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The Way Forward for Wild Salmon Protection and Recovery

by Jim Lichatowich and Bill Bakke

— Alder Fork Consulting, Native Fish Society —

Perhaps among the most important articles The Osprey *has published,* The Way Forward *is a brief preview of the some of the subjects covered in a new book by Jim Lichatowich,* Salmon People and Place: A biologist's search for salmon recovery. *Salmon biologist Jim Lichatowich owns Alder Creek Consulting and is author of the award winning book* Salmon Without Rivers: A History of the Pacific Salmon Crisis. *Co-author of this article Bill Bakke is executive director of the Native Fish Society, www.nativefishsociety.org.*

The Problem

Salmon and steelhead are managed as a commodity. Production of this commodity is through an extensive system of hatcheries whose operation is based on the myth that an industrial process can replace the ecosystems that naturally sustained the salmon. This approach, which is now in its 135th year, has had disastrous results. Wild salmon and steelhead are a small fraction of their historical abundance in most if not all rivers. Many salmon and steelhead populations are now protected under the federal Endangered Species Act or have gone extinct. We arrived at this sorry state of the salmon because we mistook commodity production for conservation and the management of fish factories for stewardship. And it was all based on a myth that was created in the 19th century as an offshoot of the industrial revolution and its concept of progress.

> *"Once a thing is perceived as having some utility and is thus perceived as a "resource," its depletion is only a matter of time."*
>
> *John Livingston*

How did our attachment to hatcheries begin and why has it persisted in spite of a 135 year record of failure? It began in 1875 with a letter from Oregonians to the US Fish Commissioner asking this question: What will reduce the abundance of salmon and what can be done to prevent it? The U. S. Fish Commissioner, Spencer Baird, replied in a letter that was published in the Portland *Oregonian*. He said habitat degradation, dams and over-harvest would reduce the abundance of salmon, but then he went onto say that regulating harvest and protecting habitat is too difficult and ineffective. He offered hope in the form of hatcheries. Hatcheries, he said, will make salmon so abundant that they will render habitat protection and harvest regulation unnecessary. Hatcheries have never come close to achieving that goal.

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FROM THE PERCH — EDITOR'S MESSAGE

Making our Way Forward to Recover and Protect Wild Fish

by Jim Yuskavitch

When Bill Bakke and Jim Lichatowich contacted us to propose that we publish their paper "The Way Forward for Wild Salmon Protection and Recovery," *The Osprey* editorial board jumped at the chance.

Most readers of *The Osprey* will recognize both of those names. Bill Bakke is the long time executive director of the Portland, Oregon-based Native Fish Society, while Jim Lichatowich, owner of Alder Creek Consulting, is a well known salmon biologist and author of the award-winning book *Salmon Without Rivers: A History of the Pacific Salmon Crisis*.

"The Way Forward" previews a number of the subjects that are covered in a new book manuscript Lichatowich has recently completed and tentatively titled *Salmon and People: A biologist's search for salmon recovery*.

As you might expect, much of the article discusses hatcheries, which have played such a major role in salmon and steelhead management, how we think about those fish and their effects on wild fish recovery.

The authors point out that key to finding a way forward for recovering and protecting wild fish within the context of the ubiquitous hatchery system is the recognition that hatcheries are a compromise that attempts to balance their benefits and risks to salmon and steelhead populations, and recognizing this fact ends the myth that hatcheries are "benign enhancement tools."

With that myth eliminated, the authors argue that hatchery managers should articulate what the ecological tradeoffs are between benefiting the hatchery supported harvest fishery and the costs to wild fish, and what risks hatchery managers are willing to take.

There is much more to this issue's cover story. So much more, in fact, that we feel it may be one of the most important pieces *The Osprey* has published in many years. We think you will agree.

THE OSPREY

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The Federation of Fly Fishers (FFF) supports conservation of all fish in all waters. FFF has a long standing commitment to solving fisheries problems at the grass roots. By charter and inclination, FFF is organized from the bottom up; each of its 360+ clubs, all over North America and the world, is a unique and self-directed group. The grass roots focus reflects the reality that most fisheries solutions must come at that local level.

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CHAIR'S CORNER

Notes from the Field

by Will Atlas

— Chair, Steelhead Committee —

In a mountain valley perched a thousand feet above sea level a river snakes towards the sea. The water is as clear as a bottle of blue sapphire gin, splashing through steep riffles and sliding over boulder covered tail outs. Despite the dramatic beauty of the mountain setting, this stream looks like it could literally be one of thousands of mountain rivers around the West, except for one thing. Sprinkled through the tail out, floating as though they are in thin air, are five ghostly grey creatures — summer run steelhead. These fish, which return from the sea each year during snowmelt in June and July when warming water temperatures and high flows facilitate migration, have climbed more than a thousand feet from sea level in only a few miles. Honed through thousands of years of natural selection, these fish complete a rugged migration; ascending falls more than 10 feet high to reach the upper river where they will wait nine months before spawning next spring.

Each fall, during a few visits I have the chance to encounter some of them, tempting them to rise through the crystalline waters of the little river and eat a dry fly. Numbering only a few hundred at best, these fish are among the many pieces of unique and miraculous diversity that makes up their species. Their beauty and astonishing determination is matched only by their fragility. Many populations of summer run steelhead in the Pacific Northwest are severely depressed; others have been wiped out by the onslaught of industrial activities that plague watersheds throughout the region. Sadly, despite a century of loss, shortsighted thinking continues to pose a threat to the few remaining strongholds of wild salmon and steelhead.

Each of these smaller pieces adds to a sum whole that can never be replaced, no matter how much money is spent on restoration, mitigation, or hatchery supplementation. For a society addicted to abundance, number crunching and stockpiling wealth, the importance of this diversity is difficult to grasp. As our society struggles to adapt to the challenges of our changing planet in the 21st Century, we must draw a line as a community of anglers and conservationists, doing whatever we can to protect the precious evolutionary legacy of our region's anadromous fish.

Sprinkled through the tail out, floating as though they are in thin air, are five ghostly creatures — summer run steelhead

The Way Forward
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A bargain was struck: hatcheries were traded for habitat and rational harvest management. Who benefited from this bargain? Salmon managers got large budgets to operate hatcheries. Developers got access to the river with minimal restrictions. Government leaders got credit for avoiding confrontation between fishermen and developers. The losers? The salmon were big losers. Commercial and recreational salmon fishermen and their dependent communities were also losers. They lost because no one bothered to determine if hatcheries were holding up there end of the bargain.

"*In some sections an almost idolatrous faith in the efficacy of artificial culture of fish for replenishing the ravages of man and animals is manifested, and nothing has done more harm than the prevalence of such an idea.*"
John Cobb

Myths retain their influence only as long as they are not examined and evaluated. Given its record of failure, the hatchery myth requires an "almost idolatrous [and unexamined] faith" to persist. How has a failing approach persisted for so long? Let's take a look at the record: Spencer Baird set the first benchmark for hatcheries and it was to break the natural limits on salmon production and increase their numbers so that harvest would not need regulation and habitat would not need protection. You could still hear echoes of Baird's expectation for hatcheries "…steelhead trout and salmon in far greater numbers than existed before" one hundred years later in the late 1970s.

By the early decades of the twentieth century salmon were in decline and it was becoming obvious that hatcheries were failing to achieve their first goal. To rebuild enthusiasm for hatcheries the goal was changed. Hatcheries would now stop the decline and maintain the current supply of salmon, but the decline persisted. After the Second World War, the construction of large main stem dams in the Pacific Northwest accelerated. Although hatcheries failed to achieve their first two goals, they would now mitigate the problems posed by the large dams. The salmon's decline continued.

By the early 1990s the impoverished state of wild salmon led to listings under the federal Endangered Species Act. By this time, by any measure, it was obvious that hatcheries had a long record of failure, but that record didn't dampen the push for more hatcheries by those invested in maintaining the status quo. Hatcheries were once again given new goals (supplementation, conservation, captive brood). Hatcheries, which had a long record of failure and actually contributed to salmon depletion, were now going to save wild salmon from extinction. As we reflect on this record of salmon management's ties to hatcheries, it reminds us of the old saying: if the only tool you have is a hammer, every problem looks like a nail.

"*What is said to be the purpose of our institutions is always something noble. Assertions of noble purpose make excellent oratory, but the significant operative purpose is what the worker within the institution thinks is the purpose.*"
Robert Kharasch

All the agencies that manage salmon and steelhead have laudable conservation missions. For example here is the mission of the Oregon Department of Fish and Wildlife (ODFW):

"To protect and enhance Oregon's fish and wildlife and their habitats for use and enjoyment by present and future generations."

Wild salmon and steelhead are an important natural resource managed by ODFW. By any reasonable measure of performance, the agency has failed in its mission to protect and enhance salmon and steelhead and their habitats for present and future generations.

The Fish Division expands on the agency's mission and restates it as:

"The mission of the Oregon Department of Fish and Wildlife (ODFW) is to protect and enhance Oregon's fish and wildlife and their habitats for use and enjoyment by present and future generations. The Department is charged by statute (ORS 506.036) to protect and propagate fish in the state. This includes direct responsibility for regulating harvest of fish, protection of fish, enhancement of fish populations through habitat improvement, and the rearing and release of fish into public waters. ODFW maintains hatcheries throughout the state to provide fish for program needs."

The Fish Division's embellishment of the mission shows that its internal machinery is geared to operate a system of hatcheries. The purpose of those hatcheries, in spite of rhetorical flourishes to the contrary, is to make a commodity. The focus on commodity production has over the long term become entrenched in the culture of management agencies creating impediments to the incorporation of new science if that science challenges the status quo. The Fish Division's internal machinery as opposed to its ostensible purpose is to run fish factories and maximize the economic return of the commodities those factories produce.

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The Way Forward for Hatcheries

At this point we want to make it clear that in spite of their record, hatcheries in some form are here to stay. We traded too many miles of salmon habitat for hatcheries to return to 1875, but maintaining the status quo isn't the answer either. The solution can be stated in rather simple terms: its time hatcheries held up their end of the bargain. It's time the myth of an industrial replacement for ecological processes is exposed and discarded. It's time salmon management re-constructs the human-salmon relationship based on ecological principles rather than commodity production. It's time the performance of that relationship be measured by more than economic metrics. We should only retain those hatcheries that can make that transition. We should only keep those hatcheries that are in harmony with the attributes and natural rhythms of salmon-sustaining ecosystems and do not negatively impact wild salmon productivity.

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Anyone who doubts that characterization of the real purpose of the ODFW's Fish Division should read the division's budget bid sheets submitted in 2012. The bid sheets are used to justify the Department's request for state funding. The Fish Division uses only economic metrics to demonstrate the performance of its programs. Those economic data are used as a proxy for the health of the resources the Division manages. It's true that robust economic value can be had from healthy salmon populations, but enhanced economic value can also be attained when stocks are over harvested. The use of economic metrics as the measure of the ODFW's performance is clear evidence that the internal machinery of the Fish Division is geared to the economics of commodity production rather than the health of salmon-sustaining ecosystems.

In his book on the sustainable management of ecosystems, Brian Norton rejects the use of economic metrics as the sole measure of environmental values. The Fish Division states in its bid sheets that it, "…conducts rigorous monitoring projects and analyzes trends in keystone species such as salmon." Surely within the results of those monitoring projects there are data that could provide an ecological measure of performance to go along with the economic metrics.

We know there are some who will disagree with our assessment, but then how do they explain the attachment to hatcheries through a century of failure and the way attempts at reform have largely been ignored? Here is an example that shows the strength of that attachment. In 1994, the Northwest Power Planning Council (Council) recognized that its piecemeal approach which relied heavily on hatcheries was failing to achieve its salmon recovery goal. The Council updated its Fish and Wildlife Recovery Plan to make it consistent with the latest ecosystem and fishery science. It was a break with the status quo, but the managers didn't take advantage of the opportunity. Instead they cherry picked through the plan and selected for implementation only those elements consistent with the status quo. For example none of the Plan's measures related to the conservation of biodiversity were selected for implementation. The managers chose instead to ask for new hatcheries. In its review of the suite of projects submitted by the fishery managers, the Independent Scientific Review Panel noted that, "There is a noticeable discrepancy between the mix of projects actually funded and the ISRP's interpretation of the intent and priorities of the FWP [Fish and Wildlife Plan]. There is a somewhat greater discrepancy between the mix of projects actually funded and the Fish and Wildlife Program, if the recommendations from recent scientific panels (report of the Snake River Recovery Team, Upstream, Return to the River, and National Fish Hatchery Review Panel) are considered" The Council's attempt to incorporate an ecosystem approach to salmon recovery consistent with the latest science was thwarted by the measures the salmon managers chose to implement. The myth retained its influence.

Sustainable ecosystem management should reject economic metrics as the sole measure of environmental values.

Science has given us disturbing insights into the consequences of hatchery operations. But that information becomes useful only after it is incorporated into salmon management's policy and programs. Science is exposing the myth, but the status quo is the salmon manager's comfort zone, a comfortable place they are very reluctant to leave. It will remain a comfort zone until salmon management is forced to confront its failures and the source of those failures.

"*No domesticate has an ecologic place. … But although dependence is a useful descriptive criterion for the domesticated animal, in the affairs of the world of natural wildness the overwhelming importance of the domesticate is its ecological placelessness.*"
John Livingston

"The result is an oddly commonplace salmon – a mechanical, schematic, engineered fish – to many of those that know the most about them. …We see salmon controlled through technologies based upon efficiency, predictability and quantification. They are at risk of becoming little different than products of hamburger joints."
Rik Scarce

One of the salmon's important biological attributes is their attachment to the place where they began life, an attachment that brings the adult salmon back to their natal stream to spawn. The attachment to the place is the source of the salmon's biological diversity. Over thousands of generations, the isolated breeding populations adapted to the environmental conditions in their home stream, which created a rich diversity of genetically distinct populations that exhibit diverse freshwater life histories. Across the Northwest landscape those locally adapted, wild salmon and steelhead comprised the biological diversity that gave wild salmon another important attribute: the ecological resilience needed to cope with environmental fluctuations. Those attributes —- attachment to place, biological diversity and resilience — were largely responsible for the highly productive wild salmon populations present when Euro-Americans arrived in the Pacific Northwest. Their attachment to place is the wellspring of much that makes the salmon and steelhead a treasure deserving of real stewardship.

How has salmon management treated the salmon's attachment to place? First, they traded place, the salmon's habitat, for an extensive system of hatcheries. Those hatcheries, through the process of domestication produced a "product" or commodity that over time became ecologically placeless. Science tells us that domestication in salmon, which is demonstrated by lower survival after release from the hatchery, begins immediately after wild salmon are taken into the hatchery. Second, salmon harvest that targets mixed aggregates of wild and hatchery fish does not take into account the salmon's attachment to place. The mixed stock fisheries overharvest the smaller and weaker popu-

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lations. In some cases, those small populations have been overharvested to the point of extinction. Salmon management has been and still is placeless, and because it ignores this key attribute, it was bound to fail in its real mission to protect an important natural resource.

"*And most important, only when government that typically ensure economic interests and values over all others decide that* ***they*** *[emphasis in the original] are willing to re-construct the human-salmon relationship as an ecological one rather than an economic one will the true salmon wars, the wars between society and the salmon, be over.*"
Rik Scarce

One hundred and thirty five years ago we bought into the myth that salmon-sustaining ecosystems could be replaced by an industrial substitute. Belief in this myth was so strong that the trade of habitat for hatcheries was deemed not only rational, but a highly desirable decision. A bargain was struck; rivers would be developed and hatcheries would maintain the supply of the commoditized salmon. By any measure hatcheries have failed to hold up their end of that bargain. The scientific evidence that hatcheries as they are currently used are part of the salmon's problem has been mounting for the past 30 to 40 years. But all the reform efforts created in response to this new understanding — and there have been at least 3 or 4 — failed to crack the defensive shell that protects the status quo. Myths retain their influence only as long as they are not examined and evaluated and only as long as responsible officials are not held accountable to conduct the evaluations and act on the results.

The most recent attempt at hatchery reform is being conducted by a panel of experts called the Hatchery Scientific Review Group (HSRG). The HSRG has produced several important documents related to hatchery reform. Among all those documents is one sentence that, in our opinion, is a concise summary of a groundbreaking conclusion. Here is that sentence, "Hatcheries are by their very nature a compromise — a balancing of benefits and risks to the target populations, other populations, and the natural and human environment they affect." This statement corrects two important problems posed by hatcheries: 1) Stating unequivocally that hatcheries are a compromise eliminates the myth that they are benign enhancement tools. 2) Since hatcheries by their very nature are a compromise, the salmon manager proposing to use hatchery-produced fish should be required to state in explicit terms the ecological tradeoffs between the hatchery benefits and the cost to wild salmon he/she is willing to make. Until the HSRG's unequivocal statement management agencies were able to easily deflect concerns about the effects of hatcheries by claiming there was uncertainty as to whether there were any negative effects.

For the past 135 years, managers achieved the appearance of control over salmon production by simply ignoring the web of ecological relationships that comprised the salmon sustaining-ecosystem and ignoring the ecological cost incurred by hatchery operations. By ignoring the salmon-sustaining ecosystems, hatcheries could be operated with a high degree of factory-like economic efficiency and control. The factory-like operation of hatcheries was intended to replace the messy ecological relationships that comprised the salmon-sustaining ecosystem. Those ecological relationships did not disappear because they were ignored. From time to time they reassert themselves in the form of problems — extinct and depleted populations, listing under the Endangered Species Act, habitat degradation, the inability to predict run size. When those problems appear, the managers have no explanation or solution. The confusion can be palpable as in this incident described in the *Oregonian.* "It's perplexing. We don't have any answers" was Curt Melcher's response to a major error in the predicted abundance of the Willamette spring Chinook run in 2006. Melcher is the assistant administrator of the Oregon Department of Fish and Wildlife's Fish Division. His attempt to explain the problem only exposed the confusion: "Remember that our forecast models are not biased. We can just as easily over predict as under. They have been so bad for the past two years that we might get one on the up side instead." In other words, he was saying we don't know why the simple industrial production system has failed, but maybe we will get lucky and the same mysterious reasons that cause declines might produce more salmon. The lesson that seems to be lost is this: You can simplify and industrialize salmon production and ignore the ecological processes that make up salmon-sustaining ecosystems, but eventually the things being ignored will extract a high price.

Monitoring and evaluation of hatchery operations could have built a scientifically informed program, but in the rush to maximize economic efficiency and the output of commodities, the appropriate monitoring was simply not done. The result is that the information we now need to evaluate the tradeoffs of hatchery operations is largely not available. The managers do not know what tradeoffs they are and have been making. So we are left with the historical knowledge that habitat was traded for hatcheries and in the end the resulting industrial production system was never able to match the levels of abundance achieved by the natural salmon-sustaining ecosystems.

The Way Forward

"*You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete.*"
Buckminster Fuller

The first step in building an alternative model is to identify what the new model is going to replace. The Independent Scientific Advisory Board (ISAB) for the Columbia River Fish and Wildlife Program has already completed that task.

Here is the ISAB's description of the current model:

• The number of adult salmon and steelhead recruited is primarily a positive response to the number of smolts produced. This assumes that human-induced losses of production capacity can be mitigated by actions to increase the number of smolts that reach the

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ocean, for example, through barging, the use of passage technology at dams, and hatchery production.

• Salmon and steelhead production can be maintained or increased by focusing management primarily on in-basin components of the Columbia River. Estuary and Ocean conditions are ignored because they are largely uncontrollable.

• Salmon species can be effectively managed independently of one another. Management actions designed to protect or restore one species or population will not compromise environmental attributes that form the basis for production by another species or population.

Here is the ISAB's description of the alternative model:

• Restoration of Columbia River salmonids must address the entire ecosystem, which encompasses the continuum of freshwater, estuarine and ocean habitats where salmonid fishes complete their life histories. This consideration includes human developments, as well as natural habitats.

• Sustained salmonid productivity requires a network of complex and interconnected habitats, which are created, altered and maintained by natural physical processes in freshwater, the estuary and ocean. These diverse and high-quality habitats, which have been extensively degraded by human activities, are crucial for salmonid spawning, rearing, migration, maintenance of food webs and predator avoidance, and for maintenance of biodiversity. Ocean conditions which are variable, are important in determining the overall patterns of productivity of salmon populations.

• Genetic diversity, life history, and population diversity are ways that salmonids respond to their complex and connected habitats. These factors are the basis of salmonid productivity and contribute to the ability of salmonids to cope with environmental variation that is typical of freshwater and marine environments.

The current model assumes that hatcheries can be operated factory-like without concern for ecological connections and relationships between and among the salmon, their habitat and other species. This assumption that ecological factors can be ignored and the salmon production system simplified is woven through all three parts of the current model. Implied in the current model but not explicitly stated is management's real purpose of commodity production.

The alternative management model recognizes that rivers are not completely wild and pristine. They are natural-cultural systems i. e., ecosystems that are culturally modified. However, within the context of a culturally modified watershed, ecological relationships and processes, habitat conditions and biodiversity will ultimately determine the productivity of both wild and artificially propagated salmon. Implied in the alternative model is the assumption that a healthy salmon-sustaining ecosystem, even one that has been culturally modified is a prerequisite to the sustainable production of wild and artificially propagated salmonids. Shifting from the current to the new, alternative model would modify our largely economic relationship with the salmon so it includes ecological considerations.

How do we move from the existing to the new, alternative model? The following steps are not the complete answer to that question, but they are a start, which, with conscientious public oversight and accountably, could lead the way forward to a sustainable relationship between humans and wild salmon.

Implement Real, Accountable Reform in the Hatchery Program

The first step is to adopt the HSRG's advice discussed earlier that all hatchery programs are compromises that require an assessment of the tradeoffs between the inherent risks to wild salmon and the benefits a hatchery might provide. This advice, if taken seriously, will have a major positive impact on wild salmon and their management. It will shift the focus of attention from the activities and problems inside the hatchery fence to the consequences of hatchery operations outside the fence in the salmon-sustaining ecosystems. Such a shift in focus would be consistent with the recommendations of the Independent Multidisciplinary Science Team.

A few paragraphs earlier, we explained why management agencies

The Word Minimize

The word minimize has been used to deflect concerns about the ecological cost of hatcheries and hide the fact that those costs are largely not known. Salmon managers have so misused the word minimize that it has lost its meaning. This misuse of the word is not limited to hatchery concerns. Each person who hears a salmon manager say that he/she is going to minimize the effects of a hatchery on wild salmon or minimize habitat degradation should be able to assume the manager means that the effects will be zero or so small as to be negligible. But for reasons we described earlier, the current approach to salmon management precludes attaining and/or documenting zero or negligible effects of hatcheries. When a manager says he/she will minimize some negative impact on wild salmon, what they are usually saying is this: "I will minimize the effects of a hatchery's operations on wild salmon consistent with the tradeoffs i. e., the risks to wild salmon I am willing to make. Furthermore, I don't want to tell you what those tradeoffs are, so attach any meaning to the word minimize that satisfies your concerns and consider the problem solved." The way minimize is used makes it a relative term. Something will be minimized relative to a set of conditions or tradeoffs that are too often not specified, but which can radically change what to minimize actually means. So every time the word minimize is used it should be followed by a description of the tradeoffs that are acceptable and a description of the monitoring program that will determine if minimize so defined is actually achieved. The meaningless way the word minimize has been used has inflicted a lot of damage to wild salmon populations.

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lack the information needed to evaluate the tradeoffs between the risks and benefits of hatcheries. So the first step in hatchery reform is to develop budgets for each hatchery that include the cost of a monitoring and evaluation program designed to collect the information needed to understand the hatchery's ecological consequences. The additional costs should be borne by the hatchery programs and not taken out of habitat protection and restoration or other management activities. In the meantime, the ecological costs for each hatchery should be assessed using information currently in the literature applying it to specific hatcheries with conservative assumptions and analysis. This should include, but not be limited to the following steps:

• Quantify hatchery risks to wild populations including conventional and native brood stock hatcheries. List the acceptable tradeoffs in natural production for each hatchery and the monitoring program that will ensure that the tradeoffs will not be exceeded.

• The impacts of hatchery programs should be reported as life stage survival rates of affected wild populations.

• Each year determine the cost to produce a harvested fish from each hatchery program and provide that information in a form accessible to the public.

• Adopt a stock transfer policy that prohibits moving fish and eggs between watersheds.

• Develop a set of standards for hatchery operations that uses the latest scientific information on hatchery impacts on wild salmon and close those hatcheries that cannot meet those standards within a reasonable period of 3 to 5 years. The standards should be peer reviewed before implementation.

• Move some of the activities/research at the Hatchery Research Center outside the hatchery fence to the real rivers where the real consequences of hatcheries are occurring. One approach to this research would be to close a few hatcheries or substantially reduce production at several hatcheries and adaptively monitor the response of the wild population.

Reconnect Salmon Management to Place

The steps described above will reduce the overriding influence of commodity production on salmon management. Once this is accomplished, it will open the possibility that our relationship with salmon will include an ecological element. Giving salmon management a strong place-based foundation is an important step in that direction. We recommend the following steps:

We recognize that fisheries managers face a difficult task, but they need to maintain the ecosystems that sustain wild fish.

• Set an escapement target for each breeding population and establish a program to monitor compliance. Subject both the method used to establish the escapement target and the compliance monitoring to peer review. Base the initial escapement target on the number of eggs needed for full seeding of habitat, then over a period of not more than 6 years increase the escapement target to achieve an ecological standard based on the need for nutrient enrichment.

• Manage harvest to achieve the escapement targets described above.

• Harvest management involves two primary activities: setting the allowable harvest and allocating the allowable harvest among the different sport and commercial fisheries. The former is a technical task, the latter is a political task. Too often the technical and the political tasks are so intertwined that their separate roles become confused. To avoid that confusion the two activities should be clearly separated (separate oversight and supervision paths) within the organization structure of the management agencies.

• Develop a catalogue of the genetic and life history diversity of each wild breeding population and periodically evaluate and report to the public on the status of those attributes.

• Establish habitat protection and improvement criteria that effectively sustain life history diversity, abundance, productivity and distribution of native wild fish in each watershed. Pay particular attention to flow, temperature and structural quality of the habitat.

• Fish and wildlife agencies should not avoid habitat protection with this excuse: Habitat protection is out of our hands because we do not have the authority to control the activities of other agencies that influence salmon habitat. In those situations the salmon managers should use their bully pulpit as the recognized experts to inform the public of habitat degrading actions.

Historical Foundation

As a group, salmon biologists do not pay much attention to the history of their profession. The lack of a sound historical perspective has several drawbacks: It freezes the status quo in place, allowing failures of the past to persist and be implemented over and over. It promotes the shifting baseline syndrome, which hides the magnitude of management's failure to achieve its mission and inhibits real accountability of agency administrators. The following steps would begin to build a needed historical context:

• Stop the practice of shifting baselines. Use the best available information and reasonable assumptions to estimate the historical abundance of salmon and steelhead for all breeding populations. Some of this work has already been done. Then every run size prediction, every recovery goal and every annual run reconstruction, must be compared to the estimate of historical abundance. Here is a hypothetical example: when reporting a predicted

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run size that is, say, 5,000 fish larger than last year's run, the manager might say something like this year's run is 5,000 fish larger than last year, which means it is now five percent of the historical abundance. Here is another hypothetical: The goal of this recovery program is to double the existing run, which would result in a population that is 20 percent of the historical abundance.

• To avoid repeating mistakes and to ensure that we are learning from the past, each new management or recovery program must provide the following information:

1. The author must demonstrate that he/she understands what was done in the past to manage or recover salmon and steelhead in the target river or in similar rivers.

2. The author must demonstrate he/she knows why the previous programs succeeded or failed to achieve their purpose.

3. The author must give convincing evidence that the new plan or program will avoid the mistakes of the past.

We recognize that those who manage native fish in the Pacific Northwest, especially the native salmonids have a difficult task. They have a dual responsibility. They must try to ensure a steady supply of commodities for the commercial fisheries and recreational anglers and the local economies that depend on them. At the same time, they need to maintain the health of the ecosystems that sustain wild salmon. Salmon management agencies have focused on the former and largely ignored the later, which has left them largely unprepared to resolve the current crisis. The steps we propose here are not the complete answer to the problem of managing wild salmon for the use and enjoyment of present and future generations, but they are a start down a management path that can lead to a sustainable relationship between us and our regional icon, the wild salmon.

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Spilling Water at Columbia and Snake River Hydroelectric Projects

How does it benefit salmon?

By Margaret Filardo
— *Fish Passage Center* —

Author Margaret J. Filardo, Ph.D. has been a senior scientist at the Fish Passage Center working on hydropower issues related to salmon populations for over 20 years. The Fish Passage Center located in Portland, Oregon, was originally established in 1982 to provide technical services to the state and federal fishery agencies and Native American tribes impacted by the operation of the Federal Columbia River Power System. Access the Fish Passage Center at: www.fpc.org.

Hydropower development in the Columbia and Snake rivers has left its mark on salmonid populations, leaving many species on the Endangered Species List. The passing of juvenile fish over a spillway (spill) at a dam has long been used to mitigate the impact of hydropower development on salmon survival. Spill was initially implemented as an alternative route of passage at hydroelectric projects to improve juvenile fish survival by avoiding the mortality associated with passing through turbines. In its first formal application in the late 1970s and early 1980s, spill for fish passage was focused at projects that were not equipped with juvenile mechanical bypass systems. The mechanical bypass systems were designed to divert fish away from turbines, and then to pass fish downstream of the hydroproject. Spill at the time was generally opportunistic, meaning that, if additional water was available that could not be marketed for power, spill could be provided for fish passage. Since that time, the provision of a spill program has evolved from only providing spill mitigation when excess energy was present in the hydrosystem, to a planned spill program at each of the Federal Columbia River Power System (FCRPS) projects, under any river flow conditions.

The evolution of the spill program took place over several years. In February of 1987 the then Northwest Power Planning Council (now Northwest Power and Conservation Council, NPCC) amended their Fish and Wildlife Program to require the U.S. Army Corps of Engineers (COE) to develop a Fish Passage Plan to provide spill to achieve better than 90% survival at a dam for 80% of juvenile salmon and steelhead that migrate to sea during the spring and summer. This only applied to years in which flow was higher than occurred in a critical water year. A critical water year is defined as a year in which the annual runoff in the Columbia River Basin is equivalent to the amount recorded in 1937, a low flow year. This plan opened the door to the Ten Year Fish Spill Memorandum of Agreement (MOA) that was signed by the state, federal and tribal fishery agencies and the Bonneville Power Administration in December of 1988. Although the COE was not a signatory to the Agreement, they agreed to implement the Spill MOA. The Spill MOA provided more planned spill specifically for fish than had occurred in any previous year. It broadened the fish spill program to include more dams under its umbrella and was incorporated into the NPPC Fish and Wildlife Program in 1989. The Spill MOA focused on projects (it included spill at Lower Monumental, Ice Harbor, John Day and The Dalles dams) with no or with insufficient mechanical bypass systems.

We have demonstrated that increased spill over the dams increases juvenile fish survival through the hydrosystem.

With the listing of Snake River sockeye salmon in 1991, and Snake River spring/summer and fall Chinook in 1992, spill was included in the 1992 FCRPS Biological Opinion (BIOP). The BIOP included spill at the non-transportation collector projects and was intended to achieve a 70% fish passage efficiency (the percent of juvenile fish passing a dam via a non-turbine route) during the spring migration, and a 50% fish passage efficiency for the summer migration. Subsequent Biological Opinions broadened both the scope of projects included and the duration of time during the migration season when the planned spill program was implemented.

The latest modification to the spill for fish passage program occurred in a June 10, 2005 Court Opinion in the National Wildlife Federation v. National Marine Fisheries Service lawsuit, when Judge Redden granted the spill portion of the National Wildlife Federation's request for injunctive relief. The Court Opinion specified that the planned spill program include spill to the level allowable under the total dissolved gas cap, and greatly expanded the existing Biological Opinion spill program by including summer spill at all FCRPS projects, including the fish transportation col-

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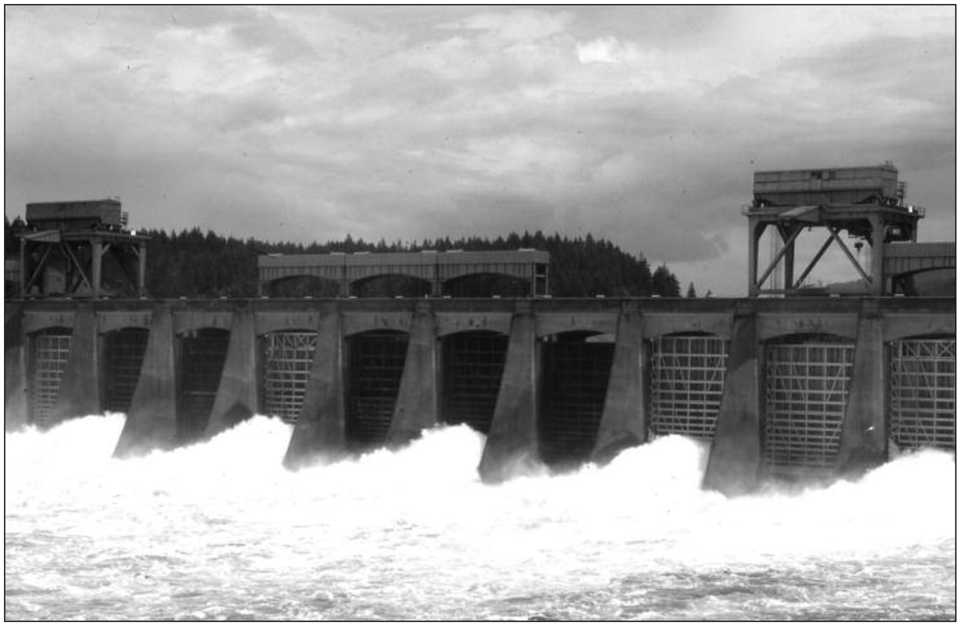
lector projects. Spill to the gas cap means that spill at a project can occur in increasing volumes until the total dissolved gas at the tailrace gage below an individual hydroelectric project measures 120% saturation, or the total dissolved gas at the next downstream hydroproject forebay gage measures 115% saturation. This Opinion effectively created a planned spill program that included more planned spill for fish passage than had ever occurred in the present hydrosystem.

This raises the question as to whether we can describe and measure the benefits to salmon and steelhead from the increases in the spill volumes that have occurred over time. At the Fish Passage Center (FPC) we have reviewed and summarized the observations of juvenile fish passage characteristics developed through annual monitoring of downstream passage in the Smolt Monitoring Program (SMP) and smolt-to-adult return rates from life cycle monitoring conducted through the Comparative Survival Study (CSS). The SMP is an annually implemented state, tribal and federal fishery agency program that has monitored the migration characteristics of juvenile salmonids passing through the Columbia and Snake rivers hydrosystem since 1983. The CSS is a multi-fishery agency (with a CSS Oversight Board comprised of state, tribal and federal fish biologists) conducted study that began in 1996 with the objective of establishing a long-term dataset of annual estimates of salmonid survival rates. The survival rates measure the full impact of the hydrosystem on salmon from their out-migration as smolts to their return to freshwater as adults to spawn (smolt-to-adult return rate or SAR). While the most extensive planned spill program has only been in effect since the Court Order in 2005, previously implemented spill programs and the annual variation in flow volumes that have occurred through the historic flow record have allowed us to evaluate spill under a wide range of scenarios.

The development and use of the Passive Integrated Transponder (PIT) tag for fish marking has provided us the opportunity to monitor juvenile migration characteristics on a much finer scale than previous generations of mark tags. Fish are uniquely tagged and tracked as they pass through the hydrosystem as juveniles, and detected again when they return to the river as adults. Knowledge of the specific timing and migration patterns of juvenile salmonids allows us to match them with the unique environmental and physical conditions during the time period when they were migrating. We can identify the specific flow, spill, temperature and other environmental variables that occurred when juveniles migrated, and to a certain extent the specific route of passage a fish took at a hydroelectric project. For a specific hydroproject, we know whether a fish was placed into a fish transportation barge, passed undetected through spill or turbines, or whether it passed the dam via the bypass system.



Increasing spill at the dams on the Columbia and Snake rivers hydro system has been shown to improve juvenile salmon and steelhead survival. Photo by Jim Yuskavitch

Through the SMP the FPC has annually evaluated environmental variables associated with each of the juvenile cohorts and evaluated fish travel time and survival based on conditions at each dam and in the specific river reaches. When we look at the different variables associated with juvenile migration characteristics, we have found through statistical analyses that the increasing proportion of spill provided for fish passage at hydroelectric projects has resulted in higher juvenile spring/summer Chinook, fall Chinook, sockeye and steelhead survival and faster juvenile fish migration rate through the Columbia River power system. The reduction in mortality from avoiding turbine or mechanical bypass passage is captured in the increases observed in juvenile survival rates. The faster juvenile fish migration rate is largely a result of fish passing a project through the spillway and the reduction in forebay delay that usually occurs as fish approach a dam and hold in areas of low water velocity. We have also observed that the increasing spill proportion provides mitigation for low flows through the hydrosystem. In observations of years with similar flow and water velocity, juvenile fish survival and fish travel time are improved in years with higher average spill. This is an important finding, since there are few mitigation measures available for fish during low flow years.

We have demonstrated that increased juvenile survival and faster migration speed through the hydrosystem are associated with increasing spill proportions at projects, but is there evidence linking migration experience through the hydrosystem to survival to adulthood? There are those who believe that the science shows that

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upon entering the ocean the conditions that affected the juvenile migrants are completely overshadowed by ocean conditions and the effects on subsequent salmonid survival to adulthood. But what do the data show?

As said before, when the surviving adults from a cohort that migrated to the sea together return to their natal areas, the juvenile conditions under which they migrated can be defined. It is true that conditions in the ocean, under which fish mature before returning to natal rivers to spawn, are highly influential in determining salmonid survival to adulthood. However, there is mounting evidence to suggest that the juvenile fresh water passage conditions affect survival soon after ocean entry. This refers to delayed hydrosystem mortality, which is defined as mortality that occurs in the estuary and early ocean, but was originally caused by earlier experience in the hydrosystem. Delayed hydrosystem mortality is likely due to the cumulative effects from: (1) injuries or stress from migrating through juvenile bypass systems or turbines; (2) the transmission of disease resulting from the concentration of fish in the forebays of dams and the bypass collection facilities, or when collected and put into fish transportation barges; (3) changes to migration rates and timing affecting the exposure to negative survival factors and the timing of entry into salt water; (4) depletion of energy reserves associated with prolonged migration and; (5) altered hydrodynamic conditions in the estuary and plume as a result of the present hydrosystem configuration and operation. Budy et al. (2002) provided evidence that some estuary and early ocean mortality was related to hydrosystem passage experience during downstream migration. Schaller and Petrosky (2007) showed that the delayed mortality of Snake River stream-type Chinook salmon remained high, even as oceanic and climatic conditions improved, indicating a link with hydrosystem development and operation. Several recent analyses have shown that early ocean survival and fresh water migration passage conditions are correlated. Petrosky & Schaller (2010) found that survival rates during the smolt to adult and first year ocean life stages for Chinook and steelhead were associated with both ocean and river conditions, providing direct evidence for hydrosystem delayed mortality. Haeseker et al. (2012) concluded that freshwater and marine survival rates of Chinook and steelhead were correlated, indicating that a portion of the mortality expressed after leaving the hydrosystem is related to downstream migration conditions. Given all the recent studies, we continue to document the relation between juvenile passage conditions and survival during later life stages (delayed hydrosystem mortality), and show the importance of spill in affecting juvenile survival and consequently influencing the survival of returning adults.

Through information that has been collected over several years we recognize that the importance of a spill program has expanded beyond the original intent of providing a way for a fish to avoid turbine passage. We now know that spill improves the downstream passage survival of juvenile salmonid stocks by providing a hydroproject passage route associated with reduced project passage delay, and with less mortality relative to powerhouse bypass or turbine passage and that these benefits translate into improved survival to adulthood. The question is, “where do we go with the information that we now have?” We know that the present hydrosystem operation and configuration does not result in the recovery of ESA listed species. The CSS Oversight Committee convened a workshop in July of 2011, to evaluate the existing data and to develop potential paths for continued testing of the hypotheses. The workshop process addressed how we use recent analyses to evaluate and optimize FCRPS operations for ESA listed groups of anadromous fish to meet the regional goals for SARs established by the NPCC as 2% to 6%. Modeling studies using existing data have determined the range of improvement that might occur if juvenile passage conditions were altered. However, to verify the models’ real biological impact, studies will need to be conducted to determine whether manipulating the factors that most affect juvenile survival, such as spill, can be used to achieve adult survival goals. One question that needs to be answered is, “will spill in low flow years translate into large survival benefits to the adult return stage?” Improvement in survival in low flow years is a key conservation concern for recovering Snake River populations. There are restrictions on the conduct of these studies. Some restrictions are easier to address, such as the physical limit on the amount of spill that can occur due to current total dissolved gas standards, while others are more difficult to approach, such as the monetary impact to the power system operation that can be tolerated for the recovery of endangered species, since spill is considered to be foregone revenue for the power system. In summary, planned spill programs are proving to be one of the most important tools in the arsenal used in the recovery of endangered species. It is now up to the region to test how much more improvement can be gained from this mitigation measure to recover the salmon and steelhead population of the Snake and Columbia rivers.

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Skeena Sockeye in a Minefield

By Will Atlas, Ken Rabnett

— Simon Fraser University, Suskwa Research—

Ken Rabnett is a resident in the Skeena watershed and has an interest in sustainable development and fish and their habitats while Will Atlas is Chair of the Federation Of Fly Fishers Steelhead Committee and is conducting fisheries research at Simon Fraser University.

Given the well-documented impacts of open pit mines on water quality and fish populations, it would be insanity to build a mine in the headwaters of the Skeena River's most productive sockeye system. But that's exactly what Pacific Booker Minerals is proposing to do with the development of an open pit copper, gold, and molybdenum mine right on the shores of Morrison Lake in the Babine Lake watershed. Morrison supports 17 species of fish, including coho salmon and four unique sockeye populations with different run timing, spawning and rearing characteristics. The mine would be built less than 100 meters from the only known location of sockeye shoreline spawning in the watershed.

It's no secret that when it comes to mining, logging, and other resource industries, British Columbia is open for business, and the province has often failed to successfully balance the need to protect fish habitat with the economic opportunities afforded by resource extraction. Recently, with the election of pro-resource industry governments at the federal and provincial level, the rate at which new projects are being developed and approved has accelerated to breakneck pace. Even with the economic and political realities in British Columbia, one would think that the public would be interested in hearing about a proposal to build a massive open pit copper mine in the most productive sockeye-bearing watershed in the province. Shockingly, the mine proposal for Babine Lake, BC's most important sockeye rearing lake, has been through public comment, and is on the brink of being approved by the Environmental Assessment Office without a single article or mention of the project appearing in the BC media.

Babine Lake is located on the Nechako plateau north of Burns Lake, a small outpost straddling the Skeena and Fraser watersheds in the heart of BC's latest mining boom region. It also happens to be home of around 90% of the Skeena River's lucrative sockeye run. The Babine run is dominated by fish returning to the spawning channels on the Fulton and Pinkut rivers and forms the backbone of commercial sockeye fisheries in Northern BC and Southeast Alaska. The lake, which covers 185 square miles, is also fed by several lakes that are accessible to spawning sockeye and coho salmon. Among these is Morrison Lake, which supports thousands of spawning sockeye each year, making it one of the most important wild spawning areas in the basin.

This mine proposal for BC's most important sockeye rearing lake is on the brink of being approved with no media attention.

Two abandoned mines, Bell and Granisle, sit dormant on the shores of Babine Lake. Both are in dire need of wastewater treatment plants to mitigate permitted and non-permitted effluent discharge, a reminder of the lasting impacts of mining and the long terms costs all too often left to local communities and taxpayers.

Given the unique importance of the Morrison and Babine as sockeye producers in the Skeena, one would think they warranted protection, and that industry proposals jeopardizing these vital watersheds would cause a public uproar similar to the one seen in response to Alaska's proposed Pebble Mine. But search Google for Morrison Lake Mine, and you will not find a single article from the mainstream media exploring the potential impacts or economic trade-offs associated with the project. Instead, you'll see links to a few obscure mining industry newsletters, and the Lake Babine First Nation (LBN) annual newsletter. LBN and their allies in the Skeena have fiercely opposed the project but face an uphill battle to stop it.

The Morrison Lake Mine would be built at the southeast corner of Morrison Lake, less than two miles from the lake outlet where thousands of fish spawn each year. Over the projected 21 year life of the mine, Pacific Booker will extract 30,000 tons of ore per day, storing waste in rock and till piles and a tailings impoundment area at the mine site. The proposed mine and tailing storage area drains directly into Morrison Lake, though the adverse effects on water quality are also expected to impact Nakinilerak Lake, which drains into the Fraser River basin.

The Environmental Assessment

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The mouth of Morrison Lake, site of a proposed mine on BC's most important sockeye rearing lake. Photo by Ken Rabnett

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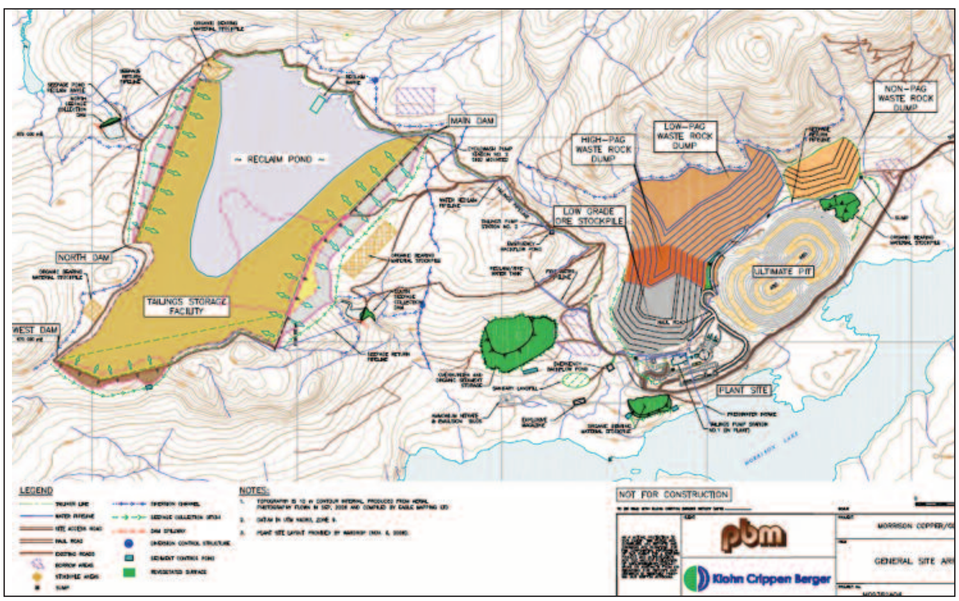
Certificate (EAC) for the project admits that treated mine tailings will be poured back into Morrison Lake, resulting in concentrations of heavy metals such as cobalt, cadmium, selenium, arsenic, and aluminum that exceed BC Water Quality Guidelines. However, a third party review of the EAC suggested that the actual level of contamination may far exceed the levels outlined in the assessment, even under the best case scenario. Copper and other heavy metals are lethal to fish at high doses but also may inhibit important neurological functions when fish are chronically exposed at lower levels. The tailings from the mine will be stored at the site, requiring treatment and management of effluent in perpetuity, meaning that like so many mining projects, the toxic legacy of the project will remain long after the benefit to the local community has dried up.



The proposed mine complex layout. Courtesy Ken Rabnett

Even if the waste is successfully contained, the impact of the toxic mine waste will harm aquatic life in Morrison Lake for the next century. However, the damage could very likely be far worse. The mine sits on two fault lines and there are concerns that the faults will leak toxic effluent into the lake. In the event of an earthquake, power outage or malfunction at tailings treatment facilities, massive amounts of toxic waste would flow directly into Morrison Lake, causing catastrophic damage to aquatic life and fish populations. In the event of such an accident, the amount of waste that could be released would mean that water quality could be severely damaged as far down stream as Babine Lake.

Several small spawning creeks will also be impacted by the construction and operation of the mine. Water requirements within the mine site will reduce flows in several creeks by as much as 90%, likely making them unusable for spawning salmon. The area of Morrison Lake directly adjacent to the proposed mine site supports the only lake spawning population of sockeye in the system. These genetically unique fish spawn in the cobble of the lakeshore where groundwater flows from nearby creeks, and ideal substrate provides perfect conditions for spawning sockeye. An independent scientific review commissioned by the LBN last year concluded that the combined effects of contamination and reductions in groundwater flow associated with the mine would likely wipe out lake spawning sockeye in the Morrison system, eliminating a unique part of the Babine's sockeye population honed by thousands of years of local adaptation.

Other significant concerns raised revolve around water quality, water balance and the integrity of aquatic ecosystems in Morrison and Babine lakes. Baseline data is limited for Morrison Lake, making it difficult to assess the adverse effects on water quality.

Despite the magnitude of the project, the environmental assessment was railroaded through by provincial and federal ministries with a stunning disregard for damage the project could do to fisheries in the Skeena. The project is particularly egregious in its lack of concern for the title and rights of the Lake Babine First Nation, who have never ceded their traditional territory in a treaty and whose right to harvest, protect and conserve sockeye and coho salmon is directly threatened by the mine.

Only after LBN intervened with their objections and pointed out that the project's impacts on fish populations were not considered in the environmental assessment did the mine proposal draw more scrutiny. At present the environmental assessment certificate has gone back to the Canadian Environmental Assessment Agency (CEAA) for review of additional information required from Pacific Booker on mitigation for impacts on water quality and ground water. However, the company expects the project to get the go ahead by 2013.

The public's objections are often given little consideration by the government agencies tasked with reviewing mining and other resource projects, and because of the lack of information on the project in the media, the public comment period finished without making so much as a blip on the radar of most BC residents. But the legal rights of First Nations within the Skeena to harvest salmon and the fact that the project area is within the unceded lands of the Lake Babine First Nation means that the legal standing of the project would be dubious were it to be brought before a judge. At this point, the only way of possibly stopping the project will be a judicial review instigated either by the public or LBN.

All told, the Morrison Lake Mine could be catastrophic for British Columbia's most important sockeye producing watershed, the economic engine behind fisheries in the Skeena

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and a vital source of food, social and ceremonial harvest for First Nations. So why hasn't the project created the same type of backlash and opposition as the similar Pebble Mine project in Alaska's Bristol Bay? In British Columbia, the vast majority of the population lives in the Lower Mainland, and with an explosion in the number of projects being permitted every year, the media is both uninterested and unable to keep track. Combine that with the fact that provincial and federal ministries tasked with reviewing the projects steamroll environmental assessments through, and small communities and First Nations are left on their own to contend against a massive, well-financed mining company and a government unconcerned with their plight.

Unfortunately, the project is nearing approval, meaning there may be little the public can do to stop it. But what we can, and will do, is stand with First Nations in telling the government that these types of destructive mining projects are unacceptable, that the willful disregard for fisheries and First Nation's interests demonstrated by the rapid approval of the project does not reflect the values of the people of British Columbia, and that we will do everything in our power to protect the future of the Babine.

Concerned public or public interest groups might register their concerns with the proposed Morrison mine with emails to the BC Ministers of Environment (Terry Lake, env.minister@gov.bc.ca) and Energy and Mines (EMH.Minister@gov.bc.ca) with cc's to Will Atlas (wiatlas@gmail.com). Due to the lack of adequate baseline studies, potential adverse effects to genetically unique sockeye salmon stocks and terrestrial and aquatic ecosystems have not been determined. Toxic effluent discharge and acid mine drainage, which will require treatment for thousands of years are not in the public interest and does ensure individuals, communities, and ecosystems. This in turn, creates confusion regarding adverse socio-cultural and economic effects and further erodes the public interest in natural resource and economic development decision-making.

Letters to the Editor

Never Stop Fighting For Wild Fish

Dear Editor:

As an old (I'm 82) wild steelhead junkie, I'd like to comment on two pieces in your May 2012 issue.

Pete Soverel's piece about Ksenya Savvaitova ("Oksana," to her friends) is a much-deserved and beautifully-written tribute. I came to know Oksana quite well during the early days of the Kamchatka Steelhead Project, both here in the Seattle area and later on the Peninsula. Among the many wonderful things I remember about her was her infinite patience as I conversed with her in my too-fractured Russian. She was an outstanding woman and our cause has indeed lost a tremendous champion.

Then there is your "From the Perch" piece about the Haig-Brown award. I happened to be one of those very early worker-bees, with typewriter in hand, as you say. The job soon induced me to buy my first desk-top computer, in 1988. That was a real blessing, as it turned out. Too many of my contemporaries avoided that transition and most of the few left today rue their shortsightedness. That aside, all of us involved with the newsletter can take some satisfaction, knowing that we have been able to pressure the managers and nay-sayers to do the right thing for wild steelhead. It would be a stretch to say that we have "succeeded," given the precarious circumstances in which these beautiful fish still find themselves. But we should never stop trying.

John Sager
Mercer Island, WA

[*Editor's Note: John Sager is a founding member of the FFF Steelhead Committee and past editor of* The Osprey.]

Just Like the Avengers

Dear Editor:

Thank you! Thank you for your dedication to the preservation of what you truly love. I see and feel it in your work, your contribution in time, energy, and current science has elevated and strengthened *The Osprey*.

The Osprey team is like the Avengers super heroes to me. I am 46 now and was lucky to begin steelhead fishing with my grandfather at the age of 10 in 76 — it was fly only since 86 — and lucky enough to learn how to steelhead fish with a fly at the tail end of what has now been deemed the glory years. Glory years to the new generation who now have very few systems to fish. I was born and raised in Bellingham and spent some time with Ralph Wahl in his final years one on one. He had a basement that was an angling museum full of the most beautiful black and white photos covering every inch of space. One day he told a story about a Kispiox trip with Enos Bradner and they didn't know what all the hype was about the area. Fishing was better back home! Man, now those were the glory years to me.

So I guess what all this means is your work reaches more people than you know, through people like me who pass it on down the line. Keep it up! We are finally seeing a change, thanks to everyone at *The Osprey*, by making us look first, not after, the damage is done.

Thank you for your commitment to the preservation of steelhead!

Gary D. Clark
Bellingham, WA

Anadromy vs Residency

Life history patterns, sex and process in rainbow trout

By John R. McMillan

— NOAA Fisheries —

John McMillan has been a fisheries biologist for the Hoh Tribe, Wild Salmon Center, and currently works for NOAA Fisheries studying the recolonization of salmon, trout and char as part of the dam removal project on the Elwha River. Much of his professional scientific study has focused on the biology, behavior and ecology of steelhead and rainbow trout, with a particular interest in the mechanisms influencing why individual fish adopt particular life history strategies, such as anadromy and residency. His latest publication is the book May the Rivers Never Sleep, *which was a collaboration with his father Bill McMillan and pays homage to the strong conservation influence of Roderick Haig-Brown.*

Why does one fish become a steelhead and the other a resident rainbow trout? Certainly this question has intrigued many people, including myself. At first glance there appears no easy and concise way to explain such a complex issue. The problem was interesting enough to draw me back to graduate school at Oregon State University to research life history expression in rainbow trout in the John Day River basin, Oregon. After spending several years peeling back the layers to the problem, I now find it is easier to conceptualize the issue by rephrasing the question: Why does one fish undertake an extensive ocean migration to mature at a larger size and older age while another matures at a smaller size and younger age in freshwater with less movement? The question now seems simpler. So simple in fact that I found many similarities between rainbow trout, baboons, geese, songbirds, and even humans, but I save those analogies for the end of the article.

The new question is about how an individual interacts with its natal environment. The end goal of life is to reproduce successfully, so the extent of migration is largely dictated by the ability of an individual to achieve an adequate level of growth in size for reproduction and to acquire enough surplus energy (e.g., fat or lipids) to produce sperm or eggs. Growth and lipid levels are a result of an interaction between environmental factors, such as water temperature and food supply, and heritable physiological traits, such as metabolism. The outcome of this interaction has direct implications for anadromy and residency in all salmonines (*Salmo*, *Oncorhynchus*, and *Salvelinus*), and offers a framework for understanding why one rainbow trout becomes a steelhead and another becomes a trout. Here I briefly overview life history patterns and processes for salmonines in general and offer insights acquired from my recent research and other recent studies on anadromy-residency in rainbow trout.

> ***Because anadromy typically produces a large benefit in size, one might assume all fish, given the chance, would head to sea. Yet this is not the case.***

Life history patterns and sex

Before examining processes, it is first helpful to have some understanding of life history patterns. Many salmonine species display anadromous and resident life histories within a single population. Residents complete their entire life cycle in freshwater, while anadromous individuals migrate from their natal freshwater streams to the ocean to access rich feeding areas before returning to spawn in freshwater. Steelhead that spend multiple years in the ocean tend to be much larger in size than the resident rainbow trout. However, rainbow trout can achieve quite large sizes in some areas — even exceeding the size of many steelhead — where environmental conditions allow for high levels of freshwater growth (e.g., Alaskan lakes and streams subsidized with salmon carcass nutrients). Similarly, some steelhead are quite small, such as half-pounders and estuarine run fish that spend only weeks to a few months in the ocean.

Considering anadromy typically provides a large benefit in size, it might be expected that all fish, given the chance, would head for the ocean. Yet, this is not the case. In many salmonines, including rainbow trout, there are life history differences in sex ratio when the forms co-exist. Studies indicate that steelhead life histories are often female biased (55 - 75%), and in places like the Columbia River, they often become increasingly female dominant the further their natal tributary is from the coast. Less information is available on the sex ratio of resident rainbows, but what does exist suggests they are often mostly male. Such patterns are especially striking on Russia's Kamchatka Peninsula where many populations of steelhead that are female-biased co-exist with rainbow trout populations that are male-biased Similar resident-male and anadromous-female patterns exist in Atlantic salmon, masu salmon and brown trout.

It is believed that more females become anadromous than males because the strategy provides the greatest opportunity for large size. Larger females tend to carry more

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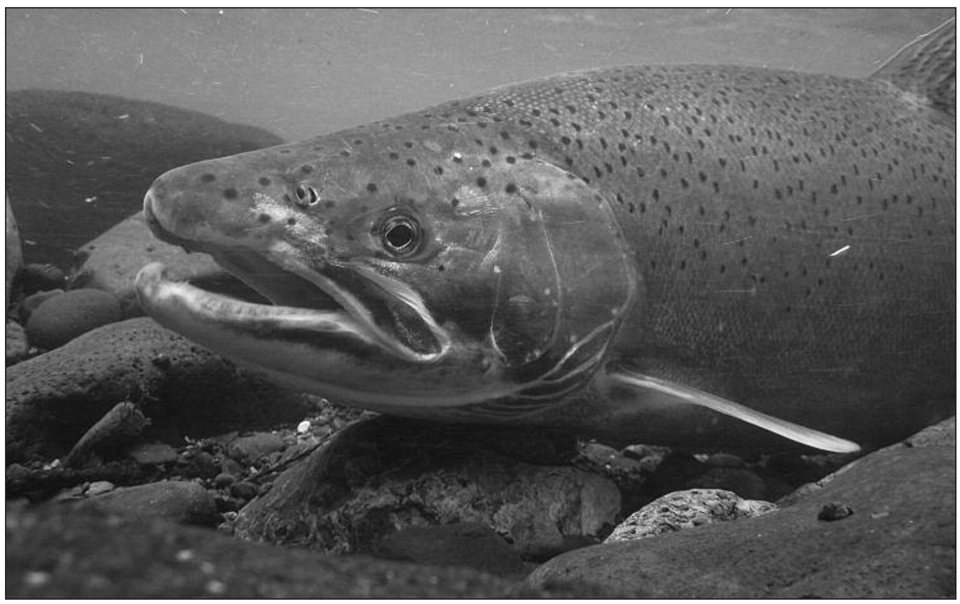
eggs, are able to excavate redds in a wider range of substrates, can dig deeper redds to reduce scour and dewatering, and may outcompete smaller females for the best spawning areas. In contrast, it is believed that more males mature as residents because their reproductive success is based on the number of eggs fertilized. Larger males often acquire more matings than smaller individuals, but males have evolved a number of behavioral strategies that ensure a wide range of sizes of fish can acquire fertilization opportunities. The drawback to anadromy is that chances of mortality increase with every extra year of life it takes to achieve maturity, and mortality can be especially high during emigration to and the first year of life in the ocean. The main advantage of maturing earlier in life, often at a smaller size, is a reduced chance for mortality. Thus, the tradeoff between mortality risk and size is apparently worth the risk, more so for females than males.

Life history expression

The patterns in life history expression are the result of a complex interaction between genetics and environment. The influence of parentage on life histories is increasingly being studied and most results suggest parents influence the life history of their offspring. For example, older research in the Cowichan River, Canada, and newer research in the Grande Ronde River, Oregon, found that trout x trout matings generally produced a greater proportion of resident trout compared to steelhead x steelhead matings, which produced a greater proportion of steelhead.

Parents pass along heritable traits, such as those that strongly influence growth (e.g., metabolism). Broad scale heritability estimates for salmonine species suggest 30 - 55% of life history development is regulated by genetics. This is a fair-size chunk. But, it also means that 45 - 70% of life history development is controlled by something else: the environment.

The interaction between a heritable trait and environment, and its influence on life history expression is explained through a theory called the conditional strategy. The theory is three-fold. First, individuals inherit variations in particular traits that influence growth. The trait that is increasingly being examined is metabolism, which tends to vary among juveniles that adopt different life histories. Second, juveniles display a wide range in growth because of differences in the ecology of their rearing habitat and genetics. Lastly, life histories are established during the first year or two in life in response to growth in length and lipid storage. These measures of condition provide physiological feedback to the endocrine system. Growth and lipids are basically cues that initiate a hormonal response to mature in freshwater or a physiological shift to smolt (migrate to the ocean).



Male steelhead resting before it resumes spawning activity, these large males may get most of the spawning opportunities but in some cases small resident male trout may fertilize a large proportion of female steelhead eggs. Photo by John McMillan/NOAA/Northwest Fisheries Science Center

Resident male maturity

John Day River research

Reverting to the question at the beginning of the article, one fish migrates to the ocean while another matures earlier and at a smaller size in freshwater because of sex and because of growth and energy storage in freshwater as a juvenile. For juvenile steelhead in the John Day River basin, Oregon, I tested whether males maturing at age-1+ (fish age-1 that will spawn at age-2) in freshwater displayed greater growth and lipid storage than immature males. I focused on age-1 males to ensure I captured fish before they had an opportunity to smolt, and most steelhead smolt at age-2 or -3 in the John Day, and age-1 smolts are very rare. I assumed that greater growth and lipid levels would result in males maturing in freshwater as residents.

We found that 38% of all the age-1+ males we collected and dissected were maturing or almost fully mature. Data analyses indicated that growth in size and lipid content positively influenced early male maturity (Figure 1). Overall, 80% of the maturing males were longer than 100 mm and had lipid levels greater than 4.0%, and fish could mature at very small sizes if they had high lipid levels. We also tested whether water temperature influenced growth and lipids. Those results indicate that fish were slightly longer in warm streams than cold streams, but lipid levels were much higher in cold streams than warm streams. We were thus able to provide evidence that growth and energy storage influenced male life history expression and that temperature moderated growth and energy storage.

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Implications of our Research

Our results are generally consistent with previous studies on Atlantic salmon and masu salmon, but contrast with research on brook trout and brown trout where there was either no difference in size between maturing and non-maturing males or non-maturing — future anadromous fish — were longer. Our study is also novel because we researched fish living in nature and the overwhelming majority of previous studies had focused on fish living in hatcheries or laboratories. Further, only one other study had measured lipid content for fish living in nature, most relied solely on growth. This is problematic because lipids are considered to be a better predictor of maturity after a fish achieves a certain size given that a surplus amount of lipid is needed to develop eggs and sperm.

There are a couple of implications for the findings. First, growth in size may not always be positively correlated with resident maturity in males, but lipid levels appear to be consistent across species except in some hatchery situations where fish are unnaturally lipid because of high food sources and low levels of energy expenditure. This is not surprising considering that larger smolts tend to survive better than smaller smolts, indicating that selection for size- and age-at-smolting may be stronger than size-at-maturity for already small maturing resident males. On the other hand, high lipid levels are nearly universally associated with earlier maturity in fish, birds, insects, mammals, and reptiles. Second, rainbow trout are fairly thermally tolerant among salmonines and may continue to grow in size at elevated water temperatures, perhaps even up to 75-77°F if prey is abundant and easily caught. However, elevated water temperatures also increase metabolic demands, which require the use of surplus lipid levels for growth and maintenance of bodily functions. Consequently, streams with cooler water temperatures likely favor lipid accumulation over growth and our results suggest juvenile male steelhead in those streams are more likely to mature as residents than their cohorts rearing in warmer streams.

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Remember that the next time you land and admire a beautiful steelhead, it may have had a father that was 5 inches long and never went to the ocean. Photo by John McMillan

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We did not examine the influence of heritability in our study, but we assume genetics had some effect. For example, recent research on Atlantic salmon, brown trout, and brook trout suggests resident males also have more efficient metabolisms than migrant or anadromous life histories, which allows them to convert a greater percentage of calories into growth and enables them to get by with less. The implication is that the ocean is one of the few places, along with large and deep lakes, where productivity can meet the energetic requirements of fish with less efficient metabolisms that must achieve a fairly large size to reproduce. The extent to which metabolism influences life history is not clear, but upcoming research should provide an extensive amount of insight.

Conclusions

So why do some fish mature in freshwater rather than migrate? All juveniles do not grow and accumulate lipids equally in fresh water due to differences in genetics and environment. For some, freshwater meets their energetic needs in terms of growth and lipids early in life, and maturity is initiated without an ocean migration. For others, their needs are met up to only a point, beyond which they must migrate to habitats that offer better opportunities for maturity, such as the ocean.

In this framework, streams with abundant food supplies, moderated stream flows and relatively cool water temperatures that favor good growth and high energy storage should favor resident maturity, at least for males. Females would still need to achieve a size adequate for spawning based on the environment and size of her competitors. Good opportunities for growth and energy storage could explain why places such as the Deschutes River (Oregon) and upper Sacramento River (California) have traditionally been or were historically strongholds for large populations of rainbow trout that co-exist(ed) with steelhead. Those rivers support abundant sources of food, and volcanic activity left a legacy of large underground springs that helps reduce variation in stream flow and provides a source of relatively cool water temperatures during the summer. If this is the case, then we might expect fish inhabiting streams with less food, more stream flow variation and elevated water temperatures to favor migration to areas with better opportunities for growth and lipid accumulation, such as the ocean or lakes.

Not unexpectedly, similar observations between growth, lipids and maturity have been documented in many organisms. For instance, Dr. Robert Sopalsky's research on baboons found that after a dump was moved into the troupe's territory, the baboons stopped undertaking their normal foraging trips, preferring instead to feed on the garbage. With easy access to a high lipid diet, the baboons matured earlier and the females had more offspring. They essentially became residents. Similarly, varying proportions of Canada geese and songbirds have altered or eliminated winter migrations to take advantage of human agricultural fields and urban bird feeders that provide a source of easy, high fat food that was historically not present prior to humans. Closer to home, humans initiate puberty earlier now than a few hundred years ago, which is attributed to diets that are increasingly high in lipids and nutrition, and the migrations of historic nomadic hunter-gatherer tribes essentially ceased once agriculture predominated and food sources became more predictable and locally available.

My simple answer is: Get a fish fat enough and it won't move because the need has been quelled. In contrast, a hungry fish will move as far as necessary to get fat.

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