Report

of

The CNFH Science Panel

Review of the

Steelhead Supplementation

Program in Battle Creek

July 12, 2004

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INTRODUCTION

In its January 2004 report, the CNFH Science Panel recommended an immediate review of steelhead supplementation in Battle Creek. The Panel asked for a review of the risks, uncertainties, alternative opportunities and compatibility with the Battle Creek recovery plan. In response to this recommendation, the California Bay-Delta Authority organized a workshop to discuss the issues raised by the Science Panel. Three members of the original CNFH Science Panel and two additional fish geneticists attended the workshop and they were asked to answer three questions:

A. What are the strengths and weaknesses of the steelhead supplementation plan?
B. What is the level of risk to the restoration of Battle Creek salmonids posed by steelhead supplementation?
C. Has the issue been adequately addressed?

This report gives the Science Panel's answers to those questions.

Members of the Science Panel are:

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Mr. Jim Lichatowich, Alder Fork Consulting
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Dr. Hankin, Dr. Reisenbichler and Mr. Lichatowich were members of the original CNFH Science Panel.

Background

CNFH proposes to continue a steelhead supplementation program in Battle Creek for five years starting in 2002/03. The release of returning adult steelhead of hatchery origin above the barrier weir began in 1995. Beginning with the 1998 brood year, all juvenile steelhead released from CNFH have been adipose-clipped, so in 2001 and thereafter, essentially all returning hatchery-origin steelhead have been visually distinguishable from presumptive wild (unmarked) fish by absence of the adipose fin. The number of hatchery-origin steelhead passed over the barrier weir for supplementation depends on the number of unmarked steelhead that enters CNFH. When low numbers of unmarked steelhead return to Battle Creek, the total number of fish to be passed above the weir is fixed at 1,000; of these, up to 80% may be hatchery-origin steelhead from CNFH. At higher numbers of unmarked fish, the combined total of hatchery

origin and unmarked steelhead may total 2,000. If unmarked fish numbers are at or above 2,000, then no hatchery-origin fish would be passed above the barrier weir. The objective of the steelhead supplementation program is to accelerate the increase in abundance of a naturally reproducing population of steelhead in Battle Creek. Once returns of unmarked fish exceed 2,000, there would be no further supplementation with hatchery-origin steelhead. After the initial five years of supplementation, the release of hatchery-origin steelhead would be discontinued for five years. Monitoring will continue during the latter five year interval. At the end of the second five-year period, the program results will be reviewed and a decision made whether or not to resume supplementation.

According to presentations made at the June 14, 2004 workshop, another objective of the steelhead supplementation program is to ensure that steelhead artificially propagated at CNFH are as similar as possible to unmarked (naturally produced) steelhead. To achieve that objective, CNFH proposes to (a) deliberately include specified numbers of unmarked steelhead in their breeding program and (b) extend spawning dates so as to include all temporal segments of the unmarked run. The exact racial origin/genetic identity of unmarked fish is unknown. The unmarked steelhead could be progeny of CFNH fish that successfully spawned in Battle Creek, they could be the progeny of a remnant wild population or they could be progeny of crosses between CNFH fish and remnant wild fish, or they could (most likely) be a mixture of all these types. However, information presented at the workshop suggests that there is a genetic difference between the unmarked steelhead and hatchery-origin steelhead returning to Battle Creek.

The steelhead supplementation program in Battle Creek differs from the supplementation programs envisioned originally for andromous salmonids in the Columbia River basin (RASP 1992, Cuenco 1993). The supplementation strategy usually includes efforts to preferentially use local natural-origin adults as broodstock (and not use a multi-generational hatchery line), and acclimate and release smolts into the stream targeted for treatment. In Battle Creek, the stock used for supplementation is a multi-generation hatchery stock and no smolts are released into the treatment stream. Only hatchery adults are used to supplement the naturally reproducing population.

ANSWERS TO QUESTIONS

A) What are the strengths and weaknesses of the steelhead supplementation plan?

The strengths and weaknesses are presented first in bullet form followed by further explanation of some of the major weaknesses in the program.

Strengths of the Program

- The program includes genetic monitoring of hatchery and natural steelhead.
- The relative reproductive success of the hatchery-origin and natural steelhead will be monitored.

- Supplementation with hatchery-origin steelhead will stop at the end of five years while monitoring and evaluation will continue for another five years.
- The program is laudable for its genetic monitoring plan and for controlling the proportion of hatchery and natural steelhead above the barrier weir.
- The limited period of proposed supplementation is unlikely to cause additional permanent harm.

Weaknesses of the Program

- The program lacks clear, quantitative justification (apart from support of harvest) for supplementation of natural production with hatchery fish.
- The estimated carrying capacity of 2,000 adults may be too high and needs greater justification.
- Hatchery-origin fish will dominate the releases of steelhead above the barrier weir, at least in the early years of the supplementation program.
- The program does not give adequate attention to life history monitoring in natural and hatchery steelhead and the possible divergence of their life histories.
- The proposed monitoring will not determine if hatchery releases benefit or erode the productivity of natural spawners.
- Mining a small natural population to achieve an "integrated" population is a weakness in the program.
- There has been an apparent lack of an evaluation of alternatives to the proposed supplementation program.
- Lack of controls for density or deleterious behavior means the FWS will not be able to determine how fast recovery would occur without supplementation.
- The supplementation proposal lacks a monitoring plan to address predation and competition.
- The program proposes to supplement the natural steelhead population in Battle Creek with a hatchery stock that has probably undergone domestication.
- The experimental design will not permit a determination of the demographic benefit attributable to natural spawning by hatchery-origin steelhead or a reduction in natural spawning fitness of natural-origin steelhead adults from interbreeding with hatchery-origin adults.

The estimated carrying capacity of 2,000 adults may be too high and needs greater justification.

Passage of large numbers of CNFH steelhead above the hatchery barrier weir *prior* to full implementation of restoration measures (removal of dams, increased flows and other improvements to passage and habitat) in Battle Creek makes little sense and could cause competition for spawning habitat between large numbers of hatchery-origin steelhead and the smaller number of unmarked steelhead. According to various sources, the ultimate capacity of the restored Battle Creek for adult steelhead seems somewhere between 1,000 fish (Hallock 1987) and 2,000 fish (Campton et al. 2004). These capacities are for steelhead spawners in Battle Creek with restored habitat. The same number of steelhead is proposed for passage above the

weir under *current* conditions of reduced interim flows and limited habitat availability. There has not been a compelling case made that the current conditions in Battle Creek are adequate to support spawning of more fish than the current numbers of unmarked fish that have been passed above the weir (about 100-500 annually).

Attachment 1 of the plan summarizes steelhead spawning habitat availability in Battle Creek. These are calculated from weighted usable area curves and then used to establish spawning escapement goals. The plan does not state whether Battle Creek is currently managed at the flow and spawning reach lengths assumed in developing the total area available. If the flow and area are yet to be achieved, then setting the current goals based on those escapements is unjustified. The plan does not address the uncertainty of these estimates, or incorporate environmental sources of variation in stock-recruitment relationships to convincingly establish that Battle Creek is currently below carrying capacity or at high risk of demographic or stochastic extirpation. Recent empirical analyses of natural production in the Umatilla River (OR) established that expectations of carrying capacity presented in planning documents were too high. In the Hood River (OR) very low adult escapement in the mid 1990s produced large cohorts of smolts and subsequent adult returns. The carrying capacity and escapement goals for Battle Creek presented in the plan could be more rigorously developed.

The program proposes to supplement the natural steelhead population in Battle Creek with a hatchery stock that has probably undergone domestication.

Steelhead have been artificially propagated at CNFH for more than 50 years (since 1952). It is reasonably safe to conjecture that there has been some domestication (unintentional selection for various morphological and behavioral traits that are genetically inherited) of the original wild population used to establish the hatchery stock. Hatchery practices at CNFH that could easily produce domestication include (a) restricted incorporation of smaller and presumably younger steelhead adults into breeding programs, and (b) restricted inclusion of spawners from the late portion of the natural run. Restricted inclusion of smaller and younger steelhead could theoretically result in selection for a later-maturing and larger hatchery stock of steelhead as compared to the original wild steelhead stock (see Tipping 1991 - steelhead, Hankin et al. 1993 - Chinook salmon). Restricted inclusion of later-returning spawners could quickly select for a hatchery stock that exhibited an earlier return timing than the original wild stock. (Waples 1991, Flagg et. Al 1995, Hard 2004). There is some evidence that the CNFH stock of steelhead has an earlier spawning schedule than unmarked fish in Battle Creek. In Dr. Campton's presentation of new genetic data at the June 14, 2004 workshop, sample sizes of CNFH steelhead by temporal period were highly skewed toward the early component of the run; almost no late-returning marked (CNFH) steelhead could be found. In striking contrast, there were substantial numbers of late-returning unmarked (presumptive "wild") steelhead collected at CNFH.

Hatchery-origin fish will dominate the releases of steelhead above the barrier weir, at least in the early years of the supplementation program.

The proposed USFWS supplementation plan calls for up to 80% of the adult steelhead passed above the Battle Creek weir to be marked hatchery-origin fish. If the unmarked steelhead

returning to Battle Creek are genetically different from CNFH steelhead and retain important life history adaptations that are no longer possessed by the CNFH steelhead, then the hatchery-origin steelhead could "swamp out" the wild gene pool. The result would be a situation where the "wild" and CNFH stocks would be essentially the same (the objective of CNFH management), but the method of achieving this result would be utterly at odds with an objective of restoring the natural population of steelhead in Battle Creek.

New genetic data (from highly variable microsatellite markers) presented at the workshop provide strong evidence of genetic differences between temporal components of the unmarked Battle Creek steelhead, CNFH steelhead, and wild steelhead from the upper Sacramento River above Battle Creek. A relatively small number (7) of microsatellites showed that unmarked Battle Creek steelhead were well differentiated genetically from CNFH and upper Sacramento wild steelhead. For the proposed CNFH supplementation program to be well justified, one would instead wish to see various temporal components of the unmarked and the marked steelhead runs group with one another. Instead, both temporal groups of fish from CNFH grouped with one another and all three temporal groups of unmarked fish grouped with one another. Finally, if unmarked fish were simply progeny of CNFH that had spawned in the wild in the previous generation, it would seem unlikely (though not impossible) that such consistent genetic differences would be detected between marked and unmarked steelhead entering CNFH. The Panel concludes there is evidence for genetic differences between the remnant unmarked steelhead run and steelhead returning to CNFH. Indeed, actual differences may be more substantial than those indicated at the workshop. If, for the sake of argument, the unmarked fish consist of first generation progeny of CNFH steelhead parents and parents from a remnant wild population, a larger number of microsatellites might allow unmarked fish to be separated into two groups: wild remnant steelhead and first generation CNFH-like steelhead. A genetic comparison of CNFH steelhead with the "wild remnant" steelhead sample from within the unmarked group might be a more informative comparison than the one available at present.

The program lacks clear, quantitative justification (apart from support of harvest) for supplementation of natural production with hatchery fish.

Answers to three important questions form the logical basis for the assessment of whether supplementation is a reasonable strategy to use to restore steelhead in Battle Creek. What is the relationship between natural-origin steelhead in Battle Creek and hatchery-origin steelhead from Coleman National Fish Hatchery - are they subcomponents of a single population or essentially independent populations? What are the population dynamics of Battle Creek and Coleman National Fish Hatchery steelhead - what evidence suggests that Battle Creek steelhead need to be supplemented and that steelhead from Coleman hatchery can accomplish the task? What is the carrying capacity for steelhead in Battle Creek? The three questions are not independent. The first two questions are addressed here. The third, dealing with carrying capacity was addressed earlier.

What is the relationship between natural-origin steelhead in Battle Creek and hatchery-origin steelhead from Coleman National Fish Hatchery - are they subcomponents of a single population or essentially independent populations? The authors of the supplementation plan

conclude that steelhead supplementation in Battle Creek is "risk tolerant" based on the belief that natural-origin steelhead in Battle Creek are likely to be derived from naturally spawning Coleman Hatchery steelhead. If natural-origin steelhead in Battle Creek are derived from resident *O. mykiss*, or other Sacramento River natural steelhead, then the "risk tolerant" status of the project would be doubtful. The data presented at the workshop provides compelling evidence that the assumption that Battle Creek natural steelhead are the progeny of Coleman Hatchery steelhead is highly uncertain. The run timing of steelhead adults at Coleman Hatchery is earlier than in the natural population. Genetic contrasts of Battle Creek and Coleman Hatchery steelhead are significantly different, but across years differences within Battle Creek and Coleman Hatchery fish were not established. The early natural-origin adults returning to Battle Creek appeared more similar to Coleman Hatchery steelhead than later run natural steelhead. There are three cases - Elochoman (WA) and Hood (OR) River winter steelhead, and Clackamas River (OR) summer steelhead - where natural populations of steelhead have maintained significant differences from multi-generation hatchery stocks even when exposed to years of stocking. A variety of evidence suggests that the hatchery-origin steelhead were largely unsuccessful in making a lasting contribution to the gene pool of the natural population. A similar outcome would not be unexpected in Battle Creek.

What are the population dynamics of Battle Creek and Coleman National Fish Hatchery steelhead - what evidence suggests that Battle Creek steelhead need to be supplemented and that steelhead from Coleman hatchery can accomplish the task? Natural-origin steelhead in Battle Creek should be below replacement to justify considering supplementation. If steelhead in Battle Creek are at or above replacement supplementation is not necessary to aid natural production, and could be justified only as a harvest augmentation strategy. No data are provided on the population's dynamics to judge the necessity of supplementation. If the population is below replacement, supplementation can provide a net demographic benefit under restricted circumstances. The size of the net benefit is a function of the combined dynamics of the hatchery and natural spawning phases. The hatchery and natural spawning replacement rates, the broodstock mining rate, harvest rate, and natural spawning performance of the hatchery-origin adults all factor into whether or not there is a net benefit. An assessment of the population dynamics of the integrated population is absent.

The supplementation proposal lacks a monitoring plan to address predation and competition.

The plan does not treat the ecological effects of supplementation on other salmonids in Battle Creek, including competition or predation. CDFG presented information on this topic, but the presentation addressed the topic superficially. Comments provided by a member of the audience suggested that relevant records from studies done locally are perhaps in the regional agency offices. This topic needs to be addressed more thoroughly.

The experimental design will not permit a determination of the demographic benefit attributable to natural spawning by hatchery-origin steelhead or a

reduction in natural spawning fitness of natural-origin steelhead adults from interbreeding with hatchery-origin adults.

The essential measure of success in supplementation programs is demonstrating that natural spawning by the hatchery-origin adults adds smolts and subsequent adults to the population. Evaluation based on monitoring only the supplemented population is insufficient because of year to year environmentally caused variation in abundance and productivity. Evaluation of the relative reproductive success of hatchery-origin and natural-origin adults spawning in the wild is important and would add to our understanding of integrated hatchery-natural populations. These evaluations, however, cannot establish whether spawning by hatchery-origin adults added smolts or just replaced smolts that would have been produced by the natural-origin adults. The required contrast is between an unsupplemented reference population and the supplemented population. The essential measure of whether domestication selection in the hatchery phase of the integrated population is decreasing the natural spawning fitness of the integrated population is a contrast of productivity between a supplemented stream and an unsupplemented reference stream. The appropriate contrast is not between natural-origin and hatchery-origin adults in the supplemented stream. This latter contrast will provide important insight into the dynamics of the integrated population, but will not provide an evaluation of the longer-term fitness effects of supplementation. The plan, and presentation at the workshop, recognized the requirement for a reference stream. Since a reference is not available, alternative approaches were outlined. The information produced by the alternative evaluation would add to the current scientific understanding of integrated steelhead populations. It would not however, provide a fully sufficient evaluation of Battle Creek steelhead supplementation. If the decision is made to continue supplementation, it needs to be made with the full appreciation that uncertainty about the efficacy will not be resolved by the monitoring.

There has been an apparent lack of an evaluation of alternatives to the proposed supplementation program.

The principal alternative approach would be to restore flows and allow unmarked steelhead access to previously blocked habitat, and monitor whether these steelhead could reestablish a viable population without supplementation. The learning that could take place with this alternative would be as important as the learning from a supplementation experiment. A future supplementation option would still be possible if natural recovery were "too slow" or if new genetic information failed to suggest continuing genetic differences between unmarked Battle Creek steelhead and CNFH steelhead. The decision tree to choose between alternatives requires addressing the same questions posed for supplementation - the relationship between the natural and hatchery populations, the population dynamics of each population, and the carrying capacity of the environment.

A more risk-averse and informative approach to monitoring the Battle Creek system would be to cease all releases of hatchery steelhead above the hatchery weir immediately, releasing only natural fish; initiate and continue monitoring of productivity in the system, including trends in life history, variation in reproductive success, and population growth rate. Alternatively, scaling hatchery releases to be similar in size to those of natural fish would be a first step to a less risky supplementation policy. The numbers of hatchery-origin and unmarked

steelhead to release above the barrier weir should be based on minimizing risk to natural production, not on an estimate of adult carrying capacity of questionable validity.

B) What is the level of risk to the restoration of Battle Creek salmonids posed by steelhead supplementation?

The level of risk to Battle Creek salmonids posed by steelhead supplementation is not quantified in the plan. Information presented in the plan and at the workshop is insufficient for the review team to quantify, with any defined boundaries, the risk posed to Battle Creek salmonids.

Risks to Chinook salmon include predation on fry by adult and yearling steelhead, and density dependent competition with under yearling steelhead. Risks to steelhead include those same predation and competition risks.

The primary risk to steelhead in the system is increased risk of extirpation from interbreeding between natural fish and hatchery fish that are domesticated and presumably have reduced fitness (measured as lifetime reproductive success) in the wild. Whether an endemic wild component rearing and spawning naturally still exists in Battle Creek is unknown, but it is possible that one has persisted despite the history of hatchery plants into Battle Creek. Nevertheless, the likelihood that any such component would continue to exist diminishes with continued supplementation, as long as the characteristics that are favored in the hatchery differ from those favored in the wild. If a distinct component does not exist, then the hatchery and natural groups have been intermixed and the fitness of the fish in this mixture depends on how they are adapting to the combined hatchery-natural system. The best insight into this problem will come from a careful monitoring program that is able to distinguish fish in the groups and compare the reproductive success and its components in the different environments.

The release of hatchery-origin steelhead into Battle Creek may also affect other salmonids in the system by altering the composition of the salmonid community through ecological interactions (predation, competition, displacement, disease transfer). The proposal does not mention any intent to monitor such effects.

The precautionary principle (Raffensperger and Tickner 1999, Restrepo 1999) seems a relevant and appropriate standard for decision-making in this context. Passage of large numbers of hatchery-origin steelhead compared to unmarked fish might seriously compromise the genetic integrity of the existing presumptive remnant population of wild Battle Creek steelhead. There is now genetic evidence that unmarked Battle Creek steelhead may indeed constitute a remnant population with genetic attributes that are distinguishable from CNFH steelhead. Once compromised, the genetic integrity of the remnant wild population could not be restored. Therefore, the precautionary approach would argue that restoration should proceed cautiously and naturally, *without* supplementation with genetically-distinct CNFH steelhead. Numbers of adults in the natural spawning run would, if conditions are suitable, eventually increase in response to improved quality and quantity of spawning and rearing habitat in a restored Battle Creek.

C) Has the issue been adequately addressed?

The answer to this question is, "no". There are numerous reasons to be concerned about the CNFH steelhead supplementation program and little new information was presented at the workshop that persuaded the Panel to be more favorably disposed to the program. Indeed, new information presented at the supplementation workshop increased rather than diminished the Panel's concerns.

The possibility remains that genetic change in steelhead reared in CNFH (caused primarily by domestication reflecting typical culture protocols for hatchery steelhead) could reduce fitness in fish released to the wild. This possibility may be small if the hatchery and natural components are extensively mixed and/or the environments do not differ substantially. However, the environments are likely to differ substantially, and if any phenotypic change that results from hatchery domestication is heritable and these fish interbreed with wild fish, productivity of wild fish could be reduced. This consequence cannot be detected with the proposed monitoring until the supplementation ceases and a sufficient period of monitoring of the reproductive success of fish with different exposures to domestication has elapsed (i.e., power to detect differences is sufficient). Therefore, determining whether this is the case would be difficult if the proposed plan is adopted.

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