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Conserving biological diversity of native fish and protecting their habitats

COMMENTS ON THE MITCHELL ACT HATCHERY EIS April 13, 2009

The Native Fish Society appreciates the opportunity to comment on the Mitchell Act Hatchery Environmental Impact Statement. We are pleased that this hatchery evaluation has been expanded beyond the Mitchell Act hatcheries to include all hatcheries within the Columbia River basin. The biological and economic effect of all hatchery programs on the human environment is an important question, having cumulative implications for the salmonid ecosystem, and it is entirely appropriate to evaluate.

Our comments are in response to the key questions identified by the National Marine Fisheries Service. We respond to each question and provide scientific references. In addition, we have added a few of our own key questions that should be incorporated into the EIS evaluation.

Initial Comment on Hatchery Salmonids Effect on Wild Salmonids

For several decades scientific research comparing the reproductive success of wild and hatchery salmonids has demonstrated that hatchery salmonids have lower reproductive success relative to wild fish. (Hoffnagle et al. 2008; Chilcote et al. 1986; Leider et al. 1990; Campton et al. 1991; Kostow et al. 2003; McLean et al. 2004; Araki et al. 2007).

The use of hatcheries in managing salmonid stocks has been questioned and debated for many years (Reisenbichler and McIntyre 1977; Waples 1999; Levin et al. 2001; Reisenbichler et al. 2003; Brannon et al. 2004).

Using hatchery salmonids to supplement wild populations is done with the purpose of integrating the hatchery and wild fish so that it is one breeding population. The purpose is to increase natural production while at the same time limiting domestication of the hatchery stock and affecting the reproductive fitness of the wild population. (ISAB 2003; Reisenbichler et al. 2003; Goodman 2004). The objective is to rebuild the wild population, rescue it from decline and potential extinction so that it is self sustaining (HSRG 2005). However, as Bowles (1995) pointed out, these goals are rarely met. Using hatchery fish to supplement a wild population may increase production of adults, but it cannot increase its productivity (Bowles personal communication).

Hatchery salmonid performance is better in the hatchery than in the natural stream; wild fish performance is better in the natural stream than in the hatchery, and hybrids of wild and hatchery fish performance is intermediate in both environments (Reisenbichler and McIntyre 1977). Consequently hatchery cultivation creates a second form of salmonid that has increasingly poor performance in streams. Naturally spawning hatchery fish can have an ecological effect on wild salmonids in terms of competition for food and rearing space, and when they interbreed with wild fish the progeny have lower survival compared to wild fish. Hatchery fish have a negative effect on naturally produced wild salmonids and should be considered an alien form of salmonid that introduces a source of mortality on wild salmonids, contributing to their decline. Therefore, hatcheries cannot be used to rebuild or recover wild salmonids. For a limited duration (two generations) hatcheries may have a conservation purpose of retaining genetic information of a wild population faced with extinction.

Key Question #1: How will hatchery operations positively or negatively affect the distribution, diversity, and abundance of the various populations?

We assume you mean the effect on wild native populations in posing this question, so we will address all key questions from that perspective. Also, the effect of hatchery operations on the productivity of wild native salmonids should be added to your list, since that is a factor in your VSP criteria.

There should be no question that hatchery operations and the fish they produce have an effect on native wild salmonids, and there is ample scientific literature to address these effects. In the rare case where a wild population and its genetic information would have been lost due to environmental disturbance (Imnaha spring-summer chinook) the hatchery program could be considered to have a positive effect for the persistence of a wild native population. However, these instances are relatively uncommon compared to the negative effects identified. Even on the Imnaha the phenotypic changes in the cultured stock diverged from the wild population, limiting its utility as a potential genetic reserve for this wild population (Hoffnagel et al. 2008; Rich Carmichael, ODFW would be a good source of information).

Another example to illustrate a negative effect of a hatchery program on wild salmonid health can be drawn from the fish management history for the Molalla River, an upper Willamette ESU tributary. The release of hatchery winter steelhead and summer steelhead into this river reduced the abundance of the wild winter steelhead and resulted in its eventual ESA-listing. Releases of hatchery spring chinook from the Santiam River are still going on and the wild spring chinook in the Molalla are now considered extinct even though as late as the 1950s, the run of wild spring chinook was 1000 fish. This hatchery program and resulting harvest programs contributed to the extinction of wild spring chinook in the Molalla River even though it remains one of the few tributaries to the Willamette that has no dams. Recovery of the upper Willamette spring chinook ESU is reliant upon recovery of wild spring chinook in the Molalla River.

There are many examples of hatchery programs having a negative effect on wild salmonids. The recent work by the HSRG on hatchery effects in the Columbia River basin is a good source of information.

Key Question #2: Are there any hatchery barriers that prevent adult salmon and steelhead from migrating upstream?

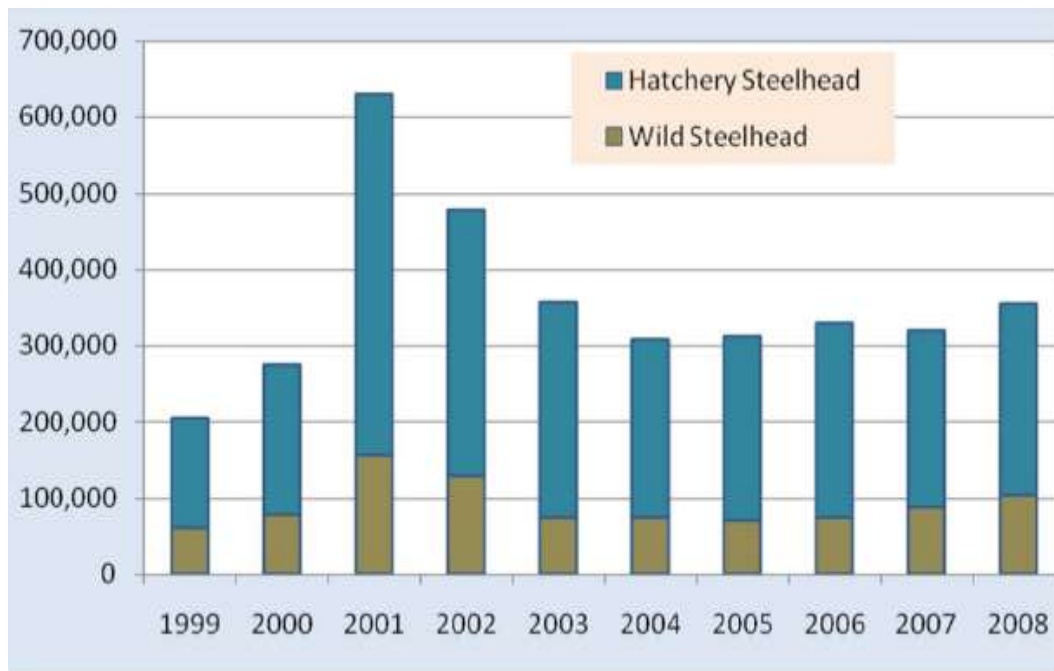
An inventory of hatchery barriers to adult salmonid migration to spawning and rearing habitats should be completed for the Columbia River basin. An example of one is Cedar Creek Hatchery

on the Sandy River, Oregon. This hatchery barrier blocks adult spawners that are ESA-listed fish. At one time water withdrawals on Wind River at Carson Hatchery prevented migration of wild steelhead into the upper river during low summer flows. This problem may have been corrected, but since the steelhead are now listed as a protected species further evaluation is appropriate. A hatchery barrier on Eagle Creek near Bonneville Dam has been a periodic barrier to ESA-listed winter steelhead when it is closed to passage during March and April for cleaning. Herman Creek has been blocked in the past to adult salmonid migration and may still be blocked at times. A few years ago winter maintenance of the south shore (Oregon side) of John Day Dam on the Columbia River prevented migration of summer steelhead into the John Day River. This work was done at a time when steelhead overwintering in the Columbia River below the dam migrate upstream to enter the John Day River. Fishway closures should not take place when known migration timing of salmonids is in progress.

Key Question #3: Are hatchery fish preserving the existence of any salmonid populations?

There are relatively few wild, native salmonid populations needing life support from hatcheries. The one obvious one is the Redfish Lake sockeye salmon. Hatcheries may be needed to maintain wild salmonid populations in the upper Columbia and Snake rivers when ecological conditions reduce juvenile survival in rearing areas and in the mainstem due to drought and when the ocean environment is simultaneously unproductive for salmonids. Otherwise, hatcheries do a good job of contributing to the degradation of wild salmonid populations through ecological impacts and loss of fitness through interbreeding. Another aspect of hatchery production is the harvest impact on wild salmonids in fisheries with wild and hatchery fish mixed together and managed under the maximum sustained yield policy. Over all, hatcheries are a major problem for wild salmonid conservation. The following information from Idaho Department of Fish and Game show that

Upriver Summer Steelhead



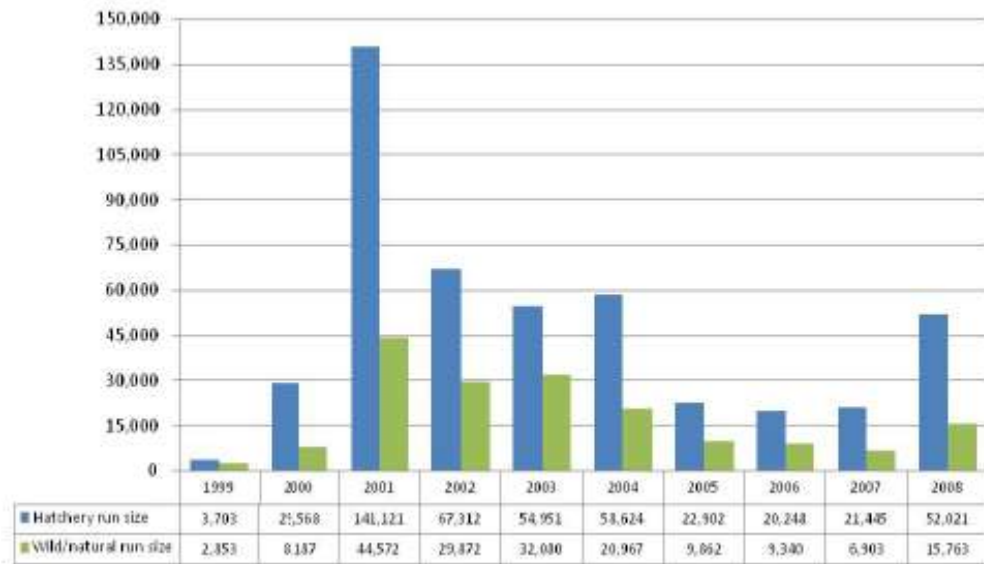
Idaho Fish and Game March 10, 2009 Steelhead passage at Bonneville Dam
<http://www.nwcouncil.org/news/2009/03/1.pdf>

hatchery chinook and steelhead are replacing wild chinook and steelhead in the Snake River basin, a direct effect of hatchery programs.

Replacing ESA-listed salmonids with hatchery fish is not consistent with the purpose of the Endangered Species Act. The existing institutional structures and commitments controlling salmonid harvest and hatchery production have successfully escaped compliance with federal responsibilities under the ESA.

There is ample scientific information available to support changes in this institutional structure on hatchery production (Araki et al. 2007, Bowles 1995, Reisenbicher and McInyre 1977, Reisenbichler et al. 2003, Knudsen et al. 2006, ISAB 2003, Kostow and Zhou 2006, Levin et al. 1990, Goodman 2004, Campton et al. 1991 Brannon et al. 1999). However, the fish and wildlife agencies and NOAA Fisheries have been successful in keeping the best available science from informing management policy. Consequently, management policy and the institutional structures it enforces are unresponsive to the recovery of ESA-listed salmon and steelhead. Hatchery programs are not preserving the existence of ESA-listed and other wild salmonids in the Columbia River basin.

Adult returns of wild/natural- and hatchery-origin
spring/summer Chinook salmon to Lower Granite Dam
1999 - 2008



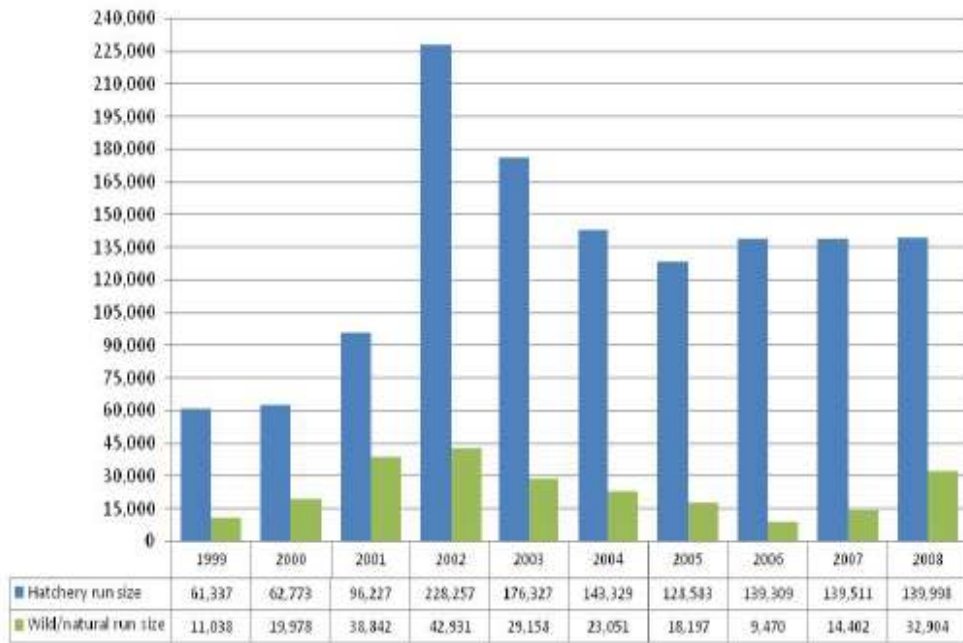
Idaho Fish and Game March 10-11, 2009

<http://www.nwcouncil.org/news/2009/03/4.pdf>

Based on the science, hatcheries cannot rebuild wild salmonid populations. There is no scientific evidence that supports this premise, even though it is routinely stated by the fish managers to justify the existing hatchery program and to expand it.

NOAA Fisheries has the responsibility to recover ESA-listed salmonids. The state and tribal fish agencies are obligated only to the extent that NOAA Fisheries requires compliance with the ESA. Controlling the effect that hatcheries have on ESA-listed salmonids and their contribution to the decline of wild salmonids, NOAA Fisheries will have to modify or closed hatchery programs that are not in compliance with recovery of ESA-listed salmonids.

Adult returns of wild/natural- and hatchery-origin
Steelhead to Lower Granite Dam
1999 – 2008



Idaho Fish and Game March 10-11-2009 <http://www.nwcouncil.org/news/2009/03/4.pdf>

The graphics provided here illustrate an emerging problem that has consequences for both the recovery of ESA-listed salmonids and for the Columbia River salmonid hatchery program. Hatchery salmonids are replacing wild salmonids in most Columbia River watersheds, including the Snake River basin. Wild salmonids are in decline throughout the Columbia River basin and represent a proportionally small number of salmon in the annual run. Hatchery chinook represent 80% of the run (Hoffnagle 2008). Hatchery production efficiency is a result of biology and cost. The longer a hatchery population is cultivated the lower its survival rate and the cost to produce a fish for harvest increases. Using wild fish in the broodstock improves the survival of hatchery fish, even though it remains lower relative to the wild fish, and the cost to produce fish that are harvested decreases while their potential contribution increases. The simple fact is that having access to wild salmonids to reinvigorate hatchery fish survival, lower cost of production and increasing contribution to fisheries is essential for a cost effective hatchery program.

Hatcheries are supported with public dollars and politics. As hatcheries become less productive, cost more for the benefits they provide and contribute less to the fisheries, the political support and funding could rapidly decline. As the wild salmonids decline access to them for hatchery recharge becomes more restricted and may become off limits. The wild fish are needed to improve hatchery fish survival, improve the cost benefit ratio and increase contribution to the

fisheries. Without wild fish to refresh hatcheries, the hatchery program will become more difficult to justify biologically or economically.

Economic evaluation of hatcheries needs to include analysis of their cost benefit, but this is seldom done and in many cases the information to do this analysis is not available. It is remarkable that an expensive program funded with public dollars lacks transparency and accountability.

Current hatchery management is replacing wild salmonids in the Columbia River basin. Unfortunately this is considered a success by the fish managers even though the whole salmonid production system is becoming unsustainable. When a run of salmon such as the chinook are composed of 80% hatchery fish it should be considered a problem rather than justification for the hatchery program.

Key Question #4: Are hatchery fish preying upon wild fish and/or competing for their food or space?

Not only has research shown that hatchery fish prey upon wild fish, they also attract predators that can consume wild salmonids. There is ample scientific information documenting these problems (Nickelson 2003, Clements and Schreck 2003). In addition, hatchery fish can and do compete with wild fish for food and space in the rearing environment, causing wild smolt production to decline (Kostow et al. 2003, Nickelson 1986; 2003). Studies on the Clackamas River, Oregon show the effect of non-native summer steelhead on native winter steelhead. In this study it was determined that the non-native summer steelhead did not interbreed with native winter steelhead but because summer steelhead spawned earlier than winter steelhead their juveniles emerged earlier and had a head start on growth. The summer steelhead juveniles effectively competed with the smaller winter steelhead juveniles and occupied much of the rearing capacity of the river. The number of wild smolts produced was reduced by 22% as a result of this competition (Kostow and Zhou 2006). Even though the summer steelhead produced smolts they did not produce many adults. Adult recruits decreased by 40% (Kostow and Zhou 2006). The result is that the winter steelhead produced fewer smolts and fewer adults. As a result of this study, the Oregon Department of Fish and Wildlife no longer release hatchery non-native summer steelhead above North Fork Dam. This portion of the river is now reserved for wild salmonid production and all hatchery salmonids are stopped at the fishway (Kostow et al. 2003).

The recent conclusions of the HSRG for lower Columbia River ESA-listed salmon and steelhead recovery recommend the construction of weirs on spawning tributaries to prevent natural spawning of hatchery origin fish with wild fish. This is necessary to recover ESA-listed salmonids in the lower Columbia River.

However, non-native hatchery summer steelhead continue to be released into the Santiam, upper Willamette and Sandy rivers where they can and do compromise the productivity of wild ESA-listed winter steelhead. These hatchery programs persist under NOAA Fisheries approval even though there is ample scientific data to show these non-native summer steelhead are impeding recovery of threatened native winter steelhead.

Key Question # 5: Are hatchery fish interbreeding with wild fish and making wild fish less able to survive and reproduce?

Reisenbichler and McIntyre (1977) concluded that hatchery steelhead had lower survival in the natural stream environment and would produce fewer adults than wild steelhead. They also

found that wild steelhead had lower survival in the hatchery environment when compared to hatchery steelhead. By crossing hatchery and wild steelhead the authors found that the progeny had an intermediate survival rate when compared to wild steelhead in the stream environment. The hatchery steelhead used in this experiment were native to the Deschutes River and had been cultivated for two generations.

The results of this study have been confirmed by numerous studies since 1978 on the Kalama River, Yakima River and Hood River. The hatchery environment changes the phenotypic traits of the wild salmonids so that survival is reduced by 20-30 percent in the first generation and 40% in the second generation (Araki 2008). Interbreeding between wild and hatchery fish reduces the fitness of the wild fish, reducing their reproductive success. Chilcote (2008) said that the reduction in fitness of a naturally spawning wild salmonid population can be predicted by the number of naturally spawning hatchery fish in the population and it is proportional, so if the hatchery fish make up 40% of the natural spawning population the reproductive success of the wild population will be reduced by 40%. This suggests that the standard used for hatchery spawner stray rates actually subtracts from the reproductive success of the wild population. Allowance for stray hatchery fish in the natural spawning population are not consistent with recovery and protection of wild populations. Hatcheries cannot be used to rebuild or recover wild salmonids.

Key Question #6: What are the effects of hatchery broodstock collection on wild populations?

Taking wild salmonids for hatchery broodstock subtracts wild fish from the breeding population. Broodstock collection for hatcheries has the same effect on the wild natural population as harvest for it reduces the number of wild spawners. Research going back to 1978, and confirmed by recent studies, clearly show that hatchery fish produced from wild native broodstock have a lower survival rate than the wild population in the first generation. When these native broodstock hatchery fish interbreed with wild salmonids in the stream they reduce the reproductive success of the wild population. The effect of collecting wild salmonids for hatchery broodstock and allowing them to spawn naturally with wild fish is a two-edged sword, compounding the risk to wild salmonids and impeding their recovery.

Key Question #7: Are hatchery fish transferring disease to wild salmonids?

There is a potential for hatchery fish to transfer disease to wild salmonids. Whirling disease in Montana streams has had a detrimental effect on rainbow trout. Early studies on the spread of IHN indicated that stray hatchery fish facilitated its spread throughout the Columbia River basin. New forms of IHN disease are found in the Deschutes River below the barrier dams on the Deschutes River and there is concern about allowing passage of fish above the dams because it would spread the disease into the upper river. The fish above the dams would be exposed for the first time to new forms of IHN. Whirling disease infected anadromous salmonids are found in the Deschutes River and the source of this disease is from Snake River hatchery fish. When the ODFW discovered whirling disease in its Snake River hatchery steelhead, they continued to release the fish and this disease has moved and is now found in tributaries of the Clackamas River.

There are few studies of disease transfer from hatchery to wild fish. It is likely, given what we know about disease spread within the Columbia River basin that hatchery fish spread disease to wild fish, but the studies have not been done to confirm it.

Key Question #8: How will hatchery operations impact other fish and wildlife species?

Hatchery programs can have an important effect on fish and wildlife that depend upon seasonal food supplies of spawning salmonids. The ecological effect of hatchery programs can limit the availability of these foods and nutrient enrichment of watersheds. One study points out that salmonid abundance is high in streams with hatcheries on them while other non-hatchery streams have low abundance of salmonids. The authors note that nutrient enrichment of streams with marine derived nutrients from salmon carcasses in non-hatchery streams was lower. Lower abundance also affects food availability for wildlife such as eagles, osprey, bears, mergansers, etc. Piccolo (2009) reviews the scientific literature on the value of salmon abundance and contribution to ecological benefits in watersheds.

Nutrients brought into streams by salmon and released to enrich their spawning streams when they die, increases the productivity of streams for salmonid production. “We observed increased densities of juvenile fish, increased body weight, and improved condition factor in the stream reaches to which salmon carcasses were added. Sixty to 96% of the material in the stomachs of juvenile coho and steelhead during the period when carcasses were present at the treated sites consisted of eggs and carcass flesh. By December the coho at the treated site were 44% larger than the coho at the reference site. Therefore availability of eggs and carcass tissue, and the resultant increase in body size of juvenile fish, may positively impact survival rates through the remainder of their life. Our results coupled with information published over the last 7 years make it increasingly apparent that adequate levels of spawning salmon are an important component of healthy stream habitat in the Pacific Northwest. It is likely that decreased numbers of returning salmon have decreased the capacity of the freshwater habitats where they spawn to support juvenile salmon and other aquatic biota (Bilby 1998).

Bilby (1998) also concludes that natural spawners are more valuable than manual distribution of salmon carcasses in supporting stream productivity, salmonids and other species for the following reasons: “Distribution of salmon carcasses from hatcheries may be used to increase the availability of carcass material in watersheds where population levels are severely depressed. However, this technique cannot replace all the ecological functions provided by naturally spawning fish. Spawning fish remove sediment from streambed gravels and alter the community composition and productivity of invertebrate populations. Ault salmon also enter streams and spawn over an extended period of time. Therefore, carcass material would be present in the channel for a longer period than would be the case with hatchery carcasses added on a single date.

Key Question #9: What are the impacts of hatchery effluent on water quality?

A few years ago the Native Fish Society in cooperation with an environmental attorney evaluated the effluent discharge from Oregon Department of Fish and Wildlife hatcheries and threatened to sue them for violations of the Clean Water Act. This resulted in cleaning up effluent discharges. It is important that individual hatcheries keep records on hatchery effluent and be able to verify that they are following labels controlling the release of toxic chemicals into public waters. This requirement must be enforced on all hatcheries reviewed under the expanded Mitchell Act Hatchery EIS. In addition, fish biologists familiar with hatchery operations are very concerned about the release of disease organisms into streams from hatcheries. In this EIS each hatchery should be able to verify that they are treating effluent so that disease organisms are not being released into streams.

Key Question #10: What is the relationship and effect of hatchery production on tribes?

Hatcheries are supported by public funding and public policies. This means that hatcheries are not sustainable because the funding and policy support can change and potentially be terminated.

Scientific research points out that hatchery fish survival decreases with each generation of cultivation. This means that hatchery fish have lower survival and cost more to produce. This problem can be modified by incorporating wild, native fish into the hatchery program, improving survival and potentially the cost of production. However, a source of wild salmonids is needed to maintain the fitness and survival of hatchery fish so their cost is lower and their contribution to fisheries can be increased. Biologically hatchery salmonids are not sustainable without access to wild salmonids to improve survival.

Consequently, the reliance upon politics and public funding for hatcheries increases the risk to tribal fisheries as funding shrinks for hatcheries or public policy support declines. In addition, the biological degradation of hatchery fish in terms of fitness, survival and resulting increases in cost and lower contribution to fisheries also places the tribal fishery at risk.

Taken together, reliance upon hatcheries to support the tribal treaty fishing rights is not sustainable. Removing the certain risk to tribal fishing rights from reliance on hatchery fish can be accomplished only by maintaining healthy and productive wild salmonid populations throughout the Columbia River basin. These locally adapted populations are the foundation for hatchery maintenance, hatchery development, and hatchery contribution to the fisheries. The wild salmonids are needed to guard against changes in funding and policy and to maintain the productivity of the hatchery program and dependent fisheries. The hatcheries are dependent upon the wild populations and if this fundamental safety net for the tribal fishery is lost or degraded so that they are no longer available to reboot the hatchery program, the hatchery-based fishery cannot be maintained.

The tribal treaty fishing right is in jeopardy as the hatchery proportion of the salmonid run increases and the wild populations decline. It is a failure of salmon management when 80% of the salmonids in the Columbia Basin are composed of hatchery fish, for it increases the potential collapse of wild salmon and eventually the hatchery programs.

Key Question #11: Will hatchery operations under any EIS alternative have disproportional impacts on lower income groups?

Lower income groups are more likely to fish near where they live. As hatcheries replace wild salmonids, contribute to wild salmonid decline, and are used to mitigate for habitat degradation, the abundance, productivity, distribution and diversity of wild locally adapted populations will be lower and abundance is being reduced. This will affect local communities in terms of access to productive fisheries. The expense of providing hatchery fish is another factor that influences the cost of fishing. There is evidence that wild fish contribute more to sport fisheries than do hatchery fish, so the catch is reduced as the wild runs decline. The kill of wild fish is prohibited in most fisheries so legal harvest of fish is reduced. Strong hatchery runs are associated with rivers that have dams, but other rivers have fewer fish returning to them. For example, on the Molalla River local anglers fish for hatchery spring chinook but the hatchery fish survival is low and when the run fails, the fishery also fails.

Given these problems, it is likely that low income people who fish locally have fewer options to harvest fish for food.

Additional Key Question Relating to the Mitchell Act Hatchery EIS:

Key Question # 12: The cost to produce a hatchery fish that is caught in the fishery (cost to catch).

The Independent Economic Advisory Board is responsible for answering economic questions posed by the Northwest Power Planning Council and NOAA Fisheries. In 2002 the IEAB published their Phase I report on the cost of hatchery fish in the Columbia River. For the most part hatchery salmonids cost more to produce at the point of harvest than the economic benefit they provide. In some cases the cost has been as high as \$891,000 per salmon harvested. While this cost can be explained, it still represents a rather high investment of public funds. In a recent letter to the Oregon Legislature Hans Radtke, a natural resource economist, said that hatchery produced spring chinook cost \$200 per fish caught while the value ranges from \$100 to \$125 per fish. Hatchery coho salmon cost \$67 per fish and their value is \$15 (Radtke 2009a). Fall chinook cost to catch, taking into account the cost of production, survival and harvest agreements, could be as much as \$174.20 per fish.

Even though the IEAB was prepared to conduct an economic evaluation of all Columbia River hatchery programs, called Phase II, they were not given the permission to complete this work by the Northwest Power Planning Council or NOAA Fisheries. A complete economic evaluation of Columbia River hatcheries should be completed and this evaluation should include how much a fish that is harvested costs the public. A complete cost-benefit analysis is necessary so the public, whose funds support these hatchery programs, can see how their money is being spent. NOAA Fisheries should be supportive of cost accountability and transparency in government spending, even though NOAA Fisheries has decided to not complete a cost-benefit analysis for about 20 Mitchell Act hatcheries in the Columbia River under the Mitchell Act EIS.

References

- Araki, H., W. R. Ardren, E. Olsen, B. Cooper, and M. S. Blouin. 2007. Reproductive success of captive-bred steelhead trout in the wild: evaluation of three hatchery programs in the Hood River. *Conservation Biology* 21:181–190.
- Bilby, R.E., B.R. Fransen, and J.K. Walter. 1998. Response of juvenile coho salmon and steelhead to the addition of salmon carcasses to two streams in southwestern Washington, USA. *Can. J. Aquat. Sci.* 55: 1909 – 1918.
- Bowles, E. C. 1995. Supplementation: panacea or curse for the recovery of declining fish stocks? Pages 277–283 in H. L. Schramm, Jr., and R. G. Piper, editors. *Uses and effects of cultured fishes in aquatic ecosystems*. American Fisheries Society, Symposium 15, Bethesda, Maryland.
- Brannon, Ernest, L., Kenneth P. Currens, Daniel Goodman, James A. Lichatowich, Brian E. Riddell, and Richard N. Williams. 1999. Review of artificial production of anadromous and resident fish in the Columbia River basin. Part I: A scientific basis for Columbia River production programs. Independent Scientific Advisory Board. Northwest Power Planning Council. Portland, OR.
- Campton, D. E., F. W. Allendorf, R. J. Behnke, F. M. Utter, M. W. Chilcote, S. A. Leider, and J. J. Loch. 1991. Reproductive success of hatchery and wild steelhead. *Transactions of the American Fisheries Society* 120:816– 827.
- Chilcote, M. W., S. A. Leider, and J. J. Loch. 1986. Differential reproductive success of hatchery and wild summer-run steelhead under natural conditions. *Transactions of the American Fisheries Society* 115:726–735.
- Goodman, D. 2004. Salmon supplementation: demography, evolution, and risk assessment. Pages 217–232 in M. J. Nickum, P. M. Mazik, J. G. Nickum, and D. D. MacKinlay, editors. *Propagated fish in resource management*. American Fisheries Society, Symposium 44, Bethesda, Maryland.

- ISAB (Independent Scientific Advisory Board). 2003. Review of salmon and steelhead supplementation. Northwest Power Planning Council, Document ISAB-2003-03, Portland, Oregon. Available: www.nwcouncil.org/Library/isab/isab2003-3.htm (January 2008).
- Knudsen, C. M., S. L. Schroder, C. A. Busack, M. V. Johnston, T. N. Pearsons, W. J. Bosch, and D. E. Fast. 2006. Comparison of life history traits between first-generation hatchery and wild upper Yakima River spring Chinook salmon. *Transactions of the American Fisheries Society* 135:1130–1144.
- Kostow, K. E., A. R. Marshall, and S. R. Phelps. 2003. Naturally spawning hatchery steelhead contribute to smolt production but experience low reproductive success. *Transactions of the American Fisheries Society* 132:780–790.
- Kostow, K. E., and S. Zhou. 2006. The effect of an introduced summer steelhead hatchery stock on the productivity of a wild winter steelhead population. *Transactions of the American Fisheries Society* 135:825–841.
- Leider, S. A., P. L. Hulett, J. J. Loch, and M. W. Chilcote. 1990. Electrophoretic comparison of the reproductive success of naturally spawning transplanted and wild steelhead trout through the returning adult stage. *Aquaculture* 88:239–252.
- Levin, P. S., R. W. Zabel, and J. G. Williams. 2001. The road to extinction is paved with good intentions: negative association of fish hatcheries with threatened salmon. *Proceedings of the Royal Society of London* 268:1153–1158.
- McLean, J. E., P. Bentzen, and T. P. Quinn. 2004. Differential reproductive success of sympatric, naturally spawning hatchery and wild steelhead trout (*Oncorhynchus mykiss*). *Environmental Biology of Fishes* 69:359–369.
- Nickelson, T.E., M.F. Solazzi, and S.L. Johnson. 1986. Use of hatchery coho salmon presmolts to rebuild wild populations in Oregon coastal streams. *Can. J. Fish. Aquat. Sci.* 43:2443-2449.
- Nickelson, Thomas. 2003. The influence of hatchery coho salmon on the productivity of wild coho salmon populations in Oregon Coastal basins. *Can. J. Fish. Aquat. Sci.* 60: 1050-1056.
- Piccolo, John, J.; Milo D. Adkison, and Frank Rue. 2009. Linking Alaskan salmon fisheries management with ecosystem escapement goals: a review and prospectus. *American Fisheries Society. Fisheries* 34:3. March.
- Radtke, Hans, D. 2009a. Testimony before the Committee on Sustainability and Economic Development. Oregon Legislature. Salem, Oregon. March 26, 2009.
- Radtke, Hans, D. 2009b. Testimony Concerning Oregon Artificial Production of Salmon and Steelhead. Oregon Legislature. Salem, Oregon. March 18, 2009.
- Reisenbichler, R. R., and J. D. McIntyre. 1977. Genetic differences in growth and survival of juvenile hatchery and wild steelhead trout, *Salmo gairdneri*. *Journal of the Fisheries Research Board of Canada* 34:123–128.
- Reisenbichler, R. R., F. M. Utter, and C. C. Krueger. 2003. Genetic concepts and uncertainties in restoring fish populations and species. Pages 149–183 in R. C. Wissmar and P. A. Bisson, editors. *Strategies for restoring river ecosystems: sources of variability and uncertainty in natural and managed systems*. American Fisheries Society, Bethesda, Maryland.
- Clements, Shaun and Carl B. Schreck. 2003. Juvenile salmonid Survival in specific areas of the Nehalem watershed. Annual Report, Final Draft, March. Oregon Cooperative Fish and Wildlife Research Unit. Department of Fish and Wildlife. Oregon State University. Corvallis, Oregon
- Waples, R. S. 1999. Dispelling some myths about hatcheries. *Fisheries* 24(2):12–21.