The Effects of Hatchery Production on Wild Salmon and Trout
OUR MISSION:

To preserve, protect and restore the Northwest’s wild fish and the ecosystems they depend on through science, education, and advocacy.
SALMON AND TROUT

- Salmonids generally exhibit 3 essential biological characteristics:
  - Anadromy
  - Homing
  - Semelparity

- Pacific salmonids diverged from Atlantic salmonids ~ 15 mya.

- Speciation of Pacific salmonids occurred ~6 mya.

-Waples et al. 2008; Quinn 2005
PRINCIPLES OF EVOLUTIONARY BIOLOGY

• “Survival of the fittest”: Inheritance of advantageous genes activates traits enabling survival.
• Selection pressures and isolation drive natural selection, genetic drift, and evolution.
• Local adaptations maintain populations.
• Genetic diversity maintains a species under changing environmental conditions.

-Reece et al. 2013; Schindler et al. 2010
EVOLUTION OF POPULATIONS

• Populations evolved to natal freshwater reaches over thousands of years through homing, local selection patterns, and heritability.

• Populations exhibit superior fitness in natal streams relative to non-native populations.

-Quinn 2005
Mean incubation temperatures for Fraser River sockeye populations

- Brannon 1987; Quinn 2014
Spawning site and the body depth of male sockeye from Iliamna and Wood River

- Quinn et al. 2001; Quinn 2014
SUCCESS OF THE BRISTOL BAY SOCKEYE FISHERY

• Habitat variability has generated rich intraspecies diversity.
• Fishery productivity has remained high due to the maintenance of genetic diversity.
• The conservation of population diversity has produced significant economic benefit.
• Habitat and genetic diversity allow adaptation to environmental changes.

-Schindler et al. 2010
COLLAPSE OF PACIFIC NORTHWEST FISHERIES

- The 4 Hs:  
  - Habitat  
  - Harvest  
  - Hydroelectricity  
  - Hatchery Production

- Diminished habitat/genetic diversity.
- Significantly reduced abundance.
- Capacity to adapt to a changing environment has been reduced.

- NOAA 1999; Schindler et al. 2010; Lichatowich 2013
WILD PUGET SOUND STEELHEAD ABUNDANCE

1900: 500,000
2014: 100,000

-PS Sthd TRT, 2013; Gayeski et al., 2011
97%

Steelhead loss
97% Steelhead loss
21% Habitat loss

-Gayeski et al., 2011; Scott and Gill 2008
HISTORY OF HATCHERY PROPAGATION

• First hatcheries in PNW constructed in the 1880s.

• Goals of establishment:
  • 1) Mitigate habitat loss.
  • 2) Supplement weak or unstable runs.
  • 3) Restore endangered runs.

LOGIC OF HATCHERY PRODUCTION

• Only one out of ten juveniles survive to emerge from the gravel.
• Hatcheries bypass the limiting embryonic life-history stage.
• Juveniles are imprinted at the hatchery facility.
• Fish use olfactory senses to return to their watershed’s of birth.

-Quinn 2005
IMPLICIT ASSUMPTIONS OF HATCHERY PRODUCTION

1) The hatchery by-passes the limiting life-history stage; other habitats are under-utilized or are not limiting.
2) There are no other biological interactions between hatchery-produced and wild fish (e.g. diseases, genetic interaction, predation, etc.).
3) The survival rate of hatchery-produced fish is similar to wild fish.
4) The hatchery does not affect habitat needed by wild fish.
5) The fisheries can accommodate the more productive hatchery population without over fishing the wild one.
6) The hatchery’s productivity will be steadier than that of wild populations.

-Modified from Quinn 2014
“The regulation of the times, methods, and apparatus of the fisheries should be such as to assure the largest opportunity practicable for reproduction under natural conditions. Artificial propagation should be invoked as an aid and not as a substitute for reproduction under natural conditions.”

- U.S. Commissioner of Fisheries (1894)
HISTORY OF HATCHERY PROPAGATION

-Mahnken et al. 1998
HATCHERY RELEASES VS. RETURNS

- Brodeur 1990; Quinn 2014
“The widespread use of traditional hatchery programs has actually contributed to the overall decline of wild populations.”

SURVIVAL AND REPRODUCTIVE RATES OF HATCHERY FISH

• Domestication in hatchery facilities alters predator avoidance, feeding behavior, genetics, and physiology.
  Hatchery fish exhibit reduced survival relative to wild fish.

• Domestication selection by hatchery practices derails the “survival of the fittest” concept.
  Those with the greatest fitness in a captive environment produce offspring that perform the worst in the wild.

- Quinn 2005; Chilcote 2011
-Stringwell et al. 2014
Snake River Chinook smolt to adult survival

% smolt to adult return

- Raymond (1988)
Smolt production of Forks Creek steelhead

- Mclean et al. 2003
Returning steelhead adults produced in Forks Creek

- Mclean et al. 2003
RISKS OF GENETIC INTROGRESSION

• If hatchery fish manage to return and escape the fishery, they often stray into wild spawning grounds.

• With lower survival, reproductive capacity, and adaptation to natural systems, genetic mixing of hatchery and wild fish reduces the potential of wild salmon recovery.

-Hilborn and Hare 1992; Chilcote 2011
Offspring produced in the wild and the proportion of hatchery-origin spawners

- Chilcote et al. 2011
SEGREGATED VS. INTEGRATED PROGRAMS

• Segregated programs utilize only hatchery-origin salmonids for brood-stock.
• Integrated programs utilize wild salmonids of the same watershed for brood-stock.
• Both forms of hatchery production reduce the survival and reproductive capacity of wild stocks.

−Araki 2009; Chilcote 2011; Christie et al. 2011; Christie et al. 2012
Carry-over effect of captive breeding reduces reproductive fitness of wild-born descendants in the wild

Hitoshi Araki*,†, Becky Cooper and Michael S. Blouin

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*Author for correspondence (hitoshi.araki@eawag.ch).

Supplementation of wild populations with captive-bred organisms (supplementation) are not clear yet.

Any negative effects of captive breeding are especially relevant for salmonid species because of the worldwide decline of native salmonid populations and the huge scale of hatchery programmes to compensate for those losses. Firstly, there is scant evidence that adding captive-bred organisms has boosted the long-term productivity of wild salmonid populations (Fraser 2008). Secondly, supplementation of declining wild populations entails risks such as disease introductions, increased competition for resources, and genetic changes in the supplemented population (Waples & Drake 2004). The genetic risk results because artificial environments can select for captive-bred individuals that are maladapted to the natural environment (hereafter ‘the wild’). For example, genetically-based loss of fitness in the wild has been well documented in the case of hatchery-reared salmonid fishes (Reisenbichler & McIntyre 1977; Reisenbichler & Rubin 1999; Araki et al. 2007a, 2008). Thus, captive-bred organisms could potentially drag down the fitness of the wild populations they are meant to support, even while temporarily boosting their num-

Reduced recruitment performance in natural populations of anadromous salmonids associated with hatchery-reared fish

M.W. Chilcote, K.W. Goodson, and M.R. Falcy

Abstract: We found a negative relationship between the reproductive performance in natural, anadromous populations of steelhead trout (*Oncorhynchus mykiss*), coho salmon (*O. kisutch*), and Chinook salmon (*O. tshawytscha*), and the proportion of hatchery fish in the spawning population. We used intrinsic productivity as estimated from fitting a variety of recruitment models to abundance data for each population as our indicator of reproductive performance. The magnitude of this negative relationship is such that we predict the recruitment performance for a population composed entirely of hatchery fish would be 0.128 of that for a population composed entirely of wild fish. The effect of hatchery fish on reproductive performance was the same among all three species. Further, the impact of hatchery fish from “wild type” hatchery broodstocks was no less adverse than hatchery fish from traditional, domesticated broodstocks. We also found no support for the hypothesis that a population’s reproductive performance was affected by the length of exposure to hatchery fish. In most cases, measures that minimize the interactions between wild and hatchery fish will be the best long-term conservation strategy for wild populations.
Genetic adaptation to captivity can occur in a single generation

Mark R. Christie\textsuperscript{a,1}, Melanie L. Marine\textsuperscript{a}, Rod A. French\textsuperscript{b}, and Michael S. Blouin\textsuperscript{a}

\textsuperscript{a}Department of Zoology, Oregon State University, Corvallis, OR 97331-2914; and \textsuperscript{b}Oregon Department of Fish and Wildlife, The Dalles, OR 97058-4364

Edited by Fred W. Allendorf, University of Montana, Missoula, MT, and accepted by the Editorial Board November 11, 2011 (received for review July 14, 2011)

Captive breeding programs are widely used for the conservation and restoration of threatened and endangered species. Nevertheless, captive-born individuals frequently have reduced fitness when reintroduced into the wild. The mechanism for these fitness declines has remained elusive, but hypotheses include environmental effects of captive rearing, inbreeding among close relatives, relaxed natural selection, and unintentional domestication selection (adaptation to captivity). We used a multigenerational pedigree analysis to demonstrate that domestication selection can explain the precipitous decline in fitness observed in hatchery steelhead released into the Hood River in Oregon. After returning from the ocean, wild-born and first-generation hatchery fish were used as broodstock in the hatchery, and their offspring were released into the wild as smolts. First-generation hatchery fish had nearly double the lifetime reproductive success (measured as the number of returning adult offspring) when spawned in captivity compared to hatchery fish, but only half the reproductive success of wild-born fish. This result indicates that hatchery practices are responsible for reduced fitness in the wild when released. The implications of this finding are wide-ranging and should guide future conservation efforts. If unintentional domestication selection is occurring, we expect to observe two unique patterns. First, captive-born individuals should perform better in captivity than wild-born individuals. Second, there should be a tradeoff among the wild-born broodstock: Those with the greatest fitness in a captive environment will produce offspring that perform the worst in the wild. These predictions are not expected under relaxed natural selection because individuals with fit and unfit genotypes (when expressed in the wild) would perform identically in a captive environment where that genetic variation is selectively neutral. We test these competing explanations with a detailed pedigree analysis of a wild steelhead (Oncorhynchus mykiss) population.
On the reproductive success of early-generation hatchery fish in the wild

Mark R. Christie,1,2 Michael J. Ford3 and Michael S. Blouin1

1 Department of Integrative Biology, Oregon State University, Corvallis, OR, USA
2 Department of Biological Sciences and Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, USA
3 Conservation Biology Division, National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, WA, USA

Keywords
captive breeding, domestication, fitness, hatcheries, relative reproductive success, salmon.

Abstract
Large numbers of hatchery salmon spawn in wild populations each year. Hatchery fish with multiple generations of hatchery ancestry often have heritably lower reproductive success than wild fish and may reduce the fitness of an entire population. Whether this reduced fitness also occurs for hatchery fish created with local- and predominantly wild-origin parents remains controversial. Here, we review recent studies on the reproductive success of such ‘early-generation’ hatchery fish that spawn in the wild. Combining 51 estimates from six studies on four salmon species, we found that (i) early-generation hatchery fish averaged only half the reproductive success of their wild-origin counterparts when spawning in the wild, (ii) the reduction in reproductive success was more severe for males than for females, and (iii) all species showed reduced fitness due to hatchery rearing. We review commonalities among studies that point to possible explanations (or reasons to retain cautionary efforts). Further research will be...
Relative reproductive success of Hatchery-origin fish spawning in the wild

- Christie et al. 2014
ECOLOGICAL IMPACTS ON WILD SALMONIDS: COMPETITION

• Limited resources: food, shelter, territory, spawning grounds.
• Density dependence: increased competition reduces wild fish growth, survival, and reproduction.
• Negative effects observed in rivers, estuaries, oceans, and spawning grounds.

-Steward and Bjournn 1990; Quinn 2005
ECOLOGICAL IMPACTS ON WILD SALMONIDS: PREDATION

- Hatchery fish are larger than rearing wild fish upon release.
- Predation of wild fish by larger hatchery fish is common.
- Domestication alters predator avoidance behavior:
  
  ![Eagle](image)

  yellow arrow: large quantities of hatchery fish draw predators which may enhance wild fish mortality.

-Naman 2008
FACILITY EFFECTS

- Hatchery facilities block fish passage and impact salmon habitat.
- Effluent discharge can affect survival.
- Water withdrawals reduce flow and affect water temperatures.
- Facilities can attract wild fish, resulting in injury.
- Broodstock collection can “mine” the wild population.
INDIRECT EFFECTS OF HATCHERIES

• “Myth” of hatchery success results in habitat loss, dam construction, and overharvest.
• Mixed-stock fisheries cause bycatch mortality of non-targeted fishes.
• Stock-selective gear-types are needed.
• Opportunity costs and trade-offs.

-Hilborn and Hare 1992; WDFW 2009
IMPLICIT ASSUMPTIONS OF HATCHERY PRODUCTION

1) The hatchery by-passes the limiting life-history stage; other habitats are under-utilized or are not limiting.  TRUE, BUT.....

2) There are no other biological interaction between hatchery-produced and wild fish (e.g. diseases, genetic interaction, predation, etc.).  FALSE

3) The survival rate of hatchery-produced fish is similar to wild fish.  FALSE

4) The hatchery does not affect habitat needed by wild fish.  FALSE

5) The fisheries can accommodate the more productive hatchery population without over fishing the wild one.  FALSE

6) The hatchery’s productivity will be steadier than that of wild populations.  FALSE

-Modified from Quinn (2014)
THE 4th “H” OF SALMONID DECLINE: HATCHERY PRODUCTION

• Hatchery production degrades wild salmonid populations through:

1. Genetic effects
2. Ecological effects
3. Facility effects
4. Indirect effects

“The widespread use of traditional hatchery programs has actually contributed to the overall decline of wild populations.”

-HSRG (2014)
ECONOMIC IMPLICATIONS

- Hatcheries account for the majority of WDFW’s Fish Program ($63.9 million per biennium excluding capital costs).
- Today’s harvest is enhanced; tomorrow’s harvest is degraded.
- External costs: Hatchery spending directly extinguishes renewable resources.
- Opportunity costs: money spent on hatcheries cannot be spent on habitat.
- Market failure: long-run costs exceed short-run benefits.

-Tietenberg and Lewis 2010; WDFW 2014
### Table 3a. Leavenworth Hatchery. Estimated Cost per Release, Adult, and Harvest

<table>
<thead>
<tr>
<th>Brood Year</th>
<th>Total Releases</th>
<th>Total Adults</th>
<th>Operations &amp; Maintenance Costs</th>
<th>Cost per Release</th>
<th>Cost Per Adult</th>
<th>Cost per Fish Caught</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>6,096,687</td>
<td>16,768</td>
<td>$647,960</td>
<td>$0.106</td>
<td>$38.6</td>
<td>$966.1</td>
</tr>
<tr>
<td>1989</td>
<td>2,771,205</td>
<td>5,776</td>
<td>$570,092</td>
<td>$0.206</td>
<td>$98.7</td>
<td>2,467.6</td>
</tr>
<tr>
<td>1990</td>
<td>2,691,639</td>
<td>1,164</td>
<td>$789,930</td>
<td>$0.293</td>
<td>$678.7</td>
<td>16,966.8</td>
</tr>
<tr>
<td>1991</td>
<td>1,792,523</td>
<td>831</td>
<td>$1,205,032</td>
<td>$0.672</td>
<td>$1,450.8</td>
<td>$36,269.3</td>
</tr>
<tr>
<td>1992</td>
<td>1,627,991</td>
<td>1,822</td>
<td>$1,195,147</td>
<td>$0.734</td>
<td>$656.0</td>
<td>16,399.1</td>
</tr>
<tr>
<td>1993</td>
<td>1,800,370</td>
<td>3,981</td>
<td>$790,518</td>
<td>$0.439</td>
<td>$198.5</td>
<td>4,963.7</td>
</tr>
<tr>
<td>1994</td>
<td>1,786,060</td>
<td>1,646</td>
<td>$943,679</td>
<td>$0.528</td>
<td>$573.5</td>
<td>14,336.4</td>
</tr>
</tbody>
</table>

| 1988-94     | 18,566,475     | 31,987       | $6,142,358                      | $0.331           | $192.0         | $4,800.6             |
| Ave./Yr.   | 2,652,354      | 4,570        | $877,480                        |                  |                |                      |

### Table 3b. Entiat Hatchery. Cost per Release, Adult Return, and Harvest

<table>
<thead>
<tr>
<th>Brood Year</th>
<th>Total Releases</th>
<th>Total Adults</th>
<th>Operations &amp; Maintenance Costs</th>
<th>Cost per Release</th>
<th>Cost Per Adult</th>
<th>Cost per Fish Caught</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>701,945</td>
<td>669</td>
<td>$223,861</td>
<td>$0.32</td>
<td>$334.65</td>
<td>$16,732.44</td>
</tr>
</tbody>
</table>
Attempts to Re-Establish Sockeye Salmon (*Oncorhynchus nerka*)
Populations in the Upper Adams River, British Columbia,
1949–84

Ian V. Williams

*Department of Fisheries and Oceans, Fisheries Research Branch, Cultus Lake, B.C.  V0X 1H0*

• “The record for success in establishing natural self-sustaining runs in barren waters within the salmon’s native range is dismal.” –Withler, F. (1982)

• “Transplants have met with limited measurable success,” long after the problems causing extinction have been rectified. –Williams, I. (1987)

• “Local fish outperform transplants and new populations are only rarely established.” –Quinn, T. (2005)
THE NEED FOR WILD SALMONID RECOVERY

• Wild salmonids are recovering in areas where the 4 Hs have been addressed: Okanogan River, Fraser River, Montana.

• Redirect funds from hatchery production toward habitat, selective harvest, dam removal, and monitoring.
130 YEARS OF HATCHERY PRODUCTION

• Management continues to rely on hatchery production to mitigate for losses of wild fish abundance and habitat.

• Artificial propagation contributes to declines in the survival and reproductive capacity of endangered wild fish through genetic introgression, ecological interactions, and fishery effects.

• Over 38% of Washington’s salmon and trout populations are extinct or in jeopardy of extinction (Quinn 2005).

• Loss of genetic and habitat diversity threaten species resilience.

• Renewable resources ➔ Non-renewable resources ➔ Economic inefficiency.
Hatcheries

Sustainable fisheries, wild stock conservation

For more than a century, WDFW hatcheries have produced fish for harvest. Today, hatcheries provide the foundation for the state's vastly popular recreational fisheries and the thousands of jobs that depend on them.

But in recent years, hatcheries have taken on an additional new role. They are becoming an essential tool in the conservation of native salmon stocks. Indeed, as far back as 1977, long before any fish species was listed under the Endangered Species Act, a WDFW hatchery was being used to stave off extinction for a spring chinook stock. Presently, about a third of the state’s hatcheries are used in some capacity for wild stock conservation work.

To ensure hatcheries can carry out this dual role of wild stock conservation and sustainable fisheries in an environmentally sound manner, WDFW has joined with tribal, federal and private scientists to examine hatchery operations and determine what structural and operational changes are necessary. The goal of this unprecedented collaborative effort, launched in 2000 and facilitated by the non-profit conservation group Long Live the Kings, is to make sure the best available science is developed and applied in the years ahead as hatcheries fulfill their new dual role.

HGMP’s Available for Public Review

- No HGMPs are currently available for public review.

Previously Submitted HGMPs

For more information on hatcheries, please contact the WDFW Fish Program. 360-902-2300.
Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho, and Washington

Willa Nehlsen, Jack E. Williams, and James A. Lichatowich

ABSTRACT

The American Fisheries Society herein provides a list of depleted Pacific salmon, steelhead, and sea-run cutthroat stocks from California, Oregon, Idaho, and Washington, to accompany the list of rare inland fishes reported by Williams et al. (1989). The list includes 214 native naturally-spawning stocks: 101 at high risk of extinction, 58 at moderate risk of extinction, 54 of special concern, and one classified as threatened under the Endangered Species Act of 1973 and as endangered by the state of California. The decline in native salmon, steelhead, and sea-run cutthroat populations has resulted from habitat loss and damage, and inadequate passage and flows caused by hydropower, agriculture, logging, and other developments; overfishing, primarily of weaker stocks in mixed-stock fisheries; and negative interactions with other fishes, including nonnative hatchery salmon and steelhead. While some attempts at remediying these threats have been made, they have not been enough to prevent the broad decline of stocks along the West Coast. A new paradigm that advances habitat restoration and ecosystem function rather than hatchery production is needed for many of these stocks to survive and prosper into the next century.
Feature

Hatcheries and the Future of Salmon in the Northwest
Ray Hilborn

ABSTRACT

Artificial propagation is often seen as a way to maintain and increase or augment fish stocks that have suffered from habitat loss and overexploitation. Large-scale hatchery programs for salmonids in the Pacific Northwest have largely failed to provide the anticipated benefits; rather than benefiting the salmon populations, these programs may pose the greatest single threat to the long-term maintenance of salmonids. Fisheries scientists, by promoting hatchery technology and giving hatchery tours, have misled the public into thinking that hatcheries are necessary and can truly compensate for habitat loss. I argue that hatchery programs that attempt to add additional fish to existing healthy wild stocks are ill advised and highly dangerous.

Below my office window at the University of Washington School of Fisheries, is our small salmon hatchery. Every fall thousands of salmonids are counted and tagged, and then released so that we can track their movements. This year, however, there was no return from the wild spawning salmon. He told me he thought that all of the habitat had been destroyed and there were no wild fish to see. It seems the fisheries are seeing the threat they pose to the wild stocks of salmonids.

Many believe that the future of fisheries lies with artificial propagation. It is the logical progression from the age of the fishery to the age of the hatchery. But this is not the case.
Genetic changes from artificial propagation of Pacific salmon affect the productivity and viability of supplemented populations

R. R. Reisenbichler and S. P. Rubin


Although several studies have shown genetic differences between hatchery and wild anadromous Pacific salmon (Oncorhynchus spp.), none has provided compelling evidence that artificial propagation poses a genetic threat to conservation of naturally spawning populations. When the published studies and three studies in progress are considered collectively, however, they provide strong evidence that the fitness for natural spawning and rearing can be rapidly and substantially reduced by artificial propagation.
The road to extinction is paved with good intentions: negative association of fish hatcheries with threatened salmon

Phillip S. Levin*, Richard W. Zabel and John G. Williams

Northwest Fisheries Science Center, National Marine Fisheries Service, 2725 Montlake Blvd E, Seattle, WA 98112, USA

Hatchery programmes for supplementing depleted populations of fish are undergoing a worldwide expansion and have provoked concern about their ramifications for populations of wild fish. In particular, Pacific salmon are artificially propagated in enormous numbers in order to compensate for numerous human insults to their populations, yet the ecological impacts of this massive hatchery effort are poorly understood. Here we test the hypothesis that massive numbers of hatchery-raised chinook salmon reduce the marine survival of wild Snake River spring chinook, a threatened species in the USA. Based on a unique 25-year time-series, we demonstrated a strong, negative relationship between the survival of chinook salmon and the number of hatchery fish released, particularly during years of poor ocean conditions. Our results suggest that hatchery programmes that produce increasingly higher numbers of fish may hinder the recovery of depleted wild populations.

Keywords: endangered species; El Niño; Pacific salmon; fish hatcheries

1. INTRODUCTION

As populations of exploited fish continue to decline worldwide, the rise of hatcheries has been met with increasing environmental resistance. Artificial propagation of salmon in hatcheries has become the cornerstone of efforts to preserve the fishery (Hilborn 1992; Meffe 1992;...
Genetic Effects of Captive Breeding Cause a Rapid, Cumulative Fitness Decline in the Wild

Hitoshi Araki,* Becky Cooper, Michael S. Blouin

Captive breeding is used to supplement populations of many species that are declining in the wild. The suitability of and long-term species survival from such programs remain largely untested, however. We measured lifetime reproductive success of the first two generations of steelhead trout that were reared in captivity and bred in the wild after they were released. By reconstructing a three-generation pedigree with microsatellite markers, we show that genetic effects of domestication reduce subsequent reproductive capabilities by ~40% per captive-reared generation when fish are moved to natural environments. These results suggest that even a few generations of domestication may have negative effects on natural reproduction in the wild and that the repeated use of captive-reared parents to supplement wild populations should be carefully reconsidered.

Captive breeding was originally used as a form of conservation for the most critical

ions (3–6). However, the extent to which captive-reared individuals contribute genetically to the
URGENCY OF ACTION

• Salmon and trout have been extirpated from 44% of their historical range.

- Lichatowich 1999

ESA Listed Stocks Utilizing Washington Rivers

Puget Sound Chinook, Upper Columbia River spring-run Chinook, Snake River spring/summer-run Chinook, Snake River fall-run Chinook, Upper Willamette River Chinook, Lower Columbia River Chinook, Hood Canal Summer-run Chum, Columbia River Chum, Lower Columbia River coho, Lake Ozette sockeye, Snake River sockeye, Puget Sound steelhead, Upper Columbia River steelhead, Snake River Basin steelhead, Middle Columbia River steelhead, Upper Willamette River steelhead, Lower Columbia River steelhead, and bull trout.

- NOAA 2014
CONCLUSION

• Hatchery production degrades wild salmonid populations through:
  1. Genetic effects
  2. Ecological effects
  3. Facility effects
  4. Indirect effects

• Hatcheries enhance short-term harvest opportunities, but diminish the ability of future generations to access the resource.
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