THE OSPREY

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Hatchery Pink Salmon Hog North Pacific Salmon Habitat

ALSO IN THIS ISSUE:

SKAGIT RIVER STEELHEAD CATCH AND RELEASE • 2019 WORLD SALMON FORUM • ROGUE RIVER RESILIENCY BAD NEWS FOR BRITISH COLUMBIA STEELHEAD

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FROM THE PERCH — EDITOR'S MESSAGE

The Crowded Sea

by Jim Yuskavitch

Long-time readers of *The Osprey* know that we often publish articles about ocean conditions as they relate to Pacific salmon and steelhead, and particularly for our ongoing coverage of the impacts of climate change on the ocean environment, and what that might mean for wild fish.

We have another ocean cover article for this issue of *The Osprey*. But this time we are featuring something a little different. Scientist Greg Ruggerone has taken a look at how the release of huge numbers of hatchery pink salmon into the north Pacific Ocean to support the commercial salmon fishing industry is affecting the ocean food chain, and especially on how that impacts wild salmon and steelhead. It's an important, but under-reported story. Some of his findings are expected while others may surprise you.

When it comes to pink salmon, the numbers are impressive. In abundant years, pink salmon numbers may be as high as 650 million. While only 16 percent of those fish are hatchery origin (mostly from Alaska hatcheries in the north Pacific) they eclipse the combined number of Chinook and coho salmon, and steelhead. Pink salmon, believed to originate from Russian hatcheries are beginning to invade Atlantic waters of Norway, Scotland and Iceland.

Ruggerone and his colleagues have found distinct correlations between high abundance years of pink salmon with lower numbers of Chinook, coho and steelhead. In addition to the unsurprising findings that hatchery pink salmon do not survive as well in the as wild pinks and that, as when large numbers of hatchery salmon and steelhead are dumped into rivers and streams, they overwhelm the wild fish and compete with them for food resources.

More surprising is that they are abundant enough to not just compete with wild salmon and steelhead for food, but to cause a trophic cascade by eating large amounts of prey species such as small fish and squid to change food chain dynamics. This is not only impacting wild salmon and steelhead, but also seabirds, and possibly orcas by interfering with their hunting behavior.

Wild fish advocates have long known about the negative impacts of stocking hatchery fish into freshwater streams and are fighting to end or at least limit the practice.

Beneath the waves, the north Pacific Ocean is becoming increasingly crowded with hatchery origin salmon to the detriment of wild populations. Photo by Jim Yuskavitch

We also need to realize that many of the same negative effects of hatchery fish in freshwater are also playing out at sea, where it is more difficult to see, study and control. However, it is clearly another threat to the survival of wild Pacific salmon and steelhead that we need to ensure remains on our radar.

How The Osprey Helps Wild Fish

The Osprey has been bringing the latest science, policy, opinion and news stories to its readers supporting wild Pacific salmon and steelhead conservation and management for 31 years. But we are much more than a publication that you subscribe to because of your own interest in wild fish conservation. The funds we receive from our subscribers allows us send *The Osprey* to wild fish conservation decision-makers and influencers including scientists, fisheries managers, politicians and wild fish advocates.

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Jim Yuskavitch
Editor, The Osprey

Bad News for BC Steelhead

By Pete Soverel

As usual, the bad news for wild Pacific salmon and steelhead outweighs the good. As a consequence, large segments of the world's wild salmon continue their slide towards local extirpations including populations in Spain, France, the Low Countries, Sweden, Norway, United Kingdom, eastern Canada, the US West Coast and much of British Columbia.

On the plus side, Bruce and Jeanne McNae, of the World Salmon Forum (and a partner organization of *The Osprey*) hosted a conference pulling together salmon experts from around the world August 21 -23, 2019 in Seattle. The conference included informative presentations from panels of experts, moderated by leaders in the field of salmon sciences. The conferees concluded unanimously that with a few exceptions — Bristol Bay, Alaska, much of the Russian Far East/Kamchatka, Iceland and the Kola Peninsula — wild Pacific and Atlantic salmon as well as steelhead were at heightened risk of extinction with particular risk of local extirpations of unique and iconic stocks in British Columbia's Thompson River and the B-run steelhead of the Clearwater River in Idaho. The conferees' conclusions and recommendations will be made available to the public in the near future. (See the article on the World Salmon Forum in this issue of *The Osprey*.)

Northern California

Hit

With the heavy rains of last winter and spring, California salmon appear to be responding favorably. Ocean catches have improved dramatically but with a cautionary note: With the "deterioration of the "Blob", there is an area of unusually cool-to-cold water off the Northern California coast that may be concentrating salmon to give the appearance of increased abundance with higher catch rates. However, the higher catch rates may also be attributable to environment-driven increased density in the coldwater area rather than increased abundance. The strength of upcoming spawning runs will help illuminate this issue.

Skagit River Steelhead

Hits

Two years ago, the Washington Department of Fish and Wildlife (WDFW) and the local Native American tribes submitted a five-year fishing plan for National Oceanic and Atmospheric Administration (NOAA) approval that allocated a small harvest fishery to the tribes and provided for a catch-and-release recreational fishery from February 1 to April 30 with strict monitoring and reporting criteria. The parties conducted these fisheries in 2018 and 2019. (See the Skagit River article in this issue of *The Osprey*.)

> ***Thirty-five years ago, fishing dry flies, I encountered 12-15 steelhead per day on the Dean. Now, with sunk flies, I hooked three in eight days.***

Miss + Hit

Despite requests to NOAA, *The Osprey* has been unable to secure any information on the Skagit River tribal fisheries or the actual tribal reports submitted to NOAA. NOAA refers us to the tribes and the tribes refer us to NOAA. This hardly seems like a transparent process. WDFW, on the other hand, provides an exceptionally detailed report including daily tabulations of the number of anglers (boat and bank), total catch by species, coverage rate, and other data. This program is extremely popular with recreational anglers.

Miss + Hit

WDFW initially deleted the Skagit River monitoring budget for 2020, meaning there would be no recreational catch-and-release fishery. Confronted with the reality that the tribes would be fishing while the recreational anglers sat fuming on the bank, WDFW rejiggered their finances and it now appears that there will be money for monitoring allowing the catch-and-release fishery. This should not have been so difficult.

Miss

In 2007, the Washington Fish and Wildlife Commission directed WDFW to designate a suite of watersheds as wild steelhead management zones around the state. These systems were to be selected on the basis of the most robust and diverse wild steelhead populations in the various regions. Twelve years later this process has still not been fully implemented. WDFW sought public input more than two years ago for the Puget Sound region. Overwhelmingly, the public recommended, hands down, the Skagit and all its tributaries from the Seattle City Light mainstem dam to tidewater, as designation. The system has the largest wild and diverse steelhead population in Puget Sound (6,000-9,000); it is off limits to hatchery fish releases as a result of a court-approved settlement; and habitat is improving. Instead of designating the Skagit as a wild steelhead management zone, WDFW invented a new advisory group with the goal of avoiding such a designation. Two years later, neither the group nor WDFW have actually done anything. Note: the catch per unit of effort on the wild steelhead management zone Solduc River is 5 to 6 times higher than on the heavily stocked Bogachiel River. Is there a lesson here? It's that transparency thing again.

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Misses

Bristol Bay, Alaska

Once again, a massive, way-over-prediction, sockeye run of 56.5 million. Imagine developing an open pit mine in the headwaters of a system producing tens of millions of wild Pacific salmon annually!

Southeast Alaska

The Southeast Alaska Chinook salmon troll fishery continues to harvest everyone else's salmon. Single handedly, this fishery prevents any realistic hope of recovering Columbia River, Puget Sound or transboundary rivers Chinook runs or saving Puget Sound orcas from extinction. Only 1.7% (that's right, 1.7%) of the Chinook they catch are of Alaskan origin. All the rest belong to British Columbia, Washington, Oregon, or Idaho. How does this travesty persist?

Skeena River, BC

Steelhead returns this year are close to the lowest ever recorded. What's being done? Well, nothing.

Dean River, BC

I have fished the Dean River annually since 1987 with my partner Greg McDonald. This year, in spite of excellent water conditions, our catch rate (and that of everyone I have contacted — about 50 anglers) was the lowest ever. I hooked three fish in eight days. Let's put this in perspective: when Greg and I first fished there, using dry flies only, we each typically encountered 12-15 fish per day. Thirty-five years later, resorting to sunk flies, I hooked three in eight days — about 3% of previous times. This year's run certainly will not exceed 2,500 to 3,000 steelhead. Again, some perspective: in 1978 the Dean run was 28,000 (that's right, 28,000). Commercial by-catch, targeting Snootli Creek hatchery chum salmon syphoned off 80% of the run. So the current population of wild steelhead on a mostly uninhabited, wilderness river with improving habitat is about 10% of that of forty years ago. There is only one explanation — by-catch in fisheries targeting hatchery Chinook and chum salmon. Not only has the wild steelhead population been decimated by about 90%, all the local wild Chinook and chum populations have been equally devastated. Department of Fisheries and Oceans Canada's (DFO) response? They don't answer the mail.

This spring, a massive landslide at Big Bar on the Fraser River created a velocity barrier for migrating fish. Photo courtesy Province of British Columbia. Creative Commons Attribution-NonCommercial-NoDerivs 2.0 Generic License

Fraser River, BC

Late last spring there was a massive slide in the upper Fraser River upstream of Clinton, which created a velocity barrier for migrating salmon and steelhead. The agencies have tried a number of Rube Goldberg solutions including moving fish around the barrier at 50 fish per helicopter flight, with 4 million fish to be transported. As the river has finally started to drop this fall, it appears at least some fish can make it past the blockage.

Thompson River, BC

A similar situation arose at the fishway on lower Bonaparte River, which prevented Thompson River steelhead from ascending upstream. Both the BC Ministry of Environment & Climate Change Strategy and federal DFO were advised of the problem months in advance. But nothing was done, notwithstanding that Thompson River steelhead had declined to about 120 fish. Here it is worth noting that Canadian authorities refused to list Thompson/Chilcotin steelhead as a species at risk under Canada's Species at Risk Act. This was done to protect rapacious mixed stock sockeye and chum salmon fisheries from conservation restrictions. Note that the Fraser River sockeye season forecast that is used to set commercial seasons was 6 million. Actual run size was 600,000. How do you suppose the 600,000 fared under a fishery predicated on a run of 6 million? The level of incompetence and indifference to future generations is stunning.

If you aren't already discouraged, consider the logical consequences of hundreds of unregulated First Nations fisheries throughout BC. That's enough bad news to hold us till next year, and reason enough to redouble your commitment and support for wild fish advocacy groups.

Pete Soverel is Chair of The Osprey *Management and Editorial Committee and founder and President of The Conservation Angler.*

Pink Salmon: Overlord of the Pacific Ocean

By Gregory T. Ruggerone, Ph.D.

During 2005 to 2015, more Pacific salmon returned to rivers and hatcheries from the North Pacific Ocean than at any time since records have been kept (an average of more than 720 million salmon per year). In fact, abundance during this period was over one-third higher than in the 1930s — the previous period of high abundance (Fig. 1).

So, are these the "good old days" for Pacific salmon? Does the number of returns indicate a golden age for fishing? The answer to these questions is no. Historically high abundance of returns during this decade owes largely to the growing number of pink salmon, which represent some 65% of all Pacific salmon returning from the ocean.

Recently, my colleagues and I, while pursuing several lines of research, have found compelling evidence that the burgeoning runs of pink salmon have had significant negative impacts on other salmon species, seabirds, and even the critically endangered southern resident killer whale.

Pink salmon abundance in North America and Asia, estimated by adding the total catch and total spawning escapement, averaged approximately 500 million fish per year during 2005-2015 compared with 88 million sockeye salmon and 137 million chum salmon. In odd-numbered years, when pink salmon are most abundant, the average was 600 million fish. By comparison, the combined abundance of Chinook salmon, coho salmon and steelhead is less than 4% of that for pink, chum and sockeye salmon.

The geographic range of pink salmon is vast. They migrate thousands of kilometers at sea where they interact with both robust and depleted salmon populations originating from distant regions. Pinks have become so ubiquitous that they have recently invaded the waters of Norway, Scotland and Iceland, presumably originating from Russian hatcheries that stocked non-native pink salmon in the Barents Sea prior to the early 1990s.

Hatchery and Wild Salmon

Hatchery salmon represent nearly 40% of the total immature and mature biomass of pink, chum, and sockeye salmon. Approximately 16% of pink salmon originated from hatcheries during the recent period (2005 -2015). This might not seem like a lot, but the number of adult hatchery pink salmon (82 million per year) exceeds those of wild chum salmon, is nearly equal to the abundance of wild sockeye salmon, and far exceeds those of Chinook, coho, and steelhead.

Most hatchery pink salmon are produced in Alaska, which supports a massive and growing private, non-profit hatchery program.

Most hatchery pink salmon are produced in Alaska where up to 48% of the commercial salmon harvest is hatchery salmon, primarily pink and chum salmon. Alaska supports a massive and growing "private non-profit" hatchery program. (1.8 billion salmon fry were released from Alaska salmon hatcheries in 2018, and plans for the Kodiak region are to increase hatchery pink salmon production until it meets or exceeds that of the already abundant wild pink salmon.) There is a general belief among decision-makers in Alaska that hatchery salmon do not adversely affect fitness of wild salmon and that the ocean can readily support both wild and hatchery salmon.

Alaska has a precautionary policy to protect wild salmon from adverse effects of hatchery salmon, and a recent Alaska Department of Fish and Game (ADF&G) report concluded that current hatchery operations were meeting these policy goals, a conclusion that contradicts findings from many published studies. Such studies include two recent ADF&G reports from Prince William Sound showing that when hatchery pink salmon spawn in streams, their progeny have ~50% lower survival than wild pinks. Many studies also indicate that salmon compete for a limited food resource at sea, especially with highly abundant pink salmon, leading to reduced growth, survival, and delayed maturation.

Catching Moon Beams: Pink Salmon as a Research Tool to Unravel Mysteries of the North Pacific

Studying the interactions of different salmon species on the high seas is not a simple business. It's like "catching a moon beam in a bottle," some colleagues say, but it's what I've been doing professionally for the past 20 years.

Recently, my colleagues and I have used the unique life history of pink salmon and their strong biennial pattern of abundance as a way to examine salmon interactions on the high seas. In doing so, we have made some surprising discoveries.

Pink salmon typically spawn in the lower reaches of rivers, their fry emerging from gravel in spring, then quickly traveling to sea. They spend only one winter at sea before returning to spawn during summer and fall. Voracious feeders, they grow exceptionally fast, migrate thousands of kilometers, and interact with salmon populations from distant regions, even different continents.

Odd- and even-year pink salmon are genetically distinct and their two-year life history leads to strong biennial patterns of abundance. For example, in the Salish Sea, approximately 18 million pink salmon return in odd years, but only 0.4 million in even years. In eastern Kamchatka Peninsula, Russia, approximately 138 million pink salmon

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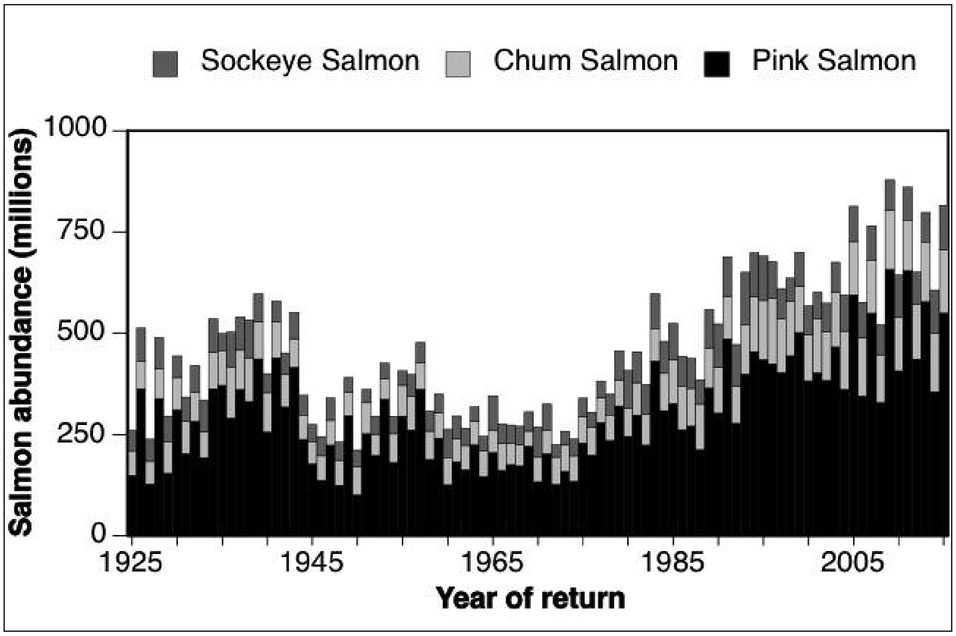

Fig. 1. Numbers of mature Asian and North American sockeye salmon, chum salmon, and pink salmon returning from the North Pacific Ocean, 1925-2015.

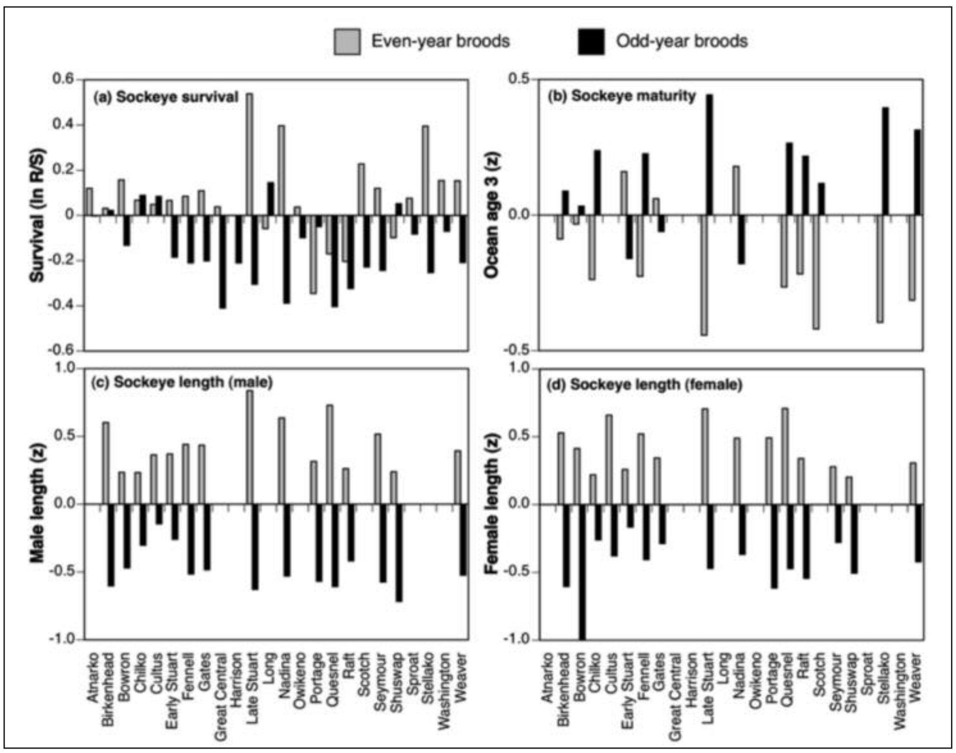

Fig. 2. Survival (a), proportion of ocean-age-3 (b), and length-at-age of male (c) and female (d) sockeye salmon populations from British Columbia and Washington during odd- versus even-numbered brood years, 1978–2005. Values are normalized (Z) relative to the entire data time series, except survival, which is the mean residual from the recruitment relationship.

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return in odd years compared with only 25 million fish in even years.

Our research initially focused on detecting biennial patterns in the diet, growth, age at maturation, and survival of Pacific salmon as signs of interaction with pink salmon. Biennial patterns provide a powerful tool to evaluate competition because: 1) physical oceanography and climate cannot explain the biennial patterns, and 2) most species do not exhibit biennial patterns of abundance unless the pattern is related to predation by pink salmon. Our findings are briefly described below. For more information, readers can consult the peer-reviewed publications from which these findings are based. (https://www.researchgate.net/profile/Gregory_Ruggerone).

Do Pink Salmon Cause a Trophic Cascade in the North Pacific Ocean?

The answer to this question is, in short, yes. A "trophic cascade" occurs when a predator population increases or decreases, leading to large reciprocal changes in its prey population, ripple effects through the food chain, and changes in ecosystem structure. In the North Pacific, pink salmon are a key predator of zooplankton (small animals), which consume phytoplankton (small algae).

In 2018, Sonia Batten, Ivonne Ortiz, and I analyzed 15 years of data collected by plankton recorders towed behind commercial ships in the Bering Sea and North Pacific Ocean.

We found three lines of evidence supporting our trophic cascade hypothesis. First, in odd years, when pink salmon were more abundant, zooplankton abundance was low and phytoplankton abundance was high; in even years, when pinks were less abundant, zooplankton abundance was high and phytoplankton abundance was low. Second, zooplankton abundance was negatively correlated with abundance of pink salmon known to occupy this region (mostly eastern Kamchatka stock) whereas phytoplankton abundance was positively correlated with pink salmon abundance. Third, in 2013, runs of pink salmon returning to eastern Kamchatka declined dramatically, zooplankton were exceptionally abundant, and phytoplankton abundance was low; i.e., just the opposite of expectations in odd years when pink salmon abundance is typically high. Thus, pink salmon caused a trophic cascade by altering the abundance of zooplankton, which in turn affected the abundance of phytoplankton.

Do Salmon Compete for Food at Sea?

Scientists have been trying to address this question since the early 1980s when Don Rogers and Randall Peterman published their separate investigations of density dependent growth of sockeye salmon.

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Most recent evidence for competition stems from interactions of pink and sockeye salmon which both feed on zooplankton, small fishes, and squid. Our research indicates that pink salmon are more efficient foragers than sockeye and other species of salmon. Nancy Davis (formerly High Sea Salmon Team, University of Washington) has collected 10 years of data on the stomach contents of salmon taken in high seas sampling. Analyzing these data, we found that consumption of prey by both pink and sockeye salmon significantly declined in odd years when pink salmon were exceptionally abundant. However, the decline was much more pronounced in sockeye than pink salmon.

Brendan Connors and I investigated multiple lines of evidence involving competition between pink and sockeye salmon, including 36 sockeye salmon populations ranging from Lake Washington and the Fraser River to northern British Columbia and Southeast Alaska, examining some data sets back to the 1950s. As expected, if pink salmon reduce prey availability, strong biennial signals were observed in sockeye survival, age-at-maturation, and length-at-age (Fig. 2). We also found consistent negative correlations between pink salmon abundance and survival, age-at-maturation, and length-at-age of sockeye salmon (Fig. 3). In other words, slower growth contributed to reduced sockeye survival and to delayed maturation.

Based on our statistical model, which allowed us to control for variables such as sockeye spawning escapement and sea surface temperature, we estimated that the average production of hatchery pink salmon in Alaska (50 million adults, 2000-2010) led to an 18% decline (1.8 million sockeye per year) in Fraser River sockeye salmon abundance.

We found consistent negative correlations between pink salmon abundance and reduced sockeye survival and delayed maturation.

Bristol Bay, Alaska has produced exceptional runs of wild sockeye salmon since the 1977 ocean regime shift (e.g., avg. 57 million sockeye, 2015-2019), yet evidence indicates Bristol Bay sockeye are also affected by high abundances of pink salmon. How can this be true?

Again, we have multiple lines of evidence. First, each major stock of Bristol Bay sockeye shows a strong biennial pattern in annual and seasonal scale growth since the mid-1960s. (Scale growth is a commonly used measure of fish growth. The biennial pattern only occurs during the second and third years at sea because this is when sockeye and pink salmon, especially eastern Kamchatka stock, overlap and share high seas feeding grounds. Few pink salmon occur in the southeastern Bering Sea, and the biennial pattern is not apparent during the first year at sea.) Second, annual scale growth and adult length-at-age is negatively correlated with pink salmon abundance in addition to sockeye abundance. Third, smolt to adult survival of age-1 smolts declined 41%, on average, and age-2 smolts declined 26% when migrating to sea in even-numbered years and interacting with abundant pink salmon during the following odd-numbered year. Fourth, adult sockeye returns from even-year smolts (which interacted with abundant pink salmon during their second year at sea) averaged 22% fewer fish than returns from odd-year smolts (which interacted with few pink salmon). Fifth, forecast error of Bristol Bay sockeye salmon since the late 1960s shows a strong biennial pattern. That is, forecasts of Kvichak, Naknek, Ugashik, and Egegik sockeye salmon runs overestimated actual returns in even-numbered years and underestimated them in odd numbered years, reflecting the interaction with pink salmon during the previous full year at sea.

So why have Bristol Bay sockeye salmon been so abundant if they are competing with highly abundant pink salmon? The answer is relatively simple: both species have benefited from highly favorable ocean conditions that support rapid growth and survival during their early life stages. Effects of good early marine conditions overwhelm the adverse effects of competition that occur during later life stages. For example, our annual and seasonal scale growth studies show that Bristol Bay and Chignik sockeye salmon experienced faster early marine growth beginning with the 1977 ocean regime shift that was associated with the doubling of pink and sockeye salmon abundance.

Detection of the adverse effects of pink salmon on Bristol Bay sockeye is only possible by focusing on specific metrics within portions of sockeye life history and by using the unique biennial

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The total abundance of pink salmon in North American and Asian waters averages 500 million per year. By comparison, sockeye annual abundance is 88 million and 137 million for chum salmon. Photo courtesy Bering Land Bridge National Preserve, Creative Commons Attribution 2.0 Generic License.

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patterns. These findings are important because the effect of pink salmon on Bristol Bay sockeye may become more adverse under less favorable ocean conditions. In fact, Fraser River sockeye salmon, in the southern range of sockeye salmon, have been adversely affected by unfavorable early marine conditions in coastal waters and then adversely affected by interactions with abundant pink salmon on the high seas.

Chinook, Coho, and Steelhead

Chinook salmon abundance during the past several decades has declined throughout the species' entire range. Degradation of spawning and early rearing habitat are well-documented factors in this decline, but the trend is seen even in wild populations in relatively pristine regions of Alaska and Russia. This decline has been associated with reduced size at age and younger age at maturation, leading to overall smaller Chinook salmon and lower fecundity.

Undoubtedly many factors have led to lower abundance of Chinook salmon, but we suspect pink salmon as a factor as well, as suggested in part by inverse relationships between harvests and pink salmon abundance (Fig. 4). For example, on the high seas, both pink and Chinook salmon eat small fishes and squid. Data collected over 10 years by Nancy Davis showed stomach fullness of Chinook salmon declined 56% and weight of small fishes and squid declined 68% in odd years when pink salmon were abundant. In contrast, consumption of fishes and squid (60% of total prey) by pink salmon declined only 28% in odd years when their abundance was high. We also analyzed scale growth, age at maturation, and productivity of Yukon, Kuskokwim, and Nushagak Chinook salmon. While sea surface temperature was the most important variable during the first year at sea for these runs, we found that pink salmon abundance was a key variable influencing these metrics during later marine life stages.

Fred Goetz and I investigated pink salmon effects on the survival, growth and maturation of 53 million coded-wire-tagged (CWT) sub-yearling Chinook salmon released from hatcheries in the Salish Sea between 1972 and 1997. From 1984 to 1997, survival of 10 Chinook salmon populations averaged 59% lower, length-at-age was smaller,

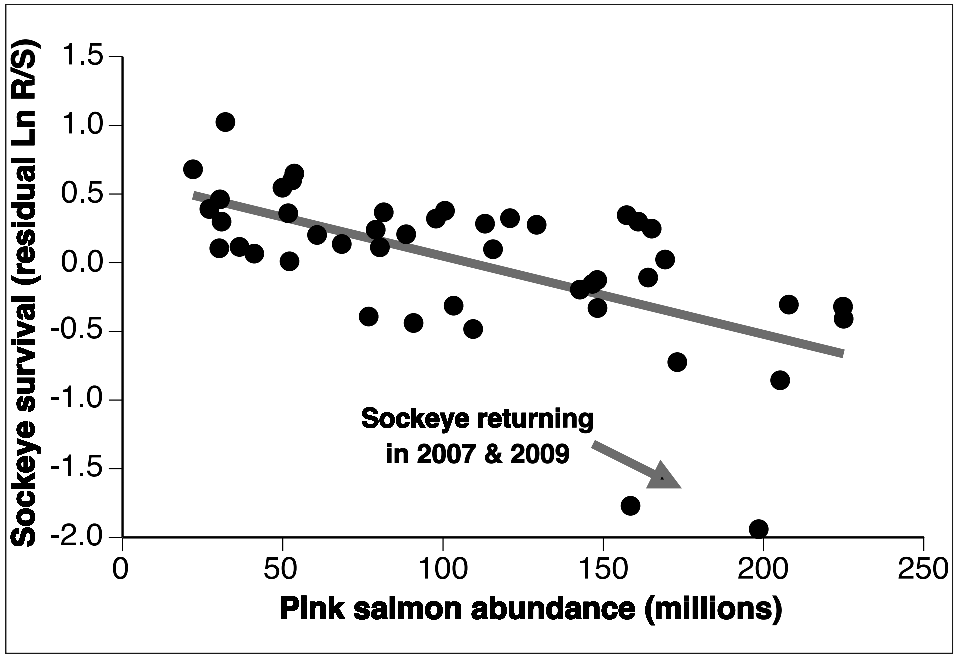

Fig. 3. Relationship between mean survival of 16 Fraser River sockeye stocks (brood years 1961-2005) and abundance of pink salmon returning to North America (excluding western Alaska).

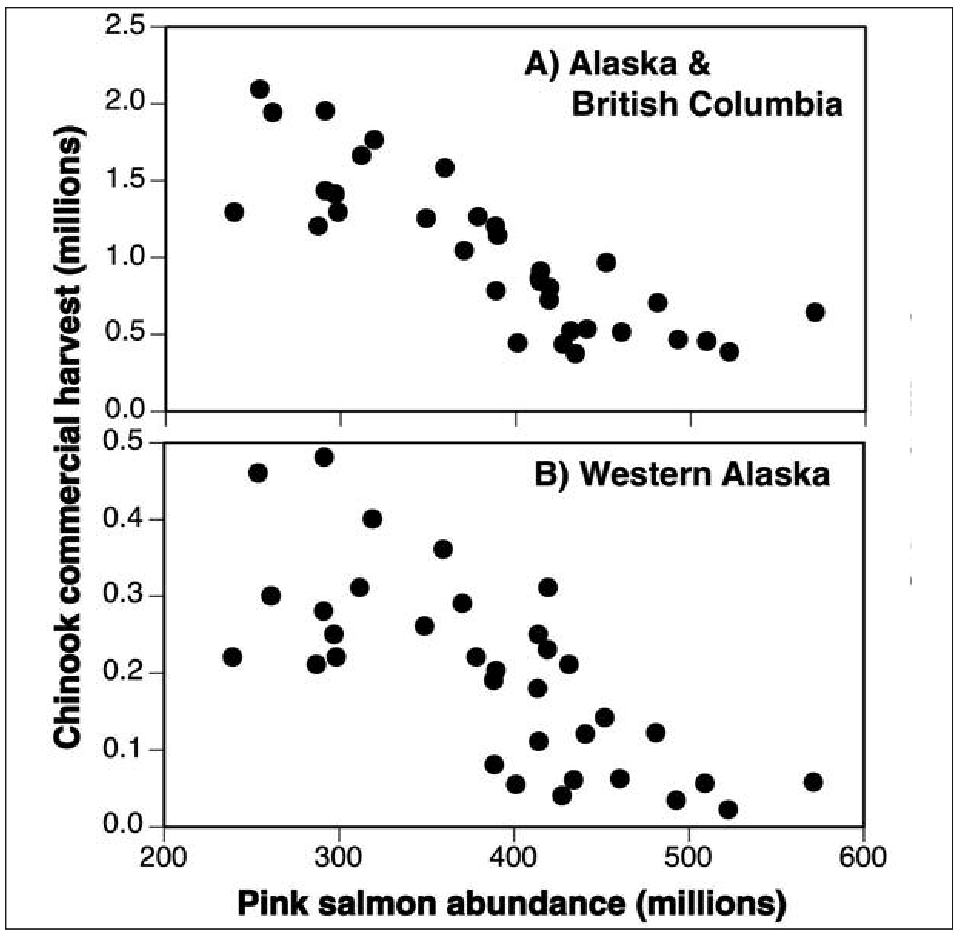

Fig. 4. Commercial harvest of Chinook salmon in (A) Alaska and British Columbia, and (B) western Alaska (1980 to 2013) in relation to average pink salmon abundance co-occurring with Chinook salmon in the North Pacific Ocean.

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and age at maturation was delayed when juveniles entered the Salish Sea in even years along with highly abundant juvenile pink salmon. Analyses indicated survival and growth were primarily influenced during the first year at sea. No biennial patterns were detected in Chinook salmon along the Washington coast and lower Vancouver Island streams where there are few or no pink salmon. New analyses by Neala Kendall and colleagues also suggest an adverse effect of pink salmon on survival of hatchery Chinook salmon in the Salish Sea.

Coho salmon can be adversely affected by pink salmon in offshore regions, whereas juvenile coho (and steelhead) may benefit by consuming small pink salmon fry in nearshore areas and streams. Leon Shaul and Hal Geiger investigated the interactions between Southeast Alaska coho salmon, pink salmon, squid, and climate over a long time period. Coho salmon exhibited strong biennial patterns in growth and survival, which was related to pink salmon predation on squid, a key prey of coho. Interestingly, size of coho salmon (and Chinook salmon) has declined dramatically as pink salmon abundance has increased. In the Salish Sea, Dick Beamish reported that early marine survival of hatchery coho in the Salish Sea was lower in even years when juvenile pink salmon were abundant, a finding that is consistent with Chinook salmon in this region.

Less is known about steelhead on the high seas. However, Megan Atcheson, Kate Myers, and others reported that the percentage of steelhead with empty stomachs and consumption of squid in the central North Pacific declined with greater abundances of pink salmon, which also consumed squid. Furthermore, Josh Korman and Rob Bison recently reported that the survival of interior Fraser River steelhead (Thompson and Chilcotin populations), which have declined significantly in recent years, was inversely related to abundance of pink, sockeye, and chum salmon in the ocean. This relationship was stronger than relationships involving ocean climate and minimum summer flows in their spawning streams.

Seabirds

Research by Alan Springer, Gus van Vliet and others has revealed a biennial signal in the breeding biology of several species of seabirds nesting in the Aleutian Island region and for at least one southern hemisphere migrant species. These species consume prey also eaten by pink salmon. The nesting period of several resident species is late in odd years when pink salmon abundance is high and early in even years when pink salmon abundance is low. Productivity of black-legged and red-legged kittiwakes is depressed by up to 62% in odd years compared to even years, and 30% to 40% of seabird productivity is explained by pink salmon abundance. Migrant short-tailed shearwaters from Australia spend their winter season in the North Pacific/Aleutian Island region and have higher mortality on their wintering grounds and nest in fewer numbers on their breeding grounds in odd years compared to even years, thereby maintaining a transhemispheric teleconnection.

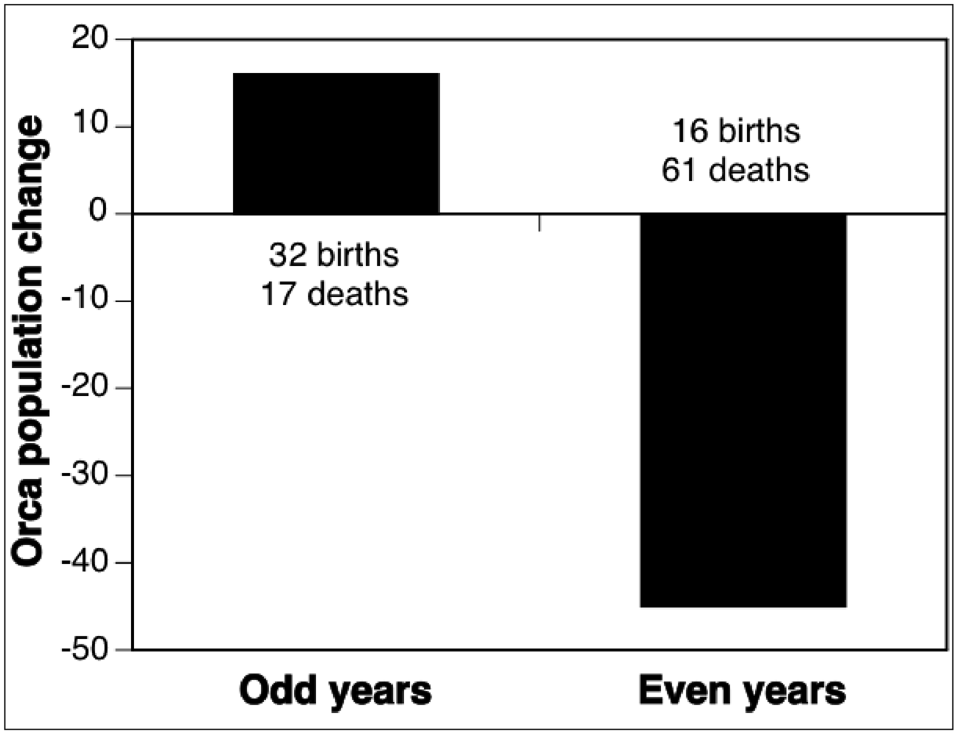

Figure 5. The number of southern resident killer whales increased in odd years and decreased in even years during the 20-year period of decline, 1998 to 2017. Understanding the mechanism leading to this pattern would inform recovery actions. Population change based on successful births minus orca deaths reported by Ken Balcomb and the Center for Whale Research.

Pink salmon in Salish Sea rivers increased 135% during the period of orca decline. We hypothesize that they interfered with orca foraging.

Southern Resident Killer Whales

Southern resident killer whales essentially never eat pink salmon, yet this critically endangered orca, which ranges from central California to mid Vancouver Island and into the Salish Sea, exhibited a highly unusual biennial pattern in both successful births and mortality. From 1998–2017, mortality of newborn and older orca was 3.6 times higher (61 versus 17 orca) and successful births 50% lower (16 versus 32 orca in even years than in odd years as the population decreased from 92 to only 76 orca (Fig. 5). This biennial pattern was not apparent during the earlier period (1976-1997) when key prey were more abundant and pink salmon were less abundant. We hypothesized that pink salmon, whose escapement to Salish Sea rivers increased 135% during the period of orca decline, interfered with the foraging efficiency of orca as they

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attempted to capture Chinook salmon. Both Chinook and pink salmon concentrate along the west side of San Juan Island and into Boundary Pass from late July through early September, but pink salmon are only abundant in odd years. Effects of reduced foraging efficiency may be expressed approximately one year later (in even years) as suggested by earlier research. We know of no other species that might cause such a strong biennial pattern.

Understanding the mechanism of this biennial pattern is critical to the recovery of the endangered orca. For example, if births and mortality during even years had been similar to that during odd years, the orca population would have substantially increased (rather than decreased) during the past 20 years (Fig. 5).

Concluding Thoughts

Evidence is growing in support of the hypothesis that salmon compete for prey on the high seas, leading to reduced growth, lower survival, and delayed maturation. Pink salmon are the "Overlord" among competing salmon: they are exceptionally abundant, consume large amounts of prey including small fishes and squid, and have caused a trophic cascade in the North Pacific. Pink salmon affect foraging seabirds and possibly even killer whales. These findings highlight the importance of species interactions for consideration by management, and indicate the need for wisdom in managers and others that desire to release more and more hatchery salmon into the North Pacific.

Author Dr. Greg Ruggerone, Ph.D. of Natural Resources Consultants, Inc. has investigated population dynamics, ecology, and management of Pacific salmon in Alaska and the Pacific Northwest for the past 40 years. Some of his earlier research involved predation on salmon by bears, seabirds, char, and coho salmon in Alaska and the Columbia River. Since 2000, he has investigated the effects of pink salmon on other species in the ocean. He often serves on independent science panels involving Pacific salmon restoration and management of fisheries.

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Wild sockeye salmon in Lake Iliamna, Alaska. Zero hatchery production and record salmon runs. Photo by Greg Ruggerone.

Return of the Skagit

Resource management plan combines wild steelhead conservation and fly angling

By Jim Scott, Edward Eleazer and Brett Barkdull

Puget Sound steelhead are listed as threatened under the Endangered Species Act (ESA) and the current wild steelhead run is less than 5% to 10% of the historical size. Hatchery-origin steelhead provide some fishing opportunities, but these opportunities have been limited to a few rivers and during brief periods in order to protect and conserve the remaining wild steelhead. Degraded habitat currently limits the productivity of our rivers, historical hatchery programs and associated fishery management practices may have reduced the diversity of our steelhead, and most steelhead smolts apparently die before they can even migrate through Puget Sound, perhaps due to a large and hungry population of seals. Our Puget Sound ecosystem is a challenging environment for steelhead and for steelheaders, and many of us may even have been inclined to call it quits.

In contrast, what follows is a story of hope. A story of how a group of anglers, Occupy Skagit, and others, worked for years to restore a fishery for wild steelhead on the Skagit River. An example of how hard-won and ongoing efforts to protect and restore habitat in the Skagit River watershed have maintained a wild steelhead run sufficiently productive to allow a three-month recreational fishery for wild steelhead in 2019. It is a story of effective co-management resulting in the development and implementation of a fishery management plan that provides for fishing opportunities as we work to rebuild and recover Skagit River steelhead. And also a story, we hope, that can be repeated as we seek to restore the Washington State Fish — steelhead — in rivers throughout Puget Sound.

The Mighty Skagit

Over 50,000 steelhead historically returned each year to the Skagit River, a testament to the size, productivity, and diversity of the watershed. A diversity that likely supported spring, summer, fall, and winter returns of adult steelhead to habitats as varied as the lowland Nookachamps Creek and the high-elevation, glacier-fed waters of the Suiattle River. The mighty Skagit, arising in the Cascade Mountains in British Columbia, and flowing through North Cascades National Park before emptying into Puget Sound at Skagit Bay, is a *steelhead* river.

It was also *the* destination for steelhead fishing in North America. Longtime Skagit River steelheader David Yamashita can regale you with stories of Skagit River fishing adventures, particularly those of several famous guides including Howard Miller (for whom the steelhead park at Rockport is named), who guided the likes of John Wayne, Curt Gowdy and Ted Williams.

> *This is a story of how people worked to restore a wild steelhead fishery on the Skagit, a story we hope to repeat on other rivers.*

In subsequent decades the mighty Skagit, like many of our rivers, was brought to its knees. A multitude of factors, including habitat degradation, historical hatchery and fishery management practices, and high mortality rates of juvenile steelhead migrating through Puget Sound, resulted in the eventual listing of the Puget Sound Distinct Population Segment (DPS) of steelhead as a threatened species. The number of steelhead spawning in the Skagit River dropped to as low as 2,500 in 2009. Fisheries directed at wild steelhead were eliminated, for good reason, and impact rates on wild steelhead were limited to a maximum of 4.2%.

Subsequently, in a remarkable display of resilience, the number of steelhead spawners rebounded to an average of over 8,800 from 2013-2015. Since the previous escapement goal had been far less than that, the co-managers — the Sauk-Suiattle Indian Tribe, the Swinomish Indian Tribal Community, the Upper Skagit Indian Tribe, and the Washington Department of Fish and Wildlife — initiated discussions with the National Marine Fisheries Service (NMFS) regarding the potential re-initiation of steelhead fisheries under strict and specific conditions prescribed in an ESA-approved Resource Management Plan (RMP). The Washington Department of Fish and Wildlife (WDFW) received strong encouragement from Occupy Skagit and other recreational anglers in this endeavor. Steelheaders like Curt Kraemer, Wayne Cline, and Steve Fransen devoted many a Saturday morning to Fish and Wildlife Commission meetings inquiring about the status of the RMP and, more pointedly, when fishing for steelhead on the Skagit River could resume.

Skagit River Steelhead Fishery RMP

What is a fishery RMP, why is it required, and why did it take so long?

After the ESA-listing of Puget Sound steelhead, it became illegal to "take" or harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct affecting Skagit River steelhead. Since a recreational catch-and-release fishery for steelhead on the Skagit River would cause "take" of ESA-listed steelhead, the fishery was prohibited by federal rules protecting this ESA-listed species.

This prohibition of "take" can be lifted under very limited conditions that are described in the federal 4(d) rule issued in 2005. Limit 6 of the 4(d) rule identifies specific criteria that NMFS must use to determine if a co-manager RMP meets the ESA requirements for the survival and recovery of a listed species. Securing approval is a lengthy and complex process. The documents

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that NMFS must complete include: 1) an Environmental Assessment or other document required by the National Environmental Protection Act; 2) an ESA section 7 consultation that provides for the take of an ESA-listed species; and 3) a Final Evaluation and Recommended Determination that confirms that the RMP meets the 4(d) rule criteria. NMFS typically takes 12-18 months to complete these processes and associated documents, provide the required opportunities for public comment, and publish the final decision in the Federal Register.

Demonstrating that an RMP meets the 4(d) criteria requires extensive supporting information and rigorous analyses. Fortunately, the co-managers had invested the funding and staff resources to collect the necessary information on the productivity, abundance, diversity, and spatial structure of Skagit steelhead. After a multi-year effort to summarize this information, complete the complex analyses necessary to assess the risks to Skagit steelhead, and write the 40-page plan, the co-managers submitted the Skagit River Steelhead Fishery RMP to NMFS in November 2016. NMFS completed its review and approved the plan in April 2018, with the review process and conclusions documented in over 300 pages of reports.

Management Objectives and Approach

The co-managers developed the RMP with the full recognition that Skagit River steelhead are part of a group of Puget Sound steelhead populations that are listed as threatened under the Endangered Species Act. Substantial improvements to enhance the productivity and protection of habitat are necessary to ensure the long-term viability of Skagit steelhead populations.

However, our assessments indicated that a low level of fishery mortality could be sustained without impeding the rebuilding and eventual recovery, with habitat improvements, of Skagit River steelhead.

In developing the RMP, the co-managers considerations included the following objectives:

1. Strictly limit fishery impact rates when abundance is low to ensure the long-term viability of Skagit River steelhead.

The Skagit River flows through North Cascades National Park on its journey from its headwaters in the British Columbia Cascade Range until it flows into Puget Sound at Skagit Bay. Photo by Jim Yuskavitch

2. Set a low maximum fishing rate, even when abundance is relatively strong, to ensure that we repeatedly test the productivity and capacity of the Skagit River, and that sufficient spawners are provided to recolonize underutilized or restored habitat.

3. Protect early-timed wild winter steelhead to contribute to restoration of this steelhead diversity component.

Schedule of Fishery Impact Rates Linked to Abundance

Preseason Forecast for Natural-Origin Steelhead	Allowable Fishery Impact Rate
Terminal Run ≤ 4,000	4%
4,001 ≤ Terminal Run	10%
6,001 ≤ Terminal Run	20%
Terminal Run ≥ 8,001	25%

Objectives 1 and 2 led the co-managers to develop an abundance-based fishery management regime that strictly constrain fishery impacts during periods of low abundance, while providing limited fisheries under more favorable conditions.

The RMP allows a maximum fishery impact rate of 4% when the run size forecast is for 4,000 or fewer steelhead entering the Skagit River. This is slightly more restrictive than NMFS' previously approved impact rate limit of 4.2%.

Unlike fishery management with a fixed escapement goal, the RMP sets a 25% limit on the maximum fishery impact rate, and that rate only occurs when the run-size is projected to exceed 8,000 steelhead.

The RMP does not allow recreational fisheries to be initiated prior to February 1 and only upstream of the town of Concrete. This provides protection for the majority of the lowland tributaries likely to have early-timed wild steelhead. Treaty fisheries will be designed to access steelhead across the entire return period.

The co-managers also recognized that we have a lot to learn about Skagit steelhead, and specifically called out the importance of collecting and analyzing additional information. Our performance indicators include the following:

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1. Do Skagit steelhead remain on average as productive as during the 1978-2007 brood years used as the basis of our analyses? The productivity of the population is an important factor in determining the allowable impact rate. The productivity (recruits per spawner) of each year class will be compared with the distribution of productivity in the reconstruction of historical runs.

2. Is the preseason forecast accurately predicting the abundance of returning adults? The accuracy and precision of the forecast method will be evaluated each year and the error of the preseason forecast evaluated.

3. Are the fisheries managed consistent with the allowable impact rates? Postseason estimates of impact rates will be compared with the allowable rates for treaty and nontreaty fisheries identified during the preseason planning process.

4. Are the number of spawners consistent with expectations? The estimated number of spawners will be compared with the range as predicted in the risk assessment simulations and forecasts.

5. Is the range of spawn timing maintained or increased? Spawn-timing information will be collected to assess long-term changes.

By tracking these performance indicators through the five-year life span of the RMP, and by improvements in our assessments of Skagit steelhead, our intent is to build the basis for even better fishery management in the future.

Annual Management Implementation

The annual implementation of the RMP is tightly coordinated between the co-managers and with NMFS. The annual management cycle includes the following steps:

By December 15:

The co-managers provide NMFS with the pre-season forecast of the number of natural-origin steelhead returning to the Skagit River, identify the maximum impact rate allowed under the RMP given that forecast, and provide preliminary recreational and tribal fishing schedules.

The pre-season forecast is jointly developed by the tribes and WDFW, and fishery schedules are based on the best available information on effort and catch/encounter rates to ensure that impacts do not exceed the limit prescribed by the RMP. The fishery schedules must take into account expected mortalities of steelhead incidentally encountered during fisheries in the river directed at spring Chinook, sockeye, and resident fish species such as trout.

During the 2019 season, there were over 6,600 steelhead angler trips on the Skagit generating more than $1 million for the local economy.

December – April 15:

Period of potential tribal fisheries. Specific time and area openings will vary depending on the pre-season forecast of steelhead abundance, catch rates, and expected impacts of steelhead in fisheries in the river directed at other species.

February – April 30:

Period of potential recreational fisheries. Specific time and area openings will vary depending on the preseason forecast of steelhead abundance, steelhead encounter rates, and expected impacts of steelhead in fisheries directed at other species.

January – April:

Monitoring of tribal fishery catches and recreational fishery impacts; regular communication between co-managers with in-season management actions to ensure impact limits are not exceeded.

By November 30:

Co-managers provide NMFS with postseason report of the prior year. The report includes total estimated fishery impacts and impact rates, estimated spawners, and estimated Skagit River steelhead run-size.

Angler Participation, Steelhead Impacts, and Community Value

We often heard during the development of the RMP and at subsequent public meetings of the importance of this fishery to the local community. Community leaders repeatedly spoke to the loss of angler traffic to gas stations, grocery stores, restaurants, and motels, and the resultant economic and social stress to the community that had accompanied the closure of the fishery in 2010. Advocates for the fishery highlighted the traditional importance of the Skagit River steelhead fishery and suggested that, managed appropriately, it could become a destination fishery drawing anglers from throughout the state, the nation, and international locations. Have those hopes and expectations been fulfilled?

With just one full year of recreational fishing completed it is too early to provide a complete answer, but the initial results are promising. During the three-month recreational fishing season in 2019 there were more than 6,600 angler trips for steelhead on the Skagit River. These angler trips are projected to have generated more than $1 million of angler expenditures with an economic impact was over $1.5 million. That boost was felt by the local community, which reported an increase in cus-

The Skagit has the potential to draw steelhead anglers from throughout the world. Photo by Joe Mabel, Converted to B&W, Creative Commons Attribution-Share Alike 3.0 Unported License.

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tomers during what had been the slowest and bleakest period of the year.

The three-month recreational fishing season was provided with fewer steelhead mortalities and a lower fishery impact rate than allowed under the RMP. With a forecasted run of more than 6,000 steelhead the allowable impact rate was 10% for the recreational fishery (50% of the total allowable rate of 20%). Our intensive creel surveys estimated that anglers encountered approximately 1,400 steelhead. With the 10% mortality rate recommended by the Statewide Steelhead Management Plan and approved by NMFS, we estimate the incidental mortality of approximately 140 wild steelhead in the recreational fishery. Although initial indications are that the steelhead run might have been lower than the pre-season forecast, we are confident that the fishery impact rate was small and well within the limits of the RMP.

Our riverside interviews confirmed that the fishery was drawing local anglers, but there were also hints of a budding destination fishery. About 10% of the anglers were from outside of Washington, some from as far away as the United Kingdom, and anglers travelled from 21 U.S. states to participate in the fishery. Anglers from 21 of Washington's counties also participated in the fishery. (We are grateful for the assistance of Curt Kraemer in analyzing angler participation.)

Will the fishery grow in the future? Initial indications are that a 2-3 month recreational catch and release fishery should be possible in most years even with additional angler participation. And our conversations with anglers and guides suggest that participation will likely increase if a 2-3 month fishery can be consistently implemented.

Sustaining and Building on the Skagit Success

Can the successful launch of the Skagit steelhead fishery be sustained? And what about the remainder of Puget Sound rivers?

The answers to these questions are dependent on maintaining investments in careful fishery management and diligent enforcement, continuing the strong working relationship with our co-managers, and ensuring that we all work to continue to protect and improve steelhead habitat in the Skagit and other watersheds.

The biggest short-term challenge may be funding. Monitoring steelhead encounter rates for three months in a recreational steelhead fishery widely dispersed across 40 miles of the Skagit and Sauk Rivers is challenging. WDFW has used a combination of aerial counts of anglers and shore-based staff to ensure we have sufficient data to effectively manage a fishery on an ESA-listed species. That monitoring does not come cheap. WDFW is requesting $272,000 per year from the legislature to maintain this monitoring, and the fishery, in future years.

More broadly, the Puget Sound Steelhead Advisory Group (PSSAG) will soon be providing WDFW with recommendations for a portfolio of watershed specific conservation, fishery, and hatchery strategies for Puget Sound steelhead. Building upon the experience gained with the Skagit River fishery, the PSSAG is assessing whether catch-and-release recreational fisheries might be possible in additional rivers. They recognize, however, the reality of conditions on the ground and the varying interests of steelheaders. Not all rivers have the same ability to contribute in the same time frame to the conservation and recovery of Puget Sound steelhead, and some steelhead anglers want to be able to harvest steelhead. The QuickSilver portfolio developed by the PSSAG recognizes this diversity of watersheds, steelhead, and steelheaders, and provides a vision for steelhead management in 2019 and beyond.

The PSSAG perspective may best be captured by the closing paragraph of the Preface to the recommendations:

"While we can't return to the past, we believe that we can achieve a brighter future for steelhead for this and future generations of anglers. Steelhead are incredibly resilient. They will rebound if given the chance. It is our intent to give them that chance — for the good of our ***State Fish*** *— while keeping anglers on the water."*

Jim Scott, and primary author, is Washington Department of Fish and Wildlfe's Special Assistant to the Director's Office addressing salmon and steelhead issues in Washington State. Edward Eleazer is the WDFW North Puget Sound Fish Program Manager and Brett Barkdull is a WDFW Fisheries Biologist and steelhead expert for the Skagit, Samish and Nooksack river systems.

Skagit River steelhead fishing circa 1970. Photo by Doug Wilson, Courtesy National Archives and Records Administration.

International Salmon and Steelhead Experts Gather for 2019 World Salmon Forum

By Bruce McNae and Dr. Anne Weekes

The World Salmon Forum took place in Seattle on August 21-23, 2019 and exceeded our expectations. An interdisciplinary group of over 60 scientists, non-government organizations and foundations from around the Atlantic and Pacific regions heard presentations that collectively gave the attendees a broader and more complete understanding of all the elements impacting the future of wild salmonids around the world. Countries represented included Norway, Russia, United Kingdom, Iceland and Pacific, Atlantic, Arctic coastal and inland regions of the US and Canada.

The WSF event was designed to build new and deeper relationships between individuals representing a wide spectrum of scientific disciplines and, at the same time, help develop additional strategies for NGO's funded by more accurately informed foundations. The core focus of all participants was on *wild* salmon survival.

Two days of presentations culminated in an active Roundtable discussion on day three. The Roundtable focused on developing consensus on future methods for preserving wild salmon globally. The group began by agreeing that there is a wild salmon emergency, especially in the southern reaches in both oceans. Specific WSF propositions that received a majority consensus included: 1) wild salmon sanctuaries should be established, 2) wild salmon and the ecosystems they depend on are a public trust, a legacy for future generations, 3) fisheries management has relied on the wrong methods in their efforts to produce more salmon, and 4) the attachment to place is the wellspring for the important attributes of biodiversity and resilience in wild salmon populations.

The World Salmon Forum ended with a gala dinner that opened with an inspirational talk given by Duwamish tribal member Ken Workman, the great, great, great, great grandson of Chief Seattle. Mark Bilsby, Chief Executive Officer for the Atlantic Salmon Trust, read a letter of support from AST's Patron, His Royal Highness, The Prince of Wales, Prince Charles to the dinner audience. Not only was it an honor to receive such a letter, but the content of this personally drafted statement was a succinct summary of the need for a timely resolution to the emergency facing wild salmon, migratory trout, and for our own species as well.

Researchers gathered at the 2019 World Salmon Forum agreed there is a salmon emergency, especially on the southern reaches of their range.

A new platform for the WSF website (https://www.worldsalmonforum.org) is under development. The new website will allow viewers to choose portions of the entire World Salmon Forum event, which was captured on video. Here is the list of speakers and their topics:

Chief Bob Chamberlin *began the presentations with a First Nations ceremony welcoming the WSF to the Pacific Northwest*
Dr. David Montgomery - *Managing the King of Fish*
Dr. Rick Williams – *Place-based Conceptual Foundation*
Dr. Torbjorn Forseth – *The management of Atlantic salmon in Norway – conservation limits, quality norm, and the major threats*
Dr. Chris Frissell – *Filtering, Distortion, and Colonizing of Scientific Information in Fishery Policies*
Dr. Jack Stanford – *Ecology of the last great wild salmon rivers*
Dr. Ken Whelan – *Atlantic salmon mortality at sea: developing an evidence based "likely suspects" framework*
Dr. Kristi Miller-Saunders – *Cumulative impacts on salmon health in the ocean*
Dr. Chase Williams – *Elevated CO2 impairs olfactory-mediated and behavior responses in ocean-phase coho salmon,*
Dr. Cody Youngbull – *Field sensors for digital quantification of eDNA*
Dr. Kyle Young – *The Science and Sociology of (Not Stocking)*
Dr. Deborah Giles – *Not Just Us! A future for Orcas and wild Chinook salmon*
Dr. Sergey Prusov – *Catches of Russian salmon in Northern Norway*
Dr. Carmel Finley – *How salmon politics shaped salmon science: the historical roots of MSY*
Dr. Nate Mantua – *Climate insurance for Pacific salmon*
Jonathan Carr – *Using telemetry to map the spatial and temporal distribution of Atlantic salmon in the ocean*
Sarah O'Neal – *Theory and practice: Defining indirect effects of development for science and policy*
Dylan Tomine – *Introduction of Patagonia's film Artifishal*
Ray Troll – *The art and humor of wild salmon*
Jon Kaldal – *Aquaculture impacts on wild salmon in Iceland*
Verner Wilson – *State of the Alaska fisheries from the Bristol Bay First Nations perspective*
Kurt Beardslee – *"What if?" Stop fishing the open ocean for mixed stock salmon and start fishing on or near their rivers of origin*
Adrian Tuohy – *Place-based selective harvest methodology: Pound-nets and Reef nets,*
Elizabeth Herendeen & Jill Weitz – *The Salmon State: Maintaining the Strongholds of Bristol Bay and S.E. Alaska*

The newly reconfigured website will continue the work of the WSF expressed during the Roundtable discussion, present forthcoming scientific papers, and provide news on upcoming initiatives affecting the future of wild salmon and migratory trout. Stay tuned!

The World Salmon Forum was sponsored by Bruce McNae, who also co-created the World Salmon Forum event in collaboration with Dr. Anne Weekes.

LETTERS TO THE EDITOR

Otolith Samples in C&R Fishery?

Dear Editor:

Regarding the Kamchatka Steelhead Project (*The Osprey*, May 2019): I can't help but wonder how the steelhead otolith samples are obtained in a catch-and-release fishery. I fully understand the need for scale age proofing and Ca/Sr ratios, but otolith analysis requires dead fish. Perhaps the authors should be more forthcoming on this issue. There was no mention in *The Osprey* article of killing any of these wondrous creatures in the name of science. Glossing over the dead fish issue is a bit disingenuous, don't you think?

Larry Brown
Via-email

Pete Soverel, co-author of The Kamchatka Steelhead Project, and Co-Director of the project replies:

First, it is important to note that KSP is not a catch and release fishery, but rather a scientific data collection program authorized by the Russian Ministry of Environment. Steelhead are listed in the Russian Red Book as a "rare and disappearing" species. Commercial and recreational "taking" is not authorized. The KSP is a scientific program specifically permitted by the Russian Ministry of Environment and listed as an approved joint Russian-American project under the terms of Area V of the US-Russia Agreement on the Environment. Participating anglers are individually licensed by the Russian MOE to collect biological samples of O. mykiss *for this science and conservation program.*

Our Russian scientific partners, (Department of Ichthyology, Moscow State University and A.N. Severtsov Institute of Ecology and Evolution of Russian Academy of Science) are responsible for securing permits for biological samples from Kamchatkan O.mykiss*. Typically, MOE authorizes non-lethal samples of approximately 700 individuals and 50 lethal samples per river system.*

A researcher with the Kamchatka Steelhead Project takes a scale sample for analysis. Photo courtesy The Kamchatka Steelhead Project.

In the early years of the program, live samples were collected by fly fishing and lethal samples by gillnet. Lethal samples are used for morphometric analysis, examination of heart tissue (spontaneous recovery from arterial sclerosis among repeat spawners), otolith (life history) and a cross check on life history determination based upon scale samples. In more recent years, we discontinued directed lethal sampling (gillnet). In the course of a field season (five weeks), we will collect about 500-600 samples from O. mykiss *captured by fly fishing. Typical unintended mortality (profuse bleeding from fish hooked in gill rakes or base of the tongue or death from exhaustion) is about 2% — i.e. 15-20 fish per season from local populations totaling up to 30,000 individual steelhead (approximately half of 1% : which is certainly regrettable but is a very small number). Our current permits provide for lethal collection which we use for these unintended mortalities which typically total less than half of our authorized lethal samples. Fly fishing, when conducted in a cautious and supervised manner, is a statistically benign collection method — but it is not a 100% non-lethal methodology — a point we recommend all catch and release anglers bear in mind in their own CnR efforts.*

THANKS TO OUR LOYAL DONORS!

The Osprey relies completely on funding from our conservation partners, and especially our subscribers and supporting organizations. In appreciation we publish their names in our annual Honors List in one issue of *The Osprey* per year. From time to time we inadvertently leave someone out. In our most recent Honors List we neglected to list two of our loyal contributors:

John Rogers

Felton Jenkins

The North Umpqua Foundation

Our apologies and many thanks to you, and all of our regular supporters!

Progress Made to Protect Santa Ynez Steelhead

After nearly 20 years of working together to compel the State Water Resources Control Board to order improved management of Bradbury Dam and the Cachuma Reservoir on the Santa Ynez River in Santa Barbara County, California, a coalition of conservation groups recently secured an agreement from the Board to improve water flows and conduct studies to benefit endangered steelhead, including the potential for fish passage over the dam and habitat improvements. This agreement will help restore the Santa Ynez River watershed for wildlife, recreation, and other uses.

The Santa Ynez River steelhead population — once the largest in southern California — was nearly wiped out by the Cachuma Project and only 1% of the population remains.

Bradbury Dam blocks access to spawning habitat in the headwaters of the Santa Ynez River and its tributaries. In addition, the very small numbers of steelhead that manage to persist below the dam are provided only meager amounts of water, as Bradbury Dam has been operated to maximize municipal and agricultural uses of Santa Ynez River water. This has exacted a heavy toll on the watershed and the wildlife dependent upon it.

Learn more about southern California steelhead conservation projects at: www.caltrout.org/regions/southern-california-region/

Restoring Rogue River Resiliency

As climate change stresses salmon, benefits of Rogue dam removals stand out

By Jim McCarthy

The Rogue River, in Oregon, is one of the most productive salmon and steelhead rivers in the Pacific Northwest, with five runs of salmon and steelhead, plus lamprey and cutthroat trout. Yet, for over one hundred years a series of dams on the mainstem and spawning tributaries severely impacted Rogue Basin fish.

After persistant leadership over three decades from WaterWatch of Oregon, Savage Rapids Dam, the City of Gold Hill Diversion Dam, and Gold Ray Dam were all removed in a three-year span from 2008 to 2010, providing unimpeded fish and boat passage on 157 miles of the mainstem Rogue from William Jess Dam to the Pacific Ocean. During that timespan, the U.S. Army Corps of Engineers notched its partially completed Elk Creek Dam, freeing up access to important salmon, steelhead, and cutthroat trout spawning areas on Elk Creek. In 2015, WaterWatch and our partners removed Wimer Dam and Fielder Dam, providing unimpeded access to 70 miles of high quality habitat in Evans Creek, another important salmon and steelhead spawning tributary. These two barriers had both been ranked in the top ten on the Oregon Department of Fish and Wildlife's statewide fish passage priority list.

Depending on the barrier, fish passage improvement may not always result in dam removal, although removal is generally the most effective option. In 2016, WaterWatch, in conjunction with the Gold Hill Irrigation District, completed a project to improve fish passage at a diversion located between the old Gold Hill and Gold Ray dam sites. This diversion was the most harmful remaining on the mainstem Rogue below the William Jess Dam and complemented the benefits of the mainstem dam removals.

These success created momentum for additional barrier removal and other river restoration projects in the basin. Because the larger fish barriers on the mainstem Rogue River have come down, the dam removal and restoration focus has shifted to tributary streams. At the same time, Rogue Basin communities have joined together to increase their capacity to get this important work done. In 2015, four watershed councils merged to create the Rogue River Watershed Council (RRWC), bringing more muscle and expertise to deliver high quality restoration projects in the Upper Rogue Basin. Among other projects, in 2017 RRWC removed the Beeson-Robison diversion dam on Wagner Creek, replacing it with a more fish friendly diversion to maintain the gravity-fed irrigation system at the site. Watershed councils and other groups doing restoration in the basin have also formed the Rogue Basin Partnership and developed an action plan to coordinate efforts, increase restoration funding capacity, and increase the effectiveness of restoration efforts in the basin.

This year, the Rogue River is projected to have the biggest fall Chinook return of any river south of the Columbia for the third year running.

Fish Response

Since this unprecedented restoration effort began, evidence — both scientific and anecdotal — has begun to emerge about the benefits to the Rogue Basin. For example, the Oregon Department of Fish and Wildlife (ODFW) recently released a summary of early observations of fish response to Rogue dam removals, which contained good news as well as detail. The report noted that for five years following the removals of Gold Ray and Savage Rapids dams, biologists surveyed the formerly inundated salmon spawning habitat in the two reservoir sites, and found that "Chinook re-colonized the habitat immediately, and large numbers of redds [salmon egg nests] were observed."

ODFW also observed benefits for Rogue steelhead, stating, "With the exception of 2015, returns of wild half pounders since 2013 have been in the top ten largest returns observed during ODFW fish monitoring in the lower Rogue (Huntley Park seining project). The three largest counts of wild half pounders are 2018, 2013 and 2017, which is encouraging for biologists and anglers, and coincides nicely with dam removal."

There is other good news. This year, the Rogue River was projected to have the biggest fall Chinook salmon return on the Pacific Coast south of the Columbia River for the third year running. In 2017, ODFW projected 246,900 fall Chinook would return in the Rogue. In 2018, the department projected a whopping 462,800 would return to the Rogue with the fall run. This year, 383,500 are anticipated. The Rogue has maintained this welcome abundance even as salmon populations in nearby rivers have declined due in significant part to drought and water management decisions which discount or ignore the critical value of healthy rivers facing increasing strain under climate change.

While initial evidence is promising, it will take a few generations of salmon and steelhead going through their varied life cycles before some of the benefits are fully realized. Ocean conditions and flow conditions can obscure the benefits of dam removals. What we do know is conditions for salmon and steelhead in the Rogue Basin have greatly improved because of dam removal. Good years will be better and bad years will not be as bad because of these important river restoration projects.

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There is now greater resiliency in the system, and one of Oregon's most spectacular rivers is now healthier, and has a better chance of maintaining salmon and steelhead runs into an uncertain future.

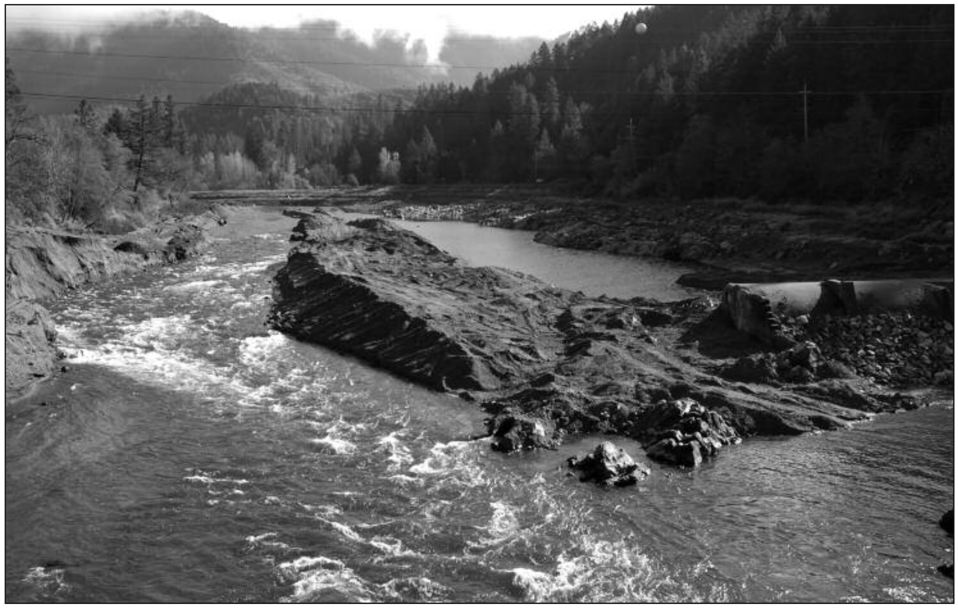
Unimpeded Fish Passage/Elimination of Delays

Dams have multiple impacts on fish and river systems. One of the most significant impacts is as a barrier impeding fish passage. 2008 to 2010 were big years for upper Rogue migratory fish. The removal of Savage Rapids, Gold Hill, and Gold Ray dams — alongside the notching of Elk Creek Dam — turned migration bottlenecks into freeways. The three mainstem Rogue dams impeded passage of significant portions of the basin's five runs of salmon and steelhead, Pacific lamprey, and cutthroat trout to over 500 miles of upstream habitat, including 50 miles of the mainstem. Spring Chinook salmon were particularly hard hit, having to navigate the three mainstem dams to get to their upstream spawning areas.

Anglers are also reporting fish in the upper river earlier than in the past, and that the fish are strong and in good shape. Eliminating the delays in adult upstream migration allows the fish to access their upper basin spawning areas in better condition and with more energy reserves for spawning effort. Having more early and healthy fish increases the likelihood that fish can take advantage of optimal flow conditions to move into tributary spawning areas, and have more energy to access habitat higher up in the system. For example, in the wake of the 2015 removals of two dams on Evans Creek, ODFW biologists observed fall Chinook spawning in the high quality habitat of tributary West Fork Evans Creek for the first time on record. This all translates into increased spawning success, and ultimately more fish.

Besides impeding fish passage for upstream migrating adult salmon, dams can completely block upstream access for juvenile fish and cutthroat trout. Juvenile fish must be able to move up and down in a river system to avoid high and low flows, and access rearing habitat. Once juvenile fish move below a dam they can no longer access important rearing habitat upstream.

Cutthroat trout in the upper Rogue are called fluvials, meaning they use the mainstem Rogue like the ocean, and use spawning tributaries the way sea-runs use coastal streams. Cutthroat trout are not good jumpers and have trouble navigating fish ladders. The mainstem dams isolated cutthroat populations. Tributary dams such as Elk Creek, Fielder, and Wimer blocked access to cutthroat spawning habitat.



The Rogue River flows free at the site of the Savage Rapids Dam shortly after it was removed in 2009. The dam was considered to be the biggest fish killer on the Rogue River system. Photo by Jim Yuskavitch

For example, in 1992 the U.S. Army Corps of Engineers began trapping migrating salmon and steelhead below what was then half-built Elk Creek Dam and hauling them to upstream spawning habitat. Technicians also hauled what cutthroat they caught in the trap. That first winter, only nine cutthroat were trapped. Three years later, the numbers grew to 68, and by winter of 2001-02 crews captured and hauled triple-digit numbers of cutthroat to spawning grounds. Since the Elk Creek Dam notching in 2008, cutthroat trout have unimpeded access to their historic spawning areas. The removal of the Evans Creek dams should similarly benefit the cutthroat in that system.

The combination of dam removals and protective fishing regulations has sparked a resurgence of cutthroat trout on the Rogue. As reported in a July 26, 2013 Medford Mail Tribune article by Mark Freeman, *Big Bite, Big Fight*, Rogue anglers are reporting tremendous catches of cutthroat troat with some more than 20 inches long.

Reduction in Mortality and Injury

Dams injure and kill fish. Adults migrating upstream can jump out of fish ladders, where they are stranded and die. Adults jumping against the face of dams are injured or killed, and adults and juvenile fish spilling over the tops of dams also suffer injury and mortality. Predators concentrate below and above dams because fish are more available and vulnerable prey at these sites. Juvenile fish are much more susceptible to predation in the slow moving water created by reservoirs upstream of the dams. At Savage Rapids Dam, there were high juvenile losses because of entrainment through and impingement at the inadequate fish screens on the irrigation canals and pump turbine system. These sources of injury and mortality are entirely eliminated by dam removal.

Reclaimed Habitat and Water Quality Improvements

The reservoir behind Savage Rapids Dam inundated approximately 3.5 miles of prime fall Chinook habitat. The reservoir behind Gold Ray Dam inundated another 1.5 miles. In a true if-you-remove-it-they-will-spawn fashion, big fall Chinook are now spawning by the hundreds in what used to be sterile sections of the Rogue inundated by water and silt behind what used to be Savage

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Rapids and Gold Ray dams. With the dams gone now and the accumulated sediment washed away, the exposed gravel bars now teem with big Chinook digging and spawning in their egg nests, called redds.

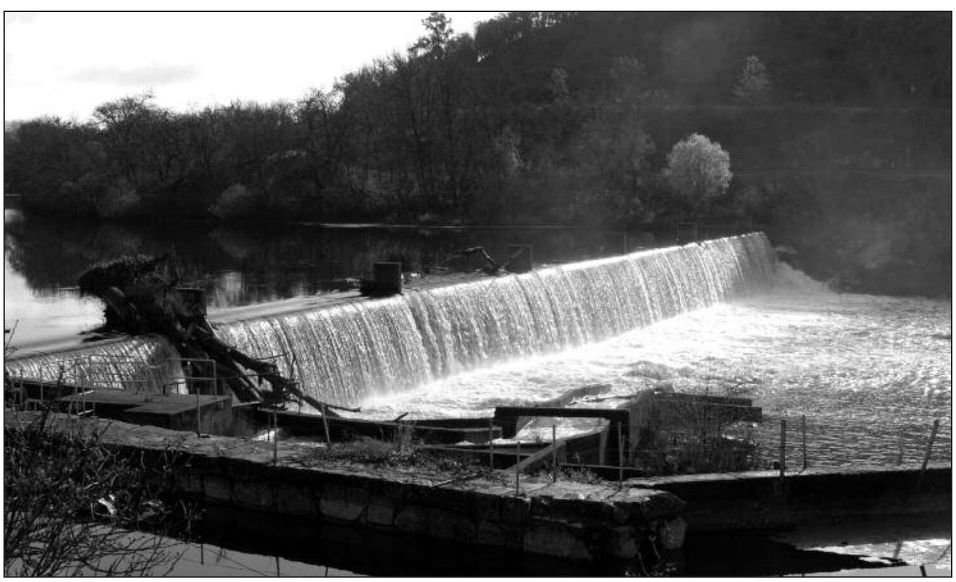
In less than a month after the removal of Gold Ray Dam in 2010, fall Chinook salmon made use of spawning gravel exposed in the old reservoir pool. The Oregon Department of Fish and Wildlife counted thirty-seven redds that first fall in the old reservoir pool. By 2013, biologists had counted 111 redds. In 2010, one year after removal of Savage Rapids Dam, there were 91 fall Chinook salmon redds in the former reservoir area. By 2012 there were 195 redds. This redd revival is a telling example of the restoration benefits of dam removal.

The notching of Elk Creek Dam also created tremendous habitat reclamation potential. This is because the U.S. Army Corps of Engineers still owns approximately 3,000 acres of what was to have been a reservoir pool for the dam. Four miles of low gradient, undeveloped Elk Creek runs through this land, which is slated for riparian and flood plain restoration. This work should make this area even more productive for salmon, steelhead and cutthroat trout in the future.

The reservoirs also harbored invasive warm water species such as largemouth bass, Umpqua pike minnow, and redside shiners. The removal of the dams has eliminated strongholds for these harmful and unwanted species.

With the elimination of the reservoir pools there are also some temperature benefits, as the reservoirs slowed the river and allowed it to warm. The cooling benefits of removing the reservoirs will become more and more important with climate change bringing higher temperatures and more severe droughts to the region.

The partially constructed Elk Creek Dam blocked salmon and steelhead from important spawning habitat, while serving no useful purpose. It was notched in 2008, opening access to upstream habitat. Photo by Jim Yuskavitch



Ceasing to produce hydropower in 1972 due to obsolete generating facilities, the Gold Ray Dam was a liability to Jackson County, which owned it. The dam was removed in 2010. Photo by Jim Yuskavitch

Restoration of Natural River Processes

The removal of the dams helps restore natural river processes such as sediment transport, gravel recruitment, and increased flood plain complexity. This helps improve overall river spawning, rearing and high flow refugial habitat. There are always some short term impacts involved in dam removal, but findings from an Oregon State University study on the impacts of the Rogue Dam removals and dam removal on the Calapooia River show that the impacts are small while the recovery is quick. Interestingly, the study found biologic recovery was even faster than physical recovery in these rivers after dam removal.

Unfortunately, there was some public scaremongering after the dam removals that attempted to spread false claims about the contamination of water supplies. These claims were shown to be totally unfounded and have been soundly debunked. The truth is these dam removals demonstrate that dam removal can be an extremely valuable restoration tool, with the benefits greatly outweighing the short-term minor impacts. That these facts are now becoming better understood — alongside public awareness that dam removals provide real benefits to rivers, fish, and local communities — is a major achievement for river conservation.

Recreational Benefits

With the removal of the mainstem dams there is not only 157 miles of unimpeded fish passage, but also 157 miles of unimpeded boat passage, increasing run of the river boating opportunities and offering one of the longest

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free-flowing reaches of river in the west for multi-day trips. In addition, more high quality day trips have opened up with dams no longer blocking passage. The stretch of the Rogue River between Touvelle State Park and Fisher's Ferry takeout is now getting a lot more use from rafts, kayaks and drift boats. The area has become popular with sportfisherman, commercial rafting companies and fishing guides, drawn to the increased access and the number of new and productive runs that hold fish. The long term benefits of an improved salmon, steelhead and cutthroat trout fishery will surely enhance the recreational experience on the Rogue.

There is also improved public access to some 500 acres of public land located upstream of Gold Ray Dam site, and 3,000 acres of public land upstream of the Elk Creek Dam site, where the public is now enjoying new outdoor recreational opportunities.

Hope for Future

Three decades ago, the idea of removing dams to benefit fish and rivers conflicted with widely held values and beliefs. For many, dams were — and for some, still remain — symbols of progress and monuments to the control of nature. But not all dams are still providing the benefits for which they were originally designed. Many have become functionally or economically obsolete. Some have been abandoned.

Today, the negative impacts of dams on river systems and fish are much better understood. The growing number of successful removals of obsolete dams on fish-bearing streams has itself become a celebrated symbol of progress, and represents a fundamental change in our relationship with rivers. Dam removal is now recognized as a legitimate river management option for restoring rivers and fish runs. The communities of the Rogue Basin have good reason to be proud of our significant contribution to this profound change. Together, we are trailblazing one of the most successful dam removal and river restoration efforts in North America.

Author Jim McCarthy is Southern Oregon Program Director for WaterWatch. You can find out more about their work at waterwatch.org.

Dams Begone!

To date 8 Rogue River dams have been removed or decomissioned

Savage Rapids Dam

Savage Rapids Dam was a 39-foot high, 500-foot long irrigation diversion dam that spanned the mainstem of Oregon's Rogue River at rivermile 107. The structure's fish ladders and screens did not meet current standards, and at times the dam completely blocked upstream fish passage. Savage Rapids Dam had long been considered the biggest fish killer on the Rogue. It was removed in 2009, after a 21 year long legal and political battle led by WaterWatch. The dam's irrigation diversion function was replaced by a modern pumping system.

City of Gold Hill Diversion Dam

Gold Hill Diversion Dam was an 8-foot high concrete dam spanning the Rogue River a mile upstream of Gold Hill, Oregon. The dam was a defunct hydro-facility only used by the city to divert its municipal water needs. It had no ladders and was the second greatest barrier to fish passage in the Rogue River Basin. The diversion function was replaced by a new municipal water pump system, and the obsolete dam was removed in 2008.

Gold Ray Dam

Spanning the mainstem of the Rogue at rivermile 12, this 38-foot high, 360-foot long dam was built in 1904 to generate power, but by 1972, power generation at the dam ceased permanently because the facility was obsolete and no longer economically viable. At that point, Jackson County took ownership of the dam and agreed to its removal as it was a liability to the county. It was removed in 2010. With the removal of Gold Ray, the Rogue River flowed freely from the Lost Creek Project to the Pacific Ocean for the first time in 106 years — a distance of 157 miles.

Elk Creek Dam

This dam was a partially completed U.S. Army Corps of Engineers Dam spanning Elk Creek, completely blocking fish access to an important spawning tributary of the Rogue River. For decades, the Elk Creek Dam sat partially constructed and served no useful purpose. Historically, an estimated thirty percent of the Rogue Basin's coho salmon spawned in Elk Creek, alongside populations of Chinook salmon, summer and winter steelhead, and cutthroat trout. It was notched in 2008, allowing fish back to historic spawning areas.

Fielder and Wimer Dams

These abandoned obsolete irrigation diversion dams were located on Evans Creek another important Rogue River spawning tributary with 70 miles of high-quality salmon and steelhead habitat above the dams. The Oregon Department of Fish and Wildlife ranked them both among Oregon's top 10 statewide fish passage priorities. Both these dams were removed in 2015, based on landowner agreements secured by WaterWatch.

Gold Hill Irrigation District Diversion Dam

WaterWatch and others worked with the Gold Hill Irrigation District (GHID) to improve fish passage at its irrigation diversion system on the mainstem of the Rogue River. This project benefits spring and fall Chinook salmon, summer and winter steelhead, coho salmon, cutthroat trout, and lamprey. The changes in the diversion system, which were completed in autumn 2016, also increased flows in a one-quarter mile stretch of the Rogue River, improving navigation through Nugget Falls, and allow for safer public access.

Beeson-Robison Dam

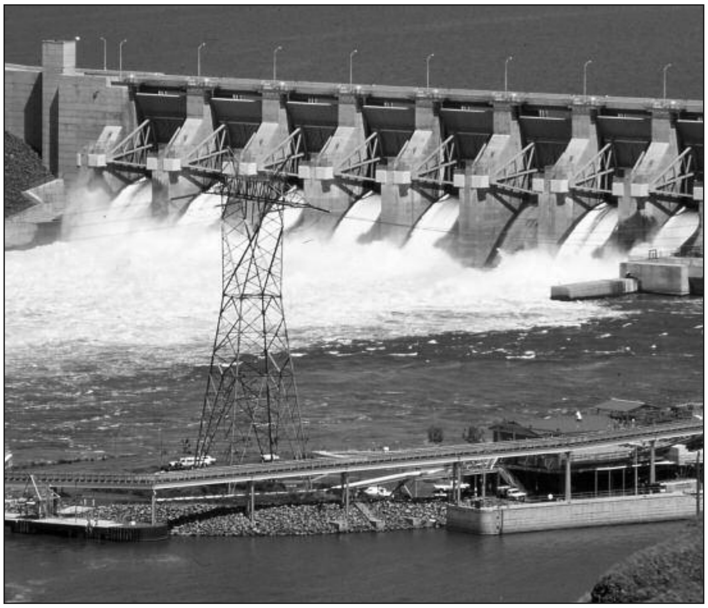
Removed by the Rogue River Watershed Council in partnership with the private landowners, Beeson-Robison dam was a 5.5-foot barrier during irrigation season and a 3-foot impediment in the winter for both adult and young salmon and steelhead accessing the cool water and spawning and rearing habitat of Wagner Creek, a tributary of Bear Creek. Workers installed a new concrete intake system and pipes, along with a flow meter, to ensure that water users receive their full water rights.

FISH WATCH — WILD FISH NEWS, ISSUES AND INITIATIVES

New Economic Analysis Makes Strong Case for Removing Snake River Dams

A recently released report — "Lower Snake River Dams, Economic Tradeoffs for Removal" — prepared by ECONorthwest makes a strong case that removing the four lower dams on the Snake River will return benefits to society far greater than with the dams in place.

The report notes that although the dams provide some hydroelectric power, that electricity could be easily replaced by other sources including emerging, cheaper renewable energy sources. About 2.2 million tons of agricultural products, primarily grain to be exported, are barged down the Snake River and through the locks at each dam. While barging is more cost effective than shipping goods by train or truck, the federal government spends more money on maintaining the river transportation system than the public gets back in benefits. Only 13 percent of farmland along the Snake River requires irrigation. Instead, for an estimated cost of $200 million groundwater wells and surface diversions should be upgraded.



Little Goose Dam is one of the four uneconomical dams on the upper Snake River that must come down if the river's wild steelhead and salmon are to avoid extinction. Photo by Jim Yuskavitch

Overall, the report concludes that the benefits of removing the dams and reducing the extinction of wild salmon and steelhead would exceed costs by more than $8.6 billion. The report further finds that removing the dams would result in a net increase of $505 million in net output of benefits, $492 million in value added, $408 million in labor income, and 317 year-round jobs.

The full report and executive summary are available at https://econw.com/projects. In addition, a series of articles providing an overview of the report is available at the Sightline Institute at https://www.sightline.org/series/the-case-for-removing-the-snake-river-dams/.

California DFW to Consider Listing Northern CA Summer Steelhead Under State ESA

The California Department of Fish and Wildlife (CDFW) has collected comments and information for the purpose of determining whether northern California summer steelhead should be listed under the state's Endangered Species Act.

The review process included soliciting information from the public regarding northern California summer steelhead ecology, genetics, life history, distribution, abundance, habitat, degree and immediacy of threats to reproduction or survival, adequacy of existing management measures, and recommendations for management of the species.

In September 2018, the Friends of the Eel River submitted a petition to the California Fish and Game Commission requesting to list northern California summer steelhead as an endangered species under the California Endangered Species Act (CESA). The petition described threats impacting the survival of the fish, specifically emphasizing habitat loss, alteration and degradation as a result of human impacts.

CDFW recommended that northern California summer steelhead be advanced to candidacy for CESA listing and the Commission voted in favor of this recommendation on June 12, 2019. The official findings of this decision were published on June 28, 2019, which triggered the start of a 12-month period during which CDFW will conduct a status review intended to inform the Commission's ultimate decision on whether to list the species.

The deadline for comments was September 22, 2019. CDFW will analyze the information provided in the comments, then produce a status review to be presented to the California Fish and Wildlife Commission followed by a 30-day public comment period.

The Osprey has recently covered this issue including: "Restoring Wild Summer Steelhead to California's Upper Eel River", *The Osprey* May 2019, and "On the Evolution and Conservation of Summer Steelhead and Spring Chinook", *The Osprey* January 2018.

The petition to list northern California summer steelhead is available at: https://fgc.ca.gov/cesa#ncss.

Bristol Bay Salmon Still at Risk from Proposed Pebble Mine

Late last July the US Environmental Protection Agency announced that it was withdrawing the clean water safeguards that it had previously required for Northern Dynasty Minerals proposed Pebble Mine within Alaska's Bristol Bay watershed. The mine would extract copper, gold and molybdenum from a 20-square-mile complex on lands owned by the State of Alaska. The proposed open pit mine would be up to 1,700 feet deep and over a mile long. A containment pond would be 10 square miles in size and hold up to 10 billion tons of mining waste.

While not yet a done deal, the EPA's recent decision helps

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A commercial fisherman with a Bristol Bay sockeye salmon. Bristol Bay habitat is one of the world's most important salmon producers. Photo by Härmägeddon

pave the way for the potential eventual development of the Pebble Mine, which would pose a serious threat to one of the world's most productive and valuable salmon fisheries.

The Bristol Bay commercial salmon fishery is worth $1.5 billion and provides 14,000 jobs, along with supporting a major recreational fishery of about 37,000 fishing trips annually.

In 2019, the Bristol Bay sockeye salmon run was 56.5 million fish, with 43 million harvested for a total value of about $304 million. In addition, commercial fishers harvested more than 30,000 Chinook salmon, 1.3 million chum salmon, 75,000 coho salmon and 5,600 pinks from the Bristol Bay fishery.

More information on the Pebble Mine, and the fight to stop it, can be found at: www.savebristolbay.org and www.wildsalmoncenter.org.

Northern Pike an Existential Threat to Columbia River ESA Listed Salmon

Non-native northern pike have established themselves in Lake Roosevelt, the reservoir formed by Grand Coulee Dam on the upper Columbia River, and present a potential serious threat to salmon and steelhead, primarily from predation.

The fish were illegally introduced by anglers into Montana waters, then turned up in Washington State in Box Canyon Reservoir on the Pend Oreille River in the northeastern part of the state. From there the pike have expanded their range into Lake Roosevelt. Northern pike surveys in Box Canyon Reservoir between 2004 and 2014 showed their population increased rapidly while the abundance of forage species such as minnows and frogs declined considerable.

Currently, WDFW and Tribes are trying to catch and remove as many as possible from Lake Roosevelt, and are offering Columbia River anglers a reward of $10 for each northern pike head they turn in.

To date, pike have not yet expanded into salmon habitat. But if this invasive species succeeds in establishing itself in other parts of the Columbia River below Grand Coulee Dam (which has no fish ladders and blocks further upstream salmon and steelhead migration), the Washington Department of Fish and Wildlife will regard it as an environmental emergency.

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