NATIVE FISH SOCIETY
CONSERVATION REPORT
NUMBER FIVE
2008

By Bill Bakke, Director

COUNTING THE IMPACT OF HARVEST ON THE COLUMBIA IN 1938. When Bonneville Dam was completed in 1938 on the Columbia River 146 miles from the sea, it became possible for scientists to estimate the impact of commercial harvesting on salmon and steelhead for the first time. The impetus for doing this was to determine how many salmon and steelhead entering the Columbia River were likely to be annihilated by Grand Coulee Dam completed in 1941, so an estimate of the number of salmonids that would be affected was needed. The salmon were subjected to an ocean harvest, and once they entered into the Columbia River they were fished intensely in commercial, sport and tribal fisheries. The following information from a study by Willis Rich (1942) gives an indication of the impact fisheries had on the spawner abundance in the Columbia River basin. His evaluation is merely an estimate and a low one at that, for it considered only reported commercial harvest; the take of fish in sport and tribal fisheries were not captured by fish managers. At this time most of the salmon and steelhead runs were of wild production since the hatchery program did not become a reliable source of fish until the 1960s.

Rich concluded in his study that the "main runs of salmon to the Columbia River are practically unprotected and are fished with destructive intensity."

In his summary of this study, Rich makes the following conclusions based on his scientific evaluation of harvest impact on Columbia River salmon and steelhead.

"May run of chinooks…only about 1 fish out of 7 escapes the fishery. For the August through December fishery about twice as many fish are taken in the commercial fishery as remain to reproduce.

"…for blueback salmon (sockeye) the ratio of catch to escapement is approximately 4:1, indicating that only about 1 fish out of 5 escape the fishery to reproduce.

"During June and July only about 1 chinook in 6 escapes the fishery to reproduce.

"The ratio for the steelheads…for the main part of the run, June to September, more than 2 out of 3 steelheads are taken in the fishery."

According to Rich, "The chinook runs are seriously depleted. The present exploitation of these depleted runs is being conducted with intensity so great that it can only lead to disaster in the not far distant future unless the present trends can be altered."

Since the 1870s the Columbia River chinook runs have been declining but following 1925 they enter a prolonged steep decline that culminates in extinct runs and protection under the federal Endangered Species Act in 1991. Even though the chinook runs Rich studied in 1938 are now listed, they are still being harvested as a by-catch for fisheries targeting hatchery origin fish. While the dams are certainly a major cause of mortality today, the wild chinook runs were "seriously depleted" in 1938, so by adding dam mortality to the portfolio of mortality, the wild chinook runs have either gone extinct or are barely hanging on in the Columbia Basin.

Historically, the Columbia River had huge runs of chinook, steelhead and sockeye. Some estimates of their total abundance ranges from 30-50 million, but the official estimate compiled by the fish agencies is 16 million.

Rich said, "The steelhead run extends broadly over the entire year, although the major part of the run comes during summer and early fall months – from the middle of June to about the first of October. This major portion shows 2 well marked modes, one at the week of July 9 and the other at the week of August 20. In addition to these 2 major modes there are at least three minor modes; one centering about the week of March 26, another about the week of May 7, and a third about the week of December 10. The run that centers about the week of March 26 evidently enters and passes through the lower river before the commercial fishing season opens." (The commercial fishery was closed in March and April) About 5% of these early run steelhead (660 fish) passed over Rock Island Dam (This dam began operating in 1933) on the upper Columbia and this run is "practically untouched by the commercial fishery." Frey (1942) reported steelhead entering the Deschutes River in April and May. Winter steelhead and spring chinook were also protected in lower and Mid-Columbia tributaries including the Willamette Basin by the March and April closed period to commercial fishing.

In order to calculate the catch of steelhead in the commercial fishery when it opened in May and to estimate the impact on steelhead bound for the upper Columbia River and affected by the construction of Grand Coulee Dam, Rich separated the commercial fishery into periods. These included May 29 to July 30; July 31 to September 24; and September 25 to December 31.

During the May 29 to July 30 period, Rich estimated the commercial catch to escapement of 2.57 to 1 and only 1 percent (7,000 steelhead) passed Rock Island Dam in the upper Columbia River. The commercial catch was about 72,500 steelhead and the escapement over Bonneville Dam was less than 30,000 fish.

In the July 31 to September 24 period the estimated catch to escapement was 2.16 to 1. While this catch was similar to the first period, most of the catch was made above Bonneville Dam in zone 6. Over 36 percent of the catch came from above Bonneville in August and September. The estimated escapement was 37,000 fish.

In the period September 25 to December 31 only 1,552 steelhead passed Bonneville Dam, but the catch in the lower river was nearly 10 times as great. Rich says, "It is clearly indicated that the steelheads spawning in tributaries below Bonneville Dam form a much larger part of the late fall run than those entering the river previous to September 25. However, the steelheads that do pass Bonneville show a relatively large percentage spawning in the Columbia above Rock Island Dam.

In 1938, the total run size of steelhead in the Columbia River from February 5 to December 31 that passed Bonneville Dam was 259,084 fish. The total harvest in the commercial fishery was 172,545. However, the escapement from all fisheries and over Celilo Falls was estimated at 72,604. Only 28% of the run escapes the fishery to reproduce. This means that steelhead had approximately a 72% harvest impact.

FUNDAMENTAL PROBLEM WITH FISH MANAGEMENT. The fundamental mistake that plagues Northwest fish managers is that management is structured to produce a product rather than maintain salmonid productivity.

Fish managers use a simple industrial based model for management: "Stock and Kill." By using this model for over 100 years, the fish management institutions have made a substantial contribution to the decline and extinction of salmon and steelhead populations, leading ultimately to federal protection under the Endangered Species Act. As Alexandra Morton has said, "Wild salmon get in the way of business."

Industrial strength exploitation of native, wild salmonids simplifies biological diversity and eventually causes instability, loss of resilience, and loss of productivity, committing them to a trajectory of impoverishment and decline.

State, federal and tribal fish management institutions have assumed that hatcheries could replace wild salmonids and their habitats while providing abundant catches for a commercial fishery with leftovers for a sport fishery. But that assumption was wrong, given the evidence of decline and destruction of the salmon runs.

Wild salmonid abundance is 3% of what it was historically and now we are closing fisheries not for the protection of remaining wild fish but to protect hatchery production. Regulating fisheries to get enough fish eggs for a hatchery is the primary management objective, and it has always been more important than fully seeding the habitat with wild spawners.

Wild salmonids on the west coast are in the emergency room and the treatment is the Endangered Species Act. However, treatment is hampered by institutional and professional resistance. Rather than doing what is good for wild salmonids, managers are using them to justify more hatchery funding. Saving wild fish with hatcheries has become the most recent fad even though it is not supported by scientific research conducted by the same agencies promoting hatcheries.

FITNESS OF HATCHERY SALMONIDS IN THE WILD IS POOR. In a recent paper by Hitoshi Araki (2008) he says "Accumulating data indicate that hatchery fish have lower fitness (survival) in natural environments than wild fish. This fitness decline can occur very quickly, sometimes following only one or two generations of captive rearing. Non-local hatchery stocks consistently reproduce very poorly in the wild; hatchery stocks that use wild, local fish for captive propagation generally perform better than nonlocal stocks, but often worse than wild fish."

The following quotes from Araki's paper confirm research he and others have done, but with a very clear statement about the risks hatcheries pose for wild fish.

"Our review indicates that salmonids appear to be very susceptible to fitness loss while in captivity. The degree of fitness loss appears to be mitigated to some extent by using local, wild fish for broodstock, but we found little evidence to suggest that it can be avoided altogether. The general finding of low relative fitness of hatchery fish, combined with studies that have found broad scale negative associations between the presence of hatchery fish and wild population performance, should give fisheries managers pause as they consider whether to include hatchery production in their conservation toolbox."

"Captive breeding is broadly defined as breeding and raising organisms in captive environments for at least part of their life cycle. This idea is now widely applied to the restoration and supplementation of many declining wild populations. To date, however, little is known about the extent to which captive-reared individuals actually contribute to the restoration of wild populations. Theoretical studies suggest that captive-reared organisms might be genetically inferior to wild ones in natural environments as a consequence of domestication, which could hinder the recovery of wild populations."

"Some programs have increased the number of adults that spawn in the wild but increases in wild population productivity or even wild production have not been documented. Furthermore, accumulating evidence suggests that domesticated hatchery fish often exhibit differences from wild fish in predator avoidance and agonistic behavior and suffer low reproductive success in the wild, and that these changes can occur rapidly. Thus, the effects of hatchery fish on wild populations remain an open question and a topic of major concern."

"We find that the relative fitness between hatchery fish and wild fish is generally lower than one, indicating that hatchery rearing generally has negative effects on fitness. Several lines of evidence suggest that genetic effects contribute to the lowered fitness of hatchery fish; the offspring of naturally spawning hatchery fish have been found to have lower survival to smolting and lower survival from smolting to adulthood.

"Offspring of fish captured from an adjacent (i.e. nonlocal) population had reduced survival in both freshwater and seawater portions of the life cycle, emphasizing the importance of local adaptation in determining fitness.

"…hatchery steelhead derived from a wild parent and a hatchery parent showed lower reproductive fitness than that of hatchery fish derived from two wild parents in each of 3 years of samples. The relative fitness of the first generation fish was 70-88% and that of the second generation fish was only around 60% (when compared to that of wild fish). The substantial difference between first and second generation hatchery fish suggests a rapid and cumulative genetic effect of hatchery culture during the first few generations of captive rearing.

Our data from our review suggest that the fitness of hatchery fish declines with increasing generations in the hatchery. In studies on steelhead, however, fitness decline has been shown to occur extremely rapidly – within the first generation or two of hatchery culture in some cases.

Araki and others studied the effect of hatchery and wild steelhead breeding on fitness. "One result of this study was that naturally spawning hatchery fish that had two wild parents (Hatchery Breeding of wild x wild fish) had relative fitness of 70-88% that of wild fish. The second main result was that hatchery fish with one wild parent and one first generation hatchery parent (Hatchery Breeding of hatchery x wild fish) had relative fitness of ~60% that of the Hatchery Bred wild x wild fish. In other words, the addition of one half of a genome with one additional generation of exposure to the hatchery resulted in a 30-40% decline in fitness." The authors say that this "reduction in fitness must involve a heritable change in fitness between generations."

Araki, Hitoshi, Barry A Berejikian, Michael J. Ford and Michael S. Blouin. 2008. Fitness of hatchery-reared salmonids in the wild. Synthesis. Blackwell Publishing Ltd. 1: 342-355.

Barbed and Barbless Hooks and their effect on Juvenile and Adult Salmonid Mortality
A Literature Review

By Bill Bakke

April 22, 2008

Introduction

When there is a conservation concern for a wild salmonid population such as one listed as threatened under the Endangered Species Act, each fish is valuable for its potential contribution to recovery of the population. The loss of juvenile steelhead and salmon can negatively affect adult abundance several years later. It is important to consider all sources of mortality and take appropriate action over those that can be affected by management. Reducing the mortality associated with angling by requiring single barbless hooks is an important policy decision. Doing so can increase survival of juvenile and adult fish by reducing handling time required to take out the hook, and injury from handling as well as exposure to the air.

The following peer-reviewed studies provide a scientific basis for angling regulations to include barbless hooks as a factor important to conservation of native, wild salmonids. While there is ample justification to use barbless hooks on adult fish as required in ocean commercial fisheries to promote easy release with less handling and a goal of reducing mortality, there is also a measurable conservation benefit from using barbless hooks when adult salmonids are captured by angling in freshwater. These studies provide the verification for this conclusion. Using barbless hooks to reduce injury and mortality for juvenile salmon and steelhead is often overlooked when setting angling regulations. Steelhead juveniles rear in freshwater for 2 to 3 years and are exposed to angling mortality in fisheries targeted on trout and adult steelhead and salmon. It only makes sense to include juvenile fish protection as a benefit of barbless hook fisheries.

With a few exceptions such as the Metolius River, the Oregon Department of Fish and Wildlife has adopted a position opposed to the use of barbless hooks as a conservation tool for vulnerable wild salmonid populations. They base this policy on a scientific literature review done by staff in 2001. Oregon stands alone among entities that are concerned about recovery and protection of wild salmon, trout and steelhead. British Columbia requires single barbless hooks province wide, Washington requires single-point barbless hooks in areas designated as "fly fishing only" or "selective gear rules; California requires single barbless hooks on most trout and steelhead fisheries; Idaho says only barbless hooks may be used when fishing for steelhead in the Salmon and Clearwater river drainages and the Snake River below Hells Canyon Dam.

The studies provided below provide the scientific justification for the Oregon Department of Fish and Wildlife and Commission to adopt single barbless hooks as a conservation management tool to protect native, wild salmonids throughout the state. In waters where these fish are threatened, a more precautionary management approach is appropriate to reduce mortality. In waters where wild fish harvest is allowed, a barbless hook regulation would provide a conservation benefit for those that are released. For example, in some rivers a limit of one wild steelhead per day and 5 per year is allowed. In those fisheries a hatchery fish may also be taken. This means that the angler may release one or more wild fish in order to take a legal limit that includes a hatchery fish. There is also evidence that wild steelhead contribute more to the fishery than their numbers would suggest, so single barbless hooks would not only help prevent mortality, they could contribute to more angler satisfaction through multiple hookings.

The point of this paper is to provide the Department and the Commission with information that provides the scientific justification and benefit of using barbless single hooks in Oregon waters for adult and juvenile fish.

Wright, Sam. 1992. Guidelines for selecting regulations to manage open-access fisheries for natural populations of anadromous and resident trout in stream habitats. North American Journal of Fisheries Management 12:517-527.

“Adding restrictions requiring single hooks, barbless hooks, or flies can provide only relatively small incremental improvements in trout survival. However, managers have realized that these can become important in situations where individual fish are hooked many times. The chance of mortality from a single hooking event was examined for various unweighted combinations of terminal gear from our compilation of research results. The categories and single-event losses were as follows:

Barbless hooks with flies	1.76%
All barbless hooks (with flies or lures),	2.16%
Barbless hooks with lures,	3.00%
All hooks with flies,	3.34%
Barbed hooks with flies,	3.88%
All barbed hooks,	5.86%
Barbed hooks with lures,	6.86%

“The most fundamental rule to remember in managing any open-access trout fishery is that effective regulatory control must be applied to every individual fish (Hunt 1970). Fishing seasons and daily bag limits, when used by themselves, are not effective management tools, because they do not apply to each fish that is captured.”

Meka, Julie, M. 2004. The influence of hook type, angler experience, and fish size on injury rates and duration of capture in an Alaskan catch-and-release rainbow trout fishery. North American Journal of Fisheries Management 24:1309-1321.

“Recent studies have emphasized a holistic approach to evaluating the effects of catch-and-release angling on fish by evaluating both sublethal and lethal effects. When fish are subjected to angling stress, they are affected by stressors that may not cause immediate mortality; in fact, some may influence ultimate survival. These stressors include physiological disruptions from landing time, handling time, and exposure to air during the hook removal process or when photographed, as well as the potentially confounding effects of nonlethal hooking injuries.”
“…fishing methods and whether J hooks were barbed or barbless significantly influenced new overall injury rates. Fish caught by spin-fishing had similar injury rates as those caught by fly-fishing; thus, significance was from higher injury rates with barbed hooks for both fishing methods as well as higher injury rates for barbed hooks between fishing methods.”

“…novice anglers injured proportionally more fish than experienced anglers. The number of new injuries per capture was more significant in small fish. Small fish were hooked in more than one location more frequently than large fish (small fish <440 mm or 17-inches)…small fish were injured more frequently, and bleeding was most significant in fish hooked in sensitive areas and in small fish…small fish had higher bleeding rates. Bleeding was more prevalent in small fish. This presumably was because they were injured in sensitive areas more often as well as injured more often.”

“…hook removal time was significantly longer when barbed J hooks were used compared to barbless J hooks. Mortality was also higher for fish caught with treble hooks compared with single hooks, presumably because the increase in hook-point penetrations increased the probability of injury to critical locations and associated bleeding. My results indicate that smaller fish (<17-inches) may be more vulnerable to mortality.”

“In this study, barbed J hooks caused significantly more new hooking injuries, took longer to remove, and were more efficient at catching fish than barbless hooks. Higher injury rates and longer handling times for barbed hooks were mostly likely due to difficulty in hook removal and hooks becoming tangled in landing nets, both of which were observed to intensify injuries and bleeding. Barbless hooks have been found to cause a lower incidence of injury and bleeding than barbed hooks and decrease the amount of time fish are handled and exposed to air while removing hooks.”

“The results of this study indicate that the use of barbless J hooks may minimize injury and reduce the amount of time fish are handled during hook removal and that angler experience can contribute to hooking injury.”

“However, a slight reduction in hooking injuries and less handling time are two important benefits to consider in support of a regulation change or promotion of angler education programs for catch-and-release trout fisheries.”

“…focus future research on the prolonged sublethal effects of hooking injury on trout populations, and develop angler education programs and gear restrictions to minimize injury.”

Schreer, Jason, F., Dayna M. Resch, and Malachy L. Gately. 2005. Swimming performance of brook trout after simulated catch-and-release angling: looking for air exposure thresholds. North American Journal of Fisheries Management 25:1513-1517.

“Air exposure has been hypothesized as one of the primary stressors present during catch-and-release angling. However, there are few studies that systematically vary air exposure duration and evaluate the consequences on individual fish. Here we evaluated the short-term sublethal effects of exercise (to simulate angling) and air exposure on the swimming performance of hatchery brook trout at 10 degrees C. (50 degrees F.). Nearly half of the fish held out of the water for 120 seconds were unwilling or unable to swim at all. This work suggests that fish possess air exposure thresholds that, once exceeded, result in performance impairments. Fish released after extended air exposure may become easy prey for predators or could be displaced downstream . We conclude that air exposure should be restricted to less than 60 seconds and ideally should be avoided entirely.”

(Note: Barbless hooks decrease the amount of time fish are handled and exposed to air while removing hooks in the study by Meka.)

Taylor, Mathew, J., and Karl R. White. 1992. A meta-analysis of hooking mortality of nonanadromous trout. North American Journal of Fisheries Management 12:760-767.

“…fish caught on barbed hooks had higher mortality rates than fish caught on barbless hooks.

“…the mortality rate for fish caught with barbed flies or lures is almost double the mortality rate of fish caught with barbless flies or lures.

“”…the effects of handling on hooking mortality have been sparsely investigated. It would be nice to know about variables such as net use, resuscitation techniques, time out of water, and the effect of barbs on handling time. Research on these variables would give a clearer understanding of how to increase survival rates.

“The overall average mortality rate in these 18 studies was just under 12%. Under the best conditions, with barbless flies or lures, the percentage dropped to under 3%.

Reingold, Melvin. 1979. Mortality and catch rates of juvenile steelhead trout caught on single versus treble barbless hooks. Idaho Department of Fish and Game.

"…even at the low level of mortalities observed, losses from treble barbless hooks were 4.5 times that of losses from single barbless hooks. In an intensive catch-and-release fishery, this could be meaningful…anglers hooked and released 75,000 cutthroat trout on the Middle Fork Salmon River in 1978. Applying the percent mortality observed, single barbless hooks would account for 428 deaths versus 1,928 for treble barbless hooks, a difference of 1,500 trout; predominately spawner size individuals. This is 83% of the estimated season trout harvest in that stream in 1969 (1,800) when it was catch and keep."

Pollard, Herbert, A., and Ted C. Bjornn. 1973. The effects of angling and hatchery trout on the abundance of juvenile steelhead trout. Transactions of the Americana Fisheries Society No. 4: 745-752

"A large proportion of juvenile steelhead trout in a stream can be removed with a moderate amount of angling. Age II-plus steelhead are especially susceptible to harvest by angling and 70 to 100% of those present in a 122 m (400 ft) section of stream were removed with 4 angler hours of effort. The normal sport fishery may take as many as half of the catchable size (age II-plus) juvenile steelhead from a stream such as the Crooked Fork each year, and thus may reduce the number of smolts produced."

"Hatchery reared, catchable sized rainbow trout did not act as a buffer to reducing the angling harvest of juvenile steelhead…"

"Removal of the larger pre-smolts by angling could decrease adult returns due to fewer smolts and decreased survival of the remaining, small smolts."

(Note: This study was included to show how vulnerable juvenile steelhead are to a trout fishery and the impact of a fishery on the future abundance of adult returns. Angling with barbed hooks increases tissue damage, handling time, exposure to air, and causes a reduction in smolt numbers and adult returns.)

Cowen, Laura. 2007. Effects of angling on chinook salmon for the Nicola River, British Columbia, 1996-2002. North Americana Journal of Fisheries Management 27:256-267

"Gjernes (1990) found that barbed hooks caused higher hooking mortality rates. Bartholomew and Bohnsack (2005) reported three studies that showed increased mortality when using barbed versus barbless hooks. We did not use barbed hooks in this study."

"The optimal angling gear and techniques used in our study included soft, knotless-mesh landing nets, suitable hook sizes, barbless hooks, short playtime, short handling time, little or no air exposure, angling only at water temperatures less than or equal to 20 degrees C, and leaving deep hooks in or removing them gently with pliers. In addition, Bartholomew and Bohnsack (2005) advocate fishing actively and setting the hook as soon as possible, use of dehooking tools, and avoidance of touching gills and handling the soft underbelly of the fish."

Pelletier, Christine, Kyle C. Hanson, and Steven J. Cooke. 2007. Do Catch-and-release guidelines from state and provincial fisheries agencies in North America conform to scientifically based best practices. Environ Manage 39:760-773

“Barbless hooks were recommended by 34 (or 69%) agencies as an alternative to barbed hooks.”

“However, there is compelling evidence that barbless hooks are easier to remove than barbed hooks. Ease of removal results in reduced handling time and tissue damage, thereby decreasing associated mortality.”

“The Ontario Ministry of Natural Resources and the Utah Division of Wildlife Resources explained that replacing treble hooks with single hooks will make live release easier. Because air exposure tends to occur when anglers remove hooks, these agencies have taken a positive approach in stressing the importance of a timely live release.”

“Air exposure was the most widely discussed catch-and-release issue among agencies. It was found that 44 of 49 agencies provided advice on the subject. The most common recommendation (64%) was to keep the fish in the water at all times. This is consistent with studies showing that air exposure is extremely harmful in fish that have experienced physiological disturbances associated with angling. Tufts (1992) found that when rainbow trout were exposed to air for either 30 or 60 seconds after exhaustive exercise, mortality increased from 38% to 72%, receptively.”

“…removing hooks (in deeply hooked fish) often results in mortality associated with increased handling time and air exposure.”

“Considering that water temperature is regarded as the ‘master factor’ in the biology of fishes, it is surprising that angling at extreme temperatures was not incorporated into all agency guidelines.”

“…mortality among Atlantic salmon is minimal when angled at water temperatures between 8 degrees C and 18 degrees C., but as water temperatures increased to greater than 18 degrees C, the risk of angling-induced mortality increases considerably.”

“…we believe that natural resource agencies are the appropriate target of initial attempts to ensure that catch-and-release guidelines are consistent with the best scientific information.”

Conclusion
In recent angler surveys by Oregon and Washington fish management agencies, a larger proportion of the respondents practiced catch-and-release fishing. Anglers are embracing live release fishing as a conservation measure. It also does not substantially deplete fish numbers like a kill fishery, and provides at least the expectation that the fish will survive to reproduce or be caught again.

The use of single barbless hooks complements the growing interest in catch-and-release fisheries. As these studies show, their use reduces sublethal and lethal impacts on juvenile and adult fish.

The Oregon Department of Fish and Wildlife and the Commission ought to review their opposition to the use of barbless hooks in selective fisheries. The goal of selective fisheries is to allow angling opportunity while achieving conservation objectives. Barbless hooks advance the conservation objectives of selective fisheries.