Robert Behnke

Wild Salmonid Genetics: An Impending Crisis?

In 1991 the American Fisheries Society published a list of 214 stocks of anadromous Pacific Coast salmonids that are already extinct or in various stages of endangerment. Since 1991, four races or stocks of Pacific salmon have been listed for protection under the Endangered Species Act. These include the winter run chinook salmon of the Sacramento River, the spring-summer and fall chinook of the Snake River, and the sockeye salmon of Redfish Lake, Idaho. The American Fisheries Society's publication warning of the precarious state of wild anadromous salmonids of the Pacific Coast stimulated a rash of petitions to list numerous races of Pacific salmon, steelhead, and coastal cutthroat trout for protection under the Endangered Species Act. The sheer number of petitions received contributed to an overload of the system. Many petitions are rejected for lack of information; others pile up in a backlog and will probably never receive adequate reviews.

The perceived urgency of the problem of conserving the genetic diversity of wild salmonid fishes is reflected in a list of priorities prepared by Trout Unlimited's Natural Resource Board at the 1994 annual meeting. Priority number four is "wild salmonid genetics." This is certainly a worthy issue for TU involvement, but I would ask: if one million or ten million dollars were made available to address the issues and problems concerning "wild salmonid genetics," how would it be spent and would the expenditures have any real benefits for conserving the genetic diversity of wild salmonids?

"Genetic research" is a classic example of a nebulous term often resulting in large expenditures with no tangible results. This is because most fisheries biologists and administrators have no more understanding of the subject matter than they do of plasma physics. They lack the understanding necessary to phrase the right questions in need of answers and thus are vulnerable to diverting large amounts of funds to obtain precise answers to irrelevant or wrong questions. Thus, it is basic for the goal of maintaining the genetic diversity of wild salmonids to have credibility, to ask the right questions, and then understand the limitations of any method or technique to answer the question before any method or technique is chosen.

A most important question we must confront was asked in a recent newsletter of the Society for Conservation Biology: "Why do we want to conserve biodiversity, anyway?" The newsletter goes on to point out that conservationists have not been highly successful in getting out our message, such as, why is wild salmonid genetics important? We have a failure in communications at various levels of society. This lack of effective communications became obvious in the outcome of the November 1994 Congressional elections. Helen Chenoweth was elected to represent Idaho in the new Congress. Ms. Chenoweth's environmental platform was essentially provided by the Wise Use Movement. To celebrate her victory, Ms. Chenoweth spoke at an "endangered salmon bake" in Stanley, Idaho (headwaters of the Salmon River, which contains three races of endangered salmon). She asked, "How can I take the salmon's endangered status seriously when you can buy a can at Albertson's?" Such a statement ignores the difference in values between meat in a can and live, wild salmon in a river, and also the fact that the dams that have made live wild salmon so rare in Idaho export most of their benefits outside the state. Her statement does, however, emphasize our failure to communicate on the question, "Why do we want to preserve biodiversity anyway?"

To counter the anti-environmental message in relation to conservation of wild salmonid genetic diversity, two common fallacies should be understood concerning causes of extinction and the "adaptiveness" of intraspecific diversity (genetic diversity within a species). These fallacies were widely propagandized during the last election in ne way or another. Their arguments enerally follow these lines of reasoning: xtinction is a natural process, it is a built-in" attribute of species to become xtinct, and man shouldn't interfere with ie laws of nature; and, minor variation mong populations and races of a species ; nonadaptive, the different parts of a pecies are interchangeable; therefore, iere is no need to save all the parts. The llacious extinction theory is based on ie outdated evolutionary theory of rthogenesis, which presumed a built-in iechanism causing extinction. Modern volutionary theory has long rejected rthogenesis as lacking any valid basis. i the past, most species became extinct irough evolutionary change. That is, iey gave rise to new species through me. Their genes were modified and assed on to maintain evolutionary iversity. In contrast, man-induced ccelerated extinctions result in termination of evolutionary lines before they can ve rise to new species.

The argument against adaptiveness of itraspecific variation is based on the itdated evolutionary theory of early eneticists concerning evolution of new iecies by "saltation." Genetic mutations ere thought of as "macromutations," hich could result in a new species in ie generation, and "micromutations," hich caused the "minor variations" nong populations and races of a ecies. In this theory, Darwinian natur- selection, the basis for adaptiveness by owly perfecting of survival, generation generation, only played the role of cepting or rejecting the new species ising from a macromutation; "adap- eness" played no role in the speciation ocess. Micromutations only supplied e "minor variations" observed within a ecies and were assumed to be non- aptive. This theory has also been long ected by most modern evolutionary neticists. The fallaciousness of the ltation" theory of evolution and its ociated arguments against adaptive- ss of intraspecific diversity has been arly demonstrated in salmonid fishes. the 1930s with the beginning of dam ilding on the Columbia River and ocking of salmon and steelhead runs, was assumed that the abundance of mon and steelhead could be maintained by substituting a few generic hatchery stocks for the great diversity of wild populations lost to dams under the mistaken notion of "interchangeable parts." We now realize, too late, that intraspecific diversity (the "minor variations") is indeed adaptive. The sockeye salmon spawning in Redfish Lake and the races of chinook salmon spawning in the headwaters of the Salmon River, Idaho, may show only minor variation in genetic structure to other populations of their species which spawn in rivers near the ocean. The fact that the Redfish Lake sockeye and the Salmon River chinook migrate almost 900 miles from the ocean (adults upstream, smolts downstream) means that they have very different life histories and physiologies compared to other populations of their species. These differences are "adaptive" for their specific spawning environments; they are not interchangeable.

Man-induced extinctions terminate evolutionary lines before they can give rise to new species.

Thus, a goal for the conservation of genetic diversity of wild salmonids would be to preserve the "range of adaptiveness" within a species. For anglers and fisheries managers, prioritizing the types of adaptations we want to preserve and utilize might be based on "trophy" fish. What populations or races have adaptive specializations that result in exceptionally large fish? For example, the world's largest steelhead are produced by populations native to the Skeena River basin. The world's largest chinook salmon are from the Kenai River, Alaska, populations. The world's largest rainbow trout is the Gerrard population of Kamloops rainbow of Kootenay Lake. The world's largest cutthroat trout is the Lahontan cutthroat trout native to Pyramid Lake (*Trout*, Summer 1993). The world's largest brook trout was the coaster population of the Nipigon River (*Trout*, Autumn 1994). Most would agree that these are the types of intraspecific adaptiveness we want to preserve. Let us now return to the issue of wild salmonid genetics and the need to ask the right questions.

All of the examples of important types of adaptations found within species of trout and salmon mentioned above — the longest migrations, the largest size, etc. — have evolved during relatively recent evolutionary times, perhaps about 10,000 years. All of the most modern, state-of-the-art techniques of genetic analysis would find all of these important types of diversity to be quite "insignificant" in terms of their quantitative degree of divergence within their respective species because they have not been separated and isolated for a sufficiently long period of time. The important differences in life history and ecology, the "adaptiveness" of a particular form of trout or salmon, cannot be understood or predicted from the tiny fraction of hereditary material sampled and analyzed by modern genetic techniques. The most important attributes of adaptiveness lie within what is called the regulatory genome, which is not sampled. We can only understand these attributes from observing the life history of an organism.

Thus, I foresee the danger that research on wild salmonid genetics, although of the best intentions, can have a negative influence on the conservation of the most important aspect of genetic diversity — preserving the range of adaptations. This danger will be manifested if people involved in decision-making substitute "data" and quantitative indices for knowledge and critical thinking and fail to ask the right questions.

There are analogies between evaluating and defining significant units of genetic diversity and critical assessment of significance in works of art, literature, and music. Just as artistic critiques require more than a quantitative assessment of colors, notes, and sequences of letters, understanding genetic diversity requires much more than a knowledge of DNA sequences. ■

Robert Behnke

Going Home Again: Revisiting Native Trout Watersheds of the West

IN 1957 I JOURNEYED FROM CONNECTICUT TO BERKELEY, CALIFORNIA, full of wonder in anticipation of participating in a fishing expedition from California to Alaska. This was the initiation of a study of the native trout of western North America that has lasted much of my lifetime.

Forty years ago it generally was known that there was a species of rainbow trout and a species of cutthroat trout, but not much more than that. The geographically distinct races could be called subspecies, but their distributions, or, even if they still existed, were unknown. Federal and state fishery agencies were concerned mainly with the propagation and stocking of hatchery trout (mostly non-native species in relation to the waters stocked). Such management policies were particularly hard on native cutthroat trout; they ranged from benign neglect to outright extermination.

I decided to do my master's graduate study on the cutthroat trout of the Great Basin—the internal basins that have no outlet to the sea. This should have been a relatively simple thesis because the only basins known to have cutthroat at the time were the Lahontan basin of Nevada, California and Oregon, and the Bonneville basin of Utah, Wyoming, Idaho, and Nevada. The published literature available in 1957 declared both the Lahontan and Bonneville cutthroat trout extinct, so my thesis could have consisted of an obituary for two cutthroat trout subspecies.

In view of the large areas of the Lahontan and Bonneville basins and the myriad of drainage networks, many remote and isolated, I thought there was a good probability that some populations of native cutthroat still existed, waiting to be discovered. I began annual summer collecting trips, which were later expanded to include the northern parts of the Great Basin (the Oregon desert basins) where the primitive interior form of rainbow trout (redband trout) is the native species.

I discovered native populations of both subspecies of cutthroat trout and redband trout, but the conditions of the watersheds where I found most of them were shocking. A long history of livestock overgrazing denuded the watersheds, initiating massive erosion. Riparian vegetation was long gone; small streams commonly were trenched down into arroyos, with trout barely surviving in pools maintained by small seeps. I found the Humboldt River form of Lahontan cutthroat to exist in 80–degree (F) water, and redband trout in temperatures up to 83 degrees. Those trout were surviving in habitats where no trout should have survived. I became fascinated with their adaptations. They had evolved over thousands of years to survive the harshest environmental conditions. For some populations, however, no amount of adaptiveness could ensure survival under conditions of continued watershed degradation. Despite supposed protection under the Endangered Species Act, five of the 10 known populations of Lahontan cutthroats in tiny tributaries in the Quinn River drainage were lost by 1990. The irony of native trout extinctions is that they were occurring in watersheds on federal lands—notably, those managed by the U.S. Forest Service and the Bureau of Land Management (BLM). Why couldn't federal agencies at least obey the Endangered Species Act and protect and restore watersheds by better livestock management practices? The conflict between resource stewardship and unregulated resource exploitation has been a matter of tradition and precedent in federal lands management as influenced by politics.

In 1905 Teddy Roosevelt and Gifford Pinchot, the first U.S. Forest Service chief, became aware of uncontrolled exploitation of natural resources, especially of the effects on watersheds from livestock overgrazing. They set aside large tracts of land as federal forest reserves (later national forests) to protect watersheds. The forest reserves were to be managed according to Pinchot's definition of conservation: The greatest good for the greatest number for the longest time. That is, in modern terms, resource sustainability.

Grazing allotments were assigned to family ranches and designed to avoid overgrazing and protect watershed integrity. How did things go wrong? Both cattle and sheep grazed on the lands of the U.S. forest reserves. Entrepreneurs bought up numerous sheep operations to form conglomerates. They didn't want to be fettered by federal regulations. They understood that it was more profitable to make money while the getting's good—make a fast buck and sell out. The devastation of the land was of no concern to them. They used their money and influence to elect members of Congress sympathetic to their interests. When William Howard Taft succeeded Roosevelt in 1909, Pinchot's days were numbered. The special interests profiting from federal lands were out to get him. The first attempt to manage federal lands on a sustainable basis was short lived. In 1910, at the annual meeting of wool growers at Ogden, Utah, Idaho's Senator Heyburn beamed as he announced to the gathering: "When the sun rolled over the eastern mountains this morning, it marked a new epic in the history of the West; Czar Pinchot has been dethroned and the western stockman is now free." Sound familiar? Do we as individuals or as agencies learn from history? I believe we do, to some extent, but it's a slow and inconsistent process.

Although the Forest Service and the BLM now operate under more environmentally enlightened guidelines of ecosystem management with a goal of restoring ecosystem health, the results are far from uniform. Large differences can be observed among areas and regions of federal lands in the success (or lack thereof) in managing livestock to restore watersheds. There are hopeful signs, however. In the fall of 1996, I had the opportunity to fish for native redband trout in the Donner and Blitzen River drainage of the Malheur Basin, Oregon. After comparing watershed conditions with what I remembered 25 years before, I was delighted to find the colorful and feisty redbands still there, and even more delighted to find them in greater abundance than 25 years earlier. The watershed had improved: grasses and other forage vegetation were still present in upland areas; willows and aspen were vigorously growing in the riparian zone; eroded banks were healing; and fish habitat had greatly improved. This was the result of the BLM's revised grazing management. By properly controlling livestock numbers and the grazing season, grazing can become sustainable and watersheds can be restored.

How some of those populations survived for the past 40 to 50 years or more in such severely degraded habitat seems almost beyond belief and is testimony to their tenacity.

In the summer of 1997, I made several trips to Nevada to examine many of the same streams where I first found the Humboldt cutthroat trout 35 to 40 years ago. Again, I was heartened to find greatly improved conditions in the streams and their watersheds. Willows were coming back to stabilize banks and shade the streams. Native cutthroat trout still occurred in all of the streams where I found them many years ago, and their continued existence appears bright. How some of those populations survived for the past 40 to 50 years or more in such severely degraded habitat seems almost beyond belief and is testimony to their tenacity. The improvements on the Nevada watersheds I observed are due to "corporate ranching." Generally, this term has negative connotations, but in this case the corporations are large gold mines that purchased large ranches and want to demonstrate that "multiple use" can be a reality. Professional range managers cooperate with the BLM to design specific grazing strategies (prescriptive grazing) for watershed restoration, especially the restoration of riparian vegetation and cutthroat trout habitat.

Historical negative experiences regarding livestock impacts on watersheds and trout habitat raised doubts in my mind on the compatibility between livestock and trout, but I've seen examples of new techniques of grazing management, and they work—if done properly.

Will the "new" grazing strategies catch on and rapidly spread throughout the country? Can we learn from history? An analogous situation would be a public school that ranked at the bottom in test scores and percent of students graduating. A new principal initiates new teaching techniques and instills discipline, raising test scores and graduation rates. Although the school is now highly rated with benefits to all its students, a few obstinate students rebel against the principal's "tyranny." They complain to their parents who have influence with members of the school board because they contributed to election campaigns. The school board fires the principal and the school soon reverts to its former condition.

Members of Congress who loudly proclaim slogans such as "genocide on the West" or "freeing stockmen" from tyrannical federal controls are ignorant of—or choose to ignore—the history of natural resource exploitation. ■

TROUT UNLIMITED

Anadromous brook trout: biology, status and enhancement.
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Date: January 5, 1998

Dear Bob:

Attached is the copyedited version of your Spring "About Trout." My questions for you are noted with asterisks. Please call or fax me with your answers.

Thank you,

Christine

Attachment (4 pages)

Spring issue

— Gouvin – re Colo rept. ?

Summer

Do we letter II

– re resource con

grazing

About Trout
Robert Behnke
Do We Learn From History?

1

condemned
Those who cannot remember the past are doomed to repeat it.
—George Santyana

The significant problems we face cannot be solved by the same level of thinking that created them.
We cannot expect to solve today's problems with the same level of thinking that caused them.
—Albert Einstein

I raised this question in my last "About Trout" column (Winter 1998) concerning the lag time between when new knowledge and new methods are known and when they are implemented (in relation to livestock management on public lands). This question came to mind again late last year regarding hatcheries, catchable trout and fisheries management. Because of whirling disease, the Colorado Wildlife Commission announced that it would stock fewer catchable trout and institute lower bag limits on trout in some waters. This evoked expressions of outrage from some state legislators. A bit of historical review of Colorado fishery data would show that if one million fewer catchable trout are stocked, the total catch of all fish in the state would be reduced by only three percent. Combining this with the fact that the overwhelming majority of anglers do not fish solely or mainly for catchable trout, the overall effect on angling would be essentially nil.

In December 1997, Trout Unlimited unveiled its recommendations for fisheries management in Colorado, with a report, *Fishing for Answers: Status and Trends of Coldwater Management in Colorado*. The report urges a shift in emphasis from dependence on stocking great numbers of catchable trout to wild trout and their habitat. *Fishing for Answers* is an example of applying "new" thinking to help solve today's problems, rather than relying on the old thinking that caused them. It is also an example of lag time. The "new" thinking of a shift in emphasis from the artificiality of catchable trout to wild trout is the same thinking that created Trout Unlimited almost 40 years ago. TU's recommendations, however, drew criticism from some people, ignorant of the historical background, who suggested that an environmental extremist organization was out to ruin fishing for the average angler.

The debate raised a question on how so large a proportion of the public, politicians, fisheries managers, and outdoor writers became locked into the cult of artificial propagation—a technological "solution" to biological problems. Some historical perspective offers a few insights into this question.

Fish culture in America began in the mid-19th century, during an era that has been called the "flowering of science." Human beings, in general, regarded themselves as separate from nature. Although there were a few people marching to the beat of a different drummer—such as Henry Thoreau, who believed humans to be a part of nature, and that nature contains intrinsic, noncommodity values apart from humans—such views were not prevailing. Rather, it was believed that nature and natural resources existed solely to benefit humankind. Human's duty was to control, dominate and manipulate nature. Science and technology were seen as tools to uncover nature's secrets so that resources could be exploited more efficiently. Nature was viewed as disorderly and chaotic; the application of science and technology would bring control, order and efficiency for increased human benefit.

Fish culture is a classic example of a naive faith that humans could improve nature by making it more efficient. Natural reproduction was believed to be terribly inefficient. Of the thousands of eggs spawned by a salmon (or millions by some fish species), only 5 to 10 percent were expected to hatch as live, baby fish. Fish culture could achieve a 90 to 95 percent hatch. This distinction was regarded as irrefutable proof that humans could improve on nature. Ecological concepts, such as carrying capacity and environmental constraints on abundance, were not part of the optimism concerning the wonders of artificial propagation. In this optimistic mood, Congress established in 1871 the United States Fish Commission to oversee the artificial propagation and dissemination of "valuable" species.

The first salmon cannery on the Columbia River began operation in 1866. By the mid-1870s, there were 30 canneries, 1,000 boats and 6,000 workers engaged in the commercial salmon fishery near the mouth of the Columbia. Some cannery operators and the Oregon legislature petitioned the U.S. Fish Commission out of concern that an unregulated fishery soon would lead to overexploitation. In 1875, Commissioner Spencer Baird responded to those concerns. He recognized the major problems threatening the abundance of Columbia River salmon to be overfishing, dams and altered habitat, yet stated that regulations were not feasible nor desirable. Economic development, not salmon, was the "highest good" that the Columbia River could be put to. Even though no hatchery yet existed on the Columbia in 1875, many believed that hatchery propagation would maintain and increase salmon abundance.

It is interesting that Baird already recognized dams and altered habitat as threats to salmon in the Columbia basin as early as 1875. The rapid increase in human population in the Washington and Oregon territories in the mid-19th century required dams to power mills and lumber for construction. The magnitude of early habitat degradation can be assessed from a diary of a man on a boat 30 miles off the mouth of the Columbia in 1852, who noted that the sea was covered by sawdust and debris from lumber mills, dumped into numerous tributary streams and transported to sea via the Columbia River. What might have been the abundance of salmon in the Columbia basin before the arrival of Euro-Americans? The peak commercial catch of chinook salmon alone was 43 million pounds in 1883 and that was comprised of only spring-run chinook. **The summer and fall runs were not commercially harvested until later, after the spring run had been greatly depressed by overfishing.** *[when did commercial harvest of the summer and fall chinook begin?]* — in early 1900s

At the World Fishery Congress in 1883, a spokesperson for the U.S. Fish Commission stated that the Columbia River industry was under the complete control of fish culturists. Even with naive faith and unbridled optimism in fish culture, this was a strange statement because there still was no salmon hatchery on the Columbia in 1883. In the U.S. Fish Commission's 1884 annual report, however, government policy was clearly stated: To make fish so abundant, through artificial propagation, that harvest regulation would be unnecessary.

When salmon hatcheries were established **big time** *[please quantify and date this – "big time" is too vague!]* (— b/c early 20th century) in the Columbia basin, they began to homogenize races and break down the site-specific population adaptations that are critical to a species' overall abundance. For example, a "central" hatchery in Oregon was built in 1909 to hatch 60 million salmon eggs. The eggs were taken from many different populations, thrown together, and the newly-hatched fish were stocked back into numerous streams within and outside the Columbia basin. As salmon runs in the Columbia declined while stocking of hatchery fish increased, a few biologists expressed concern that reliance on artificial propagation to overcome the effects of overfishing, dams, pollution, and habitat degradation was ill-founded. Still, improved technology in hatchery engineering, fish diet and disease control continually held out hope that great success would be achieved in the future, and more and more hatcheries were constructed *[throughout the 20th century?]* —

After World War II, dam building in the Columbia basin accelerated. At the time, it would have been politically incorrect to admit that the large dams on the mainstream Columbia and Snake Rivers would prove devastating to salmon and steelhead, so the slogan "We can have fish and electricity, too" became popular. It was believed (assumed) that new hatchery construction would maintain the abundance of salmon and steelhead—the same mentality and faith in a technological "fix" as expressed by the U.S. Fish Commission in 1875 and 1884.

Do we learn from history? ~~**By recent times**~~ *[when?]*, 1.3 billion dollars ~~worth of~~ hatcheries existed in the Columbia basin. By the late 1980s, 160 million chinook salmon (mostly smolts) were being stocked in the basin. **For the past several years, the total return of all salmon and steelhead to the Columbia has been between one and two million fish. About 80 percent of those are from hatcheries. At many hatcheries, only one salmon returns for every 1,000 to 10,000 smolts stocked.** *[I'd like to check these statistics. What's your source for them?]* Those returning adults represent costs of hundreds of dollars and if taken in a commercial fishery, they have a wholesale value of around 50 cents per pound. There is a certain irony in these figures as they confirm the optimistic assumptions of the 1870s and 1880s about Columbia salmon being under the control of artificial propagation. Unfortunately, the assumption that abundance would be maintained and increased because hatcheries would compensate for the effects of dams, overfishing, habitat degradation, and pollution, was disastrously mistaken. Total numbers of salmon and stealhead returning to the Columbia in recent years are only about 5 to 10 percent of their abundance before dams, altered habitat and hatcheries.

After a considerable lag time, we now are learning lessons from history, and new thinking is being applied to problems caused by the false belief in control and dominance of nature and technological "solutions" to right all wrongs.

A similar scenario applies to inland fisheries in relation to reliance on catchable trout to meet increased angler demand. During the past 50 years, improved technologies have resulted in large, efficient trout hatcheries. For example, commercial hatcheries supply great numbers of relatively low-cost trout to restaurants and supermarkets. State and federal hatcheries continuously increased production of catchable trout until in some states, such as Colorado, more than half of the state fisheries budget was devoted to rearing and stocking catchable trout. The relative merits of where to place emphasis—catchable trout or wild trout—in management programs has been the subject of a long, ongoing controversy (see "From Hatcheries to Habitat? Look Again." Autumn 1991 *Trout*; and "Catchable Trout: Are Anglers Getting Their Money's Worth?" Winter 1996 *Trout*). Again, there has been a considerable lag time in learning from the past and applying new thinking to resolve the catchable trout vs. wild trout controversy.

I am heartened by the dedication and expertise Trout Unlimited has demonstrated to delineate the elements of the controversy and expose them for intelligent discussion and critique. In addition to *Fishing for Answers*, TU produced two economic reports. One demonstrates that there is no relationship between the number of catchable trout stocked and fishing license sales. The assumption of a direct and equal relationship between the number of catchable trout stocked and license sales has driven Colorado's fisheries program; critical analysis of historical data proves it false. The other report concerns the costs of producing and stocking catchable trout and the values (willingness to pay) placed on those trout by anglers who catch them. The findings probably will come as no surprise to wild trout enthusiasts. Anglers fishing for catchable trout are not "willing to pay" what the trout costs. There is an important difference between "knowing" something by intuition or gut feeling and knowing on the basis of sound scientific analysis of a great amount of economic and statistical data. We now have a solid basis for putting catchable trout in better perspective in relation to their proper role in fisheries programs.

Learning from the past and applying new thinking do not imply doing away with hatcheries and all of the hatchery personnel (more than 50 percent of people employed by the Colorado Division of Wildlife's fishery/aquatic program work in hatcheries). What I envision is that hatcheries will become more effective in making the connection between fish stocked and fish caught by anglers. This can be done by a shift in emphasis from catchable trout production (put-and-take fishery) to production of selected strains of trout to stock in put-and-grow fisheries. In Colorado, lakes and reservoirs stocked with salmonid fishes make up about six times the surface area of all trout streams in the state. There is a long history demonstrating that selected strains of trout—Eagle Lake rainbow trout, for example—stocked at fingerling or subcatchable size, survive and grow strikingly better than the domestic strains used to produce catchable trout. When 90 to 95 percent of all hatchery biomass is tied up in catchable trout, there is little room and low priority to become seriously involved in rearing selected strains and matching them to specific waters to increase the success of put-and-grow fisheries. Hopefully, one result of de-emphasizing catchable trout will be to free up hatcheries for production of selected strains to improve put-and-grow fisheries. The net result in total angler catch would more than make up the loss caused by stocking fewer catchable trout.

I am optimistic but also realistic. Most progress can be characterized as two steps forward and one step back. I also am mindful of the old aphorisms about teaching old dogs new tricks and that the more things change, the more they stay the same.

Robert Behnke

The Perils of Anadromy: What Have We Learned From History?

'WE'VE SPENT BILLIONS OF DOLLARS TO BOLSTER DWINDLING Northwest salmon runs, yet the numbers of fish continue to decline." So began a front-page story and series of articles in the *Seattle Post-Intelligencer* last year, which explored the ramifications of the long-term, consistent decline in anadromous salmonids, namely, chinook and coho salmon and steelhead. By winter 1997, several populations or races of those species were listed for protection under the Endangered Species Act in California, Oregon and Washington. How did we get to this state of affairs? Is there hope for the future?

In my last column (Spring 1998), I examined the question, Do we learn from history? I pointed out that the decline of Columbia River salmon and steelhead could be traced to a simplistic faith in science and technology to solve all problems. The prevailing thinking was that humans could have dams, pollution, over-fishing, and degraded watersheds and still maintain the abundance of anadromous fishes because they could be artificially propagated on a massive scale. The technology is good—fish culture has been increasingly efficient in raising fish; however, the biology on which the technology is based is seriously flawed.

Species such as chinook salmon and steelhead in a large system like the Columbia River basin originally consisted of hundreds of separate populations, each site-specifically adapted to particular parts of the basin. A long evolutionary history of perfecting site-specific, life history adaptations is the basis for maximizing abundance. Dams and hatcheries have destroyed or impaired much, perhaps even most, of the site-specific adaptiveness of native populations of chinook and coho salmon and steelhead. The genetic basis to maximize abundance has been impaired. A genetic explanation is certainly not the whole story, however. It can't explain why the declines have been so severe in the past 10 years.

The Winter 1991 *TROUT* was devoted to "Pacific Salmon at the Crossroads" and documented the loss of the adaptive diversity of salmonid populations and races in the Pacific Northwest. Two years later, *TROUT* (Summer 1993) featured the topic, "Can We Save the Northwest's Salmon?" In that issue, several experts offered opinions on what needed to be done to restore salmon and steelhead. Yet by 1998, runs of chinook, coho and steelhead have continued to decline, resulting in several listings for protection under the Endangered Species Act.

Thirty years ago, the federal government began a highly-touted technological "fix" to restore anadromous salmonids—barging young salmon and steelhead around the dams on the Columbia-Snake River system and releasing them in the Columbia below Bonneville Dam, the lowermost dam. This seemed to be a logical method to reduce mortality of juveniles passing over spillways or through turbines at each dam (Snake River fish must negotiate eight dams, four on the Columbia and four on the Snake).

SCOTT RIPLEY

In the 1960s, an average of 70,000 wild steelhead returned to the Snake River headed for Idaho and Oregon. Today, Snake River steelhead are listed as threatened under the Endangered Species Act.

Barging hasn't worked. After many millions of barged salmon and steelhead, there has been no consistent, significant difference in the survival of returning adults between those fish that are barged versus those fish that move over or through dams on their own. Both groups have had abysmally low survival. Moreover, the adults that do return from the barged smolts, especially those of hatchery origin, have a strong tendency to stray to other rivers rather than return to their home streams. This results in mixing non-native, hatchery fish with wild, native populations.

Let's review the big picture on the factors that determine abundance of anadromous fishes. Major dichotomies can be made between natural phenomena and human-induced environmental impacts and between ocean and freshwater environments.

Natural phenomena include climatic changes in temperature and precipitation, changing ocean currents, patterns of upwelling, nutrients, and ocean productivity. Under virgin conditions, with no human impacts, freshwater survival from egg to smolt migrating to the ocean is greatly influenced by flow and temperature conditions to which the young are exposed. Especially for juvenile steelhead (which spend two or three years in freshwater) and coho salmon (which spend one year in freshwater), the quantity and quality of overwinter habitat is an important determinant of survival. The freshwater environment imposes greater limitations on steelhead abundance than it does on chinook young, which mainly go to sea in their first year of life.

Yakima coho were traded for fruit orchards.

Not considering fishing mortality (especially "over-fishing"), survival of smolts to returning adults is strongly influenced by ocean productivity in their forging areas of the North Pacific Ocean. Thus, even under pristine conditions, populations of salmon and steelhead would be expected to have large differences in abundance over short- and long-term cycles due to natural phenomena. For example, during a 100-year period, some years would have optimal freshwater conditions coinciding with optimal ocean conditions resulting in a cycle of high abundance of anadromous fish. When poor freshwater conditions coincide with poor ocean conditions, abundance is greatly reduced, perhaps to only 10 percent or less of the high abundance cycle, depending on the species and region.

In the Columbia and other West Coast salmon and steelhead rivers, the freshwater environment has been severely degraded. Dams have blocked spawning runs and changed temperatures and flows; logging, livestock grazing, and agriculture have degraded habitat and increased sediment input. Spawning rivers have been dredged for gold, channelized for flood control, diverted for irrigation, and subjected to toxic mine drainage and other pollutants. If all dams were eliminated, the freshwater environment would still operate at a much reduced capacity for anadromous fish because of the cumulative abuse of 150 years of human activities.

A habitat improvement project on a 1,000-foot section of a small stream can increase abundance of a resident trout population whose life history needs can be satisfied in a relatively small area. However, for anadromous juvenile salmon or steelhead, which use 100 miles or more of stream habitat from the time they hatch until they migrate to the ocean, terms such as enhancement, restoration or rehabilitation must be applied in the context of the whole watershed.

During the past 10 years or so, there has been a continuing downward trend in ocean conditions for anadromous fish. Warming temperatures and reduced nutrients and food supply have resulted in lower ocean productivity and survival of anadromous fish in the Northwest. Warmer ocean temperatures have caused northern movement of predators, further affecting salmon and steelhead in the ocean. Presently, anadromous salmonids face a double whammy: poor conditions in both the freshwater and marine parts of their life history.

Salmon and steelhead have drastically declined both in the Columbia River, with many mainstem dams, and in other rivers without dams. Consequently, many people question the premise that Columbia dams are the main cause of anadromous salmonid decline. A recently-published book by James Buchal, *The Great Salmon Hoax* (Iconoclast Publishing Co.), pursues this line of reasoning. I agree that there is much more than dams to blame for anadromous fish decline. The Columbia River once had runs of millions of chum and coho salmon. The chum salmon spawned downstream of Bonneville Dam yet became essentially extinct in the basin before the dam-building era. Something happened to their spawning streams that eliminated successful reproduction. Many coho populations migrated upstream east of the Cascade range in the mid-upper Columbia basin. For the most part, those native populations were all gone before the dam-building era. The Yakima River once had abundant coho runs. Intense demand for irrigated agriculture resulted in, on average, only about 30 percent of the Yakima's virgin flow reaching the Columbia. The coho were traded for fruit orchards.

There can be no reasonable doubt that the four dams on the Snake River have been the primary cause of the decline of chinook salmon and steelhead in Idaho's Snake River system.

There can be no reasonable doubt, however, that the four dams on the Snake River have been the primary cause of the enormous decline of the chinook salmon and steelhead in Idaho's Snake River system. Sockeye salmon returning to Lake Osoyoos, on the Okanogan River in British Columbia, still maintain a moderately abundant population. Those salmon—whether juveniles moving downstream or adults moving upstream—must pass nine dams on the Columbia River. In contrast, the sockeye salmon of Redfish Lake, Idaho went from thousands to functionally extinct after the four Snake River dams were in place (they now are maintained by captive breeding). Simply put, the nine Columbia dams are not as detrimental as the four Snake dams.

About 25 years ago, when the effects of Columbia and Snake River dams were becoming apparent, fisheries professionals expressed concern about the future of Columbia basin salmon and steelhead. A symposium on the subject was held in Vancouver, Wash. in 1976 (Trout Unlimited was one of the sponsors). The American Fisheries Society published the proceedings, which make interesting reading from a historical perspective—what was predicted and what came to pass over the next 20 years. Some people came across as quite contemporary, warning against the danger of over-reliance on hatcheries and technological fixes, and stressing the importance of preserving the remaining wild, native populations. A hatchery spokesperson, maintaining his faith in technology, however, stated that hatcheries "can provide the means of rebuilding future runs in the upper Columbia and Snake River system to the levels that existed before dams." If I were awarding a prize for the worst or most faulty prediction made at this symposium, it would be a tough choice. Washington Governor Daniel Evans, who gave the keynote address, admitted that there were indeed serious problems for salmon and steelhead, but assumed things had bottomed-out and that "we have no place to go but up."

Hindsight is a more accurate predictor than foresight. So, what can we learn from hindsight to improve the accuracy of foresight? ■

Dr. Bob Behnke has been a Professor of Fisheries Biology at Colorado State University since 1966. A fascination, or obsession, with studying the diversity of trout, salmon and their relatives developed in early childhood, which later led to seeking them out in North America, Europe and Asia. His "About Trout" column began in 1983.

Robert Behnke

The First Forty Years: From Rhetoric to Research

THE GENESIS OF TROUT UNLIMITED OCCURRED IN JULY 1959 WHEN A group of dedicated anglers met at George Griffith's home on the banks of the Au Sable River near Grayling, Michigan. The impetus for the meeting was to promote the cause of wild trout management. George Griffith was an ardent outdoorsman who loved fly fishing for wild trout. He and his fellow anglers meeting that fateful day abhorred the prevailing policy of the fisheries division of the Michigan Department of Natural Resources (DNR)—namely, dumping large numbers of catchable hatchery trout in the Au Sable and other streams with good populations of wild trout and calling it "fisheries management." The TU founding fathers wanted a change in emphasis from put-and-take catchable trout to wild trout managed with special regulations.

Griffith had served as a Michigan Conservation Commissioner for several years but was frustrated in his attempts to change the fisheries management program, which was dominated by fish culturists believing that they were simply catering to the preference of the general angling public. The need for an organization that could exert external pressure to effect change was suggested to Griffith by his neighbor George Mason, who was an early leader and driving force in Ducks Unlimited.

A strategy was developed, a scientific advisory board created, and Trout Unlimited prepared its first policy statement on wild trout management. Despite the dedication and enthusiasm sustaining Trout Unlimited in its first years, progress was slow: the power of the fish culturists and the prevailing put-and-take mentality resulted in inertia.

In 1963 the Michigan DNR restructured and dramatically turned around its fisheries division; put-and-take management was discarded and TU's wild trout policy was essentially implemented. One might assume that sound science and logical thinking were the basis for TU's first triumph. This was not the case, however; change was effected more by money and politics. Griffith told me the story many years ago and it's no secret as he recounted it in his 1993 book, *For the Love of Trout.*

An early TU member was the Kent County chairman of the Republican party. In 1962 Republican George Romney was elected Governor of Michigan. To exert pressure on the Governor to appoint a pro-TU person to the Michigan Conservation Commission (which would tip the balance of the Commission in favor of wild trout), the county's $12,000 monthly donation to the Republican party's state headquarters was withheld. This elicited a call from the Governor, TU got its man on the Commission, and the rest is history.

Trout Unlimited's success in implementing more progressive fisheries management in Michigan helped expand TU as a national organization and eventually expand its goals to become a premier national conservation organization.

TU's original purpose was rather limited in scope: advocating for wild trout management rather than put-and-take catchable trout stocking. A 40-year review on the progress of state fishery agencies on this issue is not encouraging, but that's another story for another column. I will now focus on the successes TU has had on broader conservation issues and examine the basis for success. This relates to the title of this column, "from rhetoric to research." TU's early leaders promoted research and science as a basis for fisheries management and coldwater conservation (TU's first president, Casey Westell, established the precedent that TU would only support a position that was scientifically sound), but conservation laws were weak or nonexistent. Conservationists could complain and agonize over habitat degradation, pollution, and the drying-up of streams, but there was little in the way of legal recourse to do anything about those problems until proper laws were enacted.

When government agencies dealing with natural resources were created, they were focused on a single, strictly utilitarian purpose, without regard for the environmental consequences of their actions. There was no consideration of the "costs" entailed from obtaining the "benefits." For example, the U.S. Bureau of Reclamation was created in 1903. Its purpose was to make the arid West green, the deserts bloom. It would do this by transforming "wasted" water flowing in rivers into "beneficial" water by taking it from rivers and putting it onto land for irrigated agriculture.

The Bureau's first project was the Newlands Project, named for its promoter, Nevada Senator Francis Newlands. The project removed most of the flow from Nevada's Truckee River. Its impact on Pyramid Lake and its population of the world's largest cutthroat trout was predictable—the lake level dropped by 75 feet, surface area was almost halved, and the native cutthroat trout was extinct by 1940. Commenting on these environmental concerns, Newlands retorted: "Pyramid Lake exists only to satisfy the thirsting sun." There was no assessment of costs and benefits; the benefits of irrigation vs. the loss of the world's largest cutthroat trout; or the impacts on the Pyramid Lake Paiute Tribe and on the cui-ui sucker, an ancient species found only in Pyramid Lake. Native Americans had few rights and no political clout at the time, and there was no Endangered Species Act.

This policy of single-purpose natural resource exploitation prevailed into the period of TU's early years. I recall a meeting of the University of California at Berkeley's conservation club, when Willis Evans of the California Department of Fish and Game (who after retirement became an environmental activist) gave a slide show depicting the blocking and destruction of many streams by logging debris resulting from clear-cuts made without regard to any other values except to maximize production and minimize costs. Those streams were inhabited by steelhead, coho salmon, and coastal cutthroat trout before the destructive logging operations. Most of the audience was appalled at scenes of how improper logging practices devastate streams and fish. But at least one person in the audience saw nothing improper: The Dean of the School of Forestry asked the worth of the fish that were lost and how that lost value compared to the value of the lumber from the clear-cut.

The TU founding fathers wanted a change in emphasis from put-and-take catchable trout to wild trout managed with special regulations.

This incident illustrates how students in the fields of natural resource management were "educated" at the time and suggests why, after they became agency administrators, they were resistant to change.

Environmental laws were eventually passed that allowed for legal challenges to correct the long history of environmental abuse. Many people in government agencies, however, found it difficult to change from business-as-usual single use to new paradigms of multiple use. In 1960 Congress passed the Multiple Use Sustained Yield Act, which directed the U.S. Forest Service to manage its lands "...without impairment of the productivity of the land. Consideration must be given to the relative values of all of the resources, not necessarily the use that gives the greatest dollar return or greatest unit output."

I have a 1966 report prepared by the U.S. Forest Service and the Soil Conservation Service on the Humboldt River watershed in Nevada. The report is concerned with how to create more "beneficial" water for irrigation. The solution was phreatophyte control. All vegetation in the watershed was divided into "beneficial" species (i.e., eaten by livestock) and "nonbeneficial" species (the phreatophytes that transpire large amounts of water and have no commercial value). Cottonwood trees were regarded as very nonbeneficial as they transpire four acre feet of water per acre of cottonwoods—therefore, each acre of cottonwoods exterminated would free up four acre feet of water for "beneficial" use.

During the 1960s, after the passage of the Multiple Use Sustained Yield Act, agencies of the U.S. Department of Agriculture—namely, the Forest Service and the Soil Conservation Service—continued to herbicide riparian and wetland vegetation to free-up more "beneficial" water without regard to the costs incurred, such as decreased fish and wildlife habitat, increased erosion, and declining water quality. This was a clear violation of the intent of the Act and a classic example of "lag time" mentioned in my Spring 1998 column, "Do We Learn From History?" Legal action by conservation organizations is necessary to reverse illegal actions by federal agencies and shorten the lag time before correction.

Other environmental laws important for coldwater fisheries protection are:

- National Environmental Policy Act of 1969—requires federal agencies to write environmental assessments or environmental impact statements to adequately address all consequences of any "significant action" and to avoid "irreversible loss" of any environmental component;
- Endangered Species Act of 1973—requires federal agencies to avoid any action that might jeopardize protected species; and
- 1986 Amendment to the Federal Power Act, the law that governs the Federal Energy Regulatory Commission (FERC)—requires FERC to give "equal consideration" to all values of water in relation to values of power generation (especially important for dam relicensing).

Much of Trout Unlimited's success in attaining recognition as a major conservation organization is due to its efforts—often through sharing research findings and legal expertise with other conservation organizations—to force compliance with federal law thereby achieving protection and enhancement of environments inhabited by coldwater fish.

The U.S. Bureau of Reclamation was created in 1903. Its purpose was to make the arid West green, the deserts bloom.

In the big arena of conservation, TU has accomplished great things and has received deserved recognition. As for the original goals of its founding fathers—emphasis of wild trout over catchable hatchery trout in fisheries management—that's another story; as Jim Yuskavitch points out in this issue, we're still in the rhetoric stage. But we should not despair. Further research is necessary and eventually rational thinking will prevail; however, external pressure will be needed, even to the extent of withholding political donations. ■

Dr. Bob Behnke has been a Professor of Fisheries Biology at Colorado State University since 1966. A fascination, or obsession, to study the diversity of trout, salmon and their relatives developed in early childhood, which later led to seeking them out in North America, Europe and Asia. His "About Trout" column began in 1983.

About Trout

Robert Behnke

Wild Trout and Hatchery Trout: A 40-Year Review

In my last column I mentioned that Trout Unlimited has achieved great success as a coldwater conservation organization, but that outside the organization, there has been a general lack of success in achieving TU's original goal of 40 years ago: emphasizing wild trout management over maintaining put-and-take fisheries by stocking catchable trout.

In 1989 TU celebrated its 30th anniversary. The four issues of *TROUT* that year were devoted to a celebration of progress. Ray White wrote a feature article, "From Hatcheries to Habitat" (Autumn 1991), to show that progress was being made toward greater emphasis on wild trout management. Although this was true and could be documented by the increase in miles of streams managed for wild trout, I suspected that there was no comparable decline in catchable trout production during the 1959-89 period. In fact, when I reviewed the statistics, I found that the number of catchable trout raised in state and federal hatcheries had increased from 50 million to 78 million during this era of "from hatcheries to habitat."

Later I collaborated with economists to learn more about the economics of catchable trout ("Catchable Trout: Are Anglers Getting Their Money's Worth?", Winter 1996 *TROUT*). And TU sponsored economic analysis of catchable trout programs, resulting in the 1997 report, "Fishing for Answers" (available on TU's Web site at www.tu.org). The report showed that there is no relationship between license sales and the number of catchable trout stocked (during the eighties, California showed an inverse relationship—more catchables stocked, fewer licenses sold), and that anglers are not willing to pay what it costs to provide the catchables.

Last year John Epifanio, Ph.D., TU's Conservation Geneticist, completed the report, "Status of Coldwater Fishery Management in the U.S.: An Overview of State Programs." Data were compiled for each state on the number of anglers, the total fishery budget, the percentage of the budget devoted to hatcheries, the numbers and biomass of all hatchery fish produced, and so on.

It appears that during the past 10 years, the total number of catchable trout produced in most states has slightly declined, but total biomass probably increased as the size of catchable trout generally increased from about four per pound (about eight inches) to two or three per pound (about nine to 11 inches). In 1999 in many states, the catchable trout program remains a basic, core program of fish management agencies, consuming a large part of the total fishery budget, all out of proportion to "benefits—that is, the percent of total angler days generated by catchable trout.

A generally accepted definition of "catchable trout" is any species of trout raised in a hatchery to a length of eight inches or greater. During the past 40 to 50 years, advances in nutrition, disease control, and engineering have increased growth rate, and decreased costs of rearing catchable trout (in relation to inflation). As a percentage of license fees, catchable trout might appear to be a better bargain today than 40 years ago; this is a factor in promoting and justifying the continued expansion of catchable programs.

The overwhelming majority of catchable trout produced in state hatcheries are stocked in "put-and-take" fisheries. Most of the fish that are taken are caught within a week of stocking. Most states have a goal of a 50- or 60-percent catch rate for put-and-take fisheries. With a 60-percent return of stocked fish to anglers, if catchable trout cost $3.00 per pound to stock, then each pound caught costs $5.00 (this is why anglers are not willing to pay the cost). Rarely, however, are studies performed to accurately assess return rates.

One such study in the Colorado River tailwaters below Lake Mead found that the stocking of "small" catchable trout of eight to nine inches, returned to anglers at only one to two percent and at a cost of $30 to $60 per fish caught (predators, mainly striped bass, consumed the rest). Of "large" catchable trout stocked at 13 inches, returns to anglers were 22 percent and 47 percent in two trials. Each of those large catchables cost $2.83 to raise and stock, and the cost of each fish caught was $6.02 at the 47-percent return rate, and $12.86 at the 22-percent return.

There are some highly favorable cost/benefit stocking programs that use trout of "catchable" size, but they are stocked in "put-and-grow" fisheries. For example, some notable steelhead fisheries of the Great Lakes stock hatchery-reared smolts of about eight inches or larger. Also some lakes and reservoirs have suitable temperatures and food supplies for trout but have predators, such as bass or walleye, that would consume any bite-size trout stocked. The series of reservoirs along Wyoming's North Platte River is an example of the sensible use of hatchery trout. Research using coded wire tags could identify the trout stocked in the future as to size at stocking, time and type of stocking, and species and strain stocked. Survival in the face of walleye predation could be assessed in relation to these parameters, all of which affect survival. The research findings now allow for several pounds of hatchery trout to be caught for each pound stocked. Thus, although these hatchery trout are of catchable-size, most are caught a year or more after stocking at a much larger size and can even look like wild trout.

The "Miracle Mile" of the North Platte River is a nationally famous trout fishery (74 percent of its anglers are non-residents, and they produce the highest per angler day in economic values). The largest proportion of the angler catch in the Miracle Mile is made up of hatchery rainbow trout stocked a year or two before. The North Platte trout fishery and some Great Lakes steelhead fisheries demonstrate the real need and benefits from hatcheries—where natural reproduction is lacking or severely limited. These "good" examples of maximizing efficiency and minimizing costs of fisheries based on hatchery trout are not likely to be expanded into states where put-and-take, catchable trout fisheries take up a disproportionate amount of the fishery budget, and hatcheries have no room to raise different strains and lots of fish for the necessary research. It's also unlikely that much progress will be made toward maximizing efficiency and effectiveness of the hatchery product in states where hatcheries operate independently from management and research.

The North Platte trout fishery and some Great Lakes steelhead fisheries demonstrate the real need and benefits from hatcheries–where natural reproduction is lacking or severely limited.

I hope I've made it clear that a critical analysis of the cost and benefits of catchable trout is not "anti-hatchery." It's actually pro-hatchery because it aims to make hatcheries more effective in producing diversified, high quality fisheries by freeing up more funds and facilities that would result from putting catchable trout in a true cost-benefit perspective.

In the 1990s catchable trout have made up 96 to 97 percent of total biomass produced in California Fish and Game hatcheries, and 97 percent of the biomass produced in Nevada's hatcheries—a state that in recent years has stocked 10 to 15 catchable trout per licensed angler. Forty years ago, the Leopold-Needham assessment of the Nevada Fish and Game Department highlighted the waste in Nevada's catchable trout program and called attention to a lack of emphasis on wild trout management. Yet if direction of fishery management has changed in Nevada, it's been in the direction of a catchable trout program gone out of control.

Catchable trout production in Idaho has taken up "only" about 75 percent of that state's total hatchery production, but in the 1990s, Idaho has annually stocked about four to seven catchable trout per licensed angler. Consider that Idaho has 26,000 miles of streams for wild trout and about 450,000 surface acres of lakes and reservoirs for put-and-grow trout stocking. The "need" and "importance" of catchable trout in Idaho is minuscule and completely out of proportion to its funding in the fishery budget. In relation to unit of water in miles of stream or surface acres per angler, a comparison could be made between Idaho on one hand and Connecticut and Massachusetts on the other. Massachusetts and Connecticut have been averaging three to four catchable trout per licensed angler.

Can catchable trout programs, in states where they've gotten out of control, be reformed? If we can learn from history, it is apparent that the fervor of wild trout advocates can be their own undoing when it comes to a showdown between wild trout and catchable trout. Emotional rhetoric demonizes, polarizes, and solidifies the opposition. Bite your tongue before using terms such as bait flinger, worm dunker, and meat fisherman. These people make up most of the angling public, and attempts to demean the "average" angler will be counterproductive. It is the "average" angler who has the most to gain from more efficient and effective use of hatchery fish. ■

Dr. Bob Behnke has been a Professor of Fisheries Biology at Colorado State University since 1966. He's been writing the "About Trout" column for 16 years.

40 yrs. NW

- What went wrong - How get in this mess -
log Time // (because got where going by not changing direction)
- Those who cannot remember the past are ~~doomed~~ condemned to repeat it George Santyana
- We cannot solve todays problems with the same level of thinking that caused them - Einstein
- 1957 CT → Berkeley - CA NV ID MT Can. Ax - WA OR - fell in love w/ - - cutthroat Trout
- outright extermination - benign neglect
1957 AFS Las Vegas — Zivnurka — coastal cutt coho
- - Some perspective - public policy, laws, agencies
Guiding philosophy - Utilitarianism - short term good
short slighted - focus on single use -
All Nature. plants/an sp. good/valuable/beneficial / useless / bad vermin
AFS 1870' Roosevelt - Aquarium Cr. 1873 " " " Don Young - " " = 1922 CFG: "I would eliminate all the useless nonfood fishes that are of no commercial or food value".
- Nature serves humans sci/technol >19th cent to learn secrets - control, subdue, manipulate, enslave nature
"improve on nature" - Fish Hatch. - 1-2% / >90%.
classic! - Col. R. 1866 Connors - 1875 Baird - OR reg.
1884 - Goode. (Tragedy of Commons livestock fisheries)
—— * 1909 OR Central Hatch. 60 mil. eggs
- mixing, diluting, losing site-specific adaptations - - -
"archives" Outbreeding depression much great threat than inbreeding / bottleneck, - Pyramid L. - S. Fowler
- Col. R. 1935 Grand Coulee 1939-43 Rescue/Mix but Hanford Reach dam 4-5 (no outbreeding) -
Mitigation 32 of 33 hatch W. of Cascades Lower R. -
- ~~Generic~~ Sp.: generic, homogeneous, interchangeable -

Coho - Col. R. gone!! E.S.A.

* Mendel 1903 Genetics macro/micro - minor var. adaptiveness

* "Systematics" - ~~wrong~~ misunderstood sp. - big Trouble.

- 1940's - evidence & Theory - Dobzh. - Huxley - but - political expedience - 'beneficial' water power, irrig. - navigat., flood - C.E. -

- 60s - 1974 4 S.R. dams - Lewiston ID = seaport.

(snowball momentum - Tellico TVA) - classic pork barrel

1976 AFS Symp. - Against S.R. - hatch fair

WA Gov. Evans - bottom out - * CE banging

- Hatch - lag time: 1959 Multiple Use S.Y. Act. USFS ... 1964 USDA F.S. SCS - Humbolt R. beneficial utility mountain phrase ply * control - cultural inertia

- First Bur. Rec. 1905 Newlands Truckee R. Pyramid L. -

- Hatch - investments - employment advocacy - lobby

Leavenworth Wenatchee - Salmon Festival - 200 lcd 50/12

- - ~~Fed~~. Sci. Adv. Group -- NW P.P.C. bad!

NMFS - ID steelhead hatch violate ESA -

- Tribes $10 mil - construction, operation, employ

- technol fix - banging!

40 yrs - 6

Case History Trinity R. - Clair Engle

1963 2 dams mill gal Sac. Central Valley -

"Not one bucketful of water necessary will be diverted" "claims that fishery ruined absolute nonsense" - several runs Chinook / coho / steel

- ≥ 90% diverted 1964 - FS Grass Valley Cr. clear cut → storm collapse sediment dump - no flushing

* NEPA 1973 - (1959 single or UTILITARIAN MUSYA) De Bonnie (PEER)

Wa Cooly B-J - Floyd Dominy BR. Comm. (John McPhee)

NOT JUB Dave Brower - Encounters w/ Archdruid - dam Grand Canyon

"1967 - Trinity R. below Lewiston dam improved spawning & nursery due to modified flows - 100 mi."

Evol. / Conserv.

successes . . . . . . evoke quam lipen – so min – brew pub

TETRAPLOIDS

– Use / Misuse genetics – conclusions – re: conservation – Outbreeding depression potential worse than inbreeding . . Fish. biol. . . children as new toy wanderer or don't understand how works but ignorant authority figs. – assume then as used – Conservation Genetic identity

– basis for conserv. – Evol. by N. S. – adaptive. ESU

genotype 2 bil. b.psc. 100,000

phenotype – morphol – life history – ecol

POLAR BEAR

identity marker – fingerprint

dogs – humans – L. Victoria

speed adaptation – warm adapted (Cotton Valley : 13°C max temp eff – 19° c.

– Prod. – steelhead – res. ident – RG – phenotype – –

what want to save ESU evidence

Use – Evol. Salmonidae phylogeny – G / P – not well connect

– Polar Bear – Grizzly – sp. ? sub sp. ? . . cladistics

marmoratus – Trutta / Salmothymus / Acanthobrycon smelt – Stearly / Smith

Tim Berra – Plots. convergence sub renewal / fees

Problem

– How get where we are? + follow some direct

←

theory
– orthogenesis – extinction
built-in
– ESA – type-support
terminal ex
– adaptiveness again
note N.S.

Mar 17   8 AM

panking!

Genetics / Evolutionary Genetics: Implications

mendel
Sewall
Dominion
Genetics

re. ESA D.P.S. (intraspecific) – E. S. U.

How identify, how determine "significant"
"distinct"

Col. R.
dams, salmon
1930s
single entity
interchangeable
Major legislation
bonds or
gender on
substrate
hold

* Nature / biotic / abiotic – evol. coevol. – coadapt.

by Nat. Selection – survival (of fittest) – ~~leave offspring~~

"fittest" – leave offspring – pass on DNA combination

not – dominant, top predator – wolf / coyote / fox   grizzly / black bear

agencies / govt. policy / environmental ~~protect~~ conservation   biodiv.

– Goal – preserve biodiversity – sp. diversity?

Most intrasp.

– Cutthroat – 14 subsp. – 4 major b– (1 mil. yrs) = ...

greenback – ESA – ~~nother~~ – [illegible] subsp. – taxon – but

steelhead – several DPS ~~sep~~ ESU ... Chinook & Coho –

1st Sac. winter 'race' runs ... ~~...~~ – spawns ~~May~~ only spring spawning races ...

DPS ESU – of O. tshawytscha –

→ Snake R. – 750 mi. –
~ 1000 mi. –

adaptations – range of adaptiveness –
of sp. biodiversity
– spectrum

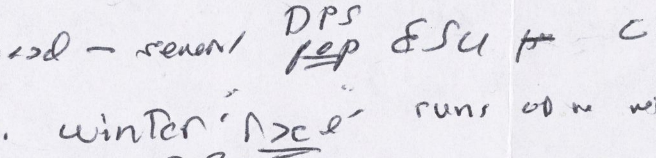
– How define? – AFS symp. – no. 18 – read [illegible] – know?

many diverse opinions – – – agendas of own

pushing own prof. prestige
research program – methods – cladistics + genetics

– How can be? – not unanimous – should preserve

but ... know! – Nature / Evol. Complex – ~~Evo~~ unpredictable



← Age fossil

species – ~~don't~~ hybridize
gen integrity –

RB – Cutt native vs nonnative –

Snake R.
Salmon & clearwater R.
pointing fish hirt
? but hatch. RB – less integrity

Quant
Music Major
English / computer
learning Shakespeare
Mozart – understand
biodiversity – singer
in DNA seq. – D.P. say what it does?

"Sp." – integrity – 7 w fire. reprod. isol. – cichlids

existing behavior – steelhead/RB – most act sterile

Memorandum

To: Dr. Behnke

From: Keith Koupal

Subj: Date of defense

I have scheduled my defense of dissertation for Monday, March 29th at 2 PM in room 114 in Forestry. If your schedule changes and this time and date is no longer possible, please notify me as soon as possible. I can most easily be notified at my home phone number of 223-0835. Thank you for your time and cooperation.

Arctic charr – Siberian – predic prey

Implications / what means?

→ although taxonomic introsp. – mixing of spawn if life hist. so distinct – A B steelhd

Chinook – 1000 mi river – 10 mi

what good is it? fish (not 2036) mgt.

Chewaucan

horse/mule – donkey – evol. sep – long – sterile – "good" sp.

RB – subsp. – aguabonita subsp. – Gila/Apache sp. but – judgement call

Darwin's – expert

Punct. Equil. – polar – vert rates of evol.

methods / philosophies

Sp. ? : – controversy – contentious

Linnaeus – 1758 – binomial

Sp. very real – special creation – immutable – invariable

typology! – 19th cent. – all dif. – dif. sp.

Jordan E. / RB/cutt. – 1931 – 32 sp.

faster than 3 phenotypes not genotypes

→ Snail darter P. tanasi – P. uranidea – 12–15,000 yrs. – not enough time to evol.?

– L. Victoria cichlids – 300 sp. – 12,000 yrs

→ One great complexity – dif. evol. rates in dif. lines – genotypic – phenotypic – morphology – life history/ecol – adaptiveness can be rapid – disconnect

quantitative scores & sci. – genetic analysis (– 100–300 b.p. DNA (2 billion) – 20–30 "genes" – 100,000 somewhere)

attractive – people – order/chaos – agencies – decisions – love standard methods – desire order – but – our student training technology training in univ. ed. – but $ – top jobs

thus – steelhead / RB / Kokanee – sockeye – "genetically identical"??

L. Victoria – 9 genera – 20 sp. / mt DNA – cyt b – less than H. sapiens – 250,000 – 10–20x

(1999) Mar. 17 8 AM 130 Glover VITIS VINIFERRA

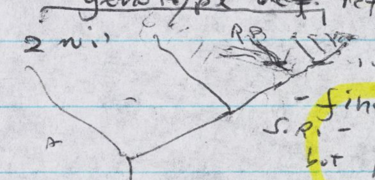
method of sampling
genotype DNA
2 billion ~ 200-300
1,000,000 genes
28-30

Genetics / Evol. Genetics : re. biodiversity speciation genotype / phenotype

Implications: E.S.A. ' D.P.S. nonTaxonomic
i.e. not recognized sp. or subsp., but pop. - "introspe diversity" "is signif."
E.S.U. : How define, how recognize? AFS symp. 18
- squirrels in city park isolated from rural pop. - qualify?
- No readily completely replaceable - some life history, ecol. - behavior
- if lost, not irreplaceable or comp. - ~~how~~ Ex, first ESU Sac. Winter run
- Redfish L. sockeye, Salmon R. S.R. chinook - 900 mi. vs. 10 mi.

winter-fall "identical" phenotype > phenotype more than genotype

Basis for Evol. Genetic - ~~s~~ significance: range of adaptations of sp. - - diverse spectrum life histories - -
Evol. by N.S. Darwinian ~~Evt~~ : "Survival"
"Survival of fittest" = survive reproduce leave offspring w/ DNA combination - not dominant - biggest, fiercest - grizzly or black bear wolf - coyote
Govt. agencie action policy : ~~modify~~ comply w/ E.S.A. + Preserve Biodiversity
→ Biodiversity? All life, but taxonomic / nontax.. D.P.S. ESU
incl. introsp. ~~not~~ tax. - sp. into subsp. - ex. cutthroat
14 recogniz. subsp. - greenback / co stomias ESA



refutes time of divergence pop. subsp. 4 mil - 50,000 - pop. 5-10,000

Species? - Horse X Donkey = Mule "good" sp.

More typical - 710 fs - RB / cutt - coevol. co-adapt. avail

hatchery RB stocked
Nanaimo R. 3 chinook 50 mi. life hist. - Col. basin 7100x

by spatial / temp. - Salmon - Clearwater R. + lewisi - P.
stielhead - resident partition life spatially envir. - / -
steelhead / RB - ~~Fates~~ steelhead A.B + residual - As if 3 sp.?
yet "gen. identical" - all maintain "integrity" but polyphyletic - sockeye / Kokanee - Genotype / Phenotype
*. life history / behavoir / adaptation - disconnect -
rates of change phenotype can be faster / slower

Glacier NP
native - cao - parasite
coevol. - predation
- bouvieri

Aleutian salmon
Canada goose

ex. nontox.
introsp.
adaptive biodiv
stocking
later
survival
pot-grow
wild rscn
- Kootenay - Pend Oreille
37 lb. 5 yr

CO
24-30 in
2 yr.
swam

(2)

2 genera — Adaptat. — Acanth. salmon — phenotype

- Ex. parallel evol. salar - trutta - lake or anadrom.
(L. Ontario) — record phenotype - similar genotype - millions yr
- L. Victoria - 300 sp. cichlids 12,000 yrs. ó ó
9 genera 20 sp. - all types adapt. niche fill-
benthic, planktivore, pots pred. - scale eater - mating behav.
how rapid process
+ Canis lupus, C. familiaris ~ 7-8,000 - dachshund, chihua, C. lupus
→ polar bear Ursus maritimus → horribilis
- Punct. Equilib.

A. genotype — phenotype — time — but

DNA
H. sapiens 200,000 y
Chimps 98% -
ex. phenotype ≠ genotype

Thus "species" 'good', dubious, controversial - what should implication understand
- human mind - nature complex - messy disorderly, unpredictable
order of chaos - govt. agencies - standard methods -
to bring order / "standards" standard methods -
"Genetics" genetic analysis - quant. genotype -
% dif. base pr. DNA, score gen. dif. genes (proteins)
- By now should realize problem of relating
some gen. score to "signif." - adaptations -
scores - "loosely" re. time of evolution - differentiation
· seek impose technol. fix on nature - illusion
of technique! · (But - agencies employment top jobs - decision-making)
technical training vs. Univ. education

Maine legislature
Floods pond
Juniper chars
reservoirs
Bangor
1 sp.
2 sub.
3 Dism
4 ~ N. sp.
blueback
5000 - 10,000 yrs

- Not recognize identify anad. vs. pop. resident (anad. - on some fall races)
big predator - Pyramid L. subsp. henshawi but 10-15 lb.
40-60 lb coevol. coadapt. - - test. Adapt. null hypoth.
- Kalama R. steelhead 10x - -
but Col. R. dams 1930s - interchangeable
parts — Why? , Darwin N.S. adaptive - generation /
by generation - slow, gradual step by step. - genetics?
- 1900 Mendel — saltation? - Role N.S.

- interchangeable parts - 'generic' stocks
Helen Chenoweth - can salmon - all same'
WHAT GOOD IS IT - Yellowstone - what's dif. ? ?
Utilitarian view nature, useful / useless
What good is it? - Don Young - shoot, eat, wear
-- what good - Col. R. - natural diversity Q. C.
What happens in the ...
1880s. - 45 mil. lbs. - < 1 mil.

- Extinction natural: Orthogenesis - sp. ontogeny - senility.
as individual - ESA life support for terminal case
- What good biodiversity? - Fish / Wildlife Prof.
- for native coevol. / ecology utilitarian sp. in nat. ecos. max abundance + resilience - functioning - "sustained use" expl.
- Intersp. div. - R. Mtn. Colo. - native cutts mainly replaced by nonnative brook, brown, rb. - Yet when utilitarian val. remain - Spec. Regs. - supply - demand - recycle catch - Cutt. - 10x 500 m brown 2x 1500-2000 h. - i.e. same catch 20x - anglers can catch
- trophy - great size: - Pyramid L. / Kootenay L. / Kenai Caspian Sea. (>100 lb.) desc. of property of pop. not sp. or subsp.

- Thus - Music major, Engl Lit major - Believe they completely understand Mozart by quant. - sum notes, Shakespeare in letters - not complete underst of biodiversity by fragment data on genotype - limitation of genetic analysis.

Maine Legislature
Sunapee Trout

CSU 25 yrs
Penrose Crk.
brown - 30 lb's
CSU Rec. student

[Salmonid Genetics 1999]

Evol / Conserv

Use & Misuse genetics

biol. Trad. Children, & rec toy ... outbreedings for 536 ... is ... ... by genes ...

Use:

Not select Evol. phylogeny, phenotype - like ... genotype - ... adapt.

don't evolve - what code, exons ... by base pr ... anadromy ... residence

genes/alleles

2 billion base pr

100,000 genes

20-30

99%

- humans

- dogs/wolves

- polar bears = grizzly

- L. Victoria

mankind

manmorean ... trout

1968 solution

hot water adapt. ... 19 C

A 35 6 sp ... Tim Benn... - little known! - too much known, confusion

what is sp.?

- ... unit

sympatry - Thiyo... alpinus

Conserv. ... - Evolution - ... theory & ... adaptiveness

Hirem et al

- ESU

- genotype phenotype

Ecol. signif. ... Phylogenetic sig. unit

RB redband Petition

Great Basin

signif.? - ...

- subsp.

- races

- supply/demand

- c x R - speciating

intelligence?

sp. dif.

Miracle Mile

Yellowstone

Penn - Spring ...

LPH 76

but - 100 ... more primitive, more signif.!

Biodiversity Foundation

- selfish gene - self interest

- more ... / ... Utah, Bonn. cutt Col. R.

HYDRO HABITAT

Fish habitat in tailwaters below large dams is a relatively recent phenomenon, first recognized in the 1930's. Trout anglers are generally aware that most of the super-productive trout fisheries are in tailwaters below large dams (see Tailwater trout in spring 1996 Trout). On the other hand, dams have been the main factor causing declines and local extinctions of anadromous salmon and steelhead (see Perils of anadromy in summer 1998 Trout).

Thus, in relation to the well-being of salmonid fishes, dams can create the best of times or the worst of times. As with hatcheries, there is no absolute pro or absolute anti position on impacts of dams on fish. Many aspects must be evaluated on a case-by-case basis. There are commonalities that distinguish good dams from bad dams. Outstanding tailwater trout fisheries, typically, reflect change in the natural annual flow regime. Flows become more stable after river regulation by a large dam and storage reservoir. Regulated high flows are lower and low flows are higher than the natural flow regime. This results in maintaining more habitat throughout the year. Water temperatures are optimal for feeding for all or most of the year in prime tailwaters. Nutrients and food such as crustaceans and fishes entrained in water from the reservoir pass through turbines to greatly increase the productivity of tailwaters. This combination of increased habitat, increased food, and optimal environmental conditions results in greatly increased trout-carrying capacity compared to the natural, pre-dam conditions. Indeed, most of the most notable tailwater trout fisheries, occur in areas where the rivers were too warm and turbid for trout to survive before dams were constructed.

Given the above scenario it's understandable why so many anglers have a positive attitude toward big dams. What are the attributes of a "bad" dam? Most large dams and reservoirs are multi-purpose. They were constructed with a primary purpose such as flood control or navigation (under jurisdiction of the Corps of Engineers) or storage of irrigation water (Bureau of Reclamation). Hydropower was the primary purpose of the Tennessee Valley Authority dams and most large dams in the Columbia River basin, but turbines for electrical generation are included in all large dams to help pay for costs of construction. During the era of large dam construction, beginning with Hoover Dam in 1930, how dams were operated depended on their primary and secondary purposes. Fish and the aquatic environment were not part of the operational equation. Because the greatest value of hydropower is peak power production, the operation of turbines on demand, the flow below a hydropower dam could vary from a raging flood to a damp river channel in a matter of hours. Obviously, such a tailwater could not be an outstanding fishery.

Dams became the classic example of pork barrel politics. Just about every congressman wanted to bring home the bacon in the form of a dam and reservoir. By the 1950's-60's, there were few feasible dam sites that had not been developed. The dam building lobby, however, was like a snowball rolling downhill; its momentum was difficult to restrain. For dam advocates, there was no such thing as a bad dam. Before the dam building momentum could be slowed, many "bad" dams (dams with unfavorable cost-benefits and doing severe environmental harm) were already underway, such as TVA's Tellico dam (the notorious snail darter dam) that obliterated a fine wild trout fishery.

My column, The first forty years: from rhetoric to research, in the winter 1999 Trout, discussed changes in public perception, public policy, and environmental laws in relation to water development projects. An example illustrating some points brought out in my winter 1999 column concerns the Trinity River, California.

The Trinity River is the largest tributary to the Klamath River. Historically, the Trinity was known as a major producer of chinook and coho salmon and steelhead with annual spawning runs up to 100,000 or more. California congressman, Clair Engle, persuaded Congress to back a pet project and the Trinity River Act of 1955 was enacted into law. Two large dams on the upper Trinity River were completed by 1963. Most of the flow (up to 90%) impounded by the dams was diverted to the Sacramento River basin. Congressman Engle addressed concerns that the loss of 109 miles of salmon and steelhead spawning and rearing habitat and the great flow depletion might be harmful.

He emphasized that: "This project does not contemplate the diversion of one bucketful of water which is necessary in this (the Trinity River) watershed," and, "The argument that it will ruin fishing is absolute nonsense." The solution, of course, was the use of technology to improve on nature in the form of a large fish hatchery designed to maintain the Trinity River's salmon and steelhead — but the hatchery failed miserably to do its job. The low flows were not conducive to survival of juveniles going to the ocean nor of adults returning from the ocean. A major, but predictable, debacle occurred in 1964. The U.S. Forest Service was clear-cutting the watershed of the first tributary stream entering the Trinity River below the downstream dam. At that time no environmental impact statement was required to predict what would likely occur when the next major storm event hit the denuded watershed. What would happen when the great sediment load from the tributary is deposited in the Trinity River, especially in recognition that the Trinity now lacks the high annual "flushing" flows that would normally have transported the sediment? In 1964 the storm event occurred. Enormous sediment loads were deposited in and along the Trinity River further degrading it to the point of losing its function to produce salmon and steelhead. It soon became apparent that many, many of the "bucketfuls" of water being diverted to the Sacramento were indeed needed in the Trinity River channel and without increased flows, the fishing was ruined.

At a 1967 reservoir symposium another avid proponent of dams, U.S. Bureau of Reclamation Commissioner Floyd Dominy (whose dream was to dam the Grand Canyon) spoke about what the Bureau of Reclamation was doing about the problems created by the Trinity River project. According to Dominy there was no problem; in fact: "The Trinity River below Lewiston has been improved both as a fishery and as a nursery stream by controlled releases from the dam." Hard to say if this statement was a bald face lie or simply misinformation fed to the Commissioner by dutiful subordinates. In any event, after more than thirty years and about 100 million dollars expended, the Trinity River and its salmon and steelhead runs are far from restored and probably never will be.

It's ironic that the traditional mitigation — build a dam, build a hatchery — intended to maintain or increase runs of salmon and steelhead, has officially been declared a failure for the Columbia River by an independent scientific review group. And, in 1999, the National Marine Fisheries Service declared that steelhead hatcheries in Idaho are in violation of the Endangered Species Act by negatively impacting protected populations of wild steelhead. The modern technology that can construct great dams can also construct state-of-the-art fish hatcheries. The problem is that we cannot "construct" the natural diversity of anadromous salmon runs lost to dams. It's taken a long time for this truism to be grasped by the agencies serving our technologically oriented society.

1o

B. H. Smith

Portland, Oregon,
Pittock Block

June 30, 1914

Mr. B. L. Jewell,
Superintendent.

Dear Sir:

We have your favor of June 26th, in which you advise us that a petition is being circulated for the purpose of protesting against the racks across the Lemhi River. We are very sorry to learn of this and I presume that it will be necessary for some action to be taken to head off this petition. Therefore, would suggest that you take the matter up with some of the leading citizens of Salmon City, with a view of getting a petition liberally signed and send in to the Game authorities protesting against any interferance with the work there.

During my visit at Boise on July last, I was assured by the Game Warden's office that they were not only glad to have us operate within the State of Idaho but that they would do everything within their power to assist us. At the same time they gave us a permit to take salmon spawn any where within the boundaries of the State of Idaho.

In taking the matter up with the citizens of Salmon City, would suggest that you explain to them fully that the eggs taken there are sent to the Bonneville Central Hatchery, the fry resulting therefrom being liberated in the Columbia River; and, as a result, are restocking the Columbia River and keeping up the supply of fish which ascend the waters of Idaho; in other words, the State of Oregon is bearing the expense entirely of restocking the river with fish from which the citizens living along the Salmon River will evêntually reap a portion of the benefits therefrom.

After going over this matter with your friends there, write me fully; and should we find it necessary to take further steps, will appeal to the Game Warden from this office.

Very truly yours,

REC/MBW

State of Oregon
DEPARTMENT OF FISHERIES

Snake River STATION, June 24 1914

Mr. R. E. Clanton
Supt. Hatcheries
Portland Ore.

Dear Sir:

We are putting pickets on the spawn rack across the Salmon River. I expect to have the rack finished by July 1st. Only a few Chinook Salmon have showed up so far. The farmers up the Lemhigh River sent a petition to the State Game Warden of Idaho to have the racks taken out of the Lemhigh River. I received stationery and pay rolls O.K.

Very Truly yours
B. T. Sumell

THE AGE OF DAMS AND ITS LEGACY

by Marc Reisner

Marc Reisner certainly is best known as the author of Cadillac Desert, the American West and its Disappearing Water, which was published in 1986 and has had an enormous influence on how people have talked about and studied the West, its water, and its water problems. It certainly had a big influence on me when I was working as a public historian and later went to graduate school. This is one of the books that influenced me and turned me toward water history. Without a doubt, this is one of the best-known and widely read books on water in the West. If you have not read it, I suggest you get the book and read it. It is a hard-hitting critique of water policies and water practices in the region. I would best describe it as part history and part muckraking journalism, although Marc Reisner is not really a journalist. I have been talking to him backstage. Cadillac Desert launched Reisner into national prominence and placed him at the center of intense debate over Western water issues. Since the publication of the book, Reisner has continued to work as a consultant and advisor to various groups and organizations on conservation matters including water. He is now at work on a book about the relationship of disaster to California history. His talk tonight is titled, "The Age of Dams and its Legacy."

Mark Fiege, History Department
Colorado State University

The past hundred years have been the hydraulic century, the Age of Dams. Nearly all of the world's mentionable dams were built in the 20th century. It was the age of levies as well, the age of infinite liberty taken with planetary hydrology. There never was — and I suspect there never again will be — an era of such gargantuan and disruptive civil engineering works.

Wally Stegner, the late novelist and Western historian, opined that the Age of Dams began not with the construction but with the destruction of a dam. On May 31, 1888, a privately owned dam erected on a fork of the Canemaugh River in Pennsylvania by the Pennsylvania Canal Company, failed during a series of tremendous rainstorms. The 50,000 acre-ft. reservoir, which was the biggest in the world at the time, wiped Johnstown, Pennsylvania and 2200 people, off the face of the earth. That disaster convinced a lot of people that the private sector had no business building dams, and that new prejudice led directly to the Reclamation Act of 1902, which in its time was revolutionary legislation. It brought the Federal Government, with all of its moral authority (it still had moral authority, back then) and powers of taxation and eminent domain, into the water development business. That was a stupendous first.

But the muscle-bound agencies that would build America's largest dams – the Bureau of Reclamation, the Corps of Engineers, TVA — never really hit their stride until a stunning little cluster of historic events occurred about a half-century later: the Great Depression, the Dust Bowl, and the election of Franklin Delano Roosevelt. In the wake of these events, harnessing rivers became the Lord's work, and as far as many people were concerned, FDR, who loved building dams, was next to God. Early in his second term, the five biggest structures on earth — Hoover Dam, Bonneville Dam, Grand Coolee, Fort Peck and Shasta Dam – were all being built at the same time, in one relatively small quadrant of one region of one big country.

The socioeconomic benefits of water development are undeniable. Even environmentalists, at least some of us, will acknowledge them. But the problems created by water development are still undervalued, and they will get worse. Here in a nutshell are some of the big ones (I am sure that many of you in environmental studies will find none of this new:

- The inexorable sedimentation of reservoirs on which hundreds of millions of people have come to depend.
- The ruin through salt buildup of millions of acres of once-fertile soil.
- The creation of monstrous cities in stark deserts where they arguably should not exist.
- Vulnerability to earthquakes, which can destroy aqueducts and cause dams to collapse. There was an earthquake in the Mojave Desert just a few weeks ago, and the first thing anybody worried about was, Did LA's Colorado River aqueduct break in half? It did not – yet.

Brett Johnson
Department of Fishery & Wildlife Biology

Brett Johnson has worked for the past three years on an interdisciplinary research effort at Shasta Lake in northern California, with the U.S. Geological Survey. He became interested in the project while serving as a non-departmental member of Laurel Saito's graduate committee. Dr. Johnson "…put in hundreds of hours providing guidance to Laurel in her research and contributing substantively to her project," according to John Bartholow, Ecologist with the U.S. Geological Survey. Bartholow added, "Devoted efforts like his are the best way to foster interdisciplinary collaboration in today's educational system."

Dr. Johnson's research collaboration on other projects includes Effects of Dam Operations on Reservoir Physics and Biology, Blue Mesa Reservoir, Colorado, with John Bartholow; Water Quality in Front Range Reservoirs, with Ben Alexander of the City of Fort Collins Water Treatment Facility; and Biogeochemistry and Biology of Nitrogen Deposition in Alpine Lakes, with Dr. Jill Baron of CSU's Natural Resource Ecology Laboratory.

Dr. Johnson teaches three interdisciplinary courses: Conservation Genetics, Regulated Rivers, and Experimentation in Ecology; and has guest-lectured on Aquatic Ecology and Water Quality in several courses.

Brett Johnson was presented his Water Center Award by Laurel Saito, Ph.D. student in Civil Engineering, Laurel nominated Dr. Johnson for the award.

WATER SUPPLY

October water supply conditions held at an acceptable level as indicated by the SWSI values, in spite of all basins experiencing a drop in their SWSI numbers from the previous month. Most basin administrators reported dry conditions during October, with precipitation amounts well below average. The dry conditions caused more irrigation water to be applied in October than is typical. Reservoir levels are above average statewide. The surface Water Supply Index (SWSI) developed by this office and the USDA Natural Resources Conservation Service is used as an indicator of mountain based water supplyconditions in the major river basins of the state.It is based on snowpack , reservoir storage, and precipitation for the winter period (November through April). During the winter period snowpack is the primary component in all basins except the South Platte basin, where reservoir storage is given the most weight. The following SWSI values were computed for each of the seven major basins for November 1, 1999, and reflect conditions during the month of October.

Basin	11/1/99 SWSI Value	Change from the Previous Month	Change from the Previous Year
South Platte	3.5	-0.1	+0.3
Arkansas	2.1	-0.4	+0.3
Rio Grande	2.0	-0.4	+0.8
Gunnison	1.5	-0.3	+1.0
Colorado	2.6	-0.2	+0.7
Yampa/White	0.0	-1.0	-2.8
San Juan/Dolores	0.8	-2.9	+0.3

SCALE

-4	-3	-2	-1	0	+1	+2	+3	+4
Severe Drought		Moderate Drought		Near Normal Supply		Above Normal Supply	Abundant Supply	

- Stoppage of river-borne sediment and the erosion of river deltas and ocean shorelines.
- The collapse of great fisheries like the Caspian Sea sturgeon and Great Lakes lake trout.
- The deoxygenation and nutrient depletion of river reaches below reservoirs and the insidious bioaccumulation of methylated mercury.
- The displacement of millions of people from fertile river valleys.

Viewing this whole situation cosmically, one is forced to conclude that our frontier mentality just boomeranged and smacked us right in the face. We had a pretty good idea even decades ago what the environmental consequences of water development would be, but we told ourselves that there are always other rivers, other wetlands, other salmon runs -- we couldn't run through this abundance.

Viewing this whole situation cosmically, one is forced to conclude that our frontier mentality just boomeranged and smacked us right in the face. We had a pretty good idea even decades ago what the environmental consequences of water development would be, but we told ourselves that there are always other rivers, other wetlands, other salmon runs — we couldn't run through this abundance. (They still say that up in Alaska.) Or, we simply decided in the end that the tradeoff was worth it. What nobody foresaw in the '40s, '50s and '60s was an imminent epochal shift in public attitudes toward nature, which gave us the ESA and other environmental laws. Now, the public demands protection or restoration of species, landscapes, and river scapes. Few people appreciate how difficult that will be without some sacrifice of water, and, most importantly, some deconstruction of the grand edifice that we have built.

Thus far, in California and up in the Northwest, we've tried to solve this dilemma mainly by sacrificing water or hydroelectricity, bypassing turbines so that the juvenile salmon don't get crunched up there, and reallocating water from agriculture back for instream flows. We have also built hatcheries, which according to many biologists is a band-aid approach that will make things worse in the end. We have installed fish ladders and fish screens, which is good, and we have even removed a few tiny dams, but reallocation of water supply remains the principal strategy. In 1992, Congress passed the Central Valley Project Improvement Act, which took ten percent of the water in that project, the biggest in the western world, going mainly to agriculture but also to Silicon Valley, and gave it back to nature. If that doesn't help meet the fish restoration goals, give water back to nature.

Although I strongly supported the CVPIA reform legislation, I have very mixed feelings about this kind of reallocation. It is a politically risky recovery strategy that can backfire, because you are taking water from some very powerful players, like Metropolitan Water District. But mainly, reallocation hasn't done much. In California, we have seen very little recovery of any salmon species. In the Northwest, they have spent $4 billion dollars directly or indirectly on salmon recovery since 1980. Basically, the result has been zip. The fishery is just as bad off as it was then. Reallocation is a zero sum game, and doesn't seem to work well. We need to try something else. Several things, actually.

First, we have to expand, appreciably, the available spawning habitat for our anadromous fisheries. That can only mean that we have to modify, or dare I say it, demolish, blow up, tear down, some dams. Not Shasta, not Grand Coolee, not Hoover (I don't even think we should take Glen Canyon down) — but especially on the salmon rivers of the Pacific Coast — some antiquated dams that offer minimal benefits, and perhaps a handful of fair-sized dams that offer serious regional benefits, and whose removal or modification will be ferociously resisted by various interest groups.

As candidates, I am thinking of the four navigation and power dams on the lower Snake River, which are huge dams, 100 feet high, a quarter-mile wide, built by the Corps of Engineers. The Corps of Engineers, however, says these dams are losing money despite the fact that they produce 1200 megawatts of electricity between them. The operation and maintenance and amortization of the cost amount to more than the value of the hydroelectricity, and that does not even count the tremendous negative impact the dams have had on the fishery. In simple economic terms, according to the Corps — which built the dams — or at least according to their consultants, it makes sense to take them down. Don't bet on it happening soon.

I am also thinking of Englebright Dam in California. I am a participant in an officially sanctioned debate over whether we can get rid of that one. If you do, you have about 140 miles of spawning habitat on the South Fork of the Yuba River that somehow the dam builders left alone. I don't know why. They went to sleep and the South Yuba above Englebright Dam made it into the 1990s looking largely as it did 500 years ago. Nowhere in my state can you take one dam down and get that much habitat back. That is why we are seriously talking about taking down this 280 foot dam, which would be the largest dam ever removed in the history of the world, for environmental reasons alone.

I am thinking of what is tops on my list of dams that should have been removed 20 years ago, the Elwha dams up in Washington State, whose removal, according to biologists, could restore a run of 350,000 salmon and steelhead. Some of those salmon in the Elwha weighed 100 pounds. That was probably the most productive salmon river, mile-for-mile, that existed on the face of the earth. Two crummy-looking old dams now prevent the restoration of that fishery. Thirty megawatts of electricity is all they produce, but because one person, Senator Slade Gordon of Washington, likes the dams and does not believe that he and his wife brought babies into this world so that they could watch dams being demolished, those dams are still there. He won't allow it.

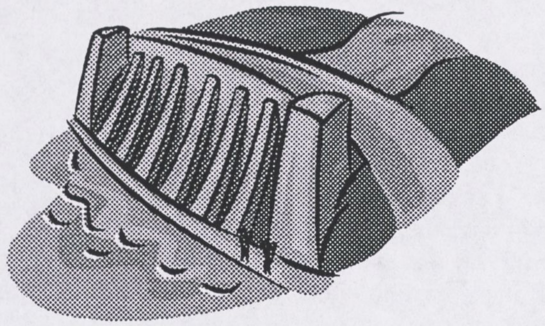
Then we have Savage Rapids dam on the famous Rogue River in Oregon, which the Bureau of Reclamation built and which the Bureau now wants to tear down. The local water board even voted twice to take the dam down; it's their dam now. But both times the members who voted to take it down were recalled by their constituency. There is a potent Wise Use movement in southern Oregon, and they abhor dam removal.

I am thinking of Condit dam on the White Salmon River in Washington, which actually is going to come down. Its private owner just agreed, under great pressure from the Federal Energy Regulatory Commission, to remove it.

I am thinking of a few dozen dams that ought to come down, mostly smaller dams and not-so-important dams that killed off important salmon fisheries. I think in virtually every instance you can make a case that getting rid of the dam is worth it just in economicterms — forgetting anything else. But if we are going to remove dams, we will lose some water storage. Most of these dams are not significant in that regard, but this is a growing region and we can't stop people from moving to Colorado, California, Oregon or anywhere else.

So, we need some more water storage, and I am one of the few environmentalists who will go on record saying that. We can't just say that the only "new" water that we will ever create in the West will come from reallocation, which means buying it from farmers and giving it to cities. The result of that is Thornton. Sooner or later, Thornton becomes Los Angeles. I actually am a guilty party in this, because I am in the water business myself now, brokering water deals, but I still maintain that reallocation can't be the only strategy.

Let me discuss voluntary reallocation of water, where you have a willing buyer and a willing seller, which is still hamstrung in some states, notably my own, by heavy-handed government restrictions regarded as fine and dandy by a lot of people who say they believe in free enterprise.



Water transfers have their obvious downside, as most everything does, but either we believe in free markets or we don't. You can't say we will have socialist, government-managed water while we super-privatize the rest of the economy. That is hopelessly hypocritical, not to say inefficient. But water transfers — reallocation legitimized by capitalism — still aren't enough. We need new storage, which doesn't necessarily mean dams. There are plenty of opportunities to store water underground. I am sure they are here; they certainly exist in California. William Mulholland, in fact, who was the father of the Los Angeles water system, was a great proponent of underground storage. He looked down his nose at dams and reservoirs; they evaporated too much water and he hated that waste. But then he got smitten with an edifice complex and he built several dams, one of which collapsed. It killed 450 people and ruined his reputation.

I don't know what is so radical about any of these ideas. Since when, in America, is the free-market system radical? But there are many people who say you can't have a free market in water – that's too radical. There is no law that says dams have to be permanent. We can take them down if they're unsafe, so why can't we take a few taxpayer-financed dams down if they cause more environmental, social, and economic disruption than they are worth? We can store water benignly in depleted aquifers underground; we can increase the capacity of those aquifers through conjunctive use programs where, for example, an irrigation district in northern California (or here in central-eastern Colorado) with a big water right agrees to forego some of its entitlement and sells that water downriver, pumps groundwater in its place, and then when wet weather returns stores some surplus water such as there is back into the aquifer or even recharges it actively under pressure. We still have some big surpluses when we have these huge storms in California. That can really stretch water supplies, but conjunctive use isn't happening, at least in California. We have been talking about groundwater storage for 20-odd years and have done next to nothing about it. Now private companies, including one that I am on the board of, the Vidler Water Company which owns the Vidler Tunnel up here, are trying to do what the government has not done — create new storage and/or new water through willing-seller/ willing –buyer deals. But the government is in our way all the time. So are a lot of people who just don't like change.

There is only one kind of political game that is allowed right now. Its name is consensus. To get anywhere with anything these days, all God's chillun have to find consensus.

That really leads me, I guess, to the summing up of this overly long lecture. What has hamstrung efforts to inaugurate a modern water era in the West: to deconstruct instead of construct, to get beyond the zero sum reallocation game, to privatize and decentralize this most centralized and unprivatized natural resource in the country? To merge the best interests of the human and natural worlds, it's less a set of laws or rules than an idea, a concept that, in my view, has been taken almost to a ludicrous extreme. You students are too young to have been in water politics much, but some of your professors and others may have been involved in water politicking. There is only one kind of political game that is allowed right now. Its name is consensus. To get anywhere with anything these days, all God's chillun have to find consensus. It has become a mantra of the CalFed program, which is vested with billions of dollars and great responsibility for new water storage and reliability on the one hand, and environmental restoration on the other. In the Northwest, there are 900 parties seeking consensus on salmon issues from morning 'til night, and they never find it — dams that, according to polls, the majority of people want removed. The Elwha dams are a good example, or the Savage Rapids dam in Oregon. They are not being removed because some people remain opposed. Usually this is because they have some tight little local self-interest, but many modern politicians are petrified of proceeding without 'consensus,' a buy-in from practically everyone.

In California, it has been exactly the same story with new water storage, even environmentally-benign underground water storage. I was involved with the owner of a big piece of land, the only undeveloped, privately owned piece of land in the San Joaquin Valley of that size – 13,500 acres, about the size of Manhattan Island. It was owned by a family that got so rich from other exploitative industries – logging, mining, railroads – that they never had to irrigate it. They didn't need the money, but all of the farmers around them did, and they all were on pumps until quite recently. They literally created a "pump hole" under Madeira Ranch. They sucked the aquifer down about 150 feet. The person I partnered with was smart enough to see that this ranch, despite its very low water table (which was a great drawback from an irrigation perspective), had "added value" simply because there was a hole in the aquifer. We are not building any dams in California (there' one big new one built by Metropolitan Water District, but that's pretty much it), and we are gaining 700,000-800,000 people a year. We need new storage. The environmental community is opposed to dams. How are we going to store water? Underground.

We thought we had a wonderful deal there, until we were clobbered by environmentalists who basically did not want any new storage. They equate it with growth. Growth is bad. Send people to Colorado — that's what they say in California. No more water development here. Take it from agriculture. Meanwhile, the local farmers, who had a bunch of reasons to oppose this project —none of which in my view was rational —, were worried about us putting selenium in the aquifer, among other things. Perhaps for the first time in history, a bunch of extremely conservative local farmers and ranchers made an alliance with the likes of the Environmental Defense Fund, Natural Resources Defense Council (where I used to work and my wife still does — this was not dinner table conversation for a while), and opposed this project. They beat it back and stopped it dead because the state, which was going to develop it together with the federal government, said it couldn't do it because there was no consensus.

I have a problem with consensus, and not just that consensus cost me potentially what could have been a lot of money. My problem with consensus is that it doesn't work, at least not in a lasting sense. That is especially true with an issue as volatile as water, and especially true in a region as Balkanized as ours. By Balkanized, I mean the way they think in Boulder compared to the way they think in Limon, for example. Buzz Thompson, a friend of mine who teaches law at Stanford, has been studying this whole consensus politics infatuation for several years, and he has come to the conclusion that consensus seeking actually wastes more time than litigation, which is what it is supposed to replace. That is partly because in a majority of cases it leads to litigation anyway. People say, "All right, I'm for it," but then when they see what they just decided they were for – when they see it in practice — they sue.

The other more serious problem I have with the politics of consensus is that we abdicate an ability to make anything happen whenever an outspoken minority doesn't want it. In Margaret Thatcher's apt phrase, and I'm not exactly a fan of hers, consensus is "the negation of leadership." It substitutes minority tyranny for majority will.

Would a colonial America so obsessed with finding consensus ever have fought the Revolutionary War? Some of those colonial governors were Anglophiles or monarchists who thought independence and democracy were rotten ideas. What sort of consensus prevailed at the constitutional convention? Intractable disagreement was the order of the day. Alexander Hamilton called Thomas Jefferson a "…contemptible hypocrite whose politics were tinctured with fanaticism." Jefferson called the venerated John Marshall, the first Chief Justice, "…a man of lax, lounging manners." Marshall in turn pronounced Jefferson "totally unfit for the chief magistry of a nation." Hamilton was killed in a duel by Aaron Burr simply because he disagreed so profoundly on what the shape of the constitution should be. But we got a constitution out of it, because the majority finally prevailed.

More to the point — and to sum this all up — how was it that we built so many dams? How was it that we decimated our salmon runs and dried up our waterfowl habitat? Was there consensus? There was not. There was, until about the 50s, but by the '60s, when some of the most objectionable projects were yet to be built — including every one of those Snake River dams — there was powerful opposition from sport fishermen, hunters, commercial fishermen, conservationists, Indians, ordinary citizens – even from conservatives who felt the government had no business being in the dam-building business in the first place. But we built them anyway. We invoked Teddy Roosevelt's gospel: the greatest good for the greatest number. If you got in the way, we moved you. Ask the Indian tribes whose reservations, promised to them forever, got flooded by the Missouri River reservoirs.

Within reason — and that is an important caveat because the opposite of minority tyranny is mob rule — within reason, the greatest good for the greatest number is the gospel we need to re-invoke today. Sure, it won't mean what it did 50 years ago because our values and needs have profoundly changed. Most of us don't want to lose our wild salmon. We want to restore them. Most of us want to restore some of our wetlands. Most of us don't want a totally regulated Colorado River any more than our forebears wanted a totally unregulated one. We may even want to stop New Orleans and southern Louisiana, the greatest coastal wetland still on the continent, from disappearing into the Gulf of Mexico.

In the end, we need leadership. Leadership willing to take this country where it wants to go, not where entrenched power, money, and habit insist it stay. Serious leadership, more than anything, is, in my view, what is missing in America today.

QUESTION AND ANSWER SESSION

Q: *We here in Colorado…have a conjunctive use project that is in the planning stages in South Park, southwest of Denver about 85 miles. The Town of Aurora has proposed it, and they are really presenting the project as environmentally benign, ignoring the growth of Aurora. They present it as Aurora taking excess water, storing it underground in wet years, and using it in dry years. If it were a situation where I knew the water tables had been depleted by 150 or 200 feet, and we were taking space that we had created, I might be able to support the conjunctive use project. But I wonder how you feel about the situation here. This particular mountain valley has a lot of both state and globally rare wetland ecosystems that are found certainly nowhere else in Colorado, and possibly nowhere else in North America…this is the Upper South Platte. I wonder how you would qualify your support of conjunctive use in this case?*

A: I am not saying that conjunctive use doesn't have a downside. In this particular instance, it may have a greater downside. The problem with Colorado is you are really up against the limit. You use practically every drop of water that you are entitled to use here. What little surplus water still manages to escape downriver somewhere does some environmental good. Your runoff that you are entitled to use, I believe, is about 7.7 million acre-feet per year. Ours in California is 70 million. We have about five or six times as many people. Basically, Colorado is second to California in every category except water. California has ten times as much water as Colorado.

I think science, and especially engineering, has a great role in solving this dilemma. For example, fish ladders have advanced tremendously. That is a combination of biology and engineering. Biologists can come up with the idea for a fish ladder but they can't build it. Engineers were building awful fish ladders until they got some input from biologists.

In my state, conjunctive use can be done with minimal impact. It varies on a case-by-case basis, but I guess the point I am trying to make here is that I don't see how you can stop people from moving where they want to go in a democratic society. There is no city, to my knowledge, that has successfully kept people out by saying, "All right, we don't have any more water," because the city next door or a suburb next door said, "We want you. Come here." So, you have the same kind of growth, just spottier growth. It's like trying to squeeze air in a balloon. It goes somewhere.

I think building dams is the most damaging way of providing a new water supply. Even off-stream reservoirs have their impacts. There is a limit to the amount of water that you can take from agriculture without having a serious impact on agricultural communities and prime farmland. It is a real pickle. And I think it is at the edge here on the East Slope as much as anywhere in the West. You have some wonderful agriculture. You don't want to see it crawling with homes. On the other hand, Aurora, if it can't do conjunctive use, will probably try to resuscitate the Two Forks Dam. That city is determined to grow, and I don't know how you stop it. When you look at the alternatives in California, which I know something about, conjunctive use looks benign compared to the other options. Of course, desalinated saltwater is probably the most benign environmental option, but it is wildly out of reach economically, and some people even say it is environmentally troublesome. Believe it or not, Metropolitan Water District was talking about scaling up a small-scale demonstration plant that they have going now, and the EPA said they had to get a permit to dump the salt. Metropolitan said, "You mean we need a permit to dump salt in the ocean?," and the EPA said, "Yes, that's right." So, there are impacts, depending on one's point of view.

Q: *What role do you think the scientific community can play?*

A: I think a lot. I gave a similar speech last night in Salt Lake, and I was asked the same question. I don't have blind faith in science. I think fusion energy is ten years away and always will be ten years away. That's what they were thinking when they built all these reservoirs – that someday we would have energy so cheap from fusion that we could pump all the silt out. It wouldn't cost a thing, and we could build ski mountains with it or something like that.

But Now, in California and also in Idaho, we are probably at the cusp – we have state-of-the-art fish ladder construction. A little dam on Butte Creek, which is a tributary of the Sacramento, got a fish ladder installed just about four years ago. Twenty years ago at that dam they counted 15 returning spawners above it. Fifteen fish had managed to get beyond that dam through the old fish ladders. Two years ago, 20 years later, 20,000 fish came up. That is partly because we had lots of runoff, lots of rain, and that helped. Also, we took a couple of downriver dams down. But the new fish ladder is unbelievably better at passing fish. Somebody saw six salmon jumping in the air at the same time, when you would have waited two months 20 years ago to see that many salmon getting above that dam. Now somebody needs to figure out how to get fish around a 200-300 foot dam, because the highest fish ladders that still manage to pass fish anywhere in this country are on those Snake River dams I mentioned, and they don't pass an appreciable portion. A lot of the fish just don't make it.

Part of the problem is cost. That is one example, and there are plenty of others. If some plant breeder could figure out how to breed a new type of alfalfa that uses 75 percent of the water that current alfalfa breeds use, in California alone that would be a savings of one million acre-feet of water which you could give back to nature, because alfalfa is the biggest water user in the state. The five biggest water users are alfalfa, pasture, irrigated rice, cotton, and metropolitan Los Angeles, in that order. Alfalfa is a crop that has its value, obviously a good rotation crop, but it is fed to cows.

Metabolically speaking, it is a tremendously inefficient user of water. That is why one pound of steak takes 6,000-8,000 pounds of water.

Q: *I suspect that tomorrow morning when we read about your speech it might say Marc Reisner says to remove all dams. I am sure that is not what you are saying.*

A: No. I emphatically am not saying that.

Q: *Would you to comment on your perception of how the media has treated the kinds of issues that you addressed this evening?*

A: The media, I think, don't have much patience for stories that have to do with something that won't happen for a couple or three years – global warming puts the media to sleep, and of course, the biggest story in the country that is not being reported on at all outside of Louisiana is the disappearance of southern Louisiana. It is an amazing story, and most people don't know anything about it.

I think the media — and I am including myself — are inclined to the dramatic, if not the melodramatic, so when a dam comes down on the Kennebeck River in Maine, which happened last summer, we learned that the dam came down but we don't exactly learn why. We don't learn that the dam was built almost 200 years ago and blocked one of the great Eastern Atlantic salmon fisheries. It is just that a dam came down and there was a big political fight about it. The media is not doing a very good job of reporting, and especially in the complex interaction between civilization and nature. In California, we used to have thousands of salmon boats fishing, and now we have hundreds. In three or four years we may have none. If we have one more species join the ESA list, the Pacific Coast Federation of Commercial Fishermen, which I represent as a consultant now and then, believes they are out of business. What that means to coastal communities all the way up to Oregon and even to Canada is terrible. The logging industry is gone; the tanning industry is gone; all that is left is tourism and fishing.

The press has been very one-sided when it comes to this issue. They look at a poor farmer and feel sorry for him because everyone wants his water. We have a very, very sentimental — and I think justifiably so — attitude in this country toward farmers. But we forget about all the impacts — and the media is largely responsible for our failure – we forget about the cumulative impacts on people of 100+ years of dam construction, especially upon the Indians. Dam construction was a terrible calamity for most Indian tribes in the West, especially those depending on salmon fishing, but also the inland tribes on the Missouri River, for example. They had their entire reservations drowned out. That is the media's biggest failing, I think — no hindsight and no foresight.

Q: *Could you elaborate more on the reallocation issue? I almost see a dichotomy, in that you advocate a capitalistic approach, but when it comes to reallocation you said that's not really the answer.*

A: You will find that I am inconsistent and ambivalent on every one of these issues. That is because I am truly torn. I believe in free markets up to a point. I am a gray-area kind of guy. I can't see anything in black and white. We should be raising the price of irrigation water that taxpayers subsidize. It is crazy to be giving Idaho potato growers water for $1 per acre-foot. That is insane, but we still do it. Of course, we – being the government – have only so much ability to raise water prices, because only 25 percent of the water supplied in the western states is supplied by the federal government, but that is a very important 25 percent.

In California, we did raise prices dramatically under the Central Valley Project Improvement Act, because that CVP project was never going to be repaid in a thousand years at the rate that the revenues were coming in. They were buying water for $3 an acre-foot. Now, they pay $40, and the farmers said they couldn't possibly survive on $40 water. We'll go broke. Well, what did they do? They got rid of a lot of cotton, about 200,000 acres of it, and they substituted high-value crops — walnuts, peaches, cherries. I personally believe that farmers, having done that, should be rewarded. They moved away from these water-consuming, relatively low-value crops, and planted what you should be growing in a semi-desert region with a limited water supply — crops that offer the greatest productivity per unit of water consumed.

Also, it is helpful if they are labor-intensive, as orchards are. You can efficiently irrigate orchards with drip irrigation. You can't really do that with cotton. So, now let's reward these guys by giving them a more reliable water supply during drought. I have advocated, along with the American Farmland Trust, that in the periphery of an urban area, where farmland could get gobbled up in the next 20 years or so, that if farmers owning that land are willing to sign an easement saying they will not allow a developer to put houses on that prime farmland for 40 years, we should give them cheaper water as a reward. Or give them a more reliable water supply in droughts as a reward. We have a bunch of dilemmas here: population growth, environmental restoration, farmland protection, and we are trying to solve them all at once. There is no perfect solution. I think that market-based water is a path we ought to be going down, and you have gone further down that path here in Colorado than anybody else. But, as I said earlier, the result is Thornton, or for that matter, Aurora.

Q: *You summed up your speech by saying someone has to take the power to put the removal of dams at ...*

A: A dictator – yes.

Q: *It seems ironic that the media doesn't have the hindsight and it would seem that politics is the same. Looking to how you have power, where do we get that kind of power?*

A sage once said that water flows uphill toward power and money. Water <u>will</u> flow uphill toward power and money.

A: NRDC does a lot of good work, but they are not really involved in dam removal efforts. The way this happens is you need somebody with vision. . Now, a lot of his vision in retrospect looks flawed, perhaps. He wanted to be a conservationist, but he really was the biggest civil engineer-type we have ever had in the White House. It was under him and Harry Truman that a great many of these dams were built, but he had vision. And that vision was taming the desert; settling people during the depression; defusing these explosive cities, where 30-40 percent of the work force was unemployed. Sending people out west. Putting them on irrigation farms. That is what we did back then. Now, we need somebody with Roosevelt's vision, determination, and cunning and willingness to play power politics to get any of this restoration agenda advanced very far. I have a great respect and admiration for Bruce Babbitt, and he has that vision. He has been talking about removing dams ever since he was appointed Interior Secretary, but Bruce has one flaw, in my view. He believes too much in consensus. He is always talking about consensus, and you will not get people who have homes around a reservoir to agree that that reservoir ought to be drained and the dam demolished. Believe me, you won't. I can show you instance after instance in California where 100 people, a houseboat community up on Englebright Lake, 190 houseboats, have basically stopped the efforts to remove a few marginal dams. I'll bet if you took an opinion poll and people understood the situation, you would find probably 70 or 80 percent that say, "Get rid of that dam." Especially in southern California, because if you don't, we will have more ESA listings, which means less water that we can bring down here. Babbitt and the head of the CalFed Program, Lester Snow, said "...we can't do that. It's a deal breaker. Not everybody buys into it." We didn't used to think that way. We moved people out the way; we had political leaders who had not just vision but a certain ruthlessness, if you want to call it that, a determination to see something through. We do the best we can for those parties who are going to be affected, but right now this is important, and you can't make the proverbial omelet without breaking eggs. Nobody thinks that way anymore.

Q: *The Bureau of Reclamation changed its mission to being more environmental. Now that you are in water development, do you see a role for the Bureau?*

A: The Bureau has certainly seen its star fade. I think their mindset has changed. The Corps of Engineers has changed. The question is, "Do they become a maintenance agency where they basically take care of these dams and meter out water and that's it, or do we give them a role in this restoration agenda. My experience in California with the Bureau has been that despite a really good regional director, Roger Patterson, the rank and file just think their mission is building dams – water development. I don't know whether or not you can change the essential nature of an agency that has spent 85 or 90 years building dams and suddenly doesn't know what else to do, and is told they ought to be doing something else and even told what it is. I think a lot of people in that agency are just biding time waiting for retirement, afraid to ruffle anybody's feathers or raise anybody's hackles. I don't know what the answer is. I don't think the Bureau of Reclamation will be abolished, but I am not sure they are the agency that ought to be tackling some of these tremendously difficult restoration agendas. I'm not sure what agency should be. We have the Departments of Fish and Game in every state; we have the U.S. Fish and Wildlife Service, the Environmental Protection Agency, but these are issues that take a tremendous amount of social sensitivity. You are affecting a lot of people who are now in a privileged position of having a reliable water supply, which you are going to make less reliable, or cheap water, which you are going to make more expensive, or flood control from a dam that you now are going to take down. I don't know whether a lot of people in government have great political skill, without meaning to be offensive to anybody in government who I know is out here in the audience.

Q: *Could you share anything you have come across lately of a predictive or prognosticative picture of what water usage is going to be over the next 20 or 30 years.?*

A: A sage once said that water flows uphill toward power and money. Water <u>will</u> flow uphill toward power and money.

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