THE OSPREY

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Seas of Change:

Can We Save Wild Steelhead and Salmon By Predicting Ocean Conditions?

by Nathan Mantua

— University of Washington —

Ocean conditions have been receiving increasing attention in recent years by those concerned with salmon and steelhead and how they are managed. What kinds of impacts do ocean conditions have on salmonid populations and how important are they compared to freshwater habitat conditions? Can we predict ocean conditions and manage our fisheries accordingly?

In this paper, prepared specifically for The Osprey, Nate Mantua, a faculty member with the University of Washington's Department of Atmospheric Sciences and School of Marine Affairs, gives us a primer on the complex subject of ocean conditions and their predictability.

INTRODUCTION

Humans have accurately predicted seasonal climate changes for thousands of years. This has been possible because we have learned that there are strong and highly predictable seasonal climate rhythms. In locations with strong seasonal climate changes, each year essentially looks the same: temperatures reach their annual peak in summer and their annual low in winter. Likewise, river runoff, ocean currents, surface winds, upper ocean temperatures, and even phytoplankton production also typically exhibit strong seasonal rhythms. Yet it is also common knowledge that no two years are exactly alike. In some cases year-to-year variations on the seasonal rhythms of climate are quite large, though rarely as large as the typical seasonal changes.

When poor ocean conditions are blamed for causing problems for salmon or steelhead, the target of that blame is rarely the strong and predictable seasonal climate change, but instead it is focused on the unexpected variations superimposed on the regular seasonal rhythms. Societies have invested large efforts at predicting this type of climate variation, with a special focus on predicting season-to-season and year-to-year climate changes.

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How Many Fish Can the Ocean Hold?

by William Pearcy

— Oregon State University —

It was long assumed that the ocean was so vast that the concept of carrying capacity simply was not a factor in steelhead and salmon management. More recently, studies have confirmed that there is indeed a carrying capacity for salmonids and its impacts can be profound. William Pearcy, Emeritus professor in the College of Oceanic and Atmospheric Sciences, Oregon State University addresses, three main questions: (1) What is the evidence for interaction among salmonids and the ocean's limited carrying capacity? (2) What is the effect of salmon hatcheries? And (3) How do limited carrying capacity, numbers of hatchery fish, and ocean and climatic conditions interact?

SALMONID INTERACTION AND CARRYING CAPACITY

What is carrying capacity? It has been defined as a biomass or weight of a population that can be supported by the ecosystem. Populations can increase only until they reach an upper limit. If the carry-

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FROM THE PERCH — EDITOR'S MESSAGE

Ocean Lovers Special

by Jim Yuskavitch

It's mid-September as I write this, occasionally looking up to gaze out the hotel room window overlooking the ocean on the central Oregon coast. Living in the state's interior, my wife and I only occasionally find the time to make the long drive here. So the chance to spend a few days by the sea is a semi-rare treat for us. Perhaps that's just as well. It makes me appreciate it more.

It's a bit too early for the winter steelhead run; they won't be showing up for another couple of months. The sea-run cutts are still in the estuaries, but the fall chinook salmon are in. You can tell how far upriver they are now by the flotilla of small boats, concentrated in tidewater, pulling spoons and spinners in their wake.

We've heard a lot about salmon, steelhead and oceans lately, mostly in reference to "ocean conditions" and how they effect adult returns. We've had some poor run years and been told that "poor" ocean conditions were largely responsible. Now we're experiencing some strong runs, and "good" ocean conditions cited as the reason. Some say that ocean conditions are the only important factor ruling salmonid numbers.

What to make of it? How do ocean conditions play into our fish management scheme? We can't control them, but can we predict them? How many fish can the ocean hold during "good" years and how many during "bad?" And if we can learn the answers to those questions, will we become better stewards of our wild salmonids?

In this issue, two experts — Nate Mantua of the University of Washington and Oregon State University's Bill Pearcy — answer those questions for us.

But for all the good that will surely come from studying oceans and salmon, there is danger as well. Says Pearcy: "Most salmon biologists assumed the ocean had unlimited carrying capacity. Now the pendulum has swung the other way — too many assume that the oceans are the only important factor in determining run sizes, neglecting the importance of freshwater conditions for naturally spawning and rearing fish."

Anadromy is a two-way street.

Letters To The Editor

Dear Editor:

I found Gary Romanic's letter in your Issue 42 both offensive and uninformed. Romanic points the finger at the wrong folks. I have traveled extensively throughout the world from Tierra del Fuego to Kola; Somalia to Siberia and many stops along the way. Most of the best, natural places left on earth are in these far away lands surrounded by the billions of brown people that Gary identifies as the problem.

The reason that so few of the world's best remaining places are found in North America is precisely because our "white, middle-class taxpaying males" wrecked the continent in about two human lifetimes — a record of profligacy unmatched in human history.

The last people who are likely to save our environment are these very same white, middle-class taxpaying males who ruined the neighborhood to start with. Consider what they've done, without any help from the unwashed, brown billions living elsewhere:

They've chopped down the forests from Maine to Alaska;

They've shot all the buffalo;

They've dammed virtually every salmon-bearing river and rivulet from the Skagit to Los Angeles and Maine to Maryland;

They've over-harvested salmon runs everywhere;

They've killed every fish they ever caught;

They've built industrial hatcheries; They've turned over the grass to grow corn;

They've watered the western deserts with salmon and drained the Everglades; They've exterminated most of the Indians;

And of course they've cashed every government wheat/farm subsidy check ever cut.

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THE OSPREY

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CHAIR'S CORNER

Potpourri of Persistence

by Bill Redman
— Steelhead Committee —

If there is an overriding theme to the various topics of this column, it is the continuing mix of hope and discouragement as we engage in the war for long term survival of wild steelhead and salmon. Sometimes it seems as if most of the victories are temporary and the defeats permanent. We are regularly reminded that extinction is forever. The only constructive response is to persist.

NMFS HATCHERY POLICY

Let's begin by acknowledging that I might have been partially wrong when I wrote in the last issue of The Osprey that the National Marine Fisheries Service appeared to be setting its agenda to delist many of the 26 Evolutionary Significant Units (ESU's) of steelhead and salmon listed as Endangered or Threatened under the Endangered Species Act (ESA). According to my logic, NMFS would use the court decision on Oregon coastal coho to claim that wild and hatchery fish are essentially identical, and, therefore, the presence of significant numbers of hatchery fish would remove the need to give the wild fish ESA protection.

A first look at the preliminary draft hatchery policy released to states and tribes in late July suggests that NMFS is trying to walk a fine line, with good and bad news for the future.

On the negative side, it states that hatchery fish will be considered part of the ESU if they are representative of the evolutionary lineage of the wild fish in the ESU and have not diverged appreciably. This would appear to set up the ESA listing process for abundant confusion, obfuscation, conflict and delays. We still favor the listing of wild fish only, as called for in the petition by the Oregon Council of FFF and other organizations. It is cleaner and much less confusing than including some hatchery fish, and adheres much more closely to the science, which says the genetic and life history diversity provided only by wild stocks is essential to the future of the runs.

On the positive side, the draft policy states that listings should be based on a wild stock's ability to sustain itself and that wild and hatchery fish in the same listed ESU will not necessarily receive equal ESA protection. NMFS also stated that it would consider the petition to list only wild fish and announced its intention to evaluate the impacts of hatchery operations on wild stocks on a case-by-case basis. While these are hopeful signs, they leave too many questions to be answered down the line.

After the state and tribal comments are considered, the policy will be subject to a critical public review process, likely some time this fall. We urge those who care about these fish to take the opportunity to testify during this process.

We are regularly reminded that extinction is forever. The only constructive response is to persist.

Two additional reminders of the problems with hatcheries made news in the last few months. First, about 200,000 summer run steelhead at the Bonneville Hatchery were euthanized due to the presence of an incurable virus. This is the same virus and same hatchery that required the same fate for sockeye salmon earlier this summer. Bad things happen at hatcheries that can wipe out an entire year class.

Second, The Native Fish Society and Washington Trout, two of the really good fish protection organizations, served notice of their intent to sue the Washington Department of Fish & Wildlife on grounds that the 18 WDFW Puget Sound chinook salmon hatcheries are killing ESA listed wild Puget Sound chinook salmon.

DAMS

No aspect of salmon recovery illustrates the ebb and flow of the battle more than dams and their removal. Three cases illustrate the frustrations and occasional breakthroughs.

First, there has been considerable discussion but not much science about delayed mortality of Columbia system steelhead and salmon caused by passage downstream through the dams. An article in the April 2002 issue of the *North American Journal of Fisheries Management* has provided a causal relationship between downstream passage and delayed mortality. This new study weakens the case for the NMFS Columbia/Snake recovery plan, which does not take significant steps to address mainstem passage.

Second, it sounded like the deal had been struck and Condit Dam on the White Salmon River in Washington would be removed. PacifiCorp, the dam's owner, found that it could not financially justify the cost of adding the fish passage required by FERC and agreed to remove the dam. FERC concurred. Now Skamania and Klictitat counties, where the dam is located, are threatening to sue the Washington Department of Ecology if it approves the PacifiCorp request to remove. Our guess is that the dam will eventually come down, but possibly later that the original planned date.

Third, even the Corps of Engineers agreed with NMFS and Oregon Governor John Kitzhaber that the partially completed Elk Creek Dam on the Rogue River was unnecessary and a financial loser. Nevertheless, U.S. Representative Greg Walden of Oregon added a rider to a House Energy and Water Development Report that would prohibit use of federal funds to breach the dam for fish passage. Why?

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GOVERNMENT AGENCIES AND CITIZEN LEGAL ACTION

The common thread in the following examples is that, properly applied, the law and the courts can be friends of the fish.

1. Klamath water flows: Three federal agencies, the National Marine Fisheries Service, the U.S. Fish & Wildlife Service and the Bureau of Reclamation, have locked horns on Klamath River water flows, with the BOR ordering cuts in flows in defiance of the Biological Opinions by NMFS for protection of listed coho and by USFWS for listed suckers. Unfortunately BOR controls dam operations and appears unlikely to budge. Legal action by citizen's groups has been initiated to force BOR to increase flows and follow the recovery plans of the other two agencies.

Healthy Pacific Northwest forests are critical factors for sustaining our wild salmonid populations. Photo by Jim Yuskavitch

2. Economic benefits of unlogged forests: Five conservation organizations have filed suit against the U.S. Forest Service for failure to include the economic benefits of unlogged forests in the cost/benefit analysis done for proposed timber sales on Forest Service land. To leave out the economic value of unlogged forests to fish and wildlife populations, water quality and recreation can only be described as a gross error of omission.

3. Pesticide impacts: In July, a U.S. District Court in Seattle ordered the Environmental Protection Agency to consult with NMFS on the potential for damage to ESA listed steelhead and salmon runs caused by 55 pesticides. Again, this would not have happened without the legal intervention of citizen's groups (see story this page).

The courts are a last resort venue, but on protection and recovery of these treasured resources, that's where we increasingly find ourselves, most often when federal and other government agencies fail to obey the law.

GLOBAL WARMING

Until now The Osprey has remained silent on the subject of global warming. Now the U.S. government's "Climate Action Report 2002" to the United Nations has acknowledged that global warming is real and that the results are likely to include "rising sea levels and higher temperatures" which are, in turn, "likely to cause fisheries to relocate and alter fish migration patterns." Given this outlook, the Administration seems to be adopting an attitude of inevitability, rather than taking steps to alter the trend. To finally acknowledge the problem and at the same time recommend a do nothing response seems, at least, peculiar in the extreme and, at most, totally irresponsible.

The probability is increasing that the southern range limit of Pacific searun salmonids will move inexorably northward through the coming century.

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The Washington Fly Fishing Club Foundation has committed a matching grant contribution equal to the total of new contributions made to *The Osprey* during the one year period beginning April 1, 2002, up to a maximum of $2,000. If you have not contributed to The Osprey previously, your contribution will be doubly effective, and the fish will thank you.

See The Osprey subscription coupon on page 19.

EPA Ordered to Protect Salmon from Pesticides

In the May 2002 issue of The Osprey, Pollyanna Lind of the Northwest Coalition for Alternatives to Pesticides, contributed an article detailing the threats pesticides pose to salmon and steelhead and filled us in on a then-ongoing lawsuit to provide fish greater protection from these chemicals. This summer, the courts ordered the Environmental Protection agency to do just that.

On July 2, 2002, the U.S. Federal District Court in Seattle ordered the U.S. Environmental Protection Agency (EPA) to take action to protect Pacific salmon from pesticides. The court found the EPA has a legal obligation under the Endangered Species Act to review the impacts of pesticide use and curtail uses that are harmful to salmon.

Earthjustice attorney Patti Goldman represented environmental and commercial fishing organizations in the case. The court decision, issued by Judge John Coughenour, called EPA's "wholesale noncompliance" with its Endangered Species Act obligations "patently unlawful."

Earthjustice represented the Northwest Coalition for Alternatives to Pesticides, Washington Toxics Coalition, and the commercial fishermen's organizations Pacific Coast Federation of Fishermen's Associations and Institute for Fisheries Resources.

EPA's own documents find that current uses for several dozen pesticides are likely to result in surface water contamination levels that threaten fish or their habitat. Additionally, water monitoring by the US Geological Survey detected 14 pesticides in salmon watersheds at concentrations at or above levels set to protect fish and other aquatic life.

Combined, the EPA's findings and the U.S. Geological Survey detections identified 55 pesticides that pose documented threats to salmon.

The court's decision is available at http://www.earthjustice.org The background factsheet on salmon & pesticides and the court ruling is available at: http://www.pesticide.org/News.html

Ocean Conditions, Continued from page 1

Much of the climate prediction effort has been motivated by the promise of societal benefits via an improved forewarning of droughts, floods, or climate-related changes in natural resources like salmonids or other valuable fish stocks. The idea here is simple: Better predictions of future climate should lead to better stewardship of limited resources. This notion fits very well with annual activities commonly found in fishery management agencies. Pre-season run-size forecasts, usually based on the number of parent spawners, hatchery smolts released, and/or cohort returns, are issued prior to harvest seasons in order to set harvest rates and determine allocations.

Errors in pre-season run-size forecasts have been partially attributed to climate and habitat changes, for instance varying ocean conditions and ocean carrying capacity like that described by Bill Pearcy in this issue of The Osprey. Thus, better climate predictions offer the promise of reducing some of the preseason run-size forecast errors, at least in cases where the link between climate, environment, and fishery productivity have been quantified.

ENVIRONMENTAL PREDICTION

The state-of-the-art skill in the science of climate prediction rests largely on a demonstrated ability to monitor and predict the status of the tropical El Niño-Southern Oscillation (hereafter simply El Niño). For lead times of one to a few seasons into the future, skill in predicting El Niño has been demonstrated for nearly a decade, with a few notable successes and a few equally notable failures in that period. Once an El Niño forecast is made, predictions for climate conditions outside the tropics can easily be made. Such climate predictions are now routinely generated from a variety of sources, ranging from past climate data to the outputs generated with sophisticated computer models.

Humans have been able to accurately predict seasonal weather changes because there are strong seasonal climate rhythms. Yet, year-to-year weather conditions can be quite different.
Photo by Jim Yuskavitch

In the early stages of the 1997-98 El Niño – as early as June 1997 – both approaches were used to make remarkably accurate forecasts for the 1998 winter and spring climate of North America.

In contrast to the relatively skillful short-term climate predictions described above, western science has demonstrated no skill in climate predictions at lead times longer than one year into the future. In spite of this situation, skillful predictions at lead times from a few years to a few decades into the future may be possible if scientists decipher the now mysterious processes that give rise to multi-year climate variations. If this happens, appropriate monitoring systems can be designed and deployed, and the necessary computer simulation models can be developed.

Climate forecasts are probabilistic in nature, and deterministic climate predictions are simply not believed to be possible by western climate scientists.

To the best of our current knowledge, future climate is subject to highly unpredictable changes because random events that we simply cannot foresee may alter future climate. Thus, climate forecasts are always presented as changes in the odds for certain events, making climate forecasting akin to riverboat gambling. Playing roulette, success comes with correctly guessing "red" or "black" more often than not. Like playing the colors on a roulette wheel, the science of climate forecasting uses an approach that assigns odds for relatively crude outcomes like "above average temperature" or "near normal precipitation". If you ever see a climate

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forecast for the exact amount of snowfall for your favorite ski resort, you should be certain that it came from someone not schooled in modern scientific approaches.

Overall ocean conditions are the result of random combinations of independent climatic processes. Knowing what the ocean temperature is this winter gives scientists no clues to what those temperatures will be next winter. Photo by Jim Yuskavitch

CLIMATE AND SALMONIDS

Because of the never ending pressures of natural selection, fish and other living creatures have evolved behaviors that allow them to "fit" into their seasonally changing habitats. For northwest salmon and steelhead, aspects of this evolved behavior include the distinct seasonal runs of various stocks of the same and different species. Thus, the strong seasonal rhythms in the life history of salmonids can more likely be explained as a consequence of evolution in an environment with strong seasonal rhythms than as a result of "climate prediction" by fish.

A recent study we took part in (Logerwell et al., currently in press) has helped us infer a few things about the predictability of climate variations thought to be important for "ocean conditions" for Oregon hatchery coho salmon. Oregon hatchery coho have a relatively simple life history, at least in comparison to other species and stocks of Pacific salmon. In the Pacific Northwest most hatchery coho adults spawn during fall or early winter months. After incubation, the eggs hatch into fry that develop as freshwater fish for the next year or so. During their second spring, hatchery juveniles undergo the smolting process. Typically, hatchery coho spend about 18 months at sea before returning to their natal rivers and/or hatcheries to spawn as mature 3 year olds.

There is abundant evidence that Pacific salmon, both of hatchery and natural origins, experience large year-to-year changes in productivity. A 30 year database for Oregon hatchery coho shows that smolt-to-adult survival rates in the period from 1969-1976 ranged from 3% to 12%, while in the period from 1991-1998 those rates were consistently below 1% (see Figure 1). In periods like 1969-1977 and 1984-1991 the year-to-year changes were quite large compared to the averages for those periods. The extremely low return rates in the 1990's indicated in Figure 1 were also observed for many other stocks of wild and hatchery salmonids in the northwest, suggesting a regionally important role for poor ocean conditions during this dismal production period.

Numerous studies have highlighted important associations between variations in climate, the ocean environment, and Oregon hatchery coho smolt-to-adult survival rates. In the Logerwell study, the results of many earlier studies were synthesized. This synthesis led to the development of a relatively simple model for explaining past changes in smolt-to-adult survival rates with physical environmental data. The model is based on four environmental indices: 1) the coastal ocean temperature in the winter prior to smolt migration; 2) the date of the so-called Spring Transition, the date at which upwelling favorable winds are initiated; 3) the amount of upwelling wind for the smolts' first spring at sea; and 4) the coastal ocean temperature during the maturing coho's first winter at sea. Each of the four environmental indices is believed to capture different influences on the quality of the near-surface coastal ocean habitat where juvenile and maturing coho are found. An important finding in this work is that the four different environmental indices are essentially uncorrelated with one another. Yet, considering these four environmental indices in sequence yields an environmental explanation for most of the ups-and-downs in Oregon hatchery coho smolt-to-adult survival rates for the past three decades.

This simple model was developed using data from 1969-1998. We have since made "nowcasts" using observed environmental data to estimate smolt-to-adult coho survival for smolts entering the ocean in 1999, 2000, and 2001 (see the *'s in Figure 1). Based on our simple model, coastal ocean conditions were much improved for Oregon coho smolts in 1999, 2000, and 2001.

Compared to conditions in 1991-1998, this improvement in ocean habitat is related to significantly cooler wintertime coastal ocean temperatures, an earlier onset of springtime upwelling winds, and more upwelling wind in the months of April, May and June.

We interpret the results of this modeling work as evidence that the

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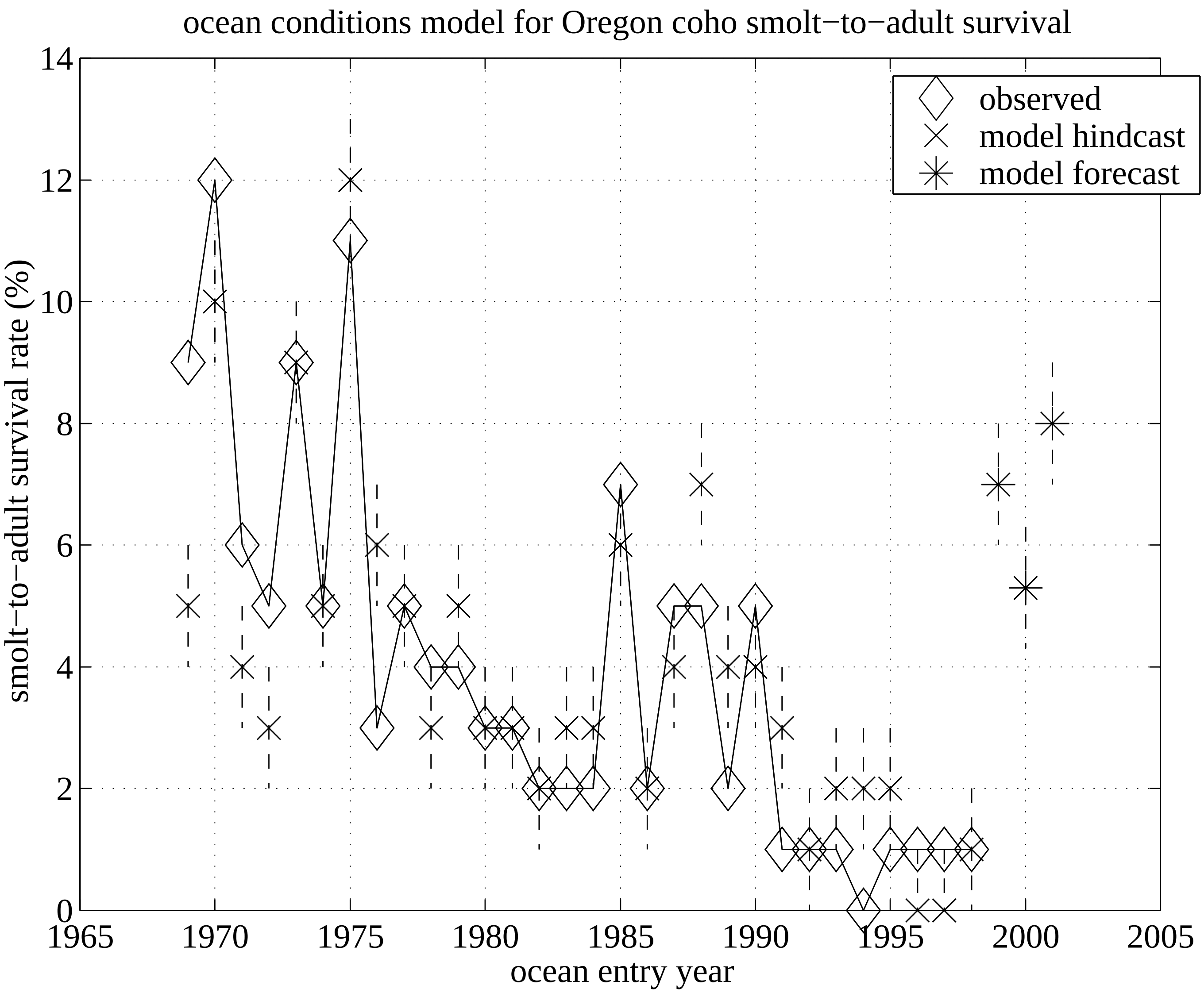
Figure 1



Comparison of modeled and observed Oregon Production Index coho smolt-to-adult survival. This simple environmental model uses observed relationships between smolt-to-adult survival and coastal ocean temperatures, coastal sea level, and winds from 1969-1998 to translate subsequent environmental conditions into smolt-to-adult survival rate estimates. Estimates for ocean entry years 1999, 2000, and 2001 indicate improved ocean conditions over those observed between 1989 and 1998. See Logerwell et al. for more details.

ocean conditions important for Oregon coho are the net result of random combinations of mostly independent climatic processes. That means that knowing the ocean temperature this winter provides no clues about how early, how strong or how often the springtime upwelling winds will blow, nor will it provide much help in predicting ocean temperatures in the subsequent winter. If this is an accurate assessment, and we believe it is, predictability for ocean conditions important for Oregon coho must be limited to the highly predictable seasonal cycle. It also suggests that Oregon coho face a high degree of environmental uncertainty every year, at least in terms of ocean conditions (but surely also in terms of stream and estuary conditions).

LIFE WITH ENVIRONMENTAL UNCERTAINTY

Is it remarkable that Oregon coho, and other salmonids, have sustained themselves in the face of past climate and environmental uncertainty? The successful species must have individual members behaving in ways that insulate

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the population as a whole from undesirable environmental impacts. Many scientists have postulated that a diversity of behaviors and environmental sensitivities serve as evolutionary responses to successful adaptation in uncertain environments. At the metapopulation level, each species of Pacific salmon exhibits many such risk-spreading behaviors via a broad diversity of time-space habitat use by different stocks and substocks of the same species. Jim Lichatowich put it this way: "Life history diversity is the salmon's response to the old adage of not putting all one's eggs in the same basket."

Empirical evidence for diverse life history behaviors and habitat use by salmonids, and their close relationship to the physical environment, are found nearly everywhere researchers have looked. For instance, according to Jeffrey Haymes of the Washington Department of Fish and Wildlife, studies of natural coho smolt production in western Washington yield evidence for a wide variety of flow sensitivities in nearby watersheds. In some systems, coho smolt production is limited by high winter flows that scour nests and damage incubating eggs; in other streams the main limiting factor is low summer flows that reduce rearing habitat; while in still other streams it is high fall flows that allows spawners to access otherwise unreachable tributary spawning beds. The bottom line here is that the complex landscape and variety of watersheds in western Washington provide a diversity of habitats with different environmental sensitivities.

We know enough about fish ecology to provide a laundry list of needs for policymakers to develop effective action plans to save threatened fish populations.

Because coho salmon occupy each of the different habitats, the species as a whole carries a diverse portfolio of climate and environmental sensitivity, what we like to think of as an evolved expression of natural climate insurance.

CONSIDERATIONS FOR FISHERY MANAGEMENT

How might an explicit consideration of climate and environmental uncertainty aid salmon and steelhead management efforts? Before offering specific remedies, we first review what we believe are key characteristics of approaches for saving threatened fish populations and saving fisheries.

It seems to us that people now know enough about fish ecology to provide a laundry list of needs for policy makers to develop effective action plans to save threatened fish populations (see Table 1). Step one is to recognize that saving fish is a matter of ecology. For saving sought-after species like salmon and steelhead, key pieces of a restoration plan include the following: restricting harvests so adequate numbers of adults can spawn; restoring diversity by reforming and/or closing hatcheries, and reconnecting fish production to habitat; restoring and protecting habitat, and where necessary, removing barriers to fish passage; finally, accepting variability, environmental uncertainty, and acknowledging a lack of predictability.

In contrast, present day efforts to sustain fisheries are clearly a matter of politics, economics, law, and ecology. As fish numbers have declined, a combination of scientific, political and socio-economic pressures have led to a slow withering of harvest opportunities and seasons that are ratcheted down to smaller and smaller windows of time.

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TABLE 1:
Key characteristics of present day efforts to save fish and save fisheries.

Saving Fish A Matter of Ecology	Saving Fisheries A Matter of Politics, Economics, Law and Ecology
❒ Restrict or eliminate harvests ❒ Restore diversity ◆ major hatchery reform, even closures if needed ◆ reconnect production to habitat ❒ Restore and protect habitat ◆ remove barriers to fish passage ❒ Accept variability ◆ acknowledge a lack of predictability	❒ Shrink seasons and harvests ❒ Focus on biomass/numbers ❒ Tweak the status quo ◆ Fish passage, hatcheries ❒ Eliminate variability ◆ Use hatcheries, divorce fish production from habitat ◆ Emphasize deterministic prediction

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Policies have generally focused on single-species biomass or numbers of fish, rather than considering the ecosystems that the target fish populations are part of. For salmon restoration, efforts have concentrated on tweaking the status quo, and this has been especially true with efforts to improve fish passage around dams and to reform hatcheries. Management agencies have attempted to reduce and/or eliminate variability by using salmon hatcheries to divorce fish production from habitat. Deterministic concepts like "maximum sustainable yield" have been used to set harvest goals, and there are few fishery managers who have not been pressured to develop better predictive models so harvests can be maximized while still offering protection for spawning stocks.

From this comparison, the main climate component of the conflict between saving fish and saving fisheries lies in the treatment of environmental variability, and it is in this realm where the potential for policy reform looks greatest. While socio-economic pressures produce political pressures to reduce variability and/or increase predictability so that resource use can be maximized, fish habitat and aquatic ecosystems contain fundamentally unpredictable dynamics. Climate enters this picture through its role in providing strong limitations on ecosystem predictability, a situation that is not likely to change in the future.

So, how might we better manage our fishery resources if changes in climate, ocean conditions, and salmon populations are so difficult to predict? It seems to us that a logical first step would be to deemphasize predictions. If predicting the future presents such a difficult challenge, it would be wise to distance management performance from predictions. Rather than focus on predictions, a more fail-safe approach would focus on monitoring. Simple environmental models like the one used to estimate coho smolt-to-adult survival provide a means for translating the products of environmental monitoring into an estimate for difficult to measure coho survival rates. An even better approach would rest on directly monitoring the target stocks, a daunting task, yet one that has received considerable attention in recent research projects along the Pacific coast. If social and political pressures demand preseason predictions, such monitoring-based "forecasts" should explicitly acknowledge the large uncertainties that exist.

Because changes in ocean conditions are so difficult to predict, one way to better manage our fishery resources is to rely less on predictions of future ocean conditions and expend more effort monitoring the health of fish populations. Photo by Jim Yuskavitch

Thus, when preseason run-size forecasts are made, stakeholders and managers should be presented with a range of possible populations to work with, along with some estimate for the odds of actually witnessing the high, low, and middle parts of the predicted range.

A second critical step is to do enough monitoring that changes in freshwater and marine productivity can be tracked and discriminated. Today, only a small number of streams are monitored for the full life-cycle of anadromous fish. Keeping track of adult spawners and estimating harvests allow for a gross estimate of productivity. A better understanding of changes in marine and freshwater productivity rests on the establishment of long-term, continuous records for the age-structure of spawners, parr and smolt production, in addition to the more commonly collected index counts used to estimate total spawners.

A final and critical step is to place a much higher priority on restoring the natural climate insurance that wild salmon and steelhead populations must have carried to survive and thrive in the face of past environmental changes. This insurance, we believe, is intimately associated with a diversity of life history behaviors, and a diversity of behaviors is directly linked to the availability of healthy, complex freshwater habitat. A diversity of freshwater habitat leads to a wide range of seasonal runoff patterns, as well as a wide range of short-term runoff responses to short term weather and geologic events. Such environmental variability effectively forces sub-stocks of the same species into different niches and different behaviors via the never-ending process of natural selection. If we are interested in purchasing climate insurance for our salmon and steelhead stocks so they can better cope with changing ocean conditions, we will likely get the best return on investments aimed at restoring the health and integrity of our beleaguered watersheds.

Ocean Carrying Capacity, Continued from page 1

ing capacity is exceeded, then individual growth or survival will reach a maximum and then decline, limited by production and availability of food, competition both within and among species, predation and/or disease. In other words, "bottom up" processes operating through food supply or/or "top down" processes operating through predation limit the population. Hence changes in growth and survival are influenced by the number of individuals in the population. This is called density dependence. It is important to realize that carrying capacity in the ocean is not static, but levels can change depending on many factors including ocean climate and productivity (see Figure 1).

Competition leading to density dependent responses of a population can be expressed within a single population of a species, among different populations of the same species originating from different regions, and among different species of salmonids and non-salmonids from the same or different regions that comingle in the ocean. And, of course, competition at sea may also occur between wild and hatchery salmonids.

Many scientific papers document the relationship between growth or size at a given age and the abundance of salmonids, indicating density-dependent growth within a population or species. When populations of Bristol Bay, Alaska sockeye salmon are high, for example, their growth rates at sea are lower, and they return at a smaller size or at an older age. The large increases in the numbers of chum salmon released from Japanese hatcheries were also accompanied by a decrease in the size of returning adults. Declines in the body size of sockeye, pink, chum, chinook and coho salmon have been well documented during the period of rapidly increasing catches in the North Pacific in the last 30 years.

Interactions among stocks of the same species from different regions may also show trends in growth that are inversely related to abundance. This has been shown for sockeye salmon from Alaskan and British Columbian streams. Randall Peterman, of Simon Fraser University, concluded that such interactions result in decreased body size and are caused by competition for food, a conclusion that is supported by the correlation he found between adult weight of Fraser River pink salmon and the ratio of pink salmon abundance to the zooplankton density in oceanic waters.

salmonids consume only a small fraction of the zooplankton directly or indirectly in the ocean, they are not the only fish in the sea. Other fishes such as Pacific pomfret have large populations and have similar diets. Large squids, carnivorous zooplankton, marine mammals, seabirds, and a large and diverse community of vertically migrating organisms utilize much of the ocean productivity. Therefore the potential exists for competitive interactions among many different species in the ocean.

How many salmon and steelhead can fit in the ocean? Competition among wild and hatchery fish affects spawning run numbers, biomass and interactions with a variety of ocean prey and predators. Photo by Jim Yuskavitch

Density–dependent growth is easy to comprehend, because individuals of the same size and species feed on similar prey organisms. In addition, competitive interactions occur among different species of salmon. This is not surprising since salmonids, including steelhead, feed opportunistically in the ocean and often prey on the same prey organisms. For example, squid are an important food for maturing salmon in the eastern North Pacific, as well as for other pelagic predators. Although

Recently, Greg Ruggerone and his colleagues at Natural Resource Consultants provided a good example of competition between species for limited resources in the ocean. The growth of North American sockeye during their second and third growing seasons at sea decreased significantly in odd years when Asian pink salmon were most abundant, again suggesting interspecies competition. When pink salmon are abundant, chum salmon shift their diet

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to less nutritious gelatinous zooplankton (jellyfish) and grow more slowly. According to the Alaska Fisheries Science Center's Kerim Aydin, a fascinating interactive triangle exists between zooplankton, squid and salmon. When pink salmon are abundant they compete among themselves for zooplankton food, reduce the zooplankton biomass, and grow slowly. But in years when pink salmon are less abundant they can grow more rapidly, attain a larger size and then are able to capture more elusive, nutritious squid, and grow rapidly. When salmon cannot feed on squid, the squid then become competitors with the salmon for the zooplankton and reduce the food supply even more (see Figure 2).

All of these studies are cogent evidence for density-dependent growth in the ocean for populations that intermingle in the ocean feeding grounds. Thus salmonids have pushed the upper limits of the ocean carrying capacity in the subarctic Pacific Ocean, at least for growth of salmon. However the total biomass of salmon remained at very high levels during this period of reduced growth in the 1980s and 1990s, and there was little evidence for density-dependent mortality. Apparently the survival of juvenile salmonids was high during early ocean life, and it is widely believed that adult population sizes are largely set by highly variable early ocean survival rates. In spite of favorable survival conditions maturing fish with their large energetic demands had difficulties obtaining enough food for high growth rates. When total production (growth summed over ocean life) declines, then we will know that carrying capacity has been exceeded as shown in Figure 1. Favorable ocean conditions for early ocean survival and reduced growth rates for maturing fish at the same time may be related to differences in their locations at different times during the life histories. Juveniles migrate out of estuaries and fiords into a coastal ocean that is usually very productive where density-dependence may be weak. In contrast, maturing salmonids, especially pinks, chum and sockeye, are distributed offshore in a different ocean environment where competition for more food may intensify.

Figure 1A

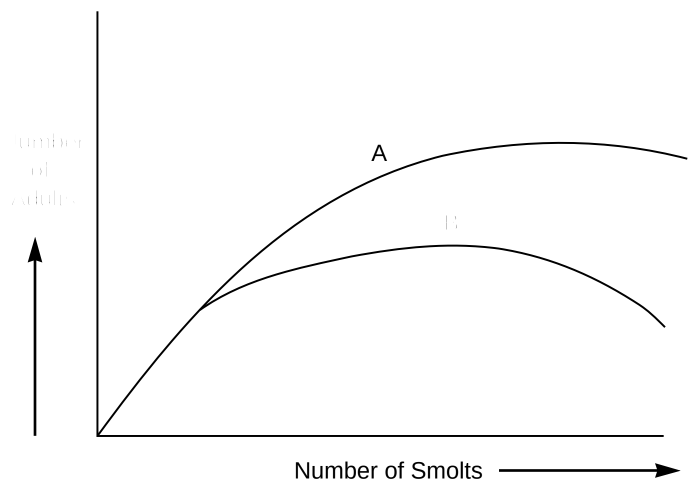

Figure 1B

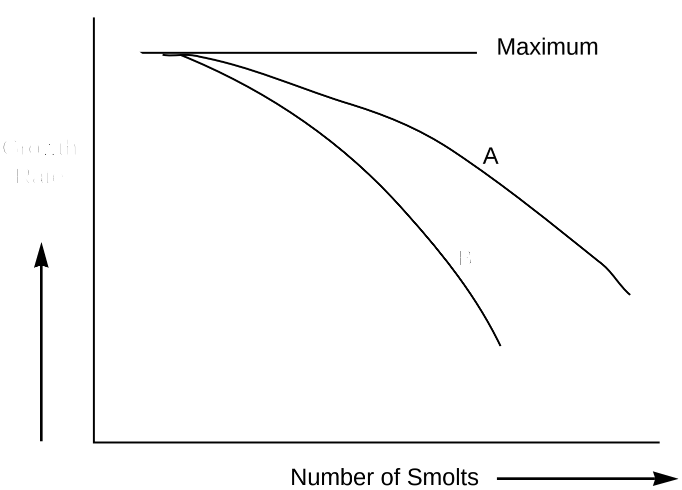

Figure 1A *shows the relationship between the number of smolts entering the ocean and their survival to adulthood. The A-line indicates good ocean conditions, while the B-line shows unfavorable ocean conditions.*

Figure 1B *illustrates the relationship between the number of smolts and their growth rate to maturity. The A-line indicates good ocean conditions, while the B-line shows unfavorable ocean conditions.*

Both figures show density-dependence as the number of smolts increases.

Although less evidence exists for density-dependent survival of salmon at sea, there are some convincing examples. Interaction occurs between out-migrating pink salmon in Alaska's Prince William Sound, zooplankton, and predatory fishes. When the spring bloom of zooplankton is large and prolonged, both juvenile pinks and their potential predators, pollock and herring, feed largely on the zooplankton. But when zooplankton become scarce, these predators switch from large copepods to other prey such as small pink salmon. Thus both bottom-up processes affecting the spring bloom and top-down processes that involve predation control survival of juvenile fish. Similar interactions may occur in the open ocean. Another example of important predator-prey interactions is provided by Ruggerone et al. They reported that Bristol Bay sockeye interacting with abundant pink salmon populations in the North Pacific had lower survival rates when pinks were abundant than when pinks were less common. Reduced growth of sockeye during years of high pink abundances may lead to increased predation rates and overall mortality for maturing, yet slow-growing, sockeye.

For coho salmon off Oregon, Tom Nickelson, with the Oregon Department of Fish and Wildlife, found evidence for declining smolt survival as populations increased, but only during low upwelling years, suggesting density-dependent mortality. He concluded that this was an artifact, attributed to the shift from mostly wild smolts with

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higher survival rates in early years to predominately hatchery smolts, which typically have lower survival rates in all years.

HATCHERY IMPACTS

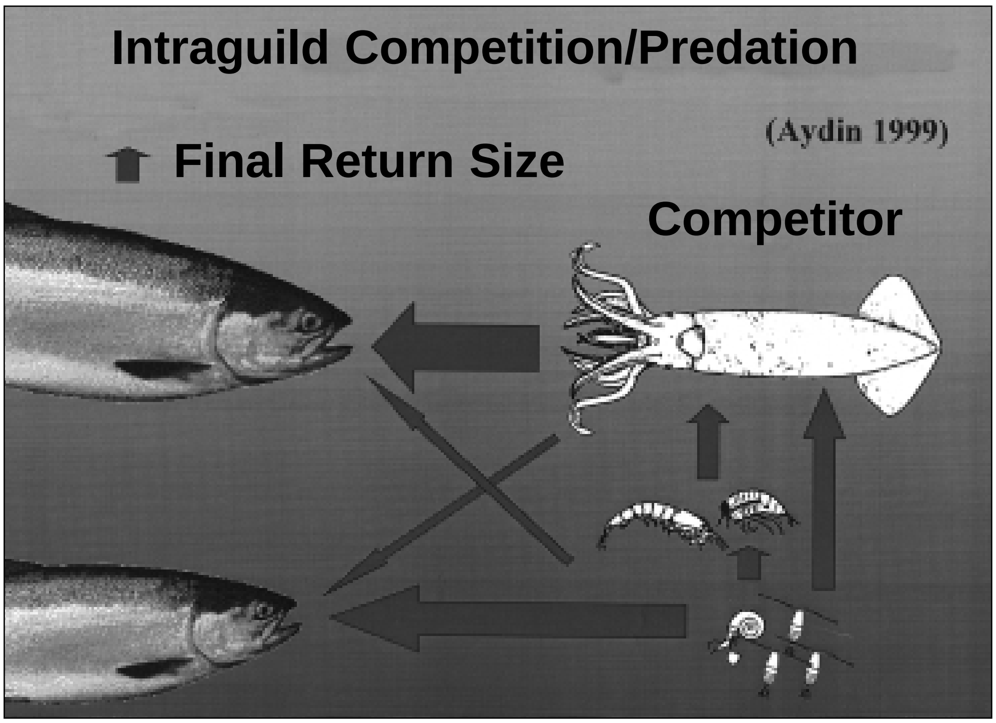
This leads us into the second major issue—do hatchery releases of salmonids affect overall survival? Phil Levin and colleagues at the Northwest Fisheries Science Center analyzed the marine survival of wild Snake River chinook salmon and found a strong negative relationship between their survival and the number of hatchery chinook salmon released, especially in years of poor ocean conditions. They concluded that hatchery fish may hinder the recovery of depleted wild populations.

These studies have strong implications for hatchery programs which initially assumed that the ocean had "surplus" or even unlimited ocean carrying capacity, and that there would be no reduction in the survival of hatchery or wild fish as the numbers released increased. About 5 billion hatchery fish are released into the ocean commons of the North Pacific Ocean each year. On average, they may comprise about 20% to 25% of the total numbers of salmonids, but in some regions of high hatchery production, hatchery fish may outnumber wild fish. Hatcheries account for over 50% of the salmon produced in the Pacific Northwest, and in some regions like Prince William Sound over 70%.

Trawl surveys in coastal waters of Oregon, Washington and British Columbia reveal that most juvenile salmonids collected in recent years have been of hatchery origin. Although hatchery releases contribute significantly to commercial and recreational catches, there is growing evidence that hatchery fish may interact and have a negative effect on the growth and survival of wild fish through ecological and genetic interactions and mixed-stock fisheries. In many Northwest watersheds hatchery fish have largely replaced wild steelhead, coho and chinook stocks during the past 50 years. Due to endangered species listings and concerns, this has led to severe restrictions on fisheries, both in the ocean and fresh water, to protect wild stocks. Nevertheless, many wild stocks are still not recovering.

All of these interactions among salmonids, hatchery and wild, are affected by changes in ocean productivity and carrying capacity. A much discussed example is the 1977 climatic regime shift that ushered in an era of consistently higher ocean temperatures to the Pacific coast of North America. At the same time, this regime shift brought cooler ocean temperatures and increased zooplankton production far offshore in the ocean pastures of the subarctic Pacific (see Osprey Issue 35 for more details). This regime shift was related to impressive increases in the survival of juvenile salmon from northern British Columbia and Alaska. Commercial salmon catches in Alaskan waters surged to record levels. But as we have seen, these large numbers of adult salmon led to density-dependent growth during maturing stages when food demands were large. However the opposite trend, with decreased productivity occurred in the California Current System off Washington, Oregon and California. In the California Current system, both coho and chinook catches off Oregon, Washington and British Columbia declined after the 1977 regime shift, especially during a period of extended El Niño like conditions from 1991 to 1998. These declines occurred despite large releases of hatchery smolts.

Figure 2



Abundance and size interact in the ocean to determine competition for food sources among different species of predators. For example, when pink salmon are less abundant, they grow large enough to feed on the elusive, but nutritious, squid. But in years when pinks are numerous, there is more competition for food and they grow more slowly. Because they are smaller, they cannot capture squid. The squid, then become competitors with salmon for zooplankton, further reducing food supplies.

CUMULATIVE IMPACTS

This brings us to a major conclusion: Although we cannot control shifts in ocean productivity, we can influence the releases of hatchery fish that interact with wild fish, especially during periods with unfavorable ocean conditions. What will be the result when the productive regime that produced banner catches of salmon in the Gulf of Alaska during the 1980s and 90s shifts

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to a less productive regime? This may have happened already. A new regime shift appears to have occurred in 1998. In recent years a drastic decline in catches of Bristol Bay sockeye has been seen, along with large runs of chinook

About five billion hatchery fish are released into the North Pacific Ocean commons every year. Photos by Jim Yuskavitch

and coho salmon in the Columbia River and many other northwest streams. If a new regime repeats the pre-1977 regime in Alaskan waters with lower productivity in the offshore waters of the subarctic Pacific, the carrying capacity for many stocks of Alaska salmon will slip to lower levels and higher mortality rates. This shift to lower ocean productivity may amplify competitive interactions between wild and hatchery fish. In contrast, direct and indirect evidence suggests that food-web productivity in the California Current System has been very high in the past five years (from the summer of 1998 to present), leading to a significant increase in the carrying capacity for the California-Oregon-Washington salmonids that reside in these waters. Presumably, the increased carrying capacity has reduced, or at least relaxed, competitive interactions between hatchery and wild stocks in these years.

Obviously, massive production of hatchery reared fish will not be necessary during a less productive regime in the subarctic Pacific. Therefore, managers need to cooperate, nationally and internationally, to reduce releases of hatchery fish if we are to conserve and recover our diverse wild stocks. Hatcheries should be viewed in the larger context of ocean productivity and consider the potential effects of competition among and within a species. The ocean carrying capacity is dynamic and directly affects salmonids. It varies depending on many factors such as El Niños, 20- to 30-year regime shifts, and even longer climatic fluctuations that have been documented during the past 2000 years.

In the near term, one thing that can be said with confidence is that future ocean conditions and the climatic forces that influence them are full of uncertainty. The recent changes to consistently cooler than average temperatures in the California Current System may indicate a 10-, 20-, or 30-year era of mostly favorable ocean conditions and high carrying capacity for Northwest salmonids, but only time will tell. Deeper into the future, the specter of increased global warming looms very large. The question facing fish interests today is: How we can improve the stewardship of our salmon and steelhead resources in the face of such large and unpredictable forces?

Letters, Continued from page 2

And, yes, this is the same constituency that votes overwhelmingly for the mindless politicians who claim global warming is a myth, who want to drill for oil in the ANWR to solve all our energy woes and who think that cutting farm/grazing subsidies will be the end of Western Civilization.

As if all that were not enough, these same good ol' boys, now as then, run all the agencies that manage fish, hydro, forests, mines, cows, and so on. If they could not manage a continent awash in fish and game, populated by a few million red and white people a few generations ago, by what logic can anyone conclude that they will lead us to the promised land now?

Meanwhile, the white, middle-class taxpaying males slurp their Bud Lites while sagely noting that the best government is no government, but Lordy don't forget to send that check.

Peter W. Soverel, Past Chairman
FFF Steelhead Committee
Edwards, Washington

Dear Editor:

The current, Number 42, issue of The Osprey is, as usual, just grand.

Lee Straight
Vancouver, British Columbia

Dear Editor:

You, your group (FFF Steelhead Committee) and The Osprey contributors are the true modern day conservationists, in my book.

John Scherner
Tigard, Oregon

Dear Editor:

I enjoyed the recent edition of The Osprey so much I wanted to double my support. Keep up the good work.

Paul Swacina
Corpus Christi, Texas

Terminal Gear and Steelhead Sport Fishery Management

by Robert Hooton

— British Columbia Ministry of Lands, Environment and Parks —

Bob Hooton has been in the British Columbia fishery management business since 1971, starting out as a habitat protection biologist and currently senior fisheries operations specialist with the British Columbia Ministry of Lands, Environment and Parks, dealing primarily with steelhead fisheries.

In the following article, Hooton summarizes some of the data currently available on steelhead mortality rates caused by different kinds of terminal gear. This article is adapted from a longer paper by Hooton entitled "Facts and Issues Associated with Restricting Terminal Gear Types in the Management of Sustainable Steelhead Sport Fisheries in British Columbia."

A life-long steelhead angler, Bob says he is "increasingly concerned about the fragility of the opportunities we often take for granted."

INTRODUCTION

In late 2000 a professional colleague advanced a regulation proposal that would eliminate the use of bait in Vancouver Island winter steelhead streams that had not already been closed to all fishing. It was a last ditch effort to conserve wild steelhead while maintaining fishing opportunity in the few remaining open streams where anglers had concentrated. Public consultation protocols were followed but, in retrospect, probably not as thoroughly as they might have been.

Imperfections of process resulted in a minor revolt fueled by a perceived lack of supporting technical evidence. To address public concerns on technical issues a background paper was prepared and distributed in April, 2001. That paper, "Facts and Issues Associated with Restricting Terminal Gear Types in the Management of Sustainable Steelhead Sport Fisheries in British Columbia," is too lengthy and detailed for reproduction in its entirety here. For that reason the following "executive summary" has been prepared for The Osprey. Copies of the original paper are available from the author on request (Bob.Hooton@gems1.gov.bc.ca).

DEFINING THE ISSUES

Virtually every time the subject of bait restrictions surfaces, the focus is on the mortality rate for that terminal gear relative to the two others commonly employed (artificial lures and flies). The overriding perception is the difference in mortality rates between different gear types is of no consequence in the larger picture of factors affecting fish abundance. What are neglected in the discussions are the efficiency of the different gear types and their frequency of use by anglers. One cannot dismiss differences in documented mortality rates between gear types as trivial or of no management significance if one gear is accounting for vastly more fish than another because fish are inherently more vulnerable to it and/or because more anglers use it. Additionally the impacts of catch and release, regardless of gear employed, may be cumulative.

Fish captured multiple times may experience sub-lethal effects that are virtually impossible to define definitively via empirical study. (Radio tags would be some investigators' choice, but the study methods are intrusive and certain to bias results). Angling methods that significantly influence multiple capture frequency could have a disproportionately large negative influence. Angler behavior can be an even greater factor. Lastly, there is commonly a mixed species or even mixed stock issue in many popular steelhead streams.

This Olympic Peninsula, Washington wild winter steelhead was released successfully. Not all are so lucky. Photo by Jim Yuskavitch

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DATA SOURCES (AND LIMITATIONS)

British Columbia

The best available sets of hooking mortality data for steelhead were collected during the 1980s on Vancouver Island. Those data have frequently been quoted out of context and misapplied in British Columbia and elsewhere. The two data sets, one related to wild steelhead angled for brood stock for a number of developing hatchery programs and the other specifically dealing with a steelhead hooking mortality investigation at the province's Keogh River research site near the northern tip of Vancouver Island, confirmed the initial mortality rates were relatively low (3.4% among 3,715 steelhead angled and retained for brood stock; 5.6% for similarly caught steelhead during the hooking mortality study). Largely ignored in subsequent interpretation and application of those results were the following:

1. The brood stock collection mortality figures were minimal because:

a. They included only fish retained and delivered to a holding facility, not fish that were occasionally released at the point of capture because they were bleeding from hook penetration and it was judged they stood a greater chance of survival in the wild than if handled and confined in artificial environments associated with transport and holding.

b. They did not include fish that died in holding more than 24 hours after being captured.

c. They did not include the occasional mortally hooked hatchery fish harvested (legally) by the brood stock collection crew.

d. The data fail to acknowledge the higher standard of fish handling exhibited by the trained fisheries professionals involved relative to that expected from "average" anglers.

2. The Keogh hooking mortality study data were misleading because:

a. The difference in catch per unit effort (CPUE or, in this case, the number of steelhead hooked and landed per hour of fishing time) between artificial lures and bait was so pronounced it was impossible to obtain required sample sized for artificial gear unless each angling data collection session commenced with that gear. Despite experiment participants starting with artificial lures and fishing the available holding water to the point of zero returns, bait still caught almost two times as many steelhead when employed immediately afterward.

b. The incidence of hooking in critical areas (base of tongue, esophagus, gills, etc.) was almost two times higher among bait caught fish than among those lure caught. The combination of higher CPUE and higher critical injury rate compounded the overall difference between the two gear types examined.

Baited hooks produced mortality rates that were three to nine times higher than artificial lures.

Other British Columbia data sets that were generally less rigorously collected revealed hooking mortality rates that ranged from 0.3% among 306 bait angled Coquihalla River (lower Fraser River tributary) summer steelhead brood stock to 8.7% among 69 bait caught summer steelhead in the Campbell River on Vancouver Island. Instructive among those and related data sets was the fact that the agency personnel involved used bait virtually exclusively because it was broadly accepted such terminal gear maximized catch efficiency.

All things considered, the most frequently cited British Columbia data on steelhead hooking mortality rate are negatively biased. From the perspective of assessing management options and in keeping with the precautionary principle, a better guideline would be to double the oft cited 3.5 % to 5.0% mortality rate associated with lures and baits. Only then should the influence of other important factors such as CPUE, proportion of anglers using different gears, multiple capture frequency, water temperature, handling effects, etc. be examined.

Elsewhere in North America

Data available from various hooking mortality studies involving a variety of species throughout North America offer instruction for local situations. The feature common to almost all the applicable hooking mortality investigations on salmonids is that the use of bait results in the highest incidence of hooks penetrating critical anatomical areas (e.g. gills, esophagus, heart). That result has been described for coho, chinook, Dolly Varden, Arctic char, summer and winter steelhead, resident rainbow trout, resident and anadromous cutthroat trout and landlocked Atlantic salmon. The higher the incidence of hooking in a critical area, the higher the mortality rate. Another consistent observation was that, when all three gear types (bait, artificial lure, fly) were examined, the mortality rate was highest with bait, followed by lures, followed by flies. Baited hooks produced mortality rates that were three to nine times higher than when artificial lures were used. Studies where flies were also examined were fewer in number (nonexistent for anadromous species) but consistently revealed the lowest mortality rates, because fly hooks normally penetrated only the periphery of the jaws or mouth.

SUB-LETHAL IMPACTS AND OTHER CONSIDERATIONS

Apart from direct mortality there are other factors worth considering in relation to angling impacts and the relationship of those impacts to terminal gear options. Sub-lethal consequences could include one or a combination of direct and indirect factors. Direct effects could include the impacts of angling related stress on spawner distribution and performance and/or cumulative effects arising from multiple captures of individual fish. The fish

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handling behavior of anglers cannot be overlooked. Indirect effects could manifest themselves as a result of water temperature, mixed stock/species fishery effects, and, possibly, through disease transmission. Any one or combination of these factors can be aggravated by terminal gear that increases the frequency of occurrence.

Sub-lethal issues are exceedingly difficult to deal with. We know from extensive reliance on angler caught brood stock for hatchery steelhead programs in British Columbia that the majority of fish captured (once) survive and produce viable gametes. What we struggle with is the explanation for the failures that occur not infrequently. Brood fish occasionally fail to ripen (both males and females), females sometimes produce lower quantities and quality of eggs than they should based on size and stock history, fertilized eggs from some female/male combinations produce high or complete mortality, etc. Also, in the wild it is not uncommon to observe angler tagged fish that have not exhibited the expected post release migration pattern or spawning distribution. It would be a stretch to relate any of these observations to terminal gear type but it is not unreasonable to assume angling was at least a partial factor. Any combination of events that increased the likelihood of more fish being caught would also increase the frequency of negative outcomes among spawners or their products. Similarly, if the impacts of angling are cumulative, the higher the proportion of the population that gets caught multiple times, the greater the consequences.

Two other factors that are clearly understood to influence salmonid health in angling situations are water temperature and air exposure. The most conclusive studies involve Atlantic salmon in eastern Canada, but the results are clearly applicable to our West Coast steelhead. Stress associated with angling can be significant (sometimes lethal) at water temperatures near the upper tolerance limit for the species.

This is not an issue in winter steelhead fisheries that occur when ambient temperature is relatively close to the preferred thermal regime for the species. However it is not unusual for water temperature to approach lethal limits in summer steelhead streams. Air exposure that occurs when angled fish are removed from the water for measurement and/or photo opportunities can result in mortality rates directly related to the time of air exposure (30 seconds has been shown to be excessive). Once again any combination of angling gear or practice that increases the frequency of encountering steelhead under circumstances of high water temperature or where fish are exposed to air for periods of more than a very few seconds warrants attention. Angler behavior is perhaps the most readily manageable issue. It is of no consequence what terminal gear was employed if a steelhead is handled inappropriately and/or removed from water for a significant period in a catch and release situation.

Fish pathologists in British Columbia have cautioned that there is disease transmission risk associated with the use of salmon/steelhead eggs as bait. Not all the "egg cure" methods employed by anglers and bait suppliers kill all significant pathogens. It is well understood the use of eggs from one species and watershed in other watersheds is virtually impossible to regulate and that movements can and do occur independent of the human animal. Suffice to say the disease transmission risk is not zero.

Fisheries that target steelhead often occur to the exclusion of consideration of non-target species. Two species that were once common in most southwestern BC steelhead waters are cutthroat trout and bull trout /Dolly Varden. Both species tend to be highly vulnerable to angling, especially when bait is employed. The current status of these co-habiting species ranges from threatened to extirpated, depending on the watercourse. How much of this is related to angling and terminal gear choice is obviously highly speculative, but the status of non-target species is no longer an issue to ignore. Similarly, wild steelhead may be at risk in situations where hatchery fish are numerically dominant and where angling pressure concentrates to take advantage of harvest opportunities. Sport fishers generally decry indiscriminate commercial net fisheries that operate in mixed stock/species situations. Is a hatchery/wild steelhead river any different?

TERMINAL GEAR IN PERSPECTIVE

One simple way of illustrating the magnitude of influence of different gear types is to develop a scenario that reflects reality on any number of streams in the populated areas of the steelhead range. Some assumptions are required. Consider a stream where there were 1000 steelhead present and equal numbers of bait, artificial lure and fly practitioners who were sufficiently skilled to catch all the steelhead once. Assume the mortality rate associated with the different gear types follows the applicable literature and experience reasonably closely (i.e. bait = 0.10%, artificial lure = 0.03%, fly = 0.01%). Further assume the CPUE for bait is three times that of lure and five times that of fly. Such circumstances would result in bait fishers catching 652 steelhead, lure fishers 217 and fly fishers 130. The mortality associated with the captures would be 65 for bait, 7 for lures and 1 for flies. In other words bait would account for more than 9 times as many mortalities as artificial lures and 65 times as many fish as flies. Any sub-lethal effects or cumulative influences of multiple captures could aggravate this picture.

Six and one half percent mortality at the population level may or may not be significant. History would suggest such a number is not likely to change anyone’s opinion or gear preference, especially when other competing fisheries or habitat issues dominate the scene. Few fishery managers of the day would pretend they have a recipe for consensus on gear regulations.

Vigilance with respect to conserving fish habitat quality and quantity is clearly the cornerstone of the future. If we do that job well there will be as many fish available for the next generation as there have been for us. However we also need to recognize and attend to business closer to home. The pressures brought to bear by an increasingly well equipped, knowledgeable, mobile and informed angling community will not diminish. The task for all of us is to bring those trends into balance with the status and vulnerability of our most valuable fish and fishing opportunities.

Managing Washington's Wild Steelhead By Closure

by Pete Soverel

— Steelhead Committee —

In this essay, Steelhead Committee member Pete Soverel critiques the Washington Department of Fish and Wildlife's practice of closing wild winter run steelhead waters to angling, and gives us some strategies on how to increase angling opportunity for wild fish while protecting the resource.

Wild steelhead populations are not what they used to be. Nor are there as many steelheaders. Of course, you might never have noticed the declines in anglers when fighting it out with the crowds in March and April on the Hoh, Bogachiel, Queets, Cowlitz, Kalama, and Wynoochee. What is going on—fewer steelheaders, more crowding?

The answer is simple enough. Washingtonians are now prohibited from fishing for wild, winter run steelhead. A brief review of the Washington fishing regulations reveals that only twenty five of the more than one hundred listed winter steelhead streams are open for angling (even catch-and-release) during the period when wild winter steelhead are present in significant numbers – roughly March 15-April 30). The reality is even more stark when you realize that of those twenty five, only nine are open throughout April which coincides with the height of the wild run in most rivers. All the rest (80-plus rivers) close on February 28, which means that they are effectively closed to angling for wild winter steelhead. Consequently, all the anglers who wish to fish for wild winter steelhead in Washington are, by regulation, confined to a handful of streams while hundreds of miles of steelhead water are devoid of anglers.

Not only are those miles devoid of anglers, increasingly they are without their natural constituency—anglers who fish them, love them and will work to protect them. The Washington Department of Fish and Wildlife (WDFW) has simply taken the easy path—closure. The Department has not petitioned for threatened or endangered status under either state or Federal statutes. It has not developed any plans or programs to recover the stocks and continues planting millions of hatchery smolts into the systems secure in the knowledge that this action in and of itself is harmful to wild stocks. The proverbial five-year old child can see that something is terribly wrong with this picture. Why can't the Department/Commission?

From where I sit, WDFW and the Washington Fish and Wildlife Commission need fresh approaches. I have three modest suggestions:

> *Miles of wild steelhead water are devoid of their natural constituency — anglers who love steelhead and work to protect them.*

1. Conduct a joint Washington-British Columbia study of Georgia Basin steelhead declines to determine what, exactly, is wrong.
2. Expand angling opportunity through gear/method restrictions on selected rivers so we can protect anglers, angling and wild steelhead.
3. Establish a Wild Steelhead Quality Angling demonstration project on several rivers. Let's try a different management model.

GEORGIA BASIN WINTER STEELHEAD STUDY PROJECT

Steelhead stocks throughout the Georgia Basin (Puget Sound, Hood Canal, Georgia Straits, east coast Vancouver Island, south and mid-British Columbia coast) are in steep decline for reasons we have neither identified nor understand. As recently as the mid-1990s many rivers in the Georgia Basin provided high quality angling for wild, winter-run steelhead. Over the past several years, virtually all these stocks have collapsed. Runs that consisted of hundreds of individual fish now are comprised of a dozen or so and these few fish produce fewer adults than spawners. It's a recipe for extinctions.

The dramatic decline of Georgia Basin winter steelhead stocks has coincided with strong returns to coastal Oregon, Olympic Peninsula, Snake River, upper Columbia, north British Columbia coast and the west coast of Vancouver Island, all of which point to excellent marine conditions. At the same time that Georgia Basin winter stocks have collapsed, wild summer-runs in the Basin (Skykomish River and Deer Creek, for example) have performed very well. The Deer Creek population has increased from 70 to 100 fish in 1990 to almost 1,000 now. Clearly, factors other than freshwater habit or high seas survival are affecting the survival of Georgia Basin stocks. Rather than simply closing the rivers to anglers and coasting along waiting to see if the situation turns around, I recommend that the Department take steps to determine, at the minimum, why the Puget Sound/Hood Canal stocks are in free fall. Better yet, it seems to me that this issue is ripe for a joint Canadian-American study involving WDFW, British Columbia Ministry of Environment, U.S. National Marine Fisheries Service and the Canadian Department of Fisheries and Oceans.

EXPAND ANGLING OPPORTUNITY

Angling closures should be the last step not the first. The Department has at its disposal a wide-range of gear/method restrictions that offer the Department effective tools to easily restore quality angling opportunity to a large number of waters that contain significant populations of wild steelhead without serious risk to those stocks.

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Catch and release angling, selective fishery regulations

The mortality associated with catch and release steelhead angling is low— certainly less than 4% with artificial lures and flies based upon long-term studies in BC. As the fish populations decline, so does the number of persons actually angling, which further reduces the exploitation rate and associated mortality. It is a natural phenomenon. If there are few fish, there will be few fishermen who will catch an even smaller percentage of the total. Consequently, given this natural relationship between numbers of fish and numbers of anglers, this management regime provides a low risk method to insure broad angling opportunity at minimum risk even to depressed populations.

Gear/Method Restrictions

From a management perspective, gear restrictions can be utilized to limit the "efficiency" of anglers including bait bans, no fishing out of boats, fly fishing only, and fly fishing with floating lines only. These efficiency regulations have nothing to do with elitism and everything to do with effectiveness. For example, a typical boat back trolling hotshots on the Sauk in April will hook 10 to 20 steelhead daily. Bank anglers will hook far fewer fish. If the bank anglers fly fish with floating fly lines and unweighted flies, they will catch very few steelhead indeed. With depressed runs, back trolling entails clear risks to wild winter-run steelhead while less effective methods reduce those risks *and* preserve angling opportunity as well as connectivity to the resource.

Limited entry fisheries based upon special tags and drawings

Limited entry is a well understood and widely utilized management technique to limit impact on the resource, increase quality and generate increased revenues.

The department might develop a set of guidelines for implementing various gear/method restrictions on several demonstration project rivers. The regulations should be related to the ratio of run size to escapement goal which, notionally, might look something like this:

1. Establish river by river wild steelhead escapement *requirements*, as distinct from escapement goals.

2. Assign each WDFW regional director with the responsibility for developing plans and programs to achieve escapement requirements while preserving angling opportunity including reducing hatchery plantings, gear/method restrictions, limitations on commercial harvest to reduce by-catch, stringent enforcement of hydrology codes/permits, and increased enforcement presence.

Based upon such an escapement driven management regime, the Department can then implement a tiered regulatory system linked to predicted run sizes. The greater the predicted run size, the less restrictive the regulations, including provisions for river specific harvest. For illustrative purposes, I recommend something along the following lines:

1. Allow harvest of fish above 150% of escapement requirement. No gear/method restrictions coupled with river specific harvest fishery. River specific, individual harvest tags. For example, sell the number of tags equal to the escapement surplus above 150% for the river in question on a first come, first served basis. Sell additional tags equal to the number of fish between 125% and 150% of escapement at a substantially higher price, perhaps on a limited entry draw basis. In all cases, these river specific harvest tags would be non-transferable. Since there are more wild deer than steelhead in Washington State, wild steelhead harvest tags should be at least as expensive as deer tags.
2. Allow harvest of fish between 125% and 150% of escapement: Selective fisheries and general catch and release fishery with limited harvest fishery (i.e. sell river specific tags equal to the escapement surplus between 125% and 150%). Depending upon demand, such tags might be controlled by a limited entry drawing.
3. Allow harvest of fish between 100% and 125% of escapement: Catch-and-release and various, river-specific gear method restrictions, such as selective fisheries and no fishing out of boats.
4. Allow harvest of fish between 80% and 100% of escapement: Utilize catch-and-release, fly fishing only and/or limited entry fishery.
5. Allow harvest of fish between 50% and 80% of escapement: Institute catch-and-release, fly fishing only and limited entry requirements.

These regulations are not some elitist ploy. They are sound regulations that conserve the resource, preserve angling opportunity and protect the local economy through implementation of tried and true practices that impose less efficient harvest methods to spread the resource among a larger user population. Many other jurisdictions employ gear/method restrictions including British Columbia, Quebec, Montana and New Brunswick.

Furthermore, the Department itself has long utilized this general concept to reduce the effectiveness of hunters while preserving hunting opportunity. The department offers long bow/muzzle-loading seasons to encourage hunters to adopt these less effective methods. These concepts should be applied to managing angling for wild steelhead. It is reasonable to conclude that anglers will adopt the less effective methods if they can fish for longer periods on more water.

Consider the consequences had WDFW used a regime along the lines outlined above instead of closing the Skagit. The Skagit (projected at 50% of escapement) would have remained open for catch-and-release fly fishing only with some daily limit on the number of anglers. Certainly, the exploitation rate would not exceed 10% to 15% with a resulting mortality of about 10 to 15 individual fish, all the while preserving angling opportunity and connections to the river and its fish, deterring poaching, not to mention local jobs.

Instead, the Department opted for a regulatory regime that is — on hard scrutiny — impossible to defend. . The only "conservation" action it proposes for the Skagit is to expand hatchery releases — a practice known to be harmful to wild steelhead. Why is the Department planting *any* steelhead in this system? At a minimum, it should select several rivers to study the response of wild stocks to discontinuation of stocking programs.

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In any case, even if the Department/Commission consider the suggestions above to be to radical, they have in place policies which have been utilized on the Skagit/Skykomish systems for managing the spring catch and release steelhead fisheries for about two decades. Specifically, those rivers are open to catch-and-release fishing during March and April under selective fisheries gear restrictions providing the predicted run is equal to or greater than 80% of the established spawning escapement. At a minimum, the Department should open all winter-run steelhead rivers closed under current regulations to catch and release angling under selective fisheries regulations subject to the 80% criterion. In and of themselves such regulations would substantially expand angling opportunity without any changes in current policy prescriptions.

WILD STEELHEAD QUALITY ANGLING DEMO PROJECT

Of course, each angler has his own set of criteria to determine the quality of his angling experience, numbers of fish caught, size, degree of difficulty, solitude, river size, and so on. Most jurisdictions recognize and protect high quality angling. Similarly, throughout the west, big game hunters may not hunt wherever and whenever they wish. They must choose a specific type of equipment, select a specific area to hunt and must choose a particular time to hunt for a specific species/animal type (elk, deer, doe only, five point or better and so on). Similar concepts are directly applicable to fisheries management and can be applied to improve angling quality. Further, just as hunters who wish to participate in the expanded seasons for less efficient methods must purchase said equipment, anglers would do likewise.

In Washington, we have used hatcheries widely and have generally equated angling quality with the quantity of harvest. Many anglers put other values ahead of harvest. The department should implement a demonstration project focused on high quality angling for wild steelhead. I envision several key elements of such a program:

1. Identify several demonstration rivers where wild populations are most likely to flourish and/or rebound. I recommend the Hoh, Skagit/Sauk and Klickitat rivers as representative of differing habitat types, health of native stocks and recovery potentials. These rivers are also geographically dispersed and thus will provide easy access for our citizens to take part in the quality angling demonstration project.
2. Stop planting hatchery steelhead and manage exclusively for wild production.
3. Implement a careful stock monitoring regime to measure how wild steelhead respond on the new management regimes.
4. Adopt gear specific regulations.
5. Sell quality angling licenses for these specific rivers. I recommend that the licenses be moderately priced—say $25/day, $150/season for residents; $50/day, $300/season for non-residents and guides with all the special license sales proceeds being returned to manage the quality angling demonstration rivers. Such a tiered licensing system would insure access by citizens of different financial means while generating substantial revenues to protect and manage these world-class steelhead fisheries.

I recognize that, at first blush, some of the foregoing may seem complicated. In real life, they are not really complicated, unfamiliar or unwieldy. Computer technology makes tracking of the various licenses, limited entry rules, river-specific harvest quotas and other factors. In fact, these management tools are widely used throughout the world to protect the resource and generate revenues to support conservation, preserve angling quality and opportunity for resident and non-resident anglers and business opportunity for commercial guides.

Various combinations of these tools can help encourage angling practices that cause the least mortality to the resource, expand angling opportunity, preserve quality angling (especially for residents) and generate substantial revenues, including river specific revenues, to conserve the resource and insure sustainable utilization.

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