

Appendix D

**San Francisquito Creek Watershed
Reference State Model**

T e c h n i c a l M e m o r a n d u m



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Introduction

A preliminary assessment of current habitat conditions for steelhead populations in the San Francisquito Creek watershed was conducted within the framework of a population dynamics model. This assessment relies on fundamental concepts in population dynamics, particularly stock production analysis. The assessment performed here was based on a combination of results from field studies conducted by Jones & Stokes and existing habitat data from the San Francisquito Creek Watershed (SCVWD 2004) and is only intended to provide a preliminary, and conservative, indication of the degree to which steelhead smolt production might be limited by current watershed habitat conditions.

The population modeling exercise involved three basic steps: (1) analyzing habitat-specific information regarding habitat quality and quantity from a suitable reach within the area of interest; (2) assigning density-independent survival and habitat-specific carrying capacity values for each salmonid life stage; and (3) integrating these values into a system of equations to express the impact of current salmonid habitat conditions on potential steelhead production. These three steps are described in further detail below.

Collecting habitat-specific information

Habitat-specific information for the population modeling exercise was collected in the fall of 2004. San Francisquito Creek was surveyed from the channel area adjacent to the eastern edge of the Oak Creek Apartment Complex (the downstream end of summer 2004 flows) upstream to the Santa Clara County Line at Alpine Road. Los Trancos Creek was surveyed from the confluence with San Francisquito Creek upstream to the Arastadero Road crossing. Basic habitat types (pool, riffle, and run) were delineated within the surveyed area according to standard habitat mapping descriptions. Length, mean width, and depth were estimated for each habitat unit. See Table 1 for a summary of habitat area available with the surveyed reaches

The percentage of habitat area composed of the dominant and subdominant substrate categories (i.e., silt, sand, gravel, cobble, boulder) were estimated for each habitat unit. In addition to these habitat parameters, the area of potential steelhead spawning habitat (if present) was estimated. Spawning habitat area estimates were based on professional judgments of steelhead spawning habitat requirements (SCVWD

2004). We collected additional field data on substrate embeddedness during focused studies to characterize winter habitat conditions in San Francisquito and Los Trancos Creek.

Table 1. Habitat availability for each surveyed reach.

Habitat type	San Francisquito Habitat area (ft ²)	Los Tancos Habitat area (ft ²)
Pool	224,625	43,001
Riffle	30,027	50,850
Run	13,130	21,765

Assigning steelhead life history parameters

Steelhead life history was separated into discrete stages having identifiable, and to some extent overlapping, habitat requirements. As discussed above, the population dynamics modeling approach that we used requires two biological parameters for each stage: (1) a carrying capacity (“K”), which describes the ultimate limits imposed by crowding and competition; and (2) an intrinsic productivity (“r”), which describes the expected dynamics under conditions for which the effects of crowding and competition can be ignored. Tables 2 and 3 summarize the K and r parameters used in the analysis, and the derivations of these values.

Table 2. Derivations of carrying capacities used in the model..

Life history segment	Habitat type	Total Habitat area (ft ²) ^a	Density (fish/ft ²)	K (fish)
Early fry rearing	Pool	267,626 ^b	0.1095 ^g	45,909
	Riffle	80,877 ^c	0.1433 ^h	
	Run	34,895 ^d	0.1437 ⁱ	
Winter rearing, first year	All	32,928 ^e	0.0266 ^j	875
Summer rearing, second year	Pool	236,380 ^f	0.0075 ^k	1,944
	Run	34,895 ^d	0.0047 ^l	
Winter rearing, second year	All	32,928 ^e	0.0096 ^m	316

a. All area estimates based on Jones & Stokes Surveys.

b. Total pools

c. Total riffles

d. Total runs

e. Area of cobble/boulder substrate in habitat units

f. Pools with summer maximum depth of at least 2 ft

g. $1.179 \text{ fish/m}^2 \text{ (Connors 1996)} \times 0.3048^2 \text{ m}^2/\text{ft}^2$

h. $1.543 \text{ fish/m}^2 \text{ (Connors 1996)} \times 0.3048^2 \text{ m}^2/\text{ft}^2$

i. $1.547 \text{ fish/m}^2 \text{ (Connors 1996)} \times 0.3048^2 \text{ m}^2/\text{ft}^2$

j. $0.03618 \text{ fish/ft}^2 \text{ (Redwood Sciences Laboratory and Stillwater Sciences 2004, unpublished data)} \times (1-(85/165)^2)$ (See footnote n)

k. $0.081 \text{ fish/m}^2 \text{ (Connors 1996)} \times 0.3048^2 \text{ m}^2/\text{ft}^2$

l. $0.051 \text{ fish/m}^2 \text{ (Connors 1996)} \times 0.3048^2 \text{ m}^2/\text{ft}^2$

m. $0.03618 \text{ fish/ft}^2 \times (85/165)^2$ (Redwood Sciences Laboratory and Stillwater Sciences 2004, unpublished data)

n. $85/165 = (0+ \text{fork length}) / (1+ \text{fork length})$. This ratio of age 0+ to age 1+ fish length was used as a scaling factor to approximate the degree to which fewer larger fish can fit in a given habitat area. Fish size was estimated from Leidy (1984) and Leidy (1999).

Population modeling

The salmonid population modeling approach used in this analysis is based on stock production theory (Ricker 1976). Stock-production theory characterizes the number of individuals of one life stage at one

time (the production) as a function of the number in the same cohort of an earlier life stage at an earlier time (the stock). This approach is particularly well suited to situations where physical habitat is believed to be limiting, and where population dynamics can be plausibly separated into density-independent and density-dependent components, such as productivity (the ratio of stock to production that would be expected if there were no limits on population density) and carrying capacity (the maximum number of individuals of a given life stage that the habitat can support for the duration of that life stage).

Table 3. Derivations of carrying capacities used in the model..

Life history segment	Stock-production relationship	r (fish/fish)	K (fish)
Spawning and superimposition (spawner to effective eggs)	Superimposition	2,751.5 ^a	222,871 ^b
Egg and alevin rearing (effective egg to spring fry)	Truncated Linear	0.28 ^c	(NA)
Early fry rearing (spring fry to 0+ summer)	Modified Beverton-Holt (2γ =)	1	45,909 ^d
Summer rearing, first year (0+ summer to 0+ fall)	Truncated Linear	1	(NA)
Winter rearing, first year (0+ fall to 1+ spring)	Modified Beverton-Holt (2γ =)	1	875 ^d
Summer rearing, second year (1+ spring to 1+ fall)	Modified Beverton-Holt (2γ =)	1	1,944 ^d
Winter rearing, second year (1+ fall to 2+ smolt)	Modified Beverton-Holt (2γ =)	1	316 ^d
Outmigration, ocean life, and return (2+ smolt to spawner)	Truncated Linear	0.05 ^e	(NA)

a. 0.5 females/total spawners × 5,503 eggs/female (estimated from Shapalov and Taft 1954)

b. 81 ft² spawning habitat × 0.2 redds/ft² × 5,503 eggs/redd

c. Inferred from permeability sampling.

d. See Table 2.

e. Shapalov and Taft (1954)

The population model uses the following relationships between a stock S and a production P . The parameter r can generally be interpreted as the intrinsic productivity (e.g., a density-independent survival rate, or in the case of reproduction, a fecundity). The parameter K is interpreted as the carrying capacity for the production stage. In practice, both of these can vary from year to year in response to varying environmental conditions, although such refinements were not used in the present analysis. All of these relationships are asymptotic to the two lines $P = rS$ and $P = K$. There are three basic types of functional relationships that are used in this model:

Truncated Linear:
$$P = \max(rS, K)$$

Modified Beverton-Holt:
$$P = \frac{rKS}{((rS)^\gamma + K^\gamma)^{1/\gamma}}$$

Superimposition:
$$P = K(1 - \exp(-rS/K))$$

The truncated linear relationship is often used when no natural carrying capacity is evident; in this case K is set to some very large value, or simply omitted. The parameter γ of the modified Beverton-Holt relationship controls the “stiffness” of the relationship: $\gamma = 1$ is the usual Beverton-Holt relationship; larger values yield curves which make more abrupt transitions between the two asymptotes $P = rS$ and $P = K$. The superimposition relationship was derived from analytical models of habitat selection.

Conclusions

Lack of suitable winter refuge in pools and other habitats appears to be limiting capacity within the study area and throughout the watershed. Lack of cobble and boulder aggregations of sufficient density and thickness, low amounts of unembedded cobble and boulder substrate, and a lack of other key habitat features such as large woody debris jams, root wads, and backwater habitat, appear to result in relatively low summer and winter carrying capacity for juvenile steelhead, with winter capacity more impaired than summer. An increase in the quantity of winter habitat would likely increase smolt production. Additional studies are needed to quantify the type and quality of available overwintering habitat throughout the upper watershed.

Juvenile summer rearing habitat is likely not as affected by fine sediment in pools throughout the watershed, but is degraded within the current study area. A lack of other key habitat features such as large woody debris jams, root wads, and backwater habitat, do appear to result in relatively low summer carrying capacity for juvenile steelhead

Survival of steelhead eggs and larvae is likely reduced by low permeability of spawning gravels throughout the watershed, but is clearly evident in gravels within the study area. However, large changes in smolt production would not be expected if egg-to-emergence survival were increased by improving spawning gravel permeability without commiserate increases in summer and winter rearing habitat.

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