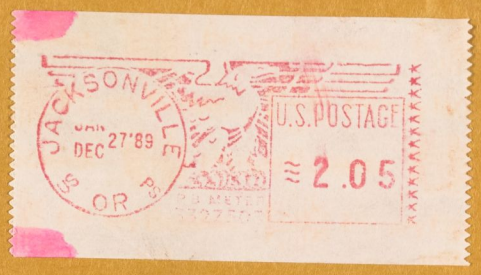

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