E N T R I X

RUSSIAN RIVER BIOLOGICAL ASSESSMENT

INTERIM REPORT 2:
FISH FACILITY OPERATIONS

Prepared for:

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and

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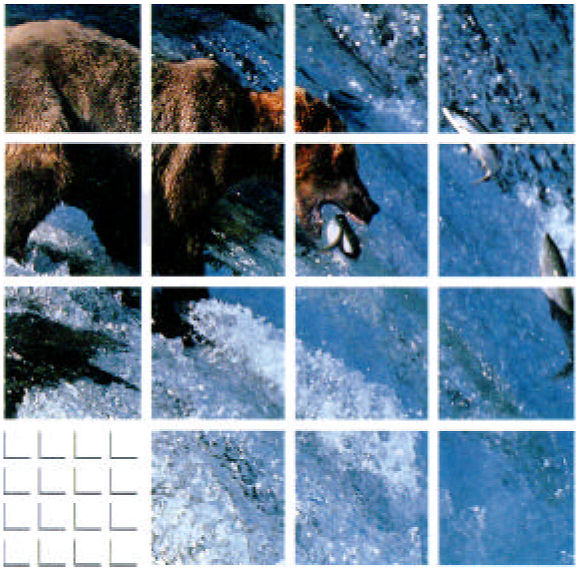

April 28, 2000

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The Sonoma County Water Agency (SCWA) and the U.S. Army Corps of Engineers (USACE) are undertaking a Section 7 consultation under the Federal Endangered Species Act (ESA) with the National Marine Fisheries Service (NMFS) to evaluate effects of operations and maintenance activities on listed species and their critical habitat. The Russian River watershed is designated as critical habitat for threatened stocks of coho salmon, chinook salmon and steelhead. SCWA and USACE operate and maintain facilities and conduct activities related to flood control, channel maintenance, water diversion and storage, hydroelectric power generation, and fish production and passage. The California Department of Fish and Game (CDFG) operates the hatchery facilities under an agreement with USACE.

Federal agencies such as USACE are required under the ESA to consult with the Secretary of Commerce to insure that their actions are not likely to jeopardize the continued existence of listed species or adversely modify or destroy critical habitat. As part of the Section 7 Consultation, USACE and SCWA will submit to NMFS a Biological Assessment (BA) that will provide the basis for NMFS to prepare a Biological Opinion (BO) that will evaluate project operations. The BA will integrate the Interim Reports on various project operations. This Interim Report addresses fish facility operations, including the Don Clausen Fish Hatchery (DCFH) located at Warm Springs Dam on Dry Creek and the Coyote Valley Fish Facility (CVFF) at Coyote Valley Dam.

Fish production facilities were developed at DCFH and CVFF to both mitigate for the loss of steelhead and coho spawning and rearing habitat upstream of Warm Springs and Coyote Valley dams, and to enhance coho and chinook salmon population. Based on operational records, the facilities are successful with spawning, early rearing and release of juvenile fish. However, actual returns of adults to the facilities have been far below the projected return rates. The release goals for DCFH and CVFF reflect an assumed survival rate from release to adult return. However, actual survival following release is affected by factors in the marine environment beyond the control of hatchery operations.

Potential effects on protected steelhead, coho and chinook in the Russian River basin that may arise from the existing fish facility operations were evaluated. In general, there is a low risk of adverse effects to protected populations. The current operations at DCFH and CVFF are likely to adversly affect protected populations, and are not likely to adversely modify critical habitat. Key findings to support this conclusion are noted as follows.

Water Quality - Based on continuous compliance with the National Pollutant Discharge Elimination System (NPDES) discharge permits, which take into account habitat requirements for salmonids, the current discharge is not likely to significantly degrade water quality.

Disease – Three areas of concern were evaluated: introduction of new pathogens, amplification of fish pathogens, and dissemination of fish pathogens.

The curtailment of past practices of stock importation from sources geographically distant to the Russian River has greatly reduced the risk of introduction of new pathogens. Importation of stocks from populations outside the Russian River occurs at DCFH with fall chinook eggs from the Eel River. Therefore, effects on the protected populations in the Russian River from these activities are very minor.

Based on the current operating practices of DCFH and CVFF, the risk of amplification or dissemination of fish pathogens is low. The hatcheries have implemented numerous changes to their spawning, disinfection, hatching and rearing protocols to produce healthy fish and reduce the incidence of disease.

They have also introduced prophylactic treatments to help reduce the effect from bacterial coldwater disease. If an occurrence of high mortality from a pathogen occurred, the risk for amplification of that pathogen would be increased. However, based on recent history at the facilities, this kind of mortality is an infrequent occurrence.

Genetic effects – Four areas of concern were examined: outbreeding depression, inbreeding depression, loss of within population diversity, and loss of between population diversity.

OUTBREEDING DEPRESSION

Beginning in 1998, all broodstock for mitigation and/or enhancement of all three salmonid species were derived solely as adult captures within the Russian River. Given this shift in broodstock collection protocols toward the target stocks, the risk of outbreeding depression is currently low as a result of operations of DCFH and CVFF. However, given the mixed stock history of DCFH and CVFF, adults currently returning to the facility may be of mixed origin, therefore the risk of outbreeding depression is potentially higher than would be the case had broodstock always been collected locally.

INBREEDING DEPRESSION

Over the last four years, the numbers of female chinook, coho, and steelhead used as broodstock has decreased considerably, reflecting the shift to local broodstock sources rather than out of basin sources. The number of chinook salmon spawned over the last four years is well below the suggested minimum of 100 adult pairs. Therefore, chinook salmon may have an unfavorable level of inbreeding. Coho salmon were present in numbers well above the suggested minimum in every year except 1998, suggesting that the risk of inbreeding depression is likely low. Steelhead broodstock was maintained well above the minimum suggested size, indicating that they are not at risk of inbreeding depression.

LOSS OF WITHIN POPULATION DIVERSITY

Three primary risk factors were formulated in regard to the loss of within population diversity, also referred to as domestication. The first risk factor examined adequate representation of the population in broodstock collection. Currently, broodstock is collected systematically across the entire adult return, or includes all captured adults, which of minimizes the potential for artificial selection due to non-representative broodstock collection. Therefore, broodstock collection practices are unlikely to adversely affect the naturally spawning population components. The second risk factor examined artificial selection in the hatchery rearing environment. DCFH and CVFF follow standard rearing procedures recommended by the California Department of Fish and Game. Inavoidably, some artificial selection will occur that favors survival under the given hatchery conditions, as compared to riverine conditions. In addition, since naturally spawned individuals are rarely captured, there is a risk of domestication as a result of repeated, indirect artificial selection imposed on the hatchery-reared component of the population. Finally, the third risk factor examined maintenance of a broodstock size commensurate with the maintenance of genetic diversity. Currently, broodstock quotas are selected on the basis of desired production rather than a minimum threshold necessary for the maintenance of genetic diversity. However, in an attempt to increase genetic diversity, more individuals are spawned than are necessary to achieve production goals. Surplus eggs are then randomly destroyed to avoid surplus production.

LOSS OF BETWEEN POPULATION DIVERSITY

While the history of stock transfers in the Russian River suggests that between population diversity, or genetic integrity of Russian River stocks, has been compromised, the 1998 policy change requiring broodstock collection from returns to the Russian River will likely prevent further compromise to Russian

River specific stocks. Further, current release strategies suggest that straying to non-natal rivers is unlikely to be a great concern.

Ecological effects – Three areas of concern were evaluated: competition, predation and overexploitation.

COMPETITION

There are only very limited data to assess the potential for competition between or among the three protected species or other fauna present in the Russian River. However, current conditions appear favorable with repect to three aspects of competition: release numbers, temporal and life history stage aspects, and geographical aspects. Current production goals call for release of smolts only. Since smolts emigrate to the ocean soon after release, the time they are in the watershed competing with the protected populations for limited Russian River resources is short. Secondly, the releases occur only in Dry Creek and the East Fork Russian River, leaving a majority of the watershed unaffected by hatchery releases.

Thirdly, though by gross observation only, the numbers of naturally spawning chinook salmon and coho samon in the Russian River are so low that it does not seem feasible they could be near the habitat capacity of the system. In contrast, naturally spawning steelhead are present in substantial numbers, suggesting that the risk of competition may be an issue. However, since we lack the data to adequately assess competitive effects for Russian River salmon, we cannot estimate direct effects of competition *per se*. Therefore we have assessed production management with regards to risk aversion techniques used at other facilities. There is a negligible risk of competition for chinook and coho salmon with the fingerling component of the protected populations, and very low risk of competition with smolts and returning adults. Hatchery production of steelhead, on the other hand, may contribute to competition among adults returning to spawn naturally within the Russian River if some hatchery-reared steelhead spawn naturally. In addition, the outplanting of surplus hatchery-reared steelhead, should they seek to spawn, may increase competition within the naturally spawning population for spawning habitat and mates. Finally, if hatchery-reared steelhead residualize (remain as rainbow trout, rather than emigrating) at a high rate, competition may occur throughout the freshwater life history stages of steelhead and rainbow trout. In our best biological opinion, competitive effects are negligible with regard to chinook salmon and coho salmon, with the potential for some competitive effects for steelhead. Since steelhead from DCFH are released lower in the basin than CVFF steelhead, the potential for competitive effects is less at DCFH.

PREDATION

Currently, hatchery-reared chinook salmon, coho salmon, and steelhead are released at a much larger size than their naturally spawned counterparts, suggesting that direct predation of hatchery fish on wild fish may occur if release areas overlap areas of natural production. However, releases are not generally made in primary spawning or rearing habitat. The risk of predation is somewhat minimized for steelhead as a result of the volitional release strategy employed at CVFF.

Overexploitation

There are no current estimates of natural production by chinook, coho, or steelhead within the Russian River, suggesting that managers are unable to determine the effects of harvest on the naturally spawning component of these populations. If a hatchery program increases the number of adults returning to a stream, fishing effort may increase, resulting in increased pressure on natural fish. While regulations prohibit the take of wild (unmarked) fish, indirect effects such as hooking mortality and harassment may still increase mortality in wild fish.

SYNTHESIS OF EFFECTS

Current operating practices of the DCFH and CVFF facilities reflect a commitment to minimizing effects on protected populations. Procedures for waste treatment demonstrate continuous compliance with recommended discharge standards for water quality. The facilities maintain good track records in the ability to manage routine fish diseases, and recent changes in policy regarding importation of stocks have resulted in a condition with minimal likelihood of affecting protected stocks through disease. Since some potential effects are not directly quantifiable and limited data exist that allow direct evaluation of genetic and ecological effects on the protected populations, the likelihood of their occurrence was qualitatively assessed by reviewing the method(s) of risk aversion employed by the facilities. Recent changes in broodstock protocol suggest that everything has been done that can be readily implemented to minimize genetic effects to protected populations. Simliarly, current operations relating to production goals and harvest indicate the best practicable approach to minimizing ecological effects. There is a low risk for some potential effects. For example, there is a low risk that hatchery fish may prey on protected natural fish because they are released at a larger size. Another example is that there may be more fishing pressure on natural fish than would have occurred if hatchery fish were not being released. In general, there is a low risk of adverse effects to protected populations. Current operations of DCFH and CVFF are likely to adversely affect the protected populations, and are not likely to adversely modify critical habitat.

1.0
INTRODUCTION

1.1 SECTION 7 CONSULTATION

The Sonoma County Water Agency (SCWA) and the U.S. Army Corps of Engineers (USACE) are undertaking a Section 7 Consultation under the Federal Endangered Species Act (ESA) with the National Marine Fisheries Service (NMFS) to evaluate effects of operations and maintenance activities. The activities of USACE and SCWA span the Russian River watershed from Coyote Valley Dam and Warm Springs Dam to the estuary, as well as some tributaries. The Russian River watershed is designated as critical habitat for threatened stocks of coho salmon, chinook salmon and steelhead. SCWA and USACE operate and maintain facilities and conduct activities related to flood control, water diversion and storage, hydroelectric power generation, and fish production and passage. SCWA and USACE also are participants in a number of institutional agreements related to the fulfillment of their respective responsibilities.

Federal agencies such as USACE are required under the ESA to consult with the Secretary of Commerce to insure that their actions are not likely to jeopardize the continued existence of listed species or adversely modify or destroy critical habitat. USACE, SCWA and NMFS have entered into a Memorandum of Understanding (MOU) which establishes a framework for the consultation and conference required by the ESA with respect to the activities of USACE and SCWA that may directly or indirectly affect coho salmon, chinook salmon and steelhead in the Russian River. The MOU acknowledges the involvement of other agencies including: the California Department of Fish and Game (CDFG), the U.S. Fish and Wildlife Service (USFWS), the State Water Resources Control Board (SWRCB), the North Coast Regional Water Quality Control Board (RWQCB), the State Coastal Conservancy, and the Mendocino County Inland Water and Power Commission (MCIWPC).

1.2 SCOPE OF THE BIOLOGICAL ASSESSMENT

As part of the Section 7 Consultation, USACE and SCWA will submit to NMFS a Biological Assessment (BA) that provides a description of the actions subject to consultation, including the facilities, operations, maintenance and existing conservation actions. The BA describes existing conditions including information on hydrology, water quality, habitat conditions, and fish populations. The BA provides the basis for NMFS to prepare a Biological Opinion (BO) that will evaluate the project, including conservation actions.

The BA will integrate a number of Interim Reports:

Report 1	Flood Control Operations
Report 2	Fish Facility Operations
Report 3	Instream Flow Requirements
Report 4	Water Supply and Diversion Facilities
Report 5	Channel Maintenance
Report 6	Restoration and Conservation Actions
Report 7	Hydroelectric Projects Operations
Report 8	Estuary Management Plan
Report 9	Healdsburg Dam Fish Ladder Operations and Maintenance

This report evaluates the effects of current operations of the fish facilities on listed species and critical habitat in the Russian River. The facilities evaluated include Don Clausen Fish Hatchery (DCFH) located at Warm Springs Dam on Dry Creek and the Coyote Valley Fish Facility (CVFF) at Coyote Valley Dam.

1.3 STATUS OF COHO SALMON, CHINOOK SALMON AND STEELHEAD IN THE RUSSIAN RIVER

The primary biological resources of concern within the project area are coho salmon, chinook salmon and steelhead trout. These species are each listed as threatened under the ESA. Hatchery fish are not protected. The pertinent Federal Register notices for these species are provided in Table 1-1. Coho salmon and steelhead are native Russian River species, although there have been many plantings from other river systems (CDFG 1991). It is uncertain whether chinook salmon used the Russian River historically (NMFS 1999), but they have been stocked in the past and continue to be. Natural reproduction has also been observed in the watershed. The Central California Coast coho salmon Evolutionarily Significant Unit (ESU), which contains the Russian River, extends from Punta Gorda in northern California south to and including the San Lorenzo River in central California, and includes tributaries to San Francisco Bay, excluding the Sacramento-San Joaquin River system. The Russian River is the largest drainage included in the Central California Coast steelhead ESU, which extends from the Russian River down the coast to Soquel Creek near Santa Cruz, California. The chinook salmon listing defined the population unit that contains the Russian River as the California Coastal ESU. This ESU encompasses the region from Cape Blanco in Oregon south to San Francisco Bay.

Critical habitat for each of these species within the Russian River is designated as the current estuarine and freshwater range of the species including “all waterways, substrate, and adjacent riparian zones.…” For each species, NMFS has specifically excluded areas above Warm Springs and Coyote Valley dams and within tribal lands.

Table 1-1 Federal Register Notices for the Salmonids of the Russian River.

Species	**Listing**	**Take Prohibitions**	**Critical Habitat**
Coho Salmon	Vol. 61, No. 212, Pgs. 56138-56147 Oct. 31, 1996	Vol. 61, No. 212, Pgs. 56138-56147 Oct. 31, 1996	Vol. 64, No. 86, Pgs. 24049-24062 May 5, 1999
Steelhead	Vol. 62, No. 159, Pgs. 43937-43954 Aug. 18, 1997	Vol. 64, No. 32, Pgs. 73479-73506 Dec. 30, 1999*	Vol. 65, No. 32, Pgs. 7764-7787 February 16, 2000
Chinook Salmon	Vol. 64, No. 179, Pgs. 50394-50415 Sept. 16, 1999	Not yet issued	Vol. 65, No. 32, Pgs. 7764-7787 February 16, 2000

*Proposed Rule only. All other citations are Final Rules

Life history descriptions for these species are provided in sections 1.2.1 through 1.2.3 so that effects from project operations can be evaluated. All three species are anadromous, but steelhead may also exhibit a life history type that spends its entire life cycle in freshwater. These species migrate upstream from the ocean as adults and spawn in gravel substrate. Their eggs incubate for a short period, depending on water temperature, and generally hatch in the winter and spring. Juveniles spend varying amounts of time rearing in the streams and then migrate out to the ocean, completing the cycle. Details on life history, timing and habitat requirements are provided for each species.

1.3.1 COHO SALMON

Coho salmon are much less abundant than steelhead in the Russian River basin. Spawning occurs in approximately 20 tributaries of the lower Russian River, including Dry Creek. In wet years, coho salmon have been seen as far upstream as Ukiah. The Don Clausen Fish Hatchery produces and releases an average of about 70,000 age 1+ coho salmon each year (1980-1998). However, no coho have been produced in the last two years.

1.3.1.1 Life History

The coho salmon life history is quite rigid, with a relatively fixed three-year life cycle. The best available information suggests that life history stages occur during times outlined in Figure 1-1 (EIP Associates [EIP] 1993, SCWA 1996, SWRCB 1997, RMI 1997, S. White, SCWA, pers. comm. 1999). Most coho enter the Russian River in November and December and spawn in December and January. Spawning and rearing occur in tributaries to the lower Russian River, for the most part downstream of Healdsburg Dam. The most upstream tributary with a population of coho salmon is Maacama Creek, a short distance above Healdsburg Dam. The mainstem below Cloverdale serves primarily as a passage corridor between the ocean and the tributary habitat.

After hatching, young coho will spend about one year in freshwater before becoming smolt and migrating to the ocean. Freshwater habitat requirements for coho rearing include adequate cover, food supply, and water temperatures. Primary habitat for coho includes pools with extensive cover. Outmigration takes place in late winter and spring. Coho salmon live in the ocean for about a year and a half, return as three-year-olds to spawn, and then die. The factors most limiting to juvenile coho production are high summer water temperatures, poor summer and winter habitat quality, and predation.

Coho	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep
Upstream Migration		■	■	■								
Spawning			■	■	▌							
Incubation			■	■	■	■						
Emergence					■	■						
Rearing	■	■	■	■	■	■	■	■	■	■	■	■
Emigration					■	■	■	▌				

(EIP Assoc. 1993, SCWA 1996, SWRCB 1997, RMI 1997, S. White, SCWA, pers. comm. 1999).

Figure 1-1 Phenology of Coho Salmon in the Russian River Basin

1.3.2 STEELHEAD

There have been no recent efforts to quantify steelhead populations in the Russian River, but there is general agreement that the population has declined in the last 30 years (CDFG 1984, 1991). SCWA, CDFG and NMFS are currently developing programs to monitor trends in salmonid populations within the designated critical habitat boundaries for the basin. There has been substantial planting of hatchery-reared steelhead within the basin, which may have affected the genetic constitution of the remaining natural population. Almost all steelhead planted prior to 1980 were from out-of-basin stocks (Steiner Environmental Consulting [Steiner] 1996). Since 1982, stocking of hatchery-reared steelhead has been limited to progeny of fish returning to the Don Clausen Fish Hatchery and the Coyote Valley Fish Facility.

Steelhead occupy all of the major tributaries and most of the smaller ones in the Russian River Watershed. Many of the minor tributaries may provide spawning or rearing habitat under specific hydrologic conditions. Steelhead use the lower and middle mainstem Russian River primarily for migration to and from spawning and nursery areas in the tributaries and the mainstem above Cloverdale. However, it is possible that juvenile rearing may occur in the mainstem before smolt outmigration. The majority of spawning and rearing habitat for steelhead occurs in the tributaries.

1.3.2.1 Life History

Adult steelhead generally begin returning to the Russian River in November or December, with the first heavy rains of the season, and continue to migrate upstream into March or April. They have been observed in the Russian River during all months (S. White, SCWA pers. comm. 1999). The peak migration period tends to be January through April (Figure 2-3). Flow conditions are suitable for upstream migration in most of the Russian River and larger tributaries during the majority of the spawning period in most years. Sandbars blocking the river mouth in some years may delay entry into the river. However, during the times the sand barrier is closed, the flow is probably too low and water temperature is too high to provide suitable conditions for migrating adults further up the river (CDFG 1991).

Steelhead	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep
Upstream Migration	▨	▨	▨	■	■	■	▨	▨	▨	▨	▨	▨
Spawning				▨	▨	▨	▨					
Incubation				▨	▨	▨	▨	▨				
Emergence						▨	▨	▨				
Rearing	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Emigration (juv)						▨	▨	▨	▨			
Emigration (adults)					▨	▨	▨	▨				

Note: Peak upstream migration occurs January through March, but adults have been observed in all months.

Figure 1-2 Phenology of Steelhead in the Russian River Basin

(EIP 1993, SCWA 1996, SWRCB 1997, RMI 1997, S. White, SCWA, pers. comm. 1999).

Most spawning takes place from January through March, depending on the time of freshwater entry (Figure 1-2). Steelhead spawn and rear in tributaries from Jenner Creek near the mouth, to Forsythe Creek in the upper basin. Steelhead usually spawn in the tributaries, where fish ascend as high as flows allow (USACE 1982). Gravel and streamflow conditions suitable for spawning are prevalent in the Russian River mainstem and tributaries (Winzler and Kelly Consulting Engineers [Winzler and Kelly] 1978), although gravel mining and sedimentation have diminished gravel quality and quantity in many areas of the mainstem. In the lower and middle mainstem (below Cloverdale) and the lower reaches of tributaries, water temperatures exceed 55°F by April in some years (Winzler and Kelly 1978), which may limit the survival of eggs and fry in these areas.

After hatching, steelhead spend from one to four years in freshwater. Fry and juvenile steelhead are extremely adaptable in their habitat selection. Requirements for steelhead rearing include adequate cover, food supply, and water temperatures. The mainstem above Cloverdale and upper reaches of the tributaries provide the most suitable habitat, as these areas generally have excellent cover, adequate food supply, and suitable water temperatures for fry and juvenile rearing. The lower sections of the tributaries provide less cover, as the streams are often wide and shallow and have little riparian vegetation, and water temperatures are often too warm to support steelhead. In the summer, these areas can dry up completely. Available cover has been reduced in much of the mainstem and many tributaries because of loss of riparian vegetation and changes in stream morphology.

Emigration usually occurs between February and June, depending on flow and water temperatures (Figure 1-2). Sufficient flow is required to cue smolt downstream migration. Excessively high water temperatures in late spring may inhibit smoltification in late migrants.

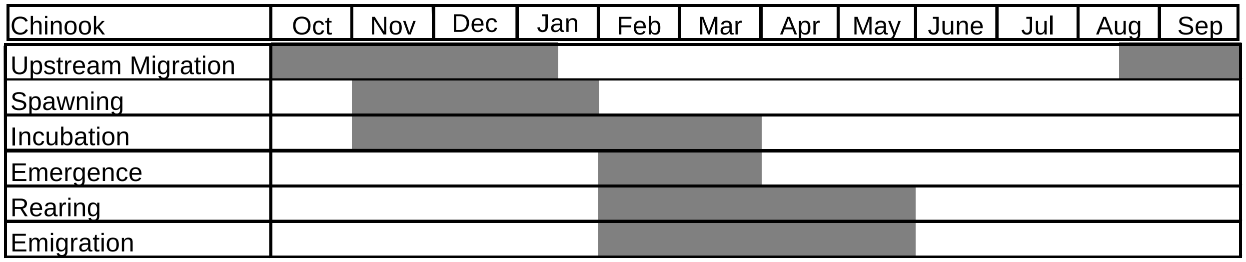
1.3.3 CHINOOK SALMON

The historic extent of naturally occurring chinook salmon in the Russian River is debated (NMFS 1999). Whether or not chinook were present historically, the total run of chinook salmon today, hatchery and natural combined, is small. Historic spawning distribution is unknown, but suitable habitat formerly existed in the upper mainstem and in low gradient tributaries. Chinook currently spawn in the mainstem and larger tributaries, including Dry Creek. Chinook tissue samples were collected this year by the SCWA and CDFG from Forsythe and Feliz creeks and Dry Creek, and there were anecdotal reports of chinook in the Big Sulphur system.

1.3.3.1 Life History

Adult chinook salmon begin returning to the Russian River as early as August, with most spawning occurring after Thanksgiving. Chinook may continue to enter the river and spawn into January (Figure 1-3) (S. White, SCWA, pers. comm., 1999).

Unlike steelhead and coho, the young chinook begin their outmigration soon after emerging from the gravel. Freshwater residence, including outmigration, usually ranges from two to four months, but occasionally chinook juveniles will spend one year in fresh water. Chinook move downstream from February through May (Figure 1-3). Ocean residence can be from one to seven years, but most chinook return to the Russian River as two to four-year-old adults. Like coho salmon, chinook die soon after spawning.



(EIP 1993, SCWA 1996, SWRCB 1997, RMI 1997, S. White, SCWA, pers. comm. 1999).

Figure 1-3 Phenology of Chinook Salmon in the Russian River Basin.

1.4 BACKGROUND OF FISH FACILITY DEVELOPMENT

The Lake Mendocino Project was authorized in Section 204 of the Flood Control Act of 1950. As part of this project, the Coyote Valley Dam and appurtenances were constructed beginning in July 1956, with completion occurring in January 1959 (USACE 1986).

The Lake Sonoma Project was authorized by the Flood Control Act of 1962. Construction of the project, including Warm Springs Dam, was initiated in 1967 and completed in 1982 (USACE 1984).

Coyote Valley Dam blocked access for steelhead to historical spawning and rearing habitat in the upper Russian River and several of its tributaries. Similarly, Warm Springs Dam blocked access for steelhead and coho salmon to historical spawning and rearing habitat above the dam. To compensate for these fish losses, various laws were enacted which ultimately led to the development of two fish facilities: the Don Clausen Fish Hatchery at the base of Warm Springs Dam, and the Coyote Valley Fish Facility at the base of Coyote Valley Dam (Figure 1-4).

Construction of DCFH was authorized by the Flood Control Act of 1962, as part of the Russian River Basin-Dry Creek Project, Sonoma County, California. DCFH went into service on October 1, 1980, operated by CDFG under an agreement with USACE.

Section 203 of the Flood Control Act of 1962 was later modified by Section 95 of Public Law 93-251, the Water Resources Development Act of 1974, requiring a program to compensate for fish losses on the Russian River attributed to the operation of Coyote Valley Dam facilities. In January 1983, the South Pacific Division of USACE directed the Sacramento District of USACE to assume responsibility for the Coyote Valley Dam Fish Mitigation Project to determine what work would be required to comply with Public Law 93-251. The determination resulted in the development of CVFF, along with an expansion of the DCFH. Both the CVFF and the DCFH expansion became operational in 1992. Like DCFH, CVFF is operated by CDFG under an agreement with USACE.

In October 1996, the South Pacific Division of USACE transferred control of Lake Sonoma and Lake Mendocino, including both fish facilities, to the San Francisco District.

The size of the adult steelhead runs into the Dry Creek sub-basin were never quantitatively estimated. It has been estimated that prior to the construction of Warm Springs Dam, the sub-basin supported a run of approximately 8,000 steelhead and 300 coho salmon (CDFG 1970). Approximately 75 percent of the steelhead (6,000) and 33 percent of the coho salmon (100) were believed to spawn in sections of Dry Creek and its tributaries that are now upstream of the dam (CDFG 1970). These figures were used to to develop mitigation goals. However, insufficient data exist to support these estimates. Salmon and steelhead currently use Dry Creek downstream of the dam for spawning and rearing.

The size of the adult steelhead run into the upper Russian River sub-basin was never quantitatively estimated. In the process of determining mitigation goals for the Lake Mendocino project, it was estimated that the sub-basin upstream from Coyote Valley Dam supported a run of 4,000 steelhead prior to construction of the dam.

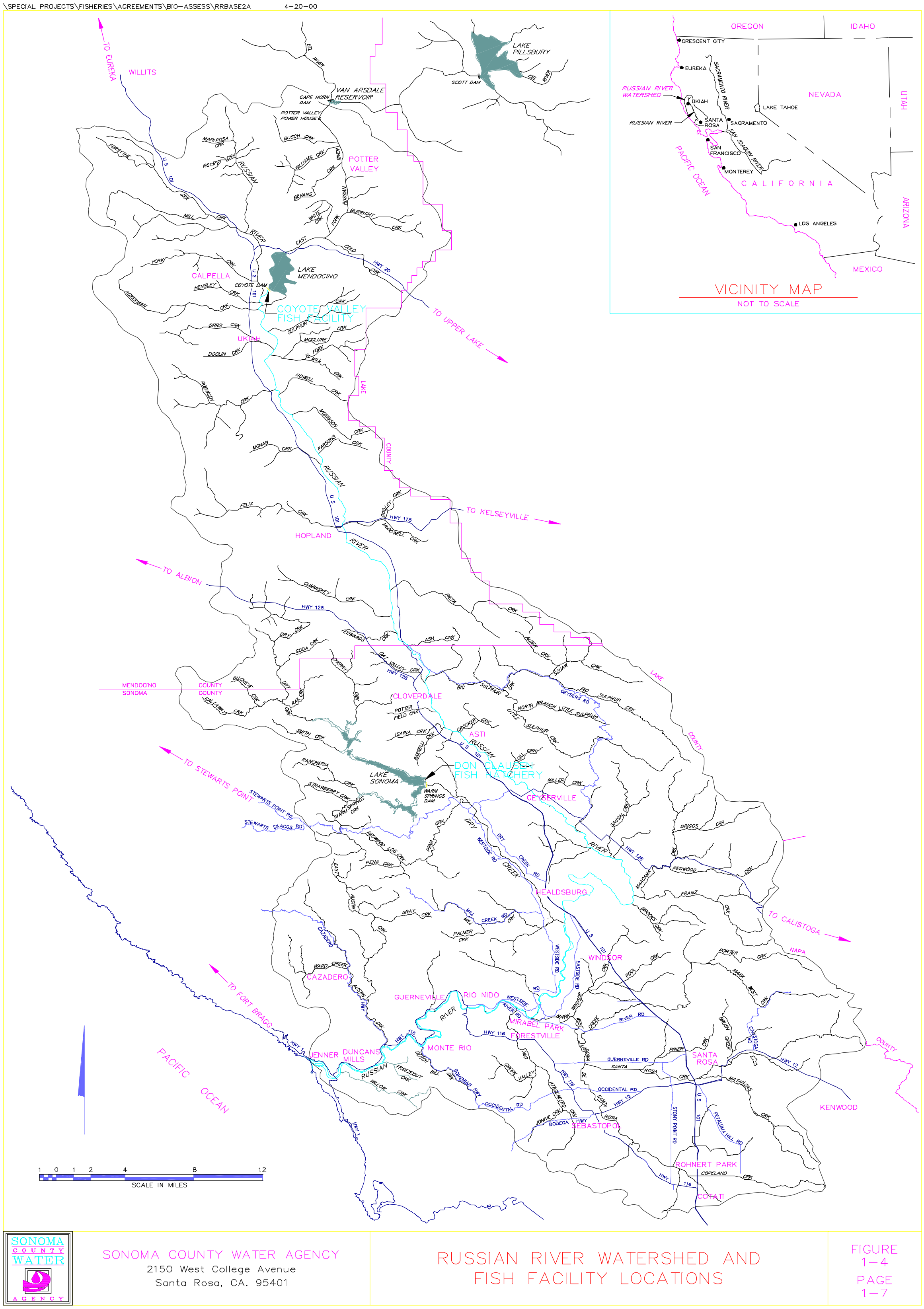


Figure 1-4 **Russian River Watershed and Fish Facility Locations.**

1.5 DCFH FACILITIES

The sections below provide a description of the structural setting at DCFH (Figure 1-5). Facility descriptions are organized into the following functional categories: broodstock collection, broodstock holding and spawning, incubation, rearing, water supply, and waste treatment. Additional detail can be found in the operations and maintenance manual for the DCFH facilities (Anderson Perry 1993a).

1.5.1 BROODSTOCK COLLECTION FACILITIES

Adult fish migrating upstream on Dry Creek to spawn enter the hatchery facilities via a fish ladder. The fish ladder is trapezoidal in shape, with removable stoplogs which provide one-foot elevation lifts for each fish ladder section. By jumping or swimming from section to section, the fish can reach the top of the ladder. At the top of the fish ladder, fish move through an upper fishway into a crowder channel. The crowder channel is 125 feet long, 4 feet wide, and 8 feet deep, with a normal water depth of about 3.5 feet. As they enter the crowder channel, fish pass through a fyke trap (a vee-shaped bar gate) which prohibits fish from returning down the ladder.

1.5.2 BROODSTOCK HOLDING AND SPAWNING FACILITIES

Broodstock holding and spawning facilities include six concrete holding ponds located outdoors under a shelter, and spawning facilities located inside the hatchery building. The crowder channel described previously acts as a conveyence route between these two areas. A mechanical crowder located in the channel is used to force fish towards the far end of the channel and subsequently lift them up over a raised entrance port into the spawning room of the hatchery building. (The fish in the crowding channel will be either fish newly arrived from the ladder, or fish previously held in one of the six concrete holding ponds, depending on actions of the hatchery staff.)

In the spawning room, fish slide over a dewatering grating and into a fish lift basket. The fish lift basket rests in an anesthetic solution using carbon dioxide as the anesthetic. The fish are held in the solution long enough to sedate them, at which point they are transferred to a table for sorting by criteria such as species, sex, and maturation. Coho and chinook salmon that have been selected as broodstock and are ripe for spawning are killed, rinsed, and subsequently moved to the egg-taking area. Selected broostock that are not ripe for spawning are slid into fish return tubes that transport them back to one of the adult holding ponds (Figure 1-6). The fish will remain in the holding ponds for up to three weeks, with periodic cycles through the crowder channel and sorting table until found ripe for spawning. Spawning for steelhead is conducted once a week, resulting in a maximum holding period of one week for fish that have entered the crowder channel. On spawning day, all steelhead are crowded to the spawning area and sorted. Since steelhead are multiple spawners, they are not killed in the spawning process. A small air compressor unit is used to inject air into the egg cavity of female steelhead and force out eggs without harming the fish. Steelhead are returned to the river within one day of spawning, along with any excess steelhead not used as broodstock and any natural steelhead that are found in the trap.

1.5.3 INCUBATION FACILITIES

The egg incubation facilities are located within the hatchery building and consist of 22 stacks of 16-tray incubation units, as well as hatching jars in a variety of sizes (6-, 8-, and 10-inch diameter). The incubation trays and the hatching jars can both be used to raise the eggs to the hatching stage. The current practice is to rely primarily on the hatching jars, since they reduce or eliminate fungus growth during incubation, require less handing of the eggs and emergent fry, and have exhibited a higher survival rate to

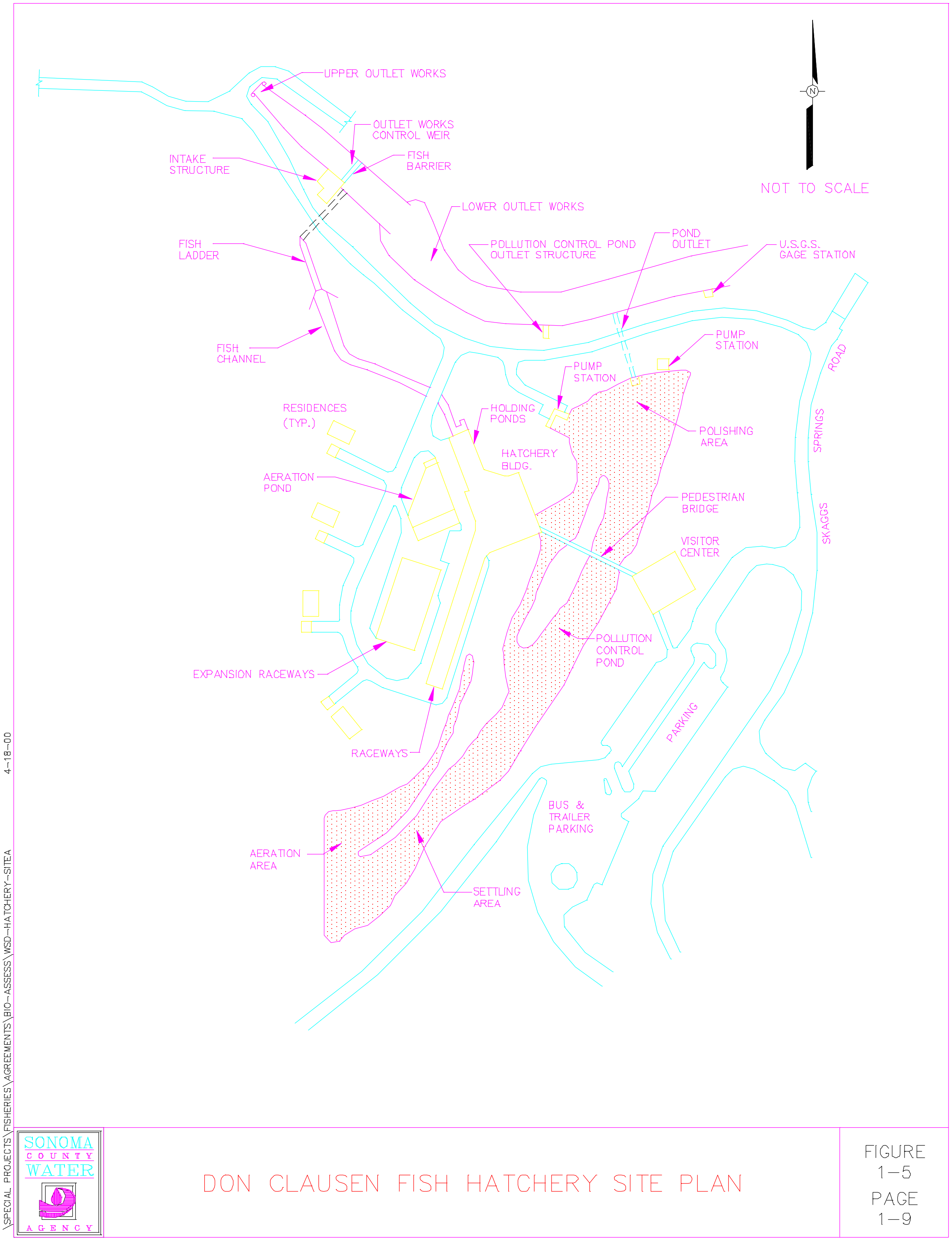


Figure 1-5 Don Clausen Fish Hatchery Site Plan.

Figure 1-6 **Adult Holding and Transfer Facilities at DCFH.**

hatching than the incubation trays. Both the incubation trays and hatching jars have two sources for water supply, one at ambient temperature and one chilled, allowing excellent control and flexibility of the water supply temperature.

1.5.4 REARING FACILITIES

There are two types of rearing facilities at DCFH: start tanks located inside the hatchery building for early rearing of fry, and outdoor raceways for final rearing of fingerling and yearlings. When eggs within the incubator trays and hatching jars reach the emergent fry stage, they are moved manually into the start tanks. After six weeks in the start tanks, the fish are transferred to the raceways where they remain until final release.

The start tank system is a series of large tanks, fish feeders, and water supply. Each of the 18 start tanks is made of aluminum and measures 28 feet in length, 3 feet in width, and 22 inches in depth. There are 8 juvenile rearing raceways, constructed of concrete, each with an available rearing volume measuring 72 feet in length, 9 feet in width, and 27 inches in water depth. These raceways are grouped in two sets of four raceways, laid out in pairs (side-by-side). An automatic fish feeder is located between the supply ends of each pair of raceways. Each feeder is capable of supplying dry or moist pellets to the raceway. The amount and timing of food delivered to the raceways are set by hatchery personnel, and are fully automated.

Due to design flaws, the raceway system supplies approximately one-half of the amount of water called for in the original specifications for the project (R. Gunter, pers. comm. 1999). The raceways have a water recirculation system, but attempted use of this system resulted in disease outbreaks and high mortality and use was discontinued. As a result, rearing production of fish was lower than originally anticipated.

In 1991, DCFH was expanded to provide additional hatchery and rearing facilities as authorized in Section 95 of Public Law 93-251, discussed previously. The hatchery raceway system was expanded with the addition of 3 sets of 4 raceways for a total of 12 new raceways, and rearing capacity is no longer a problem. The raceways are equipped with automatic fish feeders and are totally independent of the original raceways. The new raceways are 65 feet in length, 9 feet in width, and 5 feet in depth. The water supply system design for the expansion raceways was modified from the design of the original raceways to improve the production capacity, as described below.

1.5.5 WATER SUPPLY

Surface water is obtained for hatchery use from the stilling basin of the Warm Springs Dam. The water released from Lake Sonoma can be taken from four different intake portals, each at a different elevation in the lake, so that in the summer water can be mixed to optimize water temperature for successful hatchery operations (48 –58°F). Three of the intake portals are located in the wall of the dam, while the fourth portal is generally referred to as the service gates. The highest portal is currently inoperable.

Water enters the hatchery inlet structure from an opening in the right wall of the outlet works stilling basin and flows through a combination of open channels with pipe flow to the hatchery. Water flows by a 42-inch pipe to an aeration structure near the hatchery building. The aeration structure consists of a concrete basin, containing about 24,000 cubic feet of water, with five mechanical surface aerators that degas and oxygenate the water. Water enters the aeration basin through an inlet chamber and exits through an outlet chamber to the hatchery raceways. At the aeration structure, water is aerated to increase dissolved oxygen levels in the water and allowed to settle. The water then passes through a screening process, at which point and can be routed to the hatchery building for further water treatment and use in incubation and early rearing, or to the rearing raceways for use without additional water treatment. (Generally, eggs and fry require better water quality conditions than fingerling and yearlings.)

In treating water for use in the incubators and start tanks, water from the aeration structure outlet chamber is pumped through sand and charcoal pressure filters and ultraviolet sterilization units. Additionally, if water temperatures are greater than 56°F, some of the treated water will be passed through chillers. The capacity of the water treatment system is 200 gallons per minute (gpm).

The total hatchery water demand for full capacity fish production operations is 25 cubic feet per second (cfs). When broodstock collection and holding operations are occuring, the demand increases to approximately 35 cfs, to provide flows to attract adult fish migrating upstream and to provide flows to maintain the fish in holding ponds once they enter the hatchery. Minimum releases from Lake Sonoma are set at 80 cfs in typical water years and 25 cfs under drought conditions. Since it is possible to divert all releases through the hatchery, there is consequently never a problem to obtain all flow necessary to maintain hatchery operations. Water can be released from four different intake portals, each at a different elevation (depth) within Lake Sonoma. Water can be released directly from the bottom of the dam (elevation 220 feet MSL), and at elevations of 350, 390 and 430 feet MSL. (As mentioned previously, the highest portal is not functional.) During late summer and early fall, Lake Sonoma becomes thermally stratified (i.e., the warmer water tends to stay at the top of the lake, and the colder water stays at the bottom of the lake), and consequently water of varying temperature is available for release at different depths (elevations) within the lake. The portal from which water is released is determined by the hatchery manager based on water temperatures within Lake Sonoma. However, according to R. Gunter, Hatchery Supervisor, turbidity levels in the lower levels of the lake are too high to be used in the hatchery. As a result, only the two intermediate portals are typically used to provide water for the hatchery and for downstream releases. If turbidity is increased, the efficiency of the UV that is designed to kill any biological organisms not removed by the sand filter is reduced. The water supply system is equipped with a chiller to compensate for excessively warm water temperatures, should they occur.

An emergency water supply system was constructed in 1992 to be used to supply a sufficient quantity of water to the hatchery when the outlet works and power plant are not operating. When emergency water supply is needed, hatchery personnel contact the local USACE office to request activation of the system. Flow to the hatchery can be controlled by the energy dissipation valve in the stilling well at the dam. Water can be drawn from the reservoir as long as the water surface elevation is above 350 feet NGVD (National Geodetic Vertical Datum). USACE personnel follow procedures to fill the Emergency Water Supply (EWS) pipeline with water from the stilling well. The EWS pipeline can be left unwatered between uses or remain full, in standby mode, in case of unforeseen emergency water supply requirements. A standby generator is available to provide power for operations during a power outage.

The emergency water supply to the hatchery is typically in fully charged condition, and could be available immediately. However, hatchery staff are required to contact USACE to open the valve for access to the EWS pipeline, which could delay implementation. The aeration ponds can supply sufficient water to the raceways for only 8 to 10 minutes while the emergency water supply system is being implemented. Longer delays could affect the survival of the juvenile fish. Other emergency sources of water, though not as reliable as the EWS system, are available. Wells E and F, downstream of the hatchery complex along Dry Creek, were originally provided as an emergency water source. The wells are capable of supplying the hatchery with approximately 2 to 3 cfs for a short period of time. (In 1997 only one well was operational and provided the hatchery with 1.55 cfs). If no other options are available, and survival of the fish is threatened, the fish can be released into the water pollution control pond for later retrieval, or released directly into Dry Creek.

Water supply to the expansion raceways was modified in design from the original raceways to improve production capacity. Whereas the original raceway system is supplied with water from three sources (the aeration structure, non-chilled treated water, and chilled treated water), the new raceway systems receive water only from the aeration structure. In the original raceways, water passed from the raceways to a recirculation system utilizing air-lift tubes, but the high incidence of disease which followed resulted in its use being discontinued. In the expansion raceways, the water passes from the raceways to a 36-inch drainpipe which carries it to the pollution control pond. Therefore, water is continually delivered to the raceway from the aeration structure, rather than having to recirculate back through the system.

1.5.6 WASTE TREATMENT FACILITIES

The main feature of the DCFH treatment system is a 170,000 cubic foot earthen settling pond created in what was formerly the natural creek channel for Dry Creek (Anderson Perry 1993a). The pond provides approximately 4.5 hours of detention time at an inflow rate of 4800 gpm (Anderson Perry 1993a). Detention time can be as great as 12 to 16 hours depending on actual flow to the facility (R. Gunter, pers. comm., 1999). The minimum required detention time per the NPDES permit is 2.5 hours (RWQCB 1997a).

The pond has three treatment areas; aeration, settling and polishing. Wastewater entering the pond is aerated by mechanical mixers, then it passes through a primary settling area and a final polishing area prior to discharge. Effluent water is discharged into Dry Creek at the base of the adult ladder and through a second outfall just upstream of the gauging station (R. Gunter, pers. comm., 1999). The outfall at the gauging station was installed after original construction when it was found that higher flow rates created back-pressure problems within the facility (R. Gunter, CDFG, pers. comm., 1999). Under extreme high flow conditions, two 75 HP pumps can boost flow rates through the outfall to assure adequate discharge. Also, water from the settling pond is pumped automatically to the Fire and Irrigation Water System, which contains pumps, a storage tank, pipelines and other appurtenances. In addition to supply for fire and irrigation, the system supplies cooling water for the freezer condenser, the high pressure air compressor, and the chillers in the hatchery building.

1.6 CVFF FACILITIES

CVFF is located on the East Fork Russian River (East Fork) 0.8 miles upstream from the confluence with the Russian River (immediately below Coyote Valley Dam) (see Figure 1-4). As discussed in Section 1.4, CVFF was built to offset losses of fish that may have occurred as a result of the construction of Coyote Valley Dam. The dam blocked access by steelhead to essentially the entire East Fork and its tributaries. Insufficient data exist to estimate the historic adult steelhead run into the East Fork and its tributaries. Coho salmon were not reported to inhabit the East Fork historically. Historic distribution for naturally spawning chinook salmon is unknown, but suitable spawning habitat existed in the upper mainstem and low gradient tributaries (Steiner 1996).

The sections below provide a description of the structural setting at CVFF (Figure 1-7). Facility descriptions are organized into the following functional categories: broodstock collection, broodstock holding and spawning, acclimation and release, water supply, and waste treatment. Additional detail can be found in the operations and maintenance manual for the CVFF facilities (Anderson Perry 1993b).

1.6.1 BROODSTOCK COLLECTION FACILITIES

The fish ladder consists of an entry pool, two ladder sections, a resting pool between the ladder sections, and an upper fish way leading to the spawning area and raceways. At the top end of the fish ladder is a channel that allows fish to rest before crossing over a finger weir which prevents them from returning downstream. From the weir, the fish pass through a hinged vertical bar rack which allows the fish to swim upstream. When the fish passes the bar rack, the rack closes and the fish is confined to an adult fish holding area.

A fish barrier was installed as part of the original facility construction in 1992. However, the barrier no longer exists as it was washed out in 1993 or 1994. There has not been any problem with fish recruitment into the ladder without the barrier, most likely since the river terminates at the outlet works about 0.25 miles upstream of the ladder.

1.6.2 BROODSTOCK HOLDING AND SPAWNING FACILITIES

Adult steelhead are spawned at the CVFF using facilities similar to those of the DCFH. The facilities include two fish holding areas, a manual fish crowder, a fish transfer tank, a sorting table transfer basket, a dewatering bar rack, and an anesthesia tank. The two adult fish holding areas are constructed of concrete, each containing a framed screen which can be to crowd fish into the desired section of the fish holding area (Figure 1-8). Typically, the fish are crowded into the northerly adult fish holding area, where they can be moved to an anesthesia tank with the use of a sorting table transfer basket. The basket is designed to discharge the fish into the anesthesia tank once it has been lifted from the holding area and reaches the appropriate height. At the anesthesia tank, fish are passed over a dewatering bar rack to drain water away from the fish before they enter the anesthesia tank. Fish are held in a carbon dioxide anesthesia solution long enough to tranquilize them before they are transferred to the sorting table, again using the sorting table transfer basket. The fish are sorted according to species, sex, and maturation, and a determination is made to either 1) use the fish for immediate spawning, 2) place it back in the adult holding pond for later spawning, 3) release it to the Russian River with the use of fish transfer tubes, or 4) place it in a transfer truck for release into one of four tributaries that typically receive excess CVFF adults. It has been suggested that 2000 may be the last year that excess steelhead adults are released to tributaries.

CVFF also has a fish transfer tank designed for loading fish from the southern adult holding tank directly into transfer trucks. The system utilizes a three-ton overhead crane to raise, lower, and move the fish transfer tank. However, this system has not been used in recent years. Instead, excess fish have been manually loaded into trucks from the spawning slab following the typical sorting procedures described above. Fish selected to be broodstock are spawned by methods similar to those in operation at DCFH. After spawning of the adults, the eggs are transported to the DCFH for incubation and rearing.

1.6.3 ACCLIMATION AND RELEASE

After rearing at DCFH for about one year, the juveniles are transported back to CVFF for final acclimation and release. Fish are brought in when the reach a size of about 5 fish per pound, and they are held in CVFF raceways for approximately 30 days. This 30-day residency occurs during the spring when juvenile steelhead typically go through the physiological process known as smoltification, which prepares them for the transition from freshwater in the stream to saltwater in the ocean. During the residency period and smoltification process, the smolts become “imprinted” on the water released from Coyote Valley Dam. The imprinting process will increase the chances of the fish returning to CVFF to spawn as adults. The raceways at CVFF are designed to allow the smolts to leave the facility without assistance (volitional release); thus, they enter the river when they are physiologically ready to migrate downstream to the ocean (Figure 1-9). The fish may be released prior to the completion of their imprinting process only if a disruption to the primary water supply occurs. In this case, the fish would be an appropriate size for release, but would tend to imprint in the river rather than the hatchery. Therefore, adult returns to the hatchery may be less successful.

1.6.4 WATER SUPPLY

Surface water is supplied to CVFF by the City of Ukiah, which operates the Lake Mendocino Hydroelectric Power Plant. The primary source of water for the facilities is pumped from the supply water stilling well at the dam outlet works. Water is piped through a valve vault and flow meter and then to the fish-rearing facilities. At the facilities, the supply water is discharged into a degassing tower and aerated. The degassing tower consists of two packed-column aerators, which are used to remove excess nitrogen and increase dissolved oxygen levels in the water.

An emergency generator is installed to run the pumps in the event that a power outage occurs. If for some reason the generator or pumps fail and the facility is left with no water supply, the fish rearing in the raceways can be released directly to the river.

1.6.5 WASTE TREATMENT FACILITIES

CVFF utilizes in-line settling of waste solids in the last 8 to 10 feet of the rearing raceways (R. Gunter, pers. comm., 1999). Normal overflow water from the CVFF raceways is discharged to the east branch of the Russian River. However, because the in-line settling area is not disturbed by fish movement, a significant amount of solids will settle and accumulate in this section of the raceway. Periodically, cleaning operations are conducted during which the raceways are swept to resuspend the solids, while simultaneously diverting the overflow water into a 12-inch stand pipe that flows into a separate pollution abatement settling basin. Water diverted into the settling basin must have a minimum 24 hour detention time (CWQCB 1997b). Effluent water from the settling basin discharges into the east branch of the Russian River. Waste solids from the settling basin are removed annually for disposal (R. Gunter, CDFG, pers. comm., 1999). Fish production chemicals are rarely used at CVFF (R. Gunter, CDFG, pers. comm., 1999).

1.7 FISH PRODUCTION OPERATIONS AT DCFH AND CVFF

Many fish production operations are similar at both DCFH and CVFF since they follow statewide policies and guidelines, or apply to the two facilities as an integrated program. The following sections discuss program goals, broodstock origin and identity, broodstock collection, incubation and rearing, releases, and adult returns.

1.7.1 PROGRAM GOALS

DCFH and CVFF facilities were developed with the goal of developing and maintaining an escapement of 6,000 adult steelhead, 1,100 adult coho, and 1,750 adult chinook in the Dry Creek drainage and 4,000 adult steelhead in the upper Russian River drainage. As an aid to achieve these escapement goals, production goals were also established for egg harvest and release numbers at the Don Clausen Fish Hatchery. Similarly, goals for egg harvest numbers and pounds of yearling releases were established for the Coyote Valley Fish Facility. (Based on a desired CVFF release size of 5 fish to the pound, the 40,000 pounds of steelhead can be equated to 200,000 steelhead individuals). Production and adult escapement goals for DCFH and CVFF are summarized in Table 1-2.

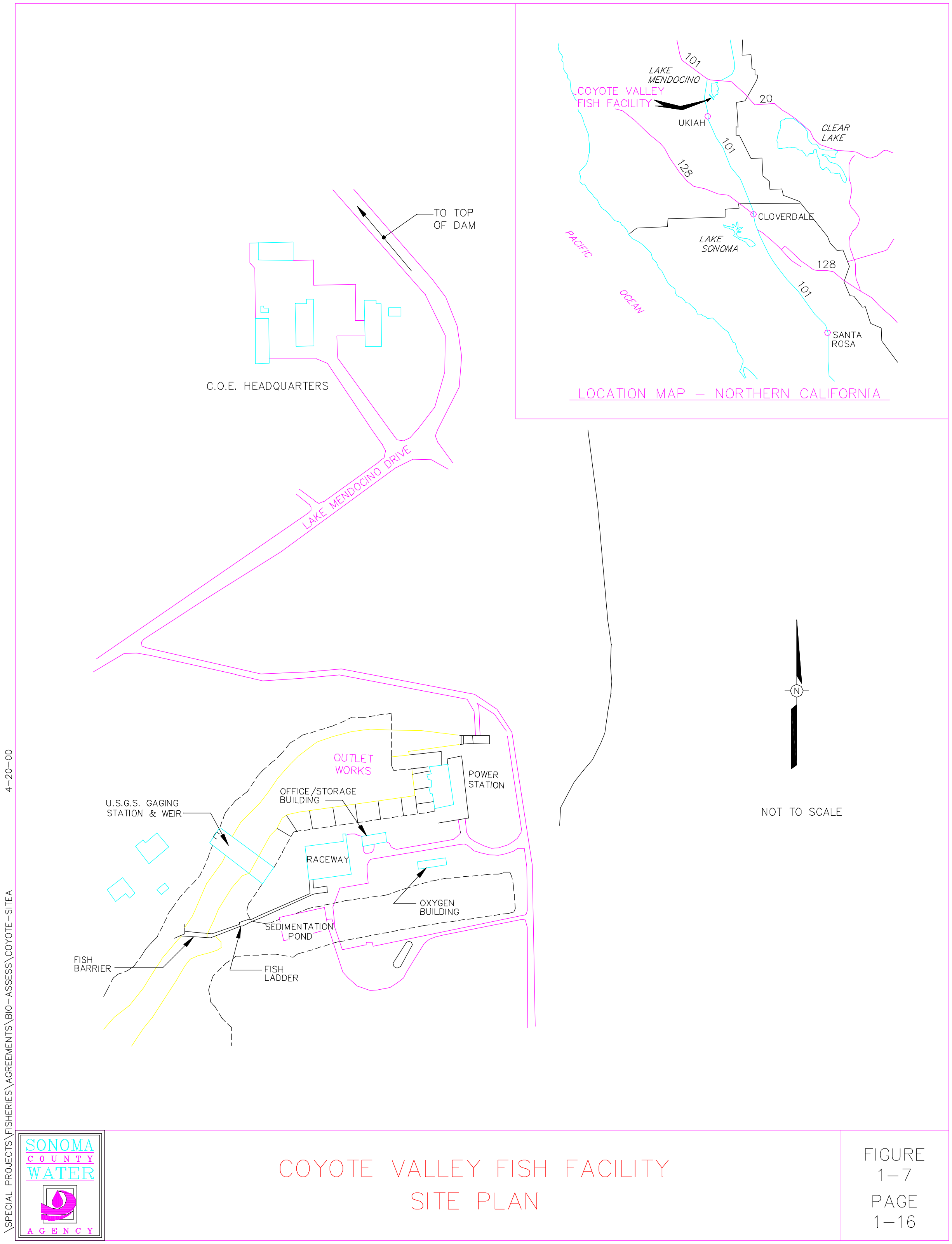


Figure 1-7 **Coyote Valley Fish Facility Site Plan.**

Figure 1-8 Adult Holding and Transfer Facilities at CVFF.

Figure 1-9 Juvenile Acclimation Ponds and Volitional Release Routing at CVFF.

Table 1-2 Goals for Production and Adult Escapement at the Don Clausen Fish Hatchery and Coyote Valley Fish Facility

Location/Species	Mitigation/ Enhancement	Egg Harvest	Juvenile Releases	Adult Escapement
Don Clausen Fish Hatchery				
Steelhead	Mitigation	600,000	300,000 yearling	6,000
Coho	Mitigation	20,000	10,000 yearling	100
Coho	Enhancement	200,000	100,000 yearling	1,000
Chinook	Enhancement	1,400,000	1,000,000 smolts	1,750
Coyote Valley Fish Facility				
Steelhead	Mitigation	320,000	200,000 yearling	4,000

In developing these goals, the following definitions and management guidelines were assumed:

- Steelhead:
    - Adult: Fish 16 inches fork length or longer
    - Yearling: Fish 4 to 5 per pound or larger
    - Fecundity: 5,000 eggs per female
    - Survival:
        - From unfertilized egg to stocked yearling: 50%
        - From stocked yearling to returning adult: 2%
- Coho:
    - Adult: Fish 20 inches fork length or longer
    - Yearling: Fish 10 per pound or larger
    - Fecundity: 2,000 eggs per female
    - Survival:
        - From unfertilized egg to stocked yearling: 50%
        - From stocked yearling to returning adult: 1%
- Chinook:
    - Adult: Fish 24 inches fork length or longer
    - Smolt: Fish 50 per pound or larger
    - Yearling: Fish 10 per pound or larger
    - Fecundity: 4,000 eggs per female
    - Survival:
        - From unfertilized egg to stocked smolt: 75%
        - From stocked yearling to returning adult: 0.175%

The mitigation and enhancement goals for DCFH and CVFF were formulated during federal, state, and local agency discussions in the early 1970's. Goals were formulated primarily as mitigation for the loss of spawning habitat resulting from the construction of the Warm Springs and Coyote Valley Dams within the Russian River watershed. No quantitative assessments were conducted to determine the actual carrying capacity of affected areas, and goals were instead developed from estimates of run size within the subbasins and additional estimates that proportioned the amount of spawning habitat upstream of the dam locations (see Section 1.4).

Only rough estimates of carrying capacity based on estimates of historical run sizes have been developed. No estimates of current carrying capacity have been developed to confirm that the remaining spawning and rearing habitat is capable of handling the mitigation and enhancement production goals. Nor are there any programs currently in place to assess the potential for competition among hatchery- and naturally spawned components of the same species, or between any of the three salmonid species or other fauna present in the Russian River during the same time periods.

The release goals for DCFH and CVFF reflect an assumed survival rate from release to adult return. Actual survival following release is affected by factors beyond the control of hatchery operations. While hatchery practices may influence marine survival of salmon, marine survival is also releated to ocean-wide factors in the marine environment in the North Pacific, such as climate changes (Beamish and Bouillon 1992). The stated management goals for yearling to adult survival are 2% for steelhead and 1% for coho. In general, these values appear to be significantly higher than the current survival rates for any West Coast stocks of steelhead or coho, whether of natural or hatchery origin (R. Coey, pers. comm., 2000). If actual conditions are not able to support the assumed survival rate, then it is unlikely that the desired adult escapement will ever be achieved if release goals are followed.

1.7.2 BROODSTOCK ORIGIN AND IDENTITY

1.7.2.1 Source

In 1999, a policy was implemented for DCFH and CVFF operations requiring that all broodstock for steelhead, coho, and chinook production programs be derived solely from adults captured within the Russian River. Broodstock for the DCFH program are collected from fish returning to the DCFH ladder and trap, while those for the CVFF program are collected from fish returning to the CVFF ladder and trap.

Prior to 1999, broodstock for these programs were derived in part by adult capture within the Russian River, and via stock transfers from a variety of sources (R. Gunter, CDFG, pers. comm., 1999).

1.7.2.2 History of Hatchery Stocks

The history of stock development in the Russian River is discussed in detail in a report by Steiner (1996). The following is a brief summary of the origin of hatchery salmonid stocks in the Russian River Basin, based on Steiner (1996) except where noted.

1.7.2.2.1 Steelhead

Out-of-basin steelhead stocks have been planted throughout the Russian River Basin since the 1890s. Sources of broodstock for these plants, along with the last known year of planting, include the Eel River (1972), Prairie Creek (1927), Mad River/Eel River hybrids (1974), San Lorenzo Creek (1973), Scott Creek (1911), and Washougal River (Washington) (1981). It should be emphasized that these fish plants occurred before the current DCFH/CVFF program was in place. There is no information regarding the survival of fish from these plants. Since 1982, stocking of hatchery-reared steelhead has been limited to progeny of fish returning to DCFH and CVFF (R. Gunter, CDFG, pers. comm., 1999).

1.7.2.2.2 Coho Salmon

Out-of-basin coho salmon stocks were first planted into the Russian River Basin beginning in the 1930's, and continued through at least 1998 (CDFG 1998b). Out-of-basin broodstock sources and the last year of outplanting that occurred prior to the DCFH/CVFF program include the Alsea River (Oregon) (1972), and Soos Creek (Washington) (1978). There is no information regarding the survival of fish from these outplants. Since the current program started, broodstock sources have included Noyo River, Klamath River, and Eel River in addition to Russian River.

1.7.2.2.3 Chinook Salmon

Out-of-basin chinook salmon stocks were first planted into the Russian River Basin beginning in the 1880s, and continued through at least 1998 (CDFG 1998b). Out-of-basin stocks that were planted before the DCFH/CVFF program include Sacramento River (1950s-1960s), Mad River (1953), and Klamath River (1955-56). Since the current program started, broodstock sources have included Eel River, Wisconsin Strain (Green River, Washington) and Silver King Creek (location unknown), in addition to Russian River.

1.7.2.2.4 Summary

A summary of Russian River outplants and their source of broodstock through 1998 is presented in Table 1-3, based on Steiner (1996) and annual reports of DCFH and CVFF operations (CDFG 1996b, 1997, 1998b). Based on this information, Russian River adults provided the source of broodstock for about 54 percent of steelhead releases, 33 percent of coho releases, and 6 percent of chinook releases. It should be emphasized that many of these fish plants occurred before the current DCFH/CVFF program was in place. Further, there is no known information regarding the survival of fish from outplants prior to the current DCFH/CVFF program. Even so, given the magnitude and duration of historical stock transfers, it is likely that naturally spawning steelhead, coho, and chinook within the Russian River represent a genetic conglomerate of many stocks, although data are unavailable to quantify the degree of introgression. Similarly, the adults used as broodstock likely are themselves descendants of many stocks. While the history of stock transfers in the Russian River suggests that genetic integrity has been compromised, the current policy of collecting broodstock from returns to the Russian River should allow selection and genetic drift to give rise to Russian River specific stocks.

1.7.3 BROODSTOCK COLLECTION

1.7.3.1 Collection Method

Broodstock for the DCFH program are collected from fish returning to the DCFH ladder and trap, while those for the CVFF program are collected from fish returning to the CVFF ladder and trap. Currently, steelhead broodstock are collected systematically across the entire adult return with weekly capture goals formulated by a 9 to 11[1] year mean for each species. In an attempt to increase genetic diversity, more individuals are spawned than are necessary to achieve production goals. Surplus eggs are then randomly destroyed to avoid surplus production. Due to the low number of returning adults, all chinook and coho that enter the DCFH are used as broodstock.

1.7.3.2 Broodstock Sample Size

Over the last four years, the numbers of female chinook, coho, and steelhead used as broodstock has varied considerably (Table 1-4). Numbers of fish returning to the DCFH and CVFF traps have been low in recent years (see Section 1.7.6). Further, in 1998, there was a change in policy that eliminated use of out-of-basin fish as broodstock. Unfortunately, the number of males used as broodstock is not recorded in hatchery records, and is difficult to determine given changes in spawning protocols. In practice, returning hatchery-reared individuals are the primary source of broodstock, although naturally spawned adults are retained whenever possible.

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[1] The 9 to 11 year mean is used to predict the shape of the distribution of adult returns, the absolute number of years used to create this distribution is arbitrary.

Table 1-3 Broodstock Source, Stocking Year, and Number of Salmon Released in the Russian River, for Steelhead, Coho and Chinook.

Broodstock Source	Years Outplanted	Total Outplants
Steelhead		
Russian River	1959, 81-98	18,167,885
Eel River	1914-19, 21-23, 58-59, 72, 96-98	5,009,156
Mad River	1975-76, 78-79, 81	324,101
Prairie Creek	1927	249,000
San Lorenzo Creek	1973	83,350
Scott Creek	1911	433,458
Unknown		8,934,122
Washougal	1980-81	270,360
Total		33,471,432
% Russian River Origin		54%
Coho		
Russian River	1983, 85-98	752,372
Alsea River	1972	58,794
Eel River	1987, 90	25,112
Klamath River	1975, 81-83, 86-88, 96-98	451,370
Noyo River	1970, 72-74, 82-84, 86-91	613,056
Soos Creek	1978	8,420
Unknown		403,340
Total		2,312,464
% Russian River Origin		33%
Chinook		
Russian River	1985, 87-90, 92-98	542,478
Eel River	1982, 84, 86-89, 96-98	218,257
Klamath River	1955-56	1,000,000
Mad River	1953	9,250
Sacramento River	1956, 59-60, 62-64	3,283,295
Silver King Creek	1982-83	70,000
Unknown		2,265,292
Wisconsin	1982-86	1,337,624
Total		8,726,196
% Russian River Origin		6%

Data compiled from Steiner Environmental Consulting (1996) and CDFG (1996b, 1997, and 1998b).

Currently, there are no reliable estimates regarding the size of the naturally spawned populations of the three species of interest within the Russian River. Ideally, broodstock quotas would be selected on the basis of a minimum threshold necessary to maintain genetic diversity in both the hatchery-reared and naturally spawned populations, rather than on desired production levels for the hatchery.

Table 1-4 Number of Chinook, Coho, and Steelhead Females Spawned at DCFH in 1995-1998.

Brood Year	Number of Females Spawned		
	Chinook	Coho	Steelhead
1995	11	349	405
1996	49	32	407
1997	24	147	401
1998	7	0	157

1.7.4 INCUBATION AND REARING

1.7.4.1 Number of Eggs Taken

Egg harvest goals have been established at DCFH and CVFF based on release goals and management goals for incubation and rearing survival rates (see Section 1.7.1). In general, DCFH and CVFF have been successful in meeting steelhead egg harvest goals due to adequate returns of steelhead adults, while low numbers of coho and chinook returns have not allowed the respective egg take goals to be achieved. Data regarding egg harvest is presented in Table 1-5.

Table 1-5 Eggs Harvested at DCFH and CVFF, 1981-1998.

	DCFH			CVFF[2]
Year[1]	Steelhead	Coho	Chinook	Steelhead
1980-1981	750,000	0	0	NA
1981-1982	552,000	0	0	NA
1982-1983	701,500	387,243	0	NA
1983-1984	1,890,000	0	0	NA
1984-1985	1,568,900	101,300	4,000	NA
1985-1986	2,143,212	0	0	NA
1986-1987	1,544,785	3,667	75,798	NA
1987-1988	1,362,631	164,741	10,533	NA
1988-1989	1,178,899	228,166	254,061	NA
1989-1990	1,134,000	53,200	17,600	NA
1990-1991	795,000	28,000	0	NA
1991-1992	1,710,000	174,250	155,600	NA
1992-1993	1,825,000	176,000	98,818	530,000
1993-1994	1,710,000	114,000	0	619,000
1994-1995	1,460,000	698,000	36,000	460,000
1995-1996	1,250,000	18,000	44,000	590,000
1996-1997	1,305,000	122,000	27,990	636,285
1997-1998	784,116	0	25,212	775,349

[1] Year extends from July 1 of the first year through June 30 of the second year.
[2] CVFF began operations in 1992.

1.7.4.2 Hatchery Rearing Techniques

Incubation and rearing at DCFH is conducted in accordance with standard hatchery operating procedures used throughout the CDFG system. CVFF rearing operations are limited to a 30-day acclimation period prior to release. Again, the operations follow standard CDFG practices.

1.7.4.3 Fish Health Monitoring and Disease Treatment Procedures

DCFH and CVFF operations include practices that work towards minimizing fish health concerns. General management decisions and guidelines relating to importation of stocks, transfer of eggs and fish, and use of chemical therapeutants are typically developed by CDFG at the state level. When requested, CDFG fish pathologists and the CDFG Fish Health Lab located at Rancho Cordova are also available to assist DCFH and CVFF hatchery managers with specific disease treatment concerns.

1.7.4.3.1 Importation of Stocks

The DCFH participates in an egg banking program for a unique run of late fall chinook from the Eel River. Eggs are brought in to the DCFH for incubation. When they reach the eyed-egg life stage, half of these eggs are sent to Mad River Hatchery to continue incubation and rearing. The remaining eggs are kept at DCFH, reared to the juvenile stage, then returned to the Eel River where they are imprinted on Eel River water and released. The adult fish that are the source for eggs for this program are tested for viral pathogens and screened for *Renibacterium salmoninarum*, the causative agent of bacterial kidney disease (Dr. W. Cox, pers. comm., 1999).

Until 1999, DCFH also received eggs from a coho stock in the Noyo River. Adult fish used as the source for these eggs were tested for viral pathogens (Dr. W. Cox, pers. comm., 1999). Upon arrival at the DCFH, the Noyo River eggs were disinfected with iodophore solution to remove surface pathogens that may have been present. Egg lots were incubated separately until completion of viral certification, after which time the egg lots could be combined. After reaching the eyed-egg life stage, the eggs were transferred to Mad River for hatching, rearing and release (R. Gunter, pers. comm., 1999). Occasionally, some of the eggs from this source were kept at DCFH and reared for planting into the Russian River for enhancement purposes, but both this practice and the entire Noyo incubation program have been discontinued (R. Gunter, pers. comm., 2000).

1.7.4.3.2 Transfer of Eggs and Fish

Steelhead eggs are transferred between CVFF and DCFH annually. Eggs are disinfected in iodophore during the water hardening process at DCFH. These eggs are hatched and the fish reared at DCFH until they are transferred back to CVFF for final acclimation and release (R. Gunter, pers. comm., 1999).

1.7.4.3.3 Incidence and Treatment of Hatchery Disease

The main fish disease problem in the steelhead program at DCFH is from *Flexibacter psychrophilus* the causative agent of bacterial coldwater disease (R. Gunter, pers. comm., 1999). Due to the historic problem with this pathogen, numerous pathogen management strategies have been put into place to reduce the effect of this pathogen. At fertilization, the eggs are rigorously disinfected to remove pathogens from the surface. There has also been a switch to the use of hatch jars instead of vertical stacks for incubation, as this has resulted in lower egg mortality and improved egg quality (Dr. W. Cox, pers. comm., 1999).

Prophylactic treatment is initiated early in the rearing of the steelhead at DCFH. At swim-up (fry that have actively begun to swim looking for feed), fry are treated with Penicillin-G, an antibiotic, in a bath solution. If required, juvenile fish are fed medicated feed during rearing. With the implementation of these practices, mortalities from bacterial coldwater disease have been reduced from past levels of 20 to 30 percent of the steelhead program, to current levels that are routinely below two percent (Dr. W. Cox, pers. comm., 1999).

The coho adults returning to DCFH have been found to have *Renibacterium salmoninarum*, the causative agent of bacterial kidney disease. Onset of this disease is density dependent and stress related. The disease has not been an annual problem at DCFH. If necessary, treatment with medicated feed is completed. Screening of the adult population has allowed for the implementation of segregation of positive and negative egg lots. Eggs from positive and negative adults are incubated separately and the resultant fish are reared separately. This has appeared to show a benefit to the health of the fish (Dr. W. Cox, pers. comm., 1999). Rigorous spawning sanitation procedures have also been implemented for the control of this pathogen (R. Gunter, pers. comm., 1999).

The juvenile fish also experience infestation of various external parasites including *Gyrodactylus, Costia (Ichtyobodo)* and *Trichodina*. If treatment becomes necessary, formalin or hydrogen peroxide is used (Dr. J. Merrix, pers. comm., 1999). Due to very stringent discharge limits imposed on the facility, use of these chemical agents is limited (Dr. W. Cox, pers. comm., 1999).

External fungal infection is very common in adult fish entering the facility and typically becomes present on all adults, sometimes resulting in high levels of adult holding mortality. Use of formalin or salt to control the fungal infection and reduce mortality has been unsuccessful (R. Gunter, pers. comm., 1999).

CVFF has limited fish pathogen and disease issues due to the fact that this facility is used as an imprinting station and fish are only held for a short time period (30 days) prior to release. Steelhead juveniles arrive at CVFF from DCFH in good health, and have no significant pathogen or disease concern (Dr. W. Cox, pers. comm., 1999).

1.7.5 RELEASE

1.7.5.1 Proposed Release Levels

Juvenile release goals have been established at DCFH and CVFF based on adult escapement goals and management goals for yearling to adult survival rates (see Section 1.7.1). It should be emphasized that yearling to adult survival rates were estimated at the same time as, and as part of, the development of mitigation and enhancement goals for the Lake Mendocino and Lake Sonoma projects (see Section 1.4). Actual survival during the yearling to adult life stage is beyond the control of hatchery operations. The stated management goals for yearling to adult survival are 2% for steelhead and 1% for coho. In general, these values appear to be significantly higher than the current survival rates for any West Coast stocks of steelhead or coho, whether of natural or hatchery origin (R. Coey, pers. comm., 2000). If conditions following release result in a survival rate that is lower than the assumed rate, then adherence to release goals will not allow the adult escapement goals to be met.

1.7.5.2 Actual Releases

1.7.5.2.1 Don Clausen Fish Hatchery

Data regarding number, pounds, and average size at release are presented for steelhead (Table 1-6), coho (Table 1-7) and chinook (Table 1-8), based on DCFH production records from 1981 to 1999. In general, it can be noted that steelhead production goal of 300,000 fish has been achieved every year since 1992, which reflects the improvements in rearing facilities and water supply that were completed that year. Releases of coho and steelhead show significant variation. Coho releases surpassed the production goal of 110,000 from 1987 to 1992, but poor returns in recent years have not allowed adequate egg harvest to meet production. Similarly, returns of chinook have never allowed adequate egg take to achieve the release goal of 1,000,000 smolts. Comparison of relevant data on adult returns (Section 1.7.6) and egg harvest (Section 1.7.4) indicates that coho and chinook release numbers are directly related to availability of broodstock, and low release numbers should not be construed as a reflection of hatchery operations. Survival from unfertilized egg to stocked yearling routinely surpasses the management goal of 50%.

The management plan for steelhead releases has been recently modified. Each year, typically beginning in December and continuing through April, grading operations are conducted on steelhead to identify fish larger than 4 fish per pound, and they are subsequently released. Previously, any remaining fish that did not meet size criteria were released by the end of April regardless of size. This practice was discontinued beginning in July 1999.

Also, practices relating to surplus egg takes have been modified. In the past, if egg-take goals were exceeded, some of the early eggs were stocked within the drainage as fry and fingerling, in order to spread the egg-take proportionate to the entire run. As of July 1999, any surplus eggs are destroyed.

The chinook releases presented in Table 1-8 illustrate a variation in release goals that is the prerogative of the hatchery manager. The management plan calls for chinook to be reared to the smolt stage (about 50 fish per pound) and released during April or May. If numbers of chinook are low, the manager may choose to rear them to yearling size (10 fish per pound and larger), with releases completed by November 1. Based on an increase in survival seen when the Central Valley facility switched from smolt to yearling releases, all DCFH chinook releases since 1994 have occurred as yearling.

1.7.5.2.2 Coyote Valley Fish Facility

Data regarding number, pounds, and average size of steelhead releases from CVFF are presented in Table 1-9, based on CVFF production records from 1993 to 1999. Each December, when grading of yearling steelhead commences at DCFH, all fish that are progeny of adults collected at CVFF and larger than 5 fish per pound are transported to CVFF to acclimate. Volitional release is allowed to occur, but any fish remaining after a 30-day period are forced from the ponds. Similar to DCFH, previous practices that allowed stocking of excess eggs and undersize fish have been discontinued as of July 1999. In general, the steelhead production goal has been achieved every year except the year of initial start-up. Survival from unfertilized egg to stocked yearling routinely surpasses the management goal of 50%.

Table 1-6 Don Clausen Fish Hatchery Steelhead Release History

Year[1]	Fingerling			Yearling		
	Number	Pounds	Avg FPP[2]	Number	Pounds	Avg FPP[2]
1981-1982	253,436	682	372	53,380	10,975	5
1982-1983	226,710	762	298	102,662	18,225	6
1983-1984	459,970	2,119	217	124,146	22,730	5
1984-1985	608,680	647	941	155,305	42,360	4
1985-1986	539,157	4,108	131	212,365	27,500	8
1986-1987	1,316,469	4,842	272	237,753	68,405	3
1987-1988	720,579	930	775	224,963	60,560	4
1988-1989	578,780	712	813	233,979	58,950	4
1989-1990	347,347	551	630	212,769	56,175	4
1990-1991	121,326	1,893	64	243,881	64,320	4
1991-1992	1,188,663	3,406	349	335,181	86,775	4
1992-1993	1,249,521	3,571	350	321,890	75,975	4
1993-1994	627,730	1,532	410	355,164	86,809	4
1994-1995	397,455	2,676	149	309,458	78,524	4
1995-1996	134,000	67	2,000	316,758	88,700	4
1996-1997	279,088	381	733	312,388	86,376	4
1997-1998	119,681	522	229	348,734	99,295	4
1998-1999	46,062	1,153	40	341,339	88,425	4

[1] Year extends from July 1 of the first year through June 30 of the second year.

[2] Avg FPP = average size (fish per pound) at release.

Table 1-7 Don Clausen Fish Hatchery Coho Release History

Year[1]	Fingerling			Yearling		
	Number	Pounds	Avg FPP[2]	Number	Pounds	Avg FPP[2]
1981-1982	66,400	1,050	63	30,820	4,600	7
1982-1983	82,987	1,190	70	32,305	3,310	10
1983-1984	3,800	126	30	30,310	4,330	7
1984-1985	67,750	1,010	67	0	0	0
1985-1986	42,525	525	81	86,425	7,325	12
1986-1987	40,809	704	58	123,570	16,250	8
1987-1988	82,211	1,350	61	104,324	17,875	6
1988-1989	0	0	0	100,680	13,083	8
1989-1990	0	0	0	128,755	14,200	9
1990-1991	0	0	0	110,690	12,625	9
1991-1992	0	0	0	137,400	15,075	9
1992-1993	0	0	0	85,859	10,605	8
1993-1994	0	0	0	55,528	9,700	6
1994-1995	0	0	0	27,186	2,699	10
1995-1996	0	0	0	96,180	27,570	3
1996-1997	0	0	0	23,380	8,500	3
1997-1998	0	0	0	60,590	8,795	7
1998-1999	0	0	0	0	0	0

[1] Year extends from July 1 of the first year through June 30 of the second year.

[2] Avg FPP = average size (fish per pound) at release.

Table 1-8 Don Clausen Fish Hatchery Chinook Release History

Year[1]	Fingerling Number	Fingerling Pounds	Fingerling Avg FPP[2]	Yearling Number	Yearling Pounds	Yearling Avg FPP[2]
1981-1982	102,360	2,160	47	0	0	0
1982-1983	68,750	2,083	33	20,900	3,074	7
1983-1984	66,120	1,740	38	0	0	0
1984-1985	211,510	4,697	45	0	0	0
1985-1986	884,520	18,595	48	0	0	0
1986-1987	92,765	1,835	51	34,592	3,225	11
1987-1988	54,150	1,275	42	0	0	0
1988-1989	237,450	6,800	35	0	0	0
1989-1990	13,770	270	51	36,037	3,837	9
1990-1991	0	0	0	0	0	0
1991-1992	113,525	2,525	45	0	0	0
1992-1993	8,877	269	33	0	0	0
1993-1994	0	0	0	50,300	4,800	10
1994-1995	0	0	0	0	0	0
1995-1996	0	0	0	25,923	13,000	2
1996-1997	0	0	0	31,990	10,000	3
1997-1998	0	0	0	7,800	750	10
1998-1999	0	0	0	11,730	2,300	5

[1] Year extends from July 1 of the first year through June 30 of the second year.
[2] Avg FPP = average size (fish per pound) at release.

Table 1-9 Coyote Valley Fish Facility Steelhead Release History

Year[1]	Fingerling Number	Fingerling Pounds	Fingerling Avg FPP[2]	Yearling Number	Yearling Pounds	Yearling Avg FPP[2]
1992-1993	0	0	0	165,469	26,839	6
1993-1994	227,313	365	623	213,872	46,472	5
1994-1995	107,667	238	452	235,416	44,659	5
1995-1996	76,670	6,950	11	224,702	44,647	5
1996-1997	122,188	594	206	206,333	40,400	5
1997-1998	110,981	369	301	242,438	48,528	5
1998-1999	164,770	1,086	152	231,320	45,448	5

[1] Year extends from July 1 of the first year through June 30 of the second year.
[2] Avg FPP = average size (fish per pound) at release.

1.7.5.2.3 Release Size

Currently, hatchery-reared chinook, coho, and steelhead are released at a larger size than their naturally spawned counterparts, suggesting that direct predation may occur if release areas overlap areas of natural production. The risk of predation is somewhat minimized for steelhead as a result of the volitional release strategy employed at CVFF. Presumably, steelhead leaving this facility emigrate immediately to the ocean, hence minimizing the period of time when freshwater predation might occur. While chinook and coho are not volitionally released, they are sorted by size, and larger individuals are released while smaller individuals are retained until reaching a larger size. Larger individuals may emigrate more quickly than smaller individuals, hence decreasing the risk of freshwater predation and competition. Furthermore, releases are not made in the smaller tributaries where primary spawning and rearing occurs, with the exception of Dry Creek, and to a lesser extent the mainstem Russian River.

1.7.5.3 Release Protocols

DCFH releases utilize a transport truck to haul the fish from the hatchery to their final release location in Dry Creek. CVFF allows volitional release of its steelhead smolts, encouraging a more natural migration behavior.

Due to release locations, all chinook, coho, and steelhead are acclimated to a certain degree within the Russian River system, suggesting that straying to out-of-basin rivers is unlikely to be a great concern. More than half of the steelhead production in the DCFH/CVFF program is acclimated at CVFF, and allowed volitional release as yearlings. The DCFH steelhead, coho and chinook are not directly acclimated *per se*, however rearing occurs on Lake Sonoma water and release occurs in Dry Creek approximately three miles downstream from the hatchery. In each case, all three species would be expected to return to capture facilities rather than non-natal tributaries.

1.7.6 ADULT RETURNS

1.7.6.1 Don Clausen Fish Hatchery

Adult returns to DCFH are presented in Table 1-10. Since operations began, DCFH has achieved the steelhead mitigation goal of 6,000 adult escapements only one time. The coho mitigation goal of 100 adult fish has been met 11 out of 19 years, but the enhancement goal calling for an additional 1,000 adult returns has never been achieved. The chinook goal of 1,750 adult returns for enhancement purposes has never been achieved, with a maximum return of 304 fish. As noted previously in Sections 1.7.1 and 1.7.5.1, the survival estimates used in establishing juvenile release goals is likely to be a contributing factor in the poor success of meeting adult escapement goals.

1.7.6.2 Coyote Valley Fish Facility

Adult returns to CVFF are reported in Table 1-11. The mitigation goal of 4,000 returning ish has yet to be achieved. Peak returns occurred in 1997, when 3,727 adult steelhead were counted at CVFF. Similar to DCFH, the survival estimates used to establishing juvenile release goals is likely to be a contributing factor in the poor success of meeting adult escapement goals.

1.7.6.3 Harvest Management

Current fishing regulations allow the take of hatchery-reared steelhead and chinook. (Steelhead and chinook releases from DCFH and CVFF are marked with clipped adipose fins.) Harvest of coho and naturally spawned steelhead and chinook is prohibited. While this strategy minimizes direct fishing mortality, indirect effects such as hooking mortality and harassment may still affect naturally spawned adults.

There are no current estimates of harvest levels of chinook, coho, or steelhead within the Russian River. Recent investigations are beginning to survey adult returns to the Russian River for both hatchery-reared and naturally spawned population components.

Table 1-10 History of Fish Trapped at Don Clausen Fish Hatchery

	Steelhead				Coho				Chinook			
Year[1]	Male	Female	1/2-Pound	Total	Male	Female	Grilse	Total	Male	Female	Grilse	Total
1980-1981	148	185	0	333	0	0	0	0	0	0	0	0
1981-1982	124	235	0	359	2	2	0	4	0	0	0	0
1982-1983	322	242	0	564	515	277	194	986	1	0	0	1
1983-1984	1,039	923	0	1,962	0	1	8	9	2	1	1	4
1984-1985	369	468	0	837	32	44	0	76	7	1	0	8
1985-1986	812	484	4	1,300	0	0	0	0	65	0	0	65
1986-1987	519	696	36	1,251	139	5	328	472	50	25	36	111
1987-1988	660	375	10	1,045	164	155	257	576	176	4	124	304
1988-1989	453	421	17	891	219	139	176	534	151	61	21	233
1989-1990	428	260	15	703	35	35	70	140	8	6	3	17
1990-1991	239	181	3	423	100	87	90	277	67	0	32	99
1991-1992	750	834	7	1,591	53	20	89	162	77	46	2	125
1992-1993	1,378	1,289	2	2,669	250	113	215	578	15	22	3	40
1993-1994	856	895	9	1,760	110	62	277	449	8	0	13	21
1994-1995	3,561	4,525	14	8,100	310	392	63	765	59	9	17	85
1995-1996	2,135	1,958	12	4,105	13	13	36	62	18	12	3	33
1996-1997	1,729	1,910	9	3,648	68	68	12	148	25	11	7	43
1997-1998	656	687	1	1,344	1	3	0	4	16	14	19	49
1998-1999	1,219	1,012	5	2,236	2	1	5	8	1	0	3	4

[1] Year extends from July 1 of the first year through June 30 of the second year.

Table 1-11 History of Fish Trapped at Coyote Valley Fish Facility

	Steelhead				Coho				Chinook			
Year[1]	Male	Female	1/2-Pound	Total	Male	Female	Grilse	Total	Male	Female	Grilse	Total
1992-1993	182	120	8	310	0	0	0	0	1	0	0	1
1993-1994	229	198	13	440	5	2	1	8	1	0	0	1
1994-1995	1,147	1,054	9	2,210	0	1	0	1	0	0	0	0
1995-1996	1,129	980	6	2,115	0	0	0	0	0	0	0	0
1996-1997	1,793	1,934	8	3,735	1	1	0	2	0	0	0	0
1997-1998	619	932	8	1,559	0	0	0	0	0	0	0	0
1998-1999	793	798	5	1,596	0	0	0	0	2	0	1	3

[1] Year extends from July 1 of the first year through June 30 of the second year.

2.0
POTENTIAL EFFECTS OF FISH FACILITY OPERATIONS

The Don Clausen Fish Hatchery (DCFH) and the Coyote Valley Fish Facility (CVFF) were developed with straightforward objectives: to mitigate for losses of steelhead and coho salmon above the Warm Springs and Coyote Valley Dams and to enhance harvest opportunities for both coho salmon and chinook salmon. But critical issues of the past decade (such as the Endangered Species Act) are forcing a general reevaluation of the objectives of fish hatchery production. For example, in a report being prepared for the U.S. Congress that reviews all federally funded fish production programs in the Columbia River Basin, the following four concerns were raised, noting that these concerns are not always reconcilable on the surface (NPPC 1999):

1. **Broaden harvest opportunities.** *Can and should artificial production programs be revised to spread harvest opportunities to greater areas of the basin?*

2. **Improve survival of hatchery fish.** *Is it possible, and economically feasible, to boost the health and survival of hatchery fish by using spawning, rearing and release techniques that mimic natural spawning, rearing and migration patterns?*

3. **Avoid harming wild runs.** *Do artificial production activities adversely affect naturally spawning fish to a significant degree and thus undermine the efforts to protect and rebuild wild runs?*

4. **Protect and rebuild naturally spawning populations.** *Can we design artificial production programs that not only avoid harm but actually benefit natural runs, that assist in the preservation and rebuilding of naturally spawning populations?*

This section identifies **potential** effects which operation of hatcheries in general may have on the surrounding environment. In particular, those effects are noted which may impact the three threatened stocks and their designated critical habitat: threatened Central California Coast ESU steelhead trout (*Oncorhynchus mykiss*), the threatened Central California Coast ESU coho salmon (*O. kisutch*) and the California Coastal ESU chinook salmon (*O. tshawytscha).* There are two basic categories of potential effects: 1) water quality, and 2) effects on fish populations. For each potential effect, there is first a discussion of the various issues of concern. Secondly, evaluation criteria are presented that both summarize each issue of concern and reflect the range of common hatchery practices that can factor into effects. It must be emphasized that the identified potential effects are intended to describe **hatcheries in general** and not the specific operations at DCFH and CVFF. The evaluation criteria are developed purposefully to describe variations in hatchery operating procedures, and as such will describe operations in addition to those currently practiced at DCFH and CVFF. This approach was used to aid future evaluations which may examine alternative operating scenarios for the facilities. A specific discussion of the potential effects in the context of current operations at DCFH and CVFF is reserved until Section 3.

2.1 WATER QUALITY

2.1.1 ISSUES OF CONCERN

Operations at most hatchery facilities, including both DCFH and CVFF, involve diversion of water into the facility with subsequent discharge back to the river. In concentrated fish production processes, waste solids from fish feces and excess feed typically become entrained in the water supply system. If not treated, the effluent from fish production facilities can affect water quality in the receiving water, most often in the areas of turbidity, settleable solids, BOD and nutrient loading.

Aquatic animal production facilities with more than 20,000 pounds annual production are subject to discharge water quality limits established through the U.S. Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES). For the Russian River area, NPDES permits are administered by the North Coast Region of the California Water Quality Control Board (RWQCB). The RWQCB has established water quality limits for the areas it administers based on designated beneficial uses for the subject waters. In Dry Creek and the Russian River, these beneficial uses include coldwater fish life, which reflects the general water quality requirements for the threatened species in this evaluation.

Discharge standards for the Russian River fish production facilities are specified in the following NPDES permits issued by the RWQCB:

- Don Clausen Fish Hatchery: Order No. 97-61, NPDES Permit No. CA0024350 (RWQCB 1997a)
- Coyote Valley Fish Facility: Order No. 97-60, NPDES Permit No. CA0024791 (RWQCB 1997b).

The permits require that the facilities be equipped with waste treatment equipment to insure compliance with specified water quality criteria (Table 2-1). Compliance is monitored by sampling the facility effluent two times per month, with results submitted in a monthly report to the RWQCB. It is further stipulated that sampling occur during cleaning operations, since this is the aspect of fish production that is most likely to produce poor water quality conditions.

Table 2-1 Discharge Standards for DCFH and CVFF

Parameter	Effluent Limit (Daily Maximum)
Total Suspended Solids	15 mg/L
Total Settleable Solids	0.2 mL/L/hr
pH	within 0.5 of receiving waters
Salinity (chloride)	250 mg/L
Temperature	no measurable change to receiving water
Turbidity	no increase > 20% of background
Dissolved Oxygen	> 7.0 mg/L
Flow – DCFH	15.5 million gallons/day
Flow – CVFF	7.11 million gallons/day

The discharge permits include stipulations in addition to the monthly monitoring noted above. As an example, discharge of wastes from pond cleaning and the bypass of wastes around the pollution control pond is prohibited. At DCFH, it is prohibited to discharge detectable levels of chemicals used for the treatment or control of disease, other than salt (sodium chloride).

2.1.2 EVALUATION CRITERIA

Since the NPDES discharge standards reflect general water quality requirements for the three subject species, they provide a practical means for assessing potential effects from DCFH and CVFF operations. Evaluation criteria for water quality effects are presented in Table 2-2, providing five categories of effect that relate to routine compliance with NPDES requirements.

Table 2-2 Water Quality Evaluation Criteria

Evaluation Criteria Categories	Category Score*
Continuous compliance with NPDES standards	5
Compliance with 75-99% of standards	4
Compliance with 50-74% of standards	3
Compliance with 25-49% of standards	2
Compliance with 0-24% of standards	1

*A score of 5 is the best score, 1 is the worst.

2.2 FISH POPULATIONS

Fish facilities have the potential to affect natural steelhead, coho and chinook in three areas: disease, genetic effects and ecological effects. In this section, each of these parameters is discussed to first identify general issues of concern. Secondly, evaluation criteria are defined that describe the range of practices that may occur in a fish production facility.

2.2.1 DISEASE

2.2.1.1 Issues of Concern

The artificial propagation of any species creates the opportunity for health problems to occur. By holding animals in artificial conditions, the potential occurs for crowding, elevated stress, and increased exposure to biological pathogens, the causative agent of a disease. Because many pathogens are present in the natural environment, animals are continually exposed to these pathogens. In most cases, both natural and cultured fish live with the presence of pathogens with no disease occurring. However, when an animal becomes injured or stressed, the pathogen may be able to overwhelm the immune response of the weakened or debilitated animal and cause disease.

The pathogens of greatest concern are infectious disease agents. A fish carrying an infectious disease agent may transmit the disease to other fish within the local population (such as a hatchery) or, in cases of straying or man-induced fish transfers, to more distant fish populations.

Hatchery operations may affect the health of natural fish populations by three mechanisms: introduction of new pathogens, dissemination of pathogens, and amplification of pathogens.

2.2.1.1.1 Introduction of New Pathogens

The introduction of new pathogens into an environment can have a particularly strong effect since there may be no natural immunities to the pathogen. In nature, the introduction of new pathogens can occur through straying of wild fish into non-native watersheds or through exposure and infection during the period of ocean inhabitance. Similarly, hatchery operations may introduce new pathogens to an area through the importation of eggs or fish from a location outside the local geographical area of concern. The introduction of new pathogens is closely related to dissemination of pathogens.

2.2.1.1.2 Amplification of Pathogens

Amplification of pathogens is an increase in the numbers of a pathogen caused by replication of that pathogen in the fish host. Pathogens are present throughout the environment, and in most cases the fish co-exist alongside the fish pathogen without the presence of disease. On occasion, conditions occur that allow amplification of a pathogen within a fish host. The pathogens shed from the host may infect another fish host and continue the cycle of amplification, possibly resulting in a disease episode.

Generally when disease is present, fish mortality increases and in some instances can cause loss of a significant portion of the population. Many disease episodes that occur in hatchery situations can be managed with the use of therapeutants, but at times treatment is unsuccessful and the disease causes severe mortality to the hatchery population. For certain pathogens, particularly viral pathogens, there are no therapeutic treatments to reduce the effect of the disease, potentially exposing many other fish to the pathogen during this time. It should be noted, however, that there is no evidence or documented examples of an endemic disease in a watershed having been transmitted directly from infected hatchery fish to wild fish (Brannon *et al.* 1999). It should also be noted that very little research has been done in the area and diseased fish are difficult to detect in the natural environment, so the risk may be underestimated.

2.2.1.1.3 Dissemination of Pathogens

Dissemination of pathogens is the increase in the geographical area that a pathogen is known to occur. Hatchery practices may cause dissemination of pathogens through the transfer of eggs or fish from one region into another. Eggs can be disinfected on the surface for many pathogens but can still carry certain pathogens within the egg. Fish can be a host to both external and internal pathogens, and can not be disinfected to remove these pathogens.

Fish resource management agencies typically protect against dissemination of pathogens by tracking the distribution of known pathogens and restricting any movement of eggs or fish that could potentially cause introduction of a pathogen to a new geographical area. With the management of anadromous stocks of fish, fish health management areas are typically a geographically isolated river basin that the fish pass through on their journey to and from the ocean. Sometimes distinct areas within a river basin are identified for restriction of egg or fish movements due to the identification of a particular pathogen that is not present outside the identified area. It is rare that screening is conducted for pathogens that are not known to exist within an area.

2.2.1.2 Evaluation Criteria

Each of the three issues of concern discussed above is associated with a distinct hatchery practice. Evaluation criteria for assessing disease-related effects on the protected populations must consequently address three separate risk factors. These factors are discussed below and summarized in Table 2-3.

The risk that hatchery operations will introduce new pathogens to the protected populations is directly related to the extent which eggs and fish are imported from outside regions. The most favorable hatchery condition would entail no importation of eggs or fish, so that there would be no avenue for new pathogens to be introduced. If importation occurs, the importation of eggs would generally have less likelihood of effect than importation of fish, since eggs are typically disinfected prior to transport. Finally, since pathogens from nearby environments will generally show greater similarity than those from distant sources, importation from nearby regions would be preferred.

The risk of amplification of pathogens due to hatchery operations can generally be gauged through the health record of the facility. Categories noted in the evaluation criteria take into account the type of disease that is likely occur in the hatchery, the typical effectiveness of therapeutic procedures, and adherence to recognized fish health management practices.

The risk that established pathogens will be disseminated to a broader geographic area is similarly related to the extent and range that transfer occurs. The criteria categories acknowledge that, due to the limited size of the Russian River watershed, specific pathogens are likely to be present through the entire basin. Also, the categories acknowledge the common practice of screening for fish pathogens as an integral part of managing the fisheries resource.

Table 2-3 Disease Evaluation Criteria

Evaluation Criteria Categories	Category Score
Risk Factor: Introduction of New Pathogens	
No importation of eggs or fish	5
Importation of certified eggs from within region	4
Importation of certified eggs from outside region	3
Importation of fish from within region	2
Importation of certified fish from outside region	1
Risk Factor: Disease Amplification	
Good health record; no need for therapeutic treatment	5
Good health record; good fish health management practices	4
Fair health record; therapeutic treatment required – good response	3
Fair health record; therapeutic treatment required – no response	2
Frequent serious disease outbreak with epizootic mortality	1
Risk Factor: Disease Dissemination	
No transfer between facilities	5
Transfer with inspection between DCFH and CVFF	4
Transfer without inspection between other facilities within watershed	3
Transfer with inspection between facilities outside of watershed	2
Transfer between facilities outside of basin without inspection	1

2.2.2 GENETIC EFFECTS

The range of topics considered in an assessment of genetic effects must take into account the objectives of the hatchery production program. Some potential effects will be applicable to any supportive breeding program while some may not require consideration. For example, a program designed as a terminal fishery to supplement commercial harvest would have different issues of concern than a conservation hatchery program designed to supplement a wild stock.

It should be stated from the outset that many of the genetic effects that are considered would be deleterious only if a multitude of assumptions were satisfied. For example, the loss of between-population diversity requires that previously isolated (or relatively isolated) populations exchange genetic material resulting in a loss of genetic identity or "uniqueness". Further, many of the potential effects are not directly quantifiable. Since probabilities cannot be assigned to the realization of some effects, and data are inadequate to resolve the potential for deleterious impacts, the likelihood of their occurrence will be qualitatively assessed by reviewing the method(s) of risk aversion employed by the facilities. To facilitate this analysis, evaluation criteria were formulated as a list of methods useful in minimizing the probability of deleterious effects resulting from the operation of hatchery facilities. For example, the risk of deleterious competitive interactions between hatchery-reared and naturally spawned juveniles can be minimized through volitional release techniques aimed at releasing fish that are prepared to immediately emigrate to the ocean. It follows that a program employing volitional release strategies would be less likely to negatively affect natural production. Since data are not available to quantitatively assess potential effects of hatchery operations in the Russian River, the listed effects must be viewed only as possible consequences of the operation of the DCFH and CVFF programs. Therefore, the assessment of current hatchery operations relative to the evaluation criteria is qualitative, and based on measures of risk aversion currently employed at the facilities. A low ranking does not imply that hatchery operations are negatively impacting wild stocks *per se*, rather that better management practices could be employed to decrease the risk of deleterious impacts.

In the following subsections, four genetic effects are discussed that appear most relevant to the DCFH and CVFF operations, based on the body of peer-reviewed, published literature. Following this discussion, current practices are described that influence the listed effects. Available data pertaining specifically to the Russian River populations will be summarized by species. Some of the terms listed in this section are defined in the glossary.

2.2.2.1 Issues of Concern

2.2.2.1.1 Outbreeding Depression

Outbreeding depression describes a genetic mechanism that results in decreased fitness manifested immediately or in subsequent generations, following hybridization of individuals with divergent genetic composition. Outbreeding depression may occur through the disruption of three processes: intrinsic coadaptation; extrinsic coadaptation; or through loss of local adaptation. Ultimately, the source of broodstock is the factor controlling the probability of outbreeding depression. For example, patterns of molecular genetic variation (Utter *et al*. 1989; Ford 1998) and geographic distributions of straying (Quinn 1993) suggest that geographically proximate stocks typically exchange a greater number of migrants, and are therefore more genetically similar than geographically distant stocks[1]. Therefore, for supportive breeding programs that derive broodstock from adult returns to the target population, outbreeding depression is unlikely because the progeny of hatchery-reared and naturally spawned adults are genetically similar. However, if programs utilize stock transfers, the risk of outbreeding depression increases as geographic distance and selective differentials increase, since the source and target stocks are more likely to be genetically dissimilar.

Intrinsic Coadaptation (Epistasis)

Intrinsic coadaptation or epistasis describes traits that rely on interactions between genes/loci (Lynch 1991). Templeton (1986a, 1986b) indicates that coadaptation occurs most readily in species with restricted recombination, a possible result of population subdivision, small population size, and inbreeding. Since salmonids exhibit a strong homing extinct (i.e. return to the natal stream) it is conceivable that populations may develop unique coadaptations resulting in a reproductive or survival advantage in the local environment. It follows that introgression by individuals not possessing the same unique coadaptation could disrupt the epistatic interaction and decrease fitness of the progeny. Unfortunately, there are no tests currently available to easily assay the existence or probability of the existence of coadaptations.

The transmission of coadaptations from parent to progeny makes direct measures of coadaptation difficult as well. For example, progeny arising from a cross between an individual possessing a coadaptation and one lacking a coadaptation (F_1 generation) will inherit the epistatic interaction. However, recombination

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[1] While patterns of genetic variation are often structured geographically, this is not always the case. However, the assumption that genetic variation is structured geographically is often used as "rule of thumb", when data are unavailable.

during gamete formation will likely disrupt the coadaptation, and it will not be passed to their progeny (F_2 generation). Therefore, breakdown of epistasis typically will not occur until the F_2 generation, and to date few studies have overcome the difficulties of tracking fish through two full generations. Gharret and Smoker (1991) documented a decrease in fitness exhibited by F_2 crosses of even and odd-year pink salmon. The authors suggest that the decrease in fitness may have resulted from the breakdown of a coadapted gene complex. Unfortunately, the authors did not incorporate F_2 controls, so their assertion that decreased fitness was the result of disruption of epistasis remains contentious.

Certainly, the life history characteristics of salmonids suggest that the evolution of population specific epistatic interactions is possible. However, our inability to assess the existence or assign a probability of occurrence to coadaptation limits the discussion of management implications to a qualitative arena. Overall, the probability of outbreeding depression increases as the probability of reproductive isolation between the target and donor stocks increases. For example, if broodstock is derived from adult returns to the target population, outbreeding depression is unlikely. However, if broodstock is derived as a stock transfer from a distant population with which natural gene flow is currently and was historically minimal, the probability of outbreeding depression increases.

Extrinsic Coadaptation

In addition to breakdown of coadapted gene complexes, outbreeding depression can result from hybridization between populations that express different karyotypes. Karyotype refers to the number of chromosomes possessed by an individual, while karyotypic race refers to the distribution of karyotypes within a population.

Successful hybridization of salmon with different karyotypes is documented (Kusunoki *et al.* 1994). For example, Thorgaard (1983) found that coastal stocks of rainbow trout that were indistinguishable morphologically or by allelic frequency, varied in chromosome number from 58-64 within and between putative populations. However, while hybridization of karyotypic races occurs, Garcia-Vazquez *et al.* (1995) suggest that wild fish undergo selection toward a standard karyotype. While outbreeding depression doesn't always occur as a result of hybridization of salmonids with differing karyotypes, management may seek to avoid mixing different karyotypic races of salmonids. To avoid mixing karyotypic races, hatchery programs could derive broodstock from the target population. Whatever the case, since individuals with differing karyotypes may occur within the same population, it is unclear whether or not outbreeding depression will occur as a result of hybridization between fish with differing karyotypes.

Disruption of Local Adaptation

The mechanisms of outbreeding depression discussed previously are dysgenic (strictly genetic) in nature. Outbreeding depression may also occur via disruption of local adaptation. Local adaptation refers to a phenotype (either physical or behavioral) resulting from the complex interaction between a genotype and the environment. An illustration of this type of outbreeding depression is provided by coho salmon hatchery practices in coastal Oregon streams. These programs obtained broodstock by capturing fish as they appeared in the river, and capture continued only until broodstock quotas were achieved. The result was selection for the earliest returning adults. Since run timing is a partially heritable trait, hatchery-reared progeny returned and spawned earlier than the mean return time of the stock prior to hatchery influence (Nickelson *et al*. 1986). Early spring freshets may have reduced the survival of progeny of early returning fish relative to those returning at the historical peak (Nickelson *et al*. 1986). Avoiding outbreeding depression as a result of loss or disruption of local adaptation could be achieved by deriving broodstock as a representative sample of the target population.

2.2.2.1.2 Inbreeding Depression

Inbreeding depression occurs when the mating of closely related individuals increases genetic drift (random loss of alleles) or results in the expression of deleterious alleles (Tave 1993). Simply stated, progeny inherit about 50% of their genetic variation from each parent, which is itself only a fraction of the genetic variability in the population as a whole. The result is that siblings are more genetically similar to one another than to progeny from the population as a whole. As a result, when siblings mate, their progeny suffer an average loss of 25% heterozygosity relative to the random mating population as a whole (Waldman and McKinnon 1993). Inbreeding is not necessarily detrimental, and is used frequently in aquaculture to increase the frequency of desirable traits (Shields 1993, Tave 1993, Wangila and Dick 1996). However, decreased heterozygosity comes at the expense of losing alternate alleles (genetic drift) which may be useful for adaptive response to a changing environment (Allendorf and Leary 1986). Further, some detrimental traits may be expressed with greater frequency as alternate alleles are lost (Tanaka 1997). For example, in common carp scale pattern is controlled by two genes, expressed here as scale coverage (S) and scale pattern (N). Fish with the ssNn genotype are termed leather pattern, ssnn are mirror, SsNn are line, and Ssnn are scaled (Tave 1993). Note that the N locus is solely heterozygous Nn or homozygous nn, the NN genotype never appears. This results from the fact that the NN genotype is lethal. In this case the effect of genetic drift or inbreeding is apparent. If the n allele is lost or its frequency decreased as a result of inbreeding, the probability of a mating giving rise to the lethal NN genotype increases.

The absolute effects of inbreeding are difficult to quantify. For example, there are no thresholds at which inbreeding depression is a certainty. As a rule of thumb, Allendorf and Ryman (1987) suggest that a minimum of 100 males and 100 females should be collected as broodstock. However, this estimate must be employed with caution, since the history of the broodstock is also important. If a hatchery collects broodstock solely from returning hatchery-reared individuals, the size of the initial founding population must be considered. For example, a hatchery program initiated with five adult pairs will likely be less genetically heterogeneous than a hatchery program initiated with a greater number of adults. Allendorf and Ryman (1987), suggest that 25 adult pairs is a reasonable minimum for initiation of a hatchery program.

Inbreeding depression may be exacerbated by supplementation programs due to non-random mating in the hatchery (accidental mating of siblings for example) or if broodstock collection substantially decreases the size of the naturally spawning population component (increasing the probability of non-random mating in the wild). Inbreeding depression is a risk that should be considered and minimized for any supportive breeding program.

2.2.2.1.3 Loss of Within Population Diversity (Domestication)

Loss of within population diversity refers to a loss of genetic variability within the composite (hatchery-reared and naturally spawned) population. Genetic drift and inbreeding (a possible result of small population size within either population component) may result in the loss of within population genetic variation as discussed above. However, as it relates to hatchery programs, the loss of within population diversity arises from the magnification of a limited sample of the total genetic variation present among the naturally spawning population component, often referred to as artificial selection. The result is termed domestication (Hindar *et al.* 1991). Artificial selection typically arises from non-representative broodstock collection and rearing under an altered selective regime. Unfortunately, mitigation for artificial selection, inbreeding and genetic drift may not be adequate for the task of conserving genetic variation within a hatchery augmented population. Programs may need to actively maintain genetic diversity by maintaining an ample effective population size. The risk of losing within population variability should be assessed regardless of the program objectives.

Non-Representative Broodstock Collection

The goal of any supportive breeding program is to increase the reproductive success of individuals spawned in the hatchery relative to those individuals spawning in the wild. It is therefore imperative that broodstock collection adequately represents the genetic variation present in the target population. As an example consider the collection of coho salmon discussed earlier (under *Outbreeding Depression*). In that example, broodstock collection began with the earliest adult returns, and continued only until broodstock quotas were achieved. Typically broodstock quotas were met long before the adult return ceased, and the result was inadvertent selection for the earliest returning adults. Since run-timing is a partially heritable trait, hatchery-reared progeny tended to return about 2.5 weeks earlier than naturally spawned progeny (Nickelson *et al*. 1986). Unfortunately, redds constructed earlier in the season were subjected to high spring runoff and reproductive success was decreased. Obviously, this was a detrimental result for the hatchery program, however the more important result is that repeated selection for the earliest returning adults resulted in a phenotypic change within the hatchery population. In this case, broodstock selection favored the genetic variation encompassed by early returning adults at the expense of genetic variation encompassed by later returning adults.

Unfortunately, retaining a genetically representative broodstock is not as straightforward as merely collecting adults systematically throughout the run. Artificial selection may result inadvertently from a variety of sources. For example, collection weirs may select against individuals that spawn downstream of the collection area. The absolute effect of non-representative broodstock collection ultimately depends upon the magnitude of the selective pressure, and the number of life-history traits that are directly or indirectly affected.

Rearing in the Hatchery Environment

The hatchery environment is necessarily different from the natural environment. For example, hatchery-reared fish are often raised in monotone raceways and fed pelleted food distributed on the surface of the water. Changes in phenotypic (Fleming and Gross 1989), genetic (Bartley and Gall 1990), and behavioral traits (Doyle and Talbot 1986) may result from the altered selective regime imposed on hatchery-reared progeny. Since selection acts on the phenotype (the expression of a genotype in a given environment), these changes may or may not be reflected as a change in the genetic composition of progeny raised in the hatchery relative to progeny reared under natural conditions.

As an example of a phenotypic change possibly resulting from hatchery-rearing, consider adult body size. Naturally-spawning females must be large enough to excavate redds in a gravel substrate, however in the hatchery females are spawned by hand suggesting that body size is irrelevant. Fleming and Gross (1989) found that hatchery-reared coho exhibited smaller body size. The authors suggested that the decrease in body size resulted from relaxation of natural selection that would otherwise favor larger females.

It follows that any divergence in natural selection resulting from hatchery rearing may increase the probability of artificial selection. Therefore, minimizing differences between the hatchery environment and the natural environment may decrease the probability of artificial selection. To this end, some hatcheries employ a rearing methodology referred to as NATURES (Natural Rearing Enhancement System), which consists of alterations to the hatchery environment aimed at mimicking the natural environment (Maynard *et al*. 1996). Alterations may include natural substrates, lower rearing densities, natural foods, overhead cover, underwater cover, sub-surface food delivery systems, and predator conditioning. These practices have the dual benefit of potentially decreasing artificial selection and preparing hatchery-reared progeny for survival under natural conditions. NATURES rearing strategies are relatively new, and the data necessary to determine the effectiveness of these practices at increasing smolt to adult survival have yet to be published. However, NATURES rearing strategies have been effective at increasing the survival of smolts during emigration, when compared to traditionally reared smolts (Maynard *et al*. 1996).

In addition to decreasing the magnitude of artificial selection, as discussed in the previous paragraphs, managers may also seek to decrease the temporal scale of artificial selection. For example, if broodstock is collected solely from hatchery-reared adult returns, any directional selection present in the hatchery environment will be repeatedly imposed on the hatchery-reared component of the population. With each generation of artificial selection, the hatchery-reared population component would likely diverge from the naturally reared population component to a greater degree. Therefore, broodstock collection protocols that include the collection of naturally reared adults may decrease divergence between the two population components and minimize the loss of genetic diversity within the hatchery-reared population component.

Effective Population Size (N_e)

Due to variation in reproductive success, unequal sex ratios, and overlapping generations the genetic contribution to the next generation by the adults spawning in the previous generation is often less than expected. For example, if 50 males and 50 females successfully spawn in a tributary, but a drought destroys half of the redds, the genetic contribution of the spawners is less than expected based on the absolute number of adults. Similarly, if one out of every ten redds produces 100 returning adults, while nine out of ten redds produce only one, certain families will be genetically over-represented when the progeny return as adults. Within the hatchery, spawning protocols may serve to increase or decrease the effective population size. For example, pairwise spawning (one male spawned with one female) followed by equalization of family size, may increase the effective population size. Alternatively, if gametes from a number of individuals are pooled during spawning, and some of the individuals are infertile, the effective population size may be lower than expected with respect to the total number of individuals spawned.

Since estimating the transmission of genetic material from one generation to the next is not as straightforward as merely enumerating the total number of spawning adults (census population size), biologists often employ a measure termed effective population size (N_e). The effective population size is roughly equivalent to the number of adults who successfully contribute genetic material to the next generation after accounting for variance in reproductive success, unequal sex ratios, and overlapping generations (among other parameters). Due to variance in reproductive success and unequal sex ratios in particular, the effective population size is typically some fraction of the census size of the spawning population over a generation. Of particular interest to hatchery managers is the effective number of breeders (N_b). N_b is simply the effective population size divided by the generation length of the species of interest (Waples 1990). For example, chinook salmon typically have a four year generation length, so $N_b=N_e/4$. Estimates of N_e and N_b can be obtained using a variety of equations that account for variation in reproductive success, unequal sex ratios, and overlapping generations (Allendorf and Ryman 1987; Waples 1990). The procedure most useful for calculating N_e or N_b depends on the availability of adequate data, and the factor(s) most likely to effect the transmission of genetic material from one generation to the next.

Once obtained, estimates of the effective number of breeders (N_b) are useful to calculate the minimum number of yearly adult returns necessary to maintain genetic variation at an acceptable rate. One method to measure the maintenance of genetic variation involves estimating the probability of maintaining rare alleles (alleles occurring in the population at a frequency of 0.01, for example). Once N_b is known, maintenance of rare alleles is a simple binomial probability: $P_{RA}=1-(1-P_R)^{8Nb}$ (modified from Kincaid 1996), where P_{RA} is the probability of rare allele retention for one generation, P_R is the frequency of the rare allele (0.01 in this case), and $8N_b$ is twice the generation length (4 in the case of chinook salmon) multiplied by N_b. The estimate can be carried out over several generations using the equation

$P_{RAT}=(P_{RA})^G$, where P_{RAT} is the probability of rare allele retention, P_{RA} is the probability of rare allele retention for one generation, and G is the number of generations of interest (i.e. 3) (modified from Kincaid 1996). A survey of the literature suggests that an acceptable conservation goal is the maintenance of a 95% probability of rare allele retention (Allendorf and Ryman 1987, Kapuscinski and Miller 1993). Using the above equations; $P_{RA}=1-(1-P_R)^{8Nb}=1-(1-0.01)^{8(38)}=0.95$. So, 38 effective breeders are necessary to maintain a 95% probability of rare allele retention for one generation. Over a longer time period, such as three generations, 38 effective breeders per year would maintain rare alleles with about an 87% probability; $P_{RAT}=(P_{RA})^G=(0.95)^3=0.87$.

Relating the equations listed above to a hatchery supported population requires an estimate of the ratio of the effective number of breeders (N_b) to census size (N=total number of adult returns). For example, if N_b is 40 and N is 160, the N_b/N ratio is 40/160=0.25. In other words four adult returns are roughly equivalent to one effective spawner. Therefore, to maintain a 95% probability of rare allele retention for one generation requires 38 effective breeders per year, or 38*4=152 total adult spawners per year.

2.2.2.1.4 Loss of Between Population Diversity

Loss of between population diversity refers to the loss of genetic differentiation between two or more populations. It should be noted that the loss of between population diversity does not imply a loss in genetic variation in any population (although this is possible), it merely describes the loss of "genetic identity" or "uniqueness" of two or more populations (homogenization). The mechanism resulting in loss of between population diversity is migration and successful reproduction of fish in non-natal locations (straying) or stock transfers. This risk should be evaluated regardless of the type of program considered.

Straying

Anadromous salmonids exhibit a high degree of fidelity to their natal stream when returning as adults to spawn (Quinn 1984). Approximately 90%, give or take 10%, of salmonids return to their natal stream (Grant 1997). However, some fraction of returning adults does not return to the natal stream, and instead spawns in alternate locations. This tradeoff is thought to be a mechanism for colonizing new habitat (Unwin and Quinn 1993) and maintaining genetic diversity within small populations (NMFS 1997). However, high rates of straying may lead to genetic homogenization, or a decrease in genetic differences between populations (Grant 1997). If straying leads to a loss of alternate alleles through genetic drift, it could be argued that straying might be detrimental due to the loss of genetic variability (Grant 1997). However, if straying increases genetic variability it could be argued to be a positive influence by increasing genetic variation. Whatever the case, management may seek to minimize straying by hatchery-reared individuals to minimize effects on non-target populations, hence maintaining between population variability.

Stock Transfers

Stock transfers, the active collection of fish from one population for use as broodstock or direct outplanting in another population, directly erodes between population diversity. Rather than maintaining a natural stray rate, adults returning after a stock transfer may constitute a substantial portion of the total return in the next generation. If stock transfers are repeated, the target stock may become genetically similar to the source population. Again, this result is not inherently detrimental (see above). However, the maintenance of adaptations to the local environment such as age at return or other life history traits may be disrupted by too much straying or by stock transfers (Quinn 1984). For example, it is hypothesized that several populations, each with unique genetic characteristics, may constitute a greater combined resiliency to environmental change than several genetically identical populations (Cooper and Mangel 1998).

2.2.2.2 Evaluation Criteria

As previously discussed, the probability of outbreeding depression increases as a function of genetic divergence. Since salmonids, in general, tend to be more genetically similar when geographically proximate, the probability of outbreeding depression increases as a function of geographic distance. Therefore, the probability of outbreeding depression is lowest when the source population(s) used as broodstock is the target population or a geographically proximate population. If the local broodstock source has a recent mixed stock history, the risk of outbreeding depression would be higher than if there had been no out-of-basin transfers.

Table 2-4 Outbreeding Depression Evaluation Criteria

Evaluation Criteria Categories	Category Score
Local broodstock source (target stock)	5
Local broodstock source (target stock), with mixed stock history	4
Transferred broodstock source (geographically proximate)	3
Transferred broodstock source (geographically distant , eg. adjacent ESU)	2
Transferred broodstock source (geographically distant, further than adjacent ESU)	1

The risk of inbreeding depression increases as the probability of mating between related individuals increases. Therefore, programs that maintain a large broodstock, or practice pedigree mating (deliberate avoidance of mating between related individuals, typically assessed genetically) decrease the probability of inbreeding depression. The probability of inbreeding depression among naturally spawning fish may be increased by programs that decrease the size of a naturally spawning population through broodstock collection.

Table 2-5 Inbreeding Depression Evaluation Criteria

Evaluation Criteria Categories	Category Score
Risk Factor: Non-Random Mating	
Pedigree mating in the hatchery and large naturally-spawning component	5
Large broodstock and large naturally spawning component	4
Large broodstock and small naturally spawning component	3
Small broodstock and large naturally spawning component	2
Small broodstock and small naturally spawning component	1

Artificial selection during broodstock collection and/or in the hatchery environment increases the probability of losing genetic diversity within a population. Therefore, systematic broodstock collection, and avoiding repeated artificial selection by incorporating naturally spawned adult returns decrease the probability of losing genetic variation. In addition, employing hatchery rearing techniques that mimic natural habitat (NATURES rearing) may decrease artificial selection within the hatchery environment. Finally, maintenance of genetic variation may require that broodstock collection goals maintain the yearly effective number of breeders (N_b) necessary to maintain rare genetic variation.

Table 2-6 Loss of Within Population Diversity Evaluation Criteria

Evaluation Criteria Categories	Category Score
Risk Factor: Non-representative Broodstock Collection	
Systematic sampling across adult returns (both naturally and hatchery-reared)	5
Systematic sampling across adult returns (hatchery-reared only)	4
Biased sampling of adult returns (both naturally and hatchery-reared) with respect to one life-history trait	3
Biased sampling of adult returns (both naturally and hatchery-reared) with respect to more than one life-history trait	2
Biased sampling of adult returns (hatchery-reared only) with respect to one or more life-history traits	1
Risk Factor: Artificial Selection	
Advanced NATURES rearing techniques	5
Some NATURES rearing techniques	4
Traditional rearing with acclimation	3
Traditional rearing	2
Risk Factor: Loss of Genetic Variability	
Maintenance of N_b necessary to maintain genetic variation with a 95% probability	5
No N_b threshold	3

The loss of between population diversity results from increasing gene flow between two genetically distinct populations, typically as a result of stock transfers or straying. Therefore, deriving broodstock from the target population, and employing acclimation techniques to imprint fish to the area of desired return decreases the probability of losing between population diversity.

Table 2-7 Loss of Between Population Diversity Evaluation Criteria

Evaluation Criteria Categories	Category Score
Risk Factor: Stock Transfers / Acclimation	
Acclimation near spawning sites, broodstock from target population	5
Acclimation near spawning sites, broodstock from proximate source	4
Traditional release (from hatchery), broodstock from local or proximate source	3
Traditional release from hatchery, broodstock from distant source	2
Acclimation near spawning sites and broodstock from distant source	1

2.2.3 ECOLOGICAL EFFECTS

Hatchery operations can affect the protected fish populations through competition, predation and overexploitation. It should be noted that a probability for the occurrence of these ecological interactions cannot be calculated with any degree of quantitative certainty.

2.2.3.1 Issues of Concern

The most obvious ecological effect of a supportive breeding program is an increase in the number of progeny and adults in the target population. As a result of increasing juvenile and adult abundance, increased levels of both competition and predation may occur. Further, an increase in adult returns may stimulate interest in a sport or commercial fishery, which could affect production of the naturally spawning population component.

2.2.3.1.1 Competition

Competition between the hatchery-reared and naturally spawned population components may occur if a resource or access to a resource is restricted. Competition may occur between individuals of the same species (intraspecific competition) or between individuals of different species (interspecific competition). Therefore, attempts to increase the population size of any one of the three protected species may adversely affect the others.

Competition is dependent not just on the numbers of fish; there are temporal and geographic aspects that also tie into the availability of resources. The life history of the three protected species results in approximately a four month to four year[2] residency in the freshwater environment of the Russian River from the egg to smolt stage, with a return years later as spawning adults. The temporal aspect of competition acknowledges that different life stages of the fish may experience differing levels of resource limitation, depending on the time and duration of resource utilization. Hatchery-reared fish released as smolts soon migrate to the ocean, and they consequently exhibit little likelihood of competing for freshwater resources utilized by naturally spawned fingerling rearing within the system. The exception is residuals, or individuals that do not undertake the typical migration to the ocean. This life-history trait is not uncommon for steelhead, which may residualize and remain in freshwater as rainbow trout. It should be noted also that smolts released through volitional release typically migrate out to the ocean at a faster rate than smolts released using traditional hatchery release methods.

The geographic aspect of competition acknowledges that competition can occur only where there is direct overlap of habitat utilization by similar life stages of the hatchery-reared and naturally spawned population components. To minimize competition, releases of fingerling should occur only in locations where the habitat capacity exceeds the requirements of the local naturally spawning fingerling population. This indicates the importance for resource managers to identify the area of habitat utilization for various life stages. Ideally, this information should be used to establish production goals for hatchery operations, specifying production numbers for specific sizes (i.e. life stages) and release locations. Further, for supplementation-type programs, there is a strong benefit of providing frequent updates to population surveys of both hatchery and naturally spawned fish. Adaptive management can then be used to evaluate and implement changes in program goals and/or techniques for artificial propagation.

2.2.3.1.2 Predation

The release of hatchery-reared juveniles can affect production among the naturally spawning population component through direct predation. For example, large hatchery-reared juveniles may consume smaller naturally reared juveniles of the same (Sholes and Hallock 1979) or other species (Cannamela 1992, 1993). Therefore, the release of hatchery-reared juveniles of a similar size as naturally spawned juveniles has been suggested as a means of limiting direct predation (Flagg and Nash 1999). However, if supportive breeding increases the number of adult returns, predation of juveniles of the same or other species may likewise increase. Unfortunately, predation by adults may be an unavoidable consequence of increased population size.

Release strategies may also play an important role in limiting predation. For example, traditional release strategies typically involve the direct release of a large number of hatchery-reared fish in one location at one point in time. The unfortunate result of this strategy may be the attraction of predators, or

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[2] Chinook salmon in the Russian River typically emigrate four months after emergence. Coho salmon emigrate approximately 15 months after emergence and steelhead may spend up to four years in freshwater before emigration (although two years is most common).

concentration of predators at the site of release. Further, hatchery releases are typically performed during daylight hours, which may make juveniles more vulnerable to visual predators (Flagg and Nash 1999). Implementing a production goal that produces only smolts and no fingerlings, and further allows the smolts to acclimate and volitionally leave the facility, may result in decreased predation. Fish leaving an acclimation site volitionally may be physiologically prepared for emigration to saltwater, minimizing residence time in the freshwater environment (Pascual *et al*. 1995). This has the dual benefit of minimizing predation of the hatchery-reared fish by freshwater predators, and minimizing predation of freshwater fish by hatchery-reared juveniles (Flagg and Nash 1999). There is also evidence that territorial aggressiveness decreases with the onset of smoltification (Iwata 1996).

2.2.3.1.3 Overexploitation

If sport or commercial harvest is allowed, management must be wary of the effect of harvest on the naturally spawning population. For example, if a hatchery program is successful at increasing the number of hatchery-reared adults returning to a stream, angler effort by both sport and commercial fisheries may be stimulated. If production by the naturally spawning component is not likewise increased, greater harvest efforts aimed at the hatchery component may result in overharvest of naturally spawned individuals (Ludwig 1995). Managers have attempted to decrease the effect of harvest on naturally spawned individuals by marking hatchery-reared adults and targeting fisheries on the capture of marked individuals. However, even mass-marking and selective fisheries may negatively affect natural populations through incidental mortality from capture and handling. Accurate assessments of the negative effects on natural populations from harvest targeting hatchery-reared adults require frequent surveys of the returning adult population and fishing effort.

2.2.3.2 Evaluation Criteria

Hatchery production may directly influence competition by exceeding habitat capacity of naturally spawned juveniles. There is a benefit to production goals that minimize temporal overlap in the hatchery-reared and naturally spawned components, suggesting a preference for smolt release programs over fingerling production. Where fingerling releases occur, stocking with hatchery-reared juveniles of a similar size to naturally spawned individuals may decrease the probability of deleterious competition. Also, minimizing geographic overlap of the two components is beneficial, focusing hatchery releases in areas where there is limited or no natural production. In all cases, the probability of assessing the current requirements of the protected populations will be directly related to the reliability of estimates of population distribution.

Table 2-8 Competition Evaluation Criteria

Evaluation Criteria Categories	Category Score
Risk Factor: Habitat use overlap between hatchery-reared and naturally spawned salmonid populations	
No overlap of temporal or geographic aspects	5
Overlap of temporal or geographic aspects in migration corridors only	4
Overlap of temporal or geographic aspects in rearing areas with low abundance of naturally spawning population	3
Overlap of temporal or geographic aspects in rearing areas with high abundance of naturally spawning population	2
Complete overlap of temporal and geographic aspects	1

Hatchery production may directly influence predation by releasing large progeny that have a competitive advantage and/or prey on smaller naturally spawned juveniles. Stocking with hatchery-reared juveniles of a similar size to naturally produced individuals may decrease the probability of deleterious predation. In addition, limiting the total amount of time during which these interactions may occur may decrease the absolute effect of predation. For example, fish released volitionally may immediately emigrate to the ocean, hence minimizing the time that they may prey on or compete with naturally-spawned juveniles. Research also indicates that territorial aggressiveness decreases with the onset of smoltification (Iwata 1996), suggesting that the release of fish actively smoltifying (ie. employing volitional release) may decrease predation.

Table 2-9 Predation Evaluation Criteria

Evaluation Criteria Categories	Category Score
Risk Factor: Release Size	
Hatchery-reared juveniles equivalent in size to naturally spawned juveniles	5
Hatchery-reared juveniles slightly larger (less than 50%) than naturally spawned juveniles	3
Hatchery-reared juveniles much larger (more than 50%) than naturally spawned juveniles	2
Risk Factor: Release Strategy	
Smolt releases only, with volitional release	5
Smolt releases only, with traditional release	4
Smolt and fingerling releases, with volitional release of smolts	3
Smolt and fingerling releases, with traditional release of smolts	2
Fingerling releases only	1

Overexploitation of naturally spawned adults may occur when fisheries are targeted toward more abundant hatchery-reared adults. Obviously, where harvest is prohibited, the probability of overexploitation is minimal;[3] however, when harvest is condoned, overexploitation may occur through direct harvest, or incidental mortality. If harvest is permitted, the probability of overexploitation is greater if quotas are based on the absolute number of returning adults rather than the number of naturally spawned returning adults. While overexploitation may still occur, visually marking hatchery-reared progeny allows mangers to target hatchery-reared adults in the fishery by allowing retention of only marked fish.

Table 2-10 Overexploitation Evaluation Criteria

Evaluation Criteria Categories	Category Score
No harvest	5
Harvest effort commensurate with minimized effects on natural production (requires surveys to assess natural production)	4
Hatchery-reared fish identifiable by visual mark harvest effort commensurate to hatchery production (No surveys to assess natural production)	3
Harvest effort commensurate to hatchery production (no surveys to assess natural production)	2
No limits on harvest	1

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[3] This statement refers to freshwater harvest, ocean fisheries may still affect some stocks for which freshwater harvest is prohibited.

EVALUATION OF EFFECTS ON PROTECTED SPECIES

The previous section identified potential effects that fish hatchery operations in general may have on natural steelhead trout, coho salmon, and chinook salmon. In addition, evaluation criteria were developed that reflect the whole range of typical hatchery operations. It was emphasized that many potential effects are influenced by independent and non-related operating procedures, and that an unfavorable condition in a single factor may not necessarily produce a significant effect to the system.

In Section 3, each of the identified potential effects is evaluated in the context of current DCFH and CVFF operations. The evaluation draws from the facility and operational information provided in Section 1 and indicates that individual practices may have an influence on one or more potential effects. Though many effects are not directly quantifiable, a semi-quantitative approach is presented by providing scores to the evaluation criteria developed in Section 2. The evaluation criteria scores include consideration of species differences.

3.1 WATER QUALITY

Effluent water quality discharge limits are established to meet beneficial use of the receiving waters. For DCFH, this includes Dry Creek and the Russian River. At CVFF, the beneficial uses are established for the East Fork Russian River below the outfall and the Russian River. Beneficial uses for both sites are the same and include the following uses applicable to the target species of this evaluation: cold freshwater habitat, preservation of rare and endangered species, fish migration and fish spawning (RWQCB 1997a and b). The daily maximum effluent limits established in the permits are created to meet these beneficial uses and allow for either a minimal acceptable change or no change to the receiving waters.

Both DCFH and CVFF have been in continuous compliance with their NPDES permit requirements (Table 3-1) (R. Gunter, pers. comm., 1999). During times of high turbidity in the influent water, the hatchery may actually discharge water less turbid than that received, thereby benefiting the receiving waters. The dissolved oxygen level in the receiving waters during times of low flows may drop below the 7mg/L limit and therefore may benefit from the hatchery maintaining a > 7mg/L effluent limit. Effluent from the hatchery will contribute to the total load of solids in the receiving waters. The settleable and suspended solid level discharged are slightly higher that incoming water, but are within the limits of the NPDES permits (R. Gunter, pers. comm., 1999).

Based on the current operation of these hatcheries and the continued compliance with their NPDES discharge permits, water quality of the hatchery effluent is not likely to significantly degrade water quality in Dry Creek or the East Fork Russian River.

Table 3-1 Water Quality Evaluation Criteria and Scoring by Species

Evaluation Criteria Categories	Category Score	Current Operations Score by Species
Continuous compliance with NPDES standards	5	Steelhead, coho and chinook
Compliance with 75-99% of standards	4	
Compliance with 50-74% of standards	3	
Compliance with 25-49% of standards	2	
Compliance with 0-24% of standards	1	

3.2 FISH POPULATIONS

3.2.1 DISEASE

3.2.1.1 Introduction of New Pathogens

The curtailment of past practices of stock importation from sources geographically distant to the Russian River has greatly reduced the risk of introduction of new pathogens. Importation of stocks from populations outside the Russian River occurs at DCFH only with fall chinook eggs from the Eel River.

A significant amount of water in the Russian River during the summer above Healdsburg comes from the diversion of the Eel River via the Potter Valley Project into Coyote Dam. Although there is no conclusive evidence, there is strong speculation that the significant presence of Eel River flow in the Russian River may serve as an attractant to draw Eel River adult strays into the Russian River. The potential for increased stray rates therefore result in an increased potential for introduction of pathogens through this activity (Dr. W. Cox, pers. comm., 1999). Adults reaching spawning maturation can shed large quantities of pathogens if they are infected. These straying adults could present a greater risk of pathogen introduction to the Russian River than egg lots transferred to DCFH. The eggs lots transferred into DCFH are disinfected for surface pathogens. Pathogens carried within the eggs would still potentially be introduced to the Russian River watershed, but these pathogens would also be potentially introduced by the straying adults from Eel River and the resultant progeny from these adults. The fish reared at DCFH from this source are returned to the Eel River and not released into the Russian River. There is consequently very little likelihood of direct contact and pathogen transmission from the Eel River stock to the protected populations.

3.2.1.2 Amplification and Dissemination of Pathogens

DCFH and CVFF have implemented numerous changes to their spawning, disinfection, hatching and rearing protocols to produce healthy fish and reduce the incidence of disease. They have also introduced prophylactic treatments to help reduce the effect from bacterial coldwater disease. Based on recent history at the facilities, it is rare for disease occurrences to result in significant mortality. Effects associated with pathogens known to occur at DCFH or CVFF are detailed below.

Flexibacter psychrophilus (Bacterial Coldwater Disease)*:* Under current management practices, the risk of amplification or dissemination of this pathogen is low as fish typically respond well to treatment. Coho and steelhead are more susceptible to this disease than chinook and hence are likely to experience a slightly greater effect from pathogen transmission to the protected populations.

Renibacterium salmoninarum (Bacterial Kidney Disease)*:* Because steelhead are typically not affected by this pathogen, this pathogen will have a greater effect on chinook and coho salmon. *R. salmoninarum* is known to occur throughout a large geographical area, especially where chinook and coho salmon occur. While the health status of the listed chinook and coho stocks in the Russian River is unknown, it is highly likely that these stocks would test positive for this pathogen. With the limited number of adult coho and chinook returning to DCFH and with the implementation of spawning protocols involving sanitation, adult testing and segregation of progeny, the risk of amplification of this pathogen is low. Since the protected populations are likely to be already infected with this pathogen, the effect of increased exposure from the hatchery would likely be very limited. Dissemination of this pathogen could occur only if the Russian River was found to be free of *Renibacterium salmoninarum.*

Gyrodactylus, Costia (Ichtyobodo) and *Trichodina* (external parasites): Risk for amplification of these parasites is dependent on the annual rearing conditions at the hatchery. Because the fish are reared on surface water, poor water quality would increase the effect of these parasites. Additionally, rearing densities at the hatchery will also influence the effect of the parasites. Under the current operating procedures, it appears that external parasites are not a major problem. Therefore, there is little likelihood of affecting the protected populations through amplification of this parasite. These parasites are very widespread in their distribution, suggesting a very low likelihood that hatchery operations would result in dissemination of these parasites to the protected populations.

Fungal Infections: Hatchery operations may impact the numbers of adults which come into contact with the protected populations while travelling in common migration corridors of the Russian River. However, it is believed that this will have an insignificant effect on the amplification and dissemination of fungal pathogens to the protected populations due to the widespread presence of fungal pathogens in the aquatic environment.

3.2.1.3 Evaluation Criteria

Scoring of evaluation criteria for disease-related operations is presented in Table 3-2. There is little likelihood of affecting protected populations through introduction of new pathogens, since there is no importation of steelhead or coho, and only a limited amount of importation of chinook conducted at the egg stage using certified stocks. There is little likelihood of affecting the protected populations through amplification of disease, since the pathogens that appear at the facilities are generally of a routine nature that respond well to the fish health management practices used for their control. Finally, there is a negligible likelihood of affecting the protected populations through dissemination of pathogens, since the hatchery program involves no transfers of coho or chinook, and steelhead transfers utilize fish reared entirely within the Russian River system.

Table 3-2 Disease Evaluation Criteria and Scoring by Species

Evaluation Criteria Categories	Category Score	Current Operations Score by Species
Risk Factor: Introduction of New Pathogens		
No importation of eggs or fish	5	Steelhead and coho
Importation of certified eggs from within region	4	Chinook
Importation of certified eggs from outside region	3	
Importation of fish from within region	2	
Importation of certified fish from outside region	1	
Risk Factor: Disease Amplification		
Good health record; no need for therapeutic treatment	5	
Good health record; good fish health management practices	4	Steelhead, coho and chinook
Fair health record; therapeutic treatment required – good response	3	
Fair health record; therapeutic treatment required – no response	2	
Frequent serious disease outbreak with epizootic mortality	1	
Risk Factor: Disease Dissemination		
No transfer between facilities	5	Coho and chinook
Transfer with inspection between DCFH and CVFF	4	Steelhead
Transfer without inspection between other facilities within watershed	3	
Transfer with inspection between facilities outside of watershed	2	
Transfer between facilities outside of basin without inspection	1	

3.2.2 GENETICS

3.2.2.1 Outbreeding Depression

Since salmonids exhibit a strong homing instinct and exhibit age-structured or overlapping generations, it is possible that populations may develop unique coadaptations, karyotypes, or local adaptations. It follows that a population possessing a unique coadaptation, karyotype, or local adaptation may be negatively affected by introgression from a genetically divergent stock. Therefore, the likelihood of outbreeding depression increases as genetic divergence between the target stock and hatchery stock increases. Theoretically, supportive breeding programs that derive broodstock from the target population would avoid mixture of genetically divergent individuals, minimizing the risk of outbreeding depression.

Since genetic divergence requires reproductive isolation or strong differential selection, geographically proximate stocks experiencing similar selective regimes may be more genetically similar than two stocks which are geographically distant and/or subject to different selective pressures. In addition, gene flow in the form of straying is more likely between proximate stocks, which suggests that proximate stocks may be less genetically divergent than geographically distant stocks. Functionally, the risk of outbreeding depression affects all life stages and species considered in this report.

Current operations were given a score of 4 for the risk of outbreeding depression for all three species (Table 3-3). Broodstocks for chinook salmon, coho salmon, and steelhead supportive breeding were previously derived in part by adult capture within the Russian River, and via stock transfers from a variety of sources (see Section 2.2.2.2.1). Beginning in 1998, all broodstock for mitigation and/or enhancement of all three salmonid species were derived solely as adult captures within the Russian River. Given the recent shift in broodstock collection protocols toward the target stocks, the risk of outbreeding depression as a result of operation of DCFH and CVFF is currently low. However, given the mixed stock history of DCFH and CVFF, adults currently returning to the facility may be of mixed origin, therefore the risk of outbreeding depression is potentially higher than would be the case had broodstock always been collected locally. Given the recent shift to local sources of broodstock, the operation of DCFH and CVFF are not likely result in outbreeding depression in naturally spawning Russian River chinook salmon, coho salmon, or steelhead.

Table 3-3 Outbreeding Depression Evaluation Criteria and Scoring by Species

Evaluation Criteria Categories	Category Score	Current Operations Score by Species
Local broodstock source (target stock)	5	
Local broodstock source (target stock), with mixed stock history	4	Steelhead, coho and chinook
Transferred broodstock source (geographically proximate)	3	
Transferred broodstock source (geographically distant , eg. adjacent ESU)	2	
Transferred broodstock source (geographically distant, further than adjacent ESU)	1	

3.2.2.2 Inbreeding Depression

At the most basic level, maintaining large population sizes in both the hatchery and wild components decrease the probability of inbreeding depression. Evidence suggests that salmonids may recognize siblings (Quinn and Busack 1985) and therefore avoid mating with close relatives, hence minimizing inbreeding depression in the wild. Unfortunately, in the hatchery, fish are typically spawned without prior knowledge of their relation. In other words, there is some probability that a male and female cross in the hatchery may be a direct mating of siblings (sib-mating). It follows that the probability of a sib-mating increases as broodstock size decreases. The probability of sib-mating also increases as variance in reproductive success increases. For example, if 100 adults return from a single spawning male and female pair, while the spawn from another pair returns only three, broodstock collection may unknowingly over-represent adult returns from the more successful pair. The result would be an increase in the probability of two siblings from the more successful pair being spawned together in the hatchery.

Unfortunately, methods to minimize accidental inbreeding in the hatchery environment are not cost-effective or realistic for a large broodstock. However, if the broodstock size is relatively small, pedigrees can be constructed using microsatellite DNA markers or mitochondrial DNA markers allowing recognition of siblings. Management could then actively seek to avoid mating close relatives. Due to the added expense and difficulty of obtaining positive individual family identification in a timely manner, pedigree mating is uncommon. Therefore, the most common approach to minimizing inbreeding in the hatchery environment is to maintain a large broodstock to lower the probability of an accidental sib-mating. The effect of inbreeding occurs functionally in all life stages following the inbreeding event, and is a concern for all species considered in this report.

Over the last four years, the numbers of female chinook, coho, and steelhead used as broodstock have decreased considerably, reflecting the shift to local broodstock sources in 1998 (see Section 2.2.2.2.2). The number of chinook salmon spawned over the last four years is well below the minimum of 100 adult pairs suggested by Allendorf and Ryman (1987), suggesting that chinook salmon likely have an unfavorable level of inbreeding. Coho salmon were present in numbers well above the suggested minimum in every year except 1998, suggesting that the risk of inbreeding depression is likely quite low. Steelhead were well above the minimum suggested broodstock size, suggesting that they are not at risk of inbreeding depression.

Currently, there are no reliable estimates regarding the size of the naturally spawned populations of the three species of interest within the Russian River. Gross observation suggests that naturally spawning chinook and coho salmon are rare, while naturally spawning steelhead are more abundant. Therefore, the risks of inbreeding depression from current operations were given a score of 4 for steelhead, 3 for coho, and 1 for chinook salmon (Table 3-4).

Due to the lack of adult return estimates for the naturally spawning Russian River chinook salmon, coho salmon, and steelhead, we cannot speculate on the potential effects of inbreeding within the hatchery environment on natural production. However, if healthy naturally spawning chinook and coho salmon populations exist in the Russian River, inbreeding in the hatchery environment coupled with natural spawning between hatchery and naturally reared chinook and coho is likely to negatively affect natural production. Hatchery-reared steelhead, on the other hand, are unlikely to suffer from inbreeding depression, and hence are unlikely to negatively affect naturally spawning steelhead through the mechanism of inbreeding depression.

Table 3-4 Inbreeding Depression Evaluation Criteria and Scoring by Species

Evaluation Criteria Categories	Category Score	Current Operations Score by Species
Risk Factor: Non-Random Mating		
Pedigree mating in the hatchery and large naturally-spawning component	5	
Large broodstock and large naturally spawning component	4	Steelhead
Large broodstock and small naturally spawning component	3	Coho
Small broodstock and large naturally spawning component	2	
Small broodstock and small naturally spawning component	1	Chinook

3.2.2.3 Loss of Within Population Diversity

Minimizing the loss of within-population diversity requires that the genetic variability of the target population is adequately represented in the hatchery (genetically representative broodstock collection), and that artificial selection within the hatchery is minimized. In part, this relies on measures to minimize inbreeding depression and genetic drift as discussed above. In addition, supportive breeding programs may aggressively seek to maintain genetic diversity. The loss of within-population diversity affects all life stages and all species considered in this report.

Three primary risk factors were formulated in regard to the loss of within-population diversity; adequate representation of the population in broodstock collection, artificial selection, and maintenance of a broodstock size commensurate with the maintenance of genetic diversity (Table 3-5). A score of 5 was given for the risk of non-representative broodstock collection for all three species. Currently, steelhead broodstock is collected systematically across the entire adult return with weekly capture goals formulated by a 9 to 11 year mean for each species. Due to the low number of returning adults, all chinook and coho returning to the hatchery facility are retained as broodstock. In effect, this practice has the same result as the systematic collection technique employed for steelhead. In practice, returning hatchery-reared individuals are the primary source of broodstock, although naturally spawned adults are retained whenever possible.

Hatchery rearing follows traditional techniques, suggesting that there is some risk of artificial selection within the hatchery environment. In addition, since naturally spawned individuals are rarely captured, there is a risk of domestication as a result of repeated artificial selection imposed on the hatchery-reared component of the population. Finally, broodstock quotas are selected on the basis of desired production rather than a minimum threshold necessary for the maintenance of genetic diversity, increasing the risk for loss of genetic variability. Therefore a score of 3 was given for all three species. However, for steelhead, in an attempt to increase genetic diversity, more individuals are spawned than are necessary to achieve production goals. Surplus eggs are then randomly destroyed to avoid surplus production.

With regard to loss of within population diversity, hatchery-reared chinook salmon, coho salmon, and steelhead are likely to deleteriously affect naturally spawning conspecifics if interbreeding is allowed[1]. Broodstock collection procedures are likely adequate, and unlikely to adversely affect the naturally spawning population component. However, since broodstock is primarily derived from hatchery-reared adult returns, the potential exists for repeated artificial selection, and associated loss of genetic variation. In addition, the lack of genetic criteria in broodstock collection goals suggests that genetic variability may not be maintained within the hatchery-reared chinook salmon, coho salmon, and steelhead population components.

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[1] The re-release of steelhead that are surplus to broodstock requirements may provide a mechanism for introgression between the hatchery and naturally reared population components. However, data regarding the spawning success of re-released steelhead are unavailable.

Table 3-5 Loss of Within Population Diversity Evaluation Criteria and Scoring by Species

Evaluation Criteria Categories	Category Score	Current Operations Score by Species
Risk Factor: Non-representative Broodstock Collection		
Systematic sampling across adult returns (both naturally and hatchery-reared)	5	Steelhead, chinook, and coho
Systematic sampling across adult returns (hatchery-reared only)	4	
Biased sampling of adult returns (both naturally and hatchery-reared) with respect to one life-history trait	3	
Biased sampling of adult returns (both naturally and hatchery-reared) with respect to more than one life-history trait	2	
Biased sampling of adult returns (hatchery-reared only) with respect to one or more life-history traits	1	
Risk Factor: Artificial Selection		
Advanced NATURES rearing techniques	5	
Some NATURES rearing techniques	4	
Traditional rearing with acclimation	3	Steelhead (CVFF)
Traditional rearing	2	Steelhead (DCFH), coho and chinook
Risk Factor: Loss of Genetic Variability		
Maintenance of N_b necessary to maintain genetic variation with a 95% probability	5	
No N_b threshold	3	Steelhead, coho and chinook

3.2.2.4 Loss of Between Population Diversity

The risk of losing between population diversity may be decreased by maximizing homing among the hatchery-reared component of the composite population and by avoiding stock transfers. Straying can be minimized by rearing and acclimation using water from the stream to which adults are expected to return (Dittman *et al*. 1994, 1996). Therefore, the loss of between population diversity can be decreased by acclimation facilities. The loss of between population genetic integrity, if detrimental, would adversely affect all life stages and all species considered in this report.

Scores for current hatchery operations are given in Table 3-6. Despite the history of repeated stock transfers within the Russian River, currently all adults retained as broodstock are captured in the Russian River. Given the magnitude and duration of historical stock transfers, it is likely that naturally spawning chinook salmon, coho salmon, and steelhead within the Russian River represent a genetic conglomerate of many stocks. Similarly, the adults used as broodstock likely are themselves descendants of many stocks. While the history of stock transfers in the Russian River suggests that between population diversity has been compromised, if the policy of collecting broodstock from returns to the Russian River is maintained, selection and genetic drift will likely give rise to Russian River specific stocks. In the meantime, the broodstock returning to the hatchery have not likely recovered from the past practice of stock transfers, and the current status of broodstock source will be considered as a proximate source, as compared to a true target population source.

Currently, chinook, coho, and steelhead are acclimated to a certain degree within the Russian River, suggesting that straying to non-natal rivers is unlikely to be of great concern. Most steelhead are acclimated at CVFF, and allowed volitional release. Chinook salmon and coho salmon are not directly acclimated *per se*, however rearing uses Lake Sonoma water and release occurs approximately three miles downstream from the hatchery. In each case, all three species would be expected to return to capture facilities rather than non-natal tributaries. Therefore, current hatchery operations within the Russian River are unlikely to negatively affect between population diversity.

Table 3-6 Loss of Between Population Diversity Evaluation Criteria and Scoring by Species

Evaluation Criteria Categories	Category Score	Current Operations Score by Species
Risk Factor: Stock Transfers / Acclimation		
Broodstock from local target population, acclimation near spawning sites	5	
Broodstock from proximate population, acclimation near spawning sites	4	Steelhead from CVFF
Broodstock from local or proximate source, traditional release (from hatchery)	3	Coho, chinook, and steelhead from DCFH
Broodstock from distant source, acclimation near spawning sites	2	
Broodstock from distant source, traditional release (from hatchery)	1	

3.2.3 ECOLOGICAL EFFECTS

3.2.3.1 Competition

Releasing hatchery-reared progeny in areas where there is no temporal or geographic overlap with the naturally spawning component may be the best means available to limit the deleterious effects of competition. A score of 4 was given to fish released from DCFH, since the program releases only smolts and yearling and the release location is in the migration corridor where there is little rearing habitat. The steelhead released from CVFF were given a score of 2, since the release location is higher in the basin and there is the potential that the smolts may residualize (Table 3-7).

The limiting factor in the Russian River is generally thought to be rearing habitat, particularly for larger juveniles, due to the lack of large woody debris. Since only smolts are released, and since they are not released in primary spawning and rearing tributaries, the risk of competition between hatchery and wild fish is low. The life history stage most likely to be affected would be wild smolts in the river downstream of release points (particularly in Dry Creek, and to a lesser extent, the mainstem). Since these fish tend to leave the system quickly, the length of time they may be exposed to competition from hatchery fish is minimal. In our best professional judgement there is a low risk of competition, with deleterious impacts primarily affecting naturally spawned smolts.

Table 3-7 Competition Evaluation Criteria and Scoring by Species

Evaluation Criteria Categories	Category Score	Current Operations Score by Species
Risk Factor: Habitat use overlap between hatchery-reared and naturally spawned salmonid populations		
No overlap of temporal or geographic aspects	5	
Overlap of temporal or geographic aspects in migration corridors only	4	Coho, steelhead and chinook (DCFH)
Overlap of temporal or geographic aspects in rearing areas wiht low abundance of naturally spawning population	3	
Overlap of temporal or geographic aspects in rearing areas with high abundance of naturally spawning population	2	Steelhead (CVFF)
Complete overlap of temporal and geographic aspects	1	

3.2.3.2 Predation

The risk for predation was assessed with two components, release size and release strategy. Scores are given in Table 3-8. Currently, hatchery-reared chinook, coho, and steelhead are released at a larger size than their naturally spawned counterparts, suggesting that direct predation may occur if release areas overlap areas of natural production. However, releases are not made in primary rearing or spawning areas, which generally occur in smaller tributaries. The risk of predation is somewhat minimized for steelhead as a result of the volitional release strategy employed at CVFF. Presumably, steelhead leaving this facility emigrate immediately to the ocean, hence minimizing the period of time when freshwater predation might occur. Coho are generally the most aggressive predators on other fish, but their numbers are low. While chinook and coho are not volitionally released, they are sorted by size, and larger individuals are released while smaller individuals are retained until reaching a larger size. Larger individuals may emigrate more quickly than smaller individuals, hence decreasing the risk of freshwater predation.

Since hatchery-reared juveniles of all three species are larger than their naturally spawned counterparts, the potential exists that hatchery-reared juveniles may prey on or outcompete naturally spawned juveniles. However, given that releases are not made in primary spawning or rearing areas, and that smolts are not likely to spend a great deal of time in the system, the opportunity for predation is probably low. However, if chinook and coho salmon utilize mainstem habitat for spawning, their progeny may be subject to predation by hatchery-reared juveniles during their emigration.

Table 3-8 Predation Evaluation Criteria and Scoring by Species

Evaluation Criteria Categories	Category Score	Current Operations Score by Species
Risk Factor: Release Size		
Hatchery-reared juveniles equivalent in size to naturally spawned juveniles	5	
Hatchery-reared juveniles slightly larger (<50%) than naturally spawned juveniles	3	
Hatchery-reared juveniles much larger (>50%) than naturally spawned juveniles	2	Steelhead, coho and chinook
Risk Factor: Release Strategy		
Smolt releases only, with volitional release	5	Steelhead released from CVFF
Smolt releases only, with traditional release	4	Coho, chinook, and steelhead from DCFH
Smolt and fingerling releases, with volitional release of smolts	3	
Smolt and fingerling releases, with traditional release of smolts	2	
Fingerling releases only	1	

3.2.3.3 Overexploitation

A score of 3 was given for the risk of overexploitation for steelhead and chinook, since hatchery-reared adults are marked and distinguishable from naturally spawned adults (Table 3-9). Coho salmon were given a score of 5, since harvest is not currently allowed. There are no current estimates of natural production by chinook, coho, or steelhead within the Russian River, suggesting that managers are unable to determine the effects of harvest on the naturally spawning component of these populations. Regulations prohibit the take of naturally spawned individuals by allowing anglers to harvest only those fish with clipped adipose fins. While this strategy minimizes direct fishing mortality, indirect effects such as hooking mortality and harassment may still affect naturally spawning populations. Therefore, we conclude that the selective fishery promoted by Russian River hatchery operations are likely to deleteriously affect naturally spawned adults. However, the magnitude of this effect is not quantifiable at this time.

Table 3-9 Overexploitation Evaluation Criteria and Scoring by Species

Evaluation Criteria Categories	Category Score	Current Operations Score by Species
No harvest	5	coho
Harvest effort commensurate with minimized effects on natural production (requires surveys to assess natural production)	4	
Hatchery-reared fish identifiable by visual mark harvest effort commensurate to hatchery production (No surveys to assess natural production)	3	Steelhead and chinook
Harvest effort commensurate to hatchery production (No surveys to assess natural production)	2	
No limits on harvest	1	

Fish production facilities were developed at DCFH and CVFF to both mitigate for the loss of steelhead and coho spawning and rearing habitat upstream of Warm Springs and Coyote Valley Dams, and to enhance coho and chinook salmon populations. Based on operational records, the facilities are successful with spawning, early rearing and release of juvenile fish. However, actual returns of adults to the facilities have been far below the projected return rates. This may be due to conditions in the marine environment beyond the control of the fish facilities.

Potential effects on protected steelhead, coho and chinook in the Russian River basin that may arise from the existing fish facility operations were evaluated. In general, there is a low risk of adverse effects to protected populations, but there is a low risk of some adverse effects. The current operations at DCFH and CVFF are likely to adversely affect protected populations, and are not likely to adversely modify critical habitat. This section provides key findings to support this generalization, alongside a summary presentation of the evaluation criteria scoring tables developed in Section 3.

4.1 WATER QUALITY

Based on continuous compliance with NPDES discharge permits, which take into account habitat requirements for salmonids, the current discharge is not likely to degrade receiving waters in Dry Creek or the East Fork Russian River (Table 4-1).

Table 4-1 Water Quality Evaluation Criteria and Scoring by Species

Evaluation Criteria Categories	Category Score	Current Operations Score by Species
Continuous compliance with NPDES standards	5	Steelhead, coho and chinook
Compliance with 75-99% of standards	4	
Compliance with 50-74% of standards	3	
Compliance with 25-49% of standards	2	
Compliance with 0-24% of standards	1	

4.2 DISEASE

Three effects were evaluated: introduction of new pathogens, amplification of fish pathogens, and dissemination of fish pathogens (Table 4-2).

The curtailment of past practices of stock importation from sources geographically distant to the Russian River has greatly reduced the risk of introduction of new pathogens. Importation of stocks from populations outside the Russian River occurs at DCFH with fall chinook eggs from the Eel River. Therefore, effects on the protected populations in the Russian River from these activities are very minor.

Based on the current operating practices of DCFH and CVFF, the risk of amplification or dissemination of fish pathogens is low. The hatcheries have implemented numerous changes to their spawning, disinfection, hatching and rearing protocols to produce healthy fish and reduce the incidence of disease. They have also introduced prophylactic treatments to help reduce the effect from bacterial coldwater disease. If an occurrence of high mortality from a pathogen occurred, the risk for amplification of that pathogen would be increased. However, based on recent history at the facilities, this kind of mortality is an infrequent occurrence.

Table 4-2 Disease Evaluation Criteria and Scoring by Species

Evaluation Criteria Categories	Category Score	Current Operations Score by Species
Risk Factor: Introduction of New Pathogens		
No importation of eggs or fish	5	Steelhead and coho
Importation of certified eggs from within region	4	Chinook
Importation of certified eggs from outside region	3	
Importation of fish from within region	2	
Importation of certified fish from outside region	1	
Risk Factor: Disease Amplification		
Good health record; no need for therapeutic treatment	5	
Good health record; good fish health management practices	4	Steelhead, coho and chinook
Fair health record; therapeutic treatment required – good response	3	
Fair health record; therapeutic treatment required – no response	2	
Frequent serious disease outbreak with epizootic mortality	1	
Risk Factor: Disease Dissemination		
No transfer between facilities	5	Coho and chinook
Transfer with inspection between DCFH and CVFF	4	Steelhead
Transfer without inspection between other facilities within watershed	3	
Transfer with inspection between facilities outside of watershed	2	
Transfer between facilities outside of basin without inspection	1	

4.3 GENETIC EFFECTS

Four effects were evaluated: outbreeding depression, inbreeding depression, loss of within population diversity (also referred to as domestication), and loss of between population diversity.

Outbreeding Depression

Beginning in 1999, all broodstock for mitigation and/or enhancement of all three salmonid species were derived solely as adult captures within the Russian River. Given this shift in broodstock collection protocols toward the target stocks, the risk of outbreeding depression is currently low as a result of operations of DCFH and CVFF (Table 4-3). However, given the mixed stock history of DCFH and CVFF, adults currently returning to the facility may be of mixed origin, therefore the risk of outbreeding depression is potentially higher than would be the case had broodstock always been collected locally.

Table 4-3 Outbreeding Depression Evaluation Criteria and Scoring by Species

Evaluation Criteria Categories	Category Score	Current Operations Score by Species
Local broodstock source (target stock)	5	
Local broodstock source (target stock), with mixed stock history	4	Steelhead, coho and chinook
Transferred broodstock source (geographically proximate)	3	
Transferred broodstock source (geographically distant , eg. adjacent ESU)	2	
Transferred broodstock source (geographically distant, further than adjacent ESU)	1	

Inbreeding Depression

Table 4-4 summarizes current operations scores for the risk of inbreeding depression. Over the last four years, the numbers of female chinook and coho salmon used as broodstock has decreased considerably, reflecting the shift to local broodstock rather than out of basin sources. The number of chinook salmon spawned over the last four years is well below the suggested minimum of 100 adult pairs. Therefore, chinook salmon may have an unfavorable level of inbreeding. Coho salmon were present in numbers well above the suggested minimum in every year except 1998, suggesting that the risk of inbreeding depression is likely low. Steelhead broodstock was maintained well above the minimum suggested size, indicating that they are not at risk of inbreeding depression.

Table 4-4 Inbreeding Depression Evaluation Criteria and Scoring by Species

Evaluation Criteria Categories	Category Score	Current Operations Score by Species
Risk Factor: Non-Random Mating		
Pedigree mating in the hatchery and large naturally-spawning component	5	
Large broodstock and large naturally spawning component	4	Steelhead
Large broodstock and small naturally spawning component	3	Coho
Small broodstock and large naturally spawning component	2	
Small broodstock and small naturally spawning component	1	Chinook

Loss of Within Population Diversity

Three primary risk factors were formulated in regard to the loss of within population diversity, also referred to as domestication (Table 4-5). The first risk factor examined adequate representation of the population in broodstock collection. Currently, broodstock is collected systematically across the entire adult return, or includes all captured adults. Therefore, broodstock collection practices are unlikely to adversely affect the naturally spawning population components. The second risk factor examined artificial selection. DCFH and CVFF utilize traditional rearing techniques, suggesting that there is some risk of artificial selection within the hatchery environment. In addition, since naturally spawned individuals are rarely captured, there is a risk of domestication as a result of repeated artificial selection imposed on the hatchery-reared component of the population. Finally, the third risk factor examined maintenance of a broodstock size commensurate with the maintenance of genetic diversity. Currently, broodstock quotas are selected on the basis of desired production rather than a minimum threshold necessary for the maintenance of genetic diversity. However, in an attempt to increase genetic diversity, more individuals are spawned than are necessary to achieve production goals. Surplus eggs are then randomly destroyed to avoid surplus production.

Table 4-5 Loss of Within Population Diversity Evaluation Criteria and Scoring by Species

Evaluation Criteria Categories	Category Score	Current Operations Score by Species
Risk Factor: Non-representative Broodstock Collection		
Systematic sampling across adult returns (both naturally and hatchery-reared)	5	Steelhead, chinook, and coho
Systematic sampling across adult returns (hatchery-reared only)	4	
Biased sampling of adult returns (both naturally and hatchery-reared) with respect to one life-history trait	3	
Biased sampling of adult returns (both naturally and hatchery-reared) with respect to more than one life-history trait	2	
Biased sampling of adult returns (hatchery-reared only) with respect to one or more life-history traits	1	
Risk Factor: Artificial Selection		
Advanced NATURES rearing techniques	5	
Some NATURES rearing techniques	4	
Traditional rearing with acclimation	3	Steelhead (CVFF)
Traditional rearing	2	Steelhead (DCFH), coho and chinook
Risk Factor: Loss of Genetic Variability		
Maintenance of N_b necessary to maintain genetic variation with a 95% probability	5	
No N_b threshold	3	Steelhead, coho and chinook

Loss of Between Population Diversity

Table 4-6 shows current operations scores for the risk of loss of between population diversity, or genetic integrity of Russian River stocks. While the history of stock transfers in the Russian River suggests that between population diversity has been compromised, the 1999 policy change requiring broodstock collection from returns to the Russian River will likely give rise to Russian River specific stocks. Further, current release strategies suggest that straying to non-natal rivers is unlikely to be a great concern.

Table 4-6 Loss of Between Population Diversity Evaluation Criteria and Scoring by Species

Evaluation Criteria Categories	Category Score	Current Operations Score by Species
Risk Factor: Stock Transfers / Acclimation		
Broodstock from local target population, acclimation near spawning sites	5	
Broodstock from proximate population, acclimation near spawning sites	4	Steelhead released from CVFF
Broodstock from local or proximate source, traditional release (from hatchery)	3	Coho, chinook, and steelhead released from DCFH
Broodstock from distant source, acclimation near spawning sites	2	
Broodstock from distant source, traditional release (from hatchery)	1	

4.4 ECOLOGICAL EFFECTS

Three effects were evaluated: competition, predation and overexploitation.

Competition

There are only very limited data to assess the potential for competition between or among the three protected species or other fauna present in the Russian River. However, current conditions appear favorable with respect to three aspects of competition: release numbers, temporal and life stage aspects, and geographical aspects (Table 4-7). Current production goals call for release of smolts only. Since smolts emigrate to the ocean soon after release, they are in the watershed competing with the protected populations for limited Russian River resources for only a limited time. Secondly, the majority of releases occur low in the basin in Dry Creek, leaving a majority of the watershed unaffected by hatchery releases. Thirdly, though by gross observation only, the numbers of naturally spawning chinook and coho salmon in the Russian River are so low that it does not seem feasible they could be near the habitat capacity of the system. By contrast, naturally spawning steelhead are present in substantial numbers, suggesting that the risk of competition may be an issue. However, since we lack the data to adequately assess competitive effects for Russian River salmon, we cannot estimate direct effects of competition *per se*, therefore we have ranked production management with regards to risk aversion techniques used at other facilities. There is a negligible risk of competition for chinook and coho salmon with the fingerling component of the protected populations, and very low risk of competition with smolts and returning adults. Hatchery production of steelhead, on the other hand, may contribute to competition among adults returning to spawn naturally within the Russian River if some hatchery-reared steelhead spawn naturally. In addition, the outplanting of surplus hatchery-reared steelhead[1], should they seek to spawn, may increase competition within the naturally spawning population for spawning habitat and mates. Finally, if hatchery-reared steelhead residualize (remain as rainbow trout, rather than emigrating) at a high rate, competition may occur throughout the freshwater life history stages of steelhead and rainbow trout. Since steelhead from DCFH are released lower in the basin than CVFF steelhead, the potential for competitive effects is less at DCFH.

Table 4-7 Competition Evaluation Criteria and Scoring by Species

Evaluation Criteria Categories	Category Score	Current Operations Score by Species
Risk Factor: Habitat use overlap between hatchery-reared and naturally spawned salmonid populations		
No overlap of temporal or geographic aspects	5	
Overlap of temporal or geographic aspects in migration corridors only	4	Coho, steelhead and chinook (DCFH)
Overlap of temporal or geographic aspects in rearing areas wiht low abundance of naturally spawning population	3	
Overlap of temporal or geographic aspects in rearing areas with high abundance of naturally spawning population	2	Steelhead (CVFF)
Complete overlap of temporal and geographic aspects	1	

Predation

Two components for predation were scored, release size and release strategy (Table 4-8). Currently, hatchery-reared chinook, coho, and steelhead are released at a larger size than their naturally spawned counterparts, suggesting that direct predation is likely to occur if release areas overlap areas of natural

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[1] Those steelhead returning to the hatchery that are not required to meet production goals.

production. However, releases are not generally made in primary spawning or rearing habitat. The risk of predation is somewhat minimized for steelhead as a result of the volitional release strategy employed at CVFF.

Table 4-8 Predation Evaluation Criteria and Scoring by Species

Evaluation Criteria Categories	Category Score	Current Operations Score by Species
Risk Factor: Release Size		
Hatchery-reared juveniles equivalent in size to naturally spawned juveniles	5	
Hatchery-reared juveniles slightly larger in size (less than 50%) than naturally spawned juveniles	3	
Hatchery-reared juveniles much larger in size (greater than 50%) than naturally spawned juveniles	2	Steelhead, coho and chinook
Risk Factor: Release Strategy		
Smolt releases only, with volitional release	5	Steelhead released from CVFF
Smolt releases only, with traditional release	4	Coho, chinook, and steelhead released from DCFH
Smolt and fingerling releases, with volitional release of smolts	3	
Smolt and fingerling releases, with traditional release of smolts	2	
Fingerling releases only	1	

Overexploitation

There are no current estimates of natural production by chinook salmon, coho salmon, or steelhead within the Russian River, suggesting that managers are unable to determine the effects of harvest on the naturally spawning component of these populations (Table 4-9). While regulations prohibit the take of wild (unmarked) fish, indirect effects such as hooking mortality and harassment may still affect wild fish.

Table 4-9 Overexploitation Evaluation Criteria and Scoring by Species

Evaluation Criteria Categories	Category Score	Current Operations Score by Species
No harvest	5	coho
Harvest effort commensurate with minimized effects on natural production (requires surveys to assess natural production)	4	
Hatchery-reared fish identifiable by visual mark harvest effort commensurate to hatchery production (No surveys to assess natural production)	3	Steelhead and chinook
Harvest effort commensurate to hatchery production (No surveys to assess natural production)	2	
No limits on harvest	1	

4.5 SYNTHESIS OF EFFECTS

Current operating practices of the DCFH and CVFF facilities reflect a commitment to minimizing effects on protected populations. Procedures for waste treatment demonstrate continuous compliance with recommended discharge standards for water quality. The facilities maintain good track records in the ability to manage routine fish diseases, and recent changes in policy regarding importation of stocks have resulted in a condition with minimal likelihood of affecting protected stocks through disease. Recent changes in broodstock protocol suggest that everything has been done that can be readily implemented to minimize genetic effects to protected populations. Similarly, current operations relating to production goals and harvest indicate the best practicable approach to minimizing ecological effects. There is a low risk for some potential effects. For example, there is a low risk that hatchery fish may prey on protected natural fish because they are released at a larger size. Another example is that there may be more fishing pressure on natural fish than would have occurred if hatchery fish were not being released. In general, there is a low risk of adverse effects to protected populations. Current operations of DCFH and CVFF are likely to adversely affect the protected populations, and are not likely to adversely modify critical habitat.

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GLOSSARY

Alleles are different forms of a gene at a single locus. A single gene contains two alleles. For example, a single gene may contain an allele that codes for blue eyes and one for brown eyes, or the gene may contain two alleles that code for blue eyes. Differences arise by mutation and are inherited by offspring.

Anadromous refers to a life-history in which growth and maturity occur in saltwater, but spawning and some juvenile rearing occurs in freshwater.

Coadaptation/Coadapted Gene Complex a synergistic interaction between loci.

Composite Population refers to the population that is comprised of both the hatchery-reared and naturally-spawned population components.

Critical Habitat for listed species consists of: (1) the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of section 4 of the Act, on which are found those physical or biological features (constituent elements) (a) essential to the conservation of the species and (b) which may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 4 of the Act, upon a determination by the Secretary that such areas are essential for the conservation of the species. [ESA §3 (5)(A)]

Epistasis a synergistic interaction between loci. It is a situation in which the phenotypic expression of genotypes at one locus depends upon the genotype at another locus.

Evoultionarily Significant Unit (ESU) The NMFS definition of a distinct population segment (the smallest biological unit that will be considered to be a species under the Endangered Species Act). A population will be/is considered to be an ESU if 1) it is substantially reproductively isolated from other conspecific population units, and 2) it represents an important component in the evolutionary legacy of the species.

F_X refers to generations removed from the parental generation. F_1 refers to the progeny of a given parental cross, F_2 refers to the offspring of those progeny. For example, F_1 refers to children and F_2 refers to grandchildren.

Fitness is the capacity of an individual to leave fertile offspring to the next generation. It is the relative probability of survival and reproduction for a genotype.

Genes are the functional units of heredity, each being comprised of two alleles.

Hatchery Fish is a fish that has spent some part of its life-cycle in an artificial environment and whose parents were spawned in an artificial environment.

Listed Species is any species of fish, wildlife or plant which has been determined to be endangered or threatened under section 4 of the Act. [50 CFR §402.02]

Locus/loci is/are the site of a gene on a chromosome, often used interchangeably with gene.

Mitigation is the use of artificial propagation to produce fish to replace or compensate for loss of fish or fish production capacity resulting from the permanent blockage or alteration of habitat by human activities.

Natural Fish is a fish that has spent essentially all of its life-cycle in the wild and whose parents spawned in the wild.

Natural Population is a population that is sustained by natural spawning and rearing in the natural habitat.

Non-Target Population refers to populations that are not directly supported by an artificial propagation activity, but that are affected indirectly by artificial propagation activities intended to benefit another population.

Overlapping Generations refers to a life-history in which adults spawned in a given year may themselves return to spawn at more than one age.

Phenotype is the physical form taken by a genetic character, or group of characters, in an individual. It is the expression of genetic information (genotype).

Population Component refers to the naturally-spawned or hatchery-reared individuals inhabiting the same river system.

Species includes any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature. [ESA §3(16)]

Stock Transfer refers to the active collection of fish from one river for use in a supportive breeding program in another river.

Supportive Breeding refers to any artificial propagation activity aimed at increasing the abundance at any life stage of a species.

Target Population refers to the population intended to benefit from an artificial propagation activity.