Enhancing Threatened Salmonid Populations: A Better Way

By Roy L. Thomas

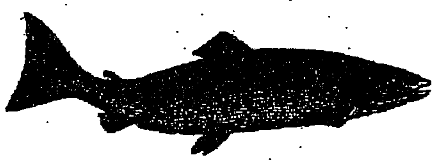
Many West Coast wild stocks of salmon and steelhead have been identified as either threatened, endangered, or extinct, and fisheries management failures associated with these situations are tragic. We can no longer practice supervised neglect, watch wild populations ride the oscillating down slope to near extinction, and then try to use the Endangered Species Act (ESA) to save the day. Implementing the act is too expensive and prone to failure, and as use of the act increases, the legislation becomes increasingly vulnerable to political efforts to weaken or destroy its foundation.

We need to act quickly to preserve our wild populations until the causes of their decline can be mitigated. In many cases, we should intercede on behalf of a declining wild population while assessing whether it represents an Evolutionary Significant Unit (ESU) or why it is declining. To finally mitigate conditions contributing to population decline only to lose the uniquely adapted population native in that habitat is a tragedy.

Recovery of endangered populations can be enhanced by supplementing the remnant spawning population with adults of the same genetic race without significant disruption of the potential for natural recovery. An at-risk wild population can be restored without many of the genetic and disease problems of traditional hatcheries. The idea of supplementing remnant spawning populations is not a perfect solution and is certainly not a substitute for nature, but it is effective at assisting struggling populations with minimal disruption to their genetic integrity.

My idea is to capture a representative number of families and races of outmigrants from a declining river population. Marking and DNA analysis could be used to genetically identify each individual, if necessary. This representative sample of outmigrants could be transported and held at an efficient saltwater-rearing facility. If efficient net-pen techniques are used, the cost of spawning adults produced from wild smolts could be a fraction of what traditional hatcheries spend to produce returning hatchery adults. The wild outmigrants are reared to sexual maturity and at the appropriate time are transported to their native stream to spawn.

Traditionally, fisheries biologists blamed degraded instream habitat as a major limiting factor in anadromous populations. By reducing mortality during the ocean phase of the life cycle, this restoration strategy maximizes enhancement of wild fish most fit to survive during the egg incubation and pre-smolt phases of the life cycle under existing conditions. Reducing mortality during the ocean phase also effectively eliminates natural selection during this stage. However, in cases where the alternative is complete loss of the genetic stock, the elimination of ocean mortality due to recent unfavorable environmental conditions (El Niño) and high-seas netting mortality may be justified.



I observed some of these smolts riding the debris-filled wave of the storm-swollen river and jumping ahead onto the dry gravel in a desperate attempt to clear the sandbar at the river mouth, only to be stranded as the surface flow disappeared into the pumped-dry river gravels.

Rearing wild smolts to maturity in a saltwater facility has such problems as acclimating smolts to salt water, maintaining appropriate temperature and salinity for gonadal development, providing appropriate diets to maintain health, and determining the appropriate time to reintroduce mature adults to fresh water. Many of these problems appear to have been solved by commercial brood-stock operations in the north Pacific and Europe.

Applying the Enhancement Approach

The Carmel River Steelhead Association (CRSA), a group of volunteer conservationists and anglers, used the approach of raising wild smolts to maturity to enhance threatened steelhead populations in the Carmel River, California. This project evolved as a result of a cooperative effort among a number of agencies, including the Monterey Bay Salmon-Trout Project, Monterey Peninsula Water Management District, California Department of Fish and Game (CDFG), and Monterey County Fish and Game Fines Commission.

Prior to 1987, the Carmel River had the largest self-sustaining run of steelhead south of San Francisco, California. This population was of the southern race (currently under consideration for listing under the ESA) and was uniquely adapted to the severe conditions of the river's high temperature and intermittent flow. For the past 20 years, the CRSA has rescued steelhead stranded by the municipal withdrawals from the lower river. From 1981 to 1987, volunteers from the association reared the stranded fish to smolt size and released them into the river when winter rains opened it to the ocean. The spring of 1990 found CRSA

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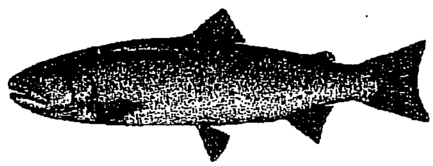
volunteers in a desperate mood because drought conditions, along with severe overdraft of the river's base flow to support golf courses and development, had prevented the river flow from reaching the ocean since 1987. During the drought, I witnessed the native ocean population being decimated by California sea lions that tore apart the overripe fish that circled while waiting for the river to open. Those adults not destroyed by sea lions died from stresses of overmaturity and age. By 1990, few smolts were left to outmigrate because of the lack of returning spawners. I observed some of these smolts riding the debris-filled wave of the storm-swollen river and jumping ahead onto the dry gravel in a desperate attempt to clear the sandbar at the river mouth, only to be stranded as the surface flow disappeared into the pumped-dry river gravels.

Although the southern and central California steelhead take advantage of storm events and high tide to pass over these sandbars, the overdraft zone at the mouth of the Carmel River was impassible for three consecutive years. Because the ocean phase for these steelhead rarely extends beyond three or four years, this unique genetic component was in significant danger of extirpation.

When the CRSA approached the CDFG with the idea of rearing captured smolts to maturity in salt water, agency personnel were initially not supportive of the plan. After negotiating, we developed a three-year cooperative project with the agency and eventually received both technical help and funding. Our association built smolt traps to capture the wild outmigrants. In 1990, with no end to the drought in sight, we captured all the smolts that attempted to outmigrate in an effort to rescue the remaining remnants of this genetic stock.

Ninety of these smolts were transported to the Granite Canyon Marine Laboratory of the CDFG and reared in a 5-ft-by-20-ft fiberglass tank, which we assembled in a parking lot. These fish, which ranged greatly in size, shape, and color, adapted well to their artificial environment. We were able to use discharge water from an abalone and rockfish experiment as a saltwater source. Volunteers worked one to two hours each, one day a week, feeding the fish and cleaning the tank. We had success introducing the wild fish to salt water and converting them from natural to pelletized food, frozen krill, and native baitfish of Monterey Bay. Information on net-pen-rearing salmonids to commercial size was available, but the technology needed for rearing salmonid brood stock in salt water was difficult to find. We called many federal, state, and university fisheries professionals for technical assistance but received little useful advice. The fisheries staff at Nanaimo, British Columbia, were most helpful, sending us a draft brood-fish manual as well as unpublished technical brood-fish information. However, it was difficult to determine when individual fish would be ready to enter fresh water or how to tell which fish would spawn that year.

Despite these problems, more than half the fish tried to spawn the first year. Instead of releasing mature fish into the river the first year, we stripped and fertilized eggs at the Monterey Bay Salmon-Trout Project Fish Hatchery. Although most of the females were successfully returned to the saltwater tank to rear another year, males died on reintroduction to salt water. Apparently, the males required a much longer post-spawning recovery time.



...the results [of our project] clearly demonstrate the potential of raising wild smolts to maturity in captive-rearing programs as a restoration technique for enhancing threatened wild populations of salmonids

The second year we collected 188,000 eggs, and some fish grew to 12 lbs. We released some unspawned adults into the river to spawn, and later we released fry and smolts back into the empty habitat. We even backpacked 53,000 swim-up fry to the headwaters of the Carmel River in the Ventana Wilderness. The third year we had fish grow to more than 20 lbs. More unspawned fish were released to the wild, and 160,000 eggs were taken at the hatchery, again with various sizes of fish released into the river. Although the project was extended to a fourth year, the CDFG terminated the project at the end of that time when drought conditions subsided. Although counts of returning adult steelhead increased as a result of this project, both the CRSA and CDFG continue to be concerned about the future of the Carmel River steelhead population.

This technique of captive-rearing wild smolts to sexual maturity demonstrated tremendous possibilities for restoring and enhancing both steelhead and other salmon. The 90 original wild steelhead smolts, which in nature represent 1.7 to 6 wild returning adults, produced the equivalent of more than 100 spawning fish in the first 3 years.

An Analysis of the Approach

The approach of rearing wild smolts to maturity is not without potential problems and concerns. Eliminating natural selection in the late outmigration and ocean phase of the life cycle has the potential to alter gene pools, especially if the approach were used throughout successive generations. Many fish biologists agree the biggest challenge facing anadromous stocks on the West Coast is degraded instream conditions. Captured wild smolts represent a gene pool that has already survived instream conditions and selection. When the released adult, raised from the captured smolt, spawns in its native stream, spawning site location, mate selection, and egg and parr survival occur under natural conditions. Resulting offspring should be better adapted to use the habitat available than the hatchery products currently in use. However, techniques to enhance the numbers of spawners will be ineffective in systems where degraded instream habitat limits egg survival and smolt production.

Special care should be taken to collect a representative sampling of outmigrating smolts (across the entire outmigration period) to avoid selecting for earlier or later outmigration. Selection occurring within the artificial rearing habitat can also be problematic.

Conditions for rearing wild smolts should be kept as natural as possible. Net-pen rearing appears to offer considerable promise for providing a cost-effective approach to producing mature spawners. The basic technology of net-pen rearing is well-established. Compared with traditional hatcheries, net-pen rearing can generate a high-quality adult for less expense. With appropriate marking, wild smolts from many different rivers could be raised together in regional facilities. However, maintaining genetic stocks at several smaller, isolated facilities would reduce the chances of a disease event destroying an entire genetic unit.

Another important aspect of this strategy is that wild adults can be left alone. No longer must wild adults be forced to spawn in a hatchery possibly with siblings or an inappropriate family or race. The most valuable fishes to a natural population are wild-spawning adults. They have survived all past challenges, and they deserve to be left to spawn naturally with a mate of their choosing. Another reason not to use wild adults in a restoration project is that they are less abundant than smolts and more difficult to catch, and it is hard to capture a representative sample of all families and races necessary to enhance a complex wild population. Compared with the impact of removing an adult, the removal of a few smolts may have less effect on the gene pool and the potential for natural recovery.

While there are genetic selection problems associated with any form of artificial propagation, I believe that the approach of raising wild smolts to maturity is less disruptive to genetic integrity than many traditional propagation programs. In addition, few would disagree that this type of intervention is preferable to the current hand-wringing approach of watching runs decline to Redfish-Lake-size runs. Our pilot project clearly demonstrates the feasibility of this approach. However, additional research and development is needed to develop this approach for widespread use.

Too many depleted and at-risk populations are suffering supervised and unsupervised neglect. Resource managers appear to be waiting and watching the decline until the populations become eligible for ESA listing. By this time restoration may be too expensive or too late. While our project was not assessed in a rigid scientific manner, the results clearly demonstrate the potential of raising wild smolts to maturity in captive-rearing programs as a restoration technique for enhancing threatened wild populations of salmonids. Although I do not think the population is completely restored, we do believe that without effort to save the gene pool, the unique Carmel River steelhead would not be restored in our lifetime, if at all. I encourage fisheries professionals to investigate the feasibility of this enhancement approach and to devote research and development effort to implementing similar programs. Similar enhancement programs could use cooperative approaches among natural resource agencies, angler and environmental groups, and aquaculture and other industries to develop programs to benefit other threatened salmonid populations. I hope that other resourceful individuals or groups will approach public resource agencies, form cooperative relationships, develop a plan, and act on it!