# ESCAPEMENT OF HATCHERY-ORIGIN WINTER CHINOOK SALMON *(ONCORHYNCHUS TSHAWYTSCHA)* TO THE SACRAMENTO RIVER, CALIFORNIA IN 1995, WITH NOTES ON SPRING CHINOOK SALMON IN BATTLE CREEK

USFWS Report

U.S. Fish and Wildlife Service
Northern Central Valley Fish and **Wildlife Office**
Red **Bluff,** California 96080

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# ERRATA

Please make the following changes to the report entitled:

Escapement of hatchery-origin winter chinook salmon *(Oncorhynchus tshawytscha)* to the Sacramento River, California in 1995, with notes on spring chinook salmon in Battle Creek

Item 1: Page 4, replace section

Main Stem--Red Bluff Diversion Dam

Fish passage at RBDD was monitored during dam operation (15 May through 15 September). The Service made actual counts of fish passage through viewing facilities at the east and west ladders from 6:00 am to 8:00 pm each day. The total number of clipped and unclipped chinook salmon was recorded. Video recordings of fish passage at the center fish ladder occurred from 6:00 am to 8:00 pm each day. The tapes were reviewed to identify and count fish that had passed. Once a week, CDFG determined night passage at the east and west ladder through actual counts from 8:00 pm to 10:00 pm and then video recorded passage from 10:00 pm to 6:00 am The tapes were reviewed to identify and count fish that had passed. This single night count was expanded to represent expected night passage for all other nights that week. CDFG also operated the fish trap located in the east fish ladder. The trap was usually operated 5 days a week from 6:00 am to 3:00 pm Collected fish were identified to species or, if a salmon, to run. Fish were measured and checked for marks (hook scars, missing fins, etc). Actual fish passage counts for the various runs were expanded using fish trap numbers. Data collected at RBDD was used to generate ***the*** winter chinook salmon run-size estimate.

Item 2: Attach previously omitted Appendix 1.

## Disclaimer

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The correct citation for this report is:

USFWS. **1996.** Escapement of hatchery-origin winter chinook salmon (0ncorhynchus tshawytscha) to the Sacramento River, California in 1995, with notes on spring chinook salmon in Battle Creek. USFWS Report. U.S. Fish and Wildlife Service, Northern Central Valley Fish and Wildlife Office, Red Bluff, CA.

## ABSTRACT

The Sacramento River, California winter chinook salmon *Oncorhynchus tshawytscha are* state and federally listed as an endangered species. A propagation program was developed at the U.S. Fish and Wildlife Service's Coleman National Fish Hatchery (NFH) to reduce the threat of extinction and supplement the natural population. We estimated escapement and determined spawning location of winter chinook salmon propagated at Coleman NFH located on Battle Creek, a tributary to the Sacramento River. We accomplished study objectives by: conducting spawning ground surveys on the Sacramento River and Battle Creek; utilizing fish traps and video recording fish passage at dams; and rescuing stranded fish. An estimated 88 hatchery-origin winter chinook salmon returned to the Sacramento River and Battle Creek during 1995 and most or all hatchery-origin winter chinook salmon returned to Battle Creek. The estimated 88 hatchery-origin winter chinook salmon represent a three fold increase over the 1992 founder population. However, the return of hatchery-origin winter chinook salmon to Battle Creek presents a problem as the intention of the propagation program is to supplement the wild population which spawn in the Sacramento River near Redding, California. Findings from this study suggest alternate methods for rearing and release of hatchery-origin winter chinook salmon are needed to imprint the salmon to the natural spawning grounds. Additionally, management alternatives for the salmon returning to Battle Creek need to be developed. Suggested alternatives include capturing the adults and either utilizing them in the propagation program or relocating them to the Sacramento River near Redding, California. Additionally, an estimated 66 spring chinook salmon returned to Battle Creek during 1995.

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## TITLE

Escapement of hatchery-origin winter chinook salmon *(Oncorhynchus tshawytscha)* to the Sacramento River, California in 1995, with notes on spring chinook salmon in Battle Creek.

## GOALS

The goals of this project were to estimate escapement of winter chinook salmon *(Oncorhynchus tschawytscha)* released from the U.S. Fish and Wildlife Service's (Service) Coleman National Fish Hatchery (NFH) to the Sacramento River, and to identify their primary homing and spawning locations (main stem Sacramento River or Battle Creek a tributary of the Sacramento River). Additionally, tissue samples from carcasses were collected for genetic and fish health analysis.

## INTRODUCTION

In 1988, the Service entered a mutual agreement with National Marine Fisheries Service (NMFS), U.S. Bureau of Reclamation and the California Department of Fish and Game (CDFG) to develop a winter chinook salmon hatchery propagation program at the Service's Coleman NFH, located on Battle Creek. The propagation program employs state of the art spawning and rearing techniques to ensure maximum contribution of the hatchery product. The program was established in effort to ensure the continued existence of the endangered Sacramento River winter chinook salmon. The goal of the propagation program is to supplement natural spawning while not developing an adult return to the hatchery.

To assess the success of the supplementation program, it is critical to 1) estimate escapement of hatchery-origin winter chinook salmon to the Sacramento River including tributaries, (i.e. Battle Creek) and, 2) locate spawning grounds of hatchery-origin winter chinook salmon.

## STUDY AREA

Surveys for adult winter chinook salmon occurred on the main stem Sacramento River from Red Bluff Diversion Dam (RBDD; RK 388) to Keswick Dam (RK 483; Figure 1). Additionally, Battle Creek, a tributary of the Sacramento River, was monitored downstream of Eagle Canyon Dam on the north fork and downstream of Coleman Diversion Dam on the south fork.

Specific survey sites in the main stem Sacramento River include:

| | |
|---|---|
| Keswick Dam fish trap | RK 483 |
| Keswick Dam stilling basin | RK 483 |
| spawning grounds | RK 470-480 |
| Red Bluff Diversion Dam | RK 388 |

Specific survey sites in Battle Creek include:

| | |
|---|---|
| Coleman NFHs barrier dam | creek kilometer (CK) 10 |
| spawning grounds | CK 8 up to Eagle Canyon Dam (north fork) |
| | CK 8 up to Coleman Diversion (south fork) |

## METHODS

Winter chinook salmon are raised to the pre-smolt stage at Coleman NFH and released into the Sacramento River near Redding, California (river kilometer [RK] 475). It is hoped these juveniles imprint to the release location and eventually return as adults to spawn naturally with wild winter chinook salmon. Prior to release, all winter chinook salmon juveniles are coded-wire tagged and adipose fin-clipped.

Observations of chinook salmon were made at six survey locations. To produce valid results, attempts were made to observe/sample 10% of the total 1995 winter chinook salmon run-size estimate. Hatchery-origin winter chinook salmon were identified by an adipose fin-clip, while wild winter chinook salmon were unmarked. Winter chinook salmon were distinguished from other runs (late-fall and spring) by run timing and physical characteristics (brightness, coloration, fin condition, and muscle tone). When possible, coded-wire tag recovery was used for positive identification of run.

### Survey Sites

#### Main Stem-- Keswick Dam Fish Trap

The fish trap at Keswick Dam operated consistent with the Service's Biological Assessment for operations of Coleman NFH (USFWS 1993). Sampling occurred from mid-December through the end of June to collected salmon for hatchery propagation programs. When possible, handled salmon were inspected for an adipose fin-clip. The numbers of adipose fin-clipped salmon and unclipped salmon was noted. Run was determined on handled salmon. Collected salmon were either retained for propagation

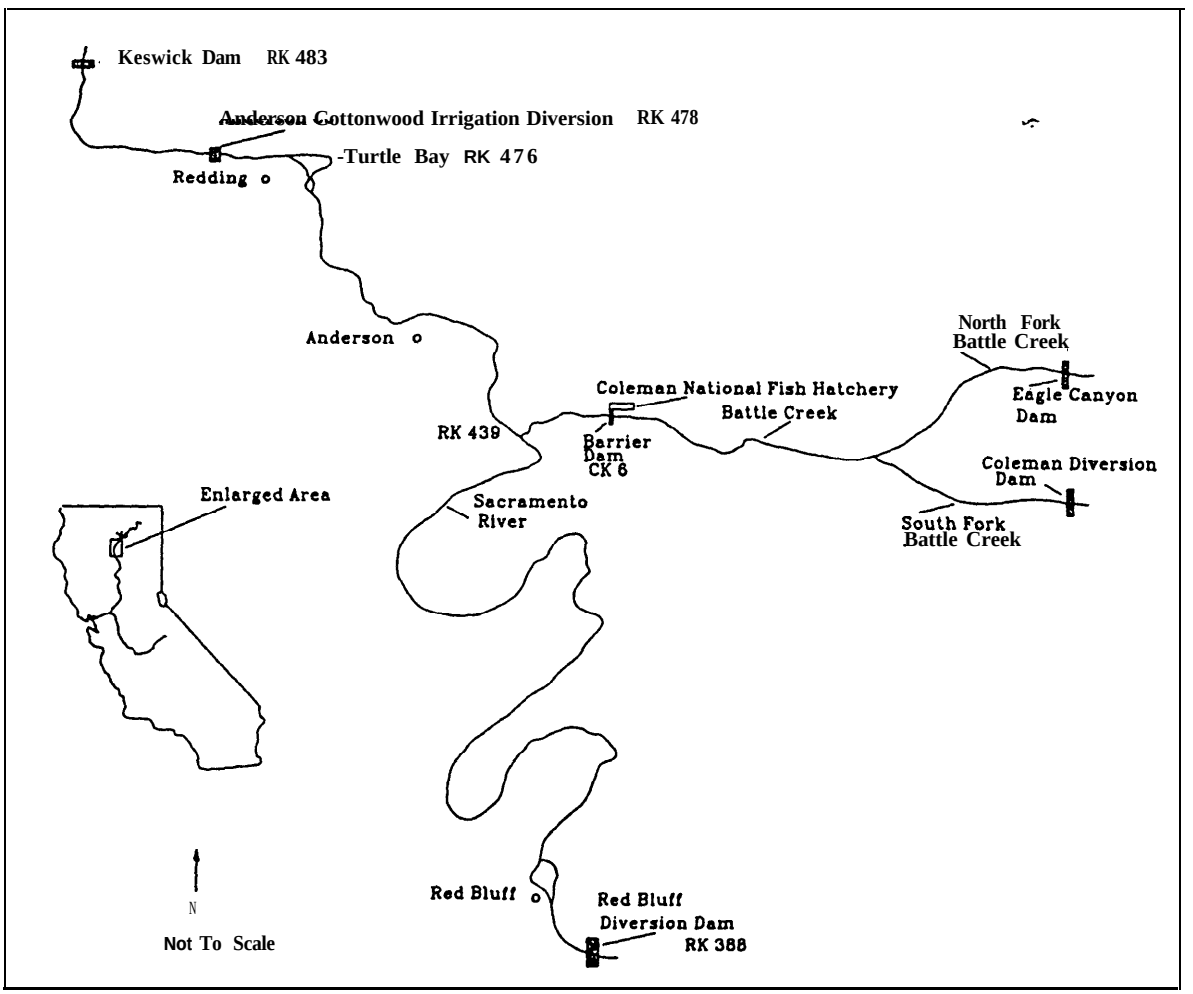


Figure l.-Location of sampling sites in the Sacramento River with relation to Red Bluff Diversion Dam (RBDD), the city of Redding and Keswick Dam and in Battle Creek with relation to Coleman National Fish Hatchery (CNFH) barrier, Eagle Canyon and Coleman Diversion dams.

programs or returned back to the river. Coded-wire tags were recovered from dead fin-clipped salmon.

Main Stem-Keswick Dam Stilling Basin

Periodically, the U.S. Bureau of Reclamation used a purse seine in the stilling basin at Keswick Dam to collect fish trapped within that structure and return them to the Sacramento River. Collected fish were observed for an adipose fin-clip. The numbers of adipose fin-clipped salmon and unclipped salmon were noted. Run was determined on handled salmon.

Main Stem--Spawning Grounds

Weekly boat surveys of winter chinook salmon spawning grounds in the Sacramento River were conducted to recover carcasses. Surveys were conducted from May through August. Salmon carcasses collected during this period were assumed to be winter chinook salmon. Target areas were downstream of spawning riffles near Redding (Lake Redding RK 478, below Redding Riffle RK 477, Turtle Bay RK 475 and Rother Riffle RK 47 1). Recovered carcasses were measured (fork length in mm), sexed, checked for marks and expression of sex products. Liver and kidney samples were collected for fish health and genetic analysis and were archived at the Northern Central Valley Fish and Wildlife Office (NCVFWO), Red Bluff, California. Scales were collected for ageing. Several aerial surveys were also conducted from May through August to identify/verify winter chinook salmon spawning grounds (redds) and carcasses. An attempt was made to recover carcasses identified during aerial surveys. Collected carcasses were observed for an adipose fin-clip and the numbers of adipose fin-clipped salmon and unclipped salmon were noted.

Main Stem--Red Bluff Diversion Dam

During the latter portion of winter chinook salmon upstream migration when the RBDD was in operation (15 May through 5 August), CDFG operated the fish trap located in the east fish ladder. Collected fish were identified to species or, if a salmon, to run. Fish were weighed (g), measured and checked for marks (hook scars, missing fins, etc). The trap was usually operated 7 days a week from 8:00 am to 4:00 pm and one night per week 8:00 pm to 6:00 am. The single night trapping effort was expanded for the remainder of the week. Actual counts of fish passage at the east, center and west ladders occurred from 6:00 am to 8:00 pm each day the dam was operating. The total number of clipped and unclipped winter chinook salmon was recorded. Actual fish passage counts for the various runs were expanded using trap numbers. Data collected at RBDD was used to generate the winter chinook salmon run-size estimate.

Battle Creek--Coleman National Fish Hatchery Barrier Dam

From July through March, the Coleman NFH barrier dam prevented upstream passage of fish in Battle Creek. During October to mid-March, fish were directed into holding ponds at Coleman NFH where salmon and steelhead were used in propagation programs. Passage upstream of the barrier was afforded from 30 March through 30 June. An under-water video camera placed in a modified weir at the upstream end of the fish ladder was used in estimating escapement of chinook salmon above the barrier. 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 24 hours (approximately 2 frames recorded per second) on the Sony EVT-820 time lapse video cassette recorder and 120 minute 8 mm tapes were used. A time-date stamp was recorded. Tapes were viewed in fast forward mode until a fish was observed, then reviewed at normal 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 the species and mark; fair suggested confidence in the species and mark but additional review was needed to classify the fish; and poor, suggested uncertainty in the species and/or mark. The quality of the picture being observed was also rated as good, fair or poor. Good signified a clear picture; fair suggested objects were discemable but extra attention or review was needed; and poor, suggested that objects were indistinguishable. All salmon passing the dam were recorded onto a file tape and reviewed by experienced personnel to determine run. The total number of clipped and unclipped salmon observed were recorded on data sheets. 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 of day, for both clipped and unclipped salmon in Battle Creek was determined. NCVFWO biologist made spot checks of video tapes verifying identification and counts.

Battle Creek--Spawning Grounds

Snorkel surveys were conducted daily on selected sections of Battle Creek (excluding weekends) to locate winter chinook salmon spawning grounds (redds) and carcasses from 27 June through 3 1 August. When possible, recovered carcasses were measured, sexed, and checked for marks and expression of sex products. Liver, kidney and spleen samples were collected for fish health and genetic analysis and archived at NCVFWO in Red Bluff, California. Scales were collected for ageing. Attempts to recover coded-wire tags occurred on clipped salmon and salmon of unknown origin (i.e., carcasses too severely decomposed to assess prior presences of an adipose fin). Redds were marked with **Bagging** or some other visible marker (pile of rocks) to avoid counting twice. The total numbers of clipped and unclipped salmon observed or recovered were recorded.

*Escapement Estimation*

Two independent methods were used to estimate escapement of hatchery-origin winter chinook salmon. One method used data obtained at RBDD to remain consistent with the method used to estimate the winter chinook salmon run-size, however, this method was based on sampling only a portion of the run. Battle Creek data was also used to generate an escapement number and accounted for the complete run timing.

Red Bluff Diversion Dam

A hatchery-origin winter chinook salmon escapement estimate was made at the Red Bluff Diversion Dam. Estimates were derived from direct visual counts of fish passage and numbers for each run were expanded and proportioned relative to data collected in the east fish ladder trap. Weekly data were then summed and expanded by the percentage of historic run timing past the RBDD for the sampling period. The methodology for this estimate was consistent with that used to generate the 1995 winter chinook salmon run-size estimate (Appendix 1).

Battle Creek

Escapement to Battle Creek was estimated based on observations of video taped passage counts at the Coleman NFH's barrier dam and supported by stream surveys. Only days with good to fair video records were used in analysis. Stream surveys were used to document spawning location(s) and time and to count redds. Carcasses were collected for positive identification of run and origin through coded-wire tag recovery. Information from collected carcasses also verified origin of clipped salmon observed during video recordings.

Escapement of clipped, unclipped and unknown clipped salmon passing the Coleman NFH's barrier dam was estimated by expanding the total number of salmon observed by the percentage of passage that was recorded:

$$\text{Escapement (above barrier)} = \text{Number } \textit{Observed} \times \frac{\text{Total Hours Passage}}{\text{Total Hours Taped}}$$

where:

*Number Observed* = number of salmon observed passing the barrier dam (calculated separately for clipped, unclipped and unknown);

*Total Hours Passage* = number of hours of unrestricted fish passage at the barrier dam; and,

*Total* Hours Taped = number of hours of actual good and fair video recorded fish passage.

Coded-wire tag recoveries identified various stocks 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. Estimated escapement of spring chinook salmon past Coleman NFH barrier dam was considered to be the estimate generated for unclipped salmon. Salmon with unknown clips were redistributed between the clipped and unclipped categories based on the proportion of each category observed.

For the 30 March through 30 June period, the number of salmon returning to Battle Creek below the barrier dam was determined by applying the salmon per redd ratio found above the barrier dam to the number of redds observed below the barrier dam This number was then added to the estimated escapement above the barrier dam to tie at a total estimated escapement to Battle Creek.

The final Battle Creek escapement estimation was divided by 96% to account for an assumed 4% stray rate. A 4% stray rate was applied to the Battle Creek estimate as this stray rate has been noted for late-fall chinook released from Coleman NFH. Late-fall chinook salmon are raised at and released directly from Coleman NFH with the intentions of imprinting them to Battle Creek. However, information from the years 1993 - 1995 indicate a minimum of a 4% stray rate to the main stem Sacramento River (Table 1). With this information, it was assumed a similar stray rate could be expected for winter chinook salmon.

Table l.-Year, number of hatchery-origin late-fall chinook salmon captured at Coleman National Fish Hatchery (NFH) and Keswick Dam fish trap and the percent that strayed from Battle Creek. Salmon captured at Keswick Dam fish trap were considered strays. All salmon were positively identified by a coded-wire tag.

| Year | # Salmon Coleman NFH | # Salmon Keswick Dam | % Stray |
|---|---|---|---|
| 1993 | 61 | 1 | 1.6 |
| 1994 | 338 | 10 | 2.9 |
| 1995 | 440 | 21 | 4.6 |
| Total | 839 | 32 | 3.8 |

Twenty-four hour video recording and unrestricted passage occurred during June with the aid of alternative lighting. Prior to 24 hour recording, passage was generally restricted from 7:30 am to 4:00 pm

*Spawning Locution*

Specific spawning locations for hatchery-origin winter chinook salmon were determined through river and stream surveys and carcass recoveries. Counts of clipped and unclipped winter chinook salmon observed at each location were recorded and the percent of hatchery-origin winter chinook salmon was determined. Comparing percent of hatchery-origin winter chinook salmon for each location and between the main stem Sacramento River and Battle Creek indicated homing tendencies.

## RESULTS

The estimated winter chinook salmon run-size past RBDD in 1995 was 1,361 (Frank Fisher, CDFG, Red Bluff, California, personal communication). Approximately 35% of the estimated run-size was sampled at all survey sites, assuming no fish were encountered more than once (Table 2). At least 13% were carcass recoveries on the Sacramento River and Battle Creek and Coleman NFH brood stock (N= 47) and therefore sampled only once.

*Escapement Estimation*

Red Bluff Diversion Dam

Using data obtained at RBDD, an estimated 32 hatchery-origin winter chinook salmon passed RBDD in 1995. This estimate was based on one clipped winter chinook salmon (observed 8 July) out of 45 sampled at the RBDD trap from 15 May (gates down) through 5 August (end of historic winter chinook salmon migration past RBDD; Appendix 1).

Battle Creek

Based on data collected in Battle Creek, an estimated 88 hatchery-origin winter chinook salmon returned to the Sacramento River system in 1995. This finding was based on observing 65 chinook salmon passing upstream of the Coleman NFH barrier dam from 30 March to 30 June 1995. No winter or spring chinook salmon were encountered at Coleman NFH while collecting for propagation programs (December through February).

Of the salmon passing the barrier dam, a total of 31 were clipped, 28 were unclipped and 6 had unknown clips. Unknown clips were observed when viewing quality was poor (N =

Table 2.-Location, number of wild and hatchery winter chinook salmon observed, percent hatchery origin and percent of the total estimated winter chinook salmon population sampled in the Sacramento River and Battle Creek during 1995. Thick line separates winter chinook salmon encountered in the main stem Sacramento River (above) and Battle Creek (below). Percent of total population sampled was based on California Department of Fish and Game's 1995 estimated escapement of **1,361** winter chinook salmon to the Sacramento River (Frank Fisher, CDFG, Red Bluff, California, personnel communication).

| Location | Number wild | Number hatchery | Percent hatchery | Percent of total population |
|---|---|---|---|---|
| Keswick Dam fish trap | 110 | --- 0 | 0 | 8 |
| Keswick Dam stilling basin | 159 | 0 | 0 | **12** |
| Sacramento River spawning grounds | 117 | 0 | 0 | 9 |
| Red Bluff Diversion Dam fish trap | 44 | 1 | 2 | 3 |
| Coleman NFH's barrier dam fish ladder | 0 | 31 | 100 | 2 |
| Battle Creek spawning grounds | 0 | 10 | 100 | 1 |
| Total | 430 | 42 | 10 | 35 |

5) or fair (N = 1). Passage was unrestricted for 1,761.37 hours during this period and 955.05 hours (54.22%) was video recorded (Table 3). The total number of hours of poor quality video recording was **211.04,** resulting in **744.01** hours or **42.24%** of good and fair video recording. Poor video recording resulted from highly turbid water, glare from the sun, *equipment failures or a dirty camera lens and was not considered in the percent of observed fish passage. Throughout the sampling period, video recording was temporally interrupted due to equipment failure.

An estimated **74** winter chinook salmon (clipped) passed the Coleman NFH barrier dam along with 66 spring chinook salmon (unclipped). Twenty winter chinook salmon redds were located in Battle Creek above the barrier dam, eight in the south fork and 12 in the main stem. No redds were observed in the north fork of Battle Creek. There was an estimated 3.7 salmon per redd above the Coleman NFH barrier dam. Two winter chinook salmon redds were observed below the Coleman NFH barrier dam which equates to 7.4

Table 3.-Weekly number of salmon observed, 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 30 March through 30 June 1995. Blanks indicate that no counting was conducted.

| Week Ending | Number Winter | Number Spring | Number unknown | Hours of Passage | Hours of Tapped Passage |
|---|---|---|---|---|---|
| 30 March | 2 3 | 0 0 | 0 0 | 36.33 | 17.83 |
| 08 April | 4 | 2 | 0 | 64.58 | 52.42 |
| 15 April | 4 | 3 | 0 | 79.09 | 47.59 |
| 22 April | 1 | 0 | 0 | 71.67 | 62.01 |
| 29 April | 2 | 2 | 0 | 144.17 | 78 |
| 06 May | | | | 168 | 0 |
| 13 May | | | | 168 | 0 |
| 20 May | | | | 168 | 0 |
| 27 May | 3 | 2 | 0 | 78.66 | 44 |
| 03 June | 2 | 0 | 0 | 145.87 | 21.33 |
| 10 June | 5 | 4 | I | 168 | 132.83 |
| 17 June | 1 | 6 | 0 | 168 | 72 |
| 24 June | 6 | 7 | 0 | 168 | 144 |
| 01 July | 1 | 2 | 0 | 133 | 72 |
| Total | 31 | 28 | 1 | 1761 37 | 744.01 |

salmon. Additionally, three unspawned hatchery-origin winter chinook salmon were recovered below the Coleman NFH barrier dam prior to the observation of the first redd and were added to the Battle Creek total. Total escapement of winter chinook salmon to Battle Creek was estimated at 84.4. No spring chinook salmon redds were observed below the barrier dam An additional 4% of the Battle Creek estimated escapement or 3.4 fish were added to the Battle Creek estimate to account for straying.

| | |
|---|---|
| Estimated escapement of winter chinook salmon: | |
| Battle Creek above barrier dam | 74 |
| Battle Creek below barrier dam | 7.4 |
| Number of carcasses recovered below Coleman NFH barrier dam prior to first redd | +3 |
| Sum for Battle Creek | 84.4 |
| Estimated 4% stray rate to Sacramento River | + 3.4 |
| Final estimated escapement | 88 |

Most spring chinook salmon (unclipped) migrated upstream during June, where migration timing for winter chinook salmon (clipped) appeared to be fairly consistent throughout the sampling period with a small peak in the beginning of June (Figure 2). Based on June data alone, most salmon moved during the daylight-hours (80%; Figure 3). Other fish observed moving upstream include Sacramento squawfish (Ptychocheilus grandis), Sacramento sucker *(Catastomus occidentalis)* and rainbow trout/steelhead (0. *mykiss).*

*Spawning Location*

Most or all hatchery-origin winter chinook salmon returned to Battle Creek (Table 2). No hatchery-origin winter chinook salmon were observed in the Sacramento River near Redding. All winter chinook salmon observed in Battle Creek were assumed to be of hatchery-origin. Ten carcasses recovered during Battle Creek stream surveys had either a coded wire-tag (N= 8) or an adipose fin-clip (N= 2; Table 4). Five other salmon carcasses were found in a condition of decay that prevented origin identification. All eight coded wire-tags recovered revealed salmon were from Coleman NFH's brood year 1992 release of winter chinook salmon.

## DISCUSSION

Based on data collected at RBDD, the estimated escapement of 32 hatchery-origin winter chinook salmon to the Sacramento River is likely very conservative. 3 1 hatchery-origin winter chinook salmon were observed during 42% of the recorded passage at Coleman NFH's barrier dam. It is highly unlikely that most hatchery-origin winter chinook salmon passing RBDD would have been actually video recorded in Battle Creek. However, some of the salmon in Battle Creek could have been counted twice as the result of fall back. Although the estimate at RBDD was only based on one observation, methods employed at RBDD to estimate escapement of hatchery-origin winter chinook salmon should be maintained to remain consistent with the winter chinook salmon run-size estimate.

Undocumented passage throughout the sampling period, particularly during high flows, and missing the potential peak migration of spring chinook salmon suggest the escapement value generated from Battle Creek data was an underestimate. The barrier dam was assumed to be 100% effective in preventing passage, however, several high water and

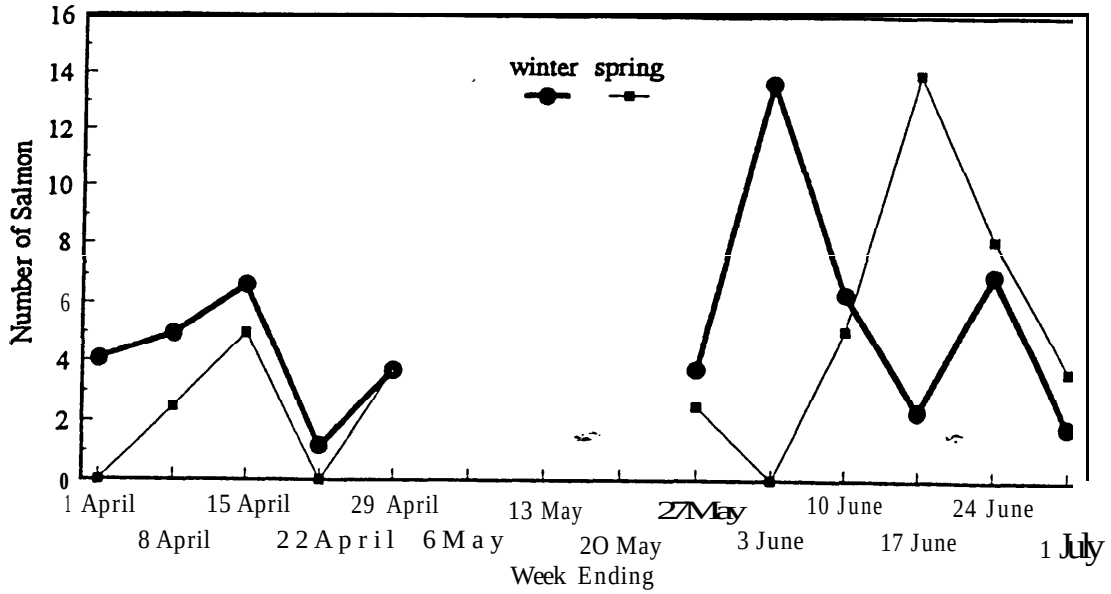


Figure 2.-Estimated numberand migration timing of titer and spring chinook salmon passing Coleman National Fish Hatchery's barrier dam for each week passage was recorded

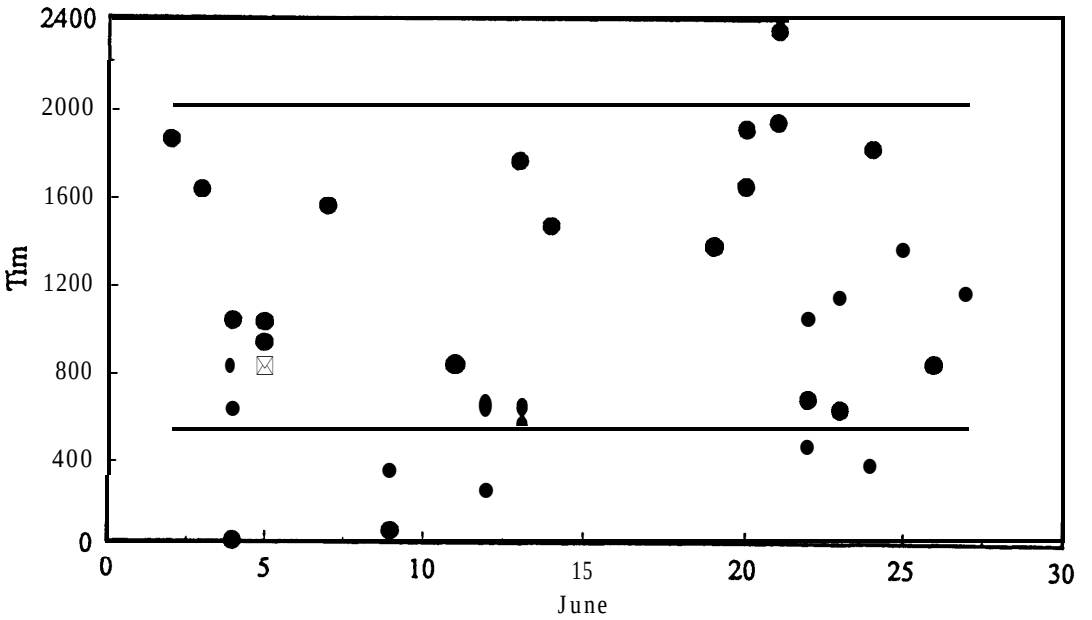


Figure 3.--Diel migration timing of chinook salmon in Battle Creek (N = 34). Daylight hours are between the lines.

Table 4.-Date, condition, coded wire-tag (CWT; if recovered), location and sex of chinook salmon carcasses recovered on Battle Creek during May through August 1995.

| Date | Carcass condition | CWT | Location | Sex |
|---|---|---|---|---|
| 5 May | Good | 0501010621 | hatchery (waste water canal) | female |
| 5 May | Good | 0501010710 | hatchery (waste water canal) | female |
| 13 May | Good | 0501010614 | hatchery (abatement pond canal) | female |
| 30 June | Severely decomposed | | main stem | male |
| 30 June | Skeleton only | | main stem | unknown |
| 6 July | Head only | 0501010712 | main stem | unknown |
| 10 July | Severely decomposed | 0501010712 | main stem | male |
| 12 July | Good, adipose fin-clip (full of eggs | | south fork | female |
| 17 July | Head only | 0501010710 | south fork | female |
| 17 July | Skeleton only | | south fork | unknown |
| 24 July | No internal organs | 0501010712 | main stem | female |
| 24 July | Skeleton & partial head | 0501010705 | main stem | female |
| 24 July | Skeleton | | main stem | female |
| 21 August | Decomposed, adipose fin-clip | | main stem | unknown |
| 21 August | Skeleton | | main stem | unknown |

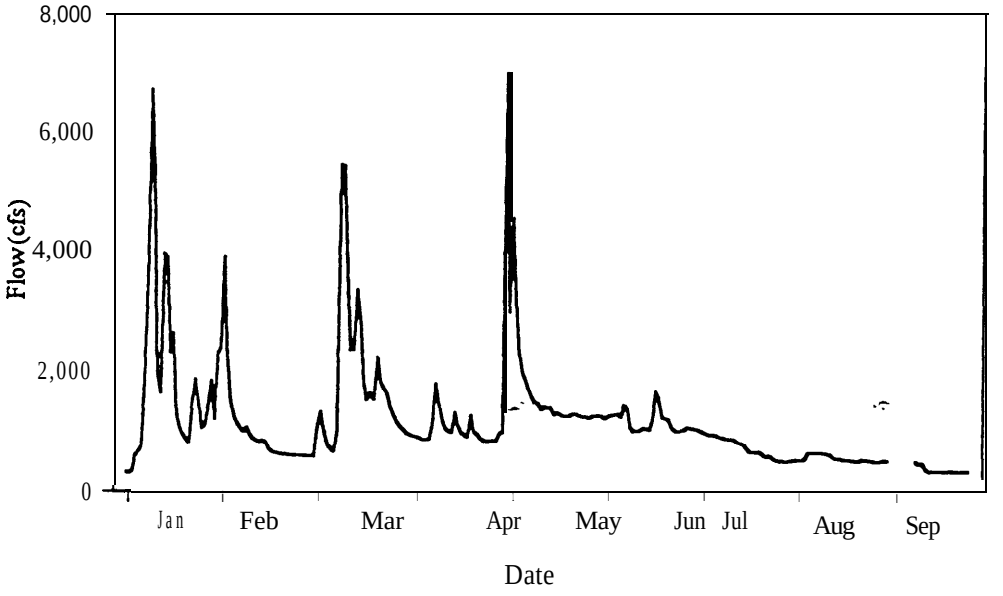


Figure 4.--Average daily flow (cfs) in Battle Creek from 1 January through 20 September 1995.

flood events undoubtably afforded undocumented passage. Three major flood events, occurred in 1995 essentially inundating the Coleman NFH, Eagle Canyon and Coleman Diversion dams (Figure 4). Salmon were observed ascending the barrier dam at Coleman NFH when creek flows were approximately 350 cfs (unpublished data, NCVFWO, Red Bluff, California). Additionally, upstream migration is generally influenced by flood events. Findings in Deer and Mill creek suggest most spring chinook salmon move upstream during May (Frank Fisher, CDFG, Red Bluff, California, personnel communication).

The Coleman NFH barrier dam provided an excellent means to count salmonids and other fish species. Passage was essentially limited to a 0.61 meter by 0.61 meter square allowing for easy monitoring with a video recording system Suggested improvements to this system include: enclosing the recording area to reduce glare; installing underwater pool lights to maintain consistent lighting; upgrading the video monitor to detect real time problems with the recording system; acquiring "back-up" equipment to limit down time; and cleaning and maintaining the equipment more effectively. Improvements will also provide better data on migration timing in Battle Creek, which at this point, is largely unknown. Movement of other fish species known to inhabit Battle Creek did not appear to be inhibited by the video system and weir.

Two redds were observed below the Coleman NFH barrier dam after it was closed to fish passage on 30 June. These two redds may account for the hatchery-origin winter chinook salmon observed at RBDD fish trap on 08 July. However, only one survey was conducted below the barrier dam (13 July) and the redds may have been constructed prior to observing hatchery-origin winter chinook salmon at RBDD. In future years, more regular surveys should be conducted below the barrier dam. A salmon to redd ratio for spring chinook salmon of 3.9 was found in the Umatilla River basin (Tribal Fisheries Program 1994) and was similar to the ratio found above the barrier dam (3.7). This finding supports the method used to determine the number of winter chinook salmon returning to Battle Creek below the barrier dam.

Undoubtably, a portion of the winter chinook salmon that unintentionally imprinted to Battle Creek strayed. The stray rate chosen (4%) for escapement estimation was based on collection of coded wire-tagged late-fall chinook salmon at the Keswick Dam fish trap. ***These*** salmon were raised at and released directly from Coleman NFH with intentions of imprinting them to the hatchery. Because of the large area in which winter chinook salmon spawn and the small percentage estimated to stray, it was presumed that none would be seen.

Alternative methods need to be developed to more accurately determine escapement for hatchery-origin winter chinook salmon that return to the main stem Sacramento River and how to incorporate them into estimates from Battle Creek. Current data suggest hatchery-origin winter chinook salmon have imprinted on and returned to Battle Creek. If imprinting problems are corrected, then escapement estimates based solely on Battle Creek data will be inadequate. Mark-recapture may be used to estimate escapement in the main stem Sacramento River, however, the small population size may limit the applicability of this approach.

Sufficient data was obtained to suggest that most or all hatchery-origin winter chinook salmon returned to Battle Creek. The return of winter chinook salmon to Battle Creek poses two concerns: 1) how to improve imprinting of hatchery-origin winter chinook salmon to the Sacramento River; and 2) how to best utilize winter chinook salmon returning to Battle Creek. Imprinting issues are discussed in the Service's "Alternate rearing and release strategies for winter chinook salmon ***(Oncorhynchus tschawytscha)*** raised at Coleman National Fish Hatchery" (USFWS 1995). The Service consistently maintains that the goal of the propagation program is to supplement the natural spawning of winter chinook salmon in the main stem Sacramento River and does not desire to establish a hatchery or Battle Creek return. However, monitoring of adult winter chinook salmon returning to Battle Creek should be continued and adults should be collected and: 1) utilized in the current propagation program or; 2) relocated, to the main stem Sacramento River near Redding, California. If natural spawning is allowed in Battle Creek, then the creek should be monitored for juveniles by beach seine, electro-fishing or

rotary screw trap. The Service will continue to cooperate with CDFG and NMFS for the management of hatchery-origin winter chinook salmon returning to Battle Creek.

Overall the propagation program at Coleman NFH was successful in developing a adult return of winter chinook salmon. The estimated 88 hatchery-origin winter chinook salmon represent a three fold increase over the 1992 founder population. Based on escapement estimates, 0.11% (escapement estimate of 32) to 0.32% (escapement estimate of 88) of the 1992 brood year winter chinook salmon returned (28,099 released). This rate of return is comparable to the hatchery's successful fall chinook salmon escapement.

## RECOMMENDATIONS

Several recommendations to improve the Service's ability to estimate escapement and determine spawning location of hatchery-or&i&inter chinook salmon are listed below. Additionally, recommendations to improve the overall winter chinook salmon hatchery propagation program are described.

1) Maintain current methods and amount of effort to obtain information relating to hatchery-origin winter chinook salmon homing tendencies, spawning locations and escapement estimation.

2) Begin stream surveys on Battle Creek the first week in June and conduct more regularly surveys below the Coleman NFH barrier dam and above the Coleman Diversion and Eagle Canyon dams.

3) Improve the quality and reliability of the video recording system deployed at Battle Creek. Modifications include; enclosing the viewing area to reduce glare and inconsistencies with ambient light; installing underwater pool lights for more consistent lighting; upgrading equipment; and instituting a better and more frequent cleaning and maintenance schedule.

4) Continue to seek alternative methods to improve escapement estimation of hatchery-origin winter chinook salmon, particularly in the Sacramento River. Methods should consider the small population size and attempt to standardize effort and findings between different locations.

5) Implement alternative methods for rearing and release of hatchery-origin winter chinook salmon aimed at improving imprinting to the main stem Sacramento River.

6) Develop a management plan for winter chinook salmon returning to Battle Creek. Suggested options include: collecting adults for use in the propagation program;

relocating captured adults; improving stream conditions or discounting them in recovery efforts.

7) Monitor success of winter chinook salmon that spawned in Battle Creek through the use of beach seine, electro-fishing equipment, rotary screw trap or other appropriate gear.

## REFERENCES


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## 1995 RED BLUFF DIVERSION DAM WINTER CHINOOK SALMON COUNTS AND POPULATION ESTIMATES

| WEEK ENDING | AVERAGE PERCENT PASSAGE | CUM PERCENT PASSAGE | ACTUAL COUNT | NIGHT FACTOR | ADJUSTED COUNT | DAYS TRAPPED | ALL FISH TRAPPED | WINTER TRAPPED | HATCHERY WINTER TRAPPED | % WINTER | % HATCHERY WINTER | EXP. WINTER | EXP. HATCHERY WINTER | CUM. WINTER | CUM HATCHERY | WEEKLY ESTIMATE | WEEKLY ESTIMATE HATCHERY | SEASONAL/ CURRENT ESTIMATE | SEASONAL/ CURRENT ESTIMATE HATCHERY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 05/02 | 2.17 | 2.17 | 77 | 1.26667 | 171 | 4 | 20 | 6 | | 0.3 | 0 | 51 | 0 | 51 | 0 | 2360 | 0 | 2360 | 0 |
| 05/27 | 3.09 | 5.26 | 67 | 1.26 | 84 | 7 | 27 | 9 | | 0.333333 | 0 | 28 | 0 | 79 | 0 | 906 | 0 | 1602 | 0 |
| 06/O3 | 2.03 | 7.29 | 64 | 1.2 | 77 | 7 | 37 | 3 | | 0.08108I | 0 | 6 | 0 | 85 | 0 | 296 | 0 | 1166 | 0 |
| 06/10 | 1.63 | 8.92 | 83 | 1.16667 | 87 | 7 | 44 | 3 | | 0.068182 | 0 | 7 | 0 | 92 | 0 | 429 | 0 | 1031 | 0 |
| 06/17 | 1.84 | 10.76 | 133 | 1.23729 | 106 | 7 | 46 | 6 | | 0.111111 | 0 | | 0 | 110 | 0 | 978 | 0 | 1022 | 0 |
| 06/24 | 0.51 | 11.27 | 110 | 1.16 | 128 | 7 | 26 | 3 | | 0.116386 | 0 | 15 | 0 | 125 | 0 | 2041 | 0 | 1109 | 0 |
| 07/01 | 0.76 | 12.03 | 71 | 1.18182 | 84 | 7 | 26 | 2 | | 0.076923 | 0 | 6 | 0 | 131 | 0 | 789 | 0 | 1088 | 0 |
| 07/08 | 1.6 | 13.63 | 245 | 1.05797 | 259 | 7 | 48 | 7 | 1 | 0.166667 | 0.020833 | 43 | 6 | 174 | 5 | 2688 | 313 | 1277 | 37 |
| 07/15 | 0.31 | 13.94 | 188 | 1.1667 | 218 | 7 | 15 | 0 | | 0 | 0 | 0 | 0 | 174 | 5 | 0 | 0 | 1248 | 36 |
| 07/22 | 1.04 | 14.98 | 674 | 1 | 674 | 7 | 113 | 6 | | 0.053087 | 0 | 36 | 0 | 210 | | 3462 | 0 | 1402 | 33 |
| 07/29 | 0.44 | 15.42 | 89 | 1.10626 | 98 | 7 | 24 | 0 | | 0 | 0 | 0 | 0 | 210 | 5 | 0 | 0 | 1362 | 32 |
| 08/05 | 0.01 | 15.43 | 713 | 1.01668 | 726 | 7 | 67 | 0 | | 0 | 0 | 0 | | 210 | 5 | 0 | 0 | 1361 | |
| | | | 2614 | | 2782 | | 512 | 44 | 1 | | | | | 210 | 6 | | | 1361 | |

Shaded values are associated with estimates of hatchery-origin winter chinook salmon