Escapement of unclipped (spring) chinook salmon (*Oncorhynchus tshawytscha*) to Battle Creek, California from March through October 1996.

USFWS Report

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ABSTRACT

Spring chinook salmon *(Oncorhynchus tshawytscha)* populations are at precarious low levels and the State of California is in the process of listing them as an endangered species. Obtaining information on population levels and basic life history information is necessary to warrant listing and identify factors that limit their success. A number of unclipped (adipose fin present) chinook salmon returning to Battle Creek could potentially be spring chinook salmon. We conducted surveys to obtain information on utilization of Battle Creek by these unclipped adult chinook salmon and identify potential limiting factors. To obtain this information in Battle Creek we conducted snorkel survey, collected salmon carcasses, counted fish passing the Coleman National Fish Hatchery (NFH) barrier dam and utilized a beach seine. Specific objectives were to: 1) estimate escapement; 2) determine the timing of migration; 3) determine age structure; 4) determine sex ratio; 5) identify holding locations; 6) identify spawning locations and timing; 7) collect tissue samples from carcasses for future genetic analysis; and, 8) collect juvenile salmon to determine spawning success. We assumed all chinook salmon with an adipose fin intact (unclipped) which passed the Coleman NFH barrier dam between 26 March and 1 July were natural-origin chinook salmon. Additionally, any chinook salmon spawning activity observed (redds) or any chinook salmon carcass recovered above the Coleman NFH barrier dam in September or October was assumed to be a potential spring chinook salmon. An estimated 34 unclipped chinook salmon returned to Battle Creek in 1996 between 26 March and 1 July which were assumed to be spring chinook salmon. All salmon appeared to be 3 years old (N = 3) as determined by reading scales. The sex ratio was not determined because of the small sample size (N = 1). Adult chinook salmon were regularly observed holding throughout the surveyed area in July and August, most were in the north fork and upper reaches of the main stem Battle Creek. Redds, which indicated spawning location and time, were first observed on 17 September and new redds were observed through 9 October when surveys stopped. Most redds were located from Wildcat Dam downstream to the Wildcat Road Bridge. A total of 15 redds were observed during this time period. Tissue samples were collected from 3 adult carcasses and 86 juveniles for genetic analysis. However, juvenile salmon were assumed to be fall or late - fall run based on expected growth rates. Although we assumed that we were monitoring Battle Creek spring chinook salmon there is reason to believe that the unclipped salmon we were monitoring could have been of a different run. Coleman National Fish Hatchery located on Battle Creek produced fall chinook salmon which have been observed as early as April at the Red Bluff Diversion Dam located approximately 56 km downstream, suggesting they are in the area. Also hatchery-origin winter chinook salmon are known inhabit in Battle Creek at the same time as spring chinook salmon. A better means to identify a “Battle Creek spring chinook salmon” needs to be developed. Additionally, genetic integrity of the spring chinook salmon in Battle Creek is questionable because of operations of dams along the creek and past spawning operations at Coleman NFH. Findings from this study suggest current operations at dams in Battle Creek need to be evaluated to determine if they can be operated to provide more favorable habitat for spring chinook salmon while reducing the potential for crossbreeding. We also suggest the implementation of a comprehensive monitoring plan

for all life stages of spring chinook salmon in Battle Creek. This monitoring plan will assist in identifying potential limiting factors and provide a means to evaluate the effectiveness of restoration actions.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

TITLE

Escapement of unclipped (spring) chinook salmon *(Oncorhynchus tshawytscha)* to Battle Creek, California from March through October 1996.

GOALS

The goal of this project was to obtain information on utilization of Battle Creek by adult unclipped chinook salmon which were present above the Coleman NFH barrier dam from March through October 1996. Specific objectives were to:

1) estimate escapement;
2) determine the timing of migration;
3) determine age structure;
4) determine sex ratio;
5) identify holding locations;
6) identify spawning locations and timing;
7) collect tissue samples from carcasses for future genetic analysis; and,
8) collect juvenile chinook salmon to determine spawning success.

INTRODUCTION

Spring chinook salmon are considered a monitored species by the State of California and are a candidate species for listing under the California Endangered Species Act. Although a small remnant population is thought to exist in Battle Creek, the genetic integrity of the Battle Creek population might be questionable. The genetic integrity has likely been influence by propagation programs conducted Coleman National Fish Hatchery (NFH), which has been in operation on Battle Creek since the early 1940's and potentially, to a lesser degree, by strays from other fish hatcheries (Feather River State Fish Hatchery). Current restoration efforts for spring chinook salmon on Battle Creek include restricting access below Eagle Canyon Dam on the north fork and Coleman Diversion Dam on the south fork (Figure 1) to allow: 1) concentration of the spawning population to increase the likelihood of finding a mate (Elliott 1995); 2) greater ability to provide adequate flow and temperature for holding, spawning and early rearing; and, 3) reduce entrainment of emigrating individuals.

In 1995 the U.S. Fish and Wildlife Service (Service) estimated winter and what were believed to be spring chinook salmon chinook salmon escapement on Battle Creek (USFWS 1996). The number of adults returning to Battle Creek was determined by counting adult salmon that ascended the Coleman NFH's barrier dam fish ladder. Passage at the Coleman NFH barrier dam was provided from late - March through late - June. Adult chinook salmon observed during this time period with an adipose fin - clip were assumed to be hatchery-origin winter chinook salmon and those with an adipose fin were assumed to be spring chinook salmon. At all other times of the year, the barrier prevented fish passage and was used to divert salmon into Coleman NFH for propagation purposes. Most passage was video recorded and the tapes were reviewed to count salmon that had passed. Estimates were then derived by expanding the total number of salmon counted by the percentage of time that was recorded. In 1995, an estimated 66 spring chinook salmon (adipose fin present) and 88 hatchery - origin winter chinook salmon returned to Battle Creek (USFWS 1996).

Results from surveys in 1995, found spring chinook salmon holding in areas downstream of the Coleman Diversion Dam on the south fork and downstream of Eagle Canyon on the north fork to the confluence of the forks (Figure 1). Surveys were not conducted above these barriers because ladders were closed to prevent access and the barriers were assumed to be very effective in preventing passage. Observations were made during daily (excluding weekends) surveys from late-June through late-September. No adult chinook salmon were observed holding in the main stem Battle Creek.

These surveys also revealed that the chinook salmon redds were observed beginning on 18 September 1995 in the Eagle Canyon reach of the north fork. A total of 13 redds were observed in the north and south forks, however, surveys stopped at the end of September. Spring chinook salmon in Deer, Mill and Butte creeks have been observed spawning until the end of October (Colleen Harvey, California Department of Fish and Game, Inland Fisheries Branch, Red Bluff, California, personal communication).

There is concern over the reproductive isolation of spring chinook salmon in Battle Creek. Spring chinook salmon could have been spawned with fall chinook salmon during propagation at Coleman NFH. Low water flows and/or high diversion rates may have resulted in passage problems at natural and man-made barriers which resulted in overlap between fall and spring chinook salmon spawning habitat. Currently, the fish ladders at the Coleman Diversion and Eagle Canyon dams are closed which restricts spring chinook salmon to the upper valley region. In 1995, fall chinook salmon were observed ascending the Coleman NFH barrier dam when that ladder was closed (USFWS 1996). This created a situation where fall chinook salmon and spring chinook salmon were in the same location at a time when both spawn.

This study was designed to obtain information on the life history aspects of adult unclipped chinook salmon that returned to and were observed in Battle Creek from March through October 1996, particularly above the Coleman NFH barrier dam. This information will assist in determining the status of spring chinook in Battle Creek. Additionally, genetic samples were also collected from carcasses and juveniles that may be used to develop baseline information on suspected spring chinook salmon and other runs of salmon in Battle Creek.

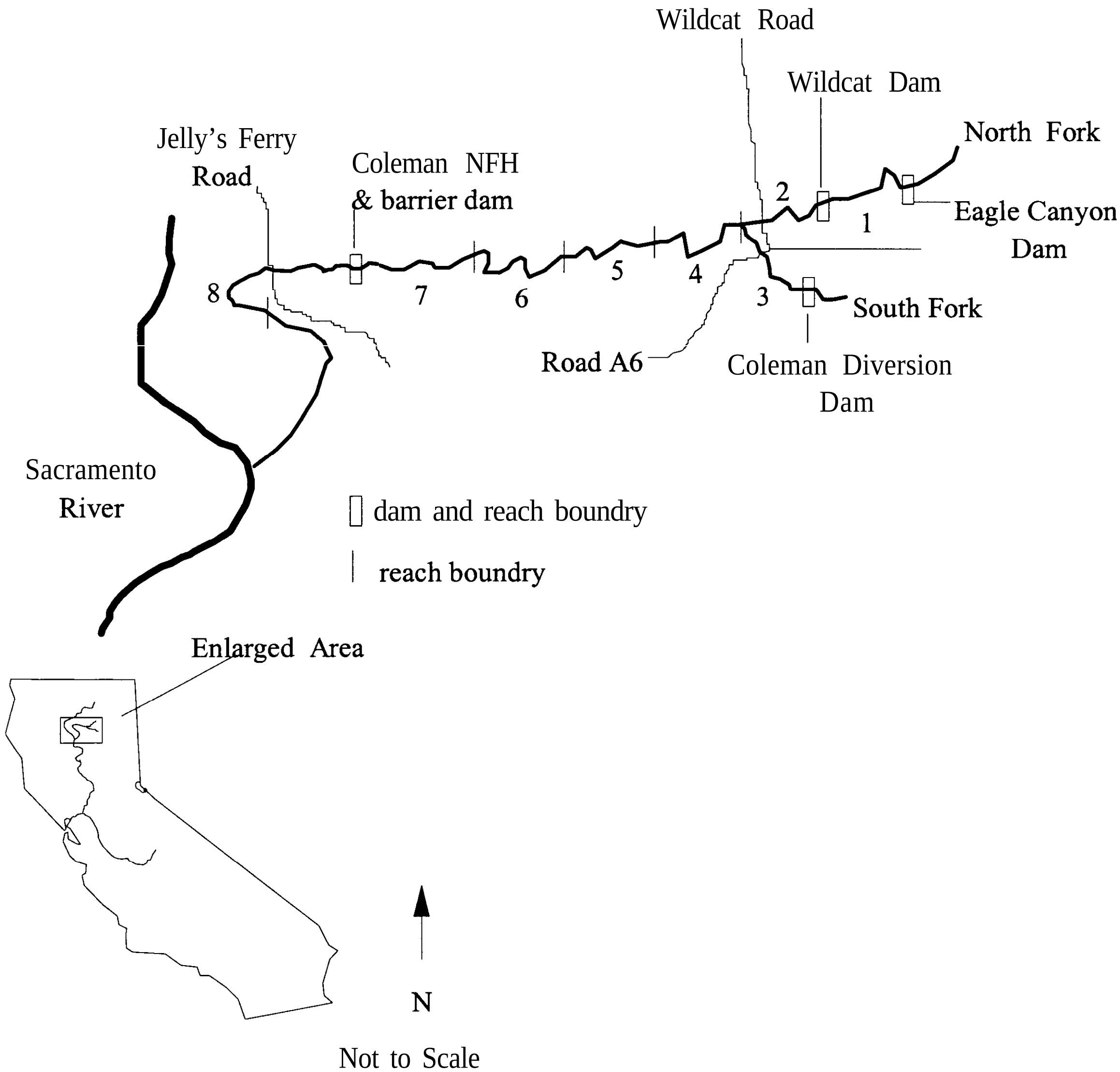

Figure 1 .-Location of 1996 chinook salmon spawning ground surveys in the Battle Creek. Maps include reach numbers, with starting and ending locations, and other identifying features such as Coleman National Fish Hatchery (NFH) and the Coleman NFH's barrier dam, County Road A-6, Wildcat Road and Jelly's Ferry Road.

STUDY AREA

Battle Creek is located in northern Tehama and southern Shasta counties, California and is fed by the volcanic slopes of Lassen Peak and numerous springs (Figure 1). Battle Creek eventually enters the Sacramento River at river kilometer 438. Battle Creek has been identified as a creek with high restoration potential because of its relatively high natural and consistent flow of cold water.

Specific survey sites in Battle Creek include:

Coleman NFH's barrier dam		creek kilometer (CK) 10
spawning grounds	main stem:	from CK 5 to confluence of forks (approximate distance = 23 km)
	north fork:	confluence of forks to Eagle Canyon Dam (approximate distance = 7 km)
	south fork:	confluence of forks to Coleman Diversion Dam (approximate distance = 4 km)

METHODS

Chinook salmon returning to Battle Creek were identified as either hatchery or wild - origin. Hatchery-origin chinook salmon were identified by an adipose fin-clip, while wild/natural-origin chinook salmon were unclipped. An attempt was made to recover coded-wire tags from adipose fin-clipped salmon and salmon of unknown origin (i.e., carcasses too severely decomposed to assess prior presences of an adipose fin) in order to determine the run. The run of an unclipped salmon was determined by assessing physical characteristics (brightness, coloration, fin condition, and external marks) and by the migration timing.

Escapement Estimation

Escapement to Battle Creek was estimated based on adult salmon observation at the Coleman NFH's barrier dam. Operation of the Coleman NFH barrier dam prevented upstream passage of fish in Battle Creek from July through March. During October to March fish were directed into holding ponds at Coleman NFH where salmon and steelhead were used in propagation programs. Uninhibited passage upstream of the barrier was afforded from 26 March through 1 July 1996. An under-water video camera placed in a modified weir at the upstream end of the fish ladder was used to estimate escapement of chinook salmon which passed the Coleman NFH barrier dam. Alternate lighting allowed 24 hour monitoring, and a time-lapse video recorder was used to reduce maintenance and viewing time. The time mode was set to 48 hours on a time lapse video cassette recorder and 120 minute 8 mm tapes were used. The time mode was switched to slower 24 hour recording mode to allow a sufficient number of frames to be captured to for positive identification of marks. A time-date stamp was recorded. Tapes were viewed until a fish was observed, then reviewed at slow playback speed or "freeze frame" mode to assist in identification and mark detection. The certainty of the observation was either rated good, fair or poor. Good signified complete confidence in determining species and presence or absence of an adipose fin; fair suggested confidence in determining species and presence or absence of an adipose fin but additional review was needed to classify the fish; and poor, suggested uncertainty in determining species and presence or absence of an adipose fin. The quality of the picture being observed was also rated as good, fair or poor. Good signified a clear picture throughout the day; fair suggested objects were discernable throughout the day but extra review was needed; and poor, suggested that objects were indistinguishable most of the day.

Salmon passing the barrier dam were recorded onto a file tape and reviewed by experienced personnel to confirm run and presence or absence of an adipose fin. The total number of clipped and unclipped salmon observed were recorded. Salmon in which the adipose fin was unidentifiable were classified as unknown. Additionally, the hours of fish passage and the hours of video recorded fish passage were logged each day. Peak migration, date and time, for both clipped and unclipped salmon in Battle Creek was determined. Northern Central Valley Fish and Wildlife Office (NCVFWO) biologists made spot checks of video tapes to verify identification and counts.

Only days with good to fair video records were used in analysis to determine escapement. For each of the 15 weeks passage was recorded, escapement of clipped and unclipped salmon passing the Coleman NFH's barrier dam was estimated by expanding the total number of clipped and unclipped salmon observed by the percentage of passage that was recorded. Salmon with unknown clips were distributed between the clipped and unclipped categories based on the proportion of each category observed prior to expanding. For this study, all unclipped salmon that were counted at the Coleman NFH barrier dam were assumed to be spring chinook salmon. The equation used was:

$$E = \sum_{i=1}^{15} \left(\left[\left(\frac{u_i}{(u_i + c_i)} \right) * unk_i \right] + u_i \right) * \left(\frac{P_i}{V_i} \right)$$

where:

E = escapement estimation of spring chinook salmon above the Coleman NFH barrier dam for 1996;

u_i = actual number of unclipped chinook salmon observed passing the Coleman NFH barrier dam during the week;

c_i = actual number of adipose fin-clipped chinook salmon observed passing the Coleman NFH barrier dam during the week;

unk_i = actual number of unknown clipped chinook salmon observed passing the Coleman NFH barrier dam during the week;

P_i = number of hours of unrestricted fish passage at the Coleman NFH barrier dam during the week; and,

V_i = number of hours of actual good and fair video recorded fish passage at the Coleman NFH barrier dam during the week.

Unclipped salmon were assumed to be spring chinook salmon unless other-wise noted and adipose fin-clipped (coded wire-tagged) salmon were of hatchery - origin. Coded-wire tag recoveries identified various stocks (brood year or run) and the percentage of each. This percentage was then multiplied by the escapement estimate for clipped salmon and resulted in an estimated escapement for hatchery-origin winter chinook salmon (Croci and Hamelberg 1997).

Migration timing

Timing and peak adult migration periods for unclipped (spring) chinook salmon was determined by observing fish passage at the Coleman NFH barrier dam. The estimated number of unclipped (spring) chinook salmon ascending the barrier dam was plotted weekly for the time period passage was observed. Peak migration, date and time of day, for both clipped and unclipped salmon in Battle Creek was determined.

Age structure

Age of returning adult chinook salmon was determined by recovering carcasses during spawning ground surveys in September and October and by estimating fish lengths at the Coleman NFH barrier dam. All salmon carcasses recovered were measured (fork length in mm), sexed, and, when possible, approximately 10 scales were collected from each carcass, returned to the laboratory, mounted on a microscope slide and read to determine age. All carcasses recovered at this time were considered spring chinook salmon based on spawn timing and expected death rate (Snider and Vyverberg 1995). Age was also determined from a length frequency distribution generated by estimating fish length of salmon that passed the video counting station at the Coleman NFH barrier dam. Estimated lengths were ascertained by calibrating the video system and then employing an advanced algorithm to the fish images contained on the file tape. The University of British Columbia, Canada was contracted to ascertain video fish lengths (Royann Petrell, University of British Columbia, Canada, Bio-resource Engineering Department).

Sex ratio

A male to female sex ratio for adult unclipped (spring) chinook salmon was determined by examining chinook salmon carcasses recovered in September and early-October.

Holding location

Snorkel surveys were conducted daily on selected reaches (Table 1; Figure 1) of Battle Creek (excluding weekends) to locate chinook salmon holding locations from 26 May through 11 October. Generally 2 of the 8 reaches were surveyed each day and all reaches were surveyed in one week. Date and location was recorded when salmon were observed. When possible, the presence or absence of an adipose fin was indicated.

Table 1 .-Reach number, upstream location and approximate creek kilometer (CK), and downstream location and approximate CK on Battle Creek where spawning grounds were surveyed for chinook salmon in 1996.

	Upstream		Downstream	
Reach	Location	CK	Location	CK
1 (north fork)	Eagle Canyon Dam	35	Wildcat Dam	32
2 (north fork)	Wildcat Dam	32	Confluence of forks	28
3 (south fork)	Coleman Diversion Dam	32	Confluence of forks	28
4	Confluence of forks	28	PG&E Pipeline	25
5	PG&E Pipeline	25	Mt. Valley Ranch	20
6	Mt. Valley Ranch	20	Ranch road	14.5
7	Ranch road	14.5	Coleman NFH barrier dam	10
8	Coleman NFH barrier dam	10	Refuge Boundary	5

Spawning location and timing

From 1 September through 11 October snorkel surveys were conducted daily on selected reaches (Table 1; Figure 1) of Battle Creek (excluding weekends) to locate chinook salmon spawning areas and to determine timing of spawning. Spawning activity by chinook salmon that occurred below the Coleman NFH barrier dam during this time was disregarded because of the presences of numerous of fall chinook salmon. Generally 2 of the 8 reaches were surveyed each day and all reaches were surveyed in one week. Chinook salmon redds indicated spawning location and timing. Redds were marked with flagging or some other visible marker (pile of rocks) to avoid counting twice. The date of discovery and location of redds were recorded. An attempt was made to deterrnine the beginning and end of unclipped (spring) chinook salmon spawning, as well as the peak spawning time, through spawning ground surveys.

Genetic sampling
Tissue samples were taken from carcasses collected during stream surveys in September and early-October. Carcasses were measured, sexed, checked for marks and expression of sex products. A hole punch was used to obtain 5 small pieces of tissue (primarily fin) which were stored in a small vial containing tris - glycine buffer. Three samples (vials) were collected from each fish and then archived at the NCVFWO, Red Bluff, California. Additionally juvenile were collected by beach seine during September and early-October to obtain genetic samples. A small, 1mm, fin-clip was obtained from captured juveniles and preserved in tris - glycine buffer, then archived at the NCVFWO.

Spawning success
Spawning success was determined by collecting juvenile chinook salmon by beach seine during September and early - October. All captured juveniles were measured and a small tissue sample was collected for genetic analysis. An attempt was made to determine the run of the juvenile salmon sampled by applying a daily length table' generated from the data collected in the upper Sacramento River and by comparing the size of the naturally produced salmon with those at Coleman NFH. This methodology could provide an assessment of the previous brood year's (1995) spawning success.

RESULTS

Escapement estimation
Data collected in Battle Creek suggest an estimated 34 spring chinook salmon returned to Battle Creek in 1996. Video taped passage at the Coleman NFH barrier dam during good and fair picture quality, showed a total of 112 were clipped (2 were late-fall chinook), 27 were unclipped and 7 had unknown clips. Most of the unknown clips (N =5) were observed during the first 3 weeks when the recorded time mode was set at 48 hours. The time mode was switched to a slower recording speed (24 hour) on 17 April. Passage was unrestricted for 2,352 hours from 26 March through 1 July and 1,871 hours (80%) was video recorded with a good or fair quality picture (Table 2). Poor video recordings resulted from highly turbid water or debris obstructing the view and were not considered in the percent of observed fish passage. On a few occasions, video recording was interrupted due to equipment failure.

'Generated by Sheila Greene, Department of Water Resources, Environmental Services Office, Sacramento (8 May 1992) from a table developed by Frank Fisher, California Department of Fish and Game, Inland Fisheries Branch, Red Bluff (revised 2 February 1992). Fork lengths with overlapping run assignments are placed with the later spawning run.

Other fish observed moving upstream while video recording at the Coleman NFH barrier dam included Sacramento squawfish *(Ptychocheilus grandis),* Sacramento sucker *(Catastomus occidentalis),* rainbow trout/steelhead (0. *mykiss),* hardhead *(Mylopharodon conocephalus),* lamprey *(Lampetra spp.),* and black bass *(Micropterous* spp.).

Migration timing

Unclipped (spring) chinook salmon were observed passing the Coleman NFH barrier dam most weeks the ladder was open (26 March through 1 July: Table 2; Figure 2). No true peak was obvious and chinook salmon passed through the ladder when afforded the opportunity. A larger percentage (70%) of the unclipped (spring) chinook salmon ascended the ladder during day light hours (Figure 3).

Age structure

The age structure of returning unclipped (spring) chinook salmon was estimated to be 39% jacks (two years old) and 61% adults (three or more years old: N =18). Three carcasses were recovered in Battle Creek from 1 September through 10 October and all were 3 years old (Table 3). The length frequency distribution by estimating fish lengths from video images displayed an age structure of 47% jacks and 53% adult (N =15: 600 mm cut off between jack and adult).

Sex ratio

Three carcasses were recovered in Battle Creek from 1 September through 10 October and only one fish could be positively identified as a male (Table 3). The sex of the two other salmon were unknown due to the advanced state of decay.

Adult holding

Adult chinook salmon were observed holding in a few reaches in Battle Creek during the months of July and August (Table 4), however, it was difficult to determine the origin of these salmon (i.e., presence or absence of an adipose fin). Most salmon observed were in reach 1 the farthest upstream location. A dramatic increase in the number of adults observed below the Coleman NFH barrier dam, reach 8, during August suggested the arrival of fall chinook salmon.

Spawning location and timing

Fifteen (15) chinook salmon redds were observed in Battle Creek above the Coleman NFH barrier dam from 1 September through 10 October 1996 (Table 5). The first redd was observed on 17 September. The termination and peak spawn timing for spring chinook salmon was not determined. Most spawning occurred in reach 2 (below Wildcat Dam and above the confluence with the north and south forks).

Genetic sampling

Genetic samples were collected from 3 adult chinook salmon recovered during spawning ground surveys (Table 3). Tissue samples were collected from 86 juvenile salmon September and early-October.

Spawning success
A beach seine was used to capture juvenile salmon that ranged in size from 60 - 158 mm. Smaller salmon were more abundant. According to the daily length table and comparing the size of naturally produced salmon with those at Coleman NFH, the smaller group could be considered late - fall and the larger group could be considered fall chinook salmon.

Table 2.-Actual number of adipose fin-clipped (clipped) chinook salmon, unclipped chinook salmon and unknown clipped salmon observed during a given week and the expanded number of unclipped (spring) chinook salmon, hours of unrestricted passage and number of hours of video taped passage for good and fair video recordings at Coleman National Fish Hatchery's barrier dam from 26 March through 1 July 1996.

Week Ending	Actual Number Clipped	Actual Number Unclipped	Actual Number Unknown	Expanded Number Unclipped	Hours of Passage	Hours of Tapped Passage
30 March	3	1	0	1	130	128
06 April	7	4	3	6	168	144
13 April	9	1	2	1	168	168
20 April	4	0	0	0	168	115
27 April	15	0	0	0	168	137
04 May	10	2	0	2	168	167
11 May	7	1	0	1	168	168
18 May	2	0	0	0	168	20
25 May	3	1	0	3	168	59
01 June	15	4	0	5	168	126
08 June	9	1	0	1	168	141
15 June	13	3	0	3	168	153
22 June	5	1	1	1	168	167
29 June	8	5	0	6	168	144
06 July	0	3	1	4	38	34
Total	110	27	7	34	2352	1871

*Expanded number unclipped =(((unclipped/(clipped+unclipped)*unknown)+unclipped)
* (total hrs. passage/total hours of good and fair quality video taped passage))

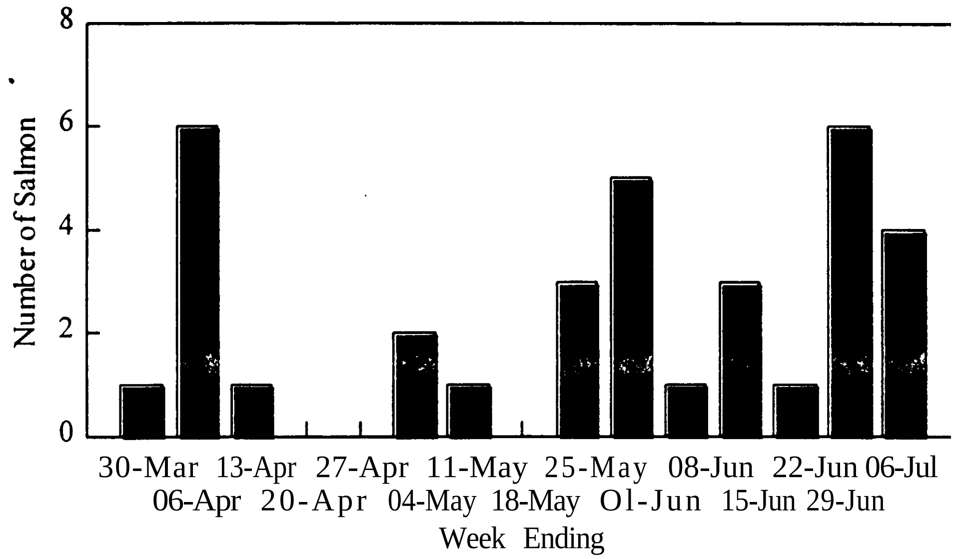

Figure 2.-Estimated number and migration timing of spring chinook salmon passing the Coleman National Fish Hatchery barrier dam by week from 26 March through 1 July 1996.

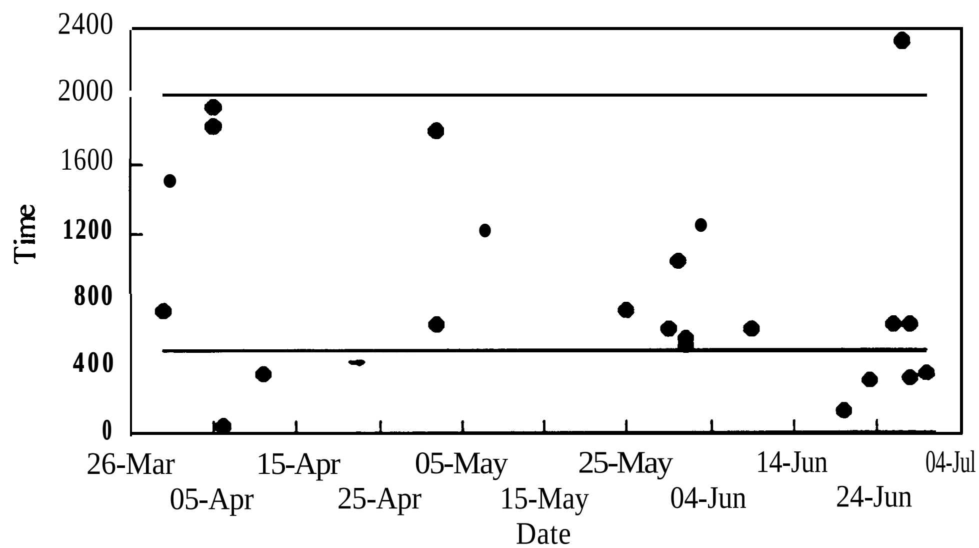

Figure 3.-Die1 migration timing of spring chinook salmon in Battle Creek (N = 23). Daylight hours are between the lines. Only days when passage was recorded for 24 hours were used in analysis.

Table 3.-Date, indication if tissues samples were collected, indication of the presence or absence of an adipose fin, length (mrn), location (reach), age* and sex of adult chinook salmon carcasses recovered in Battle Creek during stream surveys from 1 September to 10 October 1996.

Date	Tissue Samples	Adipose fin	Length (mm)	Reach	Age*	Sex
1 Oct	yes	unknown	unknown	2	3	unknown
1 Oct	yes	unknown	unknown	2	3	male
9 Oct	yes	unknown	unknown	2	3	unknown

* Age determined by reading scale patterns

Table 4.-The location (reach) and the total number of adult chinook salmon observed each month in Battle Creek during snorkel surveys from 1 July to 3 1 August 1996.

	Number of adult chinook salmon observed*	
Reach	July	August
1	12	5
2	0	1
3	0	0
4	1	1
5	6	5
6	0	2
7	2	0
8	1	67

* Unable to determine origin (hatchery or wild) on most of these salmon. Displayed values likely included multiple observations of the same salmon.

Table 5.- Date, number of new redds observed and location / reach where new redds were observed in Battle Creek from 1 September to 10 October 1996.

Date	# New redds	Location / Reach
17 September	2	2
25 September	1	2
27 September	1	2
2 October	1	4
7 October	4	6
9 October	6	2
Total	15	

DISCUSSION

The video monitoring of fish passage at the Coleman NFH barrier dam was quite reliable in 1996. Nearly 80% of fish passage was video taped with good or fair picture quality, an improvement over 1995 when only 42% was recorded. Improved lighting, a more frequent maintenance schedule and familiarizing personnel with the equipment accounted for most of the improvement. Environmental conditions (i.e., lack of high flow events) also factored heavily in the ability to monitor a larger percentage of time. The minor modification to the lighting system did not appear to affect passage of salmon or other fish species and improved the ability to monitor nocturnal passage.

Although the method to estimate chinook salmon abundance in Battle Creek appeared to be very accurate and reliable, potentially an under or overestimate of the population may have occurred. Additionally, what was assumed to be a spring chinook salmon may actually been a different run. Undocumented fish passage at the Coleman NFH barrier dam may have resulted in an underestimate of the number of chinook salmon returning to Battle Creek. The Coleman NFH barrier dam is assumed to be 100% effective in preventing passage, however, fall chinook salmon have been observed ascending the dam in flows as low as 363 cfs. Nevertheless, passage at the ladder likely occurred at greater rate than at other points at the barrier dam.

Overestimate of chinook salmon returning to Battle Creek may have occurred as a result of fallback of live salmon. Live salmon may have ascended the fish ladder, then “fellback” over the darn and ascended the ladder again. Essentially fish would be counted twice and result in a overestimate of the returning population.

The Coleman NFH barrier dam was operated to provide passage upstream of this barrier from 26 March through 1 July 1996. Assuming spring chinook salmon migration timing in Battle Creek mimics that observed in other Central Valley drainages, this time period likely encompasses most of the adult migration period for spring chinook salmon. However, assumed spring chinook salmon were observed within the first few days of installing the fish counting facility at Coleman NFH barrier dam and they were observed within the last few days prior to stopping passage. This suggest that the ladder would need to be opened sooner and closed later to fully encompass the entire spring chinook salmon migration period in Battle Creek. The barrier darn should be operated to allow uninhibited passage of salmon and other fish irnmediately after spawning activities are terminated at Coleman NFH. This generally occurs by early - March.

One concern associated with opening the ladder sooner is allowing late-fall chinook salmon access to habitat above the Coleman NFH water intakes potentially increasing the disease risk to Coleman NFH and to other private and state hatcheries farther upstream. Opening the Coleman NFH barrier dam in early-March, would likely only introduce a small number of late-fall chinook salmon above the barrier dam since the late-fall spawning period is nearly complete. However, late-fall chinook salmon are highly infected with IHN, a disease which has been a persistent problem at Coleman NFH. Operations at other barriers may afford adequate protection for Coleman NFH's water supply, such as keeping Eagle Canyon and Coleman Diversion dams closed from mid-February through April. Additionally, potential disease risks to the hatcheries in Battle Creek should be considered.

There is potential risk in extending the amount of time the barrier dam is opened, mainly because fall chinook salmon can begin to arrive in Battle Creek in July. Keeping the barrier dam open longer may result in more fall chinook salmon passing. This is a concern because current restoration actions restrict spring chinook salmon to the valley reach which is likely attainable by fall chinook salmon that pass the barrier dam. If the barrier is opened for a longer period of time then, the potential crossbreeding of spring and fall chinook salmon needs to be examined closer.

A better means to determine age and sex of returning adult spring chinook salmon needs to be developed if this is to remain a important part of the program. Using lengths from video recordings appear to be a good method to obtain age information, but, estimating lengths by this method is approximately 14% accurate (Royann Petrell, University of British Columbia, Canada, Bio-resource Engineering Department, personal communication). In an attempt to obtain better age and sex data, the effort afforded to snorkel surveys on Battle Creek during 1996 was more than doubled from the 1995 level (4 people per day from late - May through mid - October 1996 and 2 people per day from late - June through late - September 1995). This was in an attempt to recover more carcasses for age and sex determination, however, this did not occur. It is assumed that predators or scavengers got to the carcasses first, as most recovered carcasses were only partial remains. Increased effort during stream surveys, physically trapping adults or calibrating the video counting chamber to obtain fish lengths may provide alternative methods to obtain age and possibly sex information. Trapping would additionally provide a means to collect tissue samples for genetic analysis.

The Service has recommended initiating an effort to trap and relocate adult hatchery-origin winter chinook salmon returning to Battle Creek and relocate them to the main stem Sacramento River near Redding or, in the future, utilize them in a propagation program. This trapping effort for hatchery-origin winter chinook salmon should also be used to obtain information on spring chinook salmon and other unclipped salmon.

Limited juvenile sampling occurred in Battle Creek to assess the spawning success of hatchery-origin winter and spring chinook salmon and to collect tissue samples for future genetic analysis. Currently, chinook salmon life history information or spawning success is not being conducted in Battle Creek for any run. A comprehensive monitoring plan especially for all life stages of spring chinook salmon in Battle Creek should be conducted to identify potential limiting factors and evaluate the effectiveness of current restoration actions (i.e. ladder operations at Eagle Canyon and Coleman Diversion dams).

RECOMMENDATIONS

Based on our finding, several recommendations are listed that are intended to conserve, protect or enhance conditions in Battle Creek for spring chinook salmon in Battle Creek and improve our ability to monitor their status.

1) Explore the possibilities of allowing spring chinook salmon access to reaches of stream beyond Eagle Canyon Dam or Coleman Diversion Dam to prevent the potential for crossbreeding between spring and fall chinook salmon.

2) Assess/discuss operations at the Coleman NFH barrier dam to ensure uninhibited passage of all spring chinook and minimize impediments to other species. Also examine the potential to utilize the barrier dam as a tool to provide spatial separation between spring and fall runs.

Implement a comprehensive monitoring plan especially for all life stages of spring chinook salmon in Battle Creek to identify potential limiting factors and evaluate the effectiveness of restoration actions.

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