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Turning Up the Heat

Two prominent researchers look at how Global Warming might affect steelhead and their habitat.

by Nathan Mantua and William Pearcy
— *University of Washington, Oregon State University* —

In the following report, Nathan Mantua, PhD, of the University of Washington's Climate Impacts Group and William Pearcy, PhD, of the College of Ocean and Atmospheric Sciences at Oregon State University look into Global Warming from the perspective of its potential impacts on steelhead.

Pearcy may be reached at wpearcy@coas.oregonstate.edu. Mantua may be contacted at nmantua@u.washington.edu. We welcome reader comments on this article. The Osprey's *e-mail address is jyusk@bendcable.com.*

Hot weather stinks! That was the sentiment of most all the steelhead anglers that found themselves on British Columbia's Dean River in early August 2004. A sustained period of exceptionally hot summer weather had the surrounding forests burning, high-country glaciers weeping, and the fabled waters of the Dean River running warm and a turbid glacial white for several weeks in a row. One of us (NM) was with three other Puget Sound anglers who spent more time swimming in the river than hooking its elusive wild steelhead. During that heat wave most everyone in the region had wondered, "could this be part of Global Warming?" In this article we provide some perspective required to address that question by discussing a range of issues related to the global warming phenomenon. We also include our thoughts on the potential impacts of global warming on northwest steelhead and steelhead fishing.

> *There is now no debate that human-caused increases in greenhouse gases will continue into the future. The question is: To what levels?*

The Greenhouse Effect and Human Caused Global Warming

The Greenhouse Effect is an essential, natural part of the Earth's climate system that makes our planet remarkably hospitable for life as we know it. Earth's atmosphere, where clouds are absent, is nearly transparent to the visible radiation (light) that carries the bulk of the energy coming from the sun. Clouds and bright surfaces like snow cover reflect about 30 percent of the total incoming energy from the sun back to space, but the rest is absorbed by the Earth's surface. The absorbed solar radiation warms the Earth's surface, and because the Earth's surface is much cooler than the sun, its heat is radiated upward to the atmosphere at much longer infrared wavelengths. Because of trace gases in the atmosphere like water vapor, carbon dioxide (CO_2), methane, and nitrous oxide, some of the infrared radiation from the Earth's surface is absorbed and re-emitted, half going upward to space and the

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FROM THE PERCH — EDITOR'S MESSAGE

Warming Up to Global Warming

by Jim Yuskavitch

The big news this winter here in the Central Oregon Cascades, where I live, is how unseasonably balmy it has been. January temperatures have hovered well up into the sixties and there is currently more bare ground than snow on the 5,000-foot-high Santiam Pass, just twenty minutes west of my house. Snow storms, so far, have been few and far between. Although our local ski resorts are still open, one of the major Mount Hood resorts, where snowpack is 36 percent of normal, just announced a temporary closure until more snow falls.

Because of the obviously negative effect a warming climate would have on skiing, the ski resort industry has taken an official stand on the Global Warming issue, and advocates government policies and industrial practices to lessen greenhouse gases. Fish conservationists, I think, have been much slower to consider what Global Warming, and the long-term climate changes that will accompany it, might mean for wild salmon and steelhead and their environments. It's time we got up to speed.

In a series of excellent articles in the September 2004 issue of *National Geographic* Magazine, writers Daniel Glick, Fen Montaigne and Virginia Morell describe how scientists from throughout the world have been independently documenting the slow progression of human-caused climate change ranging from the dramatic, such as the retreat of glaciers, to the subtlety of increases in births of female sea turtles caused by hot weather during their incubation period.

Skeptics often dismiss the entire Global Warming scenario. And those that admit that it is occurring will argue that a worldwide rise in average temperatures of just a few degrees is no big deal — just wear a hat and put on some extra sunscreen. They cheerfully note that we'll be able to grow crops in areas we cannot now, or that living in northern regions will require less energy for heating homes.

Low mountain snowpacks may become the norm if Global Warming predictions are accurate. Photograph by Jim Yuskavitch

But there is much more to it than that. Rather than the absolute worldwide temperature increase, the most serious impact of Global Warming is more likely to be the changes in weather patterns caused by those increased temperatures. Particularly disturbing is that warming temperatures might affect ocean water temperatures and current patterns, which have a significant influence on weather across the planet. Whether those changes come slowly or swiftly is anybody's guess.

For the critters of the world, which required millennia to develop survival strategies and adaptations, the prospect of a rapid climate change is very bad news. A potentially drier climate, with less water available and perhaps completely different flow regimes, will be more than problematic for cold-water loving wild salmonids, as well as for other fish species.

In this issue of *The Osprey*, we make our contribution to the discussion on Global Warming (in my view it is no longer a "debate") with a cover story by Oregon State University's Bill Pearcy and Nate Mantua of the University of Washington who explain the subject with steelhead and other salmonids in mind. It's an eye-opener, and enough to make a fish advocate sweat a little.

THE OSPREY

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CHAIR'S CORNER

The ESA, the Politics and the Courts

by Bill Redman

— Steelhead Committee —

In the first chapter of his outstanding book, *King of Fish: The Thousand Year Run of Salmon*, David Montgomery proposes adding a fifth H to the traditional four H's of steelhead and salmon destruction (Habitat, Hydro, Harvest, and Hatcheries). His fifth H is History, or more precisely man's tendency to ignore history and the difficult lessons it teaches.

He goes on to describe in considerable detail the relentless decline of Atlantic salmon resulting from the acts of man, first in Great Britain and later in New England. He then moves on to the Pacific Northwest where he finds us repeating the same mistakes of policy and failures of will in the current decline of Pacific salmon and steelhead. It is a disturbing and unsettling read.

Then in the final sentences of the book, he suggests a sixth H and asks: "Will it be hubris or humility?" The year 2004 marked the time when the Federal government came down hard on the side of hubris and abandoned even the slightest suggestion that it was seriously interested in implementing the Endangered Species Act to protect the anadromous salmonids of the American West Coast.

In that one calendar year, NOAA Fisheries, the federal agency charged with protecting the welfare of these fish, made the following major harmful policy choices:

1. It released a revised draft hatchery policy that calls for hatchery fish and wild fish in the same geographic area to be placed in the same Evolutionarily Significant Unit (ESU), contrary to the wisdom of a host of scientific studies itemizing the numerous differences between hatchery and wild fish.

2. In its revised ESA listing determinations, NOAA declared that sea-run steelhead and resident rainbow trout are essentially the same fish and, therefore, to be placed in the same ESU, in spite of considerablescientific uncertainty and lack of knowledge about the relationships between these two dramatically different life history forms.

3. In response to U. S. District Court Judge James Redden's May 2003 ruling that its 2000 Columbia River system Biological Opinion was deficient because it relied too much on actions not likely to happen, NOAA drafted and then finalized a much more dangerous 2004 Biological Opinion, (a) stating that the dams don't jeopardize any of the Columbia system's 12 ESA listed steelhead and salmon, and (b) that arbitrarily declares the dams to be part of the "baseline", basically removing the dams from any responsibility for the decline of the fish stocks.

The year 2004 marked the time when the federal government came down hard on the side of hubris.

4. Finally, NOAA reduced by over 80% the previous Critical Habitat Designations for ESA listed steelhead and salmon. This change ignores the need for a continuum of reasonably hospitable habitat from spawning redds to ocean and return. No Critical Habitat Designations will remain where these fish once ranged but no longer do because of man's actions.

All of these changes will increase the likelihood of ESA de-listings and bring depressed stocks closer to extinction. With the determination of NOAA Fisheries management and their superiors to avoid implementing and enforcing the ESA in any meaningful way, the question becomes: if not NOAA, who?

The answer can only be a combination of citizen activists like you and me, the scientists who know these fish and what they need to thrive, and – ultimately and sadly – the courts.

The science continues to increase, in both numbers of studies and the clarity they bring to the requirements for the fish to prosper. Three current examples follow.

At the request of the Affiliated Tribes of Northwest Indians, the American Fisheries Society Western Division appointed 26 scientists to do an independent review of "whether science properly underpins the policy directives outlined" in the 2004 NOAA Columbia System Biological Opinion (BiOp). The questions asked by the tribes are right on the money, and the answers will be critical in evaluating the BiOp. The report is due for completion in February 2005.

In October 2004, the National Academy of Science's Water Science and Technology Board released a report urging that the value of intact ecosystems be factored into environmental decisions. The report states: "Unless the economic value of ecosystem goods and services is acknowledged in environmental decision making, they will implicitly be assigned a value of zero in cost-benefit analyses and policy choices will be biased against conservation." The report discusses ways to assign economic value to ecosystems, including intangible values.

The U. S. Geological Survey wrote to the Federal Energy Regulatory Commission on the effect of the Klamath River dams on the system's salmon stocks. Not surprisingly, the paper found that dam removal would make much more of the river below the dams accommodating to spawning salmon. And that doesn't even address the possibilities for salmon upstream from the impassible Iron Gate Dam.

The scientific support for real protection of these marvelous fish will continue to grow, but nothing will happen to challenge the destructive and politi-

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Global Warming, Continued from page 1

other half downward back to the Earth's surface where it is again absorbed and re-emitted back to the atmosphere. This trapped infrared energy warms both the atmosphere and the Earth's surface substantially – surface temperatures without our natural Greenhouse Effect would be an icy 60 ºF cooler than they are today!

Global warming refers to the expected impacts of human caused increases in the natural greenhouse effect. The intensity of the natural greenhouse effect has varied over the eons, with very warm eras coinciding with periods of abundant atmospheric greenhouse gases, and cool eras coinciding with periods of relatively low levels of greenhouse gases. During the most recent ice age that ended about 12,000 years ago, atmospheric CO2 was slightly less than 200 parts per million by volume (ppm), while during the period from about 10,000 years ago to the early 1700s CO2 concentrations were relatively stable at around 270ppm. Since the 1700s the human activities of burning fossil fuels and converting forests to farmlands and urban areas have added an enormous amount of CO2 to Earth's atmosphere. CO2 concentrations today are about 370ppm and rising. Human activities have also caused a 150 percent rise in methane concentrations over the past few centuries, and methane is another important greenhouse gas. There is now no debate that human-caused increases in greenhouse gases will continue into the future. However, there is much uncertainty about the future rates of increase for greenhouse gas concentrations, and at what levels those concentrations might stabilize.

Turning up the dial on the natural Greenhouse Effect: What might happen to our climate?

For the past few decades climate scientists from around the world have been assessing the possible impacts of an intensified greenhouse effect on Earth's climate. This research has relied on climate models that balance the incoming energy from the sun with the outgoing infrared energy emitted by the Earth. The most sophisticated approach employs computer simulations for key aspects of the Earth's climate system, including atmospheric winds and pressure patterns, clouds, ocean currents and temperatures, ice and snow cover, and the ecology (photosynthetic plants) and atmospheric chemistry that controls greenhouse gas concentrations. At this extreme, the climate problem is a collection of very complicated problems that require the biggest and fastest computers on Earth. Teams of scientists work together to develop, operate, and diagnose the behavior of the most sophisticated computer models. At

another extreme are energy-balance models that aim to balance the incoming energy from the sun with the Earth's outgoing infrared energy with very simplified physics. At both the very simple and very sophisticated extremes, every climate model in use today finds that increasing concentrations of greenhouse gases will intensify the greenhouse effect and warm the Earth's surface and lower atmosphere.

One of the key measures of past "global warming" and its future impacts is the global average temperature, sort of a thermometer read on planet Earth as a whole. Scientists have gone to great lengths to assemble measurements of past temperatures as recorded by thermometers all over Earth. Reliable thermometer records with enough coverage to compute a global average date back to about 1860. Since that time, Earth's average temperature has increased about 1 ºF.Uncertainty about future climate is due to two main factors. First, no one can know exactly how much CO2, methane and other important greenhouse gases will be emitted in the next century. Projecting future greenhouse gas emissions requires educated guesses about global economics, technology, and population.. The second stream of uncertainty is due to our limited ability to understand exactly how the climate system works. Today there remain major challenges in simulating the behavior of clouds and how the ocean moves heat from its surface to deeper waters. Clouds and the ocean become crucially important for understanding how sensitive climate is to changes in the greenhouse effect. For the past decade scientists have played "what if" games with these and other lines of uncertainty by simply assuming "clouds will behave this way", or "technology and greenhouse gas emissions will change in this way", then running the simulation models to see what happens. The end result of a collection of such "what if" scenarios suggests a range of 3 to 10ºF global warming by 2100, with more warming at higher latitudes and less in the tropics, and more warming over land than over the oceans (see the Intergovernmental Panel on Climate Change (IPCC) reports at http://www.ipcc.ch).

The Regional Impacts of Global Warming

Climate records show that the Northwest (regionally averaged) has warmed about 1.5 ºF since 1900, or about 50 percent more than the Earth has warmed as a whole. Most glaciers in the region reached their recent maximum extent in the mid-1800s, and since that time have been in rapid retreat. Recent studies indicate that the retreat of the past 150 years has now brought many Northwest glaciers back to levels last seen 6,000 years ago, a time near the end of a prolonged warm and dry period that is indicated by ancient pollen records and moraines. Regularly collected measurements indicate that Northwest springtime snow pack from the western Rockies to the coast, and from the central Sierras in California to southern British Columbia, has been in rapid decline since 1950. These measurements indicate that decreases have been up to 60 percent in April 1st snow pack for the "warmest" locations in the Northwest — areas like the lower elevations of the west slopes of the Cascades and the Olympic mountains in Washington. The timing of springtime snow melt runoff has also been coming earlier in the vast majority of rivers in the Northwest, with advances in peak

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runoff timing of one to a few weeks depending on the basin. Bark beetle infestations in evergreen forests, aided in part by drought stress and a relative lack of extremely cold beetle killing winter temperatures, are now occurring throughout much of the Northwest's interior. Taken together, a wealth of evidence paints a very consistent picture of a warming climate over the past 150 years for both the Pacific Northwest and the Earth as a whole.

Looking to the future, the climate models used in the latest IPCC reports now suggest that Northwest temperatures will rise another 3 to 6 ºF by the 2040s, and continue rising later this century. This range of warming rates is significantly faster than the 1ºF warming observed over the past century, and even at the low end estimate there would be extremely large impacts on Northwest snow pack and seasonal stream flows. Of particular interest for Northwest salmonids would be an acceleration of recent trends toward more fall and winter runoff, less springtime snowpack and substantially less summer snow melt and summer stream flow in snow-fed rivers. Climate warming will also cause wetlands to disappear and water tables to decline. The combined impacts of reduced flows of cool groundwater and snow melt into streams will result in increased stream temperatures and a reduced availability of already limited thermal refugia. Warmer temperatures will also alter ecological communities and ecosystem processes, and likely favor the invasion of warm-water exotic species.

A warmer future's impacts on steelhead. What might a warming climate mean for steelhead and steelhead fishing in the Pacific Northwest?

The answer to this question depends on a variety of factors. At the coarsest level, it is likely that warming temperatures alone will shift the range of steelhead and other salmonids northward as the southern (and warm) end of their range becomes less and less hospitable. However, the ultimate impacts on steelhead will depend on a variety of factors, some of which are related to climate, and others that are related to other future

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Stage-by-stage examples of the potential impacts of climatic warming on the lifecycle of steelhead.

Spawning and Incubation Periods

Warmer temperatures with no change in precipitation rates would lead to an increased runoff in fall and winter during storms, and a reduction in late spring and summer snow melt. This suggests a potential for dewatering redds of late spring spawners, but a more rapid development time for incubating eggs. Such changes would likely favor an advance in the median timing for spawning in streams that have historically had a significant snow melt runoff pulse in late spring and early summer.

Instream Rearing

Warmer water temperatures during all but the warm season will accelerate metabolic and growth rates during the instream rearing period. In contrast, lower flows and higher water temperatures in summer and early fall will reduce the availability and quality of warm season rearing habitat. In basins like those on the west slopes of the Cascades and Olympics that historically developed a significant winter snow pack, fall and winter high flow events will likely become more frequent as snowlines rise.Warmer water temperatures may lead to enough growth rate increases that many juveniles smolt at earlier ages.Warmer stream temperatures, for both winter and summer run fish, may push favorable rearing areas farther upstream to cooler headwaters and tributaries and thus reduce a basin's capacity to produce smolts.

Smolt Migration

In snow melt basins the timing of the spring freshet will come earlier in the year, and the volume of spring runoff will likely decrease. Will such changes in runoff be matched, or missed, by changes in the development of smolts in a warmer future?

Marine Survival and Growth

Will the marine environment become more or less favorable for maturing steelhead? The answer to this question will depend on ocean currents, stratification, and how those changes influence steelhead prey and predators. It is clear that steelhead habitat at sea consists of the cool upwelled waters of the California Current and subarctic waters of the North Pacific. It is less clear how changes in those regions lead to changes in the marine food web, steelhead survival, growth, migration and population productivity. Some scientists postulate that the predicted ocean temperature increases with CO_2 doubling will shift the thermal limits of salmonids in the North Pacific Ocean far to the north or even into the Bering Sea in this century, thus limiting the area and carrying capacity of the marine environment for anadromous fishes in general. El Niño events are another example of how important marine conditions can be: during El Niño periods of 1982-83 and in the mid-1990s, warm, unproductive coastal waters diminished many runs of steelhead and salmon along the Northwest coast. The future behavior of El Nino and other natural swings in Pacific climate will be very important for the subarctic ecosystems of the North Pacific, yet there is now great uncertainty about the impacts of global warming on the future behavior of El Niño.

The Spawning Migration

Flow changes may have major impacts on timing and success for summer and winter run spawners. For instance, if snowmelt timing continues to advance, and spawning migration times for summer runs have evolved to take advantage of spring flows, will they be able to evolve with a rapid advance in snowmelt runoff timing? Will winter run fish evolve their migration and spawn timing to find optimal flows and temperatures for winter/spring spawning? This will be a question of rapid adaptation and evolution.

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decisions about development, land and water use, and habitat protection. We do know that warm temperatures and low flows can result in large declines in the abundances of salmonids. Based on paleoclimatic indicators and fish remains from middens, salmonids were much less available in the Columbia River basin during the warm and dry era of 6000-8000 years ago.

Steelhead require relatively cold water during most of their life history, generally below 68⁰ F and even lower for rearing and migration. When stream temperatures are above 70⁰ to 75⁰ F, steelhead can survive for short periods, but must find cold-water seeps or refugia to survive for longer periods. Stream temperatures are closely linked with a steelhead's requirement for dissolved oxygen. Warm water holds less dissolved oxygen, and in addition fish are more susceptible to disease, stress and predation at high temperatures.

Although many factors affect stream temperatures, stream flow and water quantity, riparian cover that provides shade from sunlight, stream depth, and connections with groundwater are all very important, and all of these are affected by human activities.

In river basins that now have significant glaciers in their headwaters, a continued warming trend will likely bring a series of negative impacts. As glaciers retreat, they expose unconsolidated glacial till that has the potential to slide in heavy rainfall or glacial melt periods. As the fine silt moves downstream, it fills gravel and boulder beds, reducing rearing and holding cover, fills river channels, broadens streambeds, and increases turbidity. Degradation of the downstream mainstem habitat will raise the importance of habitat quality in those tributaries that are unaffected by glacial retreat.

In summary, a warming climate is likely to cause increased environmental stress for many Northwest steelhead populations. However, society has a lot of important choices to make with respect to the future for wild steelhead. We are confident that the best climate insurance we can purchase for wild steelhead will come with investments aimed at improving and protecting freshwater and estuary habitat. By putting water back in rivers, restoring riparian areas, removing barriers to fish passage, reforming hatchery practices, and better protecting spawning and rearing fish, the future for NW steelhead has the potential to actually be much brighter than the recent past even in the presence of a warmer climate. However, global warming may be a back-breaker for those stocks that are now already in peril if we stay the course on land and water use practices that now degrade steelhead habitat.

Climatic warming impacts on steelhead fishing

There are some impacts of a warmer climate on steelhead fishing that are relatively easy to predict. Warmer temperatures, to these authors, suggest a trend toward more and more unfavorable steelhead fishing conditions in many of the Northwest's streams. A warmer climate will lead to reduced summer flows and elevated summer water temperatures, both factors that will lead to poorer water conditions. Warmer summer water temperatures may be especially severe for summer-run steelhead fishing because most summer runs migrate to interior streams to spawn, east of the Cascades, where snowmelt is critical for maintaining late summer and fall flows and temperatures. For instance, the Deschutes River with its cool waters usually attracts migrating summer-run steelhead in the Columbia basin during the hot summer and fall months. In a warmer future, even the Deschutes may be too warm to attract migrating summer run steelhead.

While it is not possible to blame any single event on global warming — including the heat wave of August 2004 — it is likely that summer heat waves and poor springtime snow pack conditions will become more frequent in a warmer future. Where glaciers are present, intense glacial melt episodes like those observed in August 2004 will likely become more frequent, along with an increased incidence of slides after more and more loose glacial till becomes exposed by receding glaciers. Major siltation events are likely to become commonplace in basins experiencing substantial glacial melt, and those siltation events will likely degrade the quality and number of boulder-gardens that typically hold resting steelhead, while also degrading water clarity. In fall and winter, warmer temperatures may lead to an increased frequency of flood events in basins that would in a cooler climate build up a winter snowpack. In lower elevation coastal streams, and the coldest inland streams of the Columbia, Snake, Fraser and Skeena River Basins, warmer winter temperatures alone may actually improve winter fishing conditions by making steelhead more active if rainfall patterns remain more or less the same.

What can be done to buy Northwest steelhead climate insurance for the future?

At the regional scale improving the odds for sustaining steelhead populations and steelhead fisheries in the future are directly tied to improving freshwater habitat. Today, freshwater habitat for salmonids has been degraded throughout the southern end of its range through land and water use practices and damming rivers. An obvious pathway for improving stream habitat in the future, even in the face of global warming, is to implement measures that favor more natural flow regimes over those that now exist. Some opportunities will come with major projects like removing the Elwha River dams, while others may come with allocating more water for natural instream flows and less for out of stream uses. All too often, for example, water in streams east of the Cascades is over-allocated, and in such situations cold-water fish populations are imperiled. Smart growth planning for future development, increasing the width and protection of existing streamside buffers, wetlands, revegetating riparian areas, protecting cold water seeps and springs, and removing dykes and levees that now constrain rivers in floodplain habitats would also promote an improved future for anadromous fishes.

And finally, there are many opportunities for reducing future emissions of greenhouse gases as a means for reducing the risk of future greenhouse warming. For a comprehensive list of recommendations for practical solutions to the global warming problem, we recommend that interested readers visit the Climate Solutions web-site at url: http://www.climatesolutions.org.

More Thoughts on Global Warming, Steelhead and their Habitat

By Bill McMillan

Changing Stream Flow Patterns on the Rogue River

Back in 1972-73, Fred Everest did a study on the summer steelhead of the Rogue River with the Oregon State Game Commission Research Division. It was indicated that early spawning/early juvenile emergence and outmigration on small intermittent tributaries were both typical and vital to the summer steelhead population in the Rogue: "The sequence of spawning, incubation, emergence and migration is so restricted in time that any deviation in natural flow patterns in these streams could seriously impair their capacity to produce summer steelhead." This is not strictly limited to Rogue summer steelhead. I know of several intermittent streams that support wild steelhead populations, both summer and winter, in which the juveniles have to emerge and vacate the stream by late July virtually each summer but the wettest. With drier and warmer summers, it will increasingly compromise the ability of intermittent streams to sustain steelhead at all due to going dry too early, and a number of streams that are now wet year-round will become intermittent. Thus, early spawning steelhead will become increasingly important if such streams are to sustain steelhead at all.

Exceeding Adaptive Capabilities in Arid Regions

Inland stocks of steelhead, Fraser steelhead and interior Columbia River steelhead for instance, are closely related and more similar to each other than to any coastal stocks. They have adapted to the extreme inland conditions of hot arid summers and very cold winters. In this respect, I suspect that they could be called "desert steelhead" just as the inland redband rainbow trout is a "desert trout." Redbands have been found to tolerate water temperatures that reach 90 degrees for brief peaks in the afternoon, which can occur day after day. My readings of this indicate they appear to go into a sort of torpor with metabolic functions virtually shut down. I strongly suspect that inland stocks of steelhead have similar capabilities. This would probably have been particularly true during the Earth's most recent warm period of 6,000-8,000 years ago. This is the adaptation that allowed steelhead to have penetrated into the Owyhee and Malheur basins all the way into Nevada. It also permitted them to survive in tributaries in British Columbia's Thompson River basin, which still has cactus growing along its banks to this day, and of course, a number of southern California streams. What is vital about the continuing climate warming is that it must not exceed the extremes of the past, which has likely been the previous determinant of what these fish can survive. If it exceeds that past adaptive history, we go into no man's land regarding the future for cold water fishes. Beyond that point, steelhead will have to incur some sort of major evolutionary change to survive, excepting for those protected by headwater streams at extreme elevations.

Changing Snowmelt Regimes in Mountain Country

A 2003 progress report by Jon Riedel and Robert Burrows on glacial monitoring of Silver and North Klawatti glaciers in North Cascades National Park shows that the park contains some 750 glaciers — approximately 50 percent of the glaciated area in the lower 48 states. Glacier cover in North Cascade National Park is estimated to have receded by 44 percent over the last 150 years. Beginning in the late 19th century, glaciers in this area have retreated dramatically, significantly supplementing stream flow to the Skagit River. Because more of the glaciers melt in the warmer summers, they actually increase the streamflow from what it would otherwise have been. This is, of course, just the opposite of snowmelt, which would melt out very early and leave streams vacant of input except groundwater.

Delayed Migrations on the Columbia and Snake River Systems

Another impact will be increased warming of the Snake and Columbia Reservoirs that already reach or exceed 72 degrees during warmer years, sometimes for considerable lengths of time. What this does is to force fish migrations to cease by diverting them into cold water refuges such as the mouths of the Big and Little White Salmon rivers, mouth of Wind River, or any other tributary that affords a colder flow than the reservoirs. These delays can affect vital timing to barriers, such as waterfalls, for proper time of passage or for reaching the most inland destinations by spawning time. Some of these steelhead delays have already been documented at more than 60 days by radio tagging studies.

More Reliance on Groundwater on the Olympic Peninsula

It is possible that in the not-too-distant future, glaciers in Washington's Olympic National Park will be mostly gone. The once-large glacial rivers, such as the Hoh, Queets and Elwah, will be reduced to short seasonal snowmelt rivers with summer reliance entirely on groundwater. This will mean resulting rivers with great broad beds that will have summer time flows that may be half or less than the recent past. For instance, summer glacial input from some of the Skagit glaciers is 47 percent of summer flow.

The Rainbow Trout-Steelhead Debate, Continued

by Dennis McEwan, Katie Perry, and Michael Lacy
— *California Department of Fish and Game* —

In the following article, Dennis McEwan, Katie Perry and Michael Lacy provide us with a scientific perspective on the ongoing debate over the relationship between steelhead and resident rainbow trout. The authors are anadromous salmonid biologists with the California Department of Fish and Game. The opinions expressed in this article are their own and not the Department's. McEwan may be reached at dndmcewan@comcast.net We welcome reader comments on this article. The Osprey's *e-mail address is jyusk@bendcable.com.*

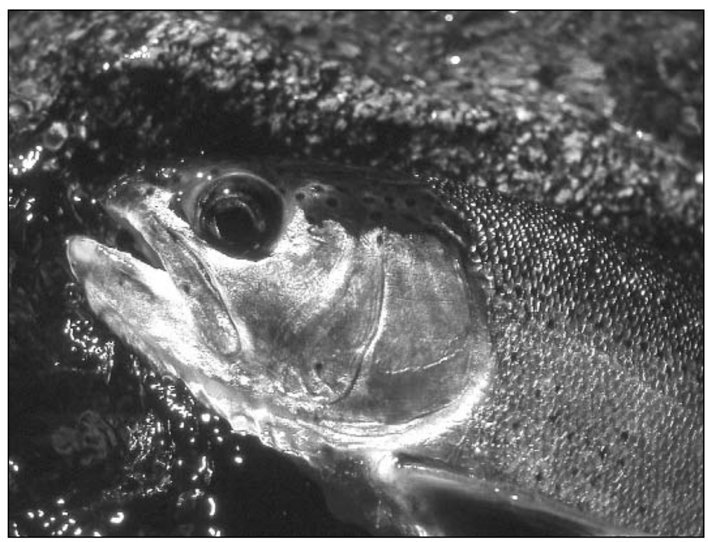
The two articles dealing with the resident rainbow trout/steelhead debate in the September 2004 issue of *The Osprey* provide a good argument for the continued protection of steelhead under the Endangered Species Act (ESA). However, we disagree with the premise that inclusion of resident rainbow trout negates the need for listing steelhead. In this article we present the argument that, when certain biological criteria are met, resident rainbow trout should be included in some Evolutionarily Significant Units (ESUs). We also argue that their inclusion should not automatically change the ESA status of the affected ESUs.

The argument for continued protection of steelhead under the ESA is grounded mostly in the relatively new field of salmonid conservation biology, the basic tenets of which are described in the NOAA Fisheries document Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units, published in June 2000. This document provides the foundation for assessing population and ESU viability and for determining the conservation status of populations. The Viable Salmonid Population (VSP) concept is integral to ESU assessment and recovery science, and provides the scientific framework for development of delisting criteria and recovery measures.

Below, we discuss some of the biological reasons to support inclusion of resident rainbow trout in some steelhead ESUs. We follow with a description of the VSP concept and its relationship to ESU viability assessment, with special emphasis on the Central Valley California Steelhead ESU, which is currently the focal point of the controversy.

Evidence for Life History Polymorphism

As a species, rainbow trout exhibit great variation in their tendency to migrate. Their life history strategies range from non-migratory (resident trout) to strongly migratory (anadromous steelhead). It is now well understood that these two forms represent two distinct life history strategies of the same taxonomic species. In some river systems, it appears that the two forms maintain separate populations; in others there is evidence that they comprise a single interbreeding population where one form can give rise to the other (residents produce steelhead progeny and vice-versa). This type of population is said to be "polymorphic" in its life history.



The relationship between resident rainbow trout and anadromous steelhead is being closely studied by both fish advocates and their opponents. Photograph by Jim Yuskavitch

In California we know that both steelhead and resident rainbow trout often occur together in the same place (i.e. they are sympatric). However, we know little about their relationship. In such cases, resident and anadromous fish could either be two components of a polymorphic population, or they might be largely separate breeding populations. This uncertainty about the relationship between the two forms, in conjunction with the often abundant populations of resident rainbow trout, has led some to argue for maintaining separate ESU status for the steelhead life history form. We believe that wherever evidence exists that the two forms comprise a single polymorphic population, that both life history forms should be included in the same ESU.

To answer the question of whether steelhead and resident rainbow trout comprise a single interbreeding population, we need to determine whether the two forms are reproductively isolated from one another. Reproductive isolation may occur through differences in spawning times, differences in spawning habitat, or assortive mating based

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on migratory behavior. In the September 2004 issue of The Osprey, Bill Redman referred to a parentage study conducted by Zimmerman and Reeves on the Deschutes and Babine rivers. They found that the steelhead and resident rainbow trout on the Deschutes River were reproductively isolated from one another. This was primarily because steelhead spawned in deeper water, used a larger substrate, and spawned earlier than resident rainbow trout. The Babine River fish, in contrast, showed evidence of polymorphism: steelhead of resident rainbow trout origin and resident rainbow trout of steelhead origin. This may indicate that the two forms represent polymorphisms occurring in a single interbreeding population. The diversity in these two examples illustrates the importance of identifying and evaluating populations within each ESU on a case-by-case basis.

Furthermore, if reproductive isolation is maintained we would expect to see evidence of genetic differentiation between populations. In their original status review in 1996, NOAA Fisheries compiled the existing genetic information for West Coast steelhead including genetic data comparing the two life history forms. In general, they were not able to distinguish the two life history forms where they were sympatric or in proximity to each other. In other words, geographically separated fish with the same life history tend to be more different genetically than fish with different life histories that live in the same place. NOAA Fisheries concluded that the two life history forms should be considered separate populations if they are reproductively isolated. It is the degree of reproductive isolation that poses difficulties in assigning ESU membership.

Zimmerman and Reeves relied upon analysis of otolith (ear bone) microchemistry to assess parentage. This technique uses variation in the ratio of strontium (Sr) to calcium (Ca) within the otolith to identify the migration history of individuals and whether that individual had a resident trout or anadromous steelhead mother. Otolith microchemistry provides a powerful tool for studying the life history of sympatric resident and anadromous rainbow trout.

This technique provides limited evidence in California's Central Valley that rainbow trout are polymorphic where the two life history forms are sympatric. In March 2000, three dead adults from the Calaveras River were found with spent gonads indicating they had recently spawned. Otolith microchemistry analysis of these three fish found that one was a steelhead and was the progeny of a steelhead female, one was a resident male that was the progeny of a steelhead female, and one was a resident male that was the progeny of a resident female. In addition, analysis of otoliths from rainbow trout smolts captured from Dry and Clear creeks and the Stanislaus and the upper Sacramento rivers shows that progeny of both steelhead and resident rainbow trout were present in the same habitat at the same time indicating that the two life history forms are sympatric.

In California, rainbows and steelhead often occur in the same place. However, we know little about their relationship.

Viable Salmonid Population Concept

A viable salmonid population is defined as one that has a negligible risk of extinction over a 100-year time frame; conversely, a non-viable population is one that has a medium or high risk of extinction over this same time frame. The VSP document also describes how to relate viability of individual populations to ESU viability as a whole. It is the ESU level (which constitutes a "species" as defined under the ESA) that is the ultimate concern of the ESA.

The VSP concept, as described in the VSP document, identifies four population parameters that are essential to properly evaluate extinction risk and population and ESU viability: abundance, population growth rate, population spatial structure, and diversity. These are discussed below.

Abundance

Populations with small numbers of individuals are at a greater risk of extinction than large ones. This is because certain ecological, genetic, and environmental processes can have much greater effects on the dynamics of small populations than they do on large populations.

Salmonids, like many cold-blooded organisms, have a high reproductive potential. That is, they can quickly produce many young so that, even at low densities, small populations can quickly expand if habitat conditions are suitable. This high reproductive potential compensates for the low survivorship of their progeny. A female steelhead can produce between 200 and 12,000 eggs, but mortality is extremely high during the first few months and only a small fraction survive to reproduce.

Conversely, the low survivability, coupled with a highly variable environment that includes extremes like floods and droughts, can cause a relatively large and robust population to crash very rapidly. The latest theories on salmonid population structure show that localized extinctions are quite common in the evolutionary history of Pacific salmonid species, especially at the highly variable southern extent of their range. For this reason, high abundance is less important to long-term persistence and ESU viability than it is to species with high survivorship (for example, grizzly bears, humans).

In theory, extinction risk of steelhead ESUs associated with this VSP parameter should be reduced due to inclusion of resident rainbow trout, simply because there are more of them. However, there is very little information on how or if this is truly the case; in California, there simply are no data or credible information to assess how the inclusion of resident rainbow trout affects this parameter.

Population Growth Rate

Population growth rate is an indicator of how well a population or ESU is "performing" in the habitats that it

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occupies. A negative population growth rate (that is, a consistent declining trend in abundance over several generations) is an indication that a population is consistently failing to replace itself, and signifies elevated extinction risk.

For the California steelhead ESUs it is difficult to assess how the inclusion of resident fish affects this parameter. In order to determine whether population size is increasing, decreasing, or remaining stable, one would need to have some year-to-year abundance measure over several generations for all components of the population in all life stages. This is usually impractical. However, in the absence of measuring population growth rate as a whole, one can measure life stage-specific productivity (for example, estimating spawner escapement or smolt production) instead, which is usually much more practical. The VSP document cautions that declines in life stage-specific productivity can be offset by other portions of the life cycle (for example, decreasing smolt production can be offset by increased ocean survival), however, if one or more measures of life stage-specific productivity exhibit declines, then the population's ability to offset these declines is reduced. This can lead to overall reduced population growth rate and a declining population.

For example, in the Central Valley California Steelhead ESU, we do not have any credible information regarding abundance or population growth rates among resident rainbow trout; however, we do have life stage-specific information for the steelhead portion of the population. Upper Sacramento River natural steelhead escapement measured at Red Bluff Diversion Dam indicates a steady and substantial decline between 1967 and 1993. In addition, lower Sacramento River rotary screw trap data show a decline of naturally-produced juvenile steelhead for the four years that that they were measured (1995 to 1999). These life stage population productivity measures provide an indication that the growth rate for the population as a whole is negative. There are no data to indicate that, even with the inclusion of resident fish, the population growth rates are increasing. Because such a substantial amount of habitat was eliminated by construction of impassable dams throughout the Central Valley, and the elimination of the upstream populations of rainbow trout from the ESU, it is likely that population growth rates of the resident portions of the population have been substantially reduced relative to historical periods.

Spatial Structure

A population's spatial structure includes the geographic distribution of individuals in the population as well as the processes that generate that distribution. How the ESU is structured spatially depends on habitat quality, habitat connectivity, and dispersal characteristics of individuals. Salmonid habitat is dynamic, with suitable habitat continually created and destroyed by natural processes. A decreasing number of habitat 'patches' (areas of suitable habitat) results in a decrease in viability associated with this parameter.

Including rainbows with steelhead has not been shown to reduce the risk of extinction in any California steelhead ESUs.

Salmonid populations are usually comprised of a number of subpopulations that are connected through some degree of gene flow by straying adults. The term 'metapopulation' is used to describe this type of structure. The subpopulations that comprise a metapopulation are generally not all equal in their productivity. Those that are larger, more robust, and occupy more productive habitats may operate as 'source' subpopulations that support, through straying, smaller, less robust subpopulations that may not be self-sustaining on their own. Without migrants from the source subpopulations, these smaller subpopulations face a much higher risk of extinction. It should be noted, however, that metapopulation processes are dynamic, and localized extinction of subpopulations occurs naturally. However, in a diverse, healthy metapopulation, the rate of extinction of subpopulations is offset by an equal or greater rate of recolonization of empty habitat.

In the California steelhead ESUs, there are very little data to assess how the inclusion of resident rainbow trout has ameliorated the extinction risk associated with this parameter. This is especially true in the Central Valley, where there has been a substantial loss of historical range due to the construction of impassable dams at low elevations on all of the major tributaries. One can surmise, however, that the substantial loss of historical range (some estimates are as high as 82 percent of historical habitat), has greatly reduced the number of habitat patches that support subpopulations of both resident and steelhead rainbow trout, and therefore, has increased the extinction risk associated with this parameter.

Diversity

This parameter refers to variation in such characteristics as genetics, life-history, run timing, spawning behavior, age at maturity, and ocean distribution. The VSP document describes three general reasons why diversity is important to population and ESU viability, especially for those ESUs in highly variable environments such as those in California. First, diversity allows a population to use a wider variety of habitats. Second, diversity protects a population against short-term changes in the environment – fish with different characteristics have different likelihoods of persisting through adverse conditions. Third, genetic diversity provides the basis for adapting to long-term environmental changes.

Diversity associated with life history can have a major influence on population and ESU viability. Populations with a diversity of life-history strategies possess a greater resiliency to environmental variation (both natural and human-induced) than do populations that consist of a single life-history type (all resident, for example). This is especially true at the southern margin of their range where there is extreme environmental variation (frequent droughts, floods, fire). In this type of environment, the anadromous life history is a critical component of ESU diver-

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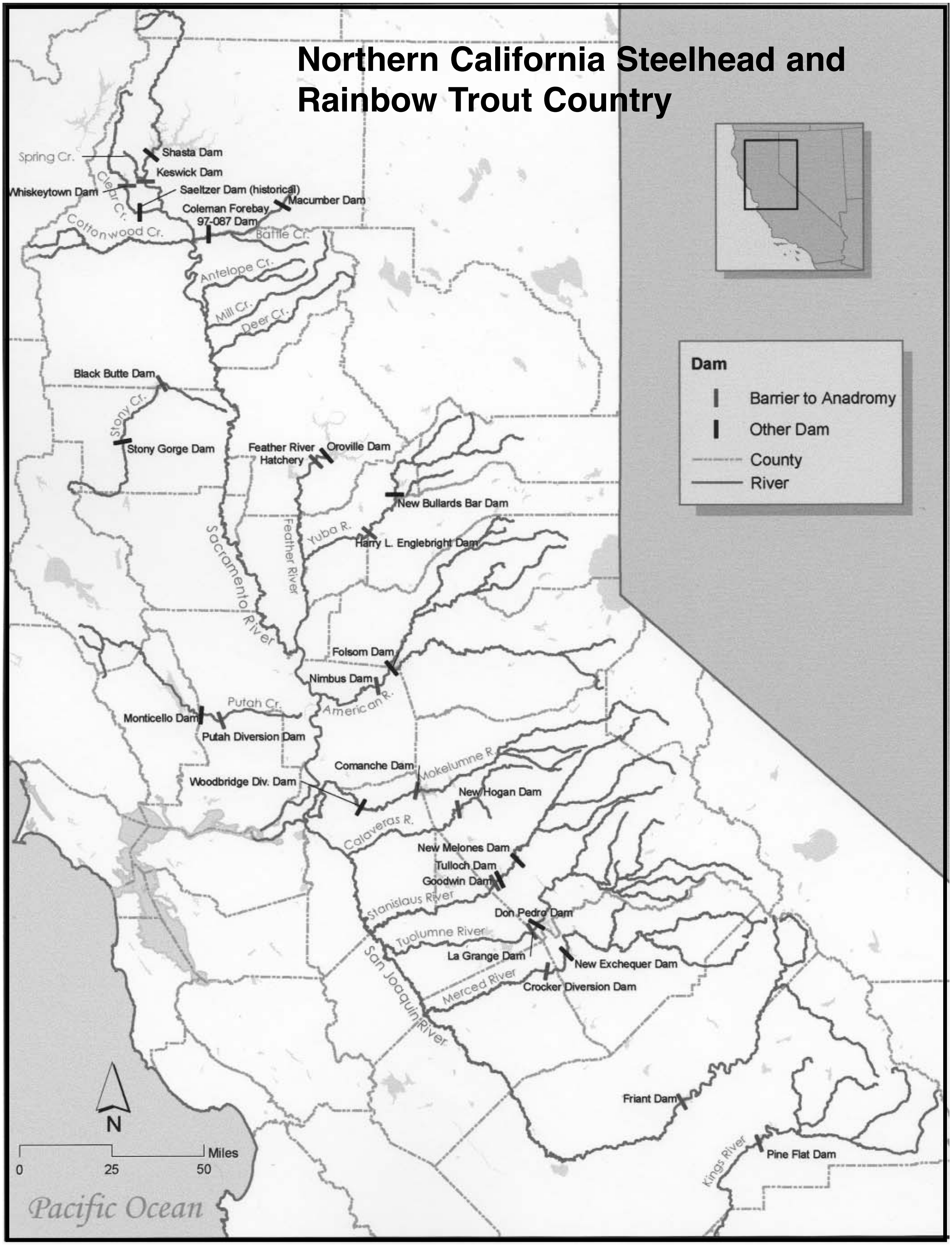
Northern California Steelhead and Rainbow Trout Country
Dam
Barrier to Anadromy
Other Dam
County
River
Spring Cr.
Shasta Dam
Keswick Dam
Whiskeytown Dam
Clear Cr.
Saeltzer Dam (historical)
Coleman Forebay 97-087 Dam
Macumber Dam
Cottonwood Cr.
Battle Cr.
Antelope Cr.
Mill Cr.
Deer Cr.
Black Butte Dam
Stony Cr.
Stony Gorge Dam
Feather River Hatchery
Oroville Dam
New Bullards Bar Dam
Yuba R.
Harry L. Englebright Dam
Feather River
Sacramento River
Folsom Dam
Nimbus Dam
American R.
Putah Cr.
Monticello Dam
Putah Diversion Dam
Comanche Dam
Mokelumne R.
Woodbridge Div. Dam
New Hogan Dam
Calaveras R.
New Melones Dam
Tulloch Dam
Goodwin Dam
Stanislaus River
Don Pedro Dam
Tuolumne River
La Grange Dam
New Exchequer Dam
Merced River
Crocker Diversion Dam
San Joaquin River
Friant Dam
Kings River
Pine Flat Dam
N
Miles
0
25
50
Pacific Ocean

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sity: steelhead provide necessary gene flow between populations, and more importantly, they can recolonize habitat where the former population has become extirpated or severely reduced by environmental catastrophe. The extreme scarcity of native resident rainbow trout populations in southern California may be due to the inability to recolonize former habitat that has recovered after fire events, due to the fact that artificial structures (dams, road crossings) now block access of steelhead into these habitats. Catastrophic events like this can cause what can be considered 'temporary extirpations', to become permanent local extinctions. These same ecological principals apply to the Central Valley as well, given the high degree of environmental variation that is present. Thus, even with the inclusion of the resident forms, extinction risk associated with diversity remains high for Central Valley rainbow trout because of the fact that the other migratory types, notably steelhead, have declined substantially. In addition, a recently completed comprehensive genetic evaluation of Central Valley rainbow trout found that there has been a recent population bottleneck that has resulted in a reduction in genetic diversity.

The resident components of the populations can help to buffer the ESU from depletion or extirpation of the anadromous forms during periods of poor ocean conditions and/or anthropogenic threats. Residents in upstream, higher elevation habitats that are more protected from drought conditions may also provide the core from which the population can expand after drought conditions subside.

Steelhead in the Central Valley were at one time abundant; therefore we can surmise that they are a component of a successful population structure of native Central Valley rainbow trout. It can be assumed a priori that any deviation from this type of structure (e.g. elimination of the steelhead forms) can have serious repercussions in terms of increased local extinction risk and decreased likelihood of long-term persistence. The population resiliency that steelhead provide in the Central Valley is severely reduced. Because of this, we believe that extinction risk associated with diversity still remains high in the Central Valley Steelhead ESU.

Conclusion

Although the science is not conclusive, it appears that in some ESUs, whether a rainbow trout migrates to the ocean or stays in the stream to mature is more a function of environment than it is a genetic predisposition. Resident rainbow trout that exist in anadromous waters that, together with steelhead, comprise a single, interbreeding population should be included within the ESU, and those that comprise a population separate from steelhead should not be included. However, the inclusion of residents should not result in removal of ESA protections for steelhead unless it can be shown that their inclusion appreciably decreases the extinction risk associated with all four VSP parameters, which is something that has not been demonstrated for any of the steelhead ESUs in California. Whether one believes that resident rainbow trout should be excluded or included in the ESU is immaterial to the question of whether steelhead should continue to warrant protection under the ESA. Removal of protections based on increased abundance alone is misguided and contrary to our scientific understanding of how these populations function.

> ***Resident components of the population can help buffer the ESU from exptirpation of anadromous forms during times of threats.***

NOAA Fisheries, in their Proposed Listing Determinations for 27 ESUs of West Coast Salmonids state:

"... the presence of relatively numerous resident populations can significantly reduce risks to ESU abundance. However, there is considerable scientific uncertainty as to how the resident form affects extinction risk through its influence on ESU productivity, spatial structure, and diversity. The threats to O. mykiss ESUs extend beyond low population size and include declining productivity, reduced resilience of productivity to environmental variation, curtailed range of distribution, impediments to population connectivity and reproductive exchange, depleted diversity stemming from loss or blockage of habitat and associated erosion of local adaptation, and erosion of diversity of expressed migratory behaviors. Thus, the BRT [NOAA Fisheries Biological Review Team] concluded that, despite the reduced risk to abundance for certain O. mykiss ESUs due to numerically abundant residents, the collective contribution of the resident life-history form to the viability of an ESU in-total is unknown and may not substantially reduce extinction risks to an ESU in-total. Based on present scientific understanding, the BRT could not exclude the possibility that complete loss of anadromous forms from within an ESU may be irreversible."

We agree with the above statement and believe it illustrates the uncertainty inherent in our understanding of rainbow trout population structure. If nothing else, this debate has focused attention on one essential fact: the science of steelhead/rainbow trout population structure is still in its infancy. Removal of ESA protection at this point is unwarranted and could very well lead to the extinction of not only steelhead, but eventually the resident component of the populations as well. The VSP document recognizes this uncertainty:

"Because of uncertainty, management application of VSP should employ both a precautionary approach and adaptive management. The precautionary approach suggests that VSP evaluations should error on the side of protecting the resource....."

Those organizations and agencies that are promoting delisting of steelhead ESUs based on increased abundance brought by the inclusion of residents should heed the above advice. To do otherwise is contrary to our understanding of rainbow trout population dynamics, recovery science, the precautionary principle, and prudent resource conservation.

Fish Advocates Lobby Calif. F&G to Protect Central Valley Steelhead

By Charles P. Bucaria, Sr.

— Northern Caifornia Council FFF —

This report is by Charles P. Bucaria, Sr., Director, Northern California Council of the Federation of Fly Fishers. He may be reached at CPBWEST@aol.com. We welcome reader comments on this article. The Osprey's e-mail address is jyusk@bendcable.com.

During 2004, NOAA Fisheries conducted a review of the listing status for salmon and steelhead under the federal Endangered Species Act (ESA). Its draft review indicated that essentially no change in the current listing status was contemplated. On November 12, 2004 the Director of California's Department of Fish and Game (DFG) sent a letter to NOAA Fisheries recommending delisting of native steelhead in California's Central Valley Evolutionarily Significant Unit (ESU). His delisting recommendation was justified by extrapolations of questionable non-anadromous native rainbow trout counts taken from the Sacramento River above the impassable Shasta Dam. Those abundance figures were applied to roughly fifty miles of the river downstream from the dam.

To summarize in an oversimplified manner, the theory presented justifying delisting seemed to be that because there were many native rainbow trout within the described area and native rainbows sometimes become anadromous, there must be many steelhead in the Central Valley system above the Sacramento River Delta. This letter prompted a delegation of California's most active sport angling groups to request a meeting with the DFG Director L. Ryan Broddrick. Their primary goal was to seek change in the Department's expressed policy position supporting delisting of Central Valley steelhead.

On January 25, 2005 Tom Weseloh of California Trout, David Katz, California Director of Trout Unlimited and the author representing the Northern California Council, FFF, met with Director Broddrick to express concern and offer to assist the Department in the ongoing attempt to secure a future for Central Valley ESA native anadromous *Oncorhynchus mykiss*. A number of issues were raised with Director Broddrick, who included in the discussion both headquarters and regional DFG staff members who have been contributors to recent initiatives which have concerned the sport angling delegation. A basic view expressed by the three groups was that, "Just because there are a lot of trout in a river doesn't mean that native steelhead numbers there are healthy."

Just because there are lots of trout in a river doesn't mean that native steelhead numbers are healthy.

Policy matters discussed focused upon the sport angling groups' view that the "Threatened" ESA listing must be retained for California Central Valley native steelhead. High among topics brought to the table was the question of whether native rainbow trout, naturally reared steelhead and hatchery steelhead should be counted together in determining whether or not naturally reared Central Valley steelhead should retain their "Threatened" designation. Among other delisting topics raised with the Director and staff were the following points arising from the Department's November 12, 2004 letter to NOAA Fisheries:

1. A dubious proposal to split the ESU into two components, one north and one south of the delta of the San Joaquin and Sacramento rivers.

2. Use of resident trout counts from the Sacramento River above Shasta Lake as a basis for projecting that enough native steelhead lie below Shasta Dam to warrant removing their ESA "Threatened" listing.

3. Use of extrapolations involving juvenile trout as an abundance indicator for natural steelhead stocks.

4. Consideration of winter run Chinook salmon as requiring continuing ESA protection while suggesting that Central Valley steelhead may be less deserving of similar protection.

5. Fully considering the extent to which future actions by federal and state agencies to increase flows down the Sacramento River will cause undesirable future steelhead rearing conditions.

6. Reconsidering DFG policy where it conflicts with hatchery issues, such as counting hatchery fish to meet Viable Salmonid Population parameters.

7. Actively supporting a proposal by NOAA Fisheries to permit angling for marked hatchery steelhead and resident *O. Mykiss* while protecting unmarked, wild anadromous fish.

The three sport angling representatives were assured by Director Broddrick that points raised in the meeting would be considered further by the Department. *The Osprey* will continue to follow this issue and report on future developments.

Petition Filed to Place Puget Sound Steelhead Under ESA Protection

Olympia, Washington fish advocate Sam Wright has filed a petition with the National Oceanic and Atmospheric Administration, National Marine Fisheries Service to list steelhead populations within the Puget Sound Evolutionarily Significant Unit as Endangered or Threatened under the federal Endangered Species Act (ESA). Wright is a fish biologist with 42 years experience in managing fish populations and fish habitat and is certified as a fisheries professional by the American Fisheries Society. He retired from the Washington Department of Fish and Wildlife in 1994.

The Puget Sound Evolutionarily Significant Unit was defined in 1996. Based on scientific information available at the time, steelhead populations within the ESU were not recommended for listing under the ESA. Currently, Puget Sound ESU anadromous salmonids listed under the ESA include Puget Sound Chinook and Hood Canal summer chum salmon. Both are listed as Threatened.

The Puget Sound ESU includes river basins within the Strait of Juan de Fuca and Hood Canal. Other river basins included in the ESU extend west to the Elwha River and north to the Nooksack.

An Evolutionarily Significant Unit is defined as "a population or group of populations inhabiting a defined geographical area that comprises a unique segment of the species; a distinct population, reproductively isolated from other conspecific populations and is an important evolutionary legacy of the species."

At the time the Puget Sound ESU was defined, eleven steelhead populations were evaluated using five years of data. Two populations in the ESU — both in the Snohomish River basin — showed increasing population trends.

According to the petition: "*The report, herein defined as Busby et al. (1996), defined an Evolutionarily Significant Unit (ESU) for Puget Sound steelhead populations but did not recommend ESA listing based on scientific evidence available at the time of report preparation. The most recent quantitative population assessment data included in the report for Puget Sound steelhead was for 1994 (Busby et al. 1996, Appendix E). At the time, the short term (five year) abundance trends for eleven defined populations were significantly different from zero (9 negative, 2 positive). The two positive trends were both for portions of the Snohomish river basin (Snohomish/Skykomish and Pilchuck River). The two largest river basins (Skagit and Snohomish) had short term increasing trends but neither were significantly different from zero. There was not a single entire river basin, large or small, that had a significant upward short-term trend in steelhead abundance. There are now ten years of additional population assessment data for Puget Sound steelhead and nearly all of the river systems now have distinct downward trends in population abundance and are not even coming close to replacing themselves from generation to generation on a one-to-one basis. In addition, there is currently a complete ban on the retention of wild steelhead (defined as fish with an adipose fin) by recreational anglers in all river systems within the Puget Sound Basin (Note: a one fish annual limit was recently enacted for naturalized or non-indigenous Green River summer run steelhead). Based on this new scientific evidence, a re-examination of the original ESA listing decision is warranted for Puget Sound steelhead. Petitioner believes that Puget Sound steelhead now clearly qualify for ESA listing as Threatened.*"

The petition goes on to say: "*The Puget Sound ESU includes two stocks that have attracted considerable public attention recently: Deer Creek summer steelhead (North Fork Stillaguamish River Basin) and Lake Washington winter steelhead. Deer Creek summer steelhead were petitioned for listing under the ESA (Washington Trout 1993), but NMFS determined that this population did not by itself represent an ESU (NMFS 1994b). Adult Lake Washington winter steelhead have experienced a high rate of predation by California sea lions (Zalophus californianus) below the fish ladder at Hiram M. Chittenden Locks (also known as the Ballard Locks), the artificial outlet of Lake Washington. Deer Creek summer steelhead and Lake Washington winter steelhead were 2 of the 178 stocks identified in the west coast steelhead petition (ONRC et al. 1994).*

"*This ESU is primarily composed of winter steelhead but includes several stocks of summer steelhead, usually in subbasins of large river systems and above seasonal hydrologic barriers. Nonanadromous O. mykiss co-occur with the anadromous form in the Puget Sound region; however, the relationship between these forms in this geographic area is unclear.*"

On why he filed the petition Wright says, "I filed the petition for the same reason that I have given my highest priority to ESA efforts since the early 1990s. It continues to be the only legal means available that might lead to responsible natural resource management. When I helped develop the Washington Department of Fish and Wildlife's Wild Salmonid Policy for Director Shanks in the late 1990s, I believed that it would eventually provide a viable alternative for success. However, the WSP is being completely ignored by the current WDFW administration, so I am back to a single choice."

If the federal government accepts the petition for a status review, it will have a full year to make its determination.

— J.Y.

Once Great Steelhead Rivers Why Not Now?

By Pete Soverel
— *Steelhead Committee* —

Pete Soverel is both a long-time member of the Federation of Fly Fishers' Steelhead Committee and steelhead angler on Washington State rivers. He may be reached at soverel@msn.com. We welcome reader comments on this article. The Osprey's e-mail address is jyusk@bendcable.com.

A number of years ago, The Osprey began publishing "Reminisces." From my perspective, these reflections on the past are especially useful in focusing our conservation goals in the present.

In recent years the quality of steelhead fly fishing on most of Washington's rivers has plummeted. The declines on the Skagit/Sauk and Skykomish rivers have been especially dramatic. Anglers, or managers for that matter, new to the sport could mistake current conditions as the norm. They are not. As recently as ten years ago, the Sky, Skagit and Sauk were as good as any steelhead destinations in the world for spring steelhead. In fact, these rivers were destinations.

I like to remember the Skykomish that way it should be — a steelheader's river perfectly suited to the fly. From late January through April, its runs and riffles were filled with thousands (5,000 - 9,000) of bright, native winter steelhead fresh from the sea. This abundance meant that the Skykomish provided superlative angling for wild, winter steelhead.

How good was good? Well, it was fantastic. I recall one ten day stretch in April 1985 while home on leave from my duty station in Europe when I hooked almost one hundred and landed fifty three wild winter runs in the lower Skykomish. Most fish were in the 10-to12-pound range but a significant number were in the upper teens and a few in the low twenties.

One of my favorite runs was locally known as Five Cedars for the five such trees that marked the location of prime holding water in an otherwise nondescript flat, downstream from the Ben Howard public access. The surface water gave few clues to Five Cedars' productivity. However, under the glassy surface flow there was a narrow slot, perhaps fifteen feet wide and fifty feet long, where the river shallowed and picked up speed going from deep frog water to perfect holding water that was easily covered with a short 40- to 50-foot cast. Steelhead loved it and most anglers ignored it.

> ***I remember the Skykomish the way it should be — a perfect steelheader's river.***

On the morning of April 7, fishing Five Cedars alone, I hooked eight and landed five beautiful native steelhead between 12 and 22 pounds. Although a very good day, such angling was not especially out of the ordinary during that wonderful April or for any number of other visits until Five Cedars was washed away in the 1989 floods. Even after Five Cedars vanished, the lower Skykomish had many other productive runs — IRS, Two Bit, Hanson's, to name a few.

Another of my favorite runs was a small break downstream from the Two Bit Hole. In March 1996 Misha Skopets, a Russian friend, and I walked towards the hole. I was explaining where the fish lay when Misha announced that he needed to go back to the car to get his fly box. I urged him to use some of mine, but he insisted on returning to the car for his own. I had intended to wait for Misha before fishing, but when I saw another angler start walking towards me I decided to fish right away. I stripped off about 25 feet of line and made a short cast into the chop and immediately had a soft pull. I waited for the fish to take the fly solidly but, instead, the fish dropped it. I repeated the identical cast and was rewarded with a slashing yank. Ten minutes later, I eased the fly from a gorgeous 10 pound hen: white belly, see through fins, square tail, big anal fin — perfect. Still no Misha, but neither had the other angler arrived, so I repeated the above — 25-foot cast, soft pull, but no take, repeat cast, hard pull and another beautiful hen.

In the twenty minutes it took Misha to make the round trip to the car, I said hello to four steelhead, landed two, lost one and broke off another on the take — a fairly typical spring outing on the Skykomish through the mid-1990's. During that period of time, I expected, and almost always did, hook steelhead every time I went out. Last season, I did not even hook a winter steelhead on the Sky, underscoring the collapse of its wild winter steelhead.

Sadly, the collapse has not been limited to the Skykomish. Rather, all winter steelhead populations in Puget Sound and the Georgia Basin are in steep decline. The Washington Department of Fish and Wildlife has no explanation for the declines. Scandalously, WDFW has made no systematic effort to understand the causes. Instead, the Department simply closed this once popular and former world class fishery.

This bankrupt approach means the department lacks the scientific basis for developing a strategy for restoring healthy wild populations, and anglers have little hope that they will soon experience the world class angling which existed on the Skykomish less than ten years ago. In my book, that is not good enough.

Better Than Natural?

By David R. Montgomery
— *University of Washington* —

Professor David R. Montgomery is internationally recognized as a leader in the study of geomorphology, the evolution of landscapes. He is the Director of the Quaternary Research Center and a professor in the Department of Earth & Space Sciences at the University of Washington. His current research interests range from the environmental history of Puget Sound rivers, to giant glacial floods in eastern Tibet, and the formation of Martian canyons. He has published over 150 publications in the scientific literature and his recent environmental history of salmon (King of Fish: The Thousand-Year Run of Salmon) reached the regional best-seller list last fall.

He may be reached at dave@ess.washington.edu. We welcome reader comments on this article. The Osprey's *e-mail address is jyusk@bendcable.com.*

Can hatcheries create sustainable fisheries more efficiently than high-quality habitat? Our experience so far suggests that the answer is no. Photograph by Jim Yuskavitch

The Bush administration recently announced its intention to count hatchery fish when evaluating salmon populations under the Endangered Species Act. This is against the advice of preeminent scientists the administration asked to evaluate the proposal, and despite the reality that hatchery operations have failed to recover salmon populations in the past. Perversely, this new policy could extend protection under the ESA to hatchery fish while delisting runs of legitimately endangered wild salmon. In light of this rather counter-intuitive approach to salmon conservation, it is worth considering the history of hatchery management in regard to protecting salmon runs.

Two distinct philosophies of hatchery management date to the mid-nineteenth century when hatcheries were viewed as the way to save Europe's declining salmon runs. Sustaining salmon populations can be seen as either a narrow technical challenge or a broad ecological problem. In the first case, hatcheries can be used to try and pump out more fish so that one can keep on fishing hard and degrading salmon habitat. In the second case, hatcheries can be used in conjunction with limited fishing and habitat restoration to let spawning runs recover—an approach based on fostering the viability of self-sustaining populations of wild salmon. Both the "salmon factory" and "wild salmon" approaches put fish back in streams to be caught by commercial fishers. Salmon factories rely on ongoing releases, whereas hatcheries operated to rebuild wild runs release hatchery fish only as necessary, but require reduced fishing intensity and protection of salmon habitat. The philosophy of managing hatcheries as salmon factories promised a painless way to treat the symptom of too few fish without curing the diseases of overfishing and environmental degradation.

Until the 1840s the practice of fish culture in continental Europe was conducted primarily to investigate the natural history of salmon. This changed when two French fishermen, frustrated by the declining salmon runs of the Moselle River, began collecting salmon eggs from streams they fished — raising the eggs into fry, and releasing them back into the wild from a small-scale hatchery operation. Impressed with this "veritable fish factory," the French government started to develop an extensive program to restock overfished rivers. As the seductive idea of fish factories attracted the attention of scientists and governments across Europe, few recognized that a critical reason for their success was that the habitat in the Moselle was still in pretty good shape.

Within a few years, an experimental salmon hatchery on the River Tay began trying to rebuild Scotland's salmon. William Brown argued that by rearing salmon in a hatchery and protecting young fish from their natural predators he would greatly increase the return of adult fish. Though Brown admitted that he did not know by how much his hatchery increased juvenile survival, he felt confident that increased salmon production from all those extra smolts could more than compensate for even very intensive fishing. By making more fish, hatcheries provided an easy answer to the problem of overfishing.

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Less seduced by the idea of creating salmon factories, fellow Scotsman Andrew Young argued for using salmon breeding as a supplement to, rather than a replacement for, natural spawning. So began an ongoing split in philosophies of hatchery management. Some, like Young, advocate using hatcheries to supplement and rebuild wild spawning runs, whereas others promote Brown's vision of hatcheries as salmon factories that could replace natural spawning. Because President Bush's new approach to salmon conservation adopts Brown's vision, it is worth asking how well it has worked in the past.

During the wave of initial enthusiasm for salmon breeding the British government established its first hatchery in 1868. Additional hatcheries soon spread across the British Isles, rearing salmon fry and then releasing them into streams and rivers. Although hopes were high that hatcheries would restock barren English rivers, the results did not live up to expectations for most rivers. British enthusiasm for reliance upon hatcheries soon faded as those hopes proved illusory for all but the few rivers where habitat remained productive and could support the hatchery smolts once they were released into the wild.

Hatcheries were also promoted as an attractive way to avoid dealing with habitat degradation in eastern North America in the late 19th century. Concerned over declining Atlantic salmon populations, Canadian fishery authorities constructed a network of eight salmon hatcheries between 1868 and 1888. Over time the effects of pollution, logging, mining, and overfishing more than offset gains from hatcheries and conservation efforts. Canadian fisheries experts soon realized that even fish from a salmon factory needed rivers that could sustain salmon once they left the hatchery.

South of the border, the first American salmon hatchery produced an impressive 70,000 eggs in 1870 to begin restocking Maine's rivers. Four years later, at the peak of the stocking program, more than 3 million eggs were shipped all over New England. Initially, hatchery operations were seen as a key element in a broad program to rebuild the region's decimated spawning runs. But while the hatcheries were built, provisions for maintaining fishways, protecting habitat, and preventing overfishing were implemented haphazardly, when they were implemented at all. Although local stocking programs appeared to be working at first, initial gains were undone by continued habitat degradation and renewed fishing intensity. By the turn of the century New England's once thriving Atlantic salmon runs were pretty much history.

Failure of early hatchery programs meant that by the turn of the century, fishery officials began questioning the wisdom of relying on hatcheries as the backbone of salmon conservation plans.

Sustaining salmon populations can be seen as either a narrow technical challenge or a broad ecological problem.

In his official report for 1895, the US Commissioner of Fish and Fisheries, Marshall McDonald, noted that hatchery operations needed to be coordinated with regulation of the fishery to ensure that operations were successful at not only producing fish for nets, but for rebuilding and sustaining wild runs.

Artificial propagation should be invoked as an aid and not as a substitute for reproduction under natural conditions.
— M. McDonald (1894, p. 4)

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The Commissioner's conclusion that reliance on hatcheries to sustain salmon production was unwise did little to dampen enthusiasm for salmon factories, which kept growing as salmon populations kept falling.

Hatcheries spread rapidly throughout the Pacific Northwest due to the combination of widespread recognition that salmon were overfished and the lack of political will to restrict fishing. The hatchery at Bonneville became the central facility of a network of hatcheries throughout the Columbia River system. Still, the millions of fry released into the Columbia every year had little apparent effect on the number of fish caught in the commercial fishery that the hatcheries were supposed to enhance. Although enthusiasm for salmon factories remained high, evidence for a beneficial impact of hatcheries proved elusive. Scientists who looked into the issue remained skeptical.

By the late 1930s, when the potential effects of the Columbia River dams on salmon fisheries became contentious, the opinions of early skeptics of hatchery programs were being repeated even by those pushing for the dams.

[A]rtificial hatching has definite limitations. At best it is only a supplement for natural spawning. ... [There are] requirements which have little, if anything, to do with artificial propagation, and cannot be managed by hatcheries. If we ignored these requirements, no matter how much we spent on building more hatcheries, the salmon fishery of the Columbia would be headed toward extinction.

- U.S. Commissioner of Fisheries Report (1937, p. 60).

John Cobb, Dean of the College of Fisheries at the University of Washington, cautioned that reliance on hatcheries to maintain salmon runs would eventually destroy the fishery.

Still, hatchery success was measured by the number of fish released rather than by progress in rebuilding wild runs. In 1896, Washington state hatcheries produced 4.5 million Chinook fry. In 1950, state hatcheries released 28.9 million.

By 1968 they were pumping out 92.7 million. But the harvest in the commercial fishery wasn't increasing. State fisheries managers knew they were replacing wild fish with hatchery fish but saw this as how to sustain a fishery in the face of regional development. Hatchery operations on the Columbia River released 100 to 120 million juvenile salmon per year in the late 1980s and early 1990s. During this period less than half a million adult salmon returned to the hatcheries each year.

This net return of less than one percent of the fish that went to sea was not all that much better than the survival rate for wild Pacific salmon. The continued

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decline of salmon populations in spite of extensive hatchery programs led more and more biologists to recognize that hatcheries were not enough by themselves to sustain salmon.

Failure to recognize the subtle biological advantages of inefficiency in juvenile survival proved the Achilles heel of reliance on hatcheries to sustain salmon runs. After leaving home and hitting the real world, hatchery-raised fish survive at much lower rates than their wild cousins. Raising fish in a hatchery may not produce any more adult fish. Instead it simply rearranges when in their life cycle most of the fish will die.

In the wild, most salmon die very young. Those few that survive are, on average, better suited for whatever life the local stream has to offer salmon. The dreadful culling of wild salmon in their early life stages equips the survivors for success on the rest of their epic journey out to sea and back home again. Charles Darwin called this natural selection.

Protected from day one, hatchery fish are not subject to this selective pressure. So when they are released into the wild, more of them are killed by predators or other natural hazards. Releasing hatchery fish into a stream is like dropping suburban teenagers into the middle of the Congo and asking them to walk out of the jungle to the coast. Few will make it. A hidden price of reliance on hatchery fish is that resilience to disturbances, environmental change, and natural hazards may be bred out of a population.

Hatcheries treated fish production as a series of technical issues that, once solved, would allow producing as many fish as desired. First, the problem of hatchery design and basic procedures needed to be addressed. Then fisheries scientists wrestled with the questions of whether to release eggs or fry; how large fry should be before release; what to feed the fish; what water temperature and pH were ideal; and how to time releases to maximize survival. Today's technical challenges for hatcheries center on maintaining genetic diversity. Such concerns are leading hatchery programs to use native stocks. So we now have native stocks being used to prop up the hatchery stocks that were supposed to save the native stocks in the first place.

Management of fisheries with a large component of hatchery fish also leads to overexploitation of wild stocks because wild salmon are caught in the same nets that seek the hatchery fish. Fishing intensity set to harvest a large proportion of a hatchery population can ensure overexploitation of remnant natural stocks.

Hatchery-produced fish also damage the gene pools of the wild stocks among which they are released, or into which they accidentally find their way.

There is little evidence that hatchery-based fisheries can be sustained over the long run.

Wild salmon have a great deal of genetic diversity, with each run adapted to its home stream. But hatchery stocks typically come from a small sample of an original population and thus exhibit a comparatively impoverished genetic variability. Even a modest number of wandering or escaped hatchery fish can genetically swamp a small wild population, thereby reducing its genetic diversity and increasing its vulnerability to environmental change.

There is no evidence that even aggressive hatchery programs can increase the total number of salmon over the long run. Instead, a century and a half of experience has shown that hatchery populations dependent upon human intervention gradually replace naturally spawning wild populations. William Brown and Andrew Young's divergent visions for hatchery management really do appear incompatible. The bottom line on hatcheries is that throughout the Pacific Northwest, salmon (both hatchery and natural) have continued to decline even though hatcheries have spent millions of dollars to produce hundreds of millions of fry. Hatcheries not only failed to revive the runs or sustain the fishery, but now most of the fish come from hatcheries.

In December 1998, the Scientific Review Team of the Northwest Power Planning Council reported on their review of science and impacts related to artificial production of salmon, and compared their review to three previous scientific reviews. There was uniform agreement on most points. Hatcheries failed to mitigate for the effects of habitat loss and damage in the Columbia River Basin, in no small measure because hatchery practices did not take into account the biological diversity of salmon and the role of environmental factors in their life history.

The Scientific Review Team found that a radically different production model was needed in order for hatcheries to have a positive role in salmon conservation. To maintain adaptability to future environmental changes, the new approach would need to minimize impacts on natural populations and preserve the genetic structure and diversity in salmon. The Scientific Review Team concluded that hatchery production was not independent of natural systems, and that the success of a hatchery program depends on the fitness of the stock, the quality and constraints of the natural habitat, and how well hatchery production is integrated with the natural ecosystem. Andrew Young's vision for the role of hatcheries in salmon management weathered the test of time better than William Brown's idea of using hatcheries as salmon factories.

Put simply, there is little, if any evidence that hatchery-based fisheries can be sustained over the long run. Perhaps the most dangerous aspect of the historic reliance on hatchery production to sustain salmon populations is that the system has created the illusion that hatcheries can make up for the environmental changes and overfishing that led to declining salmon runs in the first place. This illusion deceived the public and policy makers into believing that we can sustain production of a valuable, renewable, and culturally important resource, while simultaneously degrading the environment and the conditions upon which that production depends.

Chair's Corner,
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cally driven policy changes of the past year without the insistent advocacy of individual citizens and the fishing and conservation organizations they support.

That brings us to the courts. With the blatant moves by the Executive branch of the federal government to strip away steelhead and salmon protections, the courts become our last resort. All four of these ESA related policy changes are either already the subject of law suits or unavoidably headed that way. Our opponents, those to whom ESA protections for steelhead and salmon are a serious inconvenience or worse, will be just as active on the other side of these legal actions as we are.

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For the most part, the courts have responded well to cases brought under the ESA to protect these fish. But there is no guarantee that will continue. Anyone who thinks appointments and confirmations to the federal courts, especially the appeals courts, are not important to steelhead and salmon simply has not been paying attention. These appointments will require the continuing attention and commitment of fish advocates.

Ninth Annual Native Fish Society Banquet and Auction

Saturday, February 26, 2005

Treat yourself to an evening of fun and philanthropy at Native Fish Society's Annual Banquet and Auction on Saturday, February 26, at Portland's World Forestry Center. You will be pleasantly surprised by our classy new venue, delicious dinner menu, and this year's truly outstanding array of quality auction items.

You can't beat our new location for this ninth annual NFS Auction and Banquet. Miller Hall at the World Forestry Center is a wonderful facility, located adjacent to the Oregon Zoo. The World Forestry Center offers ample free parking and is conveniently located along the MAX light rail line (Zoo/Washington Park Station), making it easy to get to and from the event.

Doors will open at 5:30 for the Wet Fly Cocktail Hour and the opening of the raffle and silent auction. At this time we will also unveil a brand new and fun activity, with everyone who participates guaranteed to be winner! So come early and bid often to help support Native Fish Society in our unbending efforts to protect and restore the ever-threatened fish runs of the Pacific Northwest.

This year's banquet dinner will be served at 6:30 p.m. and will feature a delicious array of Oregon-grown products. Served buffet style, the menu will include dishes to accommodate everyone's tastes and needs. During dinner, you will enjoy a short program followed by the featured event of the evening – the oral auction. Get ready to bid up prices and outbid your friends! The oral auction starts promptly at 8:00 p.m. and concludes no later than 9:30 p.m.

Tickets for the Auction and Banquet are $40 each if you reserve and pay in advance, or $50 at the door. We welcome early registration, so don't delay. Make your reservation today by contacting: Native Fish Society, P.O. Box 19570, Portland, OR 97280, (503) 977-3133, www.nativefishsociety.org.

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The Osprey wishes to thank the dedicated people and organizations who gave their financial support in 2004. Our readers are our primary source of funding. It's pretty remarkable that our home-grown journal, which only comes out three times a year, has developed such a generous following. Don't think we're not grateful, and a bit humbled.

We have always skated on thin financial ice, and will continue to do so. But without your support we fold up. The usual donation envelope is provided. Whatever you can afford will be much appreciated (and used wisely).

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