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**BIASED BREEDING PRACTICES AFFECT SURVIVAL OF HATCHERY STEELHEAD:** A recent study of hatchery breeding practices reveals how inadvertent and direct selection make fish that have poor reproductive success in streams. This selection pressure on hatchery fish make them unsuitable for natural breeding with wild fish. The authors make recommendations for improving hatchery practices, assuming that hatchery fish can be improved so that they do not pose a threat to wild fish. They also make the assumption that hatchery fish survival can be improved so they are more cost effective and increase their contribution to fisheries. However, other hatchery experiments that are testing the improvement of hatchery fish survival and while improvements have been made, the hatchery fish survival and reproductive success falls short of wild fish. The following are excerpts from this study.

To improve the fitness of both hatchery fish destined to spawn in the wild and hatchery fish designed to be spawned in the hatchery, a better understanding of factors associated with the range of reproductive success and mate-choice mechanisms in the wild is vital. This knowledge may then be applied to artificial propagation programs designed for conservation or enhancement.

The goal of this study is to document the practices in a steelhead production hatchery, one whose goal is to produce fish for capture fisheries, not for research or conservation. Our project was not an experiment, but a careful set of observations to determine which steelhead were spawned in the hatchery, which were not spawned, and which were spawned together by the hatchery staff. We did not manipulate mate choice or spawning procedures at all, but merely recorded what occurred.

Forks Creek Hatchery stock was derived from a generalized hatchery stock produced in the Chambers Creek Hatchery. One of the characteristics of this stock is earlier spawning than is seen in wild steelhead (November-February) instead of April-June. Early spawning time is still favored in the Forks Creek Hatchery because the number of females that will return to the hatchery in any given year is unpredictable, and eggs are generally collected from the earliest-returning females.

The lower survival rates of hatchery fish after release (from the hatchery) may result from inappropriate conditioning with respect to foraging and predator avoidance. Hatchery practices differ considerably from natural conditions at the critical life history phase of reproduction, but virtually no attention has been paid to this aspect of artificial propagation.

Adult salmonids in hatchery programs experience very different regimes of sexual selection than do salmonids in the wild. Natural mate choice (i.e. by the fish themselves) does not exist in the hatchery; rather, mate choice is determined by hatchery staff. Body size, which influences dominance in the wild may be disregarded if all ripe fish are spawned on a given date. One the other hand, precocious males have at least some reproductive success in nature but may be discarded as potential parents in the hatchery.

Selection for Spawner Size

Over all 7 brood years, the average fork length of the 245 females spawned was 684 mm, compared with 642 mm for the females that were not spawned.

The 247 males spawned had an average fork length of 688 mm compared with 652 mm for the 487 males that were not spawned. No jack steelhead were spawned at the hatchery.

The hatchery staff selected larger fish for spawning and discarded jacks all together.

Seclection for Reproductive Timing

Hatchery steelhead, over all years, returned to Forks Creek Hatchery from 28 November to 10 June. All spawned steelhead returned between 14 December and 1 February. The probability of an individual being spawned if it returned during a specific week ranged from 0% (if it returned very early or later in the season) to 100% (if it returned in late December or early January). To some extent reproductive timing was under deliberate selection.

Selection for Sex Ratio

In 40% of the spawning groups male and female numbers were equal. In 38% of the spawning groups there were more males than females, and more females than males in 22% of the groups.

## Summary

Artificial selection in Forks Creek Hatchery favored larger individuals and those with earlier reproductive timing. Although hatchery staff did not deliberately choose individuals with larger body sizes for spawning, larger steelhead tended to be spawned, and those with smaller body sizes were more often discarded.

Early spawning time is still favored in the Forks Creek Hatchery because the number of females that will return to the hatchery in any given year is unpredictable, and eggs are generally collected from the earliest-returning females (and thus fertilized by the earliest-returning males) to ensure that egg quotas are met. The consequence of this selection, however, is that early returning (and so, to some extent, larger) fish are being spawned and later-returning (often smaller) fish are less likely to be spawned. Sex ratios within spawning groups varied considerably.

Mate choice mechanisms that occur in the wild are clearly not operating in the hatchery. This selection and pairing or grouping of fish has negative consequences for the hatchery population.

Steelhead propagated at Forks Creek Hatchery were not intended to spawn in the wild. Yet, in the first 2 brood years, significant numbers of the hatchery-produced steelhead were allowed to spawn in the wild. They produced fewer offspring per capita than wild fish.

There may be (at least) three reasons for poor reproductive success of hatchery-reared steelhead spawning naturally that are related to selection for spawning in the hatchery. First, their reproductive timing is wrong for natural spawning in Forks Creek because the hatchery steelhead spawn during the highest and most variable flows, which is a major contributor to their poor reproductive success in the wild. Second, there is no evidence for increased reproductive success as a result of large body size in the wild. Further, jacks produce offspring in the wild, but are not given this opportunity in the hatchery and are discarded before spawning. Third, mechanisms and selection for females that operate in nature (e.g. mate choice, nest choice, and nest preparation) are not considered in hatchery spawning procedures.

This lack of selection for breeding-associated traits results in captive-bred salmon with poor reproductive success in the wild as a consequence of inappropriate spawning behavior. For example, female Atlantic salmon from stocks that have been artificially bred for five generations do not display suitable breeding

behavior and construct fewer and poorer-quality nests in the wild than do wild Atlantic salmon.

Our results from Forks Creek Hatchery…indicate problems that likely occur in many other salmonid hatcheries and may be preventing hatcheries from achieving their conservation goals.

Previous investigations of reproductive success revealed unequal representation in the next generation of individuals that were spawned in the Forks Creek Hatchery. Many individuals were spawned but produced no adult offspring, whereas few individuals produced many offspring. Currently, relatedness is not often considered in hatchery mating schemes but may play a role by decreasing the fitness of offspring produced by the mating of close relatives.

To begin solving problems encountered in hatcheries that release fish to spawn in the wild, factors driving mate choice and reproductive success in the wild must be characterized and this knowledge must be applied to spawning procedures in salmonid hatcheries and other aquaculture operations.

Conservation hatcheries that intend to produce self-sustaining populations that can maintain themselves through natural production will be ineffective until natural mechanisms of mate choice can be incorporated into spawning protocols.

Source:

**McLean, Jennifer, Paul Bentzen, and Thomas P. Quinn. 2005. Nonrandom, size-and timing-biased breeding in a hatchery population of steelhead trout. Conservation Biology. Vol. 19, No. 2.**

**HOOD RIVER NATIVE BROOD STOCK EVALUATION:** The following note was provided by a member who had the opportunity to ask questions of the scientists involved in evaluating the Hood River native brood stock hatchery experiment. The researchers said:

*In short for Hood River, using the wild fish as the 100% baseline, first generation hatchery productivity was 90%, second generation 55%. Araki said roughly "this is an amazingly huge reduction". The traditional hatchery stock was rated at 20%. Also significant is that many returning adults could *not* be attributed to any hatchery or wild adults, leading to the suggestion that during years or poor adult returns, *resident life forms* may fill the void and contribute significantly to the next sea-run generation. Some of the researchers in attendance seemed quite struck (in a positive way) by the results.*

That means native broodstock do have a lower survival rate and do not have the same reproductive success as the wild stock they were derived from and that it gets worse in the succeeding generations. That result is consistent with other studies and with the theoretical science and empirical data that is available.

It is important to realize that hatchery programs are dependent upon wild native populations in order to remain cost effective and improve their performance. But in doing so there are risks involved. The consequence of operating a native broodstock hatchery is reduced productivity of the wild run through such interactions as ecological interference and genetic introgression. The only way to avoid these consequences while trying to improve the survival of hatchery fish and their contribution to the fisheries is to limit and preferably exclude hatchery fish from natural spawning populations. Also, it is necessary to make sure that the harvest of wild salmonids in mixed stock harvests does not exceed a specific mortality allowance, kill wild kelts, and mine the wild run for eggs. Obviously, the wild fish are better off spawning rather than supporting the hatchery program with their eggs. Unfortunately, the politics of native broodstock hatcheries is driving for more production under the assumption that hatchery and wild are the same in their reproductive success. The scientific research does not support this political agenda by agencies like the Oregon Department of Fish and Wildlife and the Washington Department of Fish and Wildlife and these agencies have made it abundantly clear that science will not inform decisions if it runs counter to their political agendas.

**EVALUATION OF WILSON RIVER NATIVE BROOD STOCK STEELHEAD WAS PROMISED BUT NEVER DONE BY ODFW:**

Joyce Sherman told me that ODFW promised the Wilson River wild steelhead hatchery broodstock program would be evaluated. It is 17 years later and it still has not been evaluated. Joyce is a member of the Northwest Steelheaders and at the time ODFW wanted their support and their volunteer help. As far as Joyce is concerned, ODFW fooled them in to supporting the program. Since that time ODFW has taken the wild broodstock hatchery technology and applied it to 13 other watersheds in the state, but there is still no evaluation.

The Hood River wild steelhead hatchery broodstock program is the first attempt to evaluate this technology and it is showing that the reproductive success of the hatchery fish is lower than for wild fish. In the first generation the native broodstock hatchery fish is 80-90% the survival rate of wild fish. In the second generation the survival rate is even lower, just 30% of the first generation hatchery fish. These discoveries are consistent with the published scientific literature.

The impact of this new hatchery technology on wild steelhead, however, is not consistent with ODFW's conservation mandate to prevent the depletion of native, wild fish populations. As these new hatchery fish interbreed with wild steelhead and compete with them for food and space, the wild runs decline, perpetuating the pattern of fish management by the state. Don't we have enough fish protected under the Endangered Species Act?

It is unlikely that ODFW will take the evaluation of the Hood River experiment and reform its enthusiasm for wild broodstock hatchery programs because these fish do survive better than conventional hatchery fish, contribute more to the fisheries, and more angling licenses are sold. It is a moneymaker and these days conservation is an orphan child living in the basement at ODFW.

**MARKING HATCHERY FISH MADE EASIER:** The AutoFish System, is helping Oregon Department of Fish and Wildlife staff mark and tag fish faster and more effectively.

The system uses advanced technology to sort and process Pacific salmon and steelhead in a hatchery setting. It is a cost effective way to handle juvenile fish rapidly without the use of anesthetic and minimizing human contact.

"This system is more consistent and reliable than the manual trailer," said Marion Forks Hatchery Manager Greg Grenbemer. "It works perfectly for the size of fish we are marking and tagging here at the hatchery."

When programmed and monitored, the AFS consistently achieves more precise fin clips and accurate and harmless Coded Wire tag placement in the cartilage tissue of the salmon snout. The system is capable of processing fish at a substantially higher rate than is possible with the manual marking method.

Every year, more than 25 million fish are marked by ODFW staff with most of the marking activities occurring during the spring season. The deployment of the AFS is essential to meet this high volume demand.

"Many hatcheries are located in remote areas with limited availability of temporary workers, which makes it difficult to implement large scale fish marking operations," said Christine Mallette, assistant propagation program manager. "The AFS is helping to fill that void."

Oregon Department of Fish and Wildlife currently operates four AFS units to tag and mark juvenile salmon and trout at fish hatcheries throughout the state. The $1 million AFS was federally funded. The technology enables ODFW to comply with federal mandates to mass mark hatchery fish that are released into the

Columbia River Basin and into coastal streams from facilities receiving federal funding.

**NMFS HATCHERY POLICY SET BACK:** In June Federal District Court Judge Coughenour turned the tables on the NMFS 2005 Hatchery Policy that counted hatchery fish along with wild steelhead to reduce the protection of ESA-listed upper Columbia River steelhead. By counting hatchery and wild steelhead, NMFS found that there were enough steelhead to change the listing from endangered to threatened. Trout Unlimited, Native Fish Society, Pacific Rivers Council, Wild Steelhead Coalition, Sierra Club and Federation of Fly Fishers were represented by Earthjustice in opposing this decision. We prevailed.

The judge concluded that the NMFS Hatchery Listing Policy is "fatally deficient because it shifts the status…away from naturally self-sustaining [fish] populations" under the ESA. The judge said, "The Hatchery Listing Policy is set aside" and "The downlisting of the Upper Columbia River steelhead ESU from endangered to threatened is set aside as contrary to the ESA."

During the comment period on this hatchery policy NMFS received many letters in opposition from the public, but the NMFS leadership also chose to ignore the input of scientists including those hired to give them advice. In his declaration to the court, Dr. Robert Paine, professor emeritus in the Department of Biology at the University of Washington in Seattle, provides some insight into the strained relationship between scientists and the Regional Administrator Robert Lohn.

Dr. Paine served on the NMFS salmon Recovery Science Review Panel (RSRP). He and his colleagues were asked by NMFS to review the role of hatchery salmon in stock recovery. They produced a report and "…concluded hatchery fish represented a threat to wild fish and should not be included in the ESUs of wild fish for evaluating extinction risks." Once this report was approved by all members of the panel it was forwarded to the director of the Northwest Fisheries Science Center at NMFS.

At their next meeting they were given an email from Robert Lohn, the NMFS Regional Administrator. Dr. Paine said the email was "written in an intemperate tone," and "strongly criticized the panel's report as trespassing too deeply into matters of policy."

Dr. Paine said, "According to the letter, Mr. Lohn believed that the RSRP's criticisms of the impacts of hatcheries had gone too far. He also took the position that the panel had crossed the line separating science from policy. I am not aware of any previous instance in which an RSRP report was rejected in this manner." The email was read by the panel members and initialed. No copies were made. Dr. Paine noted, "…neither I nor any of the other RSRP members have a copy of this email. The email indicated that the report was unacceptable as written. It also either stated or implied that continued funding for the RSRP members was in jeopardy as a result. Committee members were frustrated by the tone of that email, as we believed that our report was strongly grounded in science."

The RSRP members revised their report, deleting some sections of it as requested, and resubmitted it to Mr. Lohn. Dr. Paine said, "Because we believed that the report contained credible scientific information on a matter of important public interest, the panel members decided to take the step of refashioning the part of our NMFS report that we had been asked to omit, and submitting it for publication.." This article was printed in the journal Science in March 2004. In that article the scientists concluded: "…hatcheries generally reduce current fitness and inhibit future adaptation of natural populations…hatchery fish should not be included as part of an ESU."

**Fewer Americans Are Hunting and Fishing** A five-year survey of outdoor recreation finds a sharp drop in the number of Americans who cast a rod and reel—and a lesser decline in hunting. But that doesn't mean we're spending less time with animals in nature.

The number of anglers has dropped 12 percent since 2001; the hunter count has fallen off by 4 percent during the same five-year period. This doesn't mean Americans aren't spending time outdoors or interacting with wild animals; "wildlife watching" is up 8 percent since 2001. They're just choosing not to kill them so much.

Still, 12.5 million people over the age of 16 went hunting in 2006, down from about 13 million in 2001, and they dropped $23 billion on the stuff it takes to get out in the field (roughly the same amount of money spent on hunting five years ago).

Fishing participation fell three times the rate of hunting over five years—down a jaw-dropping 23 percent in the Great Lakes region. Freshwater fishing outside the Great Lakes was off 10 percent; saltwater fishing fell by 15 percent.

In 2006, 13 percent of the U.S. population still took the rod and reel out for a cast. Nearly 30 million people—five million less than 2001-went fishing, spending an average of 17 days angling during the year. They dropped about $40 billion on licenses, equipment and trips to support the activity.

Sportsmen can take heart in the fact that despite the declining numbers, nearly 34 million people still found time to fish and hunt in 2006, and spent a combined $75.4 billion doing it.

That's important, because federal taxes on guns and sporting equipment are spent on conservation efforts and wildlife refuges; without those places, many of the 71 million "watchers" identified in the survey would be left staring at a starling on a bird feeder.

Source: By Steve Tuttle. **Newsweek**
Updated: 5:21 a.m. PT June 16, 2007

**HATCHERY CHINOOK FRY ARE MORE SUSEPTABLE TO PREDATION THAN WILD CHINOOK FRY:** In a recent study comparing the survival of hatchery and wild chinook fry, the authors had the following to say: "Wild origin fry were found to have a 2.2% survival advantage over hatchery origin fry during 2 years of predation challenges. The most important findings of this study are domestication can affect the susceptibility to predation after only one generation of state-of-the-art hatchery culture practices, and the domestication effect was very small.

"Even though we detected a difference in survival after only one generation of hatchery culture, the difference was very small. Other studies have reported larger differences in survival. For example, Berejikian found nearly a 12% difference in survival of hatchery and wild origin steelhead fry. It is likely that the bigger differences in survival were due to length of hatchery culture (one to seven generations) and fish culture practices.

"Hatcheries that continually use returning hatchery-reared fish as broodstock can compound the effects of domestication over generations because the genetic traits that lead to higher vulnerability to predators will not be selected against in the protected hatchery environments. Undergoing at lease one generation of natural selection in the natural river environment between hatchery culture is theorized to reduce domestication effects in hatchery fish. Unfortunately, few empirical data exist to examine this phenomenon.

"In summary, we found that small changes in predation vulnerability occurred after only one generation of state-of-the-art hatchery culture. It is uncertain what genetic manifestations caused these fish to survive at different rates and what magnitude of impact this will have to offspring of fish that spawn in the natural environment. Additional studies will be required to understand why differences occurred and to evaluate changes compared with a wild control population and a production hatchery population over several generations so that the long-term fitness of the supplemented population can be measured. “

Source:

Fritts, Anthony L., Jennifer L. Scott, and Todd N. Pearsons. 2007. The effects of domestication on the relative vulnerability of hatchery and wild origin spring chinook salmon to predation. Can. J. Fish. Aquat. Sci. 64: 813-818.

## LEARNING FROM ATLANTIC SALMON CONSERVATION

***National Research Council et al. 2002. Genetic status of Atlantic salmon in Maine. National Academy Press, Washington D.C.***

The addition of so many nonwild genotypes from hatcheries and possibly from aquaculture escapees has led some to conclude that the fish returning to spawn in Maine’s rivers could not possibly represent anything more than some nonnative mix of genotypes from Europe, Canada, and Maine. If that were true, then options for conservation might be considerably different, and that is why it is important to understand the genetic makeup of the wild salmon populations in Maine.

Despite the extensive additions of nonnative hatchery and aquaculture genotypes to Maine’s rivers, the evidence is surprisingly strong that the wild salmon in Maine are genetically distinct from Canadian salmon. Furthermore, there is considerable genetic divergence among populations in the eight Maine rivers where wild salmon are found.

The pattern of genetic variation seen among Maine streams is similar to patterns seen elsewhere in salmon and their relatives where no stocking has occurred. Maine streams have salmon populations that are genetically as divergent from Canadian salmon populations and from each other as would be expected in natural salmon populations anywhere else in the Northern Hemisphere.

The term “Wild” is used by the committee to mean populations of salmon that have been maintained by naturally spawning for at least two full generations.

If the populations are genetically indistinguishable, then it would be hard to justify recovery programs that treat the populations in different drainages separately, whereas if they are distinguishable, then such programs might be justifiable.

Hatchery releases began soon after the first major declines in Atlantic salmon in the 1870s. Historically, 300,000 to 500,000 adults probably entered U.S. rivers each year. Since the late 1960s, the number of returning adults has been only about 5,000 or fewer. Fewer than 1,000 adults returned each year during the beginning of the period and in 1999-2000. The estimated total return for eight streams comprising the Gulf of Maine DPS was only 75-100 adults in 2000.

By the late 1960s, stocking switched (from fry stocking) largely to smolts. By the mid-1970s, the Penobscot brood stock supported essentially all the artificial propagation needs of Maine. During this recent period, Atlantic salmon throughout Maine were managed as a single population for stock-release (hatchery) purposes. Since 1991, stocking has been river-specific and based on a conservation hatchery program. The current protocol involves raising (river caught) parr to adulthood, mating them according to approved protocols of the Maine Technical Advisory Committee, rearing the embryos, and releasing the fry (usually before they begin feeding). Fry stocking began in 1992, and stocking levels had reached target density levels by 1997. There is no indication of successful increase in returning adults as yet (2002). The shift to a river-specific management and propagation system was based on the premise that naturally spawning fish from even more local waters would provide the best hope of success.

Despite 130 years of stocking, using a variety of life stages (fry, parr, smolts, and even adults) and releasing about 120 million Atlantic salmon, the systematic decline in run sizes has not been reversed. That raises the question of whether hatchery stocking has ever had a substantial impact on populations of Atlantic salmon in Maine.

The Biological Review Team (1999) and Baum (1997) concluded that the hatchery fish have not displaced the local gene pool because of the poor success of historical hatchery stocking and the likelihood that Canadian fish were poorly adapted to Maine streams.

There is now considerable evidence that stocked fish do very poorly. A review of 31 studies of incursion of hatchery genetic material into wild populations reported that 14 studies showed little or no evidence of incursion, despite prolonged hatchery releases. Of the studies showing an incursion, 16 of the 17 studies involved nonanadromous populations, suggesting that anadromous populations are more resistant to introgression.

Based on the number of fish being raised in Maine waters, 3% escapement in Maine would translate into about 180,000 escapees per year from net pens (salmon farms).

In experimental facilities, farm males had only 1-3% of the reproductive success of wild males, and farm females had only 20-40% of the reproductive success of wild females, with most matings involving wild males. Farmed salmon introduced experimentally into a wild population had only 16% the success of wild salmon in producing recruits. It is possible for wild populations to resist genetic infiltration by farm fish, but that potential drops as the number of wild fish becomes small, relative to the number of farm fish. Based on samples taken in 1994-1998, genetic infiltration of farm fish into wild Maine populations was minimal.

Conclusions:

The genetic studies reviewed above lead to consistent conclusions: there is large divergence between continental populations of Atlantic salmon in North America and Europe, considerable divergence among regional populations in Canada and in Maine, and divergence between populations in different watersheds in Maine. In addition, divergence can be substantial among populations from different tributaries within a watershed, and temporal variation occurs within a given sampling locality. Thus, the committee concludes that wild populations of Atlantic salmon in Maine are distinct from other Atlantic salmon populations and that differentiation occurs among populations within Maine.

The pattern of variation is so typical of wild salmon that it suggests considerable genetic cohesion and resilience of the resident populations, in spite of large scale stock releases (over decades – 1870s to present) that could only have homogenized the various populations, had they been effective. Stocking clearly has not been completely effective, as shown by declining run sizes over the last 30 years.

If Maine salmon are an artificial construct of non-river-specific hatchery supplementation, then the separate watershed-specific populations should be genetically indistinguishable. The genetic evidence available for review indicates that the natural populations are distinguishable from each other. Maine has wild salmon populations in the eight DPS rivers that are as divergent from Canadian populations and from each other as expected among wild salmon populations elsewhere in the Northern Hemisphere.