Ocean Acidification
Global Warming’s Evil Twin

by Caren E. Braby
— Oregon Department of Fish and Wildlife —

Ocean acidification is “sneaky,” quietly progressing without much notice while global warming gets all the attention.

Deservedly at the top of the list of the most concerning climate change impacts, ocean acidification (OA) is often referred to as global warming’s “equally evil twin”, a term first coined in 2009 by former NOAA Director and longtime Oregon State University Professor, Dr. Jane Lubchenco. Why does OA get this dubious title? Because it could be described as sneaky. Ocean acidification has been quietly progressing without much notice, while global warming (and even other climate-related impacts, such as sea-level rise) are arguably better-understood and have been receiving much of the media and policy attention.

OA is at heart a chemical change in ocean conditions due to absorption of atmospheric carbon dioxide (CO₂). In the Eastern Pacific Ocean, we have first-hand experience with this climate-related oceanic change – we are experiencing impacts today that will not be seen globally for decades. The increases in OA are resulting in biological responses that are likely to lead to broad ecosystem changes across the West Coast – probably changing what we think of as “normal” forever. While there is much we have yet to learn about OA and its impacts, we do know quite a bit about the resulting changes we are seeing in ocean chemistry and biology. And, we are seeing conversations emerge among industry members, researchers, policy-makers, and coastal communities about OA and the challenge of addressing and adapting to what lies ahead.

Whiskey Creek Shellfish Hatchery

Acidification ground zero is arguably at the Whiskey Creek Shellfish Hatchery, located in Netarts Bay, Oregon. This hatchery supports much of the oyster aquaculture industry across the West Coast, supplying larval and juvenile oysters to oyster growers in California, Oregon, Washington, and beyond. Whiskey Creek staff rear the young oysters, as well as the nutrient-rich algae that fuel the oysters to grow to a shippable size. Packets of larvae get sent overnight to oyster growers, who then entice the larvae to attach to oyster shells or other hard surfaces, after which they are called “spat”.

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FROM THE PERCH — EDITOR’S MESSAGE

The Storm Beneath the Sea

by Jim Yuskavitch

I like visiting the coast as much as anyone and try to visit as often as I am able despite the rather long four-hour drive from my home on the east side of Oregon’s Cascade Mountains.

While most people prefer to visit in the summer when the days are sunny and warm and the ocean fairly calm, I prefer to visit in the dead of winter when the Oregon coast is rainy and storm-battered. Storm watching is one of my favorite pastimes, sitting on a rock (or if the weather is really bad through my motel window) as great swells gather offshore and powerful waves crash against rocky headlands.

But below the unruly surface a storm of another sort is brewing, a sinister mix of climate and chemistry called ocean acidification whose effects scientists are just now beginning to understand.

This issue’s cover story, clearly told by Caren Braby, Marine Resources Program Manager for the Oregon Department of Fish and Wildlife, is a valuable primer on this looming threat to the world’s oceans.

As Braby relates, while climate change gets all the press, climate change’s evil twin, ocean acidification, is quietly doing its insidious damage. Particularly affecting ocean animals that use calcium carbonate to manufacture shells, the commercial oyster industry has been the first to suffer economically from ocean acidification, and oceanographers have been watching worriedly as coral beds around the world have declined and even died off from the same cause.

She points out that it is too soon to tell how ocean acidification may impact salmon and steelhead. I have a feeling we will find out soon enough.

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A s we add to our accumulat-ed knowledge over lifetimes, some things irritate us more. If we’re lucky enough, we let go of most.

Here are a couple of lesser irritants: Ever walk on the beach or leave your vehicle to fish a favorite spot? It’s virtually impossible not to see cigarette butts on the ground. What do they think? The ‘Cigarette Butt Fairy’ will be along to pick them up. I’ve heard the words ‘robust’ and ‘disingenuous’ enough for a lifetime.

And to argue, a more important irri-tant: Climate change deniers. Ross Gelbspan’s book, “The Heat Is On” was published January 1997. That was enough for me to understand something really big was up. There’s no denying Climate Change in 2016. Bill Nye, The Science Guy, author of a new book “Unstoppable” says it best: “We do have this non-trivial problem of having to get deniers out of the way. They’re trouble.” The Osprey has published several articles on climate and wild fish.

Wild salmonid fisheries are examples of the concepts of ‘Growth’ and ‘Sustainability’. How we view these terms has nudged my intellectual irri-tation bone for a long time.

Some commentators have recently pointed out that Gross Domestic Product [GDP] Growth is hovering around 2% and that 4% is required. The other ‘Growth’ of course is popula-tion. The US Census Bureau estimates the 2014 US population at 318.7 million. It projects in 2020 population will be 334.5 million and by 2050 398.3 million.

Those 80 million people will rely on GDP growth to provide jobs, housing, and infrastructure to have satisfactory lives here in the US. All that growth will undoubtedly place pressure on watersheds, rivers, etc. This is certainly not to the advantage of wild salmon and steelhead where they exist.

I first came upon the modern environmental uses of the term ‘sustain-ability’ when active with Acterra in the 1990s in Palo Alto ( www.acterra.org ). Acterra’s Business Environmental Awards [BEA] program covers the entire 9 County Bay Area and beyond. It includes education, government, and business enterprises as potential can-didates for awards. The BEA celebrated its 25th Anniversary in 2015. In 2007 Acterra and the BEA established its highest award, the Award for Sustainability. As part of the judging team in the first years, we visited some of the most well known regional entities who applied for the award. Acterra remains for me elite amongst front line environmental organiza-tions.

What these award applicants and winners analogously share with wild salmon and steelhead is the desire to continue indefinitely and endure.

The pillars of the ‘sustainability’ dis-cussion are energy, ecology, economy and social justice.

There are some great examples of ‘closed loop’ sustainability in natural systems. Undisturbed forests for example. However, two of my favorites are the Plains Indians and wild salmon and steelhead. The Plains Indians were nomadic. They moved from place to place with the seasons. Taking from the environment enough to sustain their lives and moved on as the seasons dictated. By the time the following year arrived, and they returned to the previous year’s season-al camp, not much had been changed or altered. Wild salmon and steelhead, given reasonably stable ocean conditions and largely unaltered rivers and watersheds, return year after year. I would argue examples of ‘closed loops’.

Wikipedia excellently summarizes my conflicted thoughts:

“Despite the increased popularity of the use of the term “sustainability”, the possibility that human societies will achieve environmental sustainability has been, and continues to be, ques-tioned—in light of environmental degradation, climate change, overcon-sumption, population growth and soci-eties’ pursuit of indefinite economic growth in a closed system.”

Wild salmon and steelhead grow to their maximum population and sustain those populations when least intruded upon by human actions!

This is my last column as Steelhead Committee Chair. A year volunteer commitment has passed quickly. The year 2015 was relatively (not completely) calm for wild fish. A few victories, few losses, in the widest view - not much really changed. Let us wish The Osprey great growth and sustain-ability.

The pillars of the “sustainability discussion” are energy, ecology, economy and social justice.
Ocean Acidification
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Oyster growers then transfer the spat out into the bays or estuaries for growing up to a marketable size for eating.

Whiskey Creek’s expertise is in mass production of larvae, which is an art as much as a science. The hatchery managers had been effectively producing larvae for decades. Then, unexpectedly, their skills were challenged in 2007, when they experienced inexplicable die-offs of oyster larvae. Initially attributed to bacterial infection, the die-offs continued even after the bacteria were under control. Over the next year of trial and effort in adjusting hatchery operations and working with researchers, water chemistry became a likely culprit. Connections between ocean currents, ocean acidification, and hatchery rearing success was laid out in a landmark peer-reviewed article by Alan Barton and other researchers in 2012.

How are operations at the hatchery today? The managers are successfully producing oyster larvae for the aquaculture industry, but they are doing it by carefully monitoring water chemistry and making necessary chemical adjustments to the culture water, primarily when summer upwelling brings “bad water” to their intake pump. For now, the adjustments are working. However, as ocean acidification worsens, their challenges in maintaining economically viable larvae production will likely grow.

Since the problems at the hatchery first began in 2007, a groundbreaking group of industry members, researchers and policy-makers, has risen to the challenge and collectively has discovered much about the causes and impacts of ocean acidification, locally. Equally notable, this group has brought global attention to this issue that threatens the productivity of oceans and the diversity of marine life worldwide.

Rising atmospheric carbon dioxide drives ocean acidification

The underlying causes of ocean acidification are based on the laws of physics, particularly the dynamics of how gases move from the atmosphere and dissolve (or are absorbed) into the ocean (Figure 1). Atmosphere-ocean gas exchange is constantly occurring, being that oceans cover 70% of the earth's surface. As more of a particular gas accumulates in the atmosphere, more of that gas is absorbed by the ocean. Since the beginning of the industrial era, atmospheric CO₂ (and other gases and particulates related to fossil fuel combustion) has increased at an unprecedented rate to a very high level (2015 marked the first year in modern history when CO₂ topped 400 parts per million, or “ppm”), which has led to more CO₂ being absorbed by the ocean. In fact, the ocean is recognized as one of the most important “sinks” of our growing atmospheric carbon problem, absorbing more than 25% of the globe’s combustion-generated CO₂ (with plants and atmospheric accumulation accounting for most of the remainder).

Figure 1. Atmospheric carbon dioxide (CO₂) is absorbed by the ocean and causes the water to become acidified. Acidified water is one of a multitude of stresses associated with climate change that threatens marine animals, especially those that make calcium carbonate shells. (Figure credit: Kelsey Adkisson, ODFW)
Ocean currents bring deep, old, acidified water to Oregon’s shore

Even if we were to stop combustion-generated CO₂ TODAY, we would continue to see a rise in acidification for decades to come. How can this be? The ocean water that reaches Oregon’s shore during summer upwelling has a CO₂ “signature” from the Kennedy era (when atmospheric CO₂ concentration was 320 ppm). The more acidified water from today’s gas exchange (when atmospheric CO₂ is at 400 ppm) is just now sinking in the North Pacific, being converted into deep ocean currents that will reach Oregon 50 years from now.

Here’s a rough sketch of how this all works. The ocean looks like one big pool of water but it is layered, like a big wedding cake. Ocean currents crisscross the ocean at different depths. Each layer can have a unique temperature and unique chemistry based on where the layer was generated – these unique characteristics form a “signature” for each layered water mass. Just like air masses in our atmosphere, cold water sinks below warmer layers of water. Because of this dynamic, cold water in polar seas sinks and moves below warmer water masses, generating much of the movement of deep ocean currents. At some point, these currents are pushed back up to the surface elsewhere on the globe. A newly-completed video describing this is now available for anyone to view or use, at www.OregonOcean.info.

Complicating this ocean currents story, cold ocean water can absorb more CO₂ gas than can warm water. Cold polar waters are therefore supercharged with CO₂, before they sink below the surface. Because the deep currents are isolated from the atmosphere, organisms use up the oxygen and produce additional acidifying CO₂, which is trapped deep in the ocean until it later reaches the surface and reestablishes gas exchange with the atmosphere.

In the North Pacific, off the coast of Japan, there is an area that generates two of these deep currents. One current travels eastward to the US West Coast, taking approximately 10 years to reach Oregon’s shore. Another current takes approximately 50 years to travel south to the equator, then up the coast from Ecuador, to Mexico, California, Oregon, and beyond. It is these deep, acidified waters that are upwelled each spring and summer along our coast and that continue to cause problems for oyster larvae production at the Whiskey Creek Shellfish Hatchery. But it is not just oyster culture that is at risk – it is all marine organisms that are exposed to acidic conditions. At present, we do not know enough about which species are vulnerable, or which locations will be “hotspots” of extreme OA. Now, the race is on for researchers to understand who will be next to show symptoms from our acidifying coastal waters.

What we know about ocean acidification now
(Available on www.OregonOcean.info)

1. Ocean water is rapidly becoming more acidic.

In less than two centuries, ocean acidity has increased worldwide by 30%. This rapid change is a result of human-generated CO₂ being emitted into the atmosphere, which is absorbed by the world’s oceans and increasing every year. CO₂ absorption reduces the pH, causing increased acidity that reduces carbonate, a key component of sea water. Reduced carbonate can have detrimental impacts to marine life, particularly to organisms that use it in making their shells. Increasing OA has been tracked for several

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Long-term datasets positively correlate human-generated atmospheric CO₂ production with increases in ocean acidification.

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Animals that require calcium carbonate to produce shells such as mollusks and corals have been among the first ocean creatures to suffer from ocean acidification. Photo by Jim Yuskavitch
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decades by hundreds of researchers worldwide. These long-term datasets positively correlate human-generated atmospheric CO₂ production with increases in OA.

2. Coastal Oregon and the West Coast are particularly vulnerable to OA and hypoxic zones.

The compounded effects of natural and human-generated factors increase the intensity of OA off Oregon, exacerbating the impacts from seasonal hypoxic zone formation. Naturally occurring seasonal upwelling of acidified deep ocean waters is a component of the Pacific Northwest’s ocean carbon chemistry processes. This natural occurrence results in fluctuating acidity levels throughout the year. Concurrently, low oxygen hypoxic zones form in nearshore areas. Hypoxic zones occur when oxygen becomes so depleted from decomposition that seawater can no longer support most aerobic marine life.

The oyster industry has already been seriously affected by ocean acidification and it may only be a matter of time before it harms other fisheries. Photo courtesy Pacific Shellfish Institute

Oregon’s marine species are accustomed to seasonal encounters with both upwelling and hypoxic zones. However, human-released CO₂ (and related factors) is intensifying the natural fluctuations so that they are more extreme and more frequent, resulting in acidic conditions that are intolerable to some species. For some species, even small changes in ocean carbon chemistry can cause very significant problems.

3. Organisms that use carbonate in their shells are already showing negative impacts from acidification.

Many sea animals including oysters, clams, mussels, corals and some plankton species use abundant dissolved calcium and more limited dissolved carbonate from ocean water to form their calcium carbonate shells. As CO₂ has risen, the availability of carbonate has decreased, making it more difficult for these and related organisms to produce and maintain their shells. Sensitivity to pH fluctuation has already been demonstrated in pteropods, free swimming sea snails, which are an integral component in marine food webs. Reduced pH levels can result in pteropod shell deformities, dissolution of shell exterior, and lower rates of shell development. The ripple effect that this will have on food webs is unknown.

4. Different species react differently to changing seawater chemistry.

OA will not kill all ocean life. However, many scientists agree that there will be changes in the number and abundance of marine species. With significant impacts already occurring to larval shellfish and plankton species, scientists are also concerned about amplified impacts to species higher in the food web that prey on these organisms. For example, threats to crab larvae may not only have implications for crab harvests, but could also affect survival rates of juvenile coho and Chinook salmon that rely on the larvae as an important food source. As a response to changing ocean chemistry, we might expect that some marine ecosystems will be populated by different, and potentially fewer, species in the future.

5. Oregon’s economy is already being negatively impacted by OA.

The Whiskey Creek Shellfish Hatchery appealed to Oregon researchers to help them with failed production in their hatchery. The story of the discovery of the role of OA in this hatchery failure has become well-known in the Pacific Northwest and even world-wide. Seawater chemistry modulation of their mariculture tanks has made it possible for Whiskey Creek to continue its business, but it is now more complex and expensive to maintain productivity at past levels. At least one other Pacific Northwest shellfish hatchery has given up and left the area due to challenges associated with maintaining production in the face of intensifying OA. Much less known but with greater potential impacts, are the effects of OA on wild populations in Oregon that are facing OA outside of controlled hatchery settings. Scientists and fishery managers are concerned that the fishing industry may also be vulnerable to OA. While wild fish population impacts have not yet been linked to OA, as OA and hypoxic zones increase in frequency and intensity, experts anticipate that linkages will emerge.

Beyond Whiskey Creek – Taking Action in Oregon and the West Coast

There are a number of initiatives afoot to increase the understanding of the science and build it into sound policy, with the overall goal of adapting to ocean acidification and other climate-related stressors on the West Coast. In 2011, the State of Washington convened a Blue Ribbon Task Force, comprised of regulators, researchers, industry members, and other stakeholders, to determine how to address OA locally, within that state. Then in

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2013, California initiated a science panel (which quickly grew to include members from Oregon, Washington and British Columbia) to conduct a comprehensive review of the science of ocean acidification and hypoxia, guided by specific questions and information needs of West Coast resource managers. The West Coast Ocean Acidification and Hypoxia Science Panel ("science panel") has been working for over two years to provide strategic recommendations that can be used by resource managers – and they have nearly completed their work.

The next steps will be critical – since there is always more to be done than there is time or money to accomplish. The task at hand, following on the heels of the science panel, will be to find the most strategic actions to take.

At the Forefront of Determining the Most Strategic Actions

The Pacific Coast Collaborative (including Governors from California, Oregon and Washington, and the Premier of British Columbia) has been spending considerable time preparing for the handoff from the science panel, including convening state agencies, meeting with federal partners and pursuing policy-development opportunities. The California Ocean Science Trust, which has staffed the science panel, will also play an important role in facilitating the path from science to policy.

We need help addressing this global problem - the time to act is now.

Ocean acidification is a big problem, which will require global political change to fully mitigate. But there are many things we can do locally to make our future less extreme. What can you do as an individual? Stay informed on ocean issues, especially on climate change and ocean acidification (one place to start is with the Mathis et al 2015 article that introduces an entire issue of Oceanography, dedicated to OA). Support ocean research. Talk to the people you know about these issues, to raise awareness. Engage in sound policy development, targeting climate and OA issues. And overall, do what you can to be a good steward of our climate and of the ocean.
Ocean Acidification

Acknowledgements

The work above represents leadership and contributions from many who are not listed as co-authors; their intellectual contributions have been repeated and repackaged in this article by me. In particular, the leadership of the members of the Oregon Fish and Wildlife Commission, Whiskey Creek Shellfish Hatchery managers, West Coast Ocean Acidification and Hypoxia Science Panel members (Oregon members: Jack Barth, Francis Chan, Burke Hales, George Waldbusser, Waldo Wakefield), and representatives from the Governors’ offices (California, Oregon, Washington) and Premier’s office (British Columbia), who have identified the problem and are pursuing adaptive solutions to meet this challenge collaboratively. In addition, I acknowledge the federal leadership to build the Interagency Working Group on Ocean Acidification, and invest in ocean observing, research and education on this issue.

References for Further Reading


Websites

Oregon Ocean Info (Ocean Acidification tab – includes link to the new video on ocean acidification)
www.OregonOcean.Info

West Coast Ocean Acidification and Hypoxia Science Panel
http://www.oceansciencetrust.org/project/west-coast-ocean-acidification-and-hypoxia-science-panel/

Pacific Coast Collaborative
http://www.pacificcoastcollaborative.org

Interagency Working Group on Ocean Acidification
http://oceanacidification.noaa.gov/IWGOA.aspx

Lawsuit Filed to Protect Puyallup River Salmon

A coalition of conservation organizations has filed a lawsuit against the Electron hydroelectric project on the Puyallup River, Washington to protect Puget Sound wild Chinook salmon, steelhead and bull trout.

The federal government knows that the dam kills and injures ESA-listed Chinook salmon and steelhead, but has allowed the dam owners to continue to ignore the Endangered Species Act, specifically Section 9 of the Act, which prohibits any person from “killing, trapping or harming an endangered species.”

Previously operated by Puget Sound Energy, the hydro project is now owned by Electron Hydro LLC. The lawsuit asks that the project’s operations be reviewed and modified to be compatible with salmon and steelhead recovery.

Historically, the Puyallup had Chinook salmon runs of about 42,000 wild fish annually, now down to about 1,300. In 2007, Puget Sound steelhead were listed as Threatened under the ESA, and were once much more abundant in the river.

The Puyallup River, which flows from Mt. Rainier to Commencement Bay in Puget Sound, is one of eight “core areas” for bull trout in the Puget Sound region, and a local population exists in the upper Puyallup River, where higher elevations produce the cool water temperatures they require.

In 1999, the U.S. Fish and Wildlife Service listed the populations of bull trout in the Coastal/Puget Sound region in Washington, including in the Puyallup River, as threatened with extinction under the ESA.

In 2004, USFWS issued a draft recovery plan for Coastal/Puget Sound bull trout, which lists an abundance target for bull trout in the Puyallup River at 1,000 adults. By contrast, as of 2004 the population was fewer than 100 adults.

The lawsuit was brought by the Western Environmental Law Center on behalf of American Rivers and American Whitewater.
A New Look to the Rogue
Rogue River Basin Leads Paradigm Shift on Dams

By Jim McCarthy and Bob Hunter
— WaterWatch —

Jim McCarthy lives in the Rogue Valley, and is Communications Director and Southern Oregon Program Manager for WaterWatch. Bob Hunter is a WaterWatch board member and previously the lead staff person for WaterWatch's “Free the Rogue Campaign.” Learn more about WaterWatch at: www.waterwatch.org

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 Oregon’s Rogue River 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.

The Rogue River in southwestern 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 important spawning tributaries severely impacted Rogue basin fish. After persistent leadership over three decades from WaterWatch of Oregon, Savage Rapids Dam, the City of Gold Hill Diversion Dam, and Gold Ray Dam were finally 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.

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. With the removal of these three dams, salmon and steelhead are now showing up at the hatchery at the base of William Jess Dam two weeks earlier than they have ever been observed. This gives some evidence of the delays the dams caused.

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. 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 River 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.

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 in 2015 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 trout, with some over 20 inches.

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 River inundated by water and silt behind
what used to be Savage 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 notchling 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 pikeminnow, 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.

Restoration of Natural River Processes

The removal of the dams helps restore natural river processes such as sediment transport, gravel recruitment, and increased floodplain 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, which 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 are 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 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 anglers, 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.

Elk Creek Dam, on a major tributary of the Rogue, was notched in 2008. Photo by Jim Yuskavitch

Fish Abundance

One of the big questions in connection with the Rogue dam removals is how to quantify the total increase in fish numbers. Unfortunately, this is hard to nail down because of all the other factors affecting fish runs. Ocean conditions and flow conditions
can mask the benefits from these dam removals. On top of this, it will take a few generations of salmon and steelhead going through their varied life cycles before some of the benefits are fully realized. 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. 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 the future.

Momentum for More Restoration in the Rogue

The success of the Rogue dam removals has created momentum for additional barrier removal and other river restoration projects in the basin. This year 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 damsites. This diversion was the most harmful remaining on the mainstem Rogue below the William Jess Dam and will complement the benefits of the mainstem dam removals.

Four watershed councils merged last year, creating the Rogue River Watershed Council, which now has greater capacity to deliver high quality restoration projects in the Upper Rogue Basin. Watershed councils and other groups doing restoration in the basin have 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. Information is now being developed on an additional thirty-three high impact barriers on Rogue Basin tributaries. As we celebrate the major accomplishments that have been achieved, we hope to see the continued restoration successes in the Rogue Basin.

A Roundup of Dams Recently Removed on Oregon’s Rogue River System

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 hydrofacility 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 125, 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, 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.
A Great Lakes Lesson in Local Adaptation and Naturalization

By Brain P. Morrison
— Ganaraska Region Conservation Authority—

The Great Lakes endemic fish community has been significantly altered or lost due to deforestation, overfishing, pollution, and invasive species. Concurrently, the Great Lakes have also acted as a large-scale unplanned experiment of species recovery (e.g., lake trout) and introductions involving colonization, establishment, local adaptation, and naturalization. In essence, the Great Lakes can be viewed as a microcosm of what could happen when fish have some latitude to display their life history and behavioral plasticity across a broad suite of environmental variables. An analogy would be Darwin’s finches, which are polymorphic for various traits (e.g. beak size), which offer different survival advantages based on the current environmental conditions.

In a previous edition of The Osprey (September 2010), steelhead (Oncorhynchus mykiss) within a single watershed were viewed within the context of local adaptation that has occurred since introduction in 1890. Within this summary I highlight local adaption of other Pacific salmon (Oncorhynchus sp.) across the Great Lakes. A symbol of the ecology of Pacific salmon is their ability to colonize and thrive in a wide variety of habitats. This will be explored through the unique traits (local adaptation) that have developed for species that have been introduced and are now naturalized across the Great Lakes. These include traits that are novel from source populations. The Great Lakes also host a variety of habitat types, with the physical conditions being diverse and variable over time and space. Each species vignette is based on the existing literature, along with field observations primarily from Ontario’s side of the Great Lakes, that are sustained by natural reproduction.

Pacific salmon were most recently (1960s to present) introduced as part of an attempt to restore balance and ecosystem integrity back into the Great Lakes. Commercial harvest, introduced sea lamprey (Petromyzon marinus), and pollution reduced the number of top predators in the lakes, while prey fish species such as alewife (Alosa pseudoharengus) experienced unprecedented population sizes. Pacific salmon were introduced to reinvigorate lagging recreational and commercial fisheries (Tody and Tanner 1966), while utilizing/controlling the superabundant “trash” fish (e.g. alewife), and act as a new top trophic species within the lakes. A secondary goal from these early introductions was to develop naturally reproducing populations, which would be given management priority over their hatchery conspecifics (Tody and Tanner 1966). As a contingency plan, scientists were contemplating introducing striped bass (Morone saxatilis) as an alternative, if Pacific salmon were not able to meet the cultural and ecosystem goals set for them. Since these stocking events, the success of Pacific salmon, and the ensuing recreational fisheries, a profound cultural significance is now associated with these species in the Great Lakes.

Chinook Salmon

Chinook salmon (O. tshawytscha) were first introduced in the Great Lakes in 1874, from eggs provided by Spencer Baird from California (McLeod River, Sacramento River drainage). The first documented adult return was in 1877, but limited returns were noted, and stocking ceased in 1881 for Lakes Ontario, Erie, and Superior. Ontario initiated a second attempt to introduce Chinook salmon from 1919 to 1925, but based on limited adult returns, and very little documented natural reproduction, these efforts were discontinued. It is believed that approximately 9.3 – 11 million Chinook salmon were stocked between these two stocking eras. The bulk of the contemporary Chinook stocking initiatives began in 1967 by Michigan (800,000 juveniles), and stocking of all the Great Lakes was occurring by 1971. These efforts were conducted using source fish from the Green River, Washington, and are considered to be ‘tule’ lower Columbia River strain. Chinook salmon from Puget Sound have also been included within hatchery programs, in addition to a spring run strain from Idaho and Washington, that was introduced into Lake Superior. Survival from these stocking events was exceptionally high, with over 100,000 Chinook caught in Lake Michigan during the 1969 season alone. Despite strong returns to the U.S. fisheries, Ontario was only

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seeing limited returns to Lakes Ontario, Erie, Huron and Superior during the 1970s. Between 1967 and 1998, approximately 336 million Chinook salmon were introduced, primarily on the U.S. side of the Great Lakes.

Chinook salmon fisheries in the Great Lakes were believed to be sustained by hatchery supplementation programmes. By the early 1980s as much as 23% of caught salmon were of wild origin (Carl 1982). In addition, stray hatchery Chinook were colonizing tributaries that had never been stocked. More recent studies show that approximately 99% of Chinook on the Ontario side of Lake Superior are of wild origin, 75% on Lake Huron (92% in Georgian Bay), and approximately 50% in Lake Ontario. Only Lake Superior does not receive substantial supplementation programs. It is now evident that wild reproduction is widespread and many populations are now self-sustaining.

As part of the colonization and naturalization of Chinook salmon across the Great Lakes, unique traits began to emerge. For instance, during May of 1983, spawning adults were observed in the Michipicoten River (Lake Superior) (Kwain & Thomas 1984). Since this first documentation, this life history trait has been found on tributaries of Lake Huron and Lake Ontario. Spring spawning has only been documented in one population within their native range, the Sacramento River. These spring spawning individuals are derived from parental stocks that may have spawned in November and December, but in some Great Lakes rivers, the temperatures could be too cold to initiate embryonic development (Behnke 2010). Spawning for fall run individuals can occur as early as July. An extreme example is for the Nottawasaga River (Lake Huron basin), where during July and August adult Chinook Salmon will migrate approximately 30 km upstream through warm (25-30°C), low gradient river prior to reaching their first cold water refugia, and primary spawning tributary, the Pine River. Chinook salmon have also been documented to spawn on open lake shoals (Powell and Miller 1990). The presence of young have been observed in open lake habitats, suggesting there is some natural recruitment from this spawning strategy, but it’s significance/persistence is limited at best. Chinook salmon have also been documented to use a wide breadth of depths while living in the lakes. Bergstedt (2010) documented adult Chinook salmon using habitats as deep as 750 feet in Lake Huron, which is the deepest part of the lake.

Selection has come from other interesting means. From 1988 to 1992, large fish die-offs affecting Chinook salmon occurred in Lake Michigan. Cumulative stressors were the driving cause, but the disease Bacterial Kidney Disease (Renibacterium salmoninarum) was found regularly associated with dead individuals. Following these die-off events, Great Lakes populations had greater resistance to R. salmoninarum exposure when compared to their source population, the Green River. A reciprocal transplant experiment shows that the Great Lakes population demonstrated significantly higher mortality when exposed to the marine pathogen Listonella anguillarum (causative agent of vibriosis), when compared to the Green River (Purcell et al. 2008). Despite a continued close genetic tie, this suggests that Great Lakes Chinook exposed to R. salmoninarum have diverged from their ancestral population in response to pathogen-driven selection.

Suk et al. (2012) looked at genetic population structure across 13 watersheds within the Ontario side of Lake Huron, including Georgian Bay, using microsatellite markers. They determined that within as little as 10 generations, there was low, but statistically significant, genetic differentiation. This demonstrates that natural reproduction in combination with strong selection is driving local adaptation processes and emerging genetic population structuring similar to Chinook introduced elsewhere (e.g. New Zealand – Quinn et al. 2001), where run timing, life history, and genetic differentiation has developed for each population/watershed, from a shared common ancestry.

Haw (2015) has hypothesized that a contributing element to the overwhelming success of Green River strain Chinook salmon within the Great Lakes and elsewhere is tied to the long history of watershed alteration, habitat loss, pollution, and demographic constraints that the population endured, and the resulting broodstock has traits that enable colonization success in habitats that have also been altered. However, this idea has not been tested.

Pink Salmon

Pink Salmon (O. gorbuscha) were first captured in a tributary of Lake Superior in 1959, which sparked a search to determine where the individuals came from, as there were not records of any management agency...
Continued from previous page

attempting to introduce Pink salmon in the Great Lakes. After searching, managers discovered that approximately 21,000 fry were accidentally released into an Ontario tributary in 1956. Pink salmon were originally brought from the Lakelse River (Skeena River drainage, British Columbia) to develop a recreational and subsistence fishery for First Nations people in Hudson and James Bay. The latter project ultimately failed, but the small release into the Great Lakes was successful at establishing naturalized populations (Kwain & Lawrie 1981). From their first detection, within 20 years, pink salmon had colonized Lake Superior, Lake Huron (1969), Lake Michigan (1973), and also deviated off their obligatory two-year Pacific life cycle to develop even and odd year runs. Adults were found to mature at both age 1 and age 3, in addition to the typical age 2 (Kwain & Chappel 1978). By the late 1970s, Pink salmon had successfully established the entire Great Lakes, with naturally reproducing populations documented in tributaries to all the lakes (Dermott 1982). As population sizes increased, greater effort was expended to document population dynamics. In one Ontario tributary to Lake Superior, by the late 1970s, it was estimated that greater than 90,000 adults returned! What makes this even more incredible is the early belief that pink salmon would not persist within an entirely freshwater environment, since they do not have any populations within their endemic range that are entirely landlocked. Lakelse River pink salmon were also introduced into Newfoundland and Puget Sound, and in addition to Hudson Bay, were unsuccessful (Quinn 2005), but succeeded in the Great Lakes likely due to dumb luck, past ecosystem changes (high phosphorus loading, shifts in native fish community) along with an unanticipated match between genetics and local environments. In addition to significant population sizes documented, it was also noted that pink salmon would feed while on their spawning migration. Of over 600 stomachs analyzed within one river, 15% contained food, consisting of terrestrial insects, fish, and zooplankton. Pink salmon have also been documented to hybridize with Chinook salmon in the St. Mary’s River, creating hybrids called pinooks.

Coho Salmon

Coho Salmon (O. kisutch) have been introduced from a variety of source populations, including the Skagit River, Columbia River and Cascade River. Initial stocking events occurred in the 1870s, but it is believed that large scale stocking in the late 1960s led to the current levels of abundance, and the development of naturalized populations within the Great Lakes. Successfully established across all Great Lakes, coho salmon do not seem to have deviated from their juvenile or adult life history traits, with one year in nursery streams and one to two years spent in the lake prior to spawning being the only life histories expressed.

Kokanee Salmon

Kokanee salmon (O. nerka) is a fresh-water form of sockeye salmon, native to the western half of North America. Ontario’s largest introduction of kokanee salmon occurred in Lake Huron from 1964 to 1969, using source populations from British Columbia, Colorado, Montana, and Washington (Collins 1971). These included a mix of source populations that had riverine and lacustrine spawning traits. In total, approximately 5.5 million kokanee salmon were stocked (inclusive of eggs, fry, and fingerlings). From these plantings, individuals returned to stocking sites, as well as strayed into new portions of the lakes. Adults returning ranged from 18 to 49 cm in length, and were in their third year of life. In addition to efforts in Lake Huron, kokanee were also introduced into Lake Ontario, with over 3 million stocked between 1969 – 1972 (Wainio et al 1975). Successful spawning in some streams and shorelines was documented, but over the long term kokanee did not persist within the Great Lakes.

Prior to the release of kokanee into Lake Huron, the Ontario Department of Lands and Forest stocked 250 yearlings into Boulter Lake (Hastings County) in June 1960 (Fallis 1970). These fish were a riverine spawning stock from Kootenay Lake, British Columbia. Mature kokanee were captured during the late summer and fall of 1963, indicating the initial stocking event was successful. Based on this success, an additional 920 fingerlings were released in 1965, raised from gametes collected during the fall of 1964 (Fallis 1970).

Boulter Lake is a 41.1 hectare oligotrophic lake, with a mean depth of 9.3 m, and a maximum depth of 23 m. Spawning was completed within the lake over an area of cobble and coarse gravel, with mature adults being captured from September to April. The bulk of the spawning kokanee were collected during November and December. During 1970 sampling, 184 mature Kokanee were captured (106 males and 77 females). Males had an average fork length of 286.7 mm (range 258 to 370), while females had an average fork length of 288.2 mm (range 257 – 317). The age structure of the fish comprised four ages (age 0 up to age 3+), which is consistent with other kokanee salmon populations (Collins 1971). Fish aged 2+ and 3+ comprised the adult spawning population.

The success of kokanee salmon introduction in Boulter Lake shines, relative to other introductions, especially based on the number of individuals stocked. In George Lake (southwest of Sudbury), 80,600 fry and fingerlings were introduced in 1966/67, but no adults were recovered (Fallis 1970). Similar to introductions within Lake Huron, adults were captured and successful spawning was documented, but the populations were not able to persist over time. Despite the antiquated nature of these studies, it is believed that kokanee salmon still persist within Boulter Lake.

It is hoped this paper will help to set a baseline on where species can develop adaptive traits, and provide examples of this plasticity in salmonids and align with Lichatowich and Williams (The Osprey, May 2015) demonstrating the incredible persistence of animals to survive and prosper given opportunities to do so. Additionally, it is wished that these species vignettes can be used to help restore wild populations across their native range.
Letters to the Editor

Dear Editor:

I have worked for the Yakama Nation fisheries program since 1986. I enjoyed reading Faith in Nature by Jim Lichatowich and Richard Williams in the May 2015 issue of The Osprey and agree with the authors’ “faith in nature” position, having witnessed the tremendous intrinsic productivity of salmonid populations when environmental conditions line up. However, I find myself at odds with their interpretation of the history of salmon declines in the Columbia Basin. This interpretation reflects the views of a cadre of critics who insist on blaming the status of salmonid populations in the Columbia Basin on the management systems many of them were a part of during their professional careers. These critics generally rest their arguments on the flawed perception that salmon management and salmon managers operate in a cloistered, science-based community somehow removed from the industrial and political priorities that shaped, and continue to shape, the Columbia Basin of today. By giving only passing allusion to the catastrophic history of ecosystem destruction over the last 150 years, the authors unfairly feed the impression that the status of salmonid populations today is the result of deliberate and strategic poor judgment by salmon managers who most often were simply responding to political priorities and decision processes over which they had little influence. Their theory perpetuates the myth that the remedies for the wholesale destruction of salmonid ecosystems can be found within salmon management systems by applying the “right” science-based management policies. Salmon management does not exist within a closed system where better science and smarter managers will overcome the disruption of salmonid population dynamics caused by human development of the Columbia Basin.

If we want to correct a problem, we must properly diagnose its cause. I won’t argue that the management of Columbia Basin salmonid populations is perfect; my exposure to tribal perspectives has led me to conclude that proper management is not human management of ecosystems but, rather, management of humans in ecosystems. However, in the face of the great diversity of demands on the Columbia Basin for human economy and population growth, singling out past and present salmon management systems as the cause and cure for salmon declines makes as much sense as, to paraphrase Ed Chaney, stomping out cigarette butts while the house burns down. The fact is, wild salmon need wild rivers, and no amount of tinkering with management systems or faith in nature will alter that inconvenient ecological truth.

Steve Parker
Yakama Nation Fisheries Program
White Salmon, WA
The 2015 Drought
Things Heat Up for Salmon and Steelhead

By Jim Yuskavitch  
— The Osprey —

The drought that struck the Western US last year had wide ranging impacts both on the environment and the daily lives of the region's residents. Water use austerity was imposed on California residents as their lawns went brown, wildfires burned bigger and hotter in Western forests, and the amount of water used by the agriculture industry came under increasing scrutiny. Along the West Coast, severe drought conditions that included low water and high temperatures played havoc with Pacific salmon, steelhead and trout populations.

According to a December 4, 2015 report by The Columbia Basin Bulletin, conditions were fairly unremarkable from October 2014 through March 2015 when precipitation across the basin ranged from 70 to 100 percent of normal. But in April, drought conditions hit, with precipitation — including both rain and snow — at 50 to 90 percent of average depending upon the particular region within the basin.

Throughout the first three months of 2015, temperatures in the southern Columbia River basin averaged as much as 6 degrees Fahrenheit above normal, eventually expanding to the entire basin. In January 2015, except for the Snake River basin, which had slightly more snow, snowpack through the Columbia River basin was 50 percent or less of normal and the Cascade Mountain range was down by 50 percent. The Columbia River water supply, which is measured at The Dalles Dam, was originally estimated to be 83 percent of normal, but turned out to be 67 percent. As the year went on, temperatures and precipitation began to creep back towards normal, lessening the drought's impact somewhat.

That was not necessarily much comfort for the salmon and steelhead. By mid-June, water temperatures in the Columbia River had hit 70 degrees Fahrenheit — too much for many of these coldwater species to cope with. Streams across California, Oregon and Washington became lethally hot and low for salmon and steelhead. In Washington, in June, for example, the

2015 was the hottest year on record worldwide and the second hottest recorded in the Unites States.

Adult Fish

Adult salmon could have difficulties reaching upstream spawning grounds if river flows remain below normal.

Some salmon species spawn in channel margins, side channels, and smaller tributaries. If those areas are unavailable because of low flows, some fish would have to spawn in mainstem waters, where salmon redds could be lost when flows drop. In the fall, redds in the mainstem also would be more susceptible to bed scour resulting from high water or flooding.

Warm water temperatures can increase the likelihood of outbreaks of certain diseases in adult fish populations, especially fungal and bacterial diseases, possibly leading to fish kills or reduced reproductive success.

Juvenile Fish

Downstream migration of juvenile salmon in the spring is linked to the surge in stream flows created by runoff from melting snow in the mountains. With most mountain snow packs gone, there could be changes in the migration patterns of young fish attempting to reach saltwater to continue their life cycle.

Juvenile salmon, trout and other fish species in smaller streams could become stranded in isolated pools during low stream flows.

Warmer-than-normal stream temperatures and low dissolved-oxygen levels in isolated pools can be lethal to fish, and juvenile fish trapped in small pools are susceptible to predators such as birds and raccoons.

Warm water temperatures also

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increase predation on juvenile salmon and steelhead by warm water fish species, such as northern pike minnow and smallmouth bass.

Impacts on Fish Hatcheries

Poor water quality, high temperatures and reduced water supplies can result in an increase in fish disease, treatment costs and mortalities at fish hatcheries.

A lack of water would require some facilities to pump water from deep wells, adding significant costs to operations.

Early releases of juvenile salmon and trout – plus additional stress related to handling, trucking and relocating those fish – will increase mortalities.

Structures that allow adult salmon and steelhead to return to hatcheries may have to be modified to provide passage to the facilities.

Impacts on Recreational Fishing

Fishing in rivers could be restricted if stream flows are low enough to create obvious passage problems for fish. Salmon and other fish species can become isolated and stressed by high water temperatures and low flows, making them more vulnerable to increased fishing pressure or illegal fishing activity.

Access to some freshwater fishing areas could be restricted if lake and river levels recede to a point where boat ramps are unusable.

Over the course of 2015, many of the above situations and outcomes came to pass.

High Water Temperatures Kill Fish

In June 2015, the Oregon Department of Fish and Wildlife identified high water temperatures as the main cause in the deaths of spring Chinook salmon in the Willamette River and in some tributaries. Salmon begin to come under stress, and are more susceptible to diseases, once water temperatures exceed 60 degrees Fahrenheit. By June, water temperatures in the Willamette River had ranged from 70 to 74 degrees, while temperatures in the Clackamas went as high as 64 and up to 66 in the Santiam River. In July 2015, water temperatures on the North Umpqua River exceeded 71 degrees.

Early the following month, ODFW reported finding a number of dead and distressed sockeye salmon in the lower Deschutes River, although the fish had actually been bound up the Columbia River and probably swam into the Deschutes in search of cooler water. The salmon were determined to have died from a bacterial infection called columnaris that affects fish when water temperatures are high and dissolved oxygen levels low. Ultimately, at least 250,000 sockeye salmon, half the total Columbia River sockeye run, died from high water temperature related causes. Some of these fish fruitlessly sought a coldwater refuge in the White Salmon River, as they had in the lower Deschutes. Concerned that the endangered run of Redfish Lake sockeye salmon might be threatened, Idaho Department of Fish and Game captured Idaho-bound sockeye and took them to a hatchery so they could recover in cool water. Also in July, more than 100 wild spring Chinook salmon died in the upper Middle Fork John Day River due to low flows and high water temperatures.

While there wasn’t much fishery managers could do about the drought, some efforts were made to help fish where possible. On the Sol Duc River near Forks, Washington Department of Fish and Wildlife crews put 400 sandbags out to narrow a part of the river to deepen the water, making it easier for salmon to pass upstream to spawn. In California, Governor Brown signed an executive order, “A Proclamation of Continued State of Emergency” that allowed some environmental reviews to be bypassed so that more than a dozen water and stream-related projects that would help fish and fish habitat could move forward. High water temperatures in the Sacramento River threatened that stream’s run of ESA-listed Chinook salmon, which had 22 percent fewer than normal juveniles migrating downstream in 2015.

Hatchery Programs Affected

One of the biggest impacts the drought had was on state fish hatchery programs, prompting agencies to take action at their facilities to keep water cool and releasing fish earlier than usual.

By July 2015, of 83 fish hatcheries operated by WDFW, more than a dozen were adversely affected by the drought including low water levels and high temperatures. By that time the state had lost about 1.5 million juvenile hatchery fish. Within the Green River basin, the Soos Creek Hatchery lost 34,000 steelhead — half of its typical inventory —and 153,000 coho salmon due to hot water related diseases.

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the Icy Creek Hatchery, water flows dropped by half within one week. Some of the actions WDFW took to combat those hostile conditions included recirculating water to help lower temperatures or sending fish to other hatcheries that were less impacted by the drought.

In Oregon, more than 150,000 summer steelhead fingerlings died at the Rock Creek Hatchery along the North Umpqua River due to bacterial infections and parasites resulting from high hatchery water temperatures.

Releasing hatchery fish ahead of schedule was also a strategy used by state agencies. In February 2015, the California Department of Fish and Wildlife released about 600,000 juvenile winter steelhead from its hatcheries. In May, the Oregon Department of Fish and Wildlife released trophy size hatchery trout into several lakes on the north coast four months early. Fish were also released early from the Makah and Skookum Creek hatcheries in Washington.

The US Fish and Wildlife Service euthanized 80,000 coho salmon at the Makah National Fish Hatchery that were infected with bacterial disease to prevent it from spreading. Sockeye salmon in the Quillayute River were seen with heavy fungus infections, which is an indication of gill rot.

Streams Closed to Angling

State agencies’ primary response to the drought emergency, from a fish conservation perspective, was large-scale angling closures in many rivers or river reaches throughout the region. By mid-July 2015, WDFW had closed 30 rivers in Washington to protect fish. Some rivers were closed completely while others were only open from midnight to 2 pm to keep anglers from fishing during the hottest part of the day when fish mortality would be highest.

The National Park Service closed fishing in most of the rivers in Olympic National Park including the Bogachiel, Sol Duc, Dickey, Queets, Hoh and perhaps a dozen more. Oregon closed some of its top streams as well, including the lower Deschutes, Rogue, Willamette and Clackamas rivers, among others. California closed many stream to angling as well. However, as temperatures cooled towards fall, the rivers were eventually re-opened.

In response to drought conditions, WDFW also placed limits on suction dredging for gold and mechanically removing aquatic vegetation on more that 60 rivers and streams.

What’s in Store for 2016?

Predictions for 2016 look better, although a strong El Nino (probably a factor in last year’s drought) is expected to continue into the beginning of the year. The Columbia Basin Bulletin reports that temperatures will be above normal for the first few months of the year, then drift back down towards normal, while precipitation is expected to be generally in the normal range or slightly below. Flows in the Columbia River should be in the normal range into April, and then drop slightly below normal through the summer months. If these predictions hold true, wild salmon and steelhead should have an easier time in 2016.

However, the impacts of El Nino aside, climate scientists have determined that 2015 was the hottest year worldwide since record keeping began in 1880, beating out last year’s record temperatures. It was the second hottest year in the US. Those back to back record hot years indicate that the planet is beginning to heat up at a more rapid pace due to human-caused climate change, virtually guaranteeing that salmon and steelhead will continue to find themselves in hot water in the years ahead.
2015 Honors List

The Osprey wishes to thank the dedicated people and organizations who gave their financial support in 2015. Our readers are our primary source of funding and without your support we could not continue publishing. The usual donation envelope is provided. Whatever you can afford will be much appreciated (and used wisely).

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