POTTER VALLEY PROJECT (FERC NO. 77)
FISHERIES STUDY
FINAL REPORT

Volume I

prepared by

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ABSTRACT

A three-year fisheries study began in November 1979 to determine adequate streamflow releases from the Potter Valley Project for maintenance of chinook salmon and steelhead trout populations in the upper Eel River drainage. Results, interpretations, and conclusions for the three years of study are presented in this report.

Upstream migration of chinook salmon and steelhead trout into the upper Eel River drainage is dependent on peak streamflows following major fall and winter storms; both species generally first arrive at Cape Horn Dam in November or December following the first or second major peak flow of the season. Salmon have arrived at Cape Horn Dam following peak flows as low as 100 cfs at the dam and 235 cfs above Outlet Creek, although in most years peak flows exceed 200 cfs at the dam and 900 cfs above Outlet Creek prior to first arrival. Peak flow releases from Cape Horn Dam of 135 cfs during periods of normal storm activity and 205 cfs in the absence of normal storm activity appear necessary for chinook migration. Peak releases necessary for steelhead migration appear to be less.

Fish passage over identified critical riffles between Tomki Creek and Outlet Creek is a key factor for successful upstream migration. Observations of salmon and steelhead passage over Hearst Riffle revealed that pulses in flow stimulated far greater movement than stable flows and that configuration of the stream channel below the riffle was a stronger determinant of areas used for passage than depths on the riffle. The Thompson criteria for passage over shallow riffles do not appear to be valid for the Eel River. A minimum depth of 0.6 ft was found to be adequate for passage of chinook salmon; depending on downstream channel morphology, a continuous usable width of less than 10% may be adequate; and maximum depths along the shallowest bank-to-bank transect are not necessarily used by fish for passage.

Channelization of Hearst Riffle, or other critical riffles, to improve upstream passage conditions appears to be unnecessary. Adequate passage can be achieved through flow releases alone. Channelization may be impractical due to streambed instability and inaccessibility of some riffles.

Areas of use by salmon and steelhead within the study area were separated geographically and seasonally. Chinook salmon spawn principally in the mainstem Eel River downstream of Tomki Creek and in Tomki Creek. Steelhead are limited by suitable summer rearing conditions and thus principally spawn and rear in the Eel River between Scott Dam and Cape Horn Dam and in some tributaries. Chinook salmon spawning habitat in river sections used most heavily between Tomki Creek and Outlet Creek is optimum at flow releases of 175 to 250 cfs from Cape Horn Dam. Flows that are adequate for spawning are assumed to be adequate for egg incubation. Steelhead spawning habitat between Scott and Cape Horn Dams is greatest at flow releases of 170 to 280 cfs from Scott Dam. Steelhead rearing habitat between the dams is greatest at flow releases of 68 to 265 cfs from Scott Dam.

The most important summer rearing habitat for steelhead trout exists in the Eel River between Scott and Cape Horn Dams; additional good quality rearing habitat exists in several tributary streams. Due to high water temperature, summer rearing habitat in the mainstem Eel River downstream of Cape Horn Dam is very limited and exists almost exclusively between Cape Horn Dam and Tomki Creek. Moderate flow releases from Cape Horn Dam would do little to extend the suitable habitat downstream.

Downstream migration of juvenile chinook salmon appears primarily related to water temperatures and secondarily to decreasing streamflow and reduced light intensity associated with the new moon. Peak salmon emigration occurred at temperatures between 17° and 20°C. Peak emigration of salmon from the area below Cape Horn Dam occurred in May during all years of sampling; peak emigration from the area above the dam occurred in late June during 1980 and in May during 1982. This difference in timing was probably due to differences in water temperatures between the two years. Juvenile steelhead emigration from the area between Scott and Cape Horn Dams appears to be related to rising water temperatures (14° to 20°C) and decreasing flows during spring, sudden decreases in flow during summer, sudden increases in flow during fall, and reduced light intensity associated with the new moon. Older juvenile steelhead (age 1+ and older) migrate earlier (late April-late May) than young-of-the-year (late May-mid-July). Cooler water temperatures in the Eel River between the dams apparently delays emigration of salmon and steelhead, which may result in significant losses from lethal water temperatures in the Eel River downstream of Tomki Creek. The number of salmon and steelhead diverted from the upper Eel River drainage has declined since installation of the diversion fish screen. The screen retains larger steelhead (1+ and older); however, it is not as effective at screening young-of-the-year fish.

Estimates of spawning escapement above Scott Dam prior to construction of the dam are 2,499 chinook and 3,356 steelhead. However, due to long-term habitat degradation and declines in fish runs in the north coastal region of California in the last several decades, it is extremely unlikely that the Eel River above Scott Dam could support as many fish as it did historically; estimates of probable current run sizes are 1,250 chinook and 1,499 steelhead.

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1.0 INTRODUCTION

The Potter Valley Project, owned and operated by Pacific Gas and Electric Company (PGandE), is an interbasin hydroelectric project on the Eel and Russian Rivers in the North Coast Range of California. Water is diverted from the Eel River into the Russian River for the production of electrical energy and to provide water for irrigation in the Russian River basin. The project consists of a storage dam and reservoir (Scott Dam, Lake Pillsbury); a diversion dam and forebay (Cape Horn Dam, Van Arsdale Reservoir); an inter-basin diversion system with an intake structure, tunnel, and penstock; a powerhouse (Potter Valley Powerhouse); and a tailrace canal (Figure 1.0-1).

The project is under license with the Federal Energy Regulatory Commission (FERC 77) and has been operating on annually renewed licenses since the original Federal Power Commission license expired in 1972. Although PGandE applied for relicensing in 1970, a new long-term license has not been granted due to the unresolved issue of streamflow releases. Ten parties have intervened in the relicensing process with interests in maintaining or altering the operating regime. Through a series of discussion sessions, PGandE and the eight original intervening parties were unable to develop a mutually agreeable operating regime on the basis of existing information. Therefore, they formulated a study agreement to fulfill the data needs. The agreement, which was finalized in October 1979, required a three-year study to determine adequate streamflow releases for maintenance of chinook salmon, *Oncorhynchus tshawytscha*, and steelhead trout, *Salmo gairdneri*, populations in the upper Eel River drainage.

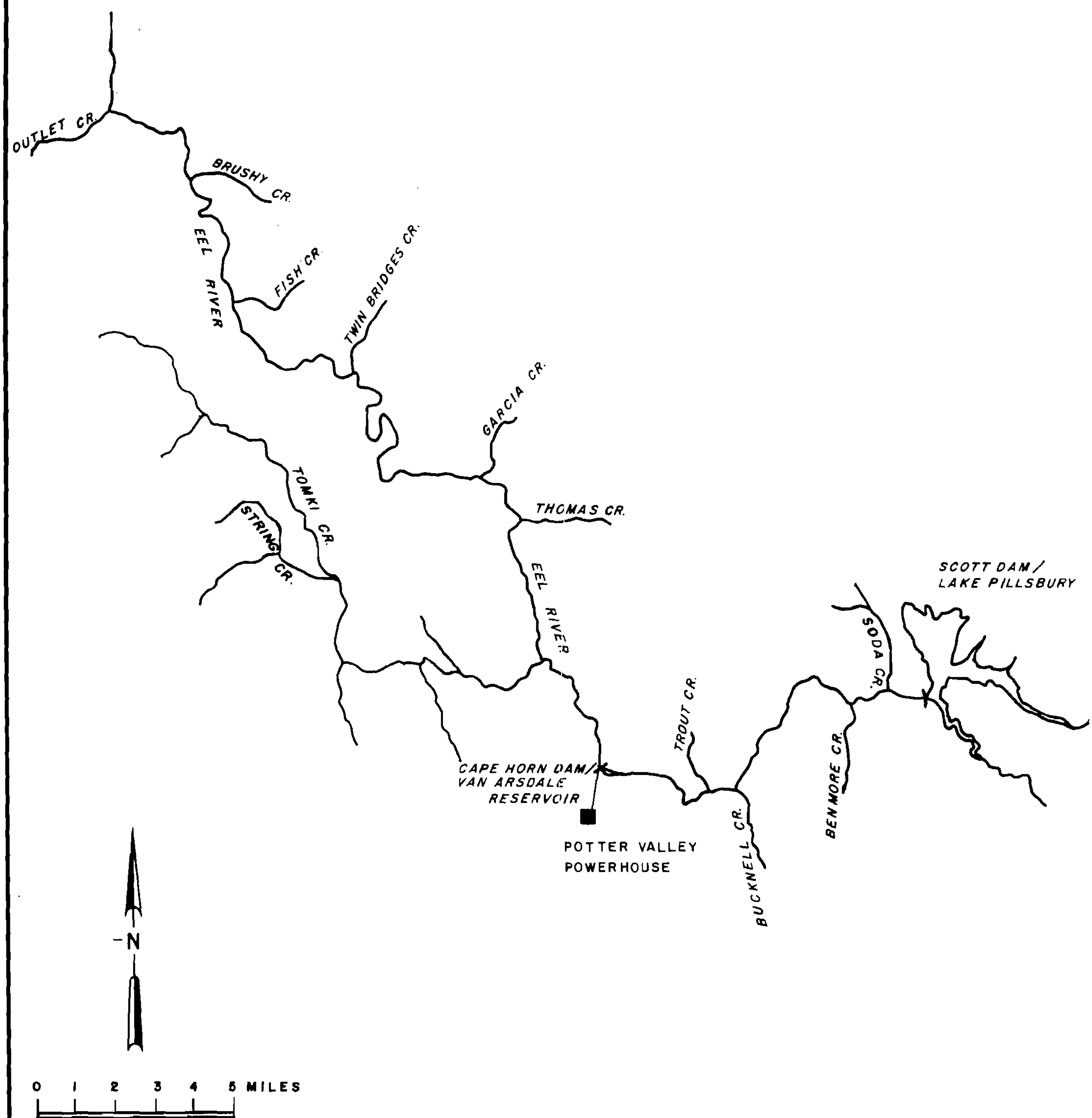

Figure 1.0-1. Study area for the Potter Valley Project Fisheries Study.

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A copy of the agreement, including the fisheries study work plan for each study year, is presented in Appendix A.

Objectives of the study were to:

Determine the minimum streamflow releases necessary to provide adequate passage of upstream migrant adult chinook salmon and steelhead trout;

Determine the timing and number of upstream migrant adult chinook salmon and steelhead trout;

Quantify the amount of spawning and rearing habitat available to chinook salmon and steelhead trout;

Determine the timing and number of downstream migrant juvenile salmonids;

Evaluate the feasibility of channeling the Hearst Riffle to provide a channel of adequate depth and velocity for passage of upstream migrants;

Determine whether, and to what extent, mitigation measures should be undertaken; and

Determine the fishing conditions for each flow being tested.

The work plan contained eleven major study elements to provide the information necessary to meet the objectives:

Cape Horn Dam Adult Fish Counts,
Tomki Creek/Eel River Salmon Carcass Survey,
Aerial Redd Survey,
Hearst Riffle Passage Study,

Critical Riffle Study,
Instream Flow Study,
Downstream Juvenile Migration Study,
Summer Fish Inventory,
Hearst Riffle Channelization Feasibility Study,
Mitigation Study, and
Fishability Study.

Minimum streamflow releases necessary to provide adequate passage of upstream migrant chinook salmon and steelhead trout were determined from the results of five study elements: Cape Horn Dam Adult Fish Counts, Tomki Creek/Eel River Salmon Carcass Survey, Aerial Redd Survey, Hearst Riffle Passage Study, and Critical Riffle Study. The number and timing of adult fish passing over the dam, the number and timing of fish spawning in Tomki Creek and the Eel River, and the distribution of fish spawning in the Eel River in relation to streamflow served as indicators for minimum flow requirements. Measurement of water depths and velocities across selected critical riffles at various streamflows were used in conjunction with observations of fish passage over Hearst Riffle, an identified critical riffle, to evaluate the ability of salmon and steelhead to pass these potential barriers at various flows.

Four task elements provided data for determining the timing and number of upstream migrant adult chinook salmon and steelhead trout: Cape Horn Dam Adult Fish Counts, Tomki Creek/Eel River Salmon Carcass Survey, Aerial Redd Survey, and Hearst Riffle Passage Study. Observations of fish passing over Hearst Riffle and Cape Horn Dam indicated the timing of the runs in the Eel River, as did weekly counts of live and dead fish in Tomki Creek and the Eel River. Population estimates in Tomki Creek and portions of the Eel River, estimates of fish and redd numbers from aerial surveys, and counts of fish at Cape Horn Dam indicated the number of spawning chinook salmon and steelhead trout using various areas in the upper Eel River drainage.

The amount of spawning and rearing habitat available to chinook salmon and steelhead trout at various flows was quantified by the Instream Flow Study. Hydraulic conditions and salmonid habitat were modeled by computer based on field measurements of water depth, velocity, and substrate types. Data collected during the Summer Fish Inventory and other study elements were used to enhance and refine the modeling. Fish inventories were also used to determine what salmonids remain in the Eel River during the summer, their relative abundance, and the habitat areas used by these fish. The relative abundance and areas of use by other species were also determined.

The timing and relative magnitude of juvenile chinook salmon and steelhead trout emigration from the upper Eel River were determined by the Downstream Juvenile Migration Study. Downstream migrants were trapped at five locations in the study area. The relationship of streamflow and other factors, such as temperature, to timing of emigration were examined.

The need for and feasibility of channelizing Hearst Riffle to provide easier upstream passage of migrants was determined by the Hearst Riffle Passage and Channelization Feasibility Studies. The ability of chinook salmon and steelhead trout to pass over Hearst Riffle at various streamflows, stability of the streambed, and construction/maintenance costs were evaluated.

The need to implement measures in addition to minimum streamflows to mitigate adverse project effects was assessed and quantified to the extent possible by the Mitigation Study using existing data and field surveys. Estimates of the amount of spawning and rearing habitat lost above Scott Dam and reduction in historical runs that can be attributed to dam construction were primary considerations for assessing possible adverse project impacts. Effects of other factors that may have impacted spawning runs, such as commercial and sport fisheries and various land and water use practices, were also considered.

This report contains a description of the methods, results, and conclusions of ten study elements conducted during the three years of study (November 1979 through October 1982):

Cape Horn Dam Adult Fish Counts,
Tomki Creek/Eel River Salmon Carcass Survey,
Aerial Redd Survey,
Hearst Riffle Passage Study,
Critical Riffle Study,
Instream Flow Study,
Downstream Juvenile Migration Study,
Summer Fish Inventory,
Hearst Riffle Channelization Feasibility Study, and
Mitigation Study.

Methods and results of study elements conducted during the first and second years of study were originally presented in annual progress reports by VTN (1981 and 1982a). A preliminary draft of the final report covering study results through January 1982 was also produced by VTN (1982b).

The fishability study element, conducted by California Trout, Inc. with assistance from the California Department of Fish and Game (CDF&G), is not included in this report. Copies of the fishability study report prepared by California Trout, Inc. may be obtained from that organization.

Most of the work was performed by VTN with assistance and cooperation from PGandE and CDF&G. PGandE personnel participated in the field work and data analysis including salmon carcass surveys, steelhead surveys, Hearst Riffle passage observations, critical riffle measurements, instream flow study, downstream juvenile migration trapping, summer fish inventories, and mitigation task reconnaissance surveys, and were the principle participants in collecting water temperature data and processing fish inventory data. The PGandE Civil Engineering Department conducted the Hearst Riffle Channelization Feasibility Study. CDF&G performed the counts of adult fish at Cape Horn Dam and trapping at the diversion structure fish screen and Cape Horn Dam fishway. CDF&G personnel also participated in steelhead surveys and summer fish inventories. CDF&G, U.S. Fish and Wildlife Service (USFWS), and California Department of Water Resources (DWR) personnel participated in selection of critical riffles and in the selection of instream flow study sites. A special note of thanks is due to personnel of the DWR. Their participation not only allowed the instream flow study to be completed in a timely and efficient manner, but also permitted a larger work effort to be completed than would otherwise have been possible.

The Technical Review Committee, composed of representatives from each of the relicensing parties, met in October 1980 and August 1981. A biological subcommittee composed of technical representatives from VTN, PGandE, CDF&G, USFWS, Sonoma and Mendocino Counties, Humboldt County, and DWR met on several occasions from October 1981 through April 1982. Discussions of study elements and suggestions for modifications from these meetings were considered in the formulation of the work plan for the second and third years of study and in the preparation of this report.

2.0 METHODS

2.1 Cape Horn Dam Adult Fish Counts

Upstream migrating adult chinook salmon and steelhead trout were trapped and counted by CDF&G personnel at CDF&G's Van Arsdale Fisheries Station trapping and egg collection facility located on the fishway ascending Cape Horn Dam on the Eel River (Figure 2.1-1).

During the 1979/80 migration season, the upstream migrant trap contained a one-way "finger weir" at the downstream end of the holding pen. The weir consisted of a set of spring-loaded vertical steel rods (fingers), each approximately three-eighths of an inch in diameter, hinged to a flashboard that was secured to the bottom of the holding pen. When an upstream migrating fish passed over the weir, the weight of the fish depressed the weir, allowing the fish to pass. Once the fish had passed, the weir returned back to its set position by means of the springs. In the set position, the weir did not allow any downstream movement of fish out of the holding pen.

In 1980, the finger weir was replaced with an array of one-inch diameter thin-wall steel conduit pipe hung vertically and independently from a frame above the water. The bottoms of the pipes rested against stops lying on the floor of the holding pen. When an upstream migrating fish swam against one or more of the pipes, the pipes swung free, allowing the fish to pass through to the holding pen. Once the fish was in the holding pen, water pressure caused the pipes to swing back to their set positions against the stops, preventing any downstream movement from the holding pen. The holding area inside the upstream migrant trap was 13.5 feet long and 5 feet wide, with a water depth of 3.5 feet. A permanent steel grating at the upstream end of the holding pen prevented any further upstream movement.

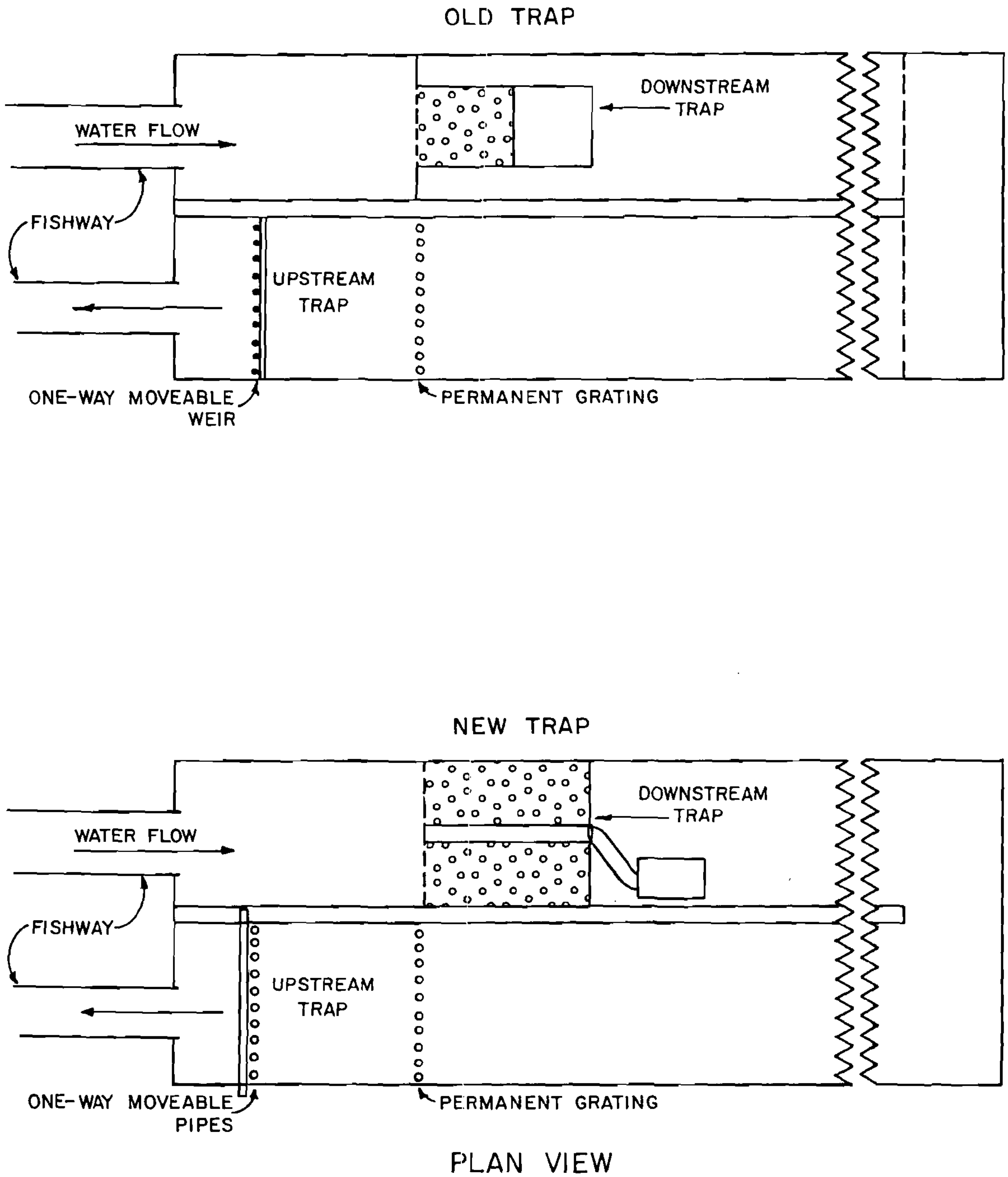

Figure 2.1-1. Old and new upstream migrant traps in the Cape Horn Dam fishway.

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The upstream migrant trap was generally serviced once or twice each day during the chinook salmon and steelhead migration season. During the 1979/80 migration season, this period extended from November 1 through the end of April; the 1980/81 season extended from December 15 through the end of April, and 1981/82 season extended from October 27 until June 29. For all three years, the trap was also operated and checked periodically before and after the given dates. All fish were released to continue their migration upstream with the following exceptions. During the 1979/80 migration season, a few fish were artificially spawned for CDF&G bioassay purposes. During the 1980/81 season, 13 female and 20 male steelhead trout were removed from the Cape Horn Dam fishway trap on February 10 to be artificially spawned; a total of 74,360 eggs were obtained for hatching and rearing at the Silverado Hatchery in Napa Valley for later release in the Eel River.

Also during the 1980/81 season, adult steelhead caught in the fishway trap were tagged on two dates and released below the fishway to determine the ability of adult steelhead to find and ascend the fishway at Cape Horn Dam. On February 24, 18 steelhead trout were tagged with non-reward Carlin-type tags and released 200 feet below the fishway. On March 4, 23 additional steelhead trout were tagged and released below the fishway. All adult steelhead caught at the Cape Horn Dam fishway trap throughout the 1980/81 migration season were examined for tags.

A similar evaluation was conducted during the 1981/82 migration season. On January 30, a total of nine steelhead received combinations of marks on the median fins (dorsal, caudal, and anal), administered with a paper punch, denoting the date of release. After a short recuperative period, these fish were released into the Eel River below the fishway entrance. All adult steelhead captured in the trap were checked for fin clips.

Data collected during the 1979/80, 1980/81, and 1981/82 migration seasons included numbers and sex by species and date. Scales were taken from adult steelhead for age determination. General weather information and Eel River water temperatures and flows below Cape Horn Dam were also recorded daily during the migration seasons.

For each year, beginning with the 1962/63 migration season, the timing of chinook salmon and steelhead arrivals at Cape Horn Dam was compared to the seasonal timing of major increases in streamflow occurring in the Eel River at Cape Horn Dam and above Outlet Creek. These increases in streamflow either occurred naturally as a result of major storm events or artifically as a result of pulsing releases made at Cape Horn Dam.

2.2 Tomki Creek/Eel River Salmon Carcass Survey

Adult chinook salmon carcass surveys were conducted in Tomki Creek and its tributaries and in the mainstem of the Eel River in 1979/80, 1980/81, and 1981/82 (Figure 2.2-1). During all years, Tomki Creek was surveyed from its mouth to its confluence with Wheelbarrow Creek (river mile (RM) 15.4). Four tributaries to Tomki Creek were also surveyed: String Creek from its mouth to RM 4.0; Long Branch Creek from its mouth to RM 2.4; Cave Creek from its mouth to RM 1.3; and Salmon Creek from its mouth to RM 2.0. Scott, Rocktree, and Wheelbarrow Creeks were not surveyed in 1979/80 or 1980/81; however, in 1981/82, the lower 1.5 miles of Wheelbarrow Creek were surveyed.

In 1979/80, the Eel River was surveyed from Cavanaugh's trailer to Hearst Riffle. In 1980/81 and 1981/82, the area from Cavanaugh's trailer to Ramsing Ranch was eliminated due to the lack of spawning area and use by chinook salmon, and the survey area was extended upstream to the next riffle above Hearst Riffle. A second area on the Eel River from the mouth of Tomki Creek downstream to Todd's footbridge, a distance of approximately 1/2 mile, was also surveyed in 1980/81 and 1981/82. This area was added to determine if chinook salmon spawned in the Eel River below Tomki Creek rather than entering Tomki Creek or continuing up the Eel River due to low streamflow.

Surveys in the study area were divided into five discrete sections. During 1979/80, each section was walked once between November 19 and 27 and once a week from December 3 to February 1. During 1980/81, each section was walked once between December 19 and 23 and once a week from December 30 to February 13. In 1981/82, surveys were conducted between December 7 and February 1. No surveys were conducted during the weeks of December 21-25 and January 4-8, and only partial surveys were conducted December 28-January 1 and January 18-22 due to high water.

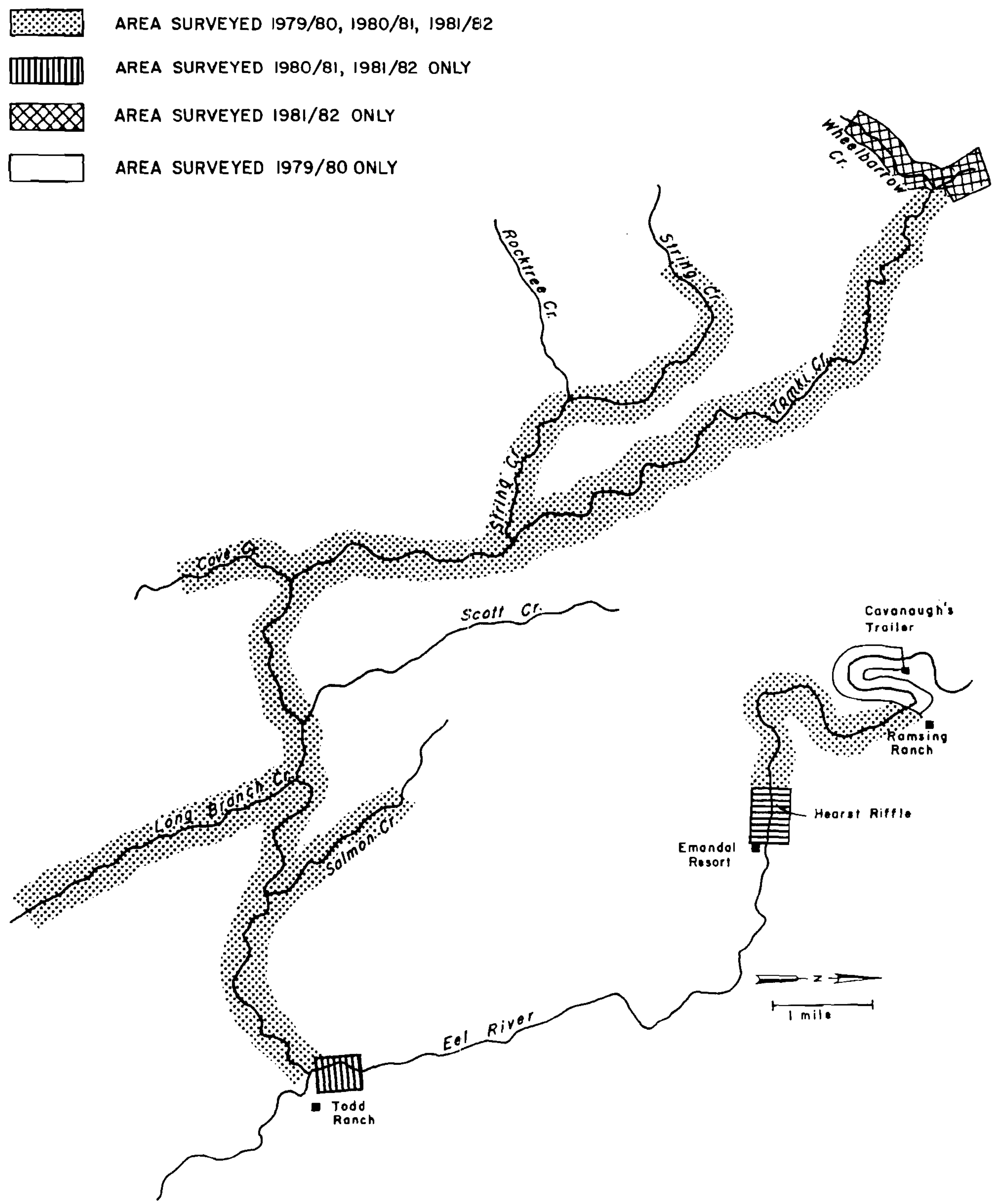

Figure 2.2-1. Chinook salmon carcass survey areas in Tomki Creek and the Eel River.

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Survey methods were similar to those used by Brown (1977). During each survey chinook carcasses were marked by attaching a hog ring and a numbered aluminum tag to the fish's mandible. Colored surveyor's tape, tied to the hog ring and fish's caudal peduncle, was used for each week to help identify the tagging period. Surveyor's tape was not used in 1981/82 to prevent possible bias by making previously tagged fish easier to see than untagged fish. If the fish's head was missing, a tag was attached to the caudal peduncle in the same manner as above. The location, length, sex, and spawning status of all carcasses were noted. All carcasses tagged were examined for egg or milt retention. Carcasses that had little or no retained eggs or milt were judged to have spawned. Otoliths were removed from a random sample of carcasses for age determination. Tag number and location of all marked carcasses observed in subsequent sampling periods were recorded. Recovered carcasses were removed from the stream to prevent duplicating observations. The number of live chinook, their distribution, activity, and sex (if possible) were recorded during carcass surveys. The number and distribution of redds were also recorded.

Spawning escapement was estimated using Schaefer's formula (Ricker 1975) corrected for sampling with replacement (Brown 1977):

$$N = \sum \left(R_{ij} \cdot \frac{M_i}{R_i} \cdot \frac{C_j}{R_j}\right) - \sum_{i=2}^{L} M_i$$

where

M_i = the number of fish marked in the i^{th} period of marking,

C_j = the number of fish caught and examined in the j^{th} period of recovery,

R_{ij} = the number of fish marked in the i^{th} marking period which are recaptured in the j^{th} recovery period,

R_i = total recaptures of fish tagged in the i^{th} period,

R_j = total recaptures during the j^{th} period,

L = total number of marking periods.

Adult Steelhead Trout Surveys

Due to a large run of steelhead trout in 1980/81, surveys were conducted in selected tributaries of the Eel River to determine the areas used for spawning by steelhead trout. Nine streams were surveyed between Scott Dam and Cape Horn Dam: Soda, Panther, Welch, Benmore, Bucknell, Trout, Dashiell, Alder, and Mill Creeks; six streams were surveyed below Cape Horn Dam: Whitney, Tomki, Thomas, Garcia, Salt, and Sage Horn Creeks (Figure 2.2-2). All of these streams were surveyed between February 9 and 16 except Garcia Creek which could not be surveyed due to high flow. Tributaries between Scott Dam and Cape Horn Dam containing steelhead in the February surveys were resurveyed on March 13: Soda, Panther, Benmore, and Bucknell. Garcia Creek was also surveyed at this time.

Distances surveyed in any one stream depended on the presence of steelhead, migration barriers, and the suitability of the stream for steelhead spawning. Numbers and locations of live and dead steelhead, redds, and possible migration barriers were noted. Quality of spawning habitat, estimated flow, and distance surveyed were also recorded.

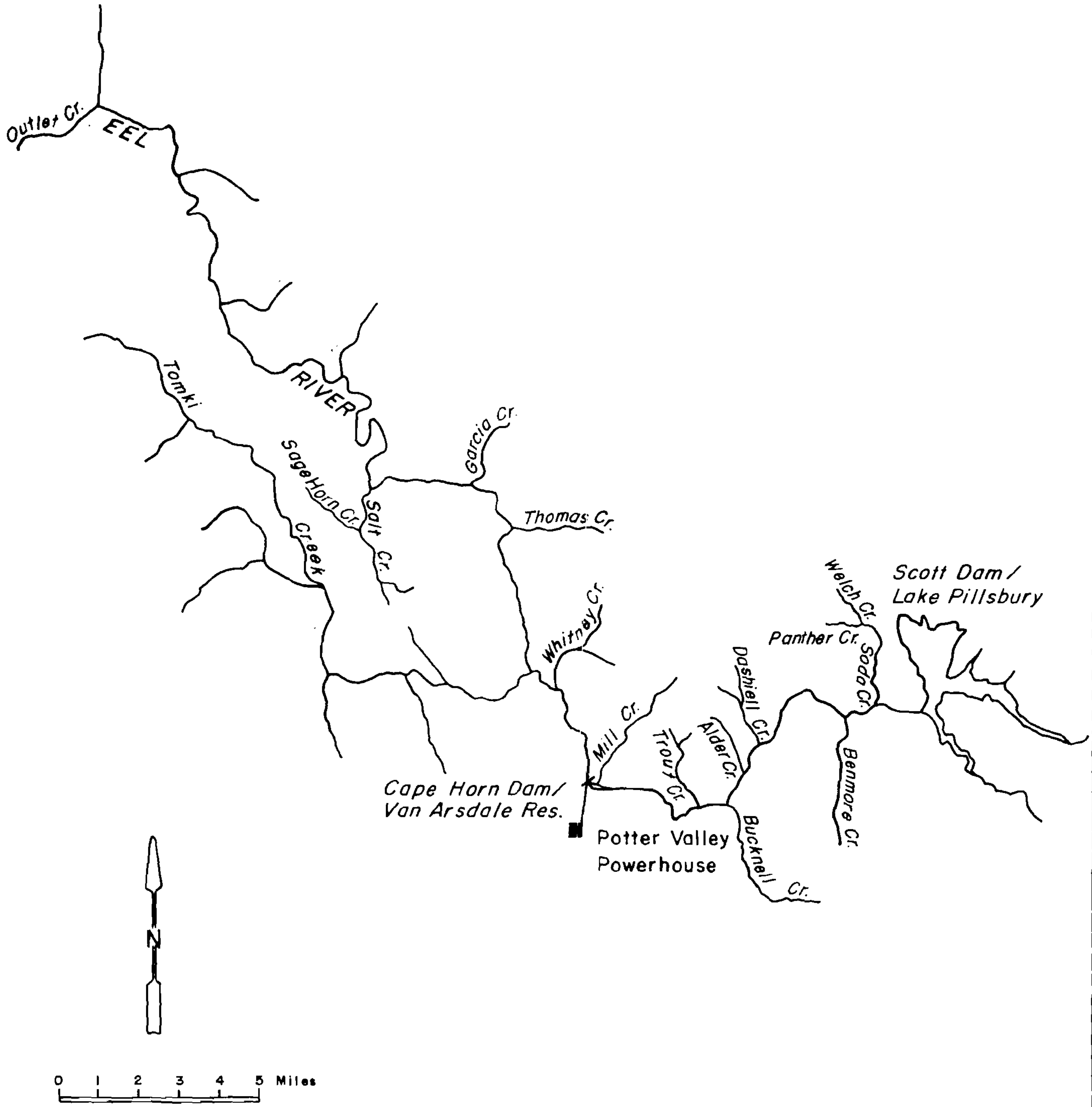

Figure 2.2-2. Adult steelhead survey areas in tributaries to the Eel River from Scott Dam to Outlet Creek, February-March 1981.

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2.3 Aerial Redd Survey

Two aerial surveys were conducted to determine the numbers and distribution of chinook salmon and their redds. The first was conducted on the Eel River from Scott Dam to Outlet Creek (42.5 miles) on December 6, 1979. Redds were counted and their general distributions were noted while flying in a helicopter about 20-30 mph at an elevation of 200-400 feet above the river. Although adult chinook salmon were not systematically counted during the survey, rough estimates of the total number of fish were made for the area from Tomki Creek to Hearst Riffle and from Hearst Riffle to Outlet Creek. Eel River discharge at the time of the survey was approximately 141 cfs at Hearst Riffle. Turbid water and/or high flows prevented additional aerial surveys from being conducted during the 1979/80 migration season.

During the 1980/81 migration season, one aerial survey was conducted on December 17 in the same manner as described above. The following areas were surveyed: the Eel River from Scott Dam to Dos Rios (49.5 miles); Tomki Creek from Wheelbarrow Creek to the Eel River (15.4 miles); and Outlet Creek from Highway 101 to the Eel River (8.2 miles). Eel River discharge at the time of the survey was approximately 66 cfs, and the turbidity was 53 NTU. High turbidity throughout the remaining chinook salmon and steelhead trout migration period again prevented additional aerial surveys from being conducted.

No aerial survey was conducted during the 1981/82 migration season for the same reasons given above.

2.4 Hearst Riffle Passage Study

Chinook salmon passage was observed over Hearst Riffle (Figure 2.4-1) to determine flows at which fish are able to successfully pass upstream and the portions of the riffle that are used for passage. Observations were made between November 18 and December 16 in 1979/80, between December 3 and January 5 in 1980/81, and from November 2 to December 17 in 1981/82. Observations were made from a four level, 21-foot high tower constructed from 5 x 7-foot painter's scaffolding and placed approximately 10 feet from the waters edge and 5 feet above the water level.

Fish movement was recorded in reference to a grid suspended over the riffle. The grid measured 66 feet in length and 280 and 213 feet in width at its top and bottom, respectively. Distance measurements were referenced to a tree on the left bank (looking downstream) to ensure consistent placement of the grid from year to year. The grid consisted of 16-foot squares formed by parallel ropes stretched across the riffle (generally perpendicular to streamflow) and surveyor's tape stretched between the ropes. Three different colors of surveyor's tape in the repeating sequence blue, yellow, blue, white were used to facilitate ease of grid cell identification. Initially in 1979 the grid was suspended about three feet above the streambed, but it washed out during the first period of high water. It was replaced by a grid suspended five feet above the streambed. This grid was also washed out on December 3, 1980 and November 16, 1981. The grid was usually two to five feet above the surface of the water depending on discharge which created some error in observed position of the fish compared to their actual position. Fish movements were recorded as observed, and no correction was made for this parallax error.

In 1979/80, observations at Hearst Riffle were conducted six to seven days per week for the first two weeks and five days per week for the remaining two weeks. Observations were made from approximately 1/2 hour before sunrise, when there was just enough light to observe fish on the riffle, to approximately 1/2 hour after sunset, when fish could no

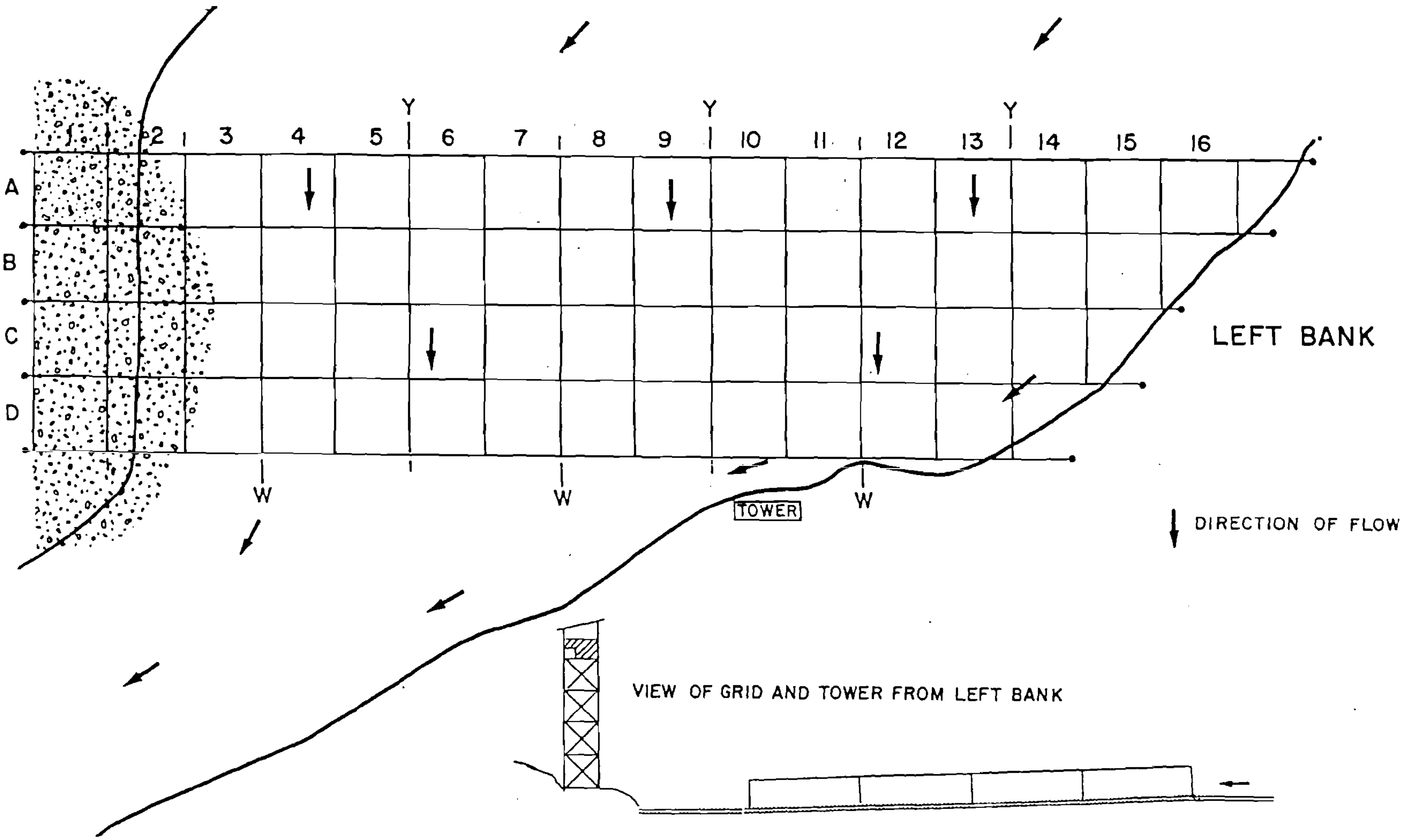


Figure 2.4-1. Hearst Riffle observation grid and tower.

longer be seen (approximately 10 hours in length throughout the study period).

In 1980/81, observations at Hearst Riffle were conducted six to seven days per week during daylight hours and on certain dates during the night. Day observations were made from approximately 1/2 hour before sunrise to approximately 1/2 hour after sunset (approximately 10 hours). Night observations were made for approximately two hours during three time periods: early evening (just after sunset; 1800-2000 hours), middle of the night (2300-0100 hours), and early morning (just before sunrise; 0500-0700 hours). Fish movements were observed at night on selected dates from December 8 to January 5. On December 8-9, observations were conducted during the early evening and middle of the night time periods. From December 9-10 through the 20-21 and on the 22-23, observations were made during all three time periods. On December 21 and 23 and January 2 through 5, only the early evening observation was done.

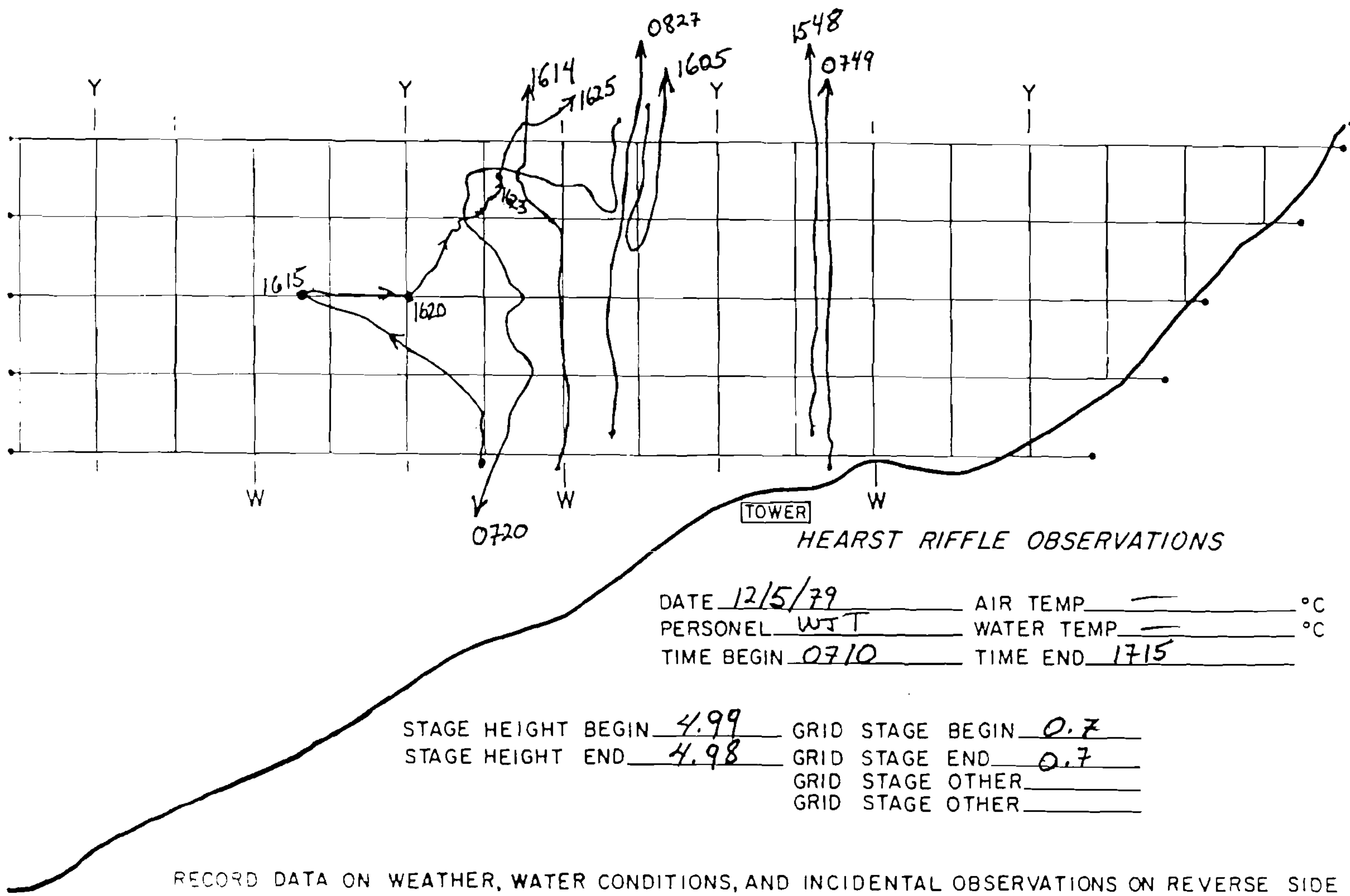
The 1981/82 observations at Hearst Riffle were conducted seven days per week during daylight hours and at night on certain dates. Day observations were made from 1/2 hour before sunrise to 1/2 hour after sunset (approximately 10 hours). Observations were not made from November 24 to 29 due to high turbid flows. Night observations during two hours before and two hours after day observations were conducted from November 5 to 15 (before sunrise) and November 5 to 12 (after sunset).

Data recorded were similar in all years and included a diagram of the fish's apparent path of travel on the riffle, time of passage, location of redds, water and air temperatures, staff gauge readings, water and weather conditions, and incidental observations. During periods of high water, when fish could not actually be seen, the path of their wake, visible on the surface of the water, was recorded.

Attempted passage was summarized into four categories: successful and unsuccessful upstream passage, downstream passage, and "other." A fish was considered to have successfully passed upstream if it was observed moving in an upstream direction and passed beyond the upper end of the grid. Fish moving in an upstream direction through the grid, but not crossing the upper end (returned downstream), were considered unsuccessful upstream attempts. Downstream passage occurred when a fish was observed moving in a downstream direction in the upper end of (or above) the grid and passed beyond the lower end of the grid. Fish that crossed the bottom or top rope of the grid, but did not proceed any farther, were put into the "other" category. Fish that entered the grid to spawn were also placed into the "other" category. Figure 2.4-2 presents a copy of a completed data sheet showing the manner of recording individual fish paths and other data.

A minimum flow release of 100 cfs from Cape Horn Dam was maintained throughout the study period in 1979/80. In 1980/81, a minimum flow release of 50 cfs was maintained from Cape Horn Dam. Flow releases from Cape Horn Dam during 1981/82 approximated 50 cfs from November 3 to 6, 250 cfs on November 7, and 100 cfs on November 8 to 11. From November 12 to the end of the study period (December 17), flows remained high (>420 cfs) due to heavy runoff. Flow over the riffle during all years was supplemented by additional discharge spilling over Cape Horn Dam during periods of storm runoff and by discharge from Tomki Creek and other tributaries between Cape Horn Dam and Hearst Riffle.

Water stage was recorded from staff gauges at two locations: the observation grid at Hearst Riffle and downstream of the grid approximately 400 yards (installed and rated by PGandE). Measurements were recorded at the beginning and end of each observation day. The PGandE staff gauge was used to determine discharge at the riffle. The gauge on the riffle was used to estimate average water depth. In addition, depth measurements (in feet) were taken at each intersection point of the grid on December 5, 1979, at a discharge of 100 cfs. During the 1980/81 study period, depths and velocities were measured at each intersection point of the grid at three discharges (66, 95, and 225



HEARST RIFFLE OBSERVATIONS

DATE *12/5/79* AIR TEMP *—* °C
PERSONEL *WJT* WATER TEMP *—* °C
TIME BEGIN *0710* TIME END *1715*

STAGE HEIGHT BEGIN *4.99* GRID STAGE BEGIN *0.7*
STAGE HEIGHT END *4.98* GRID STAGE END *0.7*
GRID STAGE OTHER ______
GRID STAGE OTHER ______

RECORD DATA ON WEATHER, WATER CONDITIONS, AND INCIDENTAL OBSERVATIONS ON REVERSE SIDE

Figure 2.4-2. Hearst Riffle observation data sheet showing the manner of recording fish passage.

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cfs). Depths and velocities were also measured across two transects below the grid at 66 cfs to characterize conditions encountered by fish approaching the riffle.

To calculate frequency of use by chinook salmon the riffle grid was separated into four horizontal rows (A, B, C, and D, Figure 2.4-1) and 16 vertical columns (1-16, Figure 2.4-1). One unit of use was assigned for each cell (square) through which a fish passed. If a fish passed through two or more cells in a horizontal row, one unit of use was assigned for the cell in which the majority of the upstream movement occurred. The cumulative units of use for each cell were divided by the total units for the row to obtain the percent frequency of use. This technique permits a direct comparison of fish use with depth along single transects as measured on Hearst Riffle and the other critical riffles.

Frequency of use of depth along the shallowest transect on Hearst Riffle was determined by relating the daily frequency of use per cell to the mean depth in that cell. Mean depth per cell per day was estimated from a depth-discharge relationship developed from measurements of depth at the grid intersection points along the transect at three known discharges. This yielded actual frequency of use of each depth which was then weighted for the availability of each depth by dividing by the percent occurrence of each depth at all flows.

2.5 Critical Riffle Study

Five riffles on the Eel River between Cape Horn Dam and Outlet Creek were studied to determine the degree to which they might impede upstream fish passage. These riffles were selected as being the most critical for upstream fish passage by a visual assessment of their potential to obstruct fish at low flows and by depth measurements at a discharge of 12 cfs. Key physical characteristics used for selection were wide, flat riffle areas, shallow depth of water, and extensive gravel bars over which the river would spread at higher flows. Selection of the critical riffles was carried out during aerial and ground surveys on July 24, 1980 by representatives from VTN, PGandE, CDF&G, and USFWS (Appendix B). Approximately eight riffles were noted as being potentially critical on the basis of prior data, examination of aerial photographs, and the initial fly-over. The five most critical riffles were selected on the basis of subsequent fly-overs, ground observations, and depth measurements taken by the selection committee (Figure 2.5-1). The approximate locations of the five selected riffles are as follows: 0.5 mi upstream of Garcia Creek (R12W, T19N, Sec 23), 0.5 mi above the Hearst Road bridge (R12W, T19N, Sec 21), 0.5 mi above Brushy Creek (R13W, T20N, Sec 16), 0.5 mi below Brushy Creek (R13W, T20N, Sec 9), and 200 yards upstream of Outlet Creek (R13W, T21N, Sec 32).

Depths and velocities were measured at all riffles in the summer of 1980. Data collection was scheduled for four target releases from Cape Horn Dam: 75, 125, 175, and 250 cfs. Actual releases were approximately 65.6, 140, 159, and 248 cfs (Table 2.5-1). Eel River discharge was measured at three locations (below Cape Horn Dam, below Hearst Riffle, and above Outlet Creek) by PGandE hydrographers to ensure that flow releases had reached the various study sites and were steady during data collection (Table 2.5-1).

Measurements were made under each flow release condition in 1980 at each riffle with the following exceptions. Velocities were not measured at

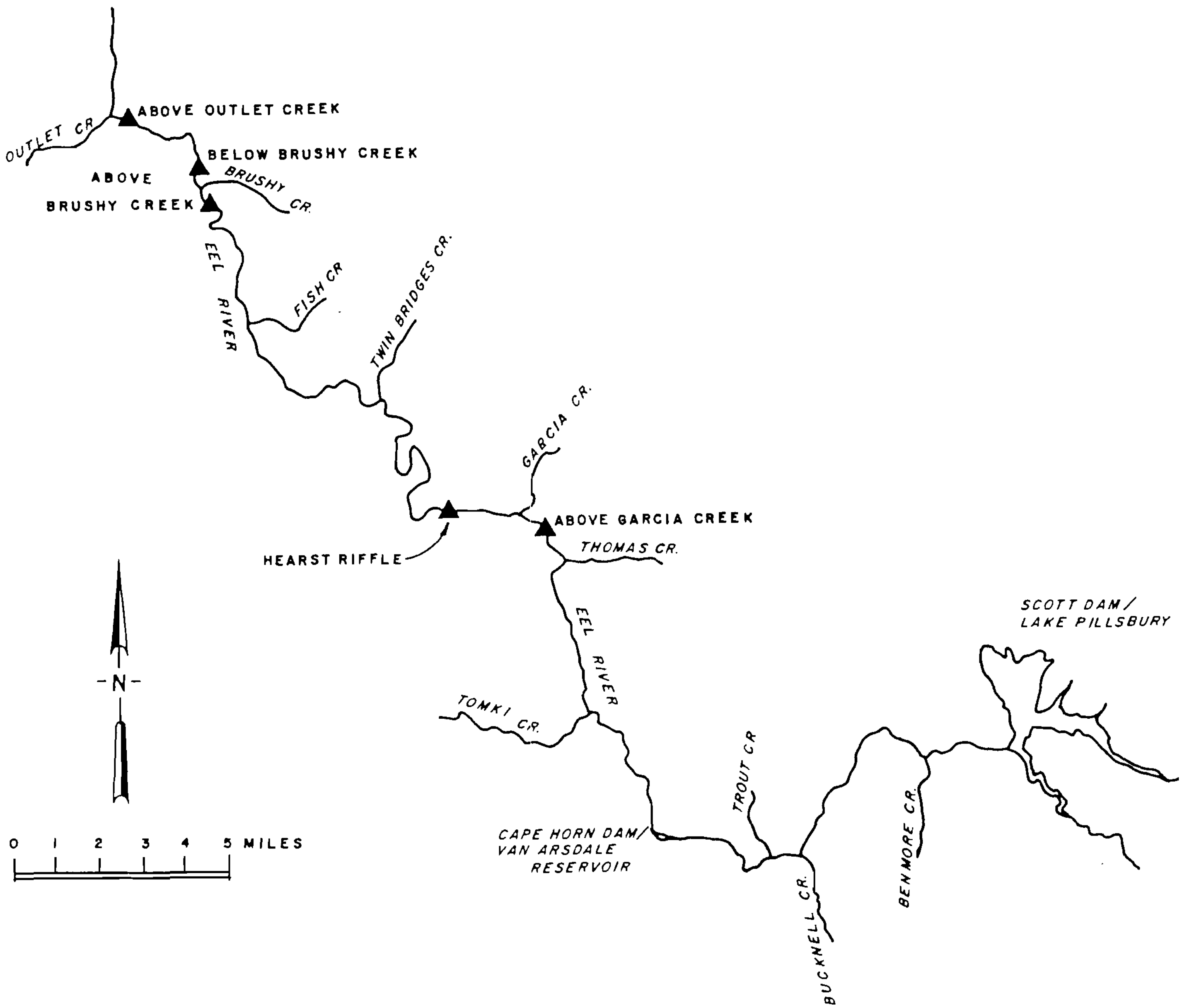

Figure 2.5-1. Location of riffles selected as being critical for upstream chinook salmon and steelhead trout passage on the Eel River.

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Table 2.5-1. Target flow releases from Cape Horn Dam and measured river flows for Critical Riffle and Instream Flow Studies during July and August, 1980.

Task	Date	Target Release from Cape Horn Dam (cfs)	Measured Flow (cfs)			
			Below Cape Horn Dam	Below Hearst Riffle	Above Outlet Creek	Below Scott Dam
Critical Riffle Selection	7/24	12	11.7	-	-	-
Instream Flow	7/31-8/2	12	7.2	8.5	-	-
Instream Flow	8/4-5	30	26.9	28.5	-	170
Instream Flow/ Critical Riffle	8/6-8	75	65.6	70.3	69.8	-
Instream Flow/ Critical Riffle	8/9-10	125	140	140	-	232
Critical Riffle	8/11	175	159	162	-	-
Instream Flow	8/12-13	200	194	-	-	301
Critical Riffle	8/14	250	-	248	240	-

the 12 cfs flow release during riffle selection. The two critical riffles above and below Brushy Creek were not measured at the 125 cfs target release level because of a temporary lack of access across private land. Depths and velocities were measured at each riffle on a single transect following the shallowest course from bank to bank as described by Thompson (1972). Placement of the transect across a particular riffle was not necessarily in the same location at each flow release. Also, if it was apparent that a single straight line transect would not represent the shallowest portions of the riffle, the transect was divided into more than one straight line segment. The riffles at Hearst, below Brushy Creek, and above Outlet Creek were fairly uniform across their width and required one straight line transect to describe them. The riffles above Garcia Creek and above Brushy Creek required one to four straight line transects due to their irregular shapes. Length measurements for each riffle were made at the edge of each transect at each flow.

Three of these riffles; above Garcia Creek, Hearst, and above Outlet Creek; were resurveyed in 1980/81 to further evaluate depth conditions on critical riffles, particularly in relation to observed passage and depth conditions on Hearst Riffle. Water depth and velocity were measured along transects across the riffles above Garcia Creek at 43 and 341 cfs and above Outlet Creek at 46 and 259 cfs. Measurements were taken at 16-foot (5-meter) intervals across three transects at each riffle. The first transect was selected as the shallowest course from bank to bank. A second transect was placed 16 feet upstream and the third 16 feet downstream of the shallowest course transect (Figures 2.5-2 and 2.5-3). Single line transects did not represent the shallowest part of the riffle above Garcia Creek at 43 cfs in May. The three transects were divided into three segments with Transect #1 in the shallowest course of each segment (Figure 2.5-4). Data were treated as though they were single straight line transects. Water depth was measured along five transects on the passage observation grid at Hearst Riffle during the 1980/81 fall migration period at flows of 66, 95, and

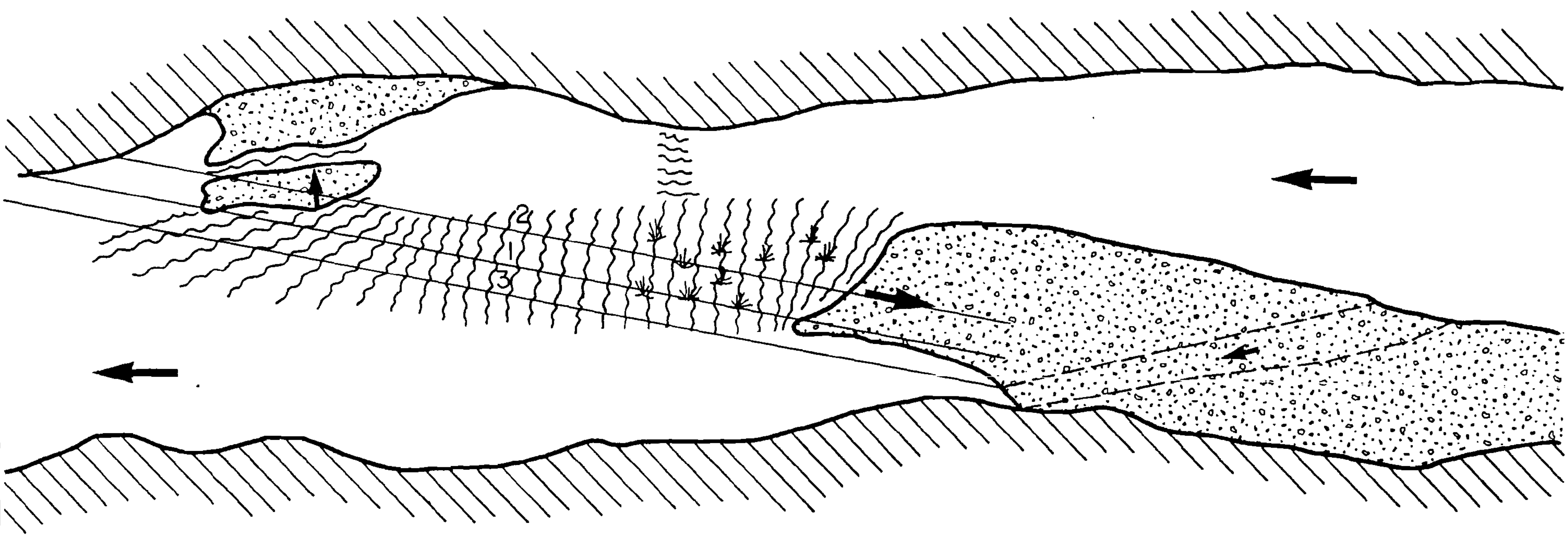

Figure 2.5-2. Transect location on the riffle above Garcia Creek, March 1981.

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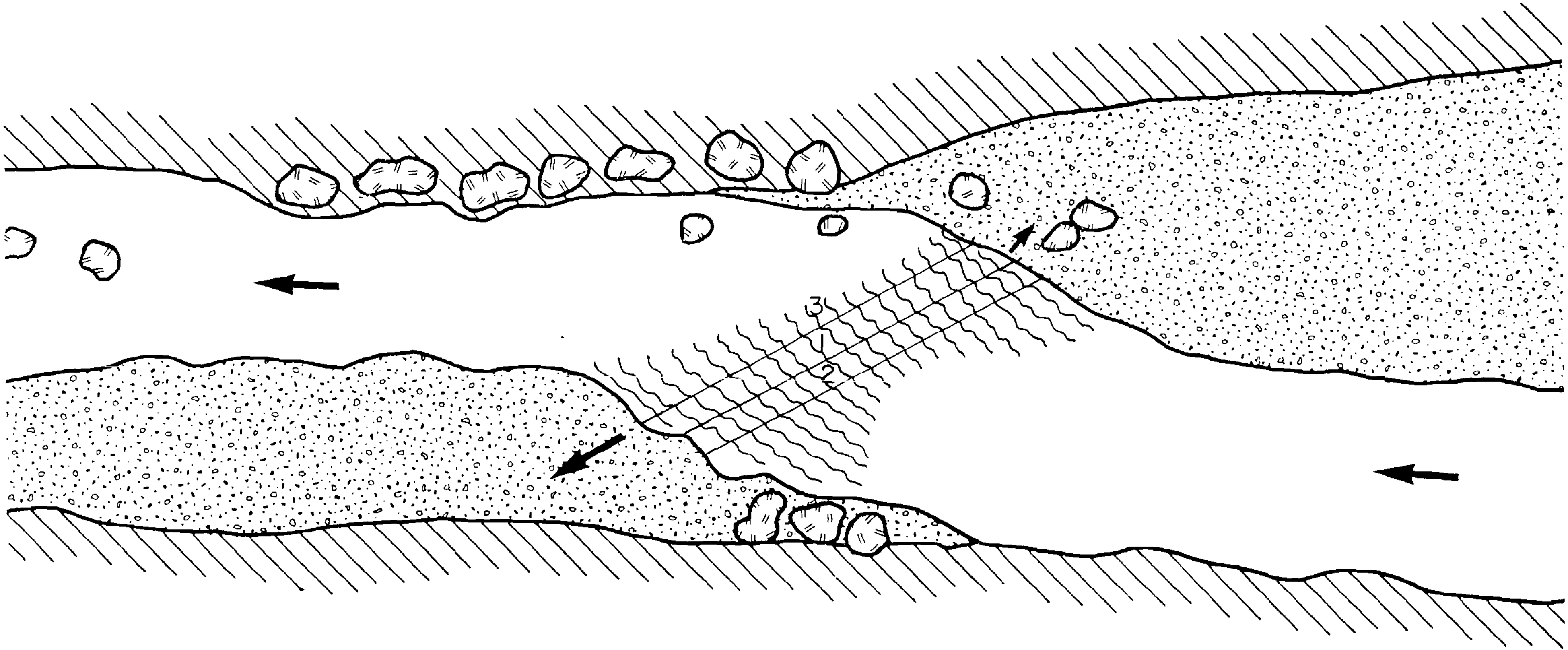

Figure 2.5-3. Transect location on the riffle above Outlet Creek, April and June 1981.

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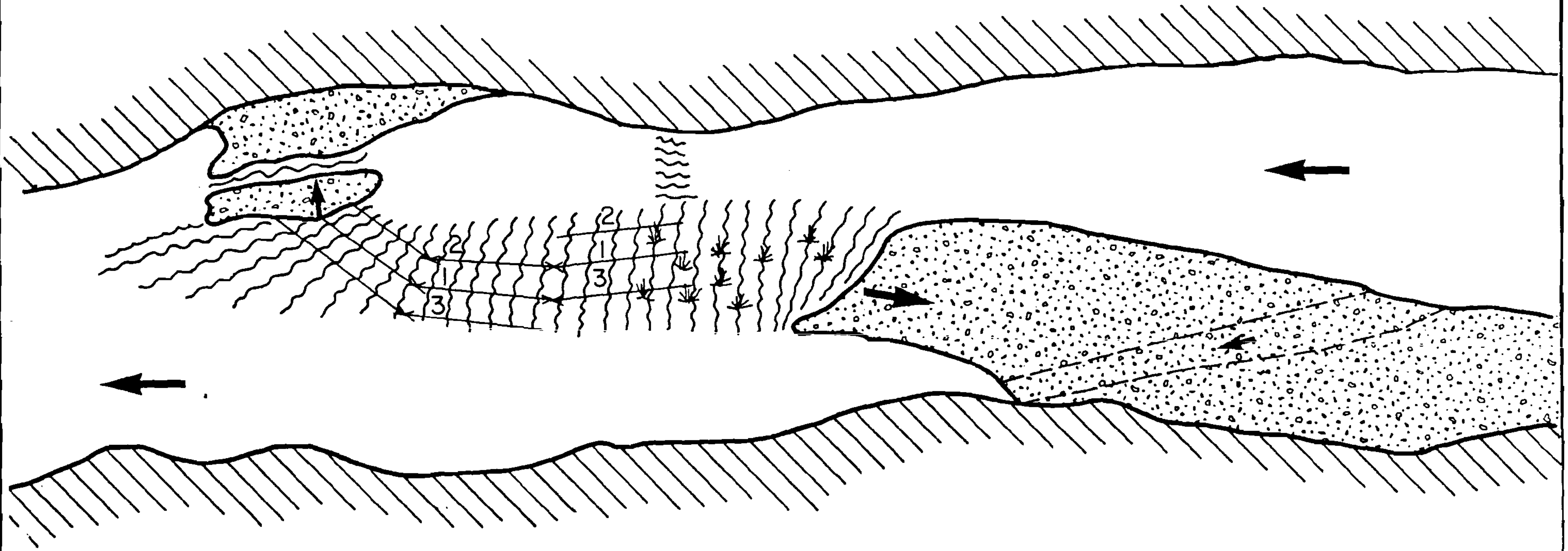

Figure 2.5-4. Transect location on the riffle above Garcia Creek, May 1981.

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225 cfs. Measurements were taken at each grid intersect point along five transects as described in Section 2.4, Hearst Riffle Passage Study (Figure 2.5-5).

Passage criteria presented by Thompson (1972) were used to estimate the required discharge for adequate passage at each riffle. The total width and longest continuous portion of each riffle meeting minimum depth and maximum velocity criteria were calculated. For chinook salmon the minimum depth criterion is 0.8 feet, and maximum velocity criterion is 8.0 feet per second (f/s). For steelhead the minimum depth is 0.6 feet, and maximum velocity is 8.0 f/s. According to Thompson, to provide adequate passage, 25% of the total width must meet these critera, and the longest continuous portion that meets these criteria must be 10% or more of the total width. Flows determined by this method for each riffle are then averaged to estimate an overall minimum passage flow.

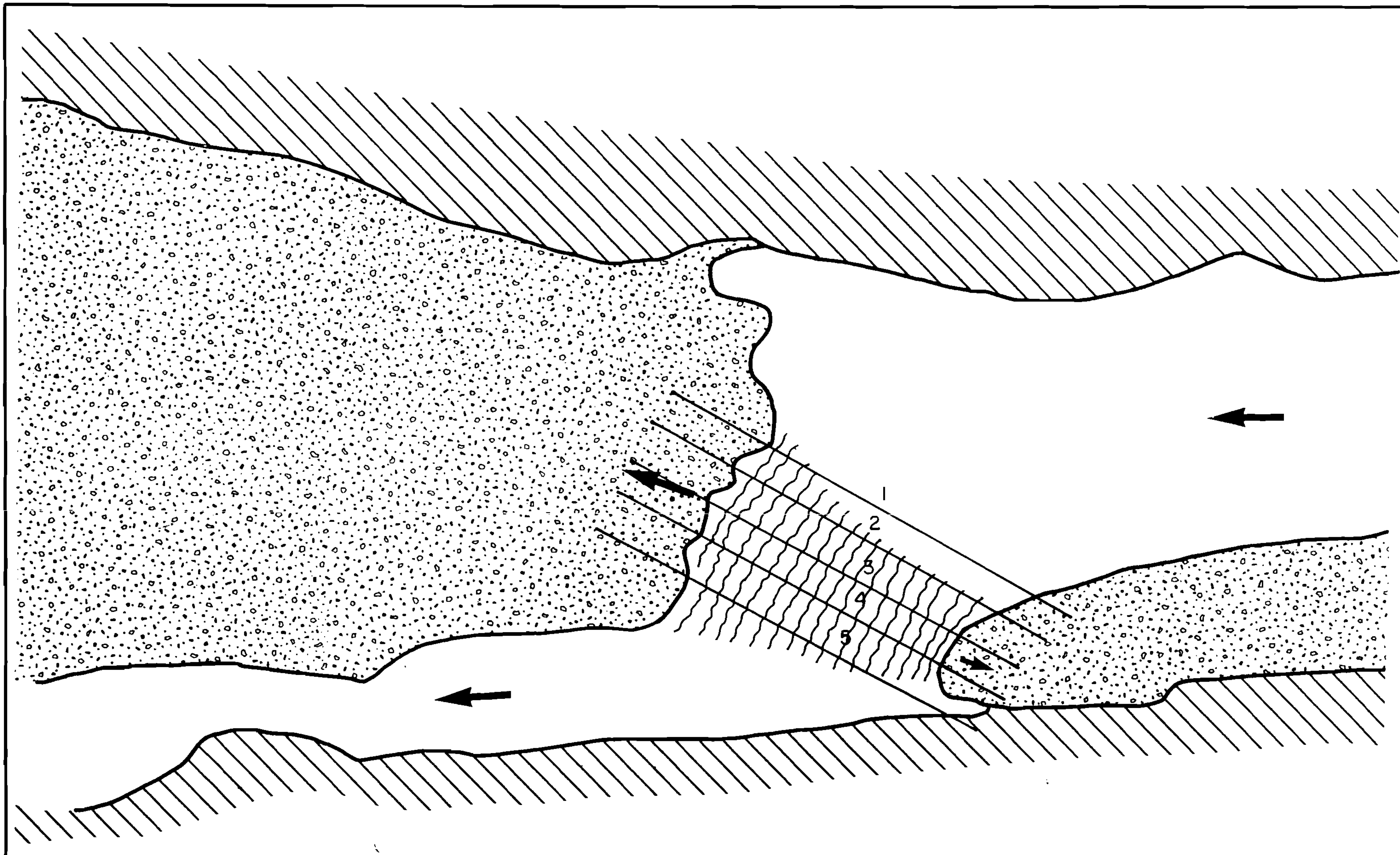

Figure 2.5-5. Transect location on Hearst Riffle, December 1980 and January 1981.

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2.6 Instream Flow Study

The USFWS Instream Flow Group (IFG) incremental methodology was used to quantify the amount of potential habitat available for various life history stages of chinook salmon and steelhead trout as a function of streamflow. This methodology is designed to demonstrate the impact of incremental changes in discharge on fishery habitat potential. It is composed of three basic parts:

1) field measurement of stream channel characteristics using a multiple transect approach;

2) hydraulic simulation to predict depths and velocities at various streamflow levels, and;

3) calculation of weighted usable area at various flow levels by interfacing substrate values and simulated depths and velocities with habitat suitability curves.

Descriptions of this methodology can be found in Trihey (1979), Bovee and Milhous (1978), and Bovee and Cochnauer (1977).

There are two approaches to study site selection utilizing the IFG incremental methodology: 1) critical reach, and 2) representative reach (Bovee and Milhous 1978). The representative reach approach was used in this study. The stream was first divided into homogeneous segments based upon stream channel morphology (gradient, channel shape, pool/riffle ratio, substrate type), streamflow regime, and existing dams. Six relatively homogeneous segments were defined from Outlet Creek to Scott Dam (Figure 2.6-1). This was done using maps and aerial photos, and later by on-site inspection by representatives from VTN, PGandE, CDF&G, USFWS, and DWR. One study site was chosen in each of these homogeneous segments on the basis of access and the study site's ability to represent that stream segment (Figure 2.6-1).

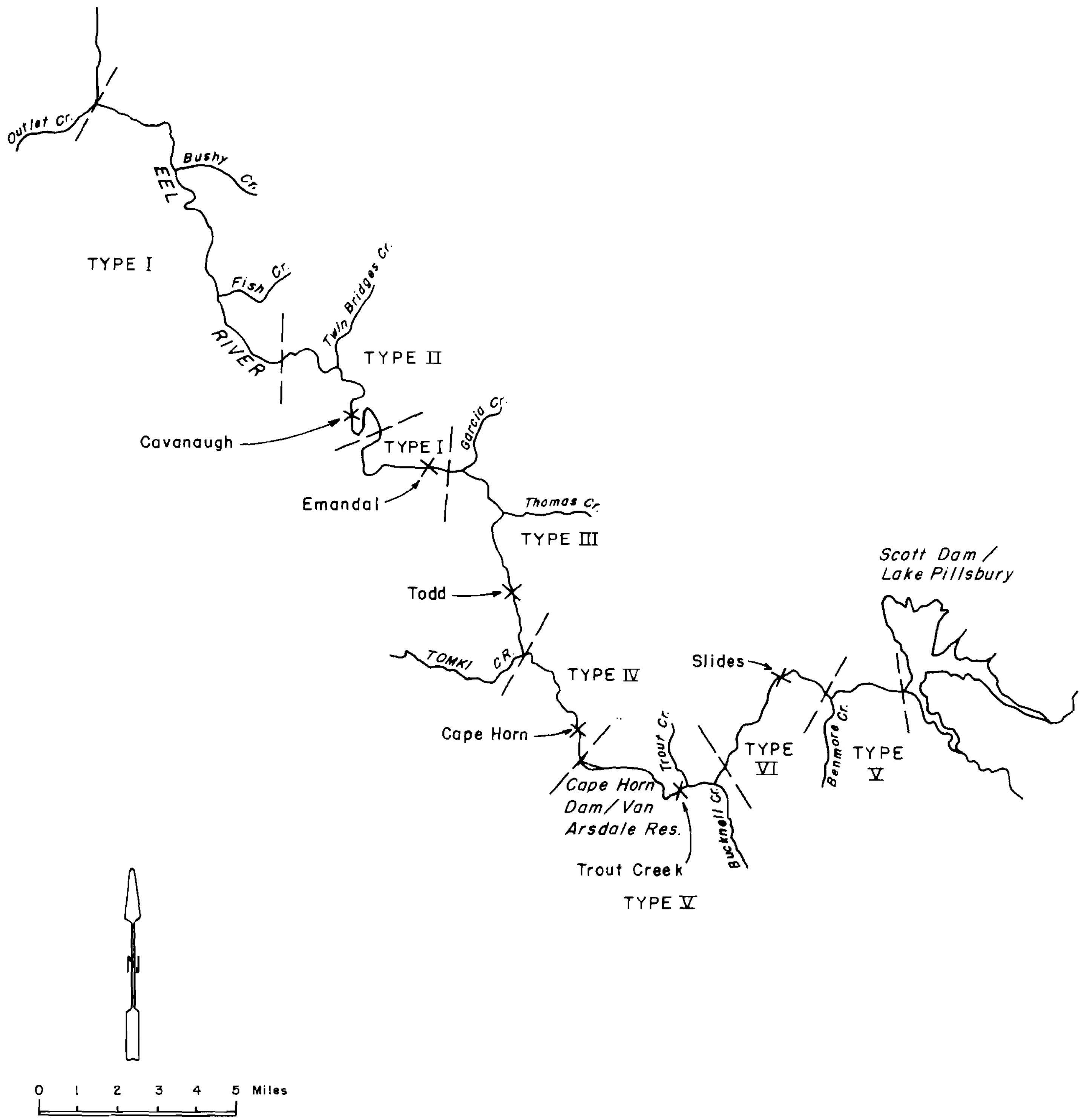

Figure 2.6-1. Reach types and representative study sites selected for the instream flow study on the Eel River, 1980.

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Appendix C contains a description of each homogeneous river segment and illustrates transect locations at each study site. Transect placement and the distance that each transect represents within each study site were determined by representatives from VTN, PGandE, CDF&G, and USFWS. Transects were placed across hydraulic controls and across discrete habitat types.

At the four study sites below Cape Horn Dam (Cape Horn, Todd, Emandal, and Cavanaugh) measurements were taken during July and August 1980 at four target flow releases: 12, 30, 75, and 200 cfs. Actual releases were approximately 7.2, 26.9, 65.6, and 194 cfs (Table 2.5-1). At the two study sites between Scott and Cape Horn Dams (Slides and Trout Creek) measurements were taken at 170, 232, and 301 cfs (Table 2.5-1). PGandE hydrographers measured the discharge below Scott Dam, below Cape Horn Dam, below Hearst Riffle, and above Outlet Creek to ensure that flows had reached the various study sites and were steady during data collection. Temporary staff gauges were also set at each instream flow site and checked several times during measurements to verify a steady flow condition.

Three field crews with representatives from VTN, PGandE, and DWR collected data for the study using the IFG incremental methodology as described by Bovee and Milhous (1978). Head stakes were placed at both ends of each transect. Each transect was divided into 15 to 40 segments. Substrate, streambed elevation, velocity, and depth were measured at the center of each segment. Streambed elevations and substrate were measured only at the 12 cfs flow release while velocities and depths were recorded at all flow releases. The percent composition of various size ranges of substrate was visually estimated using the size ranges and code numbers in Appendix F. Water surface elevations were measured at each transect and each flow release. Velocities were measured using Gurley Model No. 622 Price AA and Model No. 625 Pygmy Current Meters and Marsh-McBirney Model No. 201 Electromagnetic Current Meters. At each transect, the same meter was used for all velocity measurements. Velocities were taken at six-tenths of the depth from the surface at depths less than 3.0 feet, and eight-tenths and two-tenths of the depth from the surface at depths greater than 3.0 feet. At the Cavanaugh and Slides sites data were collected at unwadeable transects utilizing a rubber raft and sounding reel. At all other sites, a 10-foot aluminum boat and sounding reel were used at unwadeable transects. Automatic surveying levels were used by all crews to measure head stake, streambed, and water surface elevations.

The IFG4 hydraulic simulation program and the HABTAT program were used in conjunction with IFG's habitat suitability index curves to model the data (Bovee and Cochnauer 1977; Bovee 1978). The hydraulic simulation program calculates log-log regressions of stage (water surface elevation) versus discharge for each flow and velocity versus discharge for each point on each transect. These regressions are used to predict stage and velocities at discharges of interest. Depth is calculated by subtracting the bed elevation from the stage. A velocity adjustment factor (a measure of the accuracy of the velocity predictions) is calculated for each flow of interest for each transect.

The limit to the range of simulated discharges recommended by Bovee and Milhous (1978) is 0.4 times the lowest discharge measured and 2.5 times the maximum discharge measured. The range of discharges measured were 7.2 to 194 cfs at four sites between Cape Horn Dam and Outlet Creek and 170 to 301 cfs at two sites between Scott Dam and Cape Horn Dam. Twenty-two discharges from 8 to 500 cfs were simulated in the modeling of the four sites between Cape Horn Dam and Outlet Creek. Eleven discharges from 68 to 600 cfs were simulated for the two sites between Scott Dam and Cape Horn Dam.

The HABTAT program uses the depths and velocities predicted at a certain flow, in conjunction with substrate values to calculate Available Habitat Area (AHA). Habitat weighting factors (from 0 to 1.0) are determined for individual velocity, depth, and substrate values from habitat suitability curves for each life stage of each species of interest. The habitat weighting factors for depth, velocity, and substrate at a particular point are multiplied together to form a composite habitat weighting factor. The composite habitat weighting factor is multiplied by the surface area of the cell (the area represented by a point measurement of depth, velocity, and substrate) to obtain AHA for that cell. The surface area of a cell (in square feet) is determined by the interval distance between adjacent measurement points and the distance to adjacent upstream and downstream transects. The distance represented by a transect is determined by the distance between adjacent transects and the transect weighting factor, which was estimated at the time transect locations were selected (Appendix C). The total AHA for a study site is calculated by adding together all the AHA's for individual cells in the study site. The AHA is then adjusted to represent 1,000 feet of stream length, so that the units of AHA are square feet per 1,000 feet of stream. This procedure roughly equates the total surface area of the simulated study site to an equivalent area of optimal habitat.

AHA per 1,000 feet of stream from each site was expanded to represent the length of stream in each reach type. Reach Type I was divided into two segments; the Emandal subreach (3.8 miles) and the Big Bend subreach (10.2 miles). Reach Type IV (Cape Horn site) is 4.0 miles long, Reach Type III (Todd site) 7.0 miles, and Reach Type II (Cavanaugh site) 6.0 miles. The reach types from Cape Horn Dam to Outlet Creek were tabulated separately from the reach types from Scott Dam to Cape Horn Dam due to the difference in flow regimes. Reach Type V (Trout Creek site) represents 6.0 miles of river, while Reach Type VI (Slides site) represents 5.0 miles. AHA's for all reach types between Cape Horn Dam and Outlet Creek were added together to obtain the total AHA for each flow release, species, and life stage. Similar calculations were made for the reach types between Scott and Cape Horn Dams.

For selected life stages expanded AHA was adjusted for tributary inflow downstream of Cape Horn Dam. Tributary inflow, following a triggering flow over Cape Horn Dam, was estimated as the difference between the mean daily streamflow measured at the USGS gauges near Dos Rios (11472150) (upstream of Outlet Creek) and below Cape Horn Dam (11471500) for the 1967 to 1981 water years. The percent frequency of tributary inflow equal to or greater than a particular flow was calulated separately for the periods of November through January and for January through March to use for selected chinook and steelhead life stages, respectively (Figure 2.6-2). The inflow equalled or exceeded 90% of the time was selected for adjustment of AHA (i.e., 29 cfs or greater occurred 90% of the time in November through January and 69 cfs in January through March). The total tributary inflow at the 90% level was divided between reach types on the basis of drainage area occurring at the upstream end of the reach type (Table 2.6-1). Adjusted AHA was calculated based on the incremental increases in flow for each reach type. AHA's for steelhead trout fry and juvenile life stages were not adjusted for tributary inflow because during the summer months tributary inflow is negligible. Reach types from Scott Dam to Cape Horn Dam were also not adjusted for tributary inflow.

Results of the instream flow data analysis were generated using IFG's habitat suitability index curves, except for the chinook salmon spawning depth curve, which was modified to be more applicable to Eel River stocks. IFG's existing habitat suitability index curves are based on a composite of information from many western state streams and do not represent any one stream in particular (Bovee 1978). To assess the applicability of IFG's curves to Eel River fish, information was solicited from knowledgeable sources during two periods.

In 1981 prior to preparation of the second Annual Progress Report, copies of IFG's habitat suitability index curves and substrate codes (Bovee 1978) were sent to various people who may have information or experience regarding salmon and steelhead habitat preferences in

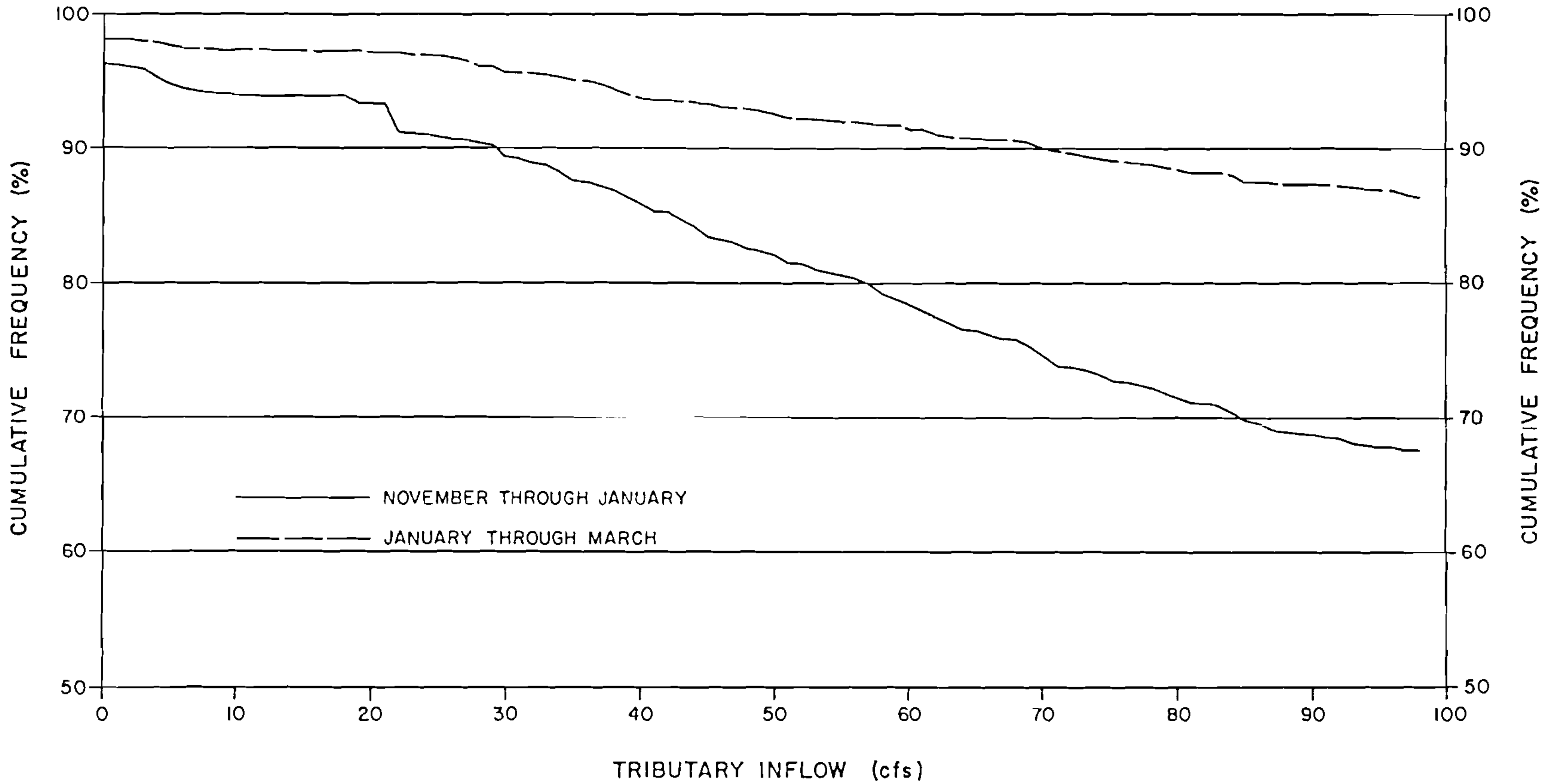

Figure 2.6-2. Percent frequency of tributary inflow greater than a particular flow, from Cape Horn Dam to Outlet Creek for the period of November through January and January through March, 1967 to 1981.

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Table 2.6-1. Percent of drainage area and tributary inflow for each reach type from Cape Horn Dam to Outlet Creek.

Reach Type	Percent of Drainage Area[a]	Tributary Inflow	
		Nov.-Jan.	Jan.-Mar.
IV	0	0	0
III	41.5	12	29
I (Emandal subreach)	62.5	18	43
II	70.9	21	49
I (Big Bend subreach)	79.2	23	55

[a] The drainage area occurring at the upstream end of each reach type was divided by the total drainage area from Cape Horn Dam to Outlet Creek (197 sq. mi.).

northern California. They were asked to review and comment on the curves based on appropriate data or their opinions. Suggested modifications received in response to this inquiry were small on most of the IFG curves except for steelhead fry and juvenile depth curves, and the chinook salmon spawning depth curve; however, because these modifications were based on minimal data not specific to the Eel River, the IFG curves were not modified. Additionally, observations of steelhead trout during summer fish inventories tended to support the existing depth curves for steelhead fry and juveniles. Unfortunately, attempts made during the present study to collect data on habitat preferences (including depth) of spawning chinook salmon in the Eel River were unsuccessful due to high turbidity and flows.

Following release of the Preliminary Draft Final Report in June 1982, information and opinions concerning the chinook spawning curves were solicited again by the USFWS Ecological Services Office in Sacramento. This inquiry was in response to considerable comment and objection to results published in the instream flow section of the Preliminary Draft Final Report. Additional data and opinions obtained in response to the USFWS inquiry were used in combination with responses to the earlier inquiry to modify the chinook spawning depth curve. A description of the development of that curve is presented in Results and Interpretation (Section 3.6, Instream Flow Study).

Eel River Water Temperatures

Six locations were selected on the Eel River and one location on Tomki Creek (1982 only) for installation of continuously recording thermographs (Figure 2.6-3):

1. 0.1 miles downstream of Scott Dam
2. 1.8 miles downstream of Trout Creek
3. 1.2 miles downstream of Cape Horn Dam
4. 0.3 miles downstream of Tomki Creek
5. less than 0.1 miles downstream of Hearst Riffle

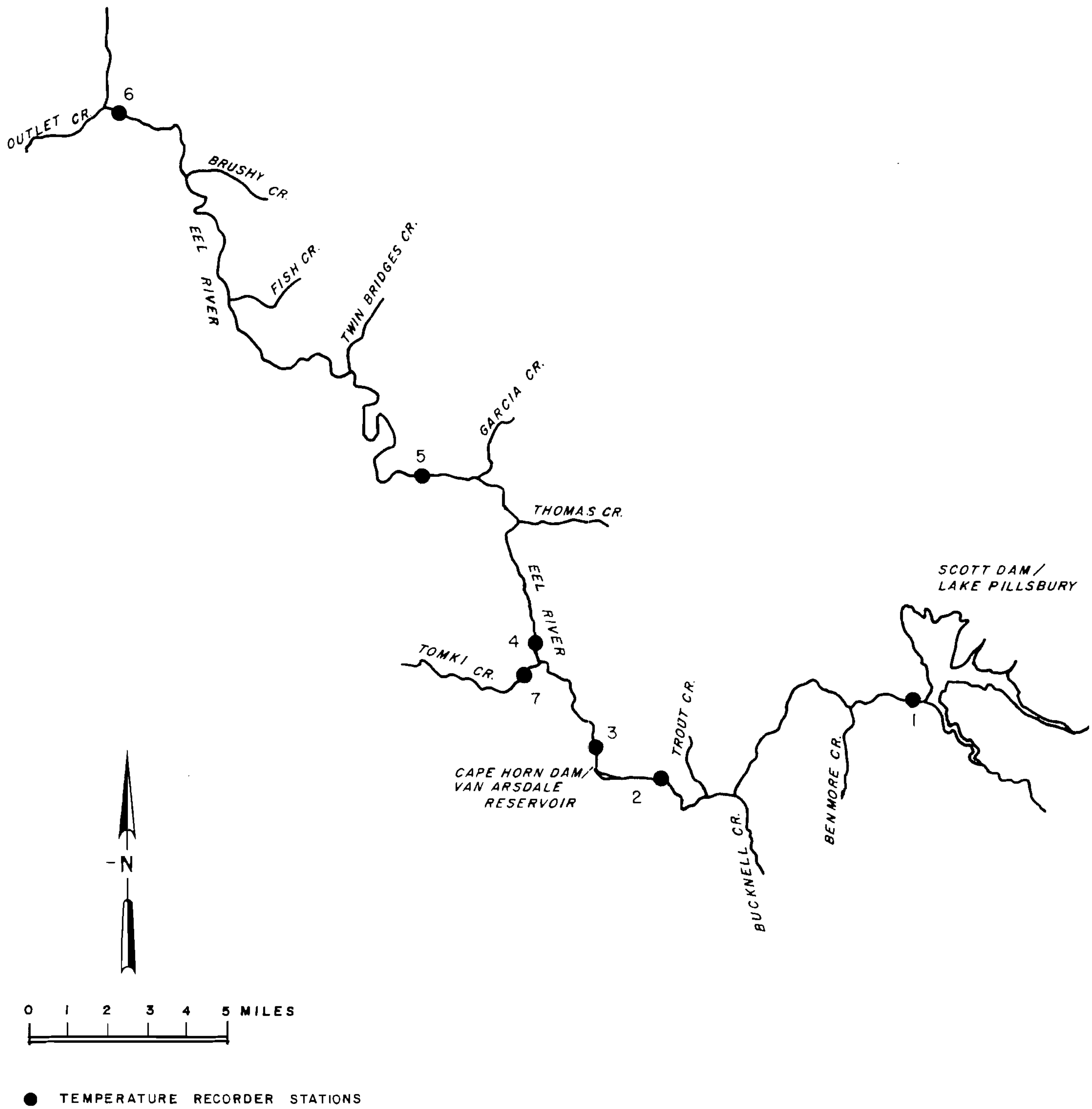

Figure 2.6-3. Locations of temperature recorders in the Eel River.

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6. 0.2 miles upstream of Outlet Creek
7. Tomki Creek, 0.2 miles upstream of confluence with Eel River.

Calibrated Peabody-Ryan thermographs, capable of recording water temperature from 0 to 30.0°C (±0.6°C) continually for 90 days, were placed in the stream at Stations 1, 2, 3, 5, and 6 on July 3, 1980 and removed on September 25, 1980. Only five recorders were available for the 1980 study year. The thermograph at Station 2 could not be recovered; thus no data are available for this location. In 1981, calibrated Peabody-Ryan thermographs were placed in the river at Stations 1, 2, and 3 on May 26 and Stations 4, 5, and 6 on May 27; thermographs were removed from Stations 1, 2, 3, and 4 on October 7 and from Stations 5 and 6 on October 2. In 1982, calibrated Peabody-Ryan thermographs were placed in the river at Stations 1, 3, and 5 on March 24, at Stations 6 and 7 on March 25, and at Station 2 on June 16. A thermograph was placed at Station 7 instead of Station 4 to gain information to evaluate downstream juvenile migrations and juvenile rearing in Tomki Creek. Thermographs were removed from all stations on October 1, 1982.

Thermographs were serviced at two to four week intervals, at which time a reference temperature was taken by a hand-held thermometer and recorded with the time and date on the recording chart paper. Differences between reference temperature and thermograph temperature were noted on the original tabluations of the data and were used to adjust the final tabulations included here. Water quality data were collected at the same time as service checks during 1981 only. Parameters measured were: air and water temperature using a hand thermometer; conductivity, using a Hach Model 2510 conductivity meter; dissolved oxygen using the azide modification of the Winkler method; turbidity, using a Hach Model 2100A turbidimeter; and pH, using a Hellige Model 605-HT pocket comparator.

Water quality data were measured in Lake Pillsbury approximately 100 feet above Scott Dam by the CDF&G in 1982. These measurements were taken to determine if temperatures in the Eel River downstream of Scott Dam could be altered significantly by the depth at which water is released from Lake Pillsbury, and consequently affect downstream migration of juvenile steelhead and chinook salmon. Measurements were taken on March 28, April 25, May 9 and 23, June 7 and 21, and July 7. Temperature and dissolved oxygen were measured at 1 m depth intervals, and turbidity was measured at 5 m depth intervals. Water quality data were also collected in the Eel River at its confluence with Lake Pillsbury and directly below Scott Dam on the same dates as collection of data in Lake Pillsbury.

Water temperatures in the Eel River from Cape Horn Dam to Outlet Creek are high in mid-summer and affect the suitability of summer rearing for steelhead trout. Thus, as part of the instream flow study analysis, a temperature habitat suitability index curve was developed for the Eel River to allow modification of AHA for steelhead trout summer rearing habitat. Development of this curve was based on a literature review of temperature effects on juvenile steelhead (Kubicek 1977). To apply this curve to the various reach types between Cape Horn Dam and Outlet Creek, the relationship between streamflow and water temperature was developed for each reach type based on temperature and flow data collected in the study area. Development of the temperature suitability curve and the relationships between streamflow and temperature are presented in Results and Interpretation (Section 3.6, Instream Flow Study). Using the temperature suitability curve and the streamflow/temperature relationships, modified AHA values for juvenile steelhead were calculated.

2.7 Downstream Juvenile Migration Study

Downstream migrating fish were trapped at four locations within the study area during the three-year study period (diversion fish screen, Potter Valley Powerhouse, Cape Horn Dam fishway, and Eel River above Outlet Creek); a fifth location, Tomki Creek, was added during the 1982 trapping season (Figure 2.7-1). In 1980, all locations were sampled for two consecutive 24-hour periods per week throughout the suspected peak migration period (February through July). During the remainder of the year (August through January), all locations except Eel River above Outlet Creek were sampled for two consecutive 24-hour periods per month; no sampling was conducted at the Eel River site during this time period. In 1981, trapping was conduted for two non-consecutive 24-hour periods per week during the peak migration period and two non-consecutive 24-hour periods per month during the remainder of the year.

In 1982, the diversion fish screen and Cape Horn Dam fishway were trapped generally as described for 1981. Trapping at the powerhouse, however, was conducted during two non-consecutive 24-hour periods per month until mid-April when trapping was increased to two 24-hour periods per week in association with the breakdown of the diversion fish pump. Semi-monthly trapping at the powerhouse resumed in mid-June after repairs to the fish pump were completed. The Tomki Creek and Eel River sites were trapped during two non-consecutive 24-hour periods per week from late February through July; trapping was terminated at both sites at the end of July.

Trapping in the Potter Valley Powerhouse tailraces (PVPH), Tomki Creek, and the Eel River above Outlet Creek was conducted by VTN. Trapping in the diversion fish screen (DFS) and Cape Horn Dam fishway (CHDF) was conducted by CDF&G. Procedures and equipment used at each site are discussed separately. Data are presented with a mixture of English and metric units; fork lengths of fish and temperature data are in metric units; all other data (dimensions, velocities, flow, etc.) are in English units.

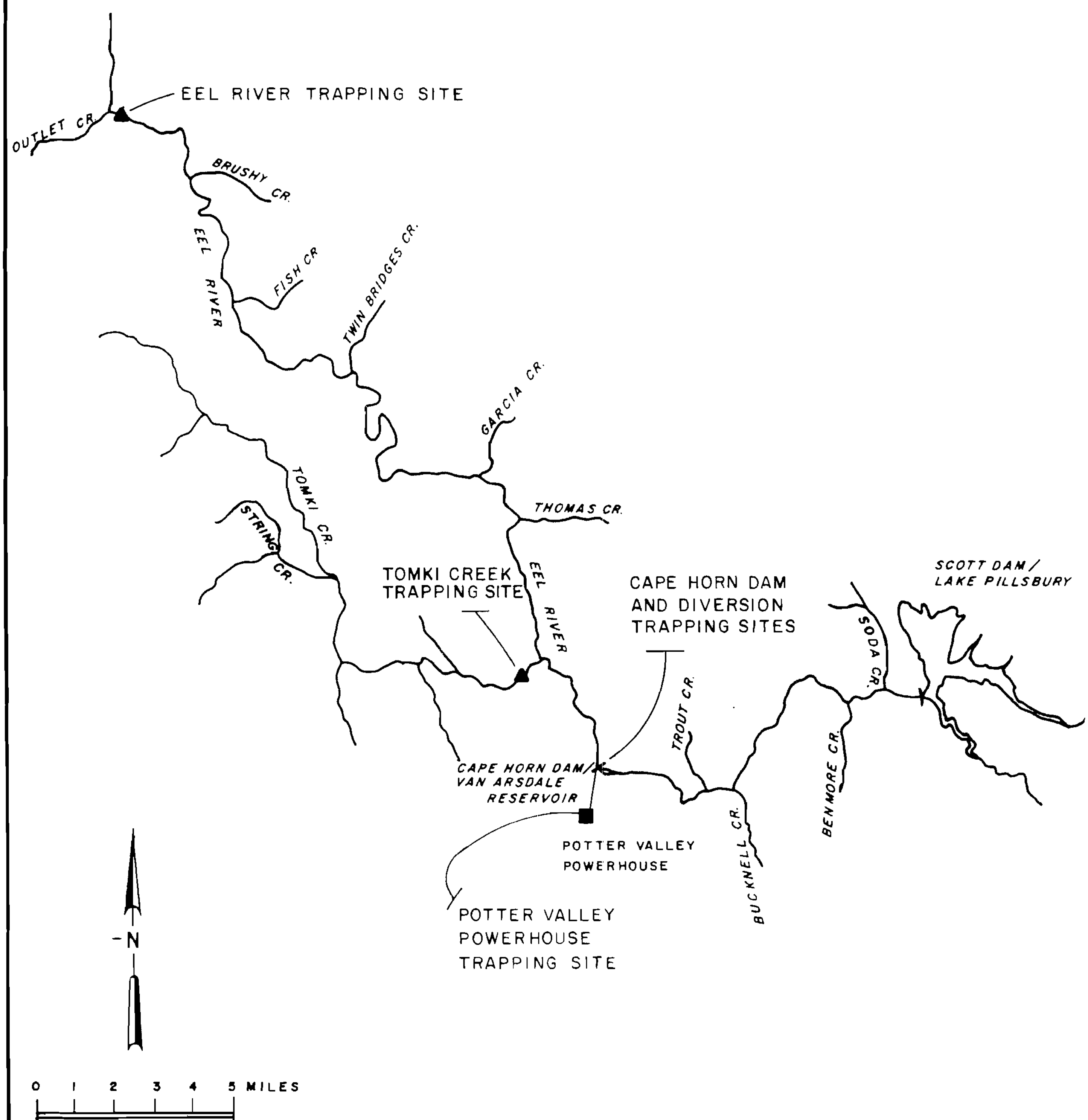

Figure 2.7-1. Trapping locations for downstream juvenile migration study in the Eel River.

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Diversion Fish Screen

Downstream migrating juvenile salmonids and other fish screened at the DFS moved with the water current along the screen into a "snorkel". They were then pumped through a 16-inch pipe to a holding tank, a short distance from the screening facility (Figure 2.7-2). The fish holding tank, 40 x 6 x 4 feet, was fitted with a small rotary fish screen at the downstream end which allowed removal of debris from the holding tank while preventing escape of trapped fish. At the downstream side of the holding tank were two pipes, one leading to the CHDF and the other to the reservoir above Cape Horn Dam. After trap servicing, the salmonids were released through the pipe leading to the CHDF, and all non-salmonid species were returned to the reservoir via the larger second pipe.

In 1980, the DFS trapping facility was operated on a nearly continuous basis from mid-March through July and periodically from August through December. The trap was checked and serviced weekly from March 17 through July 28 and monthly from August through December according to the standardized sampling schedule. The trap was also serviced on several additional days during the sampling period. CDF&G trapping was coordinated with that done at PVPH by VTN.

The trapping facility was also operated in 1981 on a nearly continuous basis from February through July and periodically in January and from August through October. The trap was checked and serviced twice a week from February through July and twice a month in January and from August through October, on the same days as trapping at PVPH.

In 1982, the trapping facility was operated on a continuous basis all year (total sampling) except for a six week period April 16 to May 18, when the breakdown of the DFS fish pump resulted in the suspension of trapping. The trap was checked and serviced twice per week (standard sampling) from March 3 through October 26. During the rest of the year and in between the standard sampling dates, the trap was checked and serviced on a variable schedule (Appendix I).

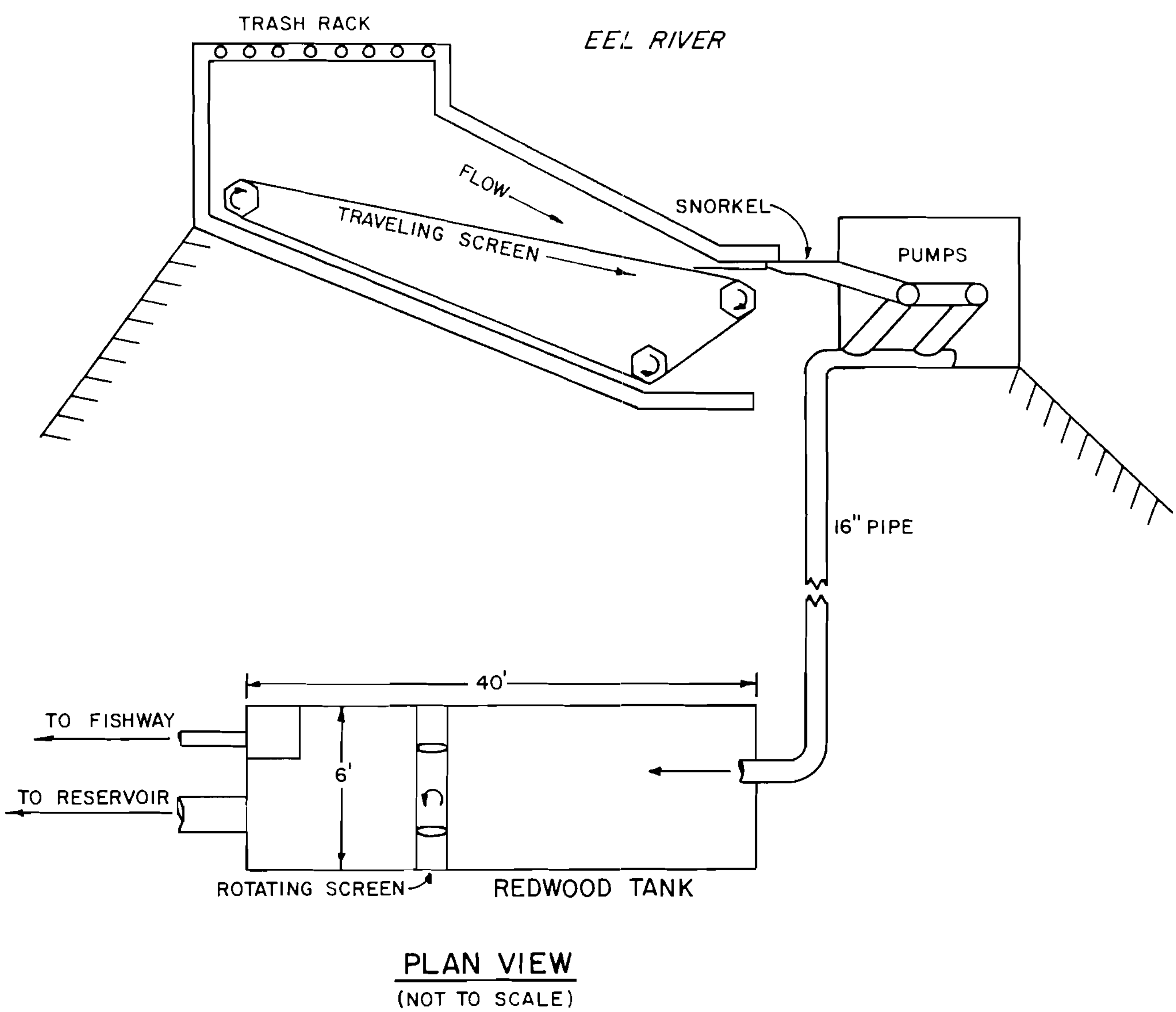

Figure 2.7-2. Downstream migrant trap at the Cape Horn Dam fish screen.

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The servicing procedure was to clear the trap of all fish at the start and end of each 24-hour trapping period and at such other times as needed. Lengths and numbers of salmonids caught were recorded. Scales were taken from dead salmonids for age and growth analysis. All other fish species trapped were identified and counted. Time of servicing, air and water temperatures, fish pump pressure (to assist in isolating the cause of any mortalities), and Eel River flows past Cape Horn Dam were also recorded.

Potter Valley Powerhouse

Trapping at PVPH was conducted for two consecutive 24-hour sampling periods per week from March 3, 1980 through July 2, 1980. After July 2, trapping was reduced to two 24-hour sampling periods per month. Two of the three tailraces were fished simultaneously from March 3 through June 18 after which only one generator remained on line. Consequently, only one tailrace was fished until October when all three generators were back on line. Generally, the fastest-flowing tailrace (#1) was fished during all sampling periods while the other two tailraces (#3 and #4) were alternately fished.

Beginning February 5, 1981, trapping at PVPH was increased to two non-consecutive 24-hour trapping periods per week until July 31, 1981, when the twice-monthly schedule was resumed. Two of the three tailraces were fished simultaneously, as above, until April 14 when only one tailrace was fished due to the relatively early seasonal shutdown of generators #3 and #4. After November 11 two tailraces were again fished, as above, through the end of the year.

In 1982, the trapping schedule at PVPH was modified based on recommendations from the biological subcommittee (Section 1.0, Introduction) for twice monthly sampling at PVPH throughout the year and twice weekly sampling in Tomki Creek during the peak migration period. However, the breakdown of the DFS fish pump caused the trapping schedule at PVPH to be altered to make up for the loss of data at the DFS. Trapping at PVPH was conducted twice a month through mid-April when the fish pump broke down. From April 20 through June 2, the trapping schedule was increased to twice a week. Following completion of repairs to the fish pump, trapping was reduced to once weekly from June 7 through June 29. The twice monthly schedule was resumed in July and continued until trapping was terminated on October 26. Two of the three tailraces at PVPH were fished simultaneously, as above, until July 12 when generators #3 and #4 were shut down. Only one tailrace was then fished until September 9 when all generators were again back on line.

Trapping was conducted using a funnel-shaped fyke net with a 5 x 5-foot mouth connected to a floating live box via 6-inch diameter PVC pipe as illustrated in Figure 2.7-3. Each fyke net consisted of three 4-foot sections of 1-inch, 3/4-inch, and 1/2-inch stretched mesh net, respectively, terminating in a nylon collar 1 foot in length and 6 1/2 inches in diameter. A 3-foot zipper was sewn into the posterior-most section of each net to facilitate removal of fish and debris. The anterior-most end of the fyke net was attached to a 5 x 5 foot pipe frame to which 3-inch lengths of 2-inch diameter pipe were welded on each corner for attachment points.

A 10-foot length of 6-inch diameter PVC pipe was attached to the collar of each net using band clamps. Additional sections of pipe were added as needed to provide enough head and subsequent water flow between the net and live box to convey fish into the live box. A 6-inch vertical drop from the end of the PVC pipe into the live box was maintained to prevent escapement of captured fish.

The live box, constructed of polyester resin-coated marine plywood and reinforced with wooden struts and angle aluminum, was 5 feet long, 3 feet wide, and 2 feet deep. "Windows" were cut in each side and covered with 1/4-inch hardware cloth. Additionally, each live box was equipped with two baffles to reduce turbulence. Two floatation pontoons were attached to the sides of the live boxes. Initially, the pontoons

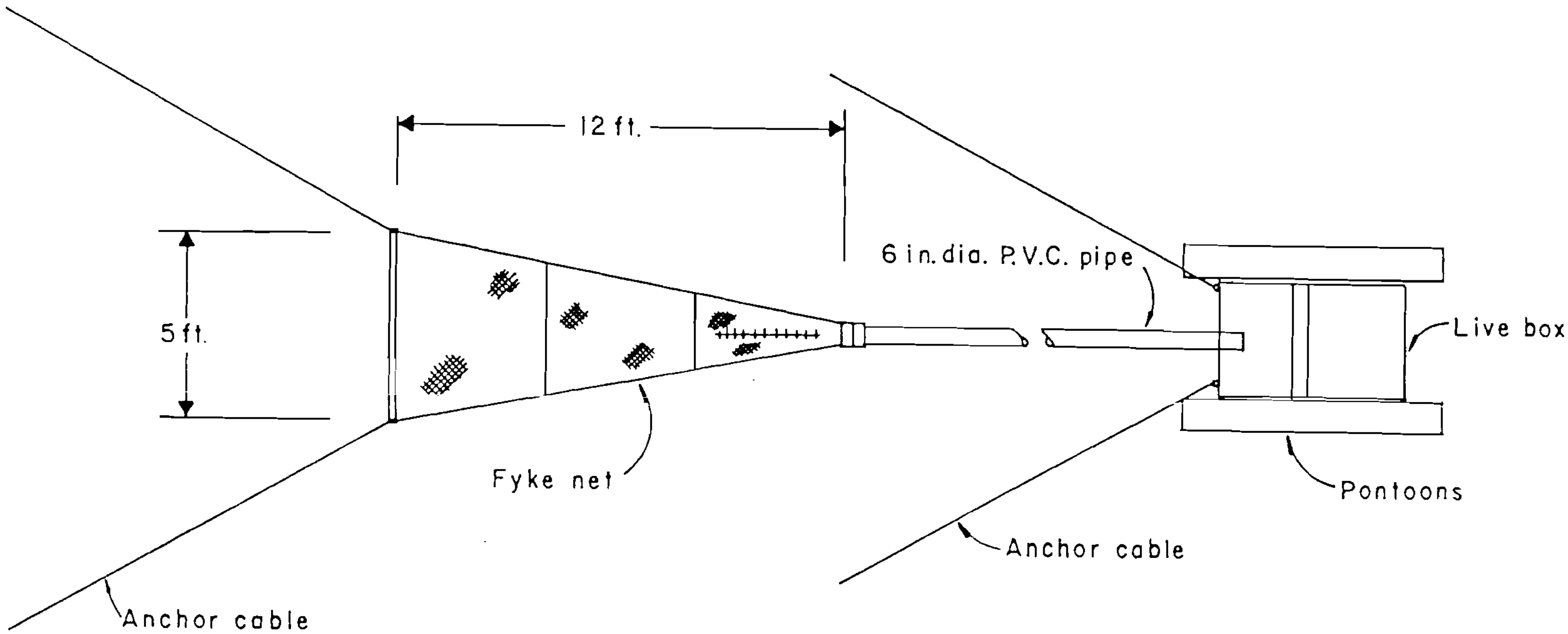

Figure 2.7-3. Diagram of fyke net and live box trap used in the Potter Valley Powerhouse tailraces.

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were constructed of plywood and filled with marine foam. During the second year of trapping, the wooden pontoons were replaced with plastic pontoons to facilitate ease of handling.

Physical parameters determined in association with each sampling period included water temperature, air temperature, water turbidity, and percentage of cloud cover. Rainfall and minimum/maximum air temperature preceeding each sampling period were also noted. Water turbidity (NTU) was determined utilizing a Hach Model 2100A turbidimeter.

Hydrological parameters determined included total discharge and flow screened by the fyke nets. Staff gauge readings were taken to determine total discharge. Flow through the nets was measured at the beginning and end of each 24-hour sampling period by taking nine equally spaced velocity measurements directly in front of each net. The measurements were then averaged for each net. Current velocities were determined using a Gurley Model No. 625 Pygmy Current Meter.

Traps were serviced in the morning at the end of each 24-hour sampling period. Fork lengths and numbers of live and dead salmonids were listed by species. If the total catch of a salmonid species was greater than 100, a random subsample of 100 individuals was selected for fork length measurement. Numbers of live and dead fish of other species were also listed by species.

Daily estimates of chinook salmon and steelhead trout passing through PVPH were calculated based on the actual numbers of fish captured per trapping period. These numbers were then adjusted to reflect catch rate (fish/24 hours). Individual catch rates were then multiplied by the ratio of total PVPH flow to net flow; the resultant being the daily estimate. The daily estimates calculated for each trapping period occurring within a one-week period (Saturday through Friday) were then averaged and multiplied by seven to obtain the weekly estimate. The weekly estimates were summed for the monthly estimates. Where trapping was conducted only during one or two weeks in a month, the average weekly estimate was multiplied by the number of weeks in that month.

To facilitate the determination of seasonal patterns of downstream salmonid migration, the catch rates of steelhead trout captured at PVPH and DFS were combined. These two sampling sites actually represent a single group of fish and were treated as such during analysis. DFS results represent total numbers of fish being retained by the fish screen. The PVPH catch rate referred to in the text is actually a daily estimate projected from the actual catch. The PVPH results had to reflect total numbers of fish passing through the powerhouse in order to combine the results of PVPH and DFS trapping. Catch rates for all sites except PVPH are actual catch rates (fish/24 hours).

Cape Horn Dam Fishway

An inclined plane-type trap was located in the trapping and egg collection facility on the CHDF. All downstream migrating fish decending CHDF were trapped and held during those periods the trap was in operation. At all other times, the trap remained open to allow the fish to pass through without delay.

Before November 1980, the downstream migrant trap in the CHDF consisted of a sloping, perforated plate and collecting box, located inside the trapping and egg collection facility (Figure 2.7-4). The perforated plate was 4.5 feet long and 2.7 feet wide and was attached on its upstream end to flashboards extending across the fishway. A screened live box measuring 3.8 feet long, 2.7 feet wide, and 3 feet deep, was attached to the lower end of the perforated plate. The upstream side of the box at the point of attachment of the perforated plate was 1 inch lower than the other three sides of the box. As the downstream migrant fish passed over the perforated plate, they were separated from the major portion of the water in which they were traveling, and were deposited in the live box where they were held until the box was serviced.

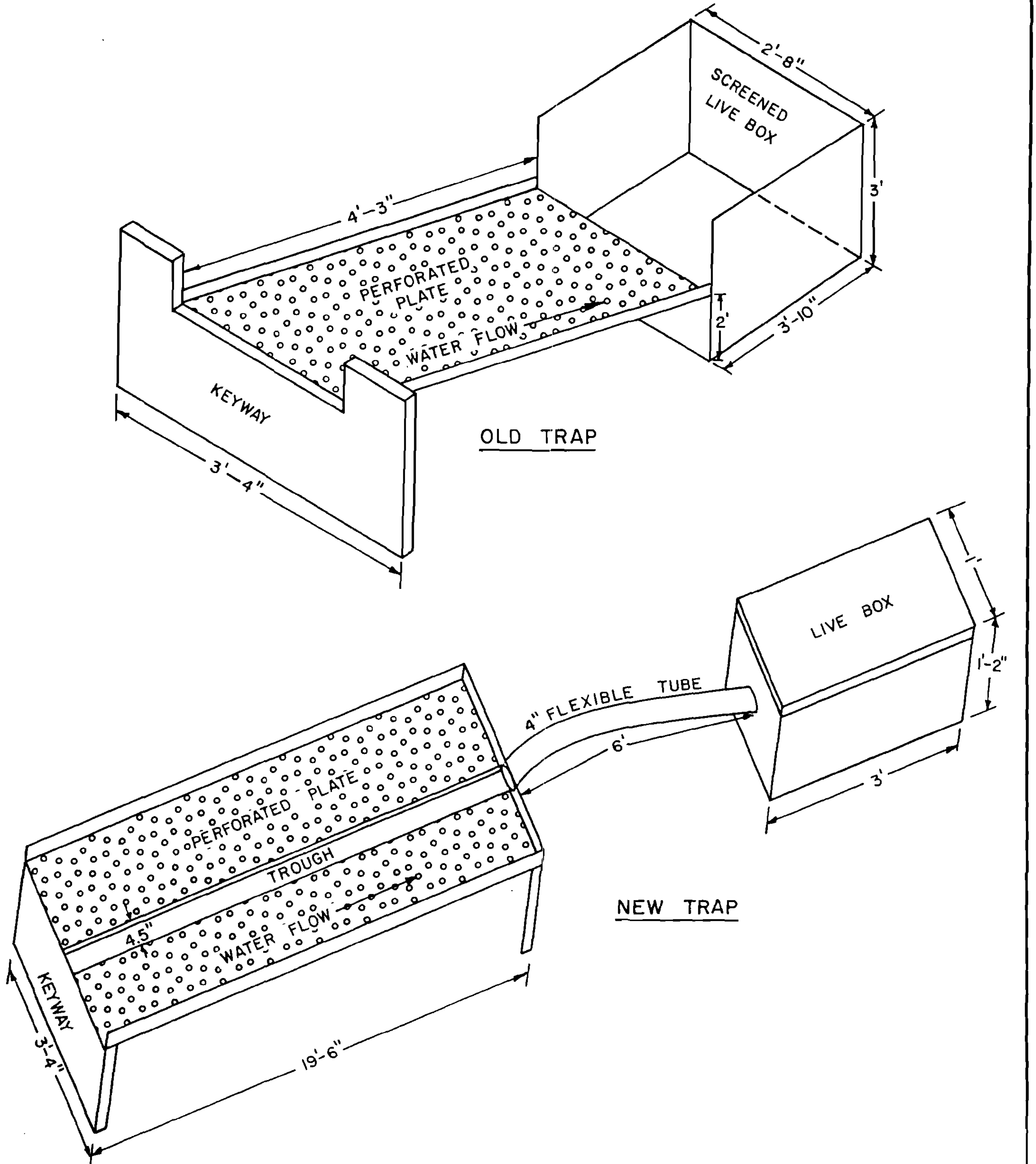

Figure 2.7-4. Old and new downstream migrant traps in the Cape Horn Dam fishway.

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In November 1980, a new downstream trap was installed in the trapping and egg collection facility (Figure 2.7-4). The new trap was needed to handle the higher flows being released through the fishway. It consisted of two perforated plates, 19.5 feet long and 1.5 feet wide, lying lengthwise in the fishway and sloping inward to a 5-inch wide trough at the center. The plates inclined toward the downstream end of the trap where a 6-foot long, 4-inch diameter flexible tube was attached. The downstream end of the tube was attached to a wooden live box, 5 feet long, 1 foot wide, and 1 foot deep, with fine mesh screening on the bottom and on the hinged wooded lid to allow passage of water through the box. This new trap worked in the same fashion as the old one, holding the trapped fish in the live box until the box was serviced.

Operation of the CHDF trap in 1980 was on a nearly continuous basis from mid-March through May and on a periodic basis in November and December. It was serviced on the same sampling schedule as the DFS trap. From June 2 through October, the CHDF trap was removed to allow construction of the new trap. In 1981, the CHDF trap was operated from February through July and periodically from August to December. In 1982, it was operated continuously from January 19 through October and was serviced on the same sampling schedule as the DFS trap except that the CHDF trap was operated during the time period that the DFS trap was inoperable. The CHDF trap was serviced on the same sampling schedule as the DFS trap. For all years, the same data were collected here as at the DFS trap.

Tomki Creek

Trapping was initiated and conducted in Tomki Creek during 1982 to determine the natural timing of chinook salmon and steelhead trout emigration. Trapping was conducted for two 24-hour periods each week from February 25 through July 30 except from March 27 through April 19 when high flows precluded trapping and from May 23 through 28 when trapping was conduced daily. The sampling apparatus and procedures were similar to those described below for the Eel River site in 1982 with the following exception; a one-quarter inch stretched mesh live box liner was used from February 24 until April 26 when a one-eighth inch stretched mesh line was installed.

Eel River Above Outlet Creek

In 1980, initiation of trapping in the Eel River above Outlet Creek was delayed until April 3, due to excessively high flows. High flows also prevented trapping during the week of April 7-13. One net and live box assembly was fished for two consecutive 24-hour sampling periods per week from April 14 through July 2. In 1981, one net and live box assembly was fished for three non-consecutive 24-hour sampling periods in the month of February, for two non-consecutive 24-hour periods per week during March, June, and July, and for three non-consecutive 24-hour periods per week during April and May. In 1982, trapping was conducted twice weekly from March 18 through July 30 except for the period between March 26 and April 29 when extremely high flows precluded trapping. In 1980 and 1981, trapping occurred on the same days as the PVPH trapping schedule. In 1982, trapping occurred on the same days as the Tomki Creek trapping schedule. However, nets were tended in the afternoon rather than the mornings. Sampling procedures were otherwise similar to those described for PVPH. Rainfall and minimum/maximum air temperature data were not available for this site.

In 1980, the fyke net and live box assembly was the same as used at PVPH (Figure 2.7-3). The net was initially placed in the fastest-flowing section of the river at the outside edge of a bend in the main channel. On May 19 the trap assembly was moved 75 yards upstream at the land owner's request. This position proved to be unsatisfactory, and on May 27 the trap was moved downstream 50 yards to a faster flowing section of the river. Additionally, a 20-foot wing was attached to the net and was stretched toward the left bank, thereby fishing approximately one-third of the stream width.

The fyke net used in 1981 was similar in design to that used at PVPH (Figure 2.7-3), but was 20 feet long rather than 12 feet. A new live box design was used at this site in 1981. The live box consisted of a one-inch square stainless steel tubing frame, four feet long, and two feet high; knotless nylon netting (one-quarter inch stretched mesh) with a zipper in the top was attached to the metal frame. A short piece of PVC pipe (about 1 1/2 feet) was used to attach the net to the live box. To prevent high velocities going through the live box, a 45° angle PVC pipe coupler was attached to the end of the pipe inside the live box. This directed water upward, reducing turbulence and preventing impingement of fish on the live box. A piece of plywood was placed on the front of the live box to reduce velocities in the live box. In order to trap at this site during high flow periods, a cable was placed across the river from bank to bank, from which the trap was suspended. The net and live box could be placed in and removed from the river by the cable arrangement. During low flow periods, the trap assembly was anchored to the stream bottom and banks, as had been done throughout the 1980 sampling period.

The same trapping apparatus used in 1981 was employed in 1982 with the following exception; the knotless nylon netting used in the live box was changed from the one-quarter inch stretched mesh to one-eighth inch stretched mesh to reduce the incidence of gilled salmonids.

In order to determine trapping efficiency in 1980, 200 chinook salmon captured on May 13 were stained with neutral red dye and released two riffles upstream from the net (approximately 400 yards). The staining procedure involved mixing four grams of neutral red dye with 10 gallons of river water; the fish were placed in the dye solution for 30 minutes and then released upstream (Conlin and Tutty 1979). Trapping was continued for two days following release. The numbers of stained and unstained fish captured in the trap were determined at the end of each 24-hour period.

Because very few smolt size steelhead were caught in the Eel River above Outlet Creek in 1980, a mark and recapture study was undertaken in 1981 to determine if the trap was effective at catching smolt-size steelhead and to determine if fish released at Cape Horn Dam emigrated immediately. On April 1, 11,835 marked smolt-size steelhead trout were released at the CHDF by CDF&G to enhance the steelhead trout run in the upper Eel River. These fish were hatched from eggs taken from steelhead captured at Cape Horn Dam in 1980. Fish were marked on March 17 with yellow flourescent dye by CDF&G and VTN personnel. Trapping frequency in the Eel River above Outlet Creek was increased in April and May to increase the likelihood of catching marked steelhead. Juvenile steelhead caught in the trap at this site were examined under ultra-violet light to detect the fluorescent dye marking.

2.8 Summer Fish Inventory

Electrofishing surveys were conducted in July 1980, June and August/September 1981, and August/September 1982 to determine fish species composition, numbers, and biomass at selected sites. Five sites on the Eel River between Cape Horn Dam and Outlet Creek were sampled from July 24 to 30, 1980 (Figure 2.8-1 and Table 2.8-1). The four reach types defined in the Instream Flow Study (Section 2.6) for this portion of the river were considered different stream types for fish inventory sampling purposes. The Instream Flow Study sites were selected as being representative of each reach type (stream type) and, therefore, were used as fish inventory sampling sites also. However, Reach Type I (comprising 49% of the total study area from Cape Horn Dam to Outlet Creek) is separated into two sections by Reach Type II (Figure 2.6-1). The instream flow study site is located in the upstream section of Reach Type I. A second fish inventory site was established in the downstream section at Big Bend to provide a better representation of the fish population in this downriver section of Reach Type I. In 1980, two riffle sections at each of the five sites were sampled.

Electrofishing surveys were expanded in 1981 to include the same five sites on the Eel River between Cape Horn Dam and Outlet Creek, plus four sites on the Eel River between Scott Dam and Cape Horn Dam, and 11 sites on tributaries from Scott Dam to Outlet Creek (Figure 2.8-1 and Tables 2.8-1 and 2.8-2). A total of 19 sites were sampled from June 9 to 16, and 17 sites were sampled from August 25 to September 2. One riffle section was sampled at each site in 1981. The same sites were sampled during both early and late summer with the following exceptions. The Fish Creek site was not sampled in early summer due to access difficulties. The String Creek, Tomki Creek above Wheelbarrow Creek, and Soda Creek near the USFS Guard Station sites were not sampled in late summer, because those sites were dry.

Electrofishing surveys were modified in 1982 to include two sites on the Eel River between Cape Horn Dam and Outlet Creek, three sites on the Eel

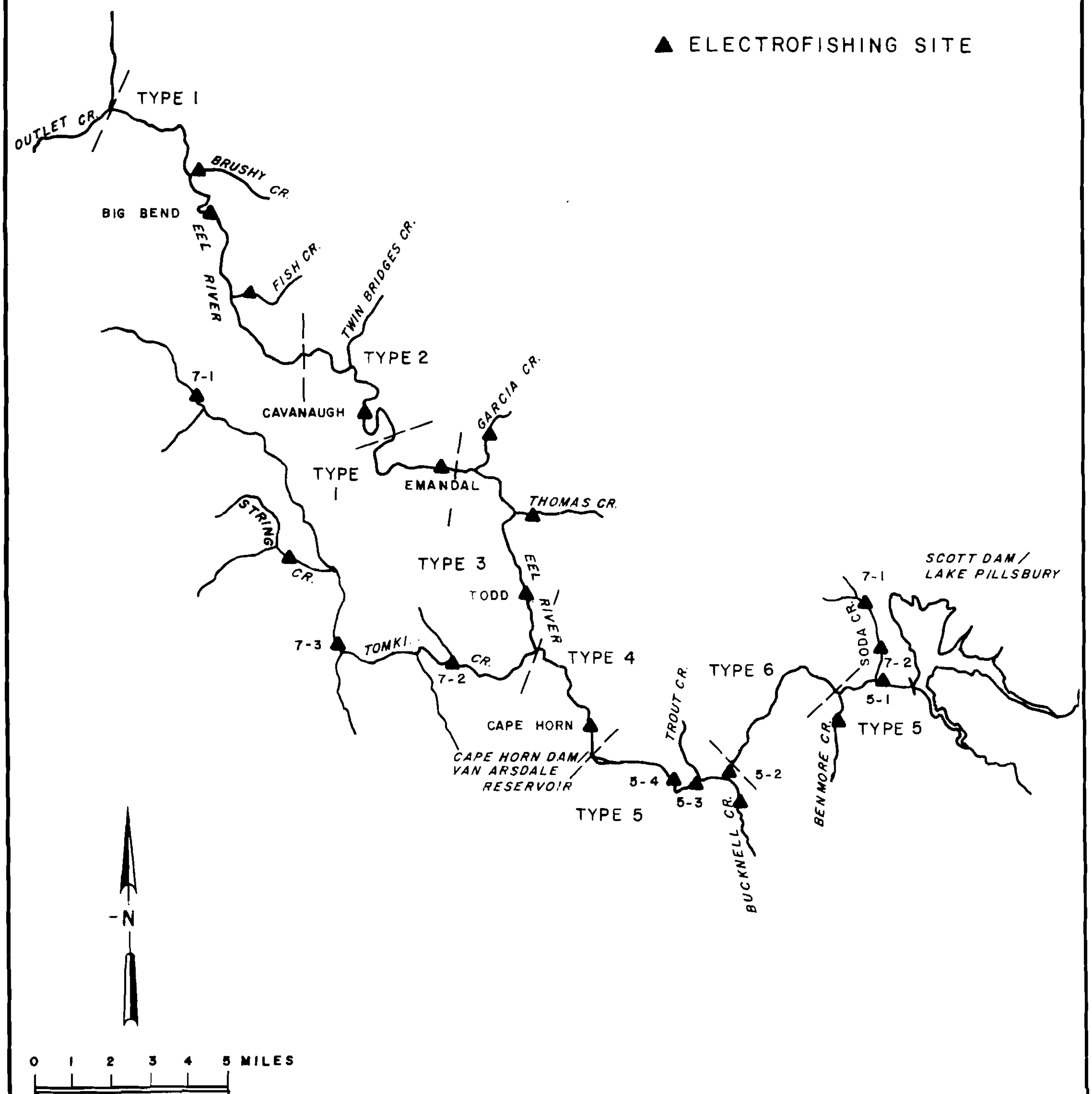

Figure 2.8-1. Electrofishing locations for the summer fish inventory in the Eel River and tributaries.

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Table 2.8-1. Reach type and station codes for electrofishing sites in the Eel River in 1980, 1981, and 1982.

Location	Reach Type	Station Number	Sampled in 1980	Sampled in 1981	Sampled in 1982
Big Bend	1				
Upper riffle		3	X	X	-
Lower riffle		4	X	-	-
Emandal	1				
Upper riffle		1	X	-	-
Lower riffle		2	X	X	X
Cavanaugh	2				
Upper riffle		1	X	X	-
Lower riffle		2	X	-	-
Todd	3				
Upper riffle		1	X	-	-
Lower riffle		2	X	X	-
Cape Horn	4				
Upper riffle		1	X	-	-
Lower riffle		2	X	X	X
Above Soda Creek	5	1	-	X	X
Above Bucknell Creek	5	2	-	X	X
Below Trout Creek	5	3	-	X	X
Above Van Arsdale Reservoir	5	4	-	X	-

Table 2.8-2. Electrofishing sites in tributaries to the Eel River between Scott Dam and Outlet Creek in 1981 and 1982.

Stream Name	Location	Station Number	Reach Type	Sampled in 1981	Sampled in 1982
Soda Creek	Below Welch Creek	1	7	X	X
	Near USFS Guard Station	2	7	X	-
Benmore Creek		1	7	X	X
Bucknell Creek		1	7	X	X
Thomas Creek		1	7	X	X
Garcia Creek		1	7	X	X
Tomki Creek	Above Salmon Creek	1	7	X	-
	Above Wheelbarrow Creek	2	7	X	-
	Above Cave Creek	3	7	-	X
String Creek		1	8	X	-
Fish Creek		1	7	X	-
Brushy Creek		1	7	X	-

River between Scott Dam and Cape Horn Dam, and six sites on tributaries from Scott Dam to Outlet Creek (Figure 2.8-1 and Tables 2.8-1 and 2.8-2). Eel River sites between Cape Horn Dam and Outlet Creek and tributary sites were sampled from August 24 to 28. Eel River sites between Scott Dam and Cape Horn Dam were sampled from September 28 to 30.

Quantitative population estimates were determined for the mainstem sites below Cape Horn Dam and the tributary sites following the methods reported by Price and Geary (1979). Each riffle section was 30-meters long (98 ft) and was blocked at its upper and lower ends by nets. Mainstem riffle sites were electrofished using two backpack shockers (Type VII Smith-Root) and two or three netters who collected stunned fish. One backpack shocker and two netters were used for sampling tributary sites. If salmonids were captured on the initial pass, one or two additional passes of equal effort were made through the riffle; otherwise no additional passes were made. Because of thick cover (algal mats) at the Cavanaugh site in 1980, two passes were made despite capturing no salmonids. After each pass, fish were identified to species and counted. Fork lengths of steelhead trout were measured to the nearest millimeter. In 1980 and 1982, all captured steelhead were measured; in 1981, up to 100 fish were randomly selected and measured. Fork lengths were measured for other species up to a maximum of 27 fish per species. The approximate total biomass of all fish of each species was determined by the volume displacement method. All fish were released outside the sampling site prior to making additional passes.

After the final electroshocking pass, water quality measurements were made just upstream of the sample area. Air temperature and surface and bottom water temperatures (°C) were measured with hand thermometers. Dissolved oxygen (ppm) was measured with a YSI Model 54A dissolved oxygen meter. Conductivity was measured in micromhos/cm with a Hach Model 2510 conductivity meter. pH was measured with a Hellige Model

605-HT pocket comparator. Turbidity (NTU) was measured using a Hach Model 2100A turbidimeter.

Stream widths were measured every 3 meters through the 30-meter sampling area, and depths were measured at three equidistant points across each width transect. Discharge was determined by measuring water velocities along with depths across one of the ten width/depth transects. The stream gradient through the sample site was measured with a clinometer.

Visual estimates of the following habitat characteristics were also made: percent riffle, pool and runs; percent of stream area providing fish cover; percent of stream with canopy; and percent streambed material composition [silt and sand (<0.1 inch diameter), gravel (0.1-3 inches), rubble (3-12 inches), boulder (>12 inches), and bedrock].

All data were recorded on data sheets developed by PGandE for fishery resource inventories (Price and Geary 1979). Data reduction and analysis were performed by PGandE. The 1978 version of the KGRA(FISH) Program on the PGandE IBM 370-168 computer was used to analyze 1980 and 1982 data. The 1981 data were analyzed using a modified 1981 version of the KGRA(FISH) Program. Data reports are expressed in metric units. Appendix J provides descriptions of calculations made during data analyses. Calculations included estimates of fish populations, standing crop (biomass), and species composition by station, reach type, and stream.

Population estimates for reach types in the Eel River below Cape Horn Dam and all tributary streams were expanded from station population estimates. Table 2.8-3 indicates the distances used to calculate reach type population estimates. The distances listed for the Eel River reach types only represent riffle habitat, because only riffles were sampled in the mainstem Eel River. Distances for the tributaries are the total distances available to steelhead trout. If barriers to adult steelhead migration were present, as determined during steelhead surveys (Section 3.2, Tomki Creek/Eel River Salmon Carcass Survey), then only the distance from the mouth to the barrier was used. If no barriers

Table 2.8-3. Distances used to calculate Eel River reach type and tributary fish population estimates. Distances for Eel River reach types only represent riffle habitat in the total reach type length. Distances for tributaries are the total distances available to steelhead trout.

		Distances (meters)			
		1980	1981		1982
Stream	Reach Type	Late Summer	Early Summer	Late Summer	Late Summer
Eel River	1	4,571	4,571	4,571	4,571
	2	2,092	2,092	2,092	-
	3	1,931	1,931	1,931	-
	4	579	579	579	579
	5	-	-	-	1,424
Soda Creek	-	-	5,600	2,880	3,733
Benmore Creek	-	-	3,200	3,200	3,200
Bucknell Creek	-	-	5,120	5,120	5,120
Thomas Creek	-	-	1,600	1,600	1,600
Garcia Creek	-	-	7,200	7,200	7,200
Tomki Creek	-	-	33,600	16,800	6,720
String Creek	-	-	8,640	0	-
Fish Creek	-	-	4,800	4,800	-
Brushy Creek	-	-	200	200	-

were present, then the distance used was from the mouth to the point where the creek became intermittent as indicated on topographic maps. The total distance available to steelhead trout was used for tributary stream distance calculations because representative sampling sites included both pools and riffles. If part of a stream was dry, then that distance was estimated and subtracted from the total distance.

At the four mainstem stations between Scott Dam and Cape Horn Dam data collection and analysis differed for 1981 and 1982 surveys. In 1981 surveys at the four sites were of a more qualititative nature than at the other sites. Electrofishing was conducted in a similar manner except that block nets were not used; only a portion of each riffle was sampled; only one pass was made; and depth, width, and velocity measurements were not taken. Length and width estimates were made of each riffle to estimate the area sampled at each station. Because of the qualitative sampling at these sites, population estimates were not calculated. In 1982, quantitative methods, similar to those described above for Eel River sites below Cape Horn Dam, were used at the three sites between Scott and Cape Horn Dams. At normal summer flow levels (>100 cfs), riffles in this section of river are too large to sample using the block net and backpack electroshocking techniques; therefore, arrangements were made to reduce the Eel River streamflow during the surveys. Releases from Scott Dam during the survey period were approximately 45 cfs. A Smith Root Type 6 electrofishing unit was used rather than two Type 7 units used in other areas.

Because electrofishing could be conducted only in riffles, snorkel surveys of pools were conducted during each sample period in 1980, 1981, and 1982. One pool at each of the five sites on the mainstem below Cape Horn Dam was surveyed each year. The number of each species was estimated and general location within a pool noted. The length of any observed steelhead trout was estimated as small (0-150 mm), medium (150-300 mm), or large (>300 mm). Numbers of California roach were difficult to estimate because of their large numbers and habit of following the divers.

2.9 Hearst Riffle Channelization Feasibility Study

An engineering study was conducted to evaluate the feasibility of constructing and maintaining a channel of adequate depth and velocity to ensure upstream passage of adult chinook salmon and steelhead trout over Hearst Riffle. Several alternative means of channelization were identified and then evaluated based on construction and maintenance requirements and costs.

The depth and velocity criteria used for the evaluation were based on Thompson (1972). Channelization alternatives were designed to provide a minimum depth of 0.8 feet and a maximum velocity of 8 feet per second over a minimum of 25 percent of the channel width, 10 percent of which must be continuous. Alternatives were evaluated for minimum flow releases of 50, 100, and 150 cfs from Cape Horn Dam and for a range of flows up to 400 cfs beyond the minimum releases to account for tributary inflow. Also taken into consideration were periodic flood flows that produce changes in streambed morphology. Information used for the evaluation included: 1) riffle photos; 2) maps; and 3) flow, width, depth, and velocity data collected at Hearst Riffle during the first two years of the fisheries study.

2.10 Mitigation Study

The Eel River and tributaries above Scott Dam were examined through a reconnaissance level field survey and review of CDF&G stream survey data to determine the quantity and quality of spawning and rearing habitat lost to chinook salmon and steelhead trout due to construction of the dam (Figure 2.10-1). Estimates of the number of adult chinook salmon and steelhead trout formerly produced were made using estimates of the length of stream formerly accessible above Scott Dam and estimates of salmon and steelhead abundance from other areas in the Eel River system.

The reconnaissance level survey of the Eel River upstream of Scott Dam was conducted on August 11 and 12, 1981. PGandE and VTN personnel made an aerial survey of the Eel River, the Rice Fork, and other selected tributaries on August 11 to gain an overview of the drainage and stream conditions. Ground surveys were conducted August 12 in selected areas to obtain details on accessibility, general substrate characteristics, fish presence, and other habitat characteristics not discernable from the air. Areas examined during ground surveys were the Eel River near Trout Creek, Corbin Creek, and Cold Creek; the Rice Fork near Salt Creek and Bear Creek; and small portions of Corbin Creek, Salt Creek, and Bear Creek.

Data from stream surveys conducted by CDF&G in 1938 and 1977-79 (CDF&G 1938 and 1977-79, unpublished) were reviewed and compared with the data collected during the reconnaissance level survey. Based on these data, the lengths of stream formerly accessible to chinook salmon and steelhead trout above Scott Dam were estimated.

Estimates of adult chinook salmon and steelhead abundance in various sections of the Eel River below Scott Dam are available from several of the study tasks in this report and from a report on fish and wildlife aspects of the Potter Valley Project by Anderson (1972). These estimates were reviewed and compared, paying particular attention to the

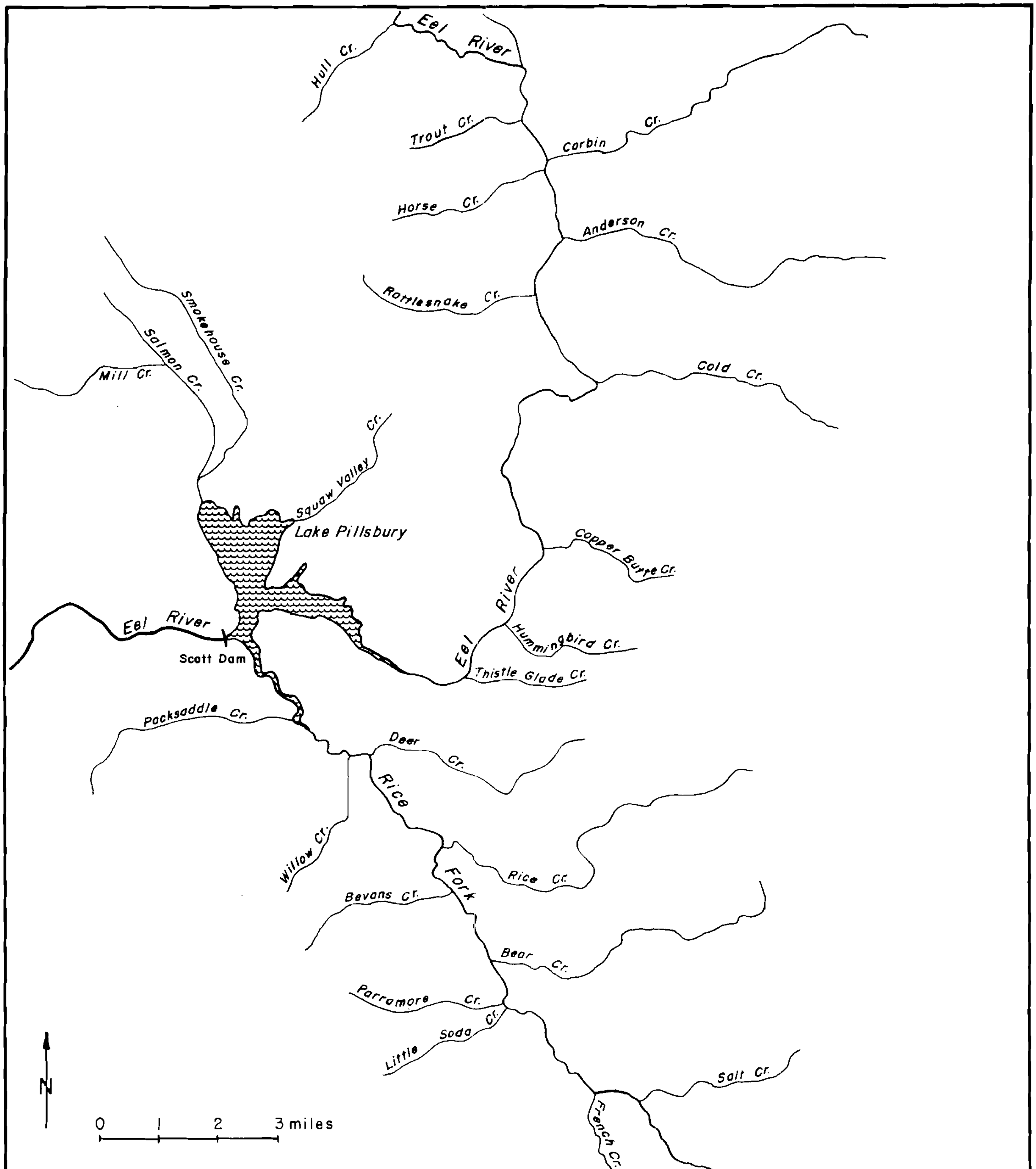

Figure 2.10-1. Eel River and tributaries upstream of Scott Dam.

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similarities and dissimilarities between the stream sections for which the estimates were made and the formerly accessible stream sections above Scott Dam. Based on this review, density estimates of spawning chinook salmon and steelhead trout (fish/mile) were developed for stream sections above Scott Dam. These density estimates were multiplied by the estimates of formerly accessible stream lengths to calculate numbers of adult chinook salmon and steelhead trout formerly produced above Scott Dam.

3.0 RESULTS AND INTERPRETATIONS

3.1 Cape Horn Dam Adult Fish Counts

The numbers of adult chinook salmon and steelhead trout counted at Cape Horn Dam showed considerable variation during the three-year study period, but were within the normal range of variability for the period of record (Table 3.1-1 and Appendix D). The numbers of chinook salmon counted in 1979/80, 1980/81, and 1981/82 were 84, 0, and 175, respectively. The 175 salmon collected in 1981/82 was the highest number since 994 salmon were counted in 1947/48. Returns of chinook salmon to the Eel River above Cape Horn have been sporadic (Table 3.1-1). During the past 27 seasons of record, salmon counts have ranged from 0 to 175; in ten of those seasons, no salmon passed over the dam.

Chinook salmon spawning escapement to the Eel River above Cape Horn Dam is a minor component of the total spawning population within the study area. Salmon passing over Cape Horn Dam comprised only 0 to 4% of the number in Tomki Creek for four years of comparable data (Table 3.1-2) (Section 3.2, Tomki Creek/Eel River Carcass Survey) and only 1.4% of the combined escapement to Tomki Creek and the Eel River between Tomki Creek and Outlet Creek in 1979/80 (Table 3.1-2) (Section 3.3, Aerial Redd Survey). A strong linear relationship between the number of salmon returning to Tomki Creek and the number passing over Cape Horn Dam (Figure 3.1-1) reflects a rather uniform variation in general abundance throughout the study area from year to year. This couly imply that there is a self-sustaining population above Cape Horn Dam and that salmon escaping to, spawning in, and emigrating from the area above Cape Horn Dam are affected by the same factors as salmon in Tomki Creek. However, these assumptions are not very sound for several reasons: upstream passage from Tomki Creek to Cape Horn Dam has historically been inhibited by artificially reduced streamflows; the ladder at Cape Horn Dam presents an impediment to upstream passage; emigration of juvenile salmon may be delayed by cooler water temperatures between the two dams;

Table 3.1-1. Number of upstream migrating adult chinook salmon and steelhead trout trapped annually at the Van Arsdale Fisheries Station, migration seasons of 1933/34 through 1981/82.

Season	Chinook Salmon	Steelhead Trout
1933/34	ND	3,247
1934/35	ND	2,255
1935/36	ND	6,310
1936/37	ND	6,861
1937/38	ND	3,413
1938/39	ND	4,786
1939/40	ND	3,889
1940/41	ND	2,225
/		
1944/45	ND	9,528
1945/46	ND	5,054
1946/47	917	4,409
1947/48	994	178
1948/49	ND	2,433
1949/50	ND	ND
1950/51	55	1,091
1951/52	ND	5,444
1952/53	ND	2,197
1953/54	ND	2,590
1954/55	ND	6,131
1955/56	5	3,719
1956/57	0	4,109
1957/58	2	5,151
1958/59	0	3,335
1959/60	0	2,206
1960/61	9	1,130
1961/62	0	1,689
1962/63	9	2,030+
1963/64	3	846
1964/65	63	921+
1965/66	93	423
1966/67	148	525
1967/68	0	531
1968/69	0	354
1969/70	15	719
1970/71	34	1,863
1971/72	0	696
1972/73	0	586
1973/74	12	1,040
1974/75	1	1,123
1975/76	2	1,078
1976/77	0	39
1977/78	23	590
1978/79	5	106
1979/80	84	87
1980/81	0	1,966
1981/82	175	650

Table 3.1-2. Chinook salmon spawning escapement to the Eel River above Cape Horn Dam compared to Tomki Creek and the Eel River from Tomki Creek to Outlet Creek.

	Eel River[a]		Eel River[c]
	Scott Dam to Cape Horn Dam	Tomki[b] Creek	Tomki Creek to Outlet Creek
1964/65	63	1,747	-
1975/76	2	367	-
1979/80	84	2,410	3,500
1980/81	0	317	-
1981/82	175	-	-

[a] Counts at Cape Horn Dam.
[b] Carcass survey population estimates.
[c] Aerial survey estimate.

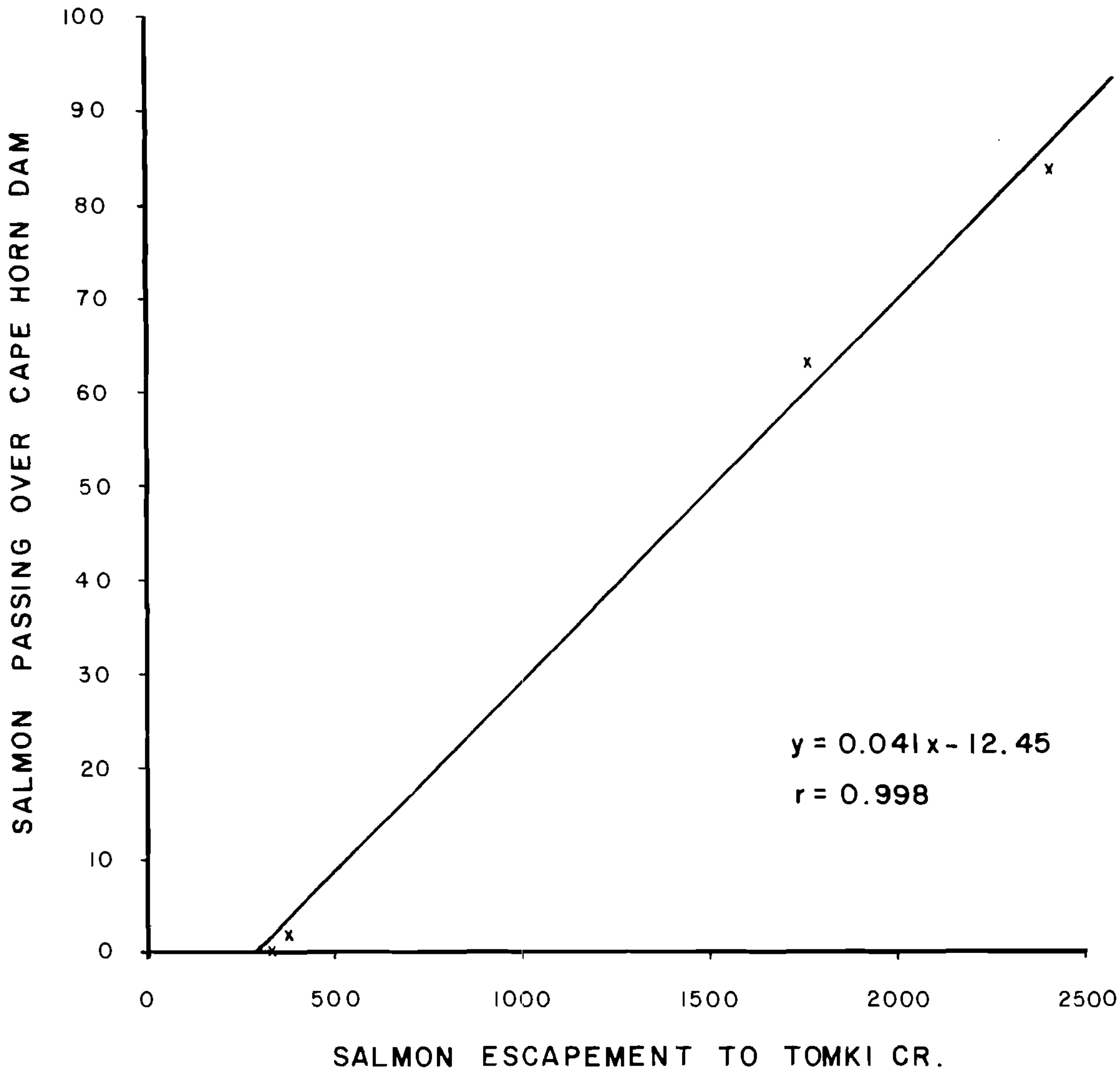

Figure 3.1-1. Relationship of chinook salmon escapement to Tomki Creek and the number of salmon passing over Cape Horn Dam.

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and many juvenile salmon are diverted from the Eel River along with the water. All of these factors probably have acted to reduce the total salmon population in the Eel River from Scott Dam to Cape Horn Dam; these factors, for the most part, do not affect salmon in Tomki Creek. A more plausible explanation of the relationship between returns to these two areas is that salmon passing over Cape Horn Dam are merely strays from the only self-sustaining salmon population in the study area, in Tomki Creek and in the Eel River below Cape Horn Dam. Additional light is shed on this by examining the returns of salmon over Cape Horn Dam three to five years prior to each run year considered in Figure 3.1-1 (Table 3.1-1). It seems extremely unlikely that 63 fish would return in 1964/65 from nine fish spawning in 1960/61 and that 84 fish would return in 1979/80 from two fish spawning in 1975/76.

The numbers of steelhead trout counted at Cape Horn Dam in 1979/80, 1980/81, and 1981/82 were 87, 1,966, and 650, respectively. These counts are low compared to data from the 1930s, 40s and 50s, but similar to counts from the 1960s and 70s (Table 3.1-1). Steelhead runs in the Eel River above Cape Horn Dam have been declining consistently since records were first started in 1933/34. The mean annual steelhead counts for each decade beginning with the 1930s and ending with the 1970s were 4,394, 3,971, 3,597, 917, and 721 fish, respectively. Despite this decline, steelhead trout spawning escapement to the Eel River above Cape Horn Dam appears to be a major component of the total spawning population within the study area; the river between Scott and Cape Horn Dams is the primary juvenile steelhead rearing habitat in the study area during summer (Section 3.8, Summer Fish Inventory).

General declines in steelhead and salmon runs have been reported for most major California coastal rivers. For example, steelhead returns to Benbow Dam on the South Fork of the Eel River declined from an average of 18,285 in the 1940s to 3,355 in the 1970s. A variety of factors such as logging, road building, dams, irrigation, and increased sport and commercial fishing probably account for the long-term decline in fish runs. The decline of fish returns on the South Fork of the Eel River, where flow manipulations have not occurred, suggests that fish declines at Cape Horn Dam are not totally project related.

The timing of adult chinook salmon and steelhead trout arrival at Cape Horn Dam varies from year to year. Based on data from the last 20 years, the first chinook salmon and steelhead trout usually arrived at Cape Horn Dam from mid-November to early December, after one or two peak flows had occurred (Table 3.1-3). It appears that peak flows are a necessary trigger to stimulate upstream movement. The earliest arrival was November 6-7 in 1979/80 and 1981/82. The latest date for first arrival at Cape Horn Dam was December 19 for chinook in 1978/79, and March 19 for steelhead in 1976/77. The majority of chinook salmon counted at Cape Horn Dam in 1979/80 and 1981/82 arrived from mid to late November; no salmon arrived later than December. Data from 1964/65, 1965/66, 1966/67, and 1970/71 (seasons of largest runs in the recent past) also showed the majority of chinook arriving at Cape Horn Dam in November. However, for the 1966/67 through 1978/79 period, November counts amounted to 45% of the total, with December accounting for 53%. Steelhead runs have a longer duration and greater variation in the timing of peak counts at Cape Horn Dam compared to chinook. Steelhead runs typically last from November through April. Peak counts at Cape Horn Dam in 1979/80, 1980/81, and 1981/82 were in April, January, and February, respectively. February has the highest returns of steelhead based on the 13-year average from 1966/67 to 1978/79 (Table 3.1-4).

Three steelhead, one female and two males, arrived at Cape Horn Dam in the first three days of June in 1982. The fish were very bright and firm, indicating a short residence and migration time from the ocean to Cape Horn Dam and appeared to be summer run steelhead (W. Jones, CDF&G, pers. comm.) This is the first known occurrence of steelhead arriving in June. The period of reliable records for steelhead counts at Cape Horn Dam goes back to 1956/57. Prior to this period, records are either unreliable or cannot be located. It is possible that steelhead may have arrived at the dam during June in some of these prior years.

Table 3.1-3. Comparison of the arrival of chinook salmon (●) and steelhead trout (■) at the Cape Horn Dam fishway with peaks in streamflow at Cape Horn Dam (CHO) and Outlet Creek (OC).

Year	Station	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY
1981/82	CHO	18, 355	146, ● ■ 100, 250, 4,850, 23,800	750, 23,500, 21,640	884	1,140, 280/25,200
	OC	31, 754	162, 168, 7,310, 6,100	1,400, 1,880, 2,660, 29,700, 7,990	>1,140, 3,220	No data
1980/81	CHO			416, ■, 72	102, 381, 1,730	4,020
	OC	33	28, 28	4,210, 439	2,750, 7,220	3,300, 2,200
1979/80	CHO	341	● ■ 119, 100, 605, 220, 303	229, 303, 6,280	24,000	16,800
	OC	1,690	1,470, 2,140, 1,830	3,720	6,890, 42,400	21,600
1978/79	CHO	61, 9	83, 6	● 280	1,180, ■ 104	605, 750, 2,740
	OC	37	39, 25	235	8,650	5,140, 2,100, 4,950
1977/78	CHO		19, 189	● ■ 945, 333, 1,530	10,300, 9,840, 18,600	8,950
	OC	17, 43	133, 2,210	8,950, 3,790, 2,280	13,200, 14,000, 27,600	14,300, 7,000
1976/77	CHO	76	26			12
	OC	30	45		103, 29	29, 164
1975/76	CHO	51, 69, 79	13, 70, ■ 128, 83	● 252, 54, 42	20	14, 213
	OC	45, 326, 211	154, 912	2,630, 146, 174	268	1,140
1974/75	CHO	26	14, 28, 11, 16	165, 18, ■ 28, 234	278, 317, 109	311, 15,900, 4,140
	OC	49	22, 26, 20, 33	1,140, 142, 1,470	1,730, 3,750, 2,870	2,400
1973/74	CHO	75, 28, 212	301, 11,300, 8,180, ●	12,700, 2,070, ■, 4,030, 3,810	31,700	942, 3,270, 3,040
	OC	59, 1,270	1,490, 15,100, 12,000	18,500, 3,750, 6,300, 6,210	56,200	1,290, 7,600, 7,200
1972/73	CHO	19, 72, 10	61, 43, ■ 148, 257	41, 76, 1,570, 405, 511	10,900, 12,800, 1,520	1,260, 3,640, 2,960, 4,140
	OC	112, 49	282, 719, 1,180, 1,400	150, 162, 8,220, 2,600, 1,060	21,400, 21,000, 3,070	2,740, 7,450, 4,580, 5,410
1971/72	CHO	32, 19, 27	18, 91, 26, 59	■, 54, 389, 35	25, 14, 12, 32, 1,430	1,150, 2,620
	OC	25, 34, 28	33, 177, 315	335, 747, 1,270, 2,330	7,010	1,920, 5,500
1970/71	CHO	62	97, ■ 143, 24, ● 157, 818	12,900, 2,270, 3,310	1,060, 17,600	
	OC	108	1,040, 1,160, 5,570	23,300, 4,090, 6,040	2,110, 36,300	
1969/70	CHO	37, 11, 14	64, 12	● ■ 923, 979, 5,240	5,240, 14,500, 22,600	3,550
	OC	48	74	6,130, 10,200	23,000, 45,000	6,130
1968/69	CHO	13, 14	38, 20, 100, ■ 35	38, 899, 684, 1,280	1,230, 18,700, 16,700, 8,100	7,200
	OC	41, 34	61, 114, 153, 96	150, 4,600, 5,000, 9,000	2,010, 28,000, 27,000, 12,500	10,700, 4,000
1967/68	CHO	22, 16	11, 47	■ 208, 239, 215, 105, 69	936, 2,480, 2,930	7,960
	OC	59, 27, 17	96, 126	2,530, 786, 192	4,500, 5,800, 3,650	13,100
1966/67	CHO		200, 888, ●, 128, ■	12,000	13,300, 13,200	
	OC		700, 5,000	19,200	21,200, 20,900	
1965/66	CHO	23, 351	97, 266, 694, ●, 612, ■	550, 944	16,300, 1,060	2,580
1964/65	CHO		20, ●, 242, ■, 344	205, 134, 49,500	17,300, 8,190	
1963/64	CHO		19, 31, ■ 102, ●, 33, 748	34, 54, 58	10, 12, 2,420	42
1962/63	CHO	1,150, 16	11, ●, 404, ■	1,250, 2,130	17,600	

Table 3.1-4. Percentage of adult steelhead trout arriving at Cape Horn Dam by month.

Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.
1966/67 through 1978/79*	1	3	13	31	25	20	2	0
1979/80	11	8	11	14	25	30	0	0
1980/81	0	19	56	20	4	4	0	0
1981/82	2	4	14	41	38	<1	1	<1

*Average percent by month for the 13-year period.

Streamflows in the Eel River below Cape Horn Dam and above Outlet Creek were compared with the timing of salmon and steelhead returns at Cape Horn Dam from 1962/63 to 1981/82 to help determine the effect of streamflow on adult fish movement in the Eel River. For successful upstream passage, flows must be adequate for fish to pass over critical areas (Section 3.4, Hearst Riffle Passage Study and Section 3.5, Critical Riffle Study). Chinook salmon and steelhead trout first arrive at Cape Horn Dam at roughly the same time. It appears that adults move upstream from the ocean to some point below Outlet Creek (possibly Dos Rios) and then wait for adequate peak flows before continuing further upstream. In nine years since 1962/63 a single major peak flow was adequate to move fish up to Cape Horn Dam. During the 10 other years, two periods of peak flows occurred before fish were counted at the dam. Years in which fish were observed at Cape Horn Dam after a single peak flow had low flows in October and November with no storms occurring until late November or early December. Storms occurred during late October or early November in years where two peak flows occurred before fish were observed at the dam.

Peak streamflows resulting from fall storms typically increase in magnitude from October through December. Eighty-five percent of peak flows during October are less than 100 cfs at Cape Horn Dam, and 80% are less than 200 cfs above Outlet Creek. In November 48% of the peak flows are less than 100 cfs at Cape Horn Dam, and 52% are less than 200 cfs above Outlet Creek. Thirty-two percent of peak flows in December are less than 100 cfs at Cape Horn Dam, while 17% are less than 200 cfs above Outlet Creek. The first arrival of chinook salmon occurred during or after peak flows of at least 100 cfs below Cape Horn Dam with 50% occurring following peaks of 200 cfs or more. Peak flows above Outlet Creek of at least 235 cfs occurred before chinook arrived at Cape Horn Dam with 60% arriving after peak flows of 900 cfs or more above Outlet Creek. Streamflows due to storms may be well above the minimum necessary to stimulate upstream movement. During natural storms large increases in streamflow occur from Cape Horn Dam to Outlet Creek due to tributary inflow. Increased streamflow between Cape Horn Dam and Outlet Creek is much smaller during artificial peak releases because of smaller tributary inflow. Thus in the absence of storm runoff, artificial peak releases need to be large enough to compensate for lack of tributary inflow. In November 1981, artificial peak releases from Cape Horn Dam of 250 cfs resulted in upstream fish migration. These data suggest that releases at Cape Horn Dam that result in flows of at least 235 cfs above Outlet Creek are necessary for chinook salmon migration. Peak releases of 135 cfs below Cape Horn Dam should be adequate for chinook migration during periods of normal storm activity when tributary inflow is 100 cfs or greater. In the absence of natural storm activity, artificial peak releases of 205 cfs below Cape Horn Dam would be necessary assuming tributary inflow of at least 30 cfs (Figure 2.6-2). Peak flows necessary for steelhead migration appear to be less.

The timing of peak flows also appears more critical to chinook salmon than steelhead because of the shorter duration of chinook runs; chinook counts at Cape Horn Dam were smaller in years where peak flows did not occur until December. As discussed earlier however, the number of salmon arriving at Cape Horn Dam may be more related to general abundance in the drainage than to impediment of migration by streamflow.

3.2 Tomki Creek/Eel River Salmon Carcass Survey

Tomki Creek

Chinook salmon spawning escapement to Tomki Creek and its tributaries was estimated to be 2,410 fish in 1979/80, based on 1,210 tagged carcasses and 684 (56.5%) recoveries, and 317 fish in 1980/81, based on 163 tagged carcasses and 64 (39.3%) recoveries (Tables 3.2-1 and 3.2-2). During the 1981/82 season, a total of 565 carcasses were tagged and 84 (14.8%) recovered (Table 3.2-3); an escapement estimate could not be calculated because of incomplete surveys due to extremely high flows and turbid water conditions. However, numbers of carcasses tagged and live salmon observed during the first two weeks of surveys suggest that the 1981/82 escapement was similar to the 1979/80 estimate. Based on the 175 fish passing over Cape Horn Dam in 1981/82 and the relationship between Tomki Creek population estimates and counts at Cape Horn Dam (Figure 3.1-1) the 1981/82 Tomki Creek escapement may have been over 4,000.

Spawning escapements estimated for the Tomki Creek drainage in the present study appear to be within the normal range of variability. In 1975/76 and 1964/65, spawning populations were estimated at 367 and 1,747, respectively (Brown 1977; Hinton 1976). In 1955, 1957, 1958, and 1965, USFWS counted 69, 205, 11, and 607 chinook salmon (carcasses and live fish), respectively, in parts of Tomki Creek on single passes; in 1965, CDF&G counted 500 fish (carcasses and live fish) on a single pass in parts of Tomki Creek (Brown 1977; Hinton 1976). These results show a high variability in the number of chinook salmon spawning in Tomki Creek from year to year.

The Tomki Creek chinook salmon run is a major component of the total run within the study area. In 1979/80, 2,410 chinook were estimated to have spawned in 34.5 miles of the Tomki Creek drainage, compared to 84 in 11.5 miles of the Eel River above Cape Horn Dam (Section 3.1, Cape Horn Dam Adult Fish Counts) and 3,500 in 25.4 miles of river between Tomki Creek and Outlet Creek (Section 3.3, Aerial Redd Survey).

Table 3.2-1. Recoveries of chinook salmon carcasses tagged during successive weeks in Tomki Creek from Wheelbarrow Creek to the Eel River and in String, Cave, Long Branch, and Salmon Creeks in 1979/80.

	Tagging Period												
Recovery Period	Nov. 19-29	Dec. 3-7	Dec. 10-14	Dec. 17-26	Dec. 27-29	Dec. 31-Jan. 4	Jan. 7-11	Jan. 14-18	Jan. 21-25	Jan. 28-Feb. 1	Tagged Carcasses Recovered (Rj)	Total Carcasses Encountered (Cj)	$\frac{Cj}{Rj}$
Nov. 19-24	-										-	17	-
Dec. 3-7	5										5	251	50.20
Dec. 10-14		186									186	568	3.05
Dec. 17-26		14	294								308	601	1.95
Dec. 27-29		1	3	51							55	129	2.35
Dec. 31-Jan. 4		1	2	7	9						19	54	2.84
Jan. 7-11		4	5	33	17	23					82	227	2.77
Jan. 14-18		0	0	0	0	0	0				0	2	-
Jan. 21-25		1	1	1	3	0	7	1			14	24	1.71
Jan. 28-Feb. 1		1	0	2	0	0	6	1	5		15	21	1.40
Tagged Carcasses Recovered (Ri)	5	208	305	94	29	23	13	2	5	0	684	1,894	
Total Carcasses Tagged (Mi)	17	246	382	293	74	35	145	2	10	6	1,210		
$\frac{Mi}{Ri}$	3.4	1.10	1.25	3.12	2.55	1.52	11.15	1.0	2.0	-			

Table 3.2-2. Recoveries of chinook salmon carcasses tagged during successive weeks in Tomki Creek from Wheelbarrow Creek to the Eel River and in String, Cave, Long Branch, and Salmon Creeks in 1980/81.

Recovery Period	Tagging Period: Dec. 19-22	Dec. 30 Jan. 3	Jan. 5-9	Jan. 12-16	Jan. 19-23	Jan. 26-30	Feb. 2-6	Feb. 9-13	Tagged Carcasses Recovered (R_j)	Total Carcasses Encountered (C_j)	$\frac{C_j}{R_j}$
Dec 19-22	-								-	0	-
Dec. 30 - Jan. 3	0								0	55	-
Jan. 5-9		31							31	67	2.16
Jan. 12-16		1	17						18	70	3.89
Jan. 19-23		2	2	4					8	17	2.13
Jan. 26-30			1	0	0				1	1	1.0
Feb. 2-6				1	2	0			3	13	4.33
Feb. 9-13				1	0	0	2		3	4	1.33
Tagged Carcasses Recovered (R_i)	0	34	20	6	2	0	2	-	64	227	
Total Carcasses Tagged (M_i)	0	55	36	52	9	0	10	1	163		
$\frac{M_i}{R_i}$	0	1.62	1.8	8.67	4.5	0	5	-			

Table 3.2-3. Recoveries of chinook salmon carcasses tagged during successive weeks in Tomki Creek from Wheelbarrow Creek to the Eel River and in Wheelbarrow, String, Cave, Long Branch, and Salmon Creeks in 1981/82.

Recovery Period	Tagging Period: Dec. 7-10	Dec. 14-18	Dec.[a] 21-25	Dec. 28-[b] Jan. 1	Jan. 4-8	Jan. 11-15	Jan.[c] 18-22	Jan.[a] 25-28	Jan. 29- Feb. 1	Tagged Carcasses Recovered (Rj)	Total Carcasses Encountered (Cj)	$\frac{Cj}{Rj}$
Dec. 7-10	-									-	148	-
Dec. 14-18	27									27	181	6.70
Dec. 21-25										-	-	-
Dec. 28-Jan. 1	4	2								6	81	13.50
Jan 4-8										-	-	-
Jan. 11-15				20						20	192	9.60
Jan. 18-22				1		1				2	4	2.00
Jan. 25-28										-	-	-
Jan. 29-Feb. 1		1		7		21				29	43	1.48
Tagged Carcasses Recovered (Ri)	31	3	-	28	-	22	0	-	0	84	649	
Total Carcasses Tagged (Mi)	148	154	-	75[b]	-	172	2[c]	-	14	565		
$\frac{Mi}{Ri}$	4.77	51.33	-	2.68	-	7.82	-	-	-			

[a] No survey conducted.
[b] Survey conducted on String and Cave Creeks only.
[c] Survey conducted on Cave Creek only.

The timing of the chinook salmon run into Tomki Creek has followed similar patterns during the three years of study, apparently in response to pulse flow events (i.e., storm run-off or artifical pulse releases). The first major storm of the 1979/80 migration season occurred in late October and probably moved fish up to Dos Rios; flows dropped in the Eel River above Outlet Creek immediately following the storm, possibly inhibiting any further upstream movement. The first chinook salmon passed over Cape Horn Dam on November 6, during the second major storm of the season. Chinook salmon were observed for the first time in Tomki Creek on November 9, but had probably moved in a few days earlier during the second storm.

The 1980/81 run was later than the 1979/80 run. Chinook salmon were observed at Dos Rios during the last week of November. A series of three minor storms had occurred beginning in mid-October, causing minor streamflow peaks in the Eel River above Outlet Creek; these small increases in flow were apparently large enough to bring the first of the run to Dos Rios. The first major storm of the year occurred during the first week of December; salmon were first observed passing over Hearst Riffle on December 5, and small numbers moved into Tomki Creek sometime before December 9. The second major storm of the season, which occurred during the third week of December, brought the main body of the run into Tomki Creek.

During the 1981/82 season, the first major storm occurred during the last week of October, and fish were observed at Dos Rios by October 31. Flows in the Eel River were artifically increased for 24 hours beginning on November 1; fish passage over Hearst Riffle began on November 2. Flows were again artifically increased for 24 hours on November 7, and increased numbers of fish were observed at Hearst Riffle later that day. Chinook salmon passage over Cape Horn Dam first occurred on November 9; movement into Tomki Creek occurred at about the same time.

There seems to be a general pattern of movement into the Eel River study area and Tomki Creek during the second major storm or artificial pulse of each migration and spawning season. This occurred both in 1979/80 and 1981/82. In 1980/81, however, chinook salmon moved into Tomki Creek during the first major storm; this storm was preceded by a series of three small storms that apparently produced the same results as one major storm by moving fish up to Dos Rios. Spawning activity in Tomki Creek generally occurred two weeks after the main run was observed in 1979/80 and 1981/82. However, in 1980/81, spawning occurred immediately after chinook salmon entered Tomki Creek; this was probably a result of the late run.

Spawning chinook salmon in Tomki Creek follow two distinct patterns of distribution which correlate with streamflow. In 1979/80, 1981/82, and 1964/65, chinook salmon occupied the higher reaches of the Tomki Creek drainage (Table 3.2-4 and Figures 3.2-1 and 3.2-2). In each of these seasons, over half of the tagged carcasses were found in upper Tomki Creek (upstream from the confluence with String Creek) and its tributaries (56, 79, and 68%, respectively). By contrast, in 1980/81 and 1975/76, spawning salmon were limited mostly to the mainstem of Tomki Creek below the confluence with String Creek (Table 3.2-4 and Figure 3.2-3); less than 25% of tagged carcasses were found in upper Tomki Creek and in the tributaries (9 and 14%, respectively). Mean monthly flows were relatively high in the Eel River above Outlet Creek during November and December of 1979 (725 and 818 cfs), 1981 (1,934 and 4,809 cfs), and 1964 (858 and 15,830 cfs). Mean monthly flows were relatively low in the Eel River during November and December of 1980 (22 and 339 cfs) and 1975 (115 and 239 cfs). Assuming that streamflow patterns are similar in the Eel River above Outlet Creet and in Tomki Creek, there is a positive correlation between the distribution patterns and streamflow. This indicates that chinook salmon occurring within the study area will migrate as far into the upper reaches as possible to utilize suitable spawning habitat, as long as water conditions are favorable.

A comparison of length and sex data for chinook salmon runs in 1979/80, 1980/81, 1981/82, 1964/65, and 1975/76 (Table 3.2-5) shows the variability which occurs in the composition of the run from year to year.

Table 3.2-4. Distribution of chinook salmon carcasses in Tomki Creek in 1979/80, 1980/81, 1981/82, 1964/65, and 1975/76.

	Number of Salmon					Relative (%) Contribution				
Stream Section or Creek	79/80[a]	80/81[a]	81/82[a]	64/65[b]	75/76[c]	79/80[a]	80/81[a]	81/82[a]	64/65[b]	75/76[c]
Tomki Cr. - Mouth to Scott Cr.	251	68	43	91	53	21	42	8	19	40
Tomki Cr. - Scott Cr. to String Cr.	276	80	71	60	60	23	49	13	13	46
Tomki Cr. - String Cr. to Wheelbarrow Cr.	382	4	148	92	11	31	2	27	19	9
Tomki Cr. - Wheelbarrow Cr. to Headwaters	NS	NS	8	22	0	NS	NS	1	5	0
Wheelbarrow Cr.	NS	NS	9	0	0	NS	NS	2	0	0
Long Brach Cr.	81	0	34	90	3	7	0	6	19	2
String Cr.	206	11	216	40	3	17	7	39	8	2
Cave Cr.	13	0	32	50	1	1	0	6	11	1
Salmon Cr.	1	0	4	30	0	0	0	<1	6	0
Total	1,210	163	565	475	131					

[a] VTN
[b] Hinton (1976)
[c] Brown (1977)

NS = not sampled

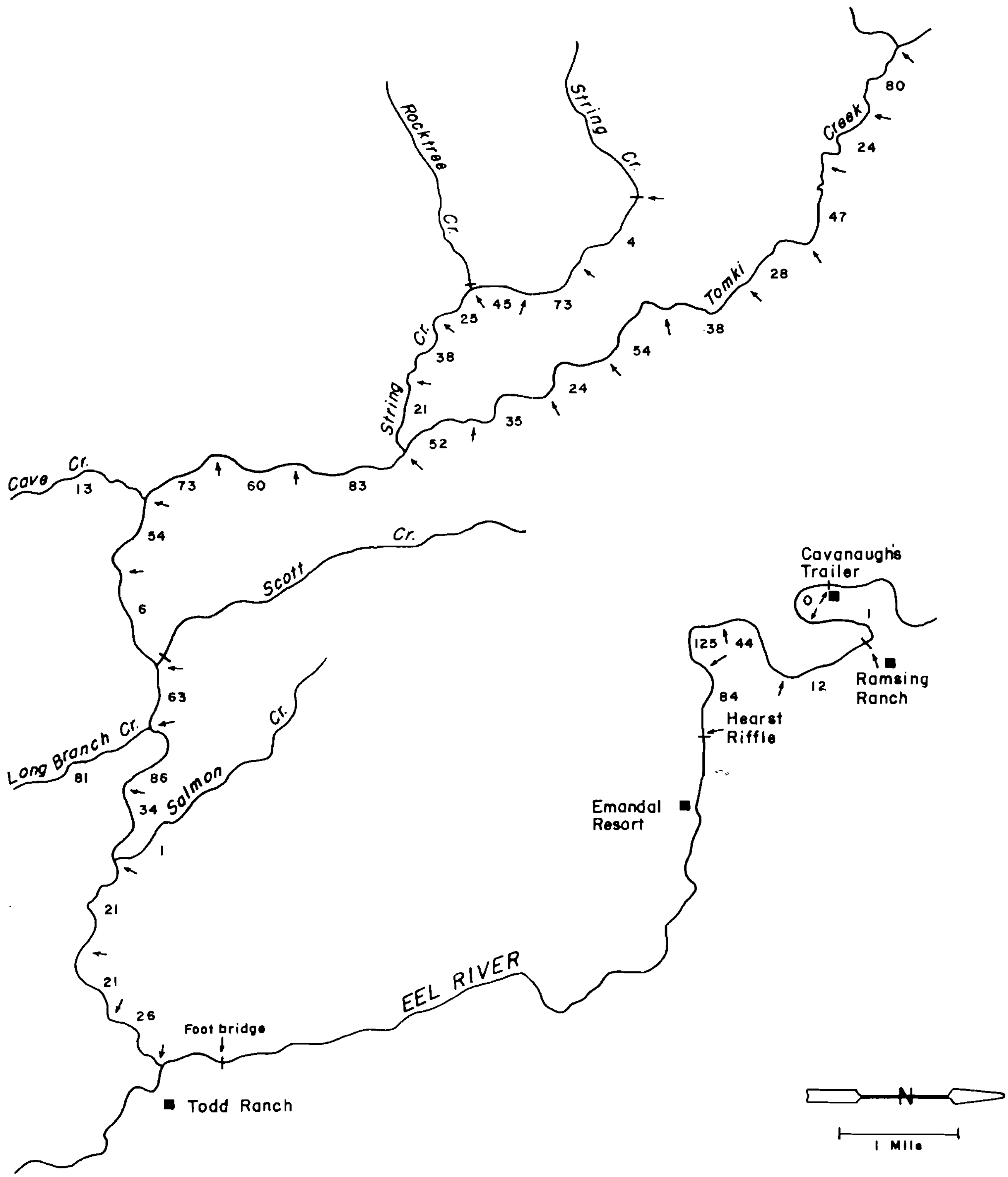

Figure 3.2-1. Chinook salmon carcasses tagged in Tomki Creek drainage and in a section of the Eel River, November 1979-December 1980.

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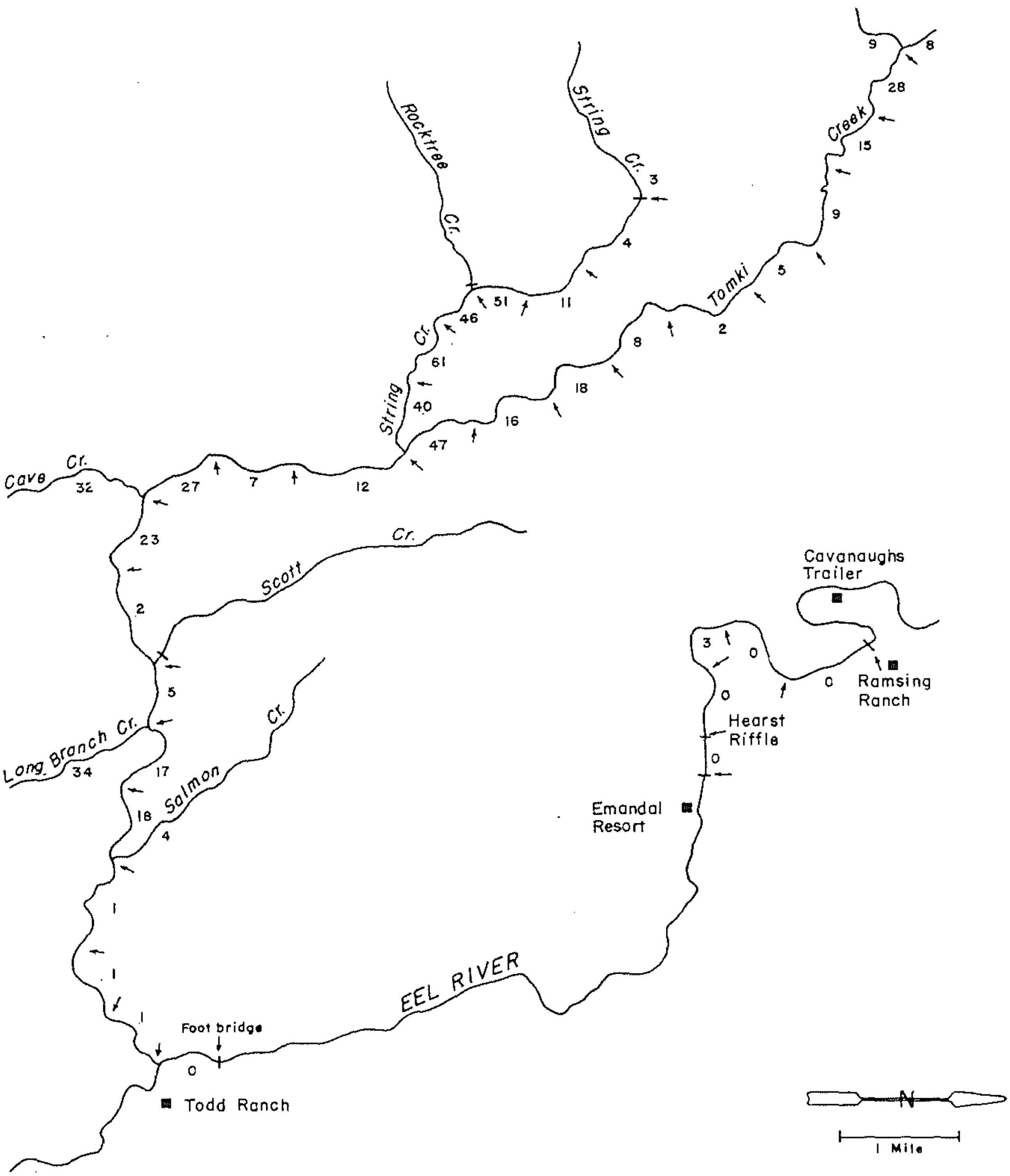

Figure 3.2-2. Chinook salmon carcasses tagged in Tomki Creek drainage and in two sections of the Eel River, December 1981-February 1982.

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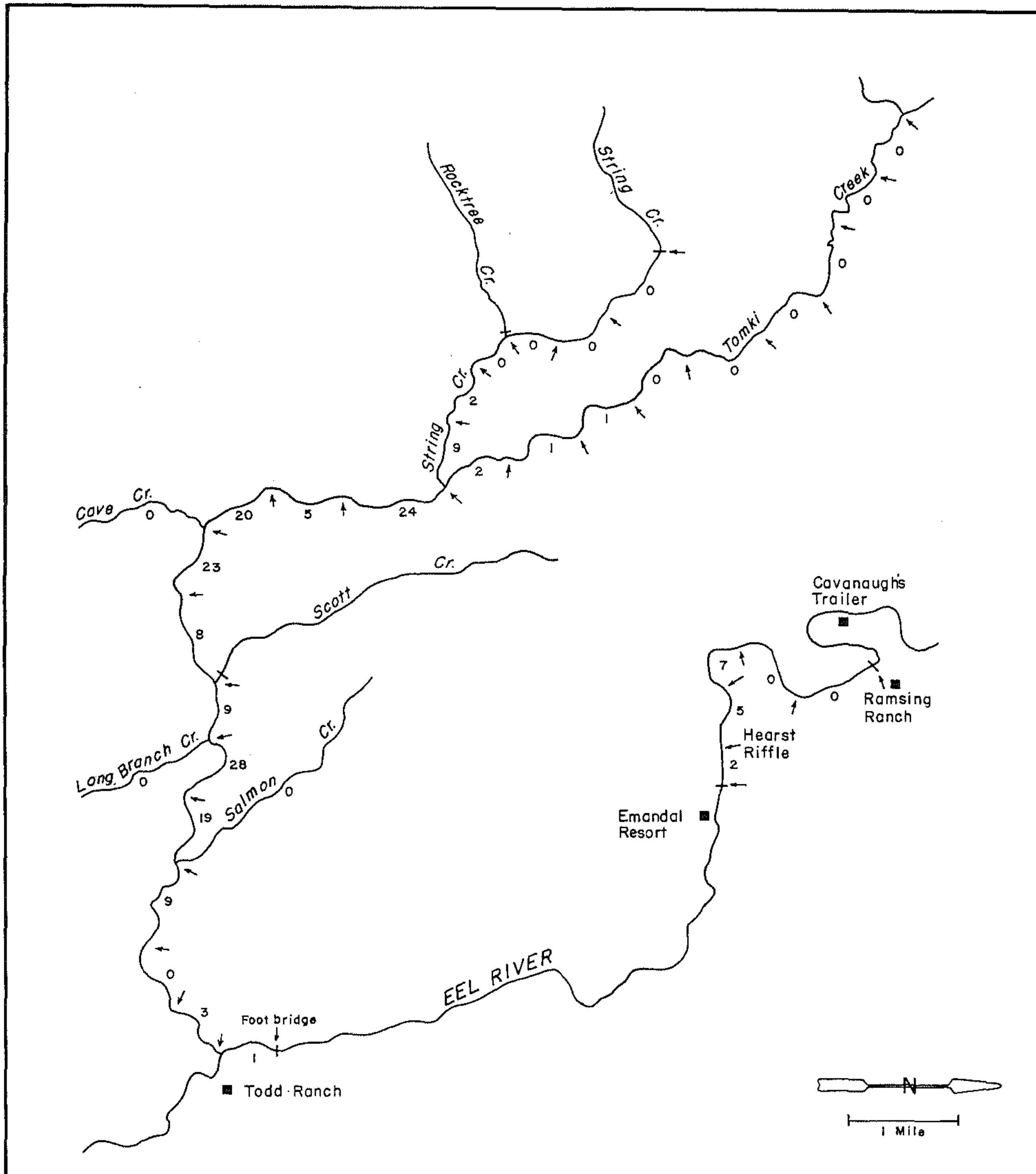

Figure 3.2-3. Chinook salmon carcasses tagged in Tomki Creek drainage and in two sections of the Eel River, December 1980-February 1981.

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Table 3.2-5. Summary of length and sex data for chinook salmon carcasses collected during tagging surveys in Tomki Creek and the Eel River in 1979/80, 1980/81, 1981/82, 1964/65, and 1975/76.

						Eel River				
	Tomki Creek					Ramsing to Emandal			Tomki Cr. to Footbridge	
	79/80	80/81	81/82	64/65[c]	75/76[f]	79/80	80/81	81/82	80/81	81/82
Carcasses tagged	1,210	163	565	475	131	266	14	3	1	0
Recovered	684	64	84	-	51	169	5	0	0	-
% Recovered	56.5	39	14.8	20-50[d]	39	63.5	36	0	0	-
Males tagged	658	56[a]	430	253	45	116	2	0	0	-
Mean length*	27.3	29.3	23.2	26.8	-	33.0	29.5	-	-	-
Range*	16-47	17-39	16-43	17-41	12-38.5	18-45	22-37	-	-	-
Grilse (<26 in.)	385	10	252	104	40	24	1	0	0	-
Mean length*	20.6	21.3	19.9	19.4	-	21.0	22.0	-	-	-
Males (>26 in.)	273	29	75	149	5	92	1	0	0	-
Mean length*	36.6	32.1	34.9	33.3	-	39.9	37.0	-	-	-
Females tagged	491	79[b]	103	139[e]	52	141	6	1	1	-
Mean length*	32.3	30.1	32.9	32.2	-	34.3	35.4	-	35.0	-
Range*	20-44	23-38	24-41	27-39.5	21-38.5	19-41	32-38	-	-	-
Male/female ratio	1.34	0.71	4.17	1.82	0.91	0.82	0.33	-	-	-
% Grilse in male population	59	26	77	41	89	21	50	-	-	-
Undetermined sex	61	28	32	83	34	9	6	2	0	-

* Mean length and range in inches.
[a] Only 39 whole fish were available for length measurements.
[b] Only 61 whole fish were available for length measurements.
[c] Hinton (1976).
[d] Percent recovery estimated by Hinton (1976).
[e] Only 18 females measured.
[f] Brown (1977).

The ratio of male to female chinook salmon in the Tomki Creek drainage during 1981/82 was 4.17, clearly the highest value for all years of record, with 77% of the male population being grilse. Results for 1980/81 show the lowest male to female ratio, 0.71, with 26% of the male population being grilse. The other years of record have male to female ratios and grilse percentages that fall between the values for 1981/82 and 1980/81, with the exception of the extremely high grilse percentage of 89% in 1975/76. This value may have been biased by the high percentage of carcasses of undetermined sex (26%) and the small sample size. Generally, the larger male to female ratios are associated with higher percentages of grilse in the male population; again, the only exception was in 1975/76 when females outnumbered males, although 89% of the male population were grilse.

Length-frequency distributions of tagged carcasses for 1979/80, 1980/81, and 1981/82 are presented in Figures 3.2-4 through 3.2-6. Modal lengths vary considerably for females and adult males; female modal lengths are 35 inches, 31 inches, and 37 inches, respectively; adult male modal lengths are 39 inches, 32 inches, and 42 inches, respectively. The modal lengths show more variability than the respective mean fork lengths, which are similar per sex class per year (Table 3.2-5). The variability of modes may indicate different age classes dominating the total populations from year to year. This may partially explain the variability in total numbers and composition of runs.

Eel River

Chinook salmon escapement within the Eel River study area (a four-mile section of the Eel River extending downstream from Hearst Riffle) was estimated at 766 fish in 1979/80 based on 266 tagged carcasses and 169 (63.5%) recoveries (Table 3.2-6). A total of 14 carcasses were tagged and 5 (36%) recovered in 1980/81 (Table 3.2-7); three carcasses were tagged and none recovered in 1981/82. During both 1980/81 and 1981/82, too few carcasses were tagged to calculate population estimates due to high, turbid water conditions.

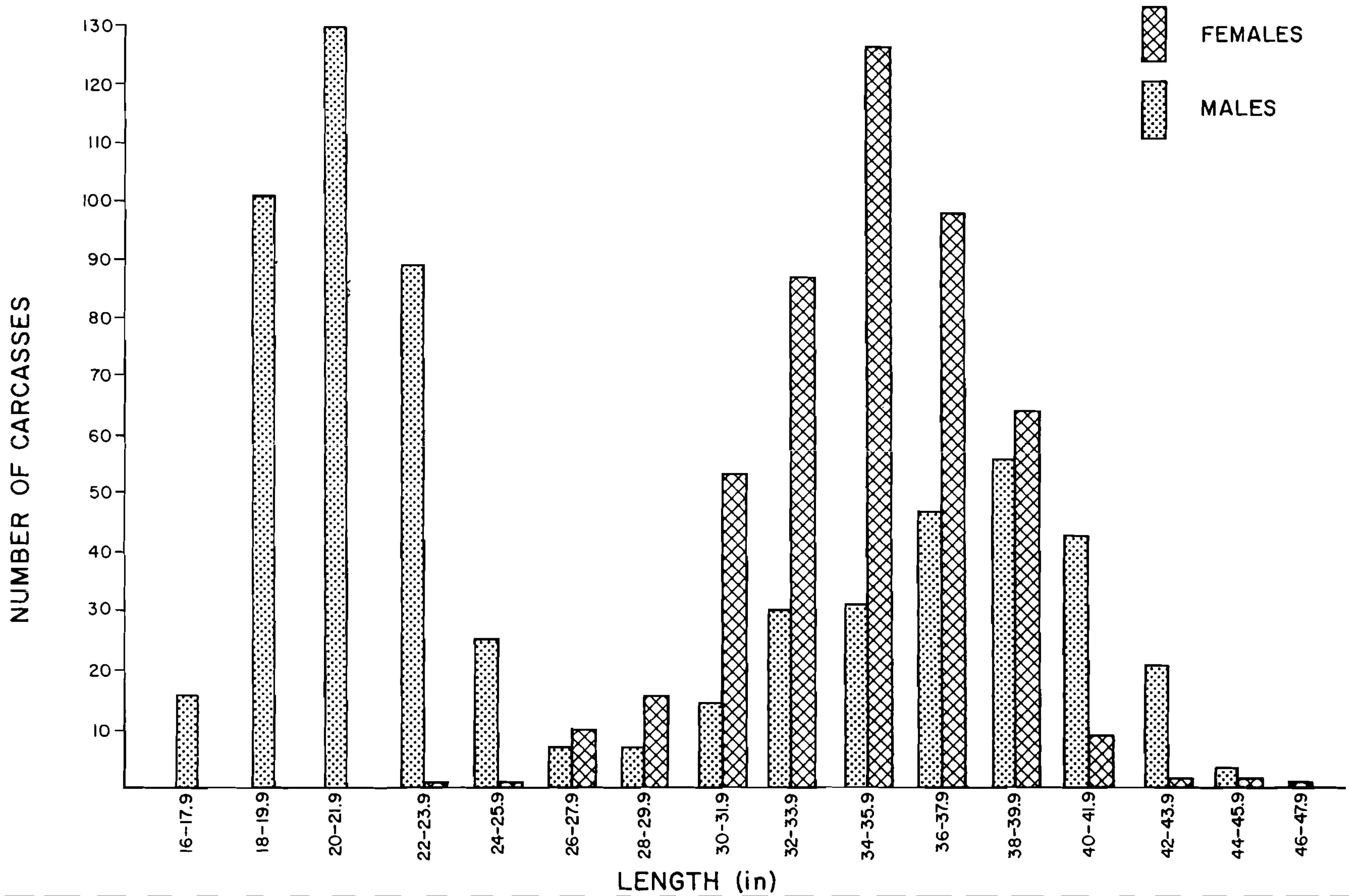

Figure 3.2-4. Length-frequency of chinook salmon carcasses tagged in Tomki Creek and its tribuaries in 1979/80.

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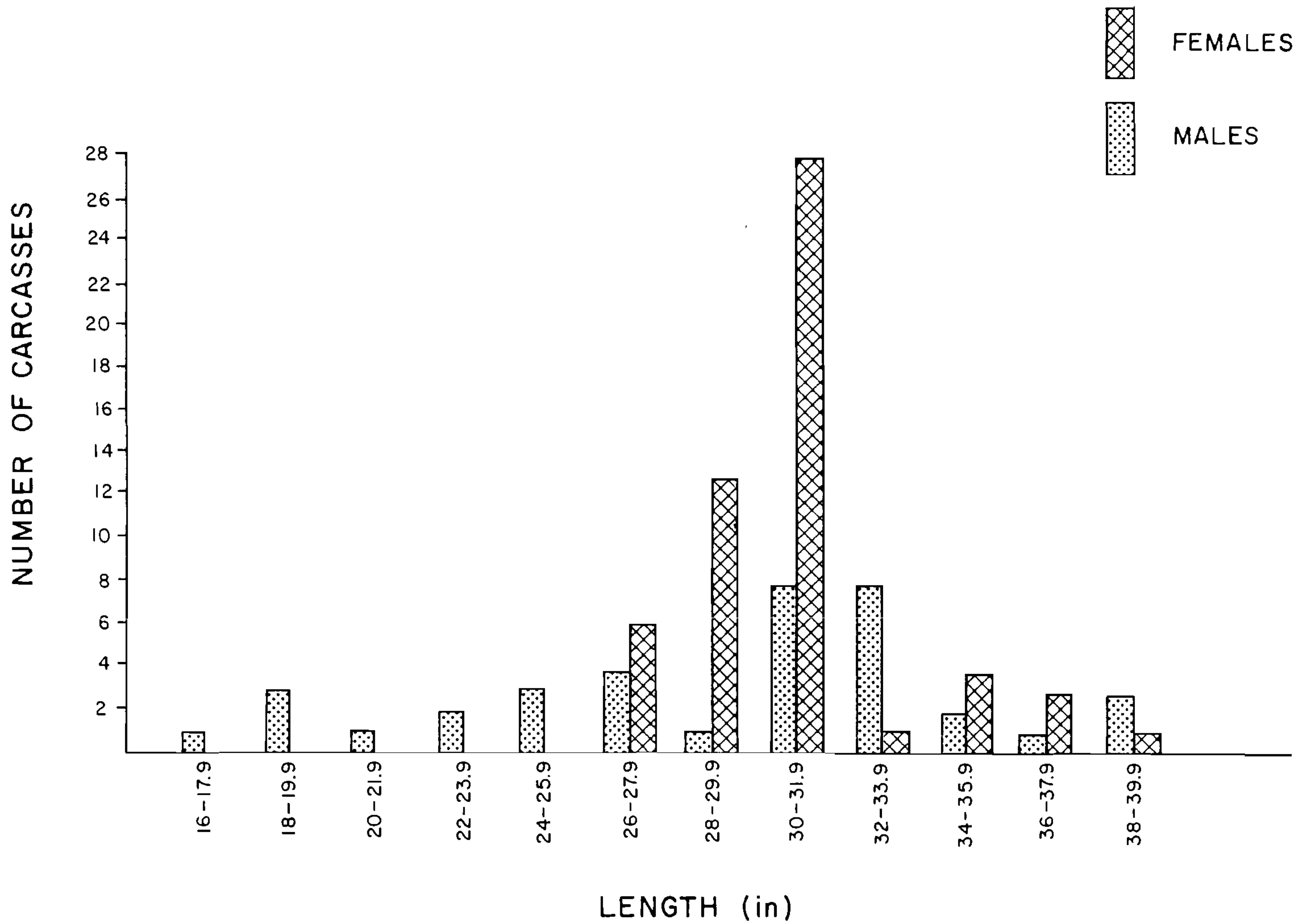

Figure 3.2-5. Length-frequency of chinook salmon carcasses tagged in Tomki Creek and its tributaries in 1980/81.

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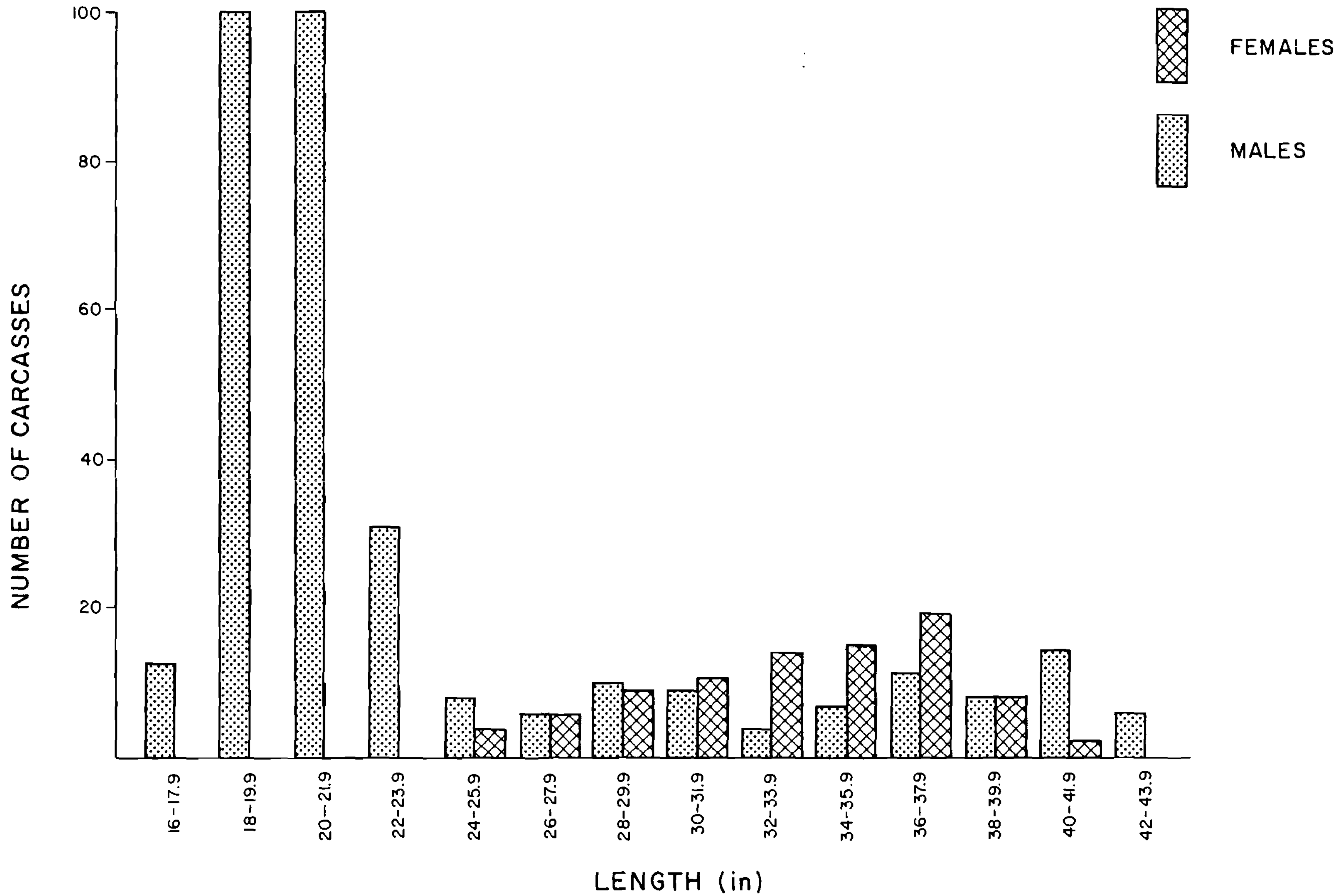

Figure 3.2-6. Length-frequency of chinook salmon carcasses tagged in Tomki Creek and its tributaries in 1981/82.

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Table 3.2-6 Recoveries of chinook salmon carcasses tagged during successive weeks in the Eel River from Hearst Riffle to Cavanaugh's trailer in 1979/80.

Recovery Period	Tagging Period: Nov. 19-29	Dec. 3-7	Dec. 10-14	Dec. 17-26	Dec. 27-29	Dec. 31-Jan. 4	Jan. 7-11	Jan. 14-18	Jan. 21-25	Jan. 28-Feb. 1	Tagged Carcasses Recovered (Rj)	Total Carcasses Encountered (Cj)	$\frac{Cj}{Rj}$
												2	-
Dec. 3-7	0										0	31	-
Dec. 10-14		17									17	63	3.71
Dec. 17-26		3	6								9	92	10.22
Dec. 27-29			4	78							82	121	1.48
Dec. 31-Jan. 4			1	1	4						6	60	10.00
Jan. 7-11			1	2	0	50					53	61	1.15
Jan. 14-18							0				0	1	-
Jan. 21-25								0			0	2	-
Jan. 28-Feb. 1									2		2	2	1.00
Tagged Carcasses Recovered (Ri)	0	20	12	81	4	50	0	0	2	0	169	435	
Total Carcasses Tagged (Mi)	2	31	46	83	39	54	8	1	2	0	266		
$\frac{Mi}{Ri}$	-	1.55	3.83	1.02	9.75	1.08	-	-	1	-			

Table 3.2-7. Recoveries of chinook salmon carcasses tagged during successive weeks in the Eel River from Emandal to Ramsing Ranch in 1980/1981.

Recovery Period	Tagging Period: Dec. 19-22	Dec. 30 Jan. 3	Jan. 5-9	Jan. 12-16	Jan.[a] 19-23	Jan.[a] 26-30	Feb. 2-6	Feb. 9-13	Tagged Carcasses Recovered (R_j)	Total Carcasses Encountered (C_j)	$\frac{Cj}{Rj}$
Dec. 30 - Jan. 3	0								0	7	-
Jan. 5-9		5							5	8	1.6
Jan. 12-16			0						0	2	-
Jan. 19-23[a]				-					-	-	-
Jan. 26-30[a]					-				-	-	-
Feb.2-6						0			0	1	-
Feb. 9-13							0		0	1	-
Tagged Carcasses Recovered (R_i)		5	0	-	-	0	0		5	19	
Total Carcasses Tagged (Mi)	0	7	3	2	-	-	1	1	14		
$\frac{Mi}{Ri}$	-	1.4	-	-	-	-	-				

[a] Not surveyed on this date due to high water.

Carcasses drifting into the survey section from upstream areas could cause a significant error in the population estimate. To assess the magnitude of this error, 66 carcasses were tagged between Emandal Resort and Hearst Riffle from December 7 through 14, 1979; only four carcasses were subsequently recovered within the study area, indicating that carcasses of fish which spawned upstream of Hearst Riffle may have accounted for only about 6% of the carcasses observed in the study area.

The distribution of carcasses coincided with the apparent distribution of suitable spawning substrate. A broad, flat channel with gravel substrate predominates the upper 1.2 miles of the study section in which 80 and 100% of the carcasses were tagged in 1979/80 and 1980/81, respectively (Figures 3.2-1 and 3.2-3). The lower portion of the study section is characterized by larger substrates (boulder and bedrock).

Male to female ratios and grilse percentages were calculated for the following years: 1979/80, 0.82 and 21%; and 1980/81, 0.33 and 50%, respectively. These male to female ratios are low when compared to Tomki Creek ratios for respective years: 1979/80, 1.34; and 1980/81, 0.71. In 1979/80, the grilse percentage in the Eel River (21%) was lower than in Tomki Creek (59%), which may help explain the lower male to female ratio in the Eel River that season. In 1980/81, the grilse percentage was higher in the Eel River (50%) than in Tomki Creek (26%); however, little confidence can be placed in the Eel River grilse percentage due to the small sample size (2 males) (Table 3.2-5).

During 1979/80, mean fork lengths of female and adult male carcasses tagged in the Eel River were larger than those tagged in Tomki Creek (Table 3.2-5). The length frequency distribution presented in Figure 3.2-7 shows modal lengths for female and adult male chinook salmon carcasses of 37 inches and 41 inches, respectively, which are also larger than the modal lengths of Tomki Creek carcasses for 1979/80 (35 and 39 inches, respectively). Small sample sizes in the Eel River in 1980/81 and 1981/82 prevent valid comparisons with Tomki Creek data.

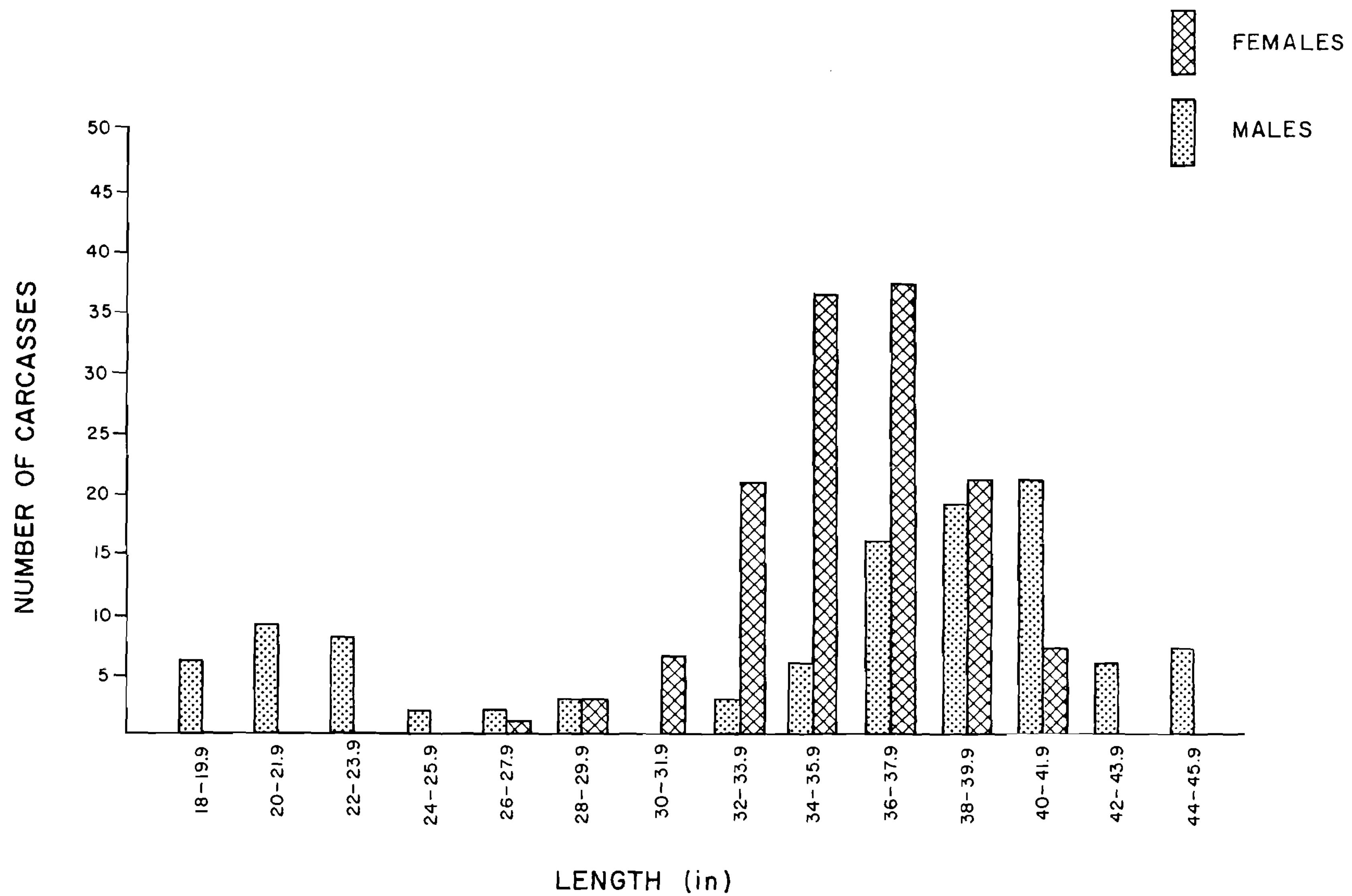

Figure 3.2-7. Length-frequency of chinook salmon carcasses tagged in the Eel River survey section in 1979/80.

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Adult Steelhead Trout Surveys

Numbers of adult steelhead and redds and important habitat characteristics observed in each survey stream in 1981 are summarized in Tables 3.2-8 through 3.2-10. During the February surveys of tributaries between Scott and Cape Horn Dams, Soda Creek contained the most steelhead (46), followed by Panther Creek (a tributary to Soda Creek) (18), Bucknell Creek (9), and Benmore Creek (2) (Table 3.2-8). At the same time, two tributaries surveyed from Cape Horn Dam to Outlet Creek contained steelhead: Tomki Creek (18) and Thomas Creek (1) (Table 3.2-9). No steelhead were observed in the other tributaries surveyed. During the March survey, Soda Creek was the only survey stream that contained steelhead (16) (Table 3.2-10). No steelhead or redds were observed during spot checks of the mainstem Eel River due to turbid water conditions, which continued throughout the steelhead spawning season.

During the 1980/81 season, a total of 1,530 adult steelhead trout passed over Cape Horn Dam through February 8 (Appendix D). However, in the tributaries surveyed from Scott to Cape Horn Dams, a total of only 75 adult steelhead were observed February 10-16, 1981. It appears that most of the steelhead spawned in the mainstem Eel River, although none were observed due to turbid water conditions. The number of steelhead in tributary streams surveyed from Cape Horn Dam to Outlet Creek (19) is also low compared to the number passing over Cape Horn Dam.

Steelhead were generally more abundant in the larger streams with good spawning areas available. Soda, Panther (tributary to Soda Creek), and Tomki Creeks had good flow conditions and contained the best available spawning habitat, as well as the most steelhead observed (Tables 3.2-8 and 3.2-9). Panther Creek contains some good spawning areas above a possible barrier falls, but no fish were seen above these falls; fish were observed spawning in pockets of gravel between large boulders below the falls. Dashiell, Alder, and Trout Creeks are small streams

Table 3.2-8. Summary of steelhead surveys conducted February 10-16, 1981 in streams tributary to the Eel River from Scott to Cape Horn Dams.

Area Surveyed	Distance Surveyed (mi)	Possible Barriers to Fish Passage	Number of Steelhead Live	Number of Steelhead Dead	Number of Redds	Flow Estimate (cfs)	Spawning Substrate Qualtiy
Soda Creek	2.5	None	45	1	37	20	Good (good gravel in lower 1.5 mi)
Welch Creek (tributary of Soda Cr.)	0.1	Log jam and 6' falls 100 yds up-stream of mouth	0	0	0	4-5	Marginal (mostly cobble and boulder)
Panther Creek (tributary of Soda Cr.)	1.5	Series of 4-5' falls 1.3 mi upstream of mouth	18	0	3	10	Good-marginal (some good spawning areas above falls)
Benmore Creek	1.6	Series of 5 to 8' falls 1.5 mi upstream of mouth	1	1	0	4-5	Poor (mostly cobble and boulder)
Dashiell Creek	0.3	6' falls at mouth	0	0	0	4	Poor (mostly boulders, steep gradient)
Alder Creek	0.75	Culvert under road 0.5 mi upstream of mouth	0	0	0	3	Poor (mostly cobble 6-12")
Bucknell Creek	2.7	5' falls and chutes 2.5 mi upstream of mouth	8	1	1	10-15	Marginal (mostly cobble and boulder with pockets of gravel)
Trout Creek	0.5	6' falls at mouth	0	0	0	4-5	Poor (mostly cobble)
Mill Creek	3.0	None	0	0	0	-	Poor (mostly rubble 6-12")

Table 3.2-9. Summary of steelhead surveys conducted February 9-16, 1981 in streams tributary to the Eel River from Cape Horn Dam to Outlet Creek.

Area Surveyed	Distance Surveyed (mi)	Possible Barriers to Fish Passage	Number of Steelhead Live	Number of Steelhead Dead	Number of Redds	Flow Estimate (cfs)	Spawning Substrate Quality
Whitney Creek	1.5	none	0	0	0	4-6	Poor (mostly rubble 6-12")
Tomki Creek	34.5	none	18	0	0	-	Wheelbarrow Cr. to approx. 1/2 mi. below Cave Cr., good spawning; Below Cave Cr. to Scott Cr., large substrate, marginal spawning; Scott Cr. to Salmon Cr., good spawning; Salmon Cr. to mouth, large substrate, marginal spawning
Thomas Creek	1.0	8' falls 0.75 mi upstream of mouth	1	0	0	30-40	Poor (rubble and boulder)
Garcia Creek	Not surveyed due to high water		-	-	-	-	Marginal-poor (cobble and boulder with some pockets of gravel) (from March survey)
Salt Creek	2.0	none	0	0	0	10-15	Marginal-good (mostly cobble and gravel)
Sage Horn Creek (tributary of Salt Creek)	0.25	3' falls at mouth and concrete apron under road bridge.	0	0	0	3	Marginal-good (mostly cobble and gravel)

Table 3.2-10. Summary of steelhead surveys conducted March 18, 1981 in streams tributary to the Eel River from Scott Dam to Outlet Creek.

Area Surveyed	Distance Surveyed (mi)	Number of Steelhead Live	Number of Steelhead Dead	Number of Redds	Flow Estimate (cfs)
Soda Creek[a]	2.5	16	0	16	25
Panther Creek[a]	0.5	0	0	0	-
Benmore Creek[a]	1.5	0	0	0	3-5
Bucknell Creek[a]	1.5	0	0	2-4	15-20
Garcia Creek[b]	1.0	0	0	0	20

[a] Above Cape Horn Dam
[b] Below Cape Horn Dam

with possible barriers at or near their mouths, as well as large substrate unsuitable for spawning. Bucknell, Thomas, and Garcia Creeks had good flow conditions, but were poor to marginal for steelhead spawning due to their large size substrates. Mill, Benmore, Whitney, and Welch (tributary to Soda Creek) Creeks are small and are also poor to marginal for spawning due to large substrate size. Although Salt Creek had good flow conditions and marginal to good substrate for spawning, no fish or redds were observed. Sage Horn Creek (tributary to Salt Creek) is small, contains a possible barrier at its mouth, and has marginal to good substrate for spawning.

3.3 Aerial Redd Survey

During the December 6, 1979 aerial survey, 200 chinook salmon redds were counted in the Eel River from Tomki Creek to Hearst Riffle (7.1 river miles), and 183 redds from Hearst Riffle to Outlet Creek (18.3 river miles). This is a density of 28 redds per river mile between Tomki Creek and Hearst Riffle and 10 redds per river mile between Hearst Riffle and Outlet Creek. Nearly all riffle areas were used for spawning. In most spawning areas redds overlapped and in some areas large sections of streambed were disrupted, making redd enumeration impossible. At best, the counts of redds are a conservative estimate; actual numbers of redds may be considerably greater, as suggested by the large number of adults observed.

Adult chinook salmon were not systematically counted during the aerial survey, but rough estimates were made for the two river sections discussed above: 2,000 from Tomki Creek to Hearst Riffle and 1,500 from Hearst Riffle to Outlet Creek. The greatest concentrations of salmon were observed over redds in the broad, shallow downstream end of pools. Whether these salmon eventually spawned within the observation area or moved to upstream areas (i.e., Tomki Creek) is unknown; unfortunately, additional surveys could not be made due to turbid water conditions. However, based on the peak spawning period of mid-December in upstream areas (Section 3.2, Tomki Creek/Eel River Salmon Carcass Survey) and the position of observed fish over suitable spawning areas, it is assumed that most of these salmon did spawn where observed.

High turbidity prevented observation of chinook salmon and their redds in the Eel River between Scott Dam and Tomki Creek. However, data from other study elements indicate that chinook salmon spawning use was minimal in this section of stream. Only 84 chinook salmon ascended Cape Horn Dam to spawn in the 11.5 miles of river between Scott and Cape Horn Dams (Section 3.1, Cape Horn Dam Adult Fish Counts). Spawning use of the Eel River between Cape Horn Dam and Tomki Creek (4 miles) is assumed to be low based on the relatively low availability of spawning habitat, particularly at flows less than 150 cfs (Section 3.6, Instream Flow Study).

The 1979 aerial survey data indicate that a large proportion of the chinook salmon run within the study area spawns in the Eel River between Tomki Creek and Outlet Creek. Compared to the 3,500 salmon that may have spawned in this 25.4-mile section of river in 1979/80, an estimated 2,410 salmon spawned in 34.5 miles of the Tomki Creek drainage (Section 3.2, Tomki Creek/Eel River Salmon Carcass Survey) and 84 in 11.5 miles of river above Cape Horn Dam (Section 3.1, Cape Horn Dam Adult Fish Counts). These data also indicate that larger numbers of salmon may spawn between Tomki Creek and Hearst Riffle than between Hearst Riffle and Outlet Creek, although there is apparently more salmon spawning habitat available below Hearst Riffle (Section 3.6, Instream Flow Study).

During the aerial redd survey conducted on December 17, 1980, turbid water (53 NTU) prevented observation of chinook salmon and their redds in the entire mainstem Eel River study section from Scott Dam to Dos Rios. One chinook salmon was observed in the Eel River near Outlet Creek only because it rolled and broke the water surface. Tomki Creek and Outlet Creek, however, were low and clear during the survey. Three live salmon and one carcass were counted in 6 miles of Tomki Creek between Cave Creek and the Eel River, but no salmon were observed in the 9 miles of stream surveyed above Cave Creek. In 8 miles of Outlet Creek between Highway 101 and the Eel River, 123 salmon were counted. No spawning activity or redds were evident in either stream.

No other aerial surveys were conducted due to turbid water conditions in the Eel River throughout the chinook salmon and steelhead trout spawning seasons in both 1980/81 and 1981/82.

3.4 Hearst Riffle Passage Study

Total numbers of chinook salmon and steelhead trout observed passing over Hearst Riffle during daylight hours were similar in the three years of study (508, 485, and 499 respectively), although timing and passage behavior varied (Tables 3.4-1 through 3.4-3 and Figures 3.4-1 through 3.4-3). Timing of chinook salmon upstream migration depends on the occurrence of fall storms that raise Eel River streamflows. Storms in October and November 1979 and November 1981 brought salmon into the Eel River study area (above Outlet Creek) by early November with the majority of movement over Hearst Riffle occurring by the end of November or early December during the 1979/80 and 1981/82 seasons (Figures 3.4-1 and 3.4-3). In 1980/81, the first storm occurred in early December, followed by an extended dry period and a second storm in late December; this resulted in a later run, concentrated mainly in late December and January (Figure 3.4-2). Timing of overall steelhead trout upstream migration (November - April) is less dependant on early fall storms, although some steelhead do migrate during this period along with the salmon.

Chinook salmon and steelhead trout attempting upstream passage appeared to have little difficulty within the range of flows observed at Hearst Riffle. The two species were distinguished by their size, coloration, and passage behavior. Chinook were generally larger, with dark green backs and light to silvery sides. Steelhead were generally smaller and had a lighter green color on the back and silvery sides with a reddish tinge. Salmon generally took a straight path over the riffle, at times exposing their backs and splashing on the water surface. Steelhead moved from side to side and rarely broke the water surface.

The proportion of successful upstream passage attempts increased from 56% in 1979/80 to 83% in 1980/81 and 86% in 1981/82, while unsuccessful upstream passage attempts declined from 15% in 1979/80 to 8% in 1980/81 and 4% in 1981/82. Other undefined movements were more variable: 16% in

Table 3.4-1. Number of adult chinook salmon and steelhead trout observed on Hearst Riffle during November and December 1979.

	DATE OF OBSERVATION																									
	NOVEMBER												DECEMBER													
ATTEMPTED PASSAGE	18	19	20	21	23	24	25	26	27	28	29	30	1	2	3	4	5	8	9	10	11	12	15	16	TOTAL	%
Upstream - successful	33	2	1	4	57	70	7	16	8	14	24	12	8	16	2	1	5	3	1	7	2	1	0	0	294	58
Upstream - unsuccessful	6	0	2	1	16	3	4	3	13	2	11	8	4	2	0	1	1	0	0	0	0	0	0	0	77	15
Downstream	14	2	1	0	6	0	3	1	2	0	2	3	3	10	5	2	3	1	0	0	0	0	0	0	58	11
Other	25	2	1	0	11	0	10	2	1	19	2	4	0	0	0	1	1	0	0	0	0	0	0	0	79	16
TOTAL FISH	78	6	5	5	90	73	24	22	24	35	39	27	15	28	7	5	10	4	1	7	2	1	0	0	508	
Hours of Observation	10.0	9.75	10.0	7.75	9.5	10.25	9.5	6.0	6.75	9.5	10.0	10.25	9.75	9.75	9.75	10.25	10.0	9.0	10.0	9.75	10.0	9.75	9.75	10.25	227.25	
Eel River Streamflow (cfs):																										
at Van Arsdale (11471500)	133	84	82	92	133	200	115	303	151	53	56	104	100	105	107	102	100	105	100	98	109	105	92	102		
at Hearst (PGandE E-18)	416	274	204	416	>489	>489	>489	>489	416	251	228	251	228	204	204	161	161	141	141	141	141	141	123	123		
near Dos Rios (11472150)	843	508	348	266	1440	1410	1660	1830	886	549	384	340	298	264	240	219	201	179	176	168	162	163	150	145		
Water visibility (ft)	0.3	1.0	2.0	-	0	0	0.5	0	0.3	0.3	1.7	1.5	1.7	1.7	2.0	2.0	2.0	3.0	3.0	3.0	4.0	4.0	4.0	4.0		
Water temperature (°C)	-	-	-	-	-	-	-	-	-	-	-	-	-	9.0	-	-	-	-	11.0	8.0	6.7	4.5	5.4	4.4		

Table 3.4-2. Number of adult chinook salmon and steelhead trout observed on Hearst Riffle during daylight observations (dawn to dusk), December 1980 and January 1981[a].

	DECEMBER																							JANUARY						
Attempted Passage	3	4	5	6	7	8	9	10	11	12	14	16	17	18	19	20	21	22	23	26	27	28	29	1	2	3	4	5	TOTAL	%
Upstream - successful	0	0	7	14	5	2	1	3	0	2	1	3	5	13	13	7	11	111	131	10	0	31	5	0	0	9	17	3	404	83
Upstream - unsuccessful	0	0	0	1	3	1	2	0	0	0	0	0	0	0	1	1	2	5	11	3	1	3	2	0	0	1	0	0	37	8
Downstream	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	2	0	7	2	1	1	0	2	0	0	1	2	1	22	5
Other	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	8	3	0	0	1	3	0	0	1	1	3	22	5
TOTAL FISH	0	0	8	15	9	3	3	4	0	2	1	3	5	13	16	10	13	131	147	14	2	35	12	0	0	12	20	7	485	
Hours of Observation	6.0	9.5	10.2	10.0	10.0	9.75	10.0	10.0	10.0	10.0	9.75	9.8	10.5	10.0	10.0	10.0	11.0	10.0	10.25	8.5	6.5	9.0	8.5	8.5	9.5	11.0	10.5	10.75	269.5	
Eel River Streamflow (cfs)																														
at Van Arsdale (11471500)	416	206	50	60	47	47	50	51	48	50	59	51	47	49	47	47	72	47	45	49	49	49	48	47	46	54	52	47		
at Hearst (PGandE-18)	>524	>524	251	178	121	95	87	62	76	75	84	73	67	68	65	63	217	225	129	85	85	87	85	71	67	78	113	85		
near Dos Rios (11472150)	4210	1550	498	252	180	150	125	128	118	94	102	99	88	85	88	88	354	439	205	118	118	118	111	105	108	125	151	139		
Turbidity (NTU)[b]	-	123	42	27	23	41	41	52	51	55	61	54	54	34	39	37	71	77	35	34	33	31	28	28	30	29	28	26		
Water visibility (ft)	-	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	-	-	-	-	-		
Water temperature (°C)[b]	-	10.0	9.5	7.5	5.6	4.5	4.5	3.8	2.9	3.0	3.5	5.2	4.0	6.3	7.3	6.9	8.0	8.1	8.0	8.1	7.0	8.7	8.3	6.4	5.8	6.7	7.7	7.1		

[a] All fish observed in January were probably steelhead trout.
[b] Daily averaged values

Table 3.4-3. Number of adult chinook salmon and steelhead trout observed on Hearst Riffle during daylight observations, November and December, 1981.

	NOVEMBER																						
	2	3	4	5	6	7	8	9	10	11	12	13	14	15[a]	16	17	18	19	20	21	22	23	30
Upstream - successful	13	2	0	0	0	17	3	1	1	2	95	63	5	4	0	0	0	0	0	0	0	0	2
Upstream - unsuccessful	0	0	0	0	0	2	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
Downstream	4	0	0	0	0	3	1	0	0	1	0	11	0	0	0	0	0	0	0	0	0	0	0
Other	8	0	0	0	0	1	0	0	1	1	0	5	0	0	0	0	0	0	0	0	0	0	0
TOTAL FISH	25	2	0	0	0	23	4	1	2	4	95	83	5	4	0	0	0	0	0	0	0	0	2
Hours of Observation	12.25	11.25	11.5	11.25	10.25	11.25	10.5	11.25	11.0	11.5	11.25	10.75	11.5	9.75	4.00	4.00	10.75	10.75	10.75	10.0	10.0	7.5	10.25
Eel River Streamflow[b] (cfs)																							
at Van Arsdale (11471500	146	58	43	45	79	100	100	100	100	250	150	150	150	4,850	1,090	-	1,930	1,780	1,240	2,340	4,310	12,500	1,280
at Hearst (PGandE-18)	206	67	50	51	49	185	93	95	93	87	448	256	>524	343	>524	>524	>524	>524	>524	>524	>524	>524	>524
near Dos Rios (114721500)	162	116	67	56	56	168	136	133	136	118	524	820	1,350	6,740	7,310	4,850	2,950	1,850	1,400	1,900	2,950	4,900	955
Turbidity (NTU) [b]	7.2	5.9	4.6	4.2	4.1	7.0	5.2	4.6	3.5	3.4	19.5	25	57	240	140	97	56	101.5	86.5	110	84	220	41
Water visibility (ft)	-	-	-	-	-	-	-	-	-	-	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	0.5	0.5	<.5	<.5
Water temperature (°C)[b]	11.9	11.8	13.8	13.0	14.1	13.5	12.9	12.6	12.8	13.1	13.6	12.9	11.5	11.7	12.8	11.5	9.7	10.3	11.0	11.5	11.2	11.3	8.1

	DECEMBER										
	1	2	3	5	6	7	9	11	17	TOTAL	%
Upstream - successful	11	6	11	18	76	54	40	2	0	428	86
Upstream - unsuccessful	0	0	0	0	0	0	0	0	0	6	1
Downstream	0	0	0	1	1	0	0	0	0	22	4
Other	1	0	1	2	8	3	9	3	0	42	8
TOTAL FISH	12	6	12	21	85	57	49	5	0	499	
Hours of Observation	10.25	10.25	10.25	2.0	9.75	8.25	9.5	9.75	10.0	313.25	
Eel River Streamflow[b] (cfs)											
at Van Arsdale (11471500	951	746	609	415	337	459	666	1,480	2,480		
at Hearst (PGandE-18)	>524	>524	>524	420	420	>524	>524	>524	>524		
near Dos Rios (114721500)	800	705	610	480	650	1,400	945	1,330	1,640		
Turbidity (NTU) [b]	34	32	31	23	34	38	-	35	95		
Water visibility (ft)	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5		
Water temperature (°C)[b]	8.1	8.9	8.8	9.4	9.5	9.7	9.3	7.9	7.8		

[a] Grid washed out
[b] Daily average values

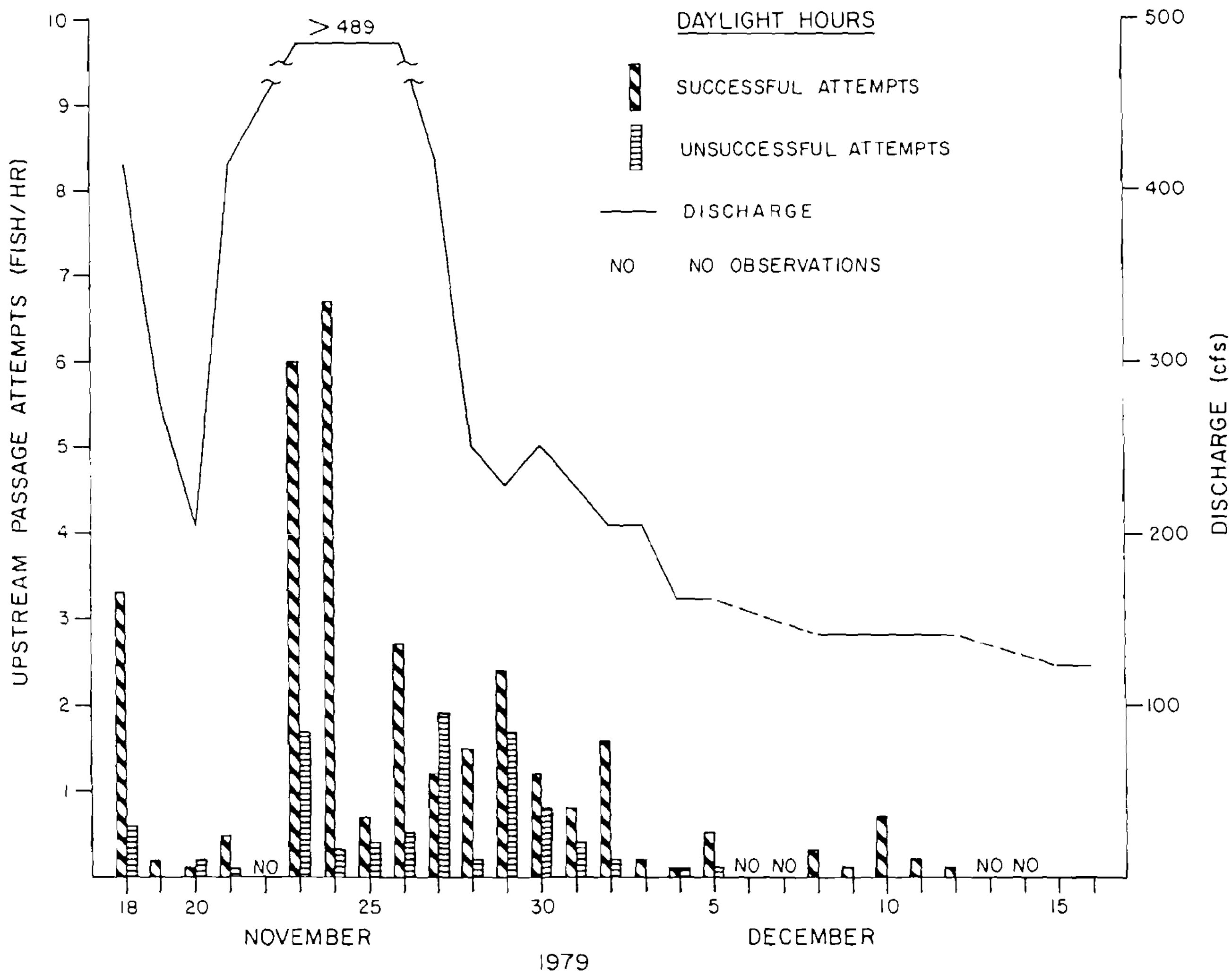

Figure 3.4-1. Discharge (cfs) and successful and unsuccessful attempts at upstream passage (fish/hour) over Hearst Riffle by adult chinook salmon and steelhead trout during day observations, November and December 1979.

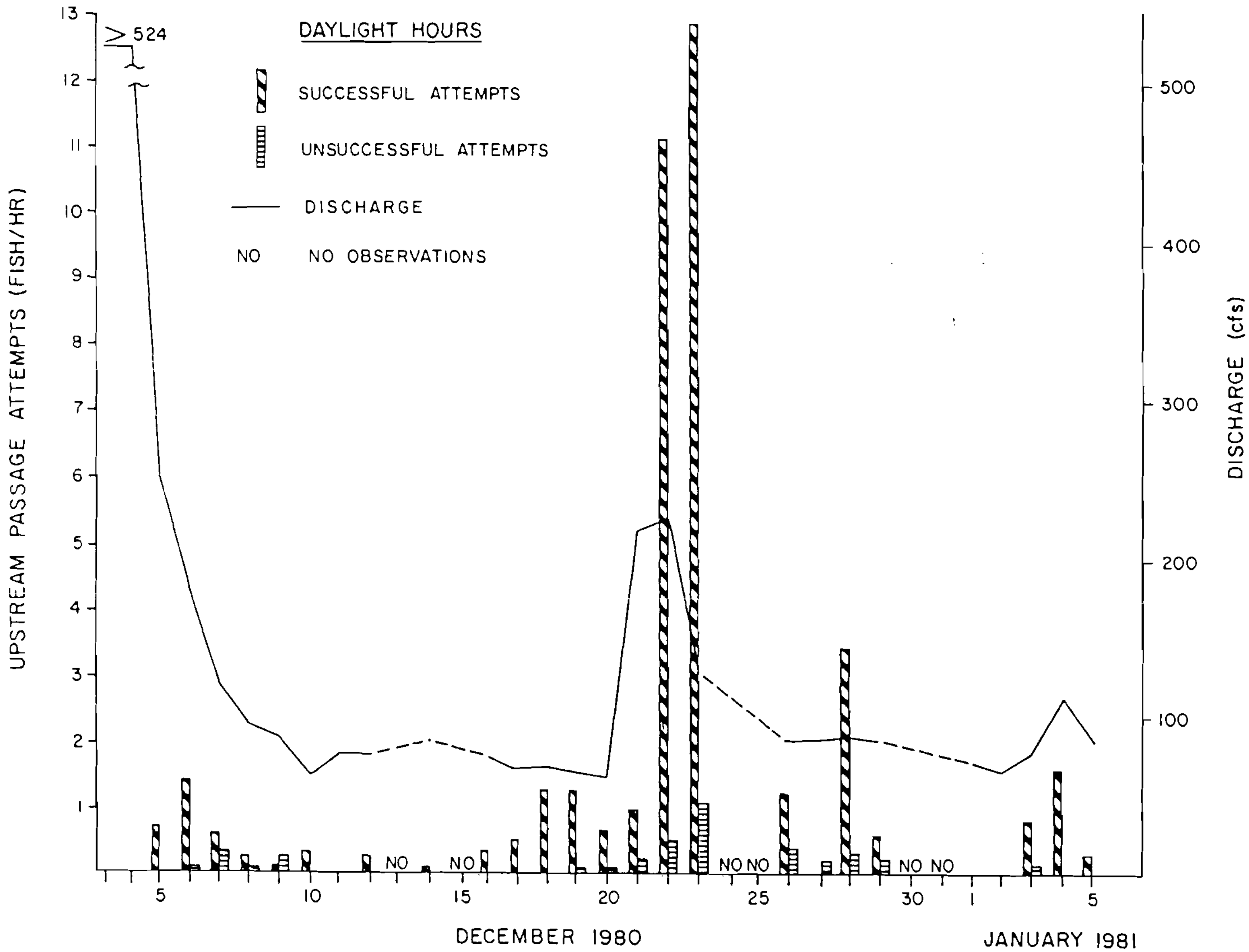

Figure 3.4-2. Discharge (cfs) and successful and unsuccessful attempts at upstream passage (fish/hour) over Hearst Riffle by adult chinook salmon and steelhead trout (all fish after January 1 are probably steelhead trout), during day observations, December 1980 and January 1981.

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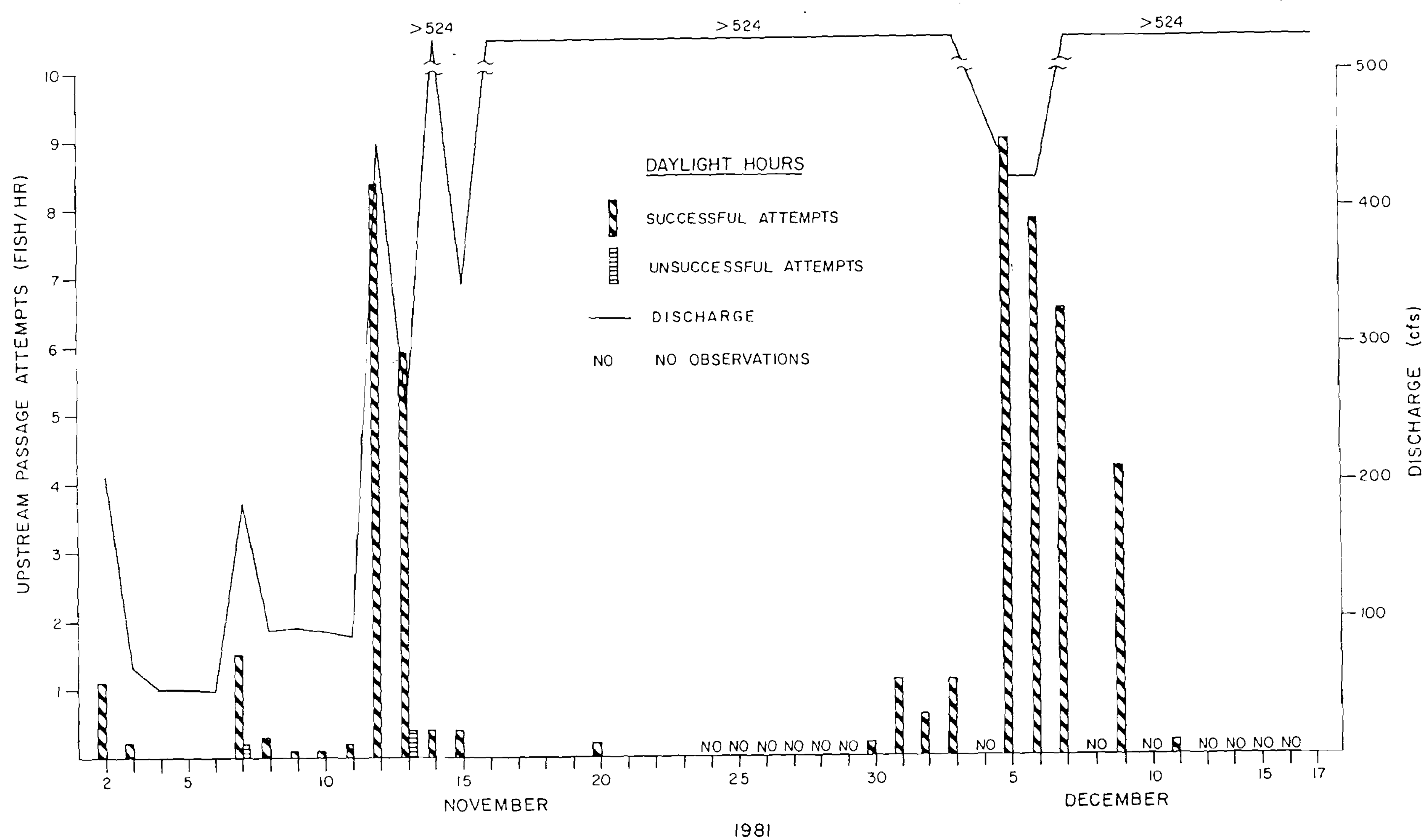

Figure 3.4-3. Discharge (cfs) and successful and unsuccessful attempts at upstream passage (fish/hour) over Hearst Riffle by adult chinook salmon and steelhead trout during day observations, November and December 1981.

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1979/80, 5% in 1980/81, and 8% in 1981/82. Extensive spawning of chinook salmon on and immediately downstream of Hearst Riffle in 1979/80 (Figure 3.4-4) but not in 1980/81 or 1981/82 probably accounts for much of the difference in total upstream attempts and other fish movements between 1979/80 and the following two years. Some of the fish movements recorded as unsuccessful upstream passage in 1979/80 may have been the result of spawning activity rather than genuine upstream passage attempts.

Observed passage of fish during the nighttime periods totaled 150 in 1980/81 and 36 in 1981/82 (Tables 3.4-4 and 3.4-5 and Figures 3.4-5 and 3.4-6) and followed a pattern similar to daytime periods.

Frequency of upstream passage attempts (fish/hour) at Hearst Riffle was dependant on streamflow; the highest frequencies were associated with changes in flow, usually short duration peaks (2-4 days) rather than extended periods of stable flow (Table 3.4-6). Passage of fish over Hearst Riffle was readily observable up to streamflows of about 500 cfs. Above 500 cfs, passage was relatively unobservable, presumably because fish could pass over the riffle without creating a wake on the water surface. In all three years, mean daytime passage attempts were greatest (3.1 to 5.2 fish/hr) during or immediately following storm activity or regulated releases that caused streamflows at Hearst Riffle to rise above 200 cfs (Table 3.4-6). High successful passage rates lasting two days were associated with at least one peak flow event in each year: 6.4 fish/hr in 1979/80, 12.3 fish/hr in 1980/81, and 7.2 fish/hr in 1981/82. The highest daily passage (13.9 fish/hr) observed during all three years occurred on December 23, 1980, at an average streamflow of 129 cfs, following a flow of 225 cfs on December 22. (Figure 3.4-2).

Passage during extended periods of stable streamflow did not appear to be strongly dependant on flow magnitude (Table 3.4-6). During daylight periods mean passage rates at flows from 50 to 185 cfs were low (0 to 0.6 fish/hr), but increased at flows from 204 to 274 cfs (1.7 fish/hr).

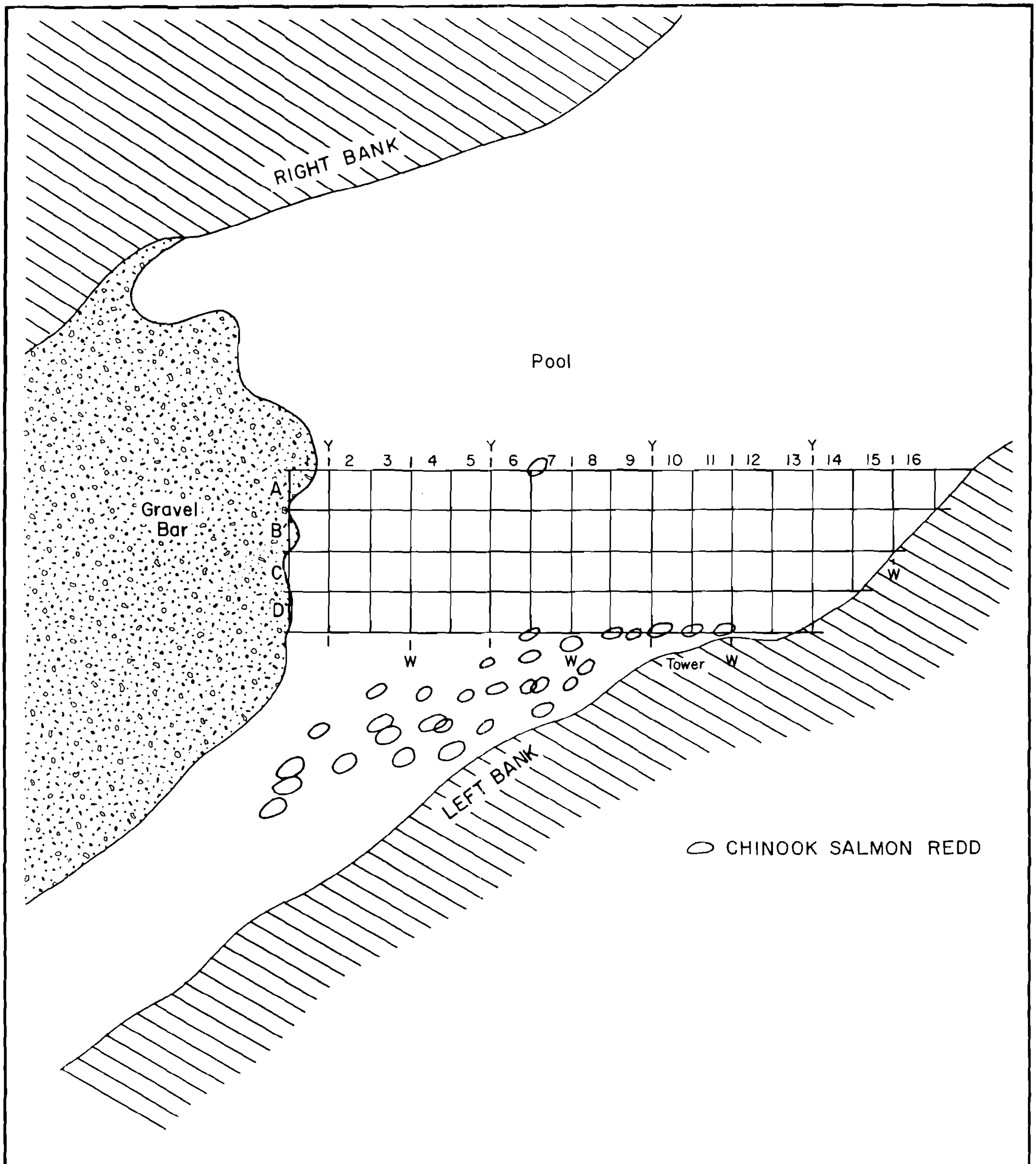

Figure 3.4-4. Location of chinook salmon redds below Hearst Riffle during passage observation study, November and December 1979.

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Table 3.4-4. Number of adult chinook salmon and steelhead trout observed on Hearst Riffle during night observations[a], December 1980 and January 1981[b].

	DECEMBER											JANUARY					
Attempted Passage	8-9[c]	9-10	10-11	11-12	17-18	18-19	19-20	20-21	21[d]	22-23	23[d]	2[d]	3[d]	4[d]	5[d]	TOTAL	%
Upstream - successful	7	3	0	1	14	27	22	13	3	20	17	1	9	0	0	137	91
Upstream - unsuccessful	4	1	0	0	1	0	0	1	0	0	1	0	1	0	0	9	6
Downstream	0	1	0	0	0	1	0	0	0	0	2	0	0	0	0	4	3
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL FISH	11	5	0	1	15	28	22	14	3	20	20	1	10	0	0	150	
Hours of Observation	4.0	6.0	6.0	7.0	6.5	5.0	6.75	6.5	2.0	6.0	2.5	2.0	2.0	2.0	2.0	66.25	

[a] Observations were conducted during three time periods: 1800-2000, 2300-0100 on the first date shown, and 0500-0700 on the second date.
[b] All fish observed in January were probably steelhead trout.
[c] 1800-2000 and 2300-0100 hours, only.
[d] 1800-2000 hours only.

Table 3.4-5. Number of adult chinook salmon observed on Hearst Riffle during night observations, November 1981.

	NOVEMBER												
	5[b]	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	14[b]	15[b]	TOTAL	%
Upstream - successful	0	0	2	5	2	1	1	0	21	0	0	32	88
Upstream - unsuccessful	0	0	0	0	1	0	0	0	0	0	0	1	3
Downstream	0	0	2	0	0	0	0	0	0	0	0	2	6
Other	0	0	0	0	0	1	0	0	0	0	0	1	3
TOTAL FISH	0	0	4	5	3	2	1	0	21	0	0	36	
Hours of Observation	2.0	4.0	4.0	4.25	4.0	4.0	4.5	4.5	4.0			35.25	

[a] Observations were conducted during two time periods: 1800-2000 on the first date shown, and 0400-0600 hours on the second date.

[b] 0400-0600 hours only on the date shown.

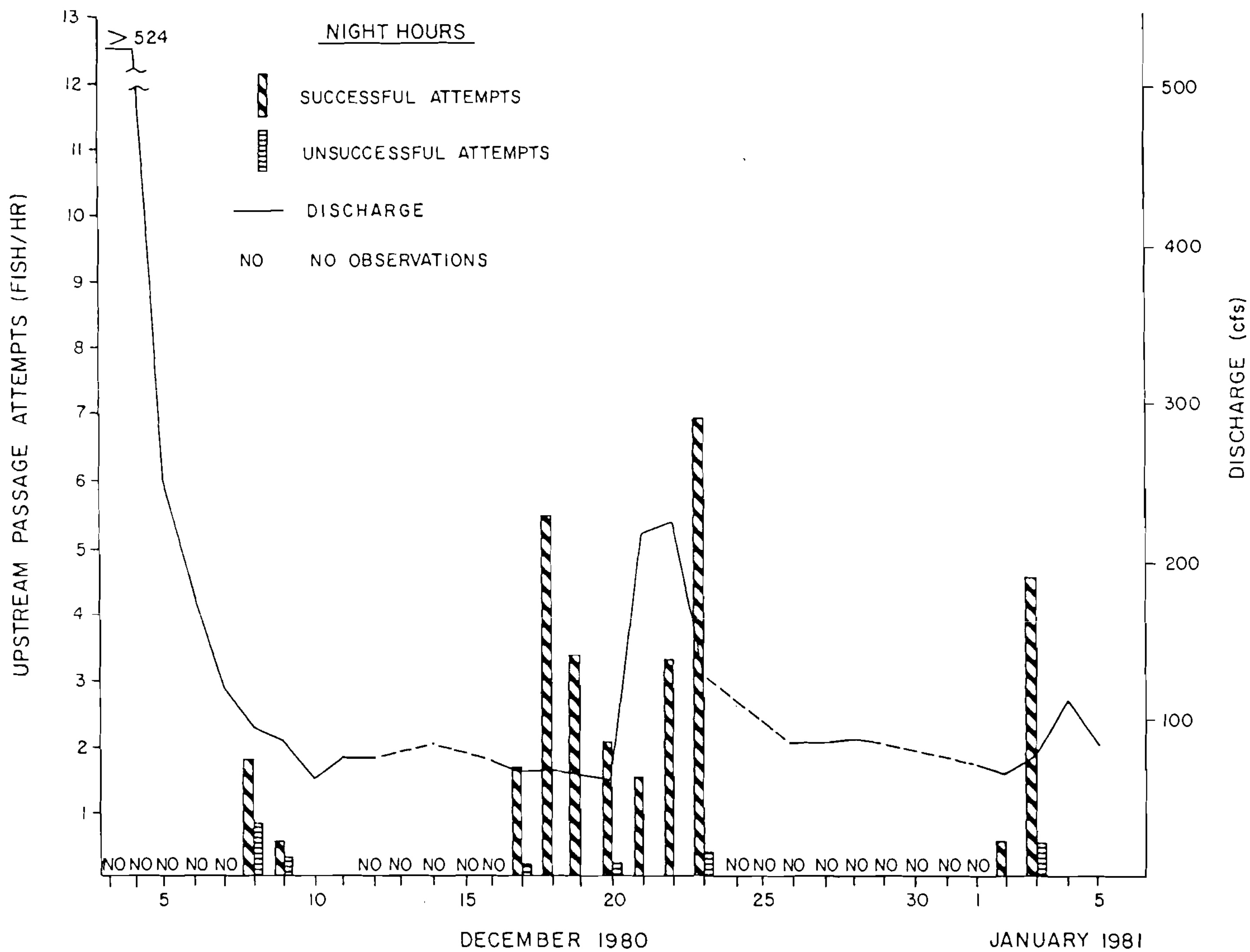

Figure 3.4-5. Discharge (cfs) and successful and unsuccessful attempts at upstream passage (fish/hour) over Hearst Riffle by adult chinook salmon and steelhead trout (all fish after January 1 are probably steelhead trout), during night observations, December 1980 and January 1981.

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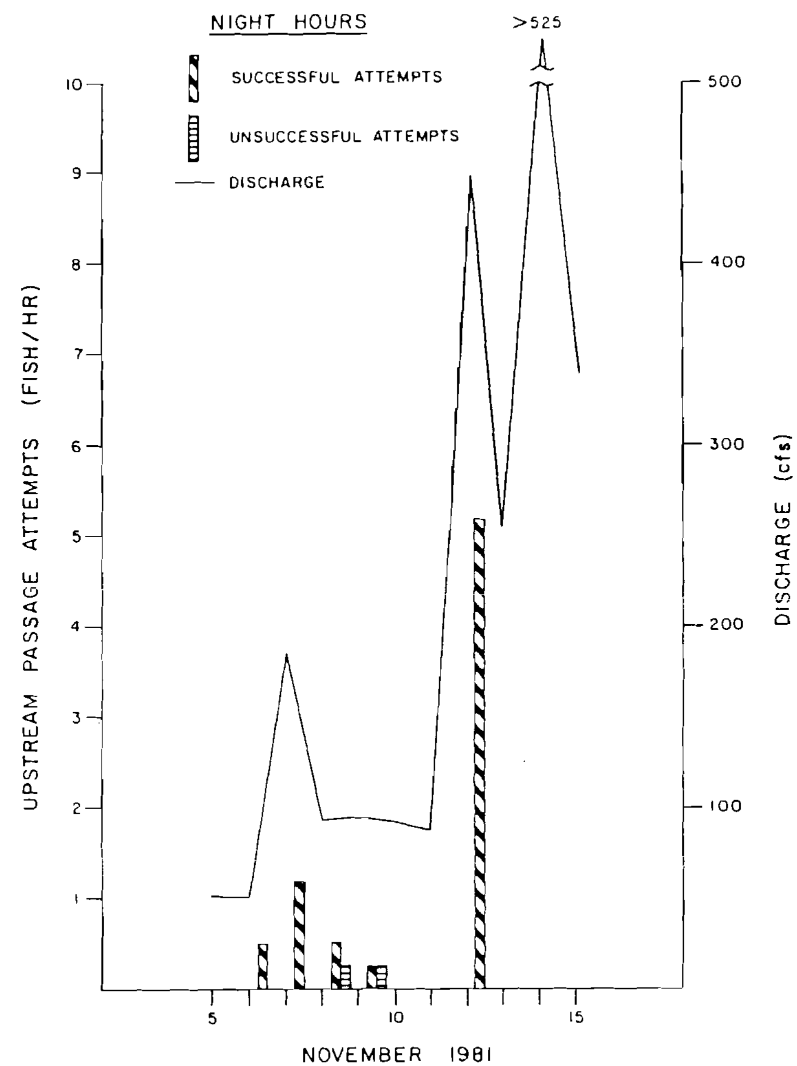

Figure 3.4-6. Discharge (cfs) and successful and unsuccessful attempts at upstream passage (fish/hour) over Hearst Riffle by adult chinook salmon and steelhead trout during night observations, November 1981.

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Table 3.4-6. Mean rate (fish/hr) of upstream passage attempts on Hearst Riffle by chinook salmon and steelhead trout in the 1979/80, 1980/81, and 1981/82 migration seasons.

Flow Range (cfs)	Day/ Night	Mean Passage Rate (fish/hr)			
		During Stable Flow Periods		During Short Duration[a] Peak Flow Periods	
		$\bar{x}$	(n)[b]	$\bar{x}$	(n)
49-51	Day	0	(3)	-	(0)
	Night	-	(0)	-	(0)
62-95	Day	0.6	(24)	-	(0)
	Night	2.4	(6)	-	(0)
113-185	Day	0.4	(11)	5.2	(3)
	Night	-	(0)	4.2	(2)
204-274	Day	1.7	(6)	3.1	(7)
	Night	-	(0)	3.4	(3)
>400	Day	0.5	(14)	5.0	(8)
	Night	-	(0)	-	(0)

[a] 2-4 days.
[b] Number of observation days.

Stable flow passage was greatest (2.4 fish/hr) during the night at flows from 62 to 95 cfs. However, data on nighttime passage at other stable flow levels are not available for comparison. The low observed passage (0.5 fish/hr) at stable flows over 400 cfs is not considered represena-tive of actual passage since large numbers of fish may have passed unobserved.

These data indicate that while stable flows less than 200 cfs appear to inhibit passage during daytime periods, substantial numbers of fish pass during nighttime periods, even at flows as low as 62 cfs, and that the greatest number of fish pass over the riffle in response to peak flows regardless of the magnitude.

Frequency of unsuccessful upstream passage attempts by chinook salmon was generally low in all three years of observation (0.0 to 1.9 fish/hr), with the highest frequencies associated with peak successful upstream attempts or with spawning activity on and below the riffle (Figures 3.4-1 through 3.4-3). As noted above, some of the fish movements recorded as unsuccessful attempts in 1979/80 may have actually been the result of spawning activity on and below the riffle. In 1980/81 and 1981/82, when no spawning occurred on the riffle and very little was observed below the riffle, the frequency of unsuccessful attempts was quite low; with most failures occurring during or immediately following peaks in streamflow and total upstream attempts (Figures 3.4-1 through 3.4-3).

Chinook salmon passage attempts (successful and unsuccessful) on Hearst Riffle were concentrated in the center and left portions of the riffle; grid sections 8, 9, and 10 were used most often in all three years (Figures 3-4.7 through 3.4-9). Passage in 1979/80 and 1981/82 was more uniformly distributed across the eleven sections, 6 through 16 (Figures 3.4-7 and 3.4-9), while in 1980/81 it was highly concentrated in sections 7 through 10, with sections 11 through 15 being used only at flows over 250 cfs. Grid sections 1 through 5, on the right side of the

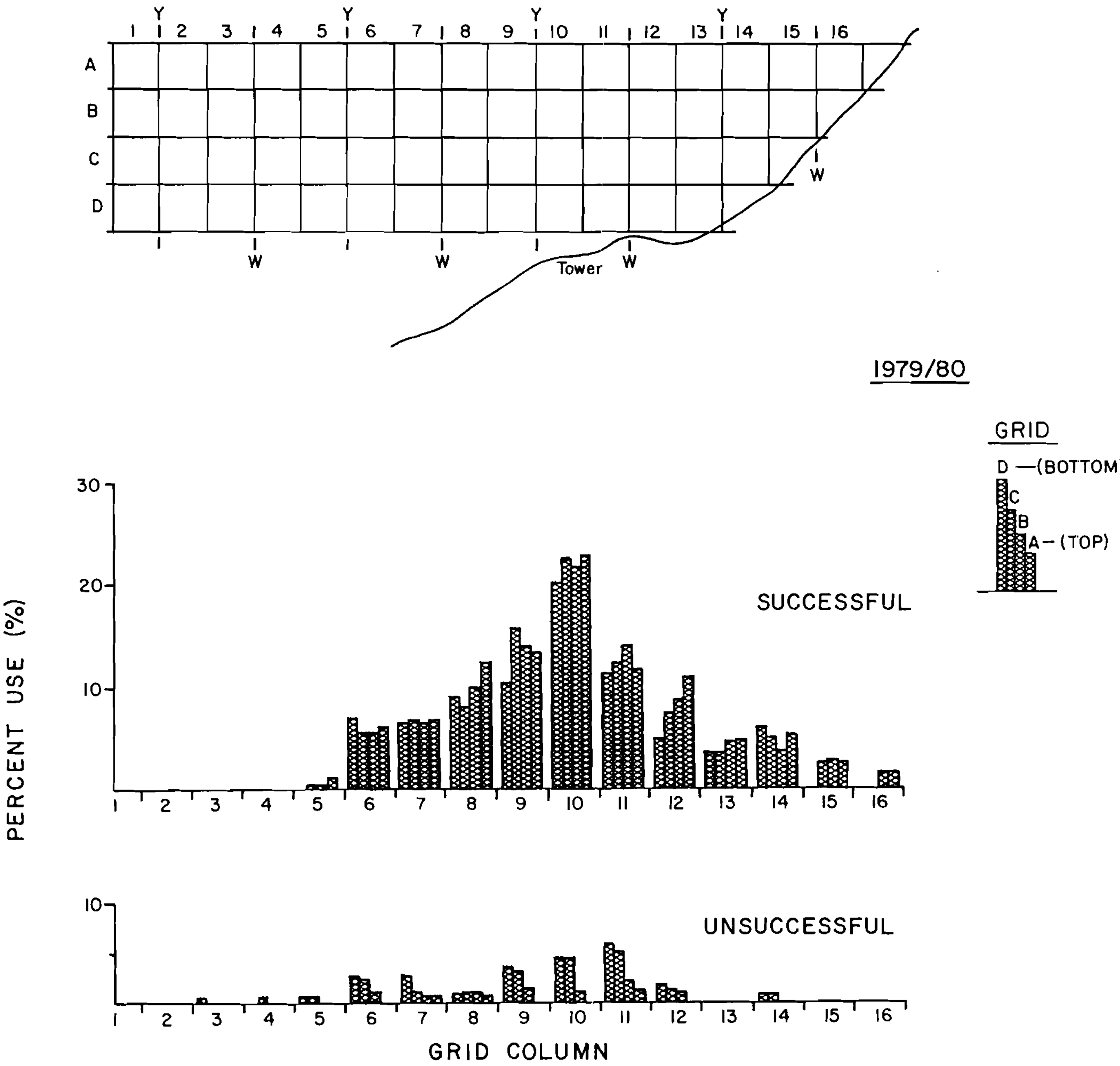

Figure 3.4-7. Distribution of passage attempts of chinook salmon and steelhead trout on Hearst Riffle in 1979/80.

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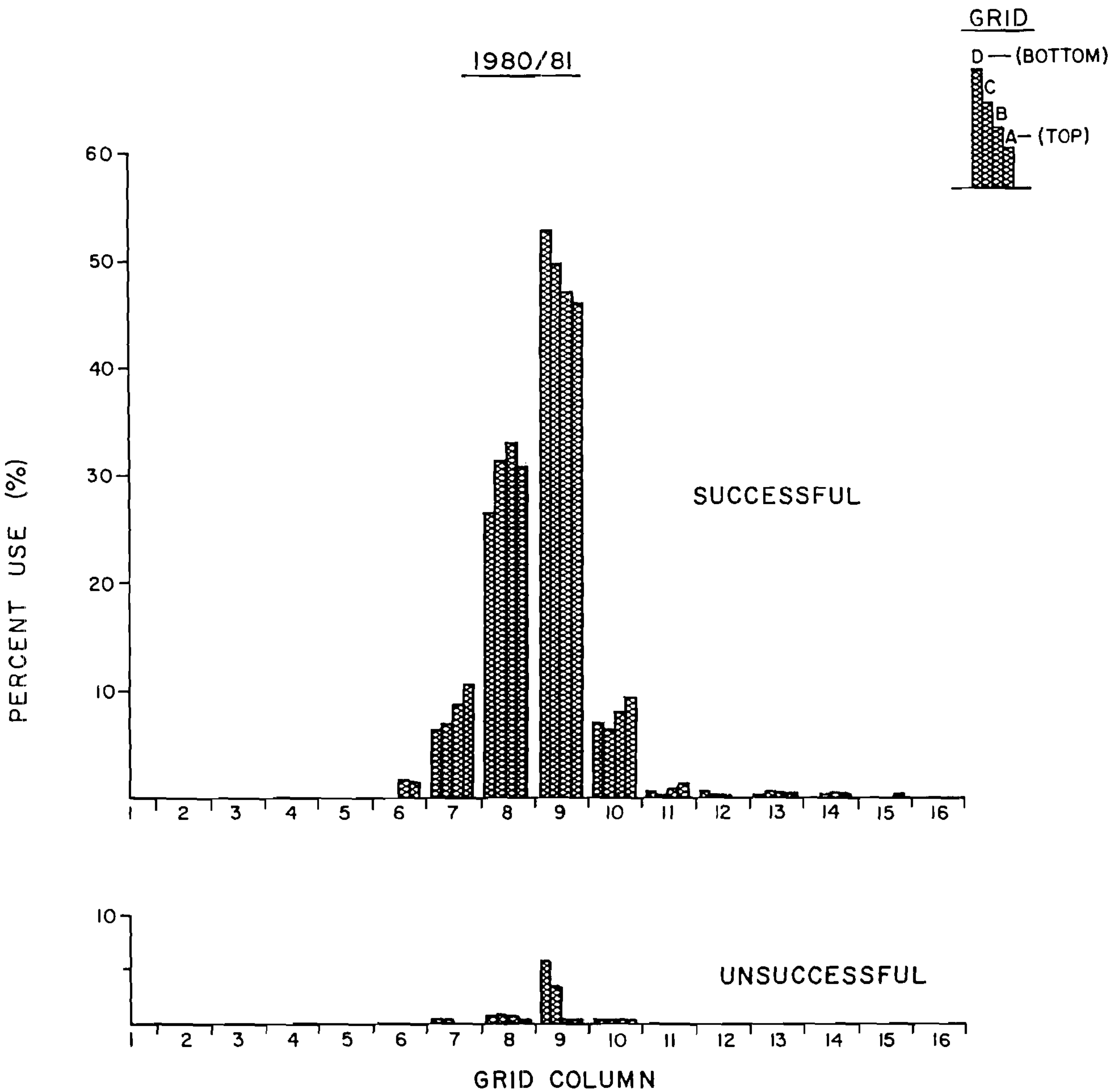

Figure 3.4-8. Distribution of passage attempts of chinook salmon and steelhead trout on Hearst Riffle in 1980/81.

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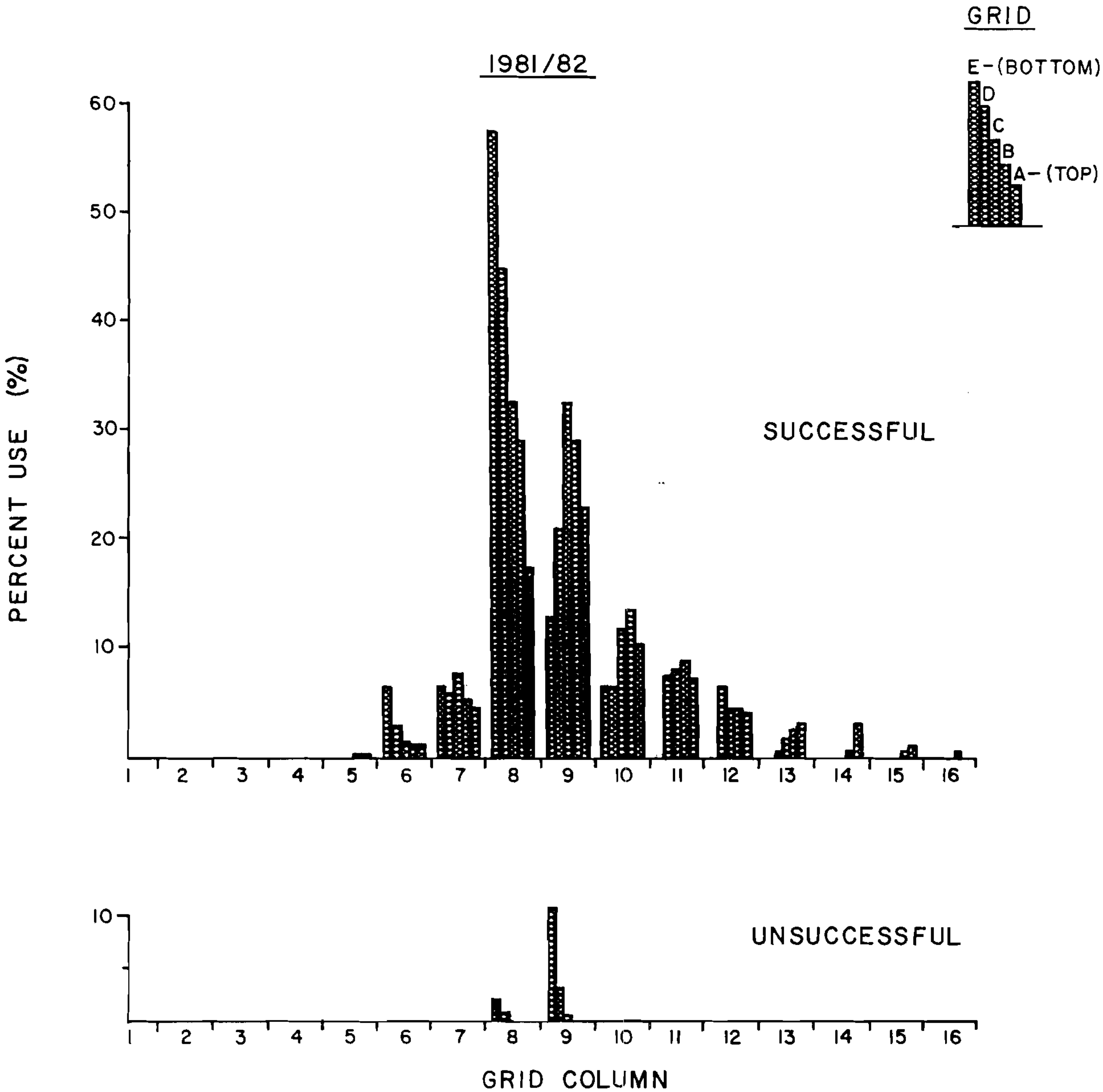

Figure 3.4-9. Distribution of passage attempts of chinook salmon and steelhead trout on Hearst Riffle in 1981/82.

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riffle were rarely used for passage by salmon or steelhead. Unsuccessful passage attempts were highest in grid sections receiving the highest number of successful attempts, particularly in 1980/81 and 1981/82 (Figures 3.4-8 and 3.4-9). Unsuccessful attempts were more evenly distributed in 1979/80 (Figure 3.4-7); however, this may be due to random movements into the riffle, associated with extensive spawning occurring immediately downstream (Figure 3.4-4).

Fish passage patterns on Hearst Riffle were dependent on the morphology and flow patterns in the channel both below and on the riffle, and on streamflow magnitude. Water depths across the riffle were more uniformly distributed in 1979/80 than in 1980/81 and 1981/82 (Figure 3.4-10). During 1979/80 depths were generally greatest in the center of the riffle (sections 5 through 10) and decreased gradually to each bank. Deposition of a gravel bar on the left bank in the spring of 1980 restricted flow to the center and right portions of Hearst Riffle in 1980/81 and 1981/82 (Figures 3.4-11 and 3.4-12). Indirect observations suggest that the gravel bar was removed by high streamflows in mid-November 1981.

Flow patterns on the riffle reflected changes in the configuration of the riffle and streamflow magnitude. At flows below about 400 cfs, water flowed over the riffle generally parallel to the grid lines (Figure 3.4-11) and in proportion to depth (Figures 3.4-10 and 3.4-12). Above 400 cfs, flows were generally parallel to the channel banks, at a diagonal to the grid lines.

Fish passage patterns reflected these changes in riffle configuration and flow patterns. Fish generally approached the riffle following the deepest channel below the riffle along the left bank. They entered the riffle at the head of this channel, which terminated in the bottom row of the grid in sections 9 and 10 in 1979/80 and below riffle sections 8 and 9 in 1980/81 and 1981/82.

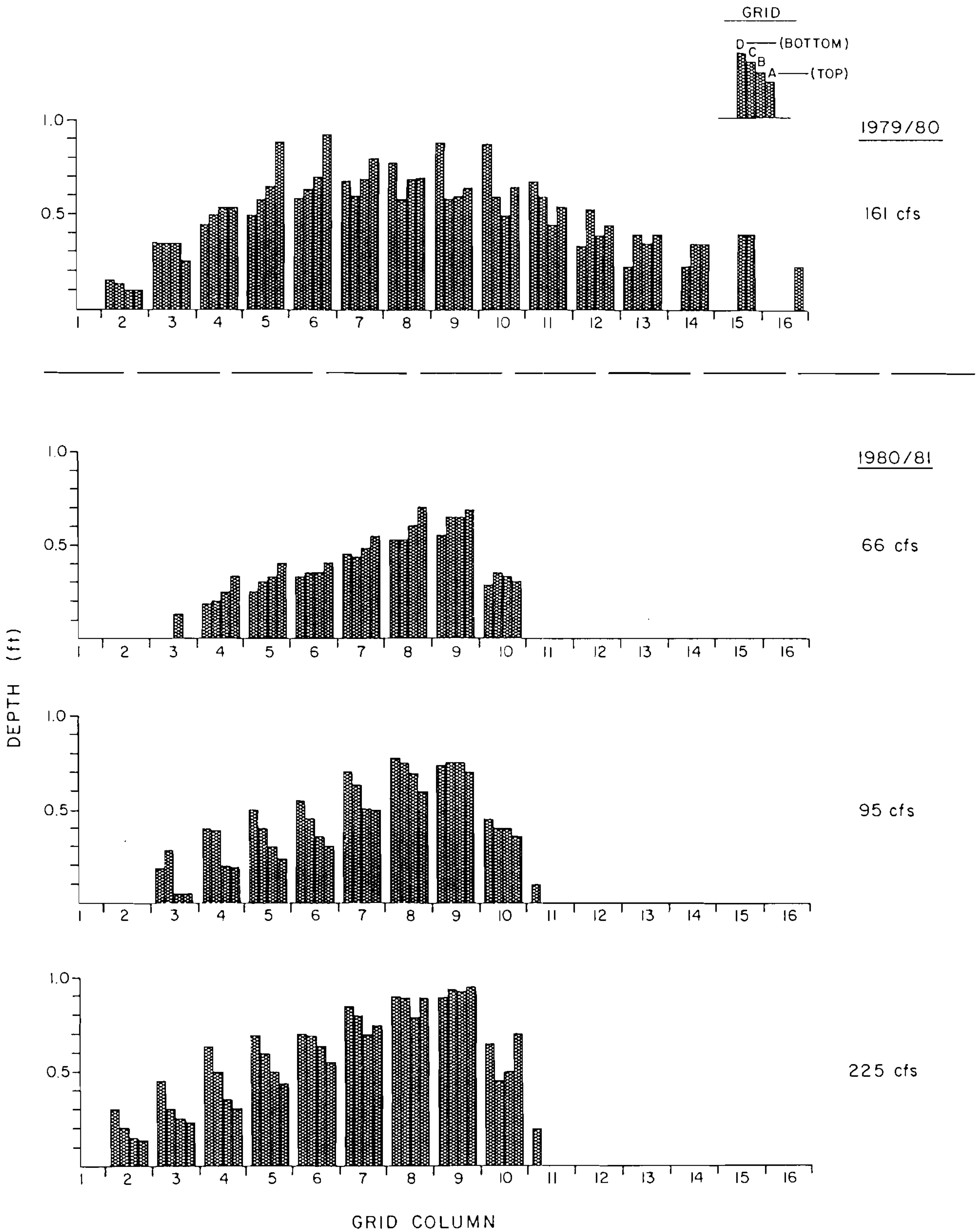

Figure 3.4-10. Mean depth (ft) of Hearst Riffle grid cells during passage observation.

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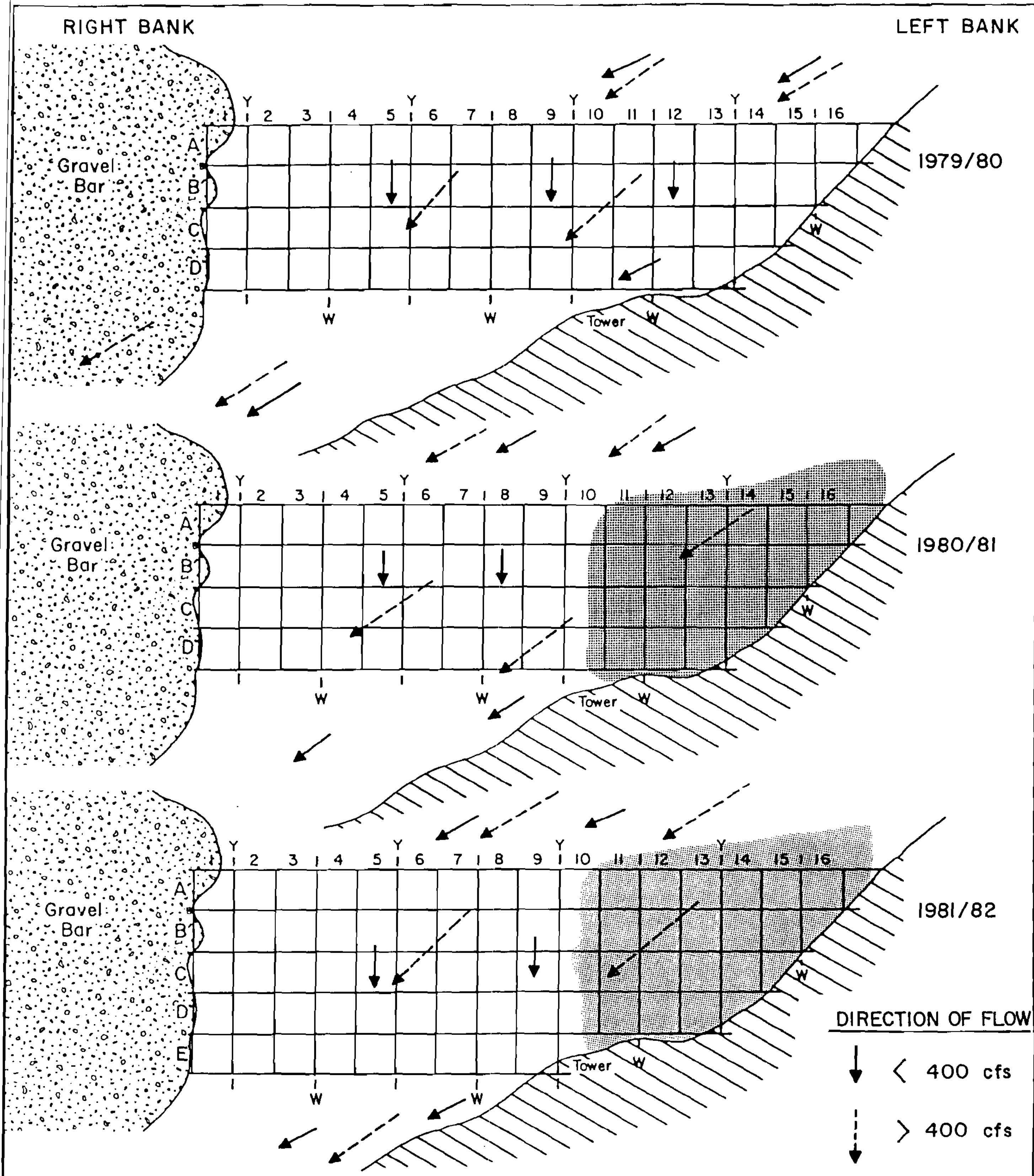

Figure 3.4-11. Configuration of gravel bars and direction of flow on Hearst Riffle during three chinook salmon migration seasons, 1979/80, 1980/81, and 1981/82.

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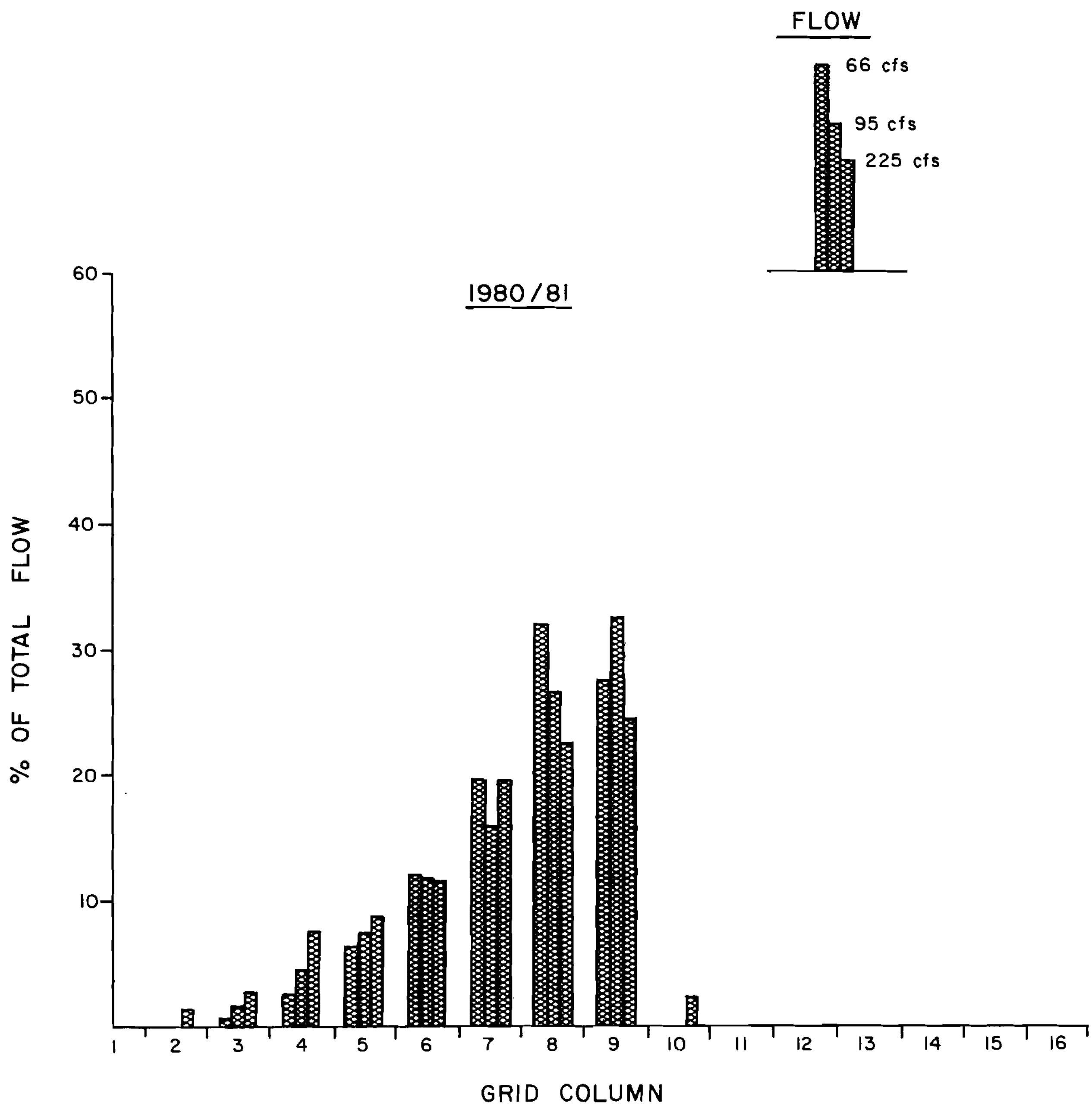

Figure 3.4-12. Distribution of flow among grid columns on Hearst Riffle in 1980/81.

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After entering the riffle, fish generally took the most direct path over the riffle, parallel to the current (and grid lines at flows less than 400 cfs), not necessarily seeking the deepest area on the riffle. At flows over about 400 cfs fish passage, like streamflow, was parallel to the channel banks, diagonal to the grid lines.

The influence of downstream channel morphology on location of passage is most dramatically shown by the 1979/80 data. Depths were relatively uniform across most of the center sections (Figure 3.4-10); the greatest depths occurred in sections 9 and 10 along the bottom of the riffle and in sections 5 and 6 along the top of the riffle. Fish passage was greatest in sections 9, 10, and 11, from bottom to top, indicating that fish swam directly over the riffle from their beginning point rather than seeking the path of greatest depth while on the riffle. In 1980/81 depths, flow distribution, and passage were strongly influenced by the presence of the gravel bar on the left bank (Figures 3.4-8, 3.4-10, 3.4-11, and 3.4-12). Fish passage was greatest where depth and flow were greatest, coinciding with the termination of the deep channel below the riffle. In early November 1981, the gravel bar was still present; fish passage patterns were the same as in 1980/81 even at flows greater than 524 cfs. High flows in mid-November apparently removed the gravel bar and subsequent fish passage patterns at flows down to 420 cfs were similar to 1979/80 patterns.

Chinook salmon moved successfully over the shallowest transect (#3 in 1979/80 and #4 in 1980/81) on Hearst Riffle in large numbers at depths down to 0.6 ft (Figure 3.4-13), but selected for depths of 0.8 ft and greater (Figure 3.4-14). Combined successful passage for 1979/80 and 1980/81 (the only years for which depth data are available) was greatest at 0.6 ft (141 fish) and fell off rapidly at 0.5 ft (36 fish) (Figure 3.4-13). The high rate of passage at 0.6 and 0.7 ft is partially due to high availability of these depths and low availability of greater depths. Weighting these data for the relative availability of each depth indicates that while fish can and do pass with high success at 0.6

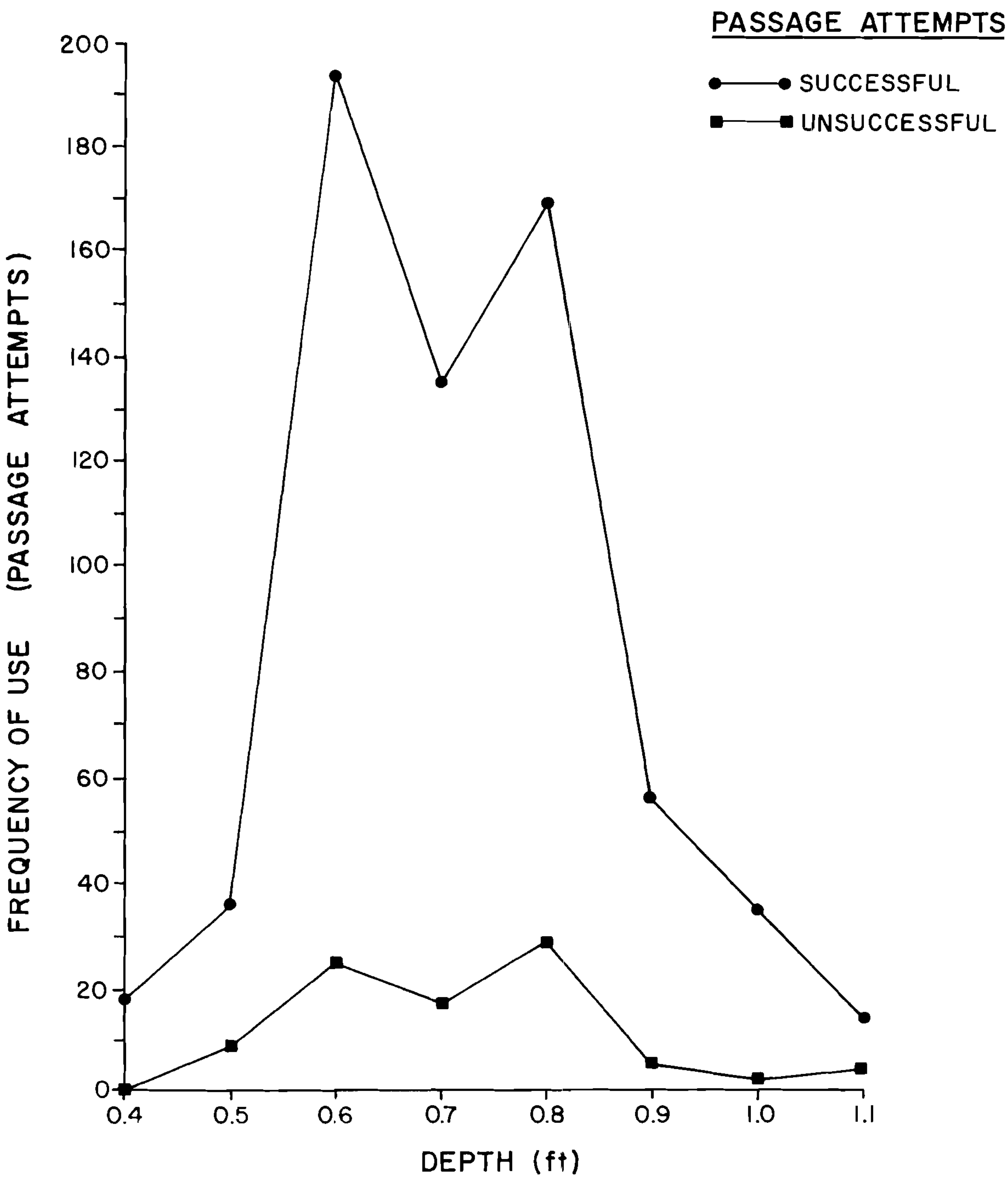

Figure 3.4-13. Frequency of use of depths on Hearst Riffle.

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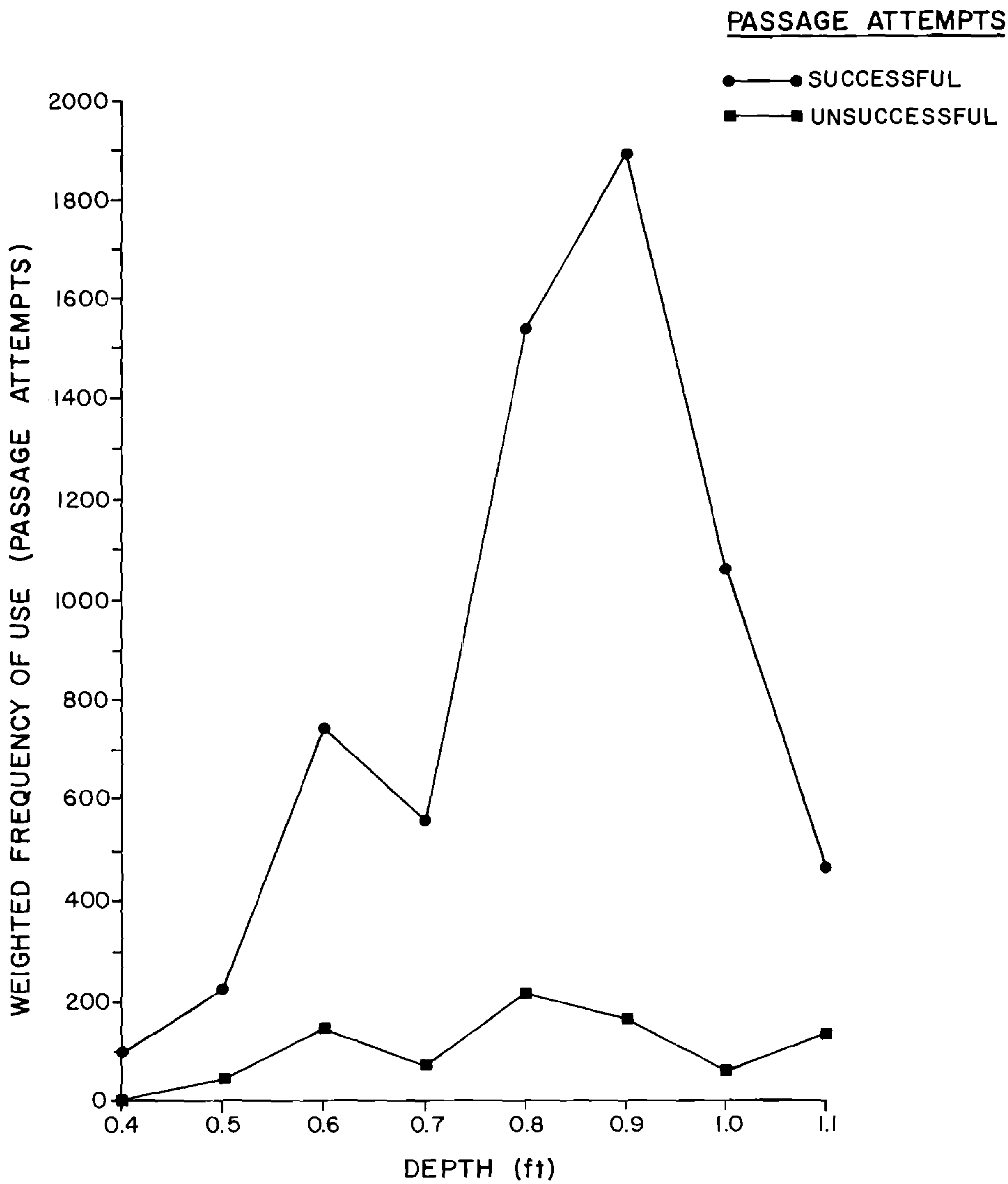

Figure 3.4-14. Weighted frequency of use of water depths on Hearst Riffle.

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and 0.7 ft depths, they will select for depths of 0.8 ft and greater, if available. This is probably a direct result of higher passage associated with peak flows and concurrently greater depths on Hearst Riffle, and may result from responses to stimuli, other than depth, related to the peak flows.

Observations of chinook salmon and steelhead trout passage over Hearst Riffle indicate that several factors affect the portion of a shallow riffle used for passage and the streamflows required for passage. Channel morphology immediately downstream of the riffle had a greater influence on the portion of the riffle used for passage than depth on the riffle. Upon entering the riffle, fish passed directly upstream from their beginning point and did not seek greater depths. Passage was greater during and immediately following storm events or regulated pulse releases than during extended periods of stable flow. During periods of stable flow, passage was generally greater at night. The frequency and relative proportion of unsuccessful passage attempts was proportional to successful attempts and not related to depth.

Although not investigated in this study, the length of the riffle undoubtedly has a large influence on the adequacy of streamflow for passage. At 0.6 ft depth, a fish can successfully swim over short riffles as occur in the Eel River; however, greater depths would likely be required for substantially longer riffles.

3.5 Critical Riffle Study

Depths and velocities measured across the shallowest transect at five identified critical riffles (above Garcia Creek, at Hearst, above and below Brushy Creek, and above Outlet Creek) at selected Eel River discharges in 1980 and 1981 are listed in Appendix E. General characteristics of the riffles are shown in Figures 3.5-1 through 3.5-5.

Water depth measurements during 1981 at the riffles above Garcia Creek and Outlet Creek confirm that the transect selected as the shallowest course across each riffle was in fact placed in the shallowest area (Appendix E). The increase in maximum depth from the shallowest transect to the upstream and downstream transects ranged from 16 to 100%. Transects at Hearst Riffle were not selected based on the shallowest course. The shallowest course across Hearst Riffle was generally along one of the downstream most transects. Maximum depths on Hearst Riffle were more uniform than on the other riffles, increasing 0 to 29% from the shallowest to deepest transects.

Calculations of total usable width and the longest continuous portion of usable width available for chinook salmon and steelhead trout passage according to the Thompson criteria (Thompson 1972) are presented in Tables 3.5-1 through 3.5-10 for each riffle at each flow release during 1980; calculations using data collected in 1981 are shown in Tables 3.5-11 through 3.5-16. The percent total usable width and longest continuous portion of usable width versus discharge for 1980 data are presented in Figures 3.5-6 and 3.5-7 for chinook salmon and Figures 3.5-8 and 3.5-9 for steelhead trout; and for 1981 data in Figures 3.5-10 and 3.5-11 for chinook salmon and Figures 3.5-12 and 3.5-13 for steelhead trout.

These figures were used to estimate the discharge at which Thompson criteria were met. The discharges at which the graphed line for each site intersects the 25% level for the total usable width and

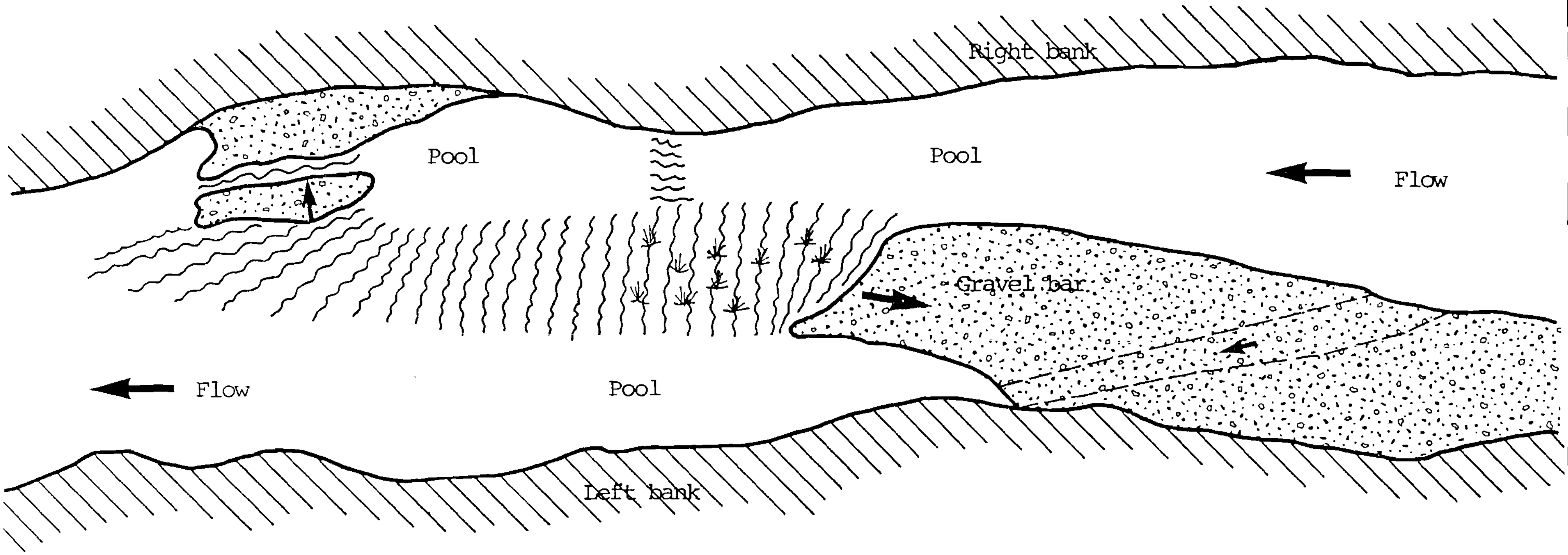

Figure 3.5-1. Riffle above Garcia Creek at 70 cfs discharge, August 8, 1980. Arrows at riffle margin indicate the direction and relative magnitude of water spread at higher discharges. A small channel was formed near the left bank at 162 cfs.

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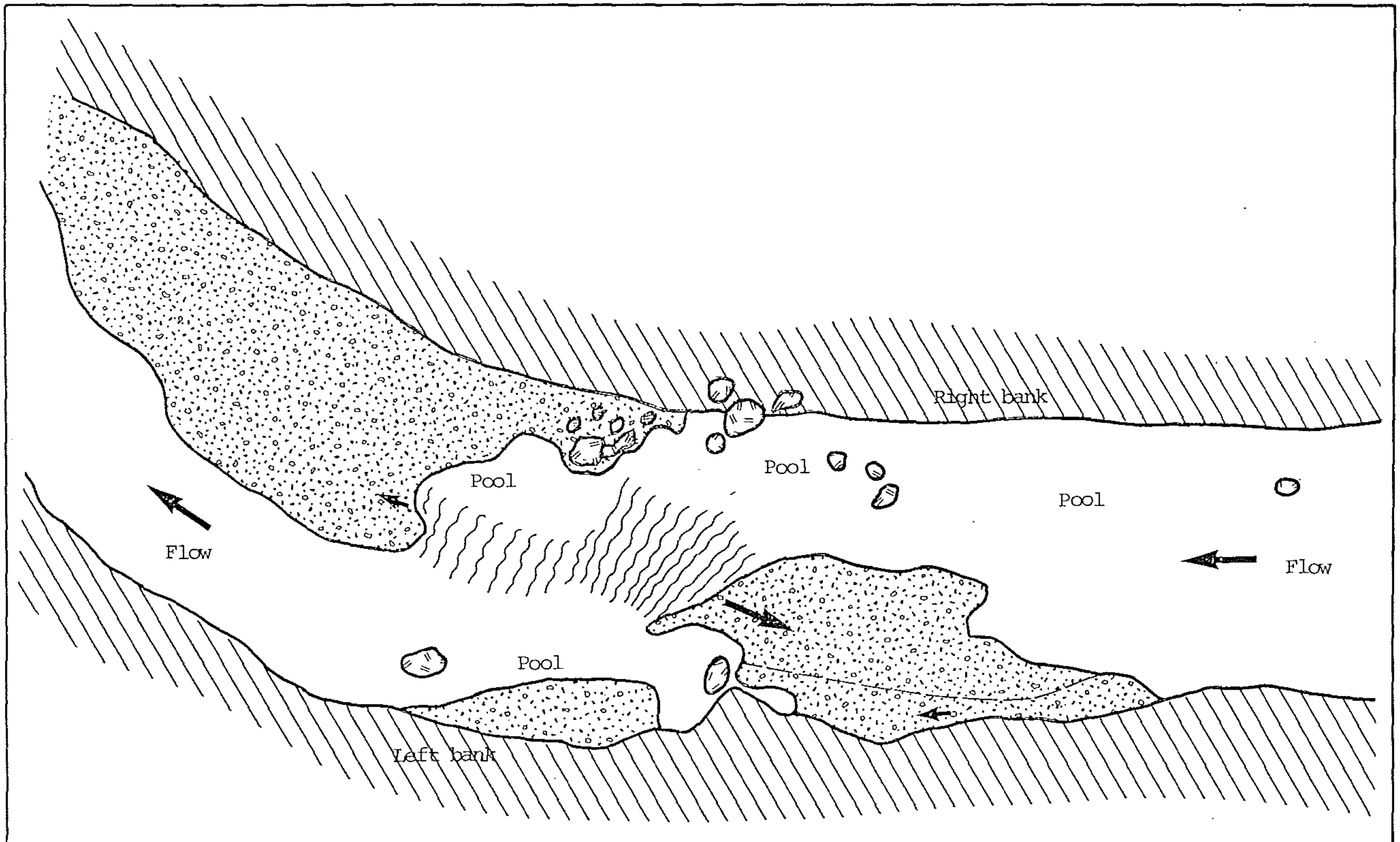

Figure 3.5-3. Riffle above Brushy Creek at 70 cfs discharge, August 8, 1980. Arrows at riffle margin indicate the direction and relative magnitude of water spread at higher discharges. Gravel bar on left bank flooded and a shallow channel was formed at 162 cfs.

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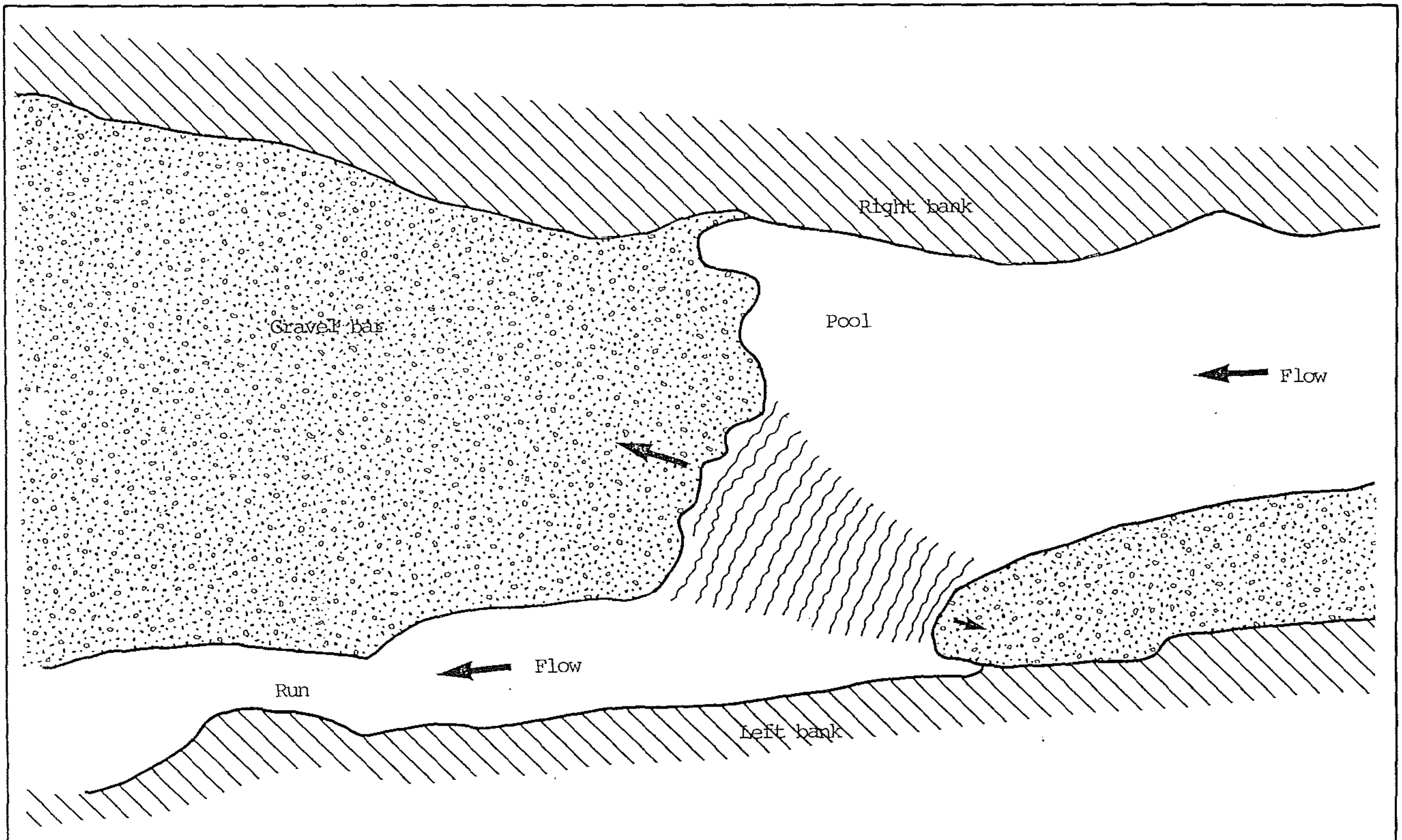

Figure 3.5-2. Hearst Riffle at 70 cfs discharge, August 8, 1980. Arrows at riffle margin / indicate the direction and relative magnitude of water spread at higher discharges. Gravel bar at left bank deposited between December 1979 and July 1980.

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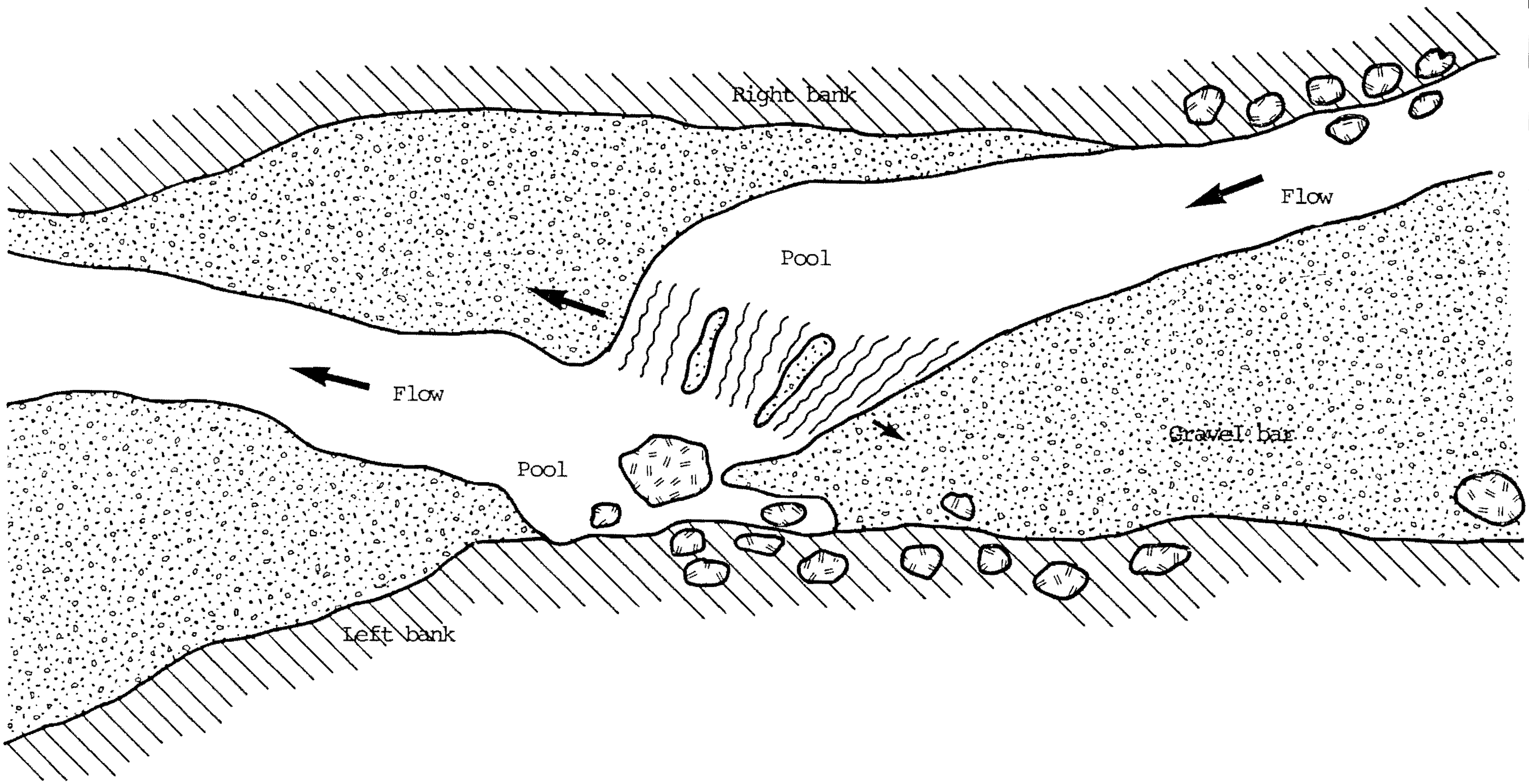

Figure 3.5-4. Riffle below Brushy Creek at 70 cfs discharge, August 8, 1980. Arrows at riffle margin indicate the direction and relative magnitude of water spread at higher discharges. Gravel bars in center of riffle flooded between 70 and 162 cfs.

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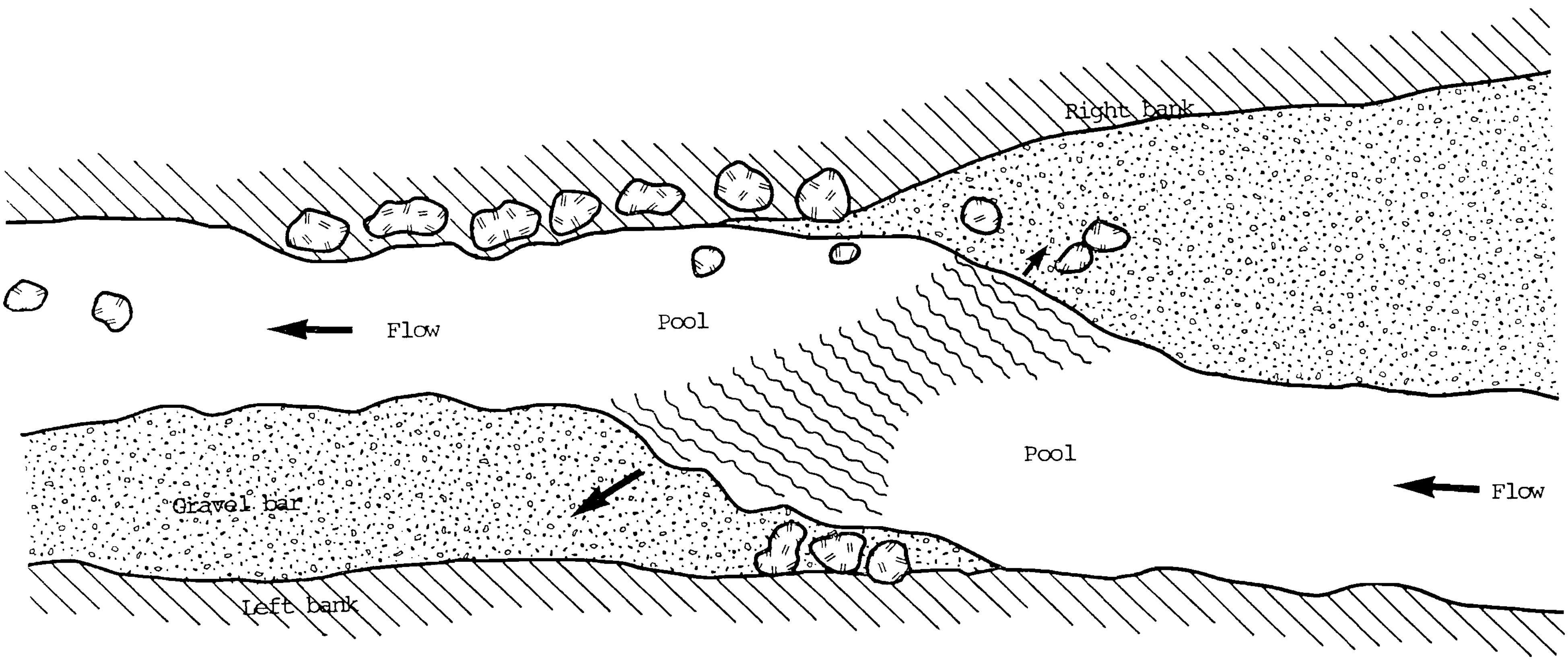

Figure 3.5-5. Riffle above Outlet Creek at 70 cfs discharge, August 8, 1980. Arrows at riffle margin indicate the direction and relative magnitude of water spread at higher discharges.

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Table 3.5-1. Summary of chinook salmon passage data for the critical riffle above Garcia Creek in 1980 based on Thompson criteria of 0.8 feet minimum depth and 8.0 fps maximum velocity.

Above Garcia Creek

Measured Flow	Date	Wetted Width	Total Usable Width Feet	Total Usable Width %	Longest Continuous Portion Usable Feet	Longest Continuous Portion Usable %
12	7/24/80	143	0	0	0	0
70	8/8/80	218	0	0	0	0
140	8/10/80	271.5	0	0	0	0
162	8/11/80	323.5	4	1	3	1
248	8/14/80	324	85	24.7	50	15.4

Table 3.5-2. Summary of steelhead trout passage data for the critical riffle above Garcia Creek in 1980 based on Thompson criteria of 0.6 feet minimum depth and 8.0 fps maximum velocity.

Above Garcia Creek

Measured Flow	Date	Wetted Width	Total Usable Width Feet	Total Usable Width %	Longest Continuous Portion Usable Feet	Longest Continuous Portion Usable %
12	7/24/80	143	0	0	0	0
70	8/8/80	218	0	0	0	0
140	8/10/80	271.5	28	10.3	12	4.4
162	8/11/80	323.5	52	16	40	12.3
248	8/14/80	324	95	29	50	15.4

Table 3.5-3. Summary of chinook salmon passage data for Hearst Riffle in 1980 based on Thompson criteria of 0.8 feet minimum depth and 8.0 fps maximum velocity.

Hearst

Measured Flow	Date	Wetted Width	Total Usable Width Feet	Total Usable Width %	Longest Continuous Portion Usable Feet	Longest Continuous Portion Usable %
12	7/24/80	59	0	0	0	0
70	8/8/80	126	0	0	0	0
140	8/10/80	133	8	6	4	3
162	8/11/80	144	15	10.4	10	7
248	8/14/80	154	38	25	23	15

Table 3.5-4. Summary of steelhead trout passage data for Hearst Riffle in 1980 based on Thompson criteria of 0.6 feet minimum depth and 8.0 fps maximum velocity.

Hearst

Measured Flow	Date	Wetted Width	Total Usable Width Feet	Total Usable Width %	Longest Continuous Portion Usable Feet	Longest Continuous Portion Usable %
12	7/24/80	59	0	0	0	0
70	8/8/80	126	16	13	8	6
140	8/10/80	133	40	30	36	27
162	8/11/80	144	58	40	58	40
248	8/14/80	154	68	44	48	31

Table 3.5-5. Summary of chinook salmon passage data for the critical riffle above Brushy Creek in 1980 based on Thompson criteria of 0.8 feet minimum depth and 8.0 fps maximum velocity.

Above Brushy Creek

Measured Flow	Date	Wetted Width	Total Usable Width		Longest Continuous Portion Usable	
			Feet	%	Feet	%
12	7/24/80	91.5	0	0	0	0
70	8/8/80	146	0	0	0	0
162	8/11/80	260	8	3	4	1.5
240	8/14/80	221	28	13	13	6

Table 3.5-6. Summary of steelhead trout passage data for the critical riffle above Brushy Creek in 1980 based on Thompson criteria of 0.6 feet minimum depth and 8.0 fps maximum velocity.

Above Brushy Creek

Measured Flow	Date	Wetted Width	Total Usable Width		Longest Continuous Portion Usable	
			Feet	%	Feet	%
12	7/24/80	91.5	0	0	0	0
70	8/8/80	146	0	0	0	0
162	8/11/80	260	32	12	16	6
240	8/14/80	221	75	34	29	13

Table 3.5-7. Summary of chinook salmon passage data for the critical riffle below Brushy Creek in 1980 based on Thompson criteria of 0.8 feet minimum depth and 8.0 fps maximum velocity.

Below Brushy Creek

Measured Flow	Date	Wetted Width	Total Usable Width Feet	Total Usable Width %	Longest Continuous Portion Usable Feet	Longest Continuous Portion Usable %
12	7/24/80	57	0	0	0	0
70	8/8/80	128	0	0	0	0
162	8/11/80	139	8	6	4	3
240	8/14/80	138	20	14	15	11

Table 3.5-8. Summary of steelhead trout passage data for the critical riffle below Brushy Creek in 1980 based on Thompson criteria of 0.6 feet minimum depth and 8.0 fps maximum velocity.

Below Brushy Creek

Measured Flow	Date	Wetted Width	Total Usable Width Feet	Total Usable Width %	Longest Continuous Portion Usable Feet	Longest Continuous Portion Usable %
12	7/24/80	57	0	0	0	0
70	8/8/80	128	8	6	8	6
162	8/11/80	139	48	34	48	34
240	8/14/80	138	70	51	50	36

Table 3.5-9. Summary of chinook salmon passage data for the critical riffle above Outlet Creek in 1980 based on Thompson criteria of 0.8 feet minimum depth and 8.0 fps maximum velocity.

Above Outlet Creek

Measured Flow	Date	Wetted Width	Total Usable Width Feet	Total Usable Width %	Longest Continuous Portion Usable Feet	Longest Continuous Portion Usable %
12	7/24/80	121	0	0	0	0
70	8/8/80	146	0	0	0	0
140	8/10/80	165	0	0	0	0
162	8/11/80	175	0	0	0	0
240	8/14/80	174	42	24	28	16

Table 3.5-10. Summary of steelhead trout passage data for the critical riffle above Outlet Creek in 1980 based on Thompson criteria of 0.6 feet minimum depth and 8.0 fps maximum velocity.

Above Outlet Creek

Measured Flow	Date	Wetted Width	Total Usable Width Feet	Total Usable Width %	Longest Continuous Portion Usable Feet	Longest Continuous Portion Usable %
12	7/24/80	121	0	0	0	0
70	8/8/80	146	0	0	0	0
140	8/10/80	165	24	15	18	11
162	8/11/80	175	54	31	37	21
240	8/14/80	174	119	68	104	60

Table 3.5-11. Summary of chinook salmon passage data for the critical riffle above Garcia Creek in 1981 based on Thompson criteria of 0.8 feet minimum depth and 8.0 fps maximum velocity.

Above Garcia Creek

Measured Flow	Date	Transect Number	Wetted Width	Total Usable Width Feet	Total Usable Width %	Longest Continuous Portion Usable Feet	Longest Continuous Portion Usable %
43	5/29/81	1	162.4	0	0	0	0
		2	159.1	7.4	5	7.4	5
		3	167.3	0	0	0	0
341	3/13/81	1	387	140	36	130	34
		2	405	323	80	180	44
		3	395	180	46	120	30

Table 3.5-12. Summary of steelhead trout passage data for the critical riffle above Garcia Creek in 1981 based on Thompson criteria of 0.6 feet minimum depth and 8.0 fps maximum velocity.

Above Garcia Creek

Measured Flow	Date	Transect Number	Wetted Width	Total Usable Width Feet	Total Usable Width %	Longest Continuous Portion Usable Feet	Longest Continuous Portion Usable %
43	3/13/81	1	162.4	0	0	0	0
		2	159.1	15.6	10	8.2	5
		3	167.3	4.9	3	4.9	3
341	5/29/81	1	387	160	41	160	41
		2	405	357.5	88	330	81
		3	395	235	59	130	33

Table 3.5-13. Summary of chinook salmon passage data for Hearst Riffle in 1981 based on Thompson criteria of 0.8 feet minimum depth and 8.0 fps maximum velocity.

Hearst

Measured Flow	Date	Transect Number	Wetted Width	Total Usable Width Feet	Total Usable Width %	Longest Continuous Portion Usable Feet	Longest Continuous Portion Usable %
66	1/2/81	1	131	16.4	12.5	16.4	12.5
		2	115	0	0	0	0
		3	115	16.4	14	16.4	14
		4	108	0	0	0	0
		5	115	0	0	0	0
95	12/8/81	1	148	49	33	49	33
		2	131	16.4	12.5	16.4	12.5
		3	115	32.8	28.5	32.8	28.5
		4	115	0	0	0	0
		5	123	0	0	0	0
225	12/22/81	1	185	49	26	16.4	9
		2	164	49	30	49	30
		3	147.6	49	33	32.8	22
		4	135	32.8	24	32.8	24
		5	156	65.6	42	65.6	42

Table 3.5-14. Summary of steelhead trout passage data for Hearst Riffle in 1981 based on Thompson criteria of 0.6 feet minimum depth and 8.0 fps maximum velocity.

Hearst

Measured Flow	Date	Transect Number	Wetted Width	Total Usable Width Feet	Total Usable Width %	Longest Continuous Portion Usable Feet	Longest Continuous Portion Usable %
66	1/2/81	1	131	49	37	49	37
		2	115	32.8	29	32.8	29
		3	115	36	31	36	31
		4	108	32.8	30	32.8	30
		5	115	16.4	14	16.4	14
95	12/8/81	1	148	82	55	82	55
		2	131	65.6	50	65.6	50
		3	115	49	43	49	43
		4	115	32.8	29	32.8	29
		5	123	32.8	27	32.8	27
225	12/22/81	1	185	131	71	131	71
		2	164	98	60	98	60
		3	147.6	82	56	82	56
		4	135	65.6	49	65.6	49
		5	156	82	53	82	53

Table 3.5-15. Summary of chinook salmon passage data for the critical riffle above Outlet Creek in 1981 based on Thompson criteria of 0.8 feet minimum depth and 8.0 fps maximum velocity.

Above Outlet Creek

Measured Flow	Date	Transect Number	Wetted Width	Total Usable Width Feet	Total Usable Width %	Longest Continuous Portion Usable Feet	Longest Continuous Portion Usable %
37	6/2/81	1	120	0	0	0	0
		2	120	0	0	0	0
		3	120	0	0	0	0
259	4/16/81	1	134	77.5	58	77.5	58
		2	122	70	57	70	57
		3	163	91	56	70	43

Table 3.5-16. Summary of steelhead trout passage data for the critical riffle above Outlet Creek in 1981 based on Thompson criteria of 0.6 feet minimum depth and 8.0 fps maximum velocity.

Above Outlet Creek

Measured Flow	Date	Transect Number	Wetted Width	Total Usable Width Feet	Total Usable Width %	Longest Continuous Portion Usable Feet	Longest Continuous Portion Usable %
37	6/2/81	1	120	0	0	0	0
		2	120	0	0	0	0
		3	120	0	0	0	0
259	4/16/81	1	134	95	71	90	67
		2	122	80	66	80	66
		3	163	112	69	105	64

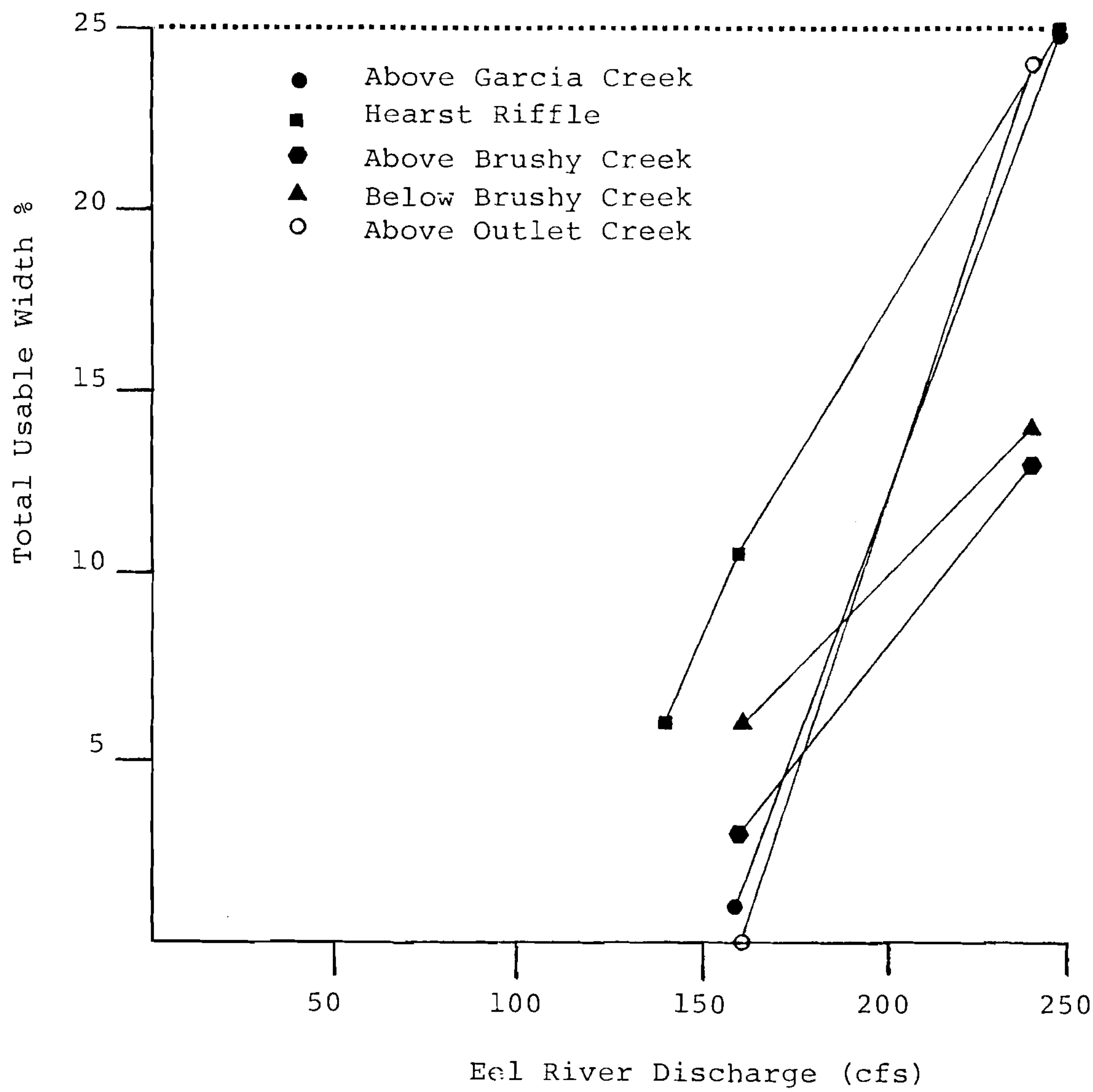

Figure 3.5-6. Relationship between Eel River discharge and the total usable width for chinook salmon passage at five critical riffles during 1980. Dotted line represents the Thompson Criteria for the minimum acceptable flow for chinook salmon passage.

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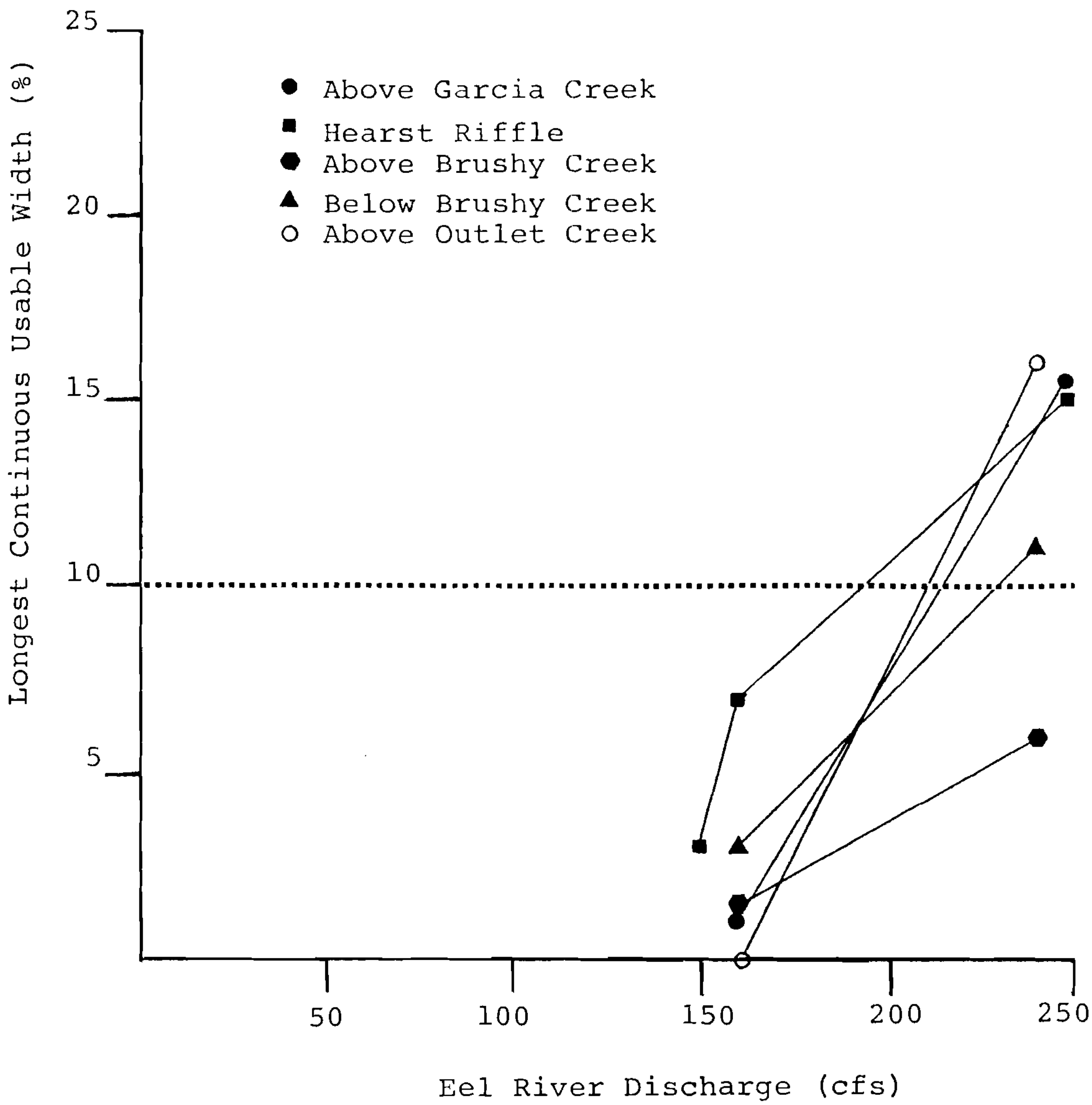

Figure 3.5-7. Relationship between Eel River discharge and the longest continuous usable width for chinook salmon passage at five critical riffles during 1980. Dotted line represents the Thompson Criteria for the minimum acceptable flow for chinook salmon passage.

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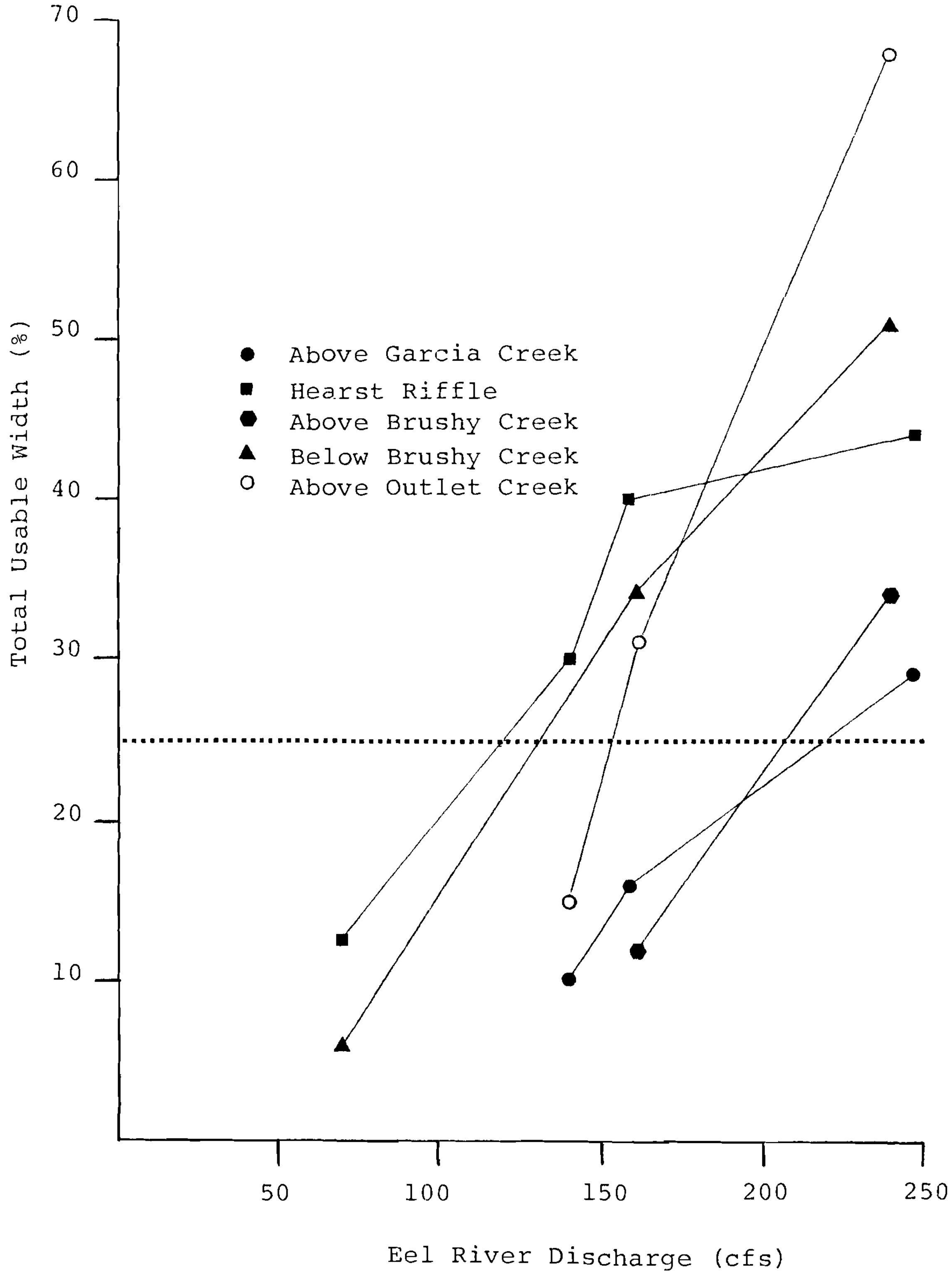

Figure 3.5-8. Relationship between Eel River discharge and the total usable width for steelhead trout passage at five critical riffles during 1980. Dotted line represents the Thompson Criteria for the minimum acceptable flow for steelhead trout passage.

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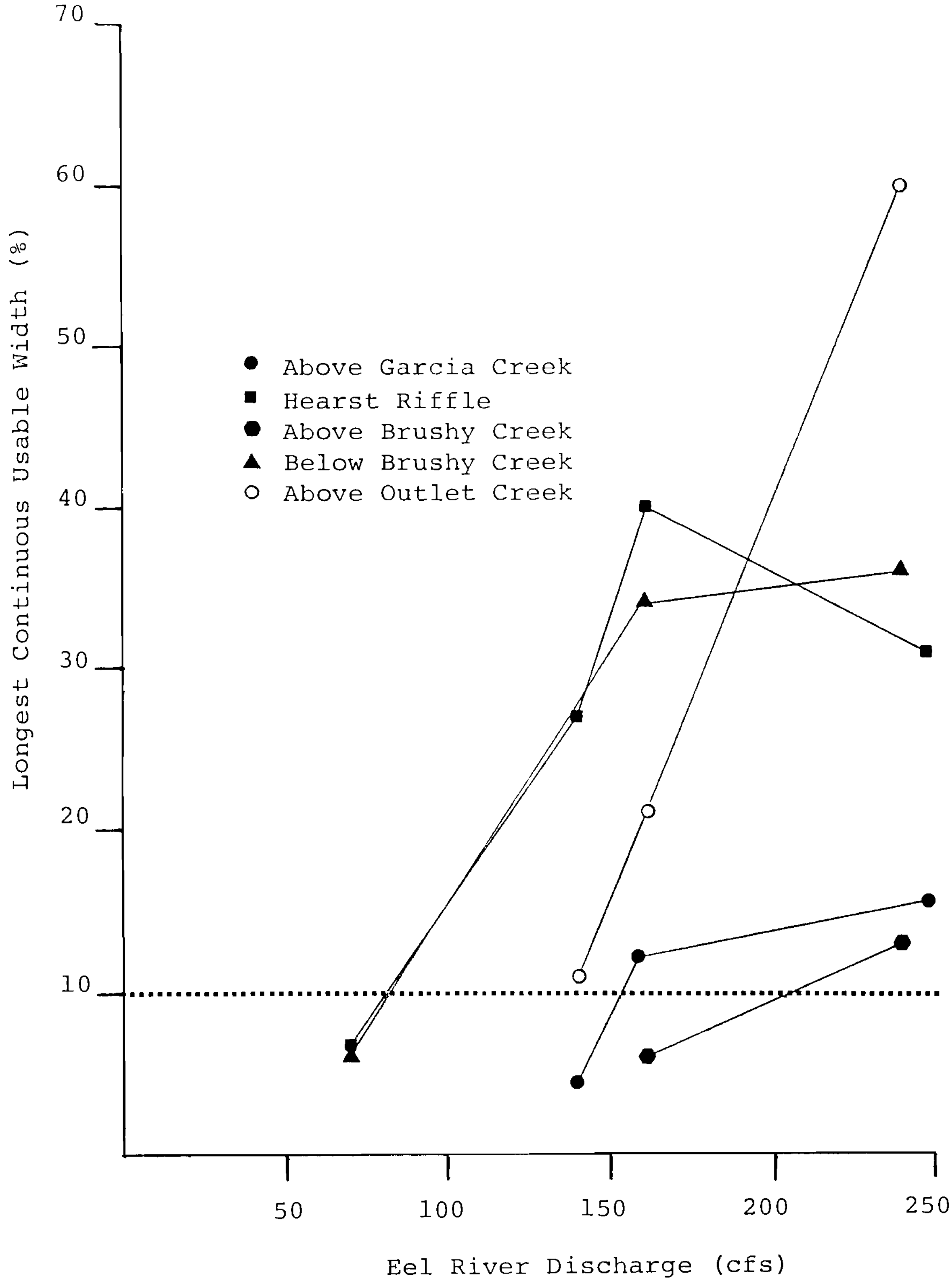

Figure 3.5-9. Relationship between Eel River discharge and the longest continuous usable width for steelhead trout passage at five critical riffles during 1980. Dotted line represents the Thompson Criteria for the minimum acceptable flow for steelhead trout passage.

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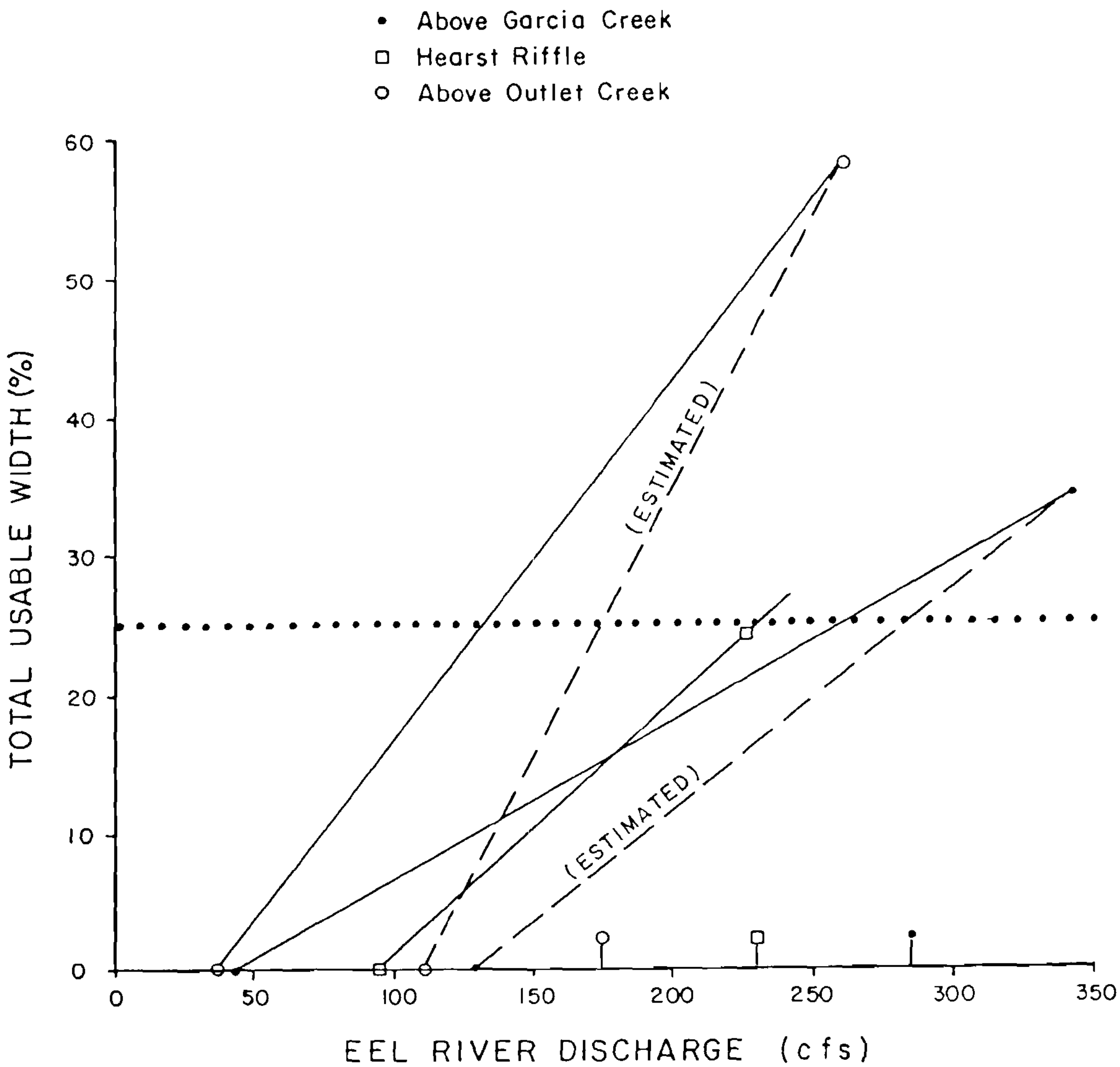

Figure 3.5-10. Relationship between Eel River discharge and the total usable width for chinook salmon passage across the shallowest transect at three critical riffles measured in 1981. Dotted line represents the Thompson Criteria for the minimum acceptable flow for upstream passage of chinook salmon.

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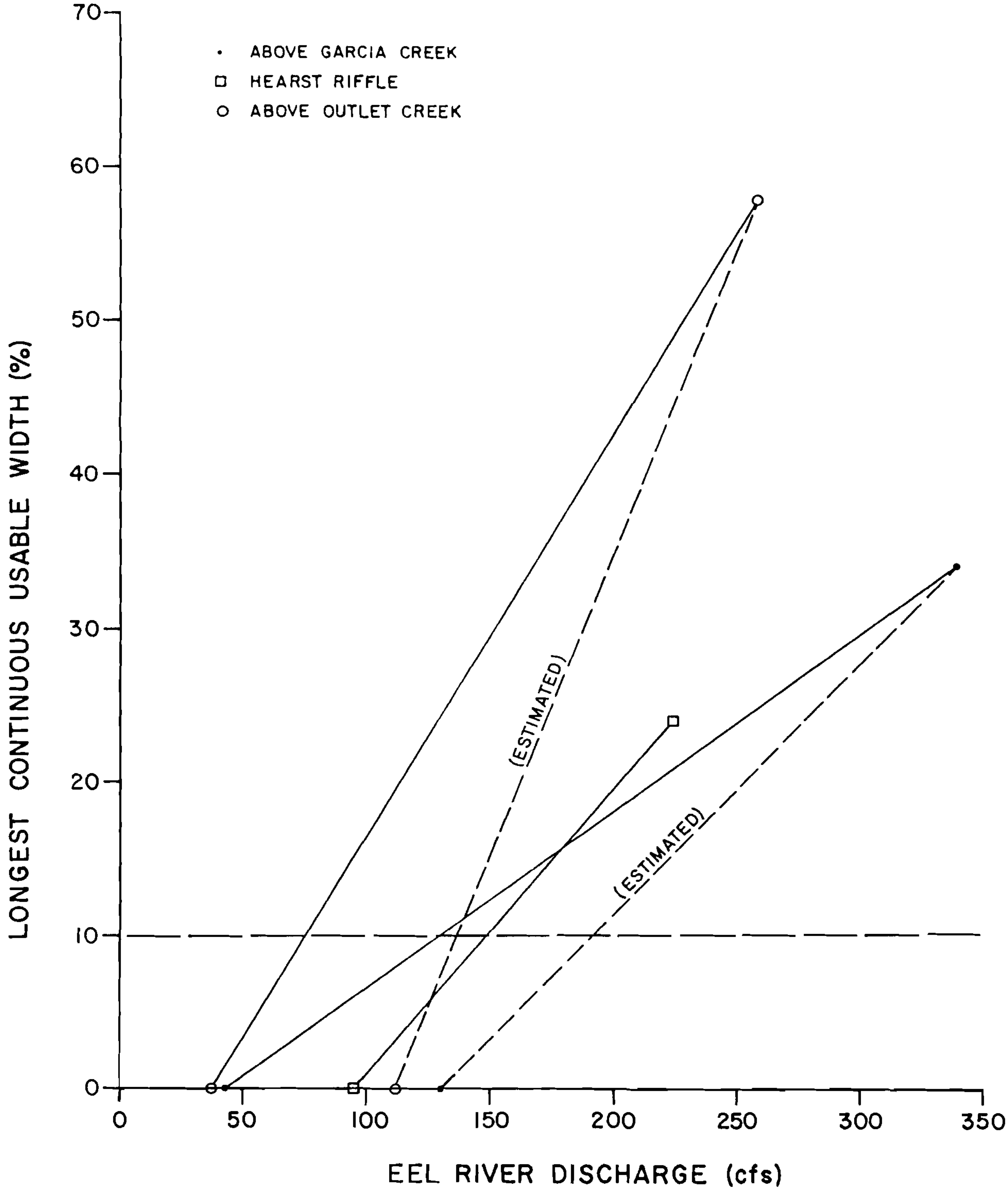

Figure 3.5-11. Relationship between Eel River discharge and the longest continuous usable width for chinook salmon passage across the shallowest transect at three critical riffles measured in 1981. Dotted line represents the Thompson Criteria for the minimum acceptable flow for upstream passage of chinook salmon.

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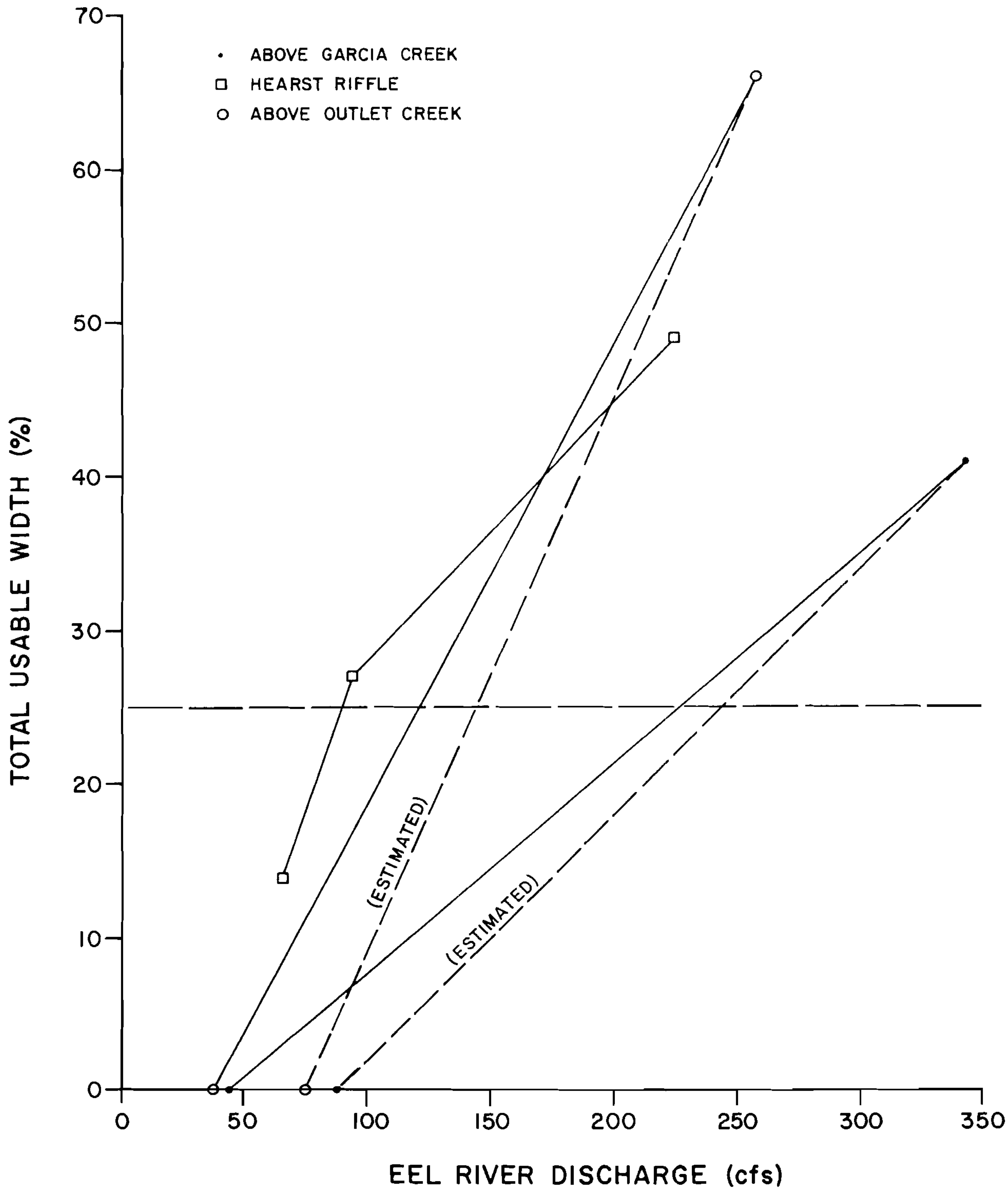

Figure 3.5-12. Relationship between Eel River discharge and the total usable width for steelhead trout passage across the shallowest transect at three critical riffles measured in 1981. Dotted line represents the Thompson Criteria for the minimum acceptable flow for upstream passage of steelhead trout.

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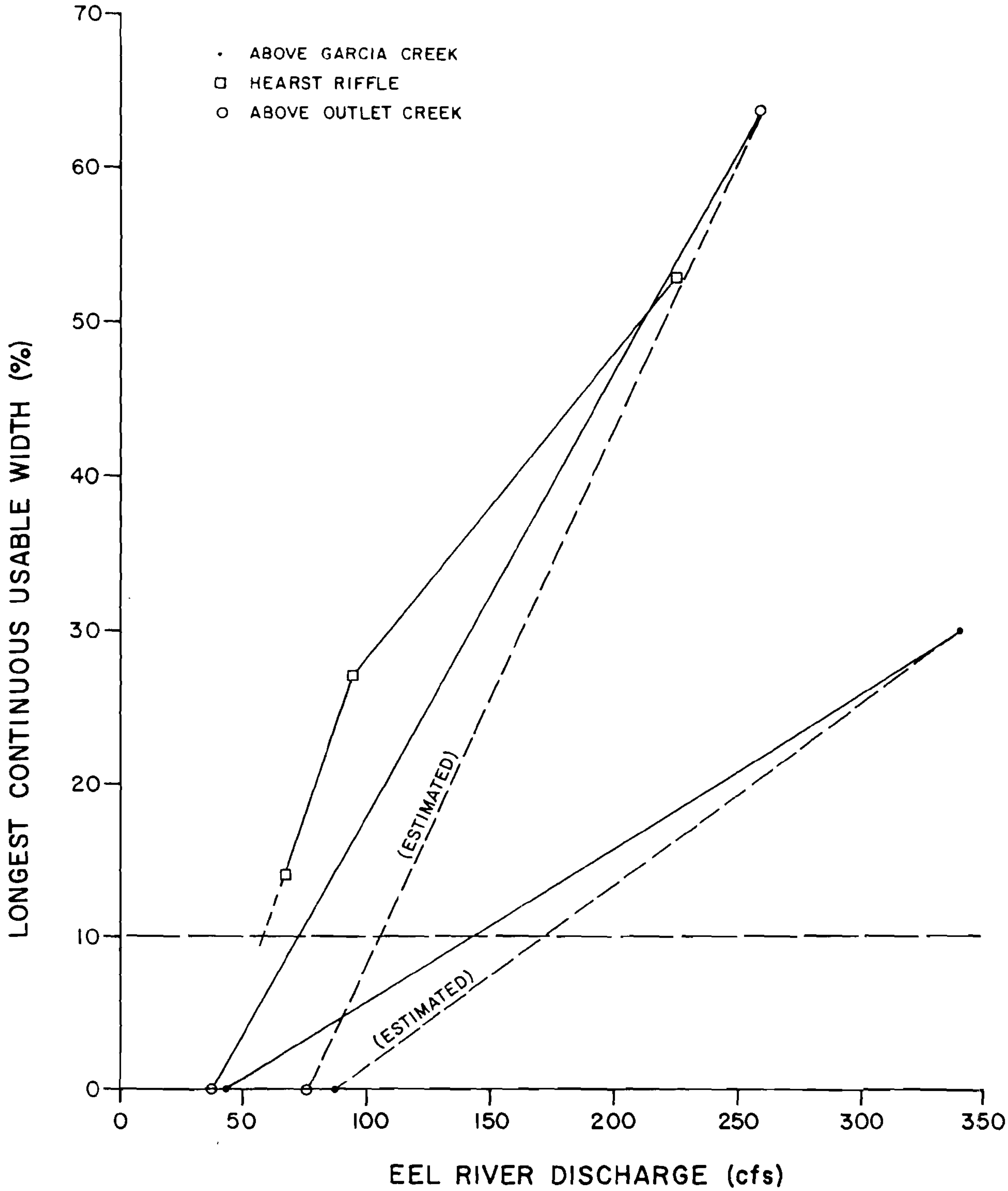

Figure 3.5-13. Relationship between Eel River discharge and the longest continuous usable width for steelhead trout passage across the shallowest transect at three critical riffles measured in 1981. Dotted line represents the Thompson Criteria for the minimum acceptable flow for upstream passage of steelhead trout.

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the 10% level for the longest continuous portion usable width for chinook salmon and steelhead trout are presented in Tables 3.5-17 and 3.5-18. The discharge was determined by extrapolation for those sites where the line did not intersect the 25% or 10% level at the highest flow measured.

Flows that meet the minimum passage criteria for the 1981 data from the riffles above Garcia Creek and above Outlet Creek could not be accurately estimated because a value of 0% usable width was obtained at the low flow level. The plot of the actual data in Figure 3.5-10 shows that the minimum passage flows for chinook salmon are not less than about 260 cfs for the riffle above Garcia Creek and 130 cfs for the riffle above Outlet Creek. A more refined estimate of minimum passage flows for the riffles above Garcia Creek and above Outlet Creek can be obtained by first estimating the minimum flow at which some usable area exists. The maximum depth on the shallowest transect of these riffles for the lowest flow measured was 0.4 ft, one-half of the 0.8 ft minimum depth criteria for chinook salmon (Thompson 1972). Inspection of 1980 data for these riffles (Appendix E) reveals that a three-fold increase in flow was required to affect an increase in maximum depth from 0.4 to 0.8 ft. If this relationship is true for the riffles in 1981, flows of 129 cfs and 111 cfs might be required on the riffles above Garcia Creek and Outlet Creek, respectively, to obtain a maximum depth of 0.8 ft. These flows were plotted on Figures 3.5-10 and 3.5-11 and used to estimate the flows that meet the 0.8 ft chinook salmon depth criteria (Table 3.5-17). A similar analysis was used to estimate flows meeting the steelhead trout depth criteria of 0.6 ft (Table 3.5-18 and Figures 3.5-12 and 3.5-13).

Minimum flows required for passage according to the Thompson criteria were different in 1980 and 1981 for the riffles measured in both years. (Tables 3.5-17 and 3.5-18). These differences reflect the dynamic nature of the Eel River streambed, which complicates selection of a recommended minimum passage flow based on these criteria.

Table 3.5-17. Eel River flows required for five critical riffles to meet the Thompson criteria for passage of adult chinook salmon during 1980 and 1981.

Riffle	Minimum Flow to Meet Criteria of 0.8 feet Depth			
	Total Usable (25%)		Longest Continuous Usable (10%)	
	1980	1981	1980	1981
Above Garcia Creek	250	285	215	188
Hearst	250	230	195	150
Above Brushy Creek	335[a]	-	315[a]	-
Below Brushy Creek	360[a]	-	230	-
Above Outlet Creek	245	175	210	159
Average[b]	288		233	

[a] Estimated by extrapolation.
[b] Recommended minimum passage flow calculated according to Thompson (1972).

Table 3.5-18. Eel River flows required for five critical riffles to meet the Thompson criteria for passage of adult steelhead trout during 1980 and 1981.

Riffle	Minimum Flow to Meet Criteria of 0.6 feet Depth: Total Usable (25%) 1980	Total Usable (25%) 1981	Longest Continuous Usable (10%) 1980	Longest Continuous Usable (10%) 1981
Above Garcia Creek	220	244	155	174
Hearst	120	91	80	59
Above Brushy Creek	205[a]	-	205[a]	-
Below Brushy Creek	130[a]	-	80	-
Above Outlet Creek	155	106	138	106
Average[b]	166		132	

[a] Estimated by extrapolation.
[b] Recommended minimum passage flow calculated according to Thompson (1972).

The Thompson criteria for water depth and velocity on shallow riffles appear to be based on intuitive knowledge of the relationship between flow (depth, velocity, and cross-sectional distance) and passage ability of chinook salmon and steelhead trout. These criteria were developed for Oregon streams and have not been validated by direct observation of passage at known depths and streamflow; however, they probably yield conservative estimates of minimum streamflows required for upstream passage, in the absence of other data.

Observations of chinook salmon passage at Hearst Riffle in 1979/80 through 1981/82, and measurements of depths and velocities on the riffle at several flow levels provide data necessary to evaluate the Thompson criteria and develop alternate criteria specific to the Eel River. These data show that several factors, including channel morphology downstream of the riffle, flow patterns over the riffle, and peak flows affect the portion of the riffle used and the streamflow required for passage. Chinook salmon passed in large numbers and with little apparent difficulty at depths of 0.6 ft and greater, while depths of 0.5 ft and less were used infrequently. These data indicate that 0.6 ft may be a more realistic minimum depth criteria for chinook salmon than 0.8 ft. This is supported by passage observations in 1980/81 when nearly all (99%) chinook salmon passed at flows less than 230 cfs, the lower of the two minimum passage flows determined using the 0.8 ft depth criteria (Table 3.5-17). However, channel morphology, particularly depth and flow, immediately downstream of Hearst Riffle had a greater influence on the path taken over the riffle than depth on the riffle. Regardless of the minimum depth criteria used, it will have little significance for fish passage unless that depth coincides with the area on the riffle to which fish are directed by the channel leading up to the riffle.

For the same reason, the longest continuous usable width or total usable width along the shallowest cross-section also has little relevance unless a portion of it is aligned with the head of the downstream channel. A total usable width of less than 5% of the wetted or bank to bank channel width could be entirely adequate for passage if properly aligned in this manner.

Hearst Riffle passage data also indicate that changes in streamflow stimulate much greater movement than stable flows. This information and the dynamic nature of the gravel bars suggest that a single, stable release flow based on the passage criteria above may not achieve the desired goal of providing adequate transportation conditions for chinook salmon or steelhead trout. Instead, a release schedule based on flows required for other purposes (i.e., spawning) and incorporating regulated pulse releases to supplement naturally occurring peak flows would probably better achieve both goals.

3.6 Instream Flow Study

Data, observations, and opinions from various knowledgeable sources concerning IFG's chinook salmon spawning depth curve indicated that modification was necessary (Table 3.6-1 and Appendix F). IFG's depth curve has an optimum suitability at about 0.6 ft to 1.1 ft and then declines sharply to a low suitability from 1.5 ft to 5.0 ft (Figure 3.6-1). This curve is based on data from Sams and Pearson (1963) and Smith (1973) (Table 3.6-1 and Appendix F). Data and observations from other sources indicate that spawning occurs at greater depths than indicated by the IFG curve (Table 3.6-1, Figure 3.6-2, and Appendix F). Individual depths measured over chinook salmon redds range from 0.3 ft (small coastal streams in Oregon) to 7.5 ft (Columbia River). Redds have been observed in depths to 15 ft in the Columbia River and 12 ft in the Sacramento River. Smith's (1973) data have been lost and are no longer available (Smith, pers. comm.) and Sams and Pearson's (1963) data are mostly from small streams on the Oregon coast. Data from medium size rivers more comparable to the Eel River like the Kalama River in Washington (Chambers, et al. 1955) and the Trinity River in California (Hinton, Appendix H) indicate comparatively more utilization of depths from 1.0 ft to 2.0 ft than indicated by Sams and Pearson's (1963) data (Figure 3.6-2). All recommended modifications to the depth curve indicated an extension of the curve to encompass greater depths (Figure 3.6-1).

All data and suggested modifications to the curves were reviewed to determine a more applicable depth curve for Eel River chinook salmon. The chinook spawning depth curve developed (Figure 3.6-1, VTN curve) increases rapidly from zero suitability at 0.5 ft to optimum levels between about 0.9 ft and 1.7 ft, declines rapidly to a low suitability at about 3.5 ft, and then declines gradually to zero suitability at 6.0 ft. This curve's optimum emcompasses the mean depths indicated by most data while also indicating some suitability at higher depths as indicated for rivers of similar size to the Eel River. This curve was used

Table 3.6-1. Summary of measurements and observations of depth on chinook salmon redds from various sources.

Source	Location	Number of Redds Observed	Mean Depth (ft)	Range (ft)	Criteria	Observations
Briggs (1953)	Prairie and Lost Creeks, N. California	8	1.1	0.8-1.3	-	-
Burner (1951)[a]	Kalama and Toutle Rivers, Washington	232	1.2	-	-	-
Chamberlain (1907)	Alaska	0	-	-	-	Spawning occurred in depths up to 2 or 3 ft.
Chambers, et al[a] (1955)	Kalama and Coweman Rivers, Washington;	137	-	0.5-3.25	-	1.0 to 2.25 ft (84%).
	Columbia River	44	-	1.8-7.5	-	4.0 to 6.5 ft (71%)
Chapman (1943)	Columbia River	0	-	-	-	Observed fish spawning in depths from 2 to 15 ft.
Hamilton and Remington (1962)	S.F. Coquille River, Oregon	12	1.1	0.7-1.6	-	-
Hinton (Appendix F)	Trinity River, N. California	35	1.25	0.8-2.0	-	-
Horton and Rogers (1969)	Van Duzen River, N. California	-	-	-	Minimum of 0.7 ft	-
Li (Appendix F)	Tucannon River, Washington	2	1.65	1.3-2.0	-	-
Miller (Appendix F)[b]	Trinity River, N. California	24	1.05	0.6-1.6	-	-
Puckett and Hinton (1974)	Main Eel and S.F. Eel Rivers, N. California	0	-	-	Minimum of 0.8 ft	-
Rantz (1964)	Eel and Mad Rivers, N. California	0	-	-	Minimum of 0.8 ft	-
Reynolds (Appendix F)	Upper S.F. Eel River, N. California	0	-	-	-	Observed spawning to occur at 1.2 to 1.5 ft. In smaller creeks observed redds in depths down to 0.8 ft.
Sams and Pearson (1963)	Humbug, E. Humbug, and Moon Creeks, Tillimook River, Oregon	107	0.87 (±.87 SD)	0.3-1.5	Minimum of 0.6 ft	-
Savage (Appendix F)	Sacramento River, N. California	0	-	-	-	Observed redds by SCUBA in in 9 to 12 ft of water.
Smith (1973)[a]	7 Oregon streams	50	1.28 (±1.75 SD)	-	Minimum of 0.8 ft	-
Westgate (1958)	Cosumnes River, California	0	-	-	0.4-4.0 ft	-

[a] Actual measurements not available.

[b] Measurements are from a man-made spawning channel where depths ranged from 0.6 ft to 1.6 ft.

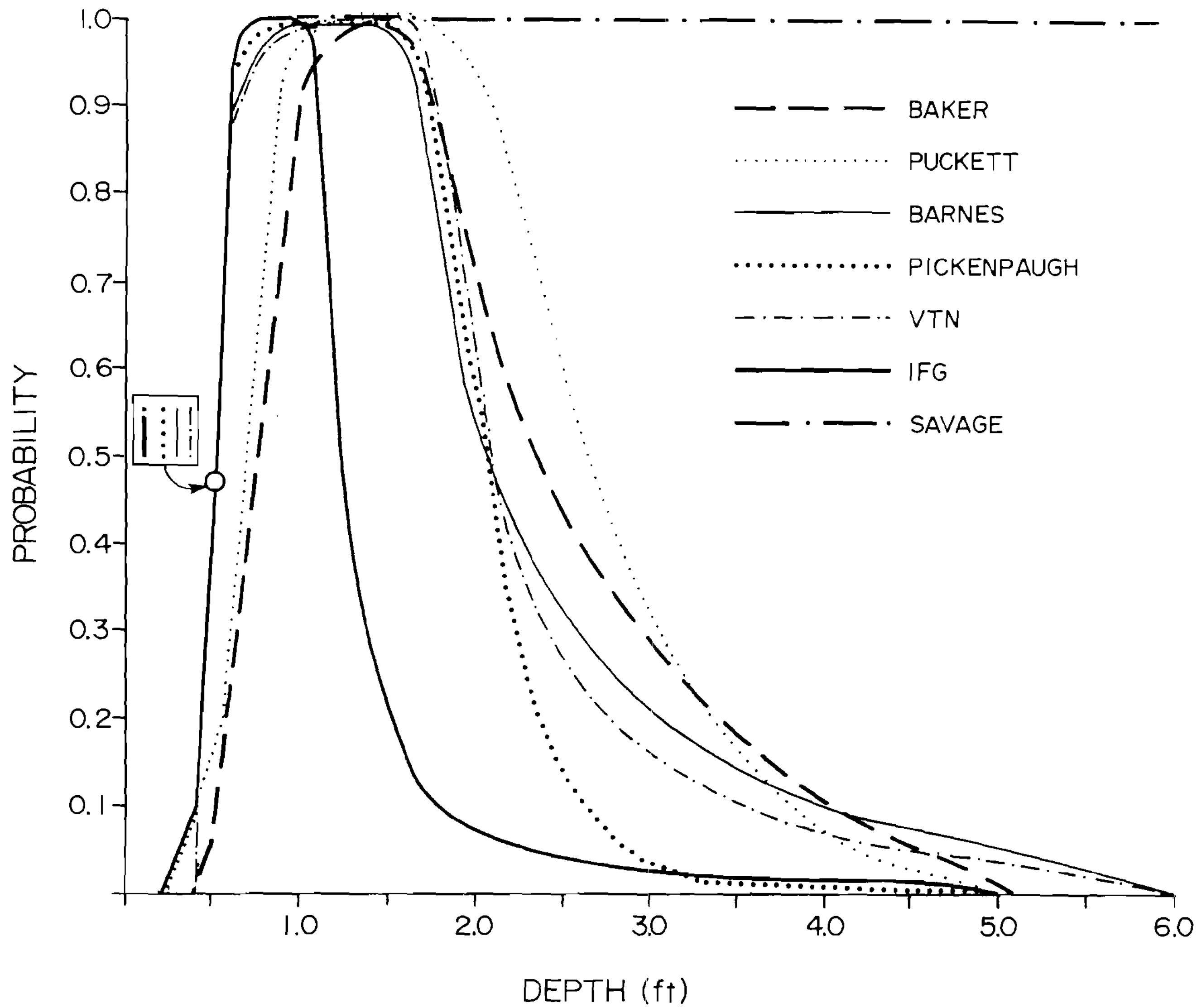

Figure 3.6-1. Depth habitat suitability index curves for chinook salmon spawning.

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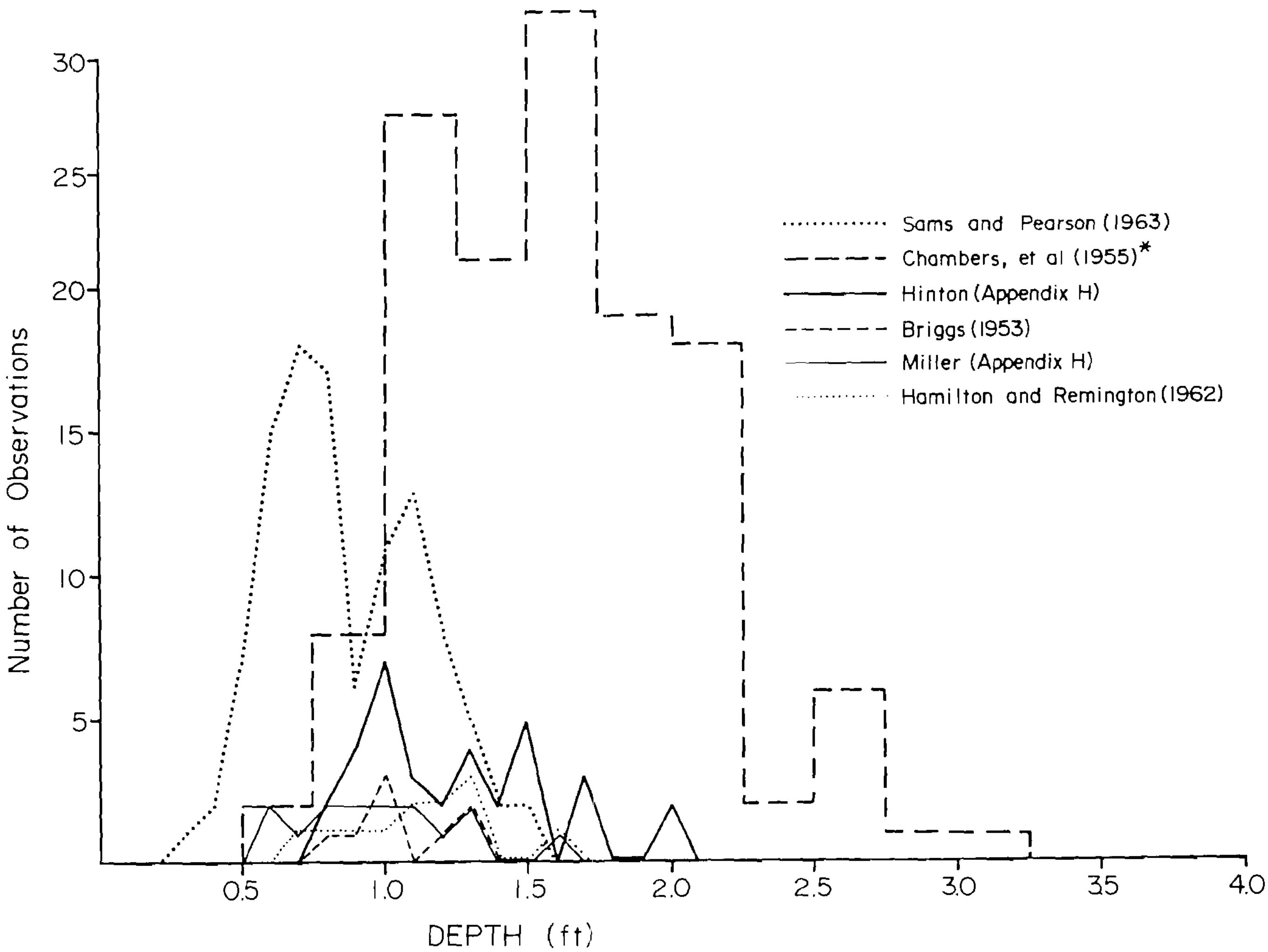

Figure 3.6-2. Water depths measured on chinook salmon redds. Data from Chambers, et al. (1955) were estimated from a graph.

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along with IFG's curves for velocity and substrate in the computer simulation for chinook spawning habitat.

Tables of Available Habitat Area (AHA) per 1,000 feet of stream and AHA expanded for each reach type, species, and life stage are shown in Appendix G. AHA per 1,000 feet of stream and expanded AHA are tabulated separately for reach types from Scott Dam to Cape Horn Dam and for reach types from Cape Horn Dam to Outlet Creek. Tables of expanded AHA with adjustment for tributary inflow for chinook salmon incubation and for steelhead incubation, adults, and fry are also in Appendix G.

Chinook salmon spawning occurs in the Eel River from November through January, with most spawning occurring in December. Following triggering flows over Cape Horn Dam during this period, tributary inflow between Cape Horn Dam and Outlet Creek is greater than 29 cfs, 90% of the time (Figure 2.6-2). AHA for chinook salmon spawning from Cape Horn Dam to Outlet Creek, adjusted for increments in tributary inflow for each reach type, is shown in Table 3.6-2 and Figure 3.6-3. Total AHA for all reach types combined peaks at a flow release of 200 cfs, with over 85% of the peak AHA still available between 150 and 300 cfs; as flows decrease below 150 cfs, total AHA declines steadily to 36% of peak at 75 cfs and continues to decline, but at a slower rate, to 13% at 8 cfs.

AHA for chinook salmon spawning is highest in Reach Types I (Emandal and Big Bend subreaches) and III, and lowest in Reach Types II and IV. AHA for Reach Type IV (no tributary inflow) peaks at a flow release of 350 cfs and remains above 90% of peak down to 300 cfs; as flows decrease, AHA decreases steadily to 19% of peak at 125 cfs, increases slightly to 23% at 60 cfs, and then continues to decrease to less than 1% at 8 cfs. For Reach Type III (12 cfs tributary inflow), AHA peaks at a flow release of 175 cfs, with over 80% of peak available between 125 cfs and 225 cfs; as flows decrease below 125 cfs, AHA decreases fairly rapidly to 27% at 60 cfs, increases slowly to 36% at 15 cfs, and then decreases to 31% at 8 cfs. For Reach Type I (Emandal and Big Bend subreaches) (18

Table 3.6-2. Available habitat area (AHA) for each reach type and total AHA for all reach types combined for chinook salmon spawning at various flows in the Eel River from Cape Horn Dam to Outlet Creek, adjusted for tributary inflow in each reach type.

Flow Release at Cape Horn Dam (cfs)	Available Habitat Area (AHA)[a] for Chinook Salmon Spawning						
	Reach Type						
	IV	III	I	II	I		Percent of Peak
	(Cape Horn) (+0 cfs)	(Todd) (+12 cfs)	(Emandal) (+18 cfs)	(Cavanaugh) (+21 cfs)	(Big Bend) (+23 cfs)	Total	Total AHA
8	55	60,467	4,886	85,289	20,461	171,158	13
12	370	67,859	6,866	91,066	28,059	194,220	15
15	955	70,490	8,974	96,686	33,757	210,862	16
20	2,781	70,135	12,487	101,909	44,614	231,926	18
25	5,204	66,310	15,633	106,956	56,378	250,481	19
30	7,160	63,069	20,854	111,502	67,655	270,240	21
40	9,780	57,939	29,077	116,258	92,174	305,228	23
50	12,675	52,414	39,757	117,967	122,787	345,600	26
60	14,060	51,699	52,097	114,625	160,725	393,206	30
75	13,208	59,303	74,765	106,513	214,660	468,449	36
85	12,525	74,555	91,183	100,871	271,716	550,850	42
100	11,814	106,754	119,159	91,701	347,347	676,775	51
125	11,512	158,925	177,959	74,958	515,446	938,800	71
150	15,349	188,419	230,382	57,988	648,826	1,140,964	87
175	23,657	193,482	267,190	43,023	739,850	1,267,202	96
200	32,247	182,062	286,556	32,370	782,405	1,315,640	100
225	40,061	158,366	285,499	25,630	768,022	1,277,578	97
250	46,200	135,241	278,502	23,040	749,127	1,232,110	94
300	57,360	98,497	257,596	21,590	687,402	1,122,445	85
350	61,663	77,434	227,122	23,903	607,090	997,212	76
400	61,469	63,836	206,425	27,349	554,797	913,876	69

[a] AHA in square feet.

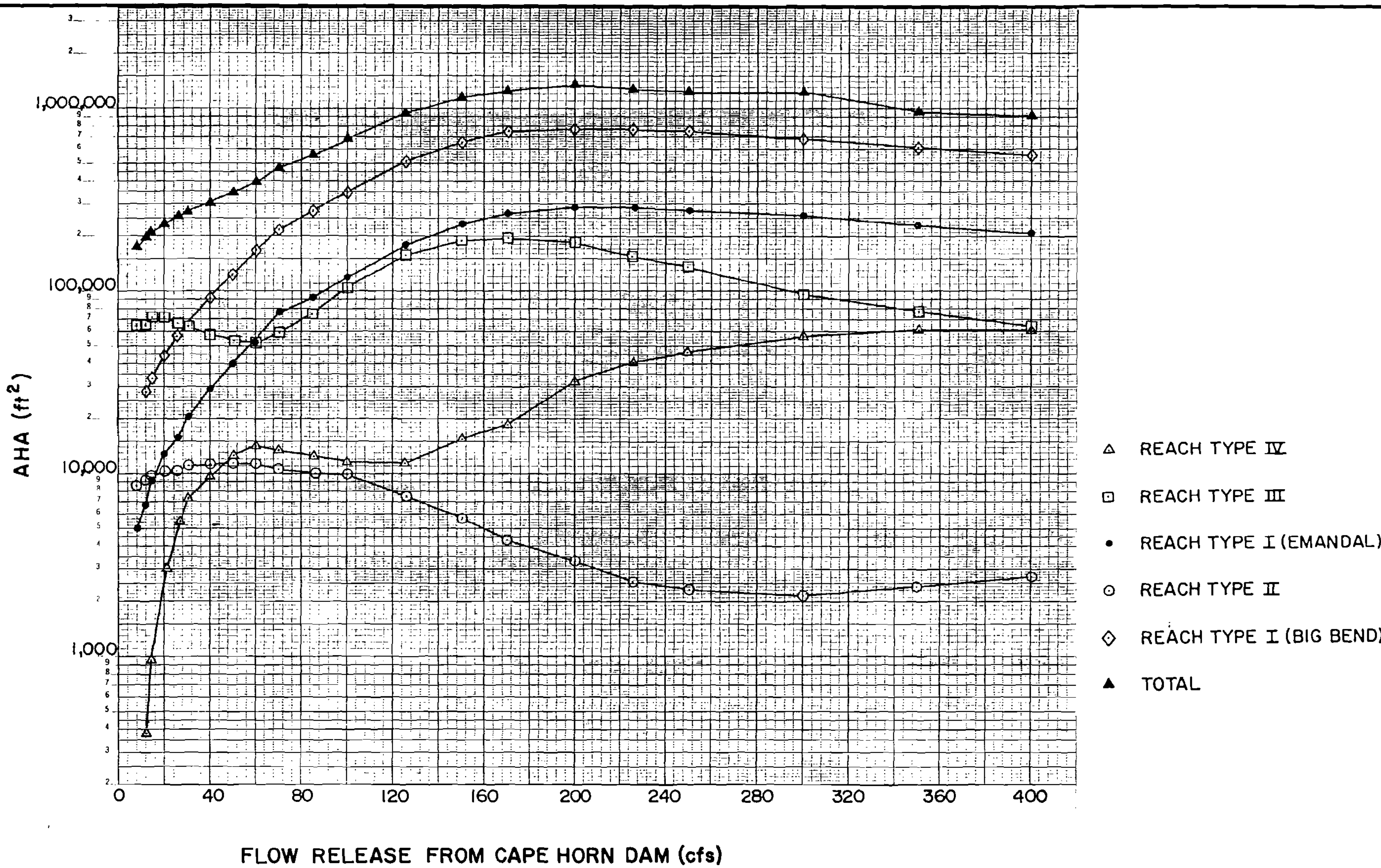

Figure 3.6-3. Available habitat area adjusted for tributary inflow for chinook salmon spawning for each reach type and total AHA for all reach types combined from Cape Horn Dam to Outlet Creek.

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and 23 cfs tributary inflows, respectively), AHA peaks at 200 cfs and remains above 75% of peak between 150 and 350 cfs; as flows decrease below 150 cfs, AHA decreases steadily to about 27% at 75 cfs and continues to decrease, but at a slower rate to about 2% at 8 cfs. AHA for Reach Type II (21 cfs tributary inflow) peaks at a 50 cfs flow release, with over 70% of peak AHA still available between 8 and 100 cfs; as flows increase above 100 cfs, AHA decreases steadily to 27% of peak at 200 cfs and then fluctuates between 18 and 23%. High AHA at low flows in Reach Type II may be due to the narrow stream channel, where depth and velocity are suitable for spawning at low flows but are not at high flows.

A flow release of 175 to 250 cfs is the optimum range (>90% of peak total) for chinook salmon spawning considering total AHA in the Eel River from Cape Horn Dam to Outlet Creek. However, when considering overall optimum flow conditions, each reach type should be weighted based on its relative importance to the specific life stage. An aerial redd survey of the Eel River between Cape Horn Dam and Outlet Creek during the 1979/80 season indicated most chinook salmon spawning activity occurred in Reach Types I and III, with Reach Type III receiving the most use (Section 3.3, Aerial Redd Survey). Thus, Reach Types I and III should probably be weighted more heavily than the other reaches when considering chinook salmon spawning flows. A flow release of 175 to 300 cfs is the optimum range for Reach Type I (Emandal and Big Bend subreaches), where the majority of the total AHA occurs. Reach Type III, which may be a more important area for chinook salmon spawning, has an optimum flow range of 150 to 200 cfs. Considering both reaches, an optimum flow release appears to be in the range of 175 cfs to 200 cfs.

The majority of steelhead trout spawning within the study area occurs between January and March. During this period, tributary inflow from Cape Horn Dam to Outlet Creek is greater than 69 cfs, 90% of the time (Figure 2.6-2). AHA for steelhead trout spawning adjusted for tributary inflow is shown in Table 3.6-3 and Figure 3.6-4. Total AHA for all

Table 3.6-3. Available habitat area (AHA) for each reach type and total AHA for all reach types combined for steelhead trout spawning at various flows in the Eel River from Cape Horn Dam to Outlet Creek, adjusted for tributary inflow in each reach type.

Flow Release at Cape Horn Dam (cfs)	Available Habitat Area (AHA)[a] for Steelhead Trout Spawning						
	Reach Type						
	IV (Cape Horn) (+0 cfs)	III (Todd) (+29 cfs)	I (Emandal) (+43 cfs)	II (Cavanaugh) (+49 cfs)	I (Big Bend) (+55 cfs)	Total	Percent of Peak Total AHA
8	277	78,626	9,242	129,442	45,367	262,954	28
12	572	84,676	11,650	134,048	53,012	283,957	30
15	978	86,919	13,455	135,282	58,745	295,379	31
20	2,583	90,659	16,780	137,337	68,301	315,661	33
25	5,936	92,939	20,314	139,393	78,444	337,026	36
30	8,962	94,853	23,848	138,455	88,587	354,704	38
40	16,474	95,315	31,264	134,158	108,222	385,434	41
50	24,261	94,238	38,575	128,481	131,407	416,961	44
60	28,976	90,256	46,625	120,739	158,141	444,738	47
75	32,979	82,969	61,457	108,784	204,565	490,753	52
85	33,557	80,469	72,748	102,041	243,945	532,760	56
100	35,584	80,030	94,596	92,130	304,057	606,397	64
125	34,668	95,610	132,396	70,148	402,615	735,438	78
150	36,769	116,468	163,944	53,094	474,453	844,729	90
175	39,973	131,278	184,438	45,054	516,116	916,858	97
200	42,255	132,465	195,138	40,668	533,288	943,813	100
225	43,615	124,974	196,773	37,319	530,842	933,523	99
250	44,098	112,455	195,869	34,007	524,844	911,273	97
300	46,824	91,157	182,760	28,843	482,877	832,462	88
350	43,938	73,966	162,869	24,699	427,947	733,419	78
400	38,711	63,755	145,436	22,356	382,248	652,506	69

[a] AHA in square feet.

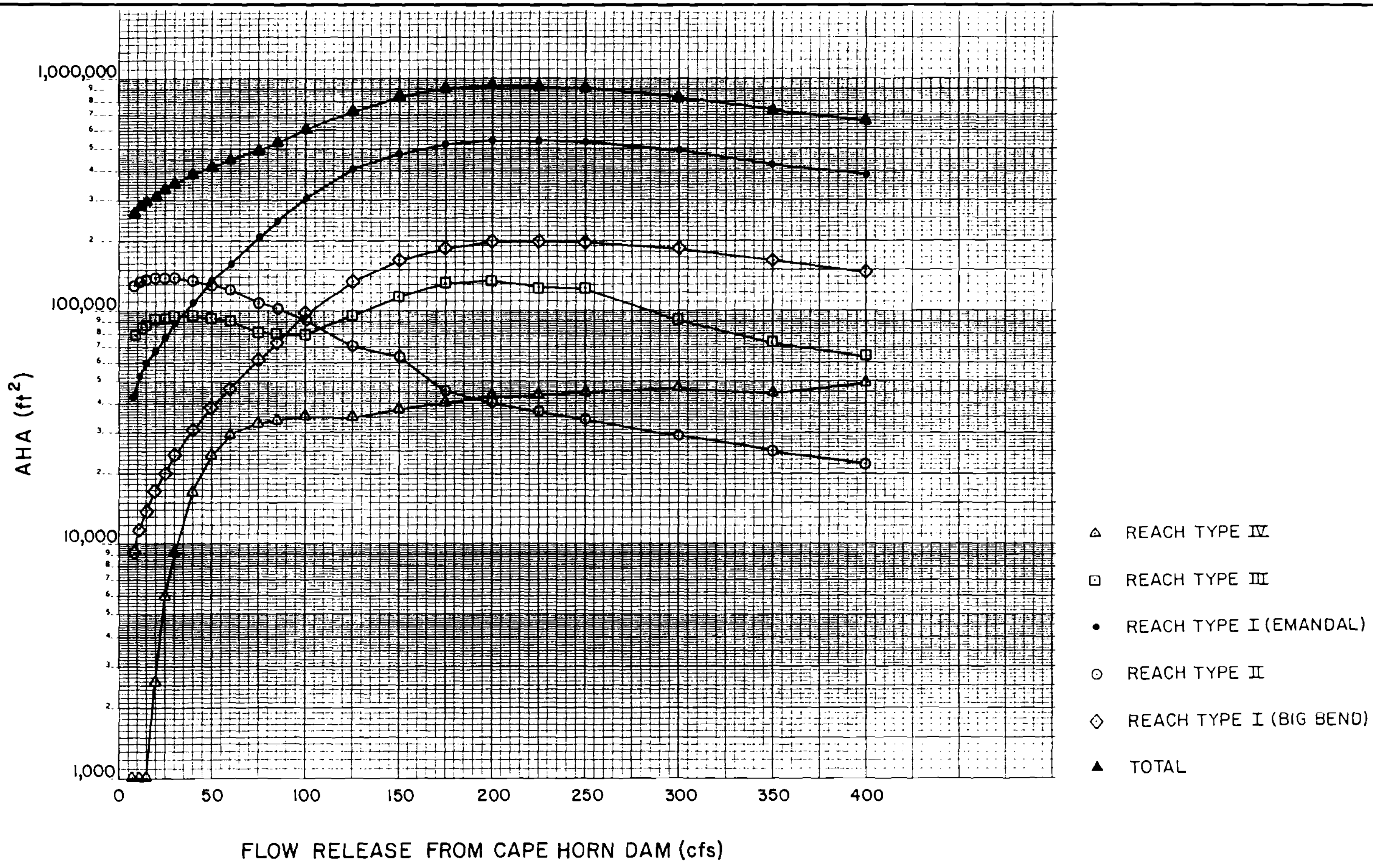

Figure 3.6-4 Available habitat area adjusted for tributary inflow for steelhead spawning for each reach type and total AHA for all reach types combined from Cape Horn Dam to Outlet Creek.

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reach types combined peaks at a flow release of 200 cfs, with over 75% of peak AHA still available between 125 and 350 cfs; as flows decrease below 125 cfs, AHA steadily decreses to 28% of peak at 8 cfs. AHA is highest in Reach Types I and III, and lowest in Reach Types II and IV. AHA for Reach Type IV (no tributary inflow) peaks at 300 cfs and remains above 70% of peak between 75 and 400 cfs; as flows decrease below 75 cfs, AHA decreases rapidly to less than 1% at 8 cfs. AHA for Reach Type III (29 cfs tributary inflow) peaks at a 200 cfs flow release, with over 80% of peak AHA still available between 150 and 250 cfs; as flows decrease below 150 cfs, AHA decreases to 60% of peak at 100 cfs, increases slowly to 72% at 40 cfs, and then decreases to 59% at 8 cfs. AHA for Reach Type I (Emandal subreach) (43 cfs tributary inflow) peaks at a 225 cfs flow release and remains above 80% of peak between 150 and 350 cfs; as flows decrease below 150 cfs, AHA decreases steadily to 31% of peak at 75 cfs and continues to decrease, but at a slower rate to 5% at 8 cfs. AHA for Reach Type II (49 cfs tributary inflow) peaks at a flow release of 25 cfs, with over 75% of peak AHA still available between 8 and 75 cfs; as flows increase above 75 cfs, AHA steadily decreases to 38% of peak at 150 cfs and continues to decrease, but at a slower rate to 16% at 400 cfs. AHA for Reach Type I (Big Bend subreach) (55 cfs tributary inflow) peaks at 200 cfs and follows a pattern similar to the Emandal subreach; AHA remains above 80% of peak between 150 and 350 cfs; as flows decrease below 150 cfs, AHA decreases steadily to 38% at 75 cfs and continues to decrease to 9% at 8 cfs. Weighing all reaches equally, optimum flow releases for steelhead spawning range from 150 to 250 cfs from January through March.

Little information exists about steelhead spawning in the mainstem Eel River from Cape Horn Dam to Outlet Creek due to turbid water conditions during their spawning period. Although surveys of tributaries to the Eel River indicate that most steelhead going over Cape Horn Dam spawn in the mainstem Eel River (Section 3.2, Tomki Creek/Eel River Salmon Carcass Survey), this may not be the case from Cape Horn Dam to Outlet Creek due to unsuitable summer rearing conditions in the mainstem.

Production of juvenile steelhead smolts in the Eel River from Cape Horn Dam to Outlet Creek appears low due to high summer temperatures (Section 3.8, Summer Fish Inventory), possibly resulting in low returns of adults to this river section. Maintaining flows for chinook salmon spawning and incubation from Cape Horn Dam to Outlet Creek and steelhead passage over Cape Horn Dam may be more appropriate than maintaining flows for steelhead spawning below Cape Horn Dam.

Flow releases following a triggering flow at Cape Horn Dam should be maintained at a level adequate for chinook salmon passage, spawning, and incubation. From February through April, flows should be maintained for chinook salmon incubation, for passage of steelhead over Cape Horn Dam, and less importantly for steelhead spawning and incubation. Due to increased tributary inflow during February and March, optimum conditions could be maintained with lower flow releases from Cape Horn Dam. Flow releases that are adequate for spawning should also be adequate for incubation.

As discussed in Methods (Section 2.6, Instream Flow Study), initial calculations of AHA for juvenile steelhead between Cape Horn Dam and Outlet Creek were modified for temperature suitability. To accomplish this, a habitat suitability curve for temperature had to be developed. Kubicek (1977) categorized maximum daily temperatures $\geq$28.0°C for at least 100 continuous minutes as lethal to steelhead trout; from 26.5°C up to, but not including, 28.0°C as marginal; 20.0°C to 26.5°C as submarginal; and $\leq$20.0°C as optimum. The habitat suitability curve for temperature was developed using these categories in conjunction with observations of steelhead trout during summer fish inventories (Section 3.8, Summer Fish Inventory) (Figure 3.6-5). The curve was drawn using a probability scale for habitat suitability versus maximum daily water temperature from 20.0°C to 30.0°C. A straight line was drawn from 0.9999 probability at 20.0°C to 0.0001 probability at 30.0°C. On a linear scale this would appear as a sigmoid curve.

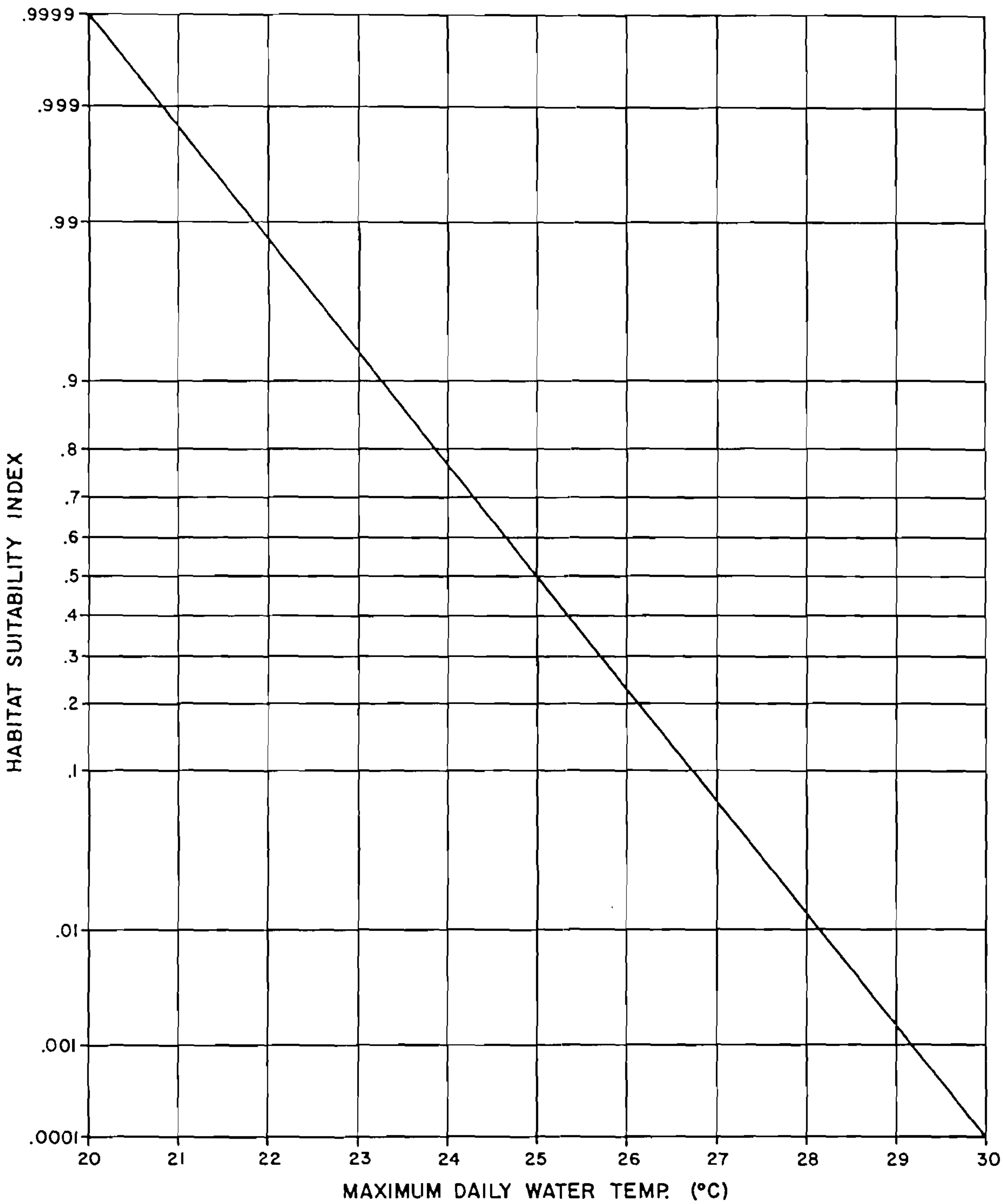

Figure 3.6-5. Temperature habitat suitability curve for juvenile steelhead in the Eel River from Cape Horn Dam to Outlet Creek.

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To apply the habitat suitability curve for temperature to the instream flow study data, the relationship between streamflow and maximum daily water temperature had to be developed for each reach type. Simple linear regressions of maximum daily temperatures versus flow were calculated using daily maximum temperature data collected during mid-summer by DWR in 1973 (DWR 1973, unpublished data) and during the 1980 mid-summer flow releases from Cape Horn Dam for the instream flow and critical riffle studies (Figure 3.6-6). Temperatures in Reach Type IV are shown to be below marginal levels (<26.5°C) at all flows, although marginal temperatures as high as 27.5°C have been recorded in this reach. AHA was reduced the least by temperature modification in Reach Type IV. Temperatures declined below lethal levels (<28.0°C) above 32 cfs in Reach Type III, 35 cfs in Reach Type I (Emandal subreach), 47 cfs in Reach Type II, and 96 cfs in Reach Type I (Big Bend subreach). Temperatures declined below marginal levels (<26.5°C) above 76 cfs in Reach Type III, 83 cfs in Reach Type I (Emandal subreach), 91 cfs in Reach Type II, and 166 cfs in Reach Type I (Big Bend subreach). A discussion of temperature effects on steelhead is included in Section 3.8, Summer Fish Inventory.

AHA for juvenile steelhead modified for temperature is shown in Table 3.6-4 and Figure 3.6-7. At low flows, total AHA for steelhead juveniles is very close to AHA for Reach Type IV, alone. AHA for Reach Types III, II, and I are very low at low flows due to unsuitable temperatures. Increases in modified AHA for small increases in flow are due to slight reductions in temperature as well as increases in wetted area. Even though modified AHA increases as flows increase in all reach types, flows needed to maintain temperatures below lethal or marginal levels (<28.0°C and 26.5°C, respectively) are relatively high (e.g., 30 and 75 cfs, respectively, in Reach Type III).

AHA expanded for each reach type in the Eel River from Scott Dam to Cape Horn Dam for chinook and steelhead spawning and steelhead juveniles are shown in Tables 3.6-5 through 3.6-7. Reach Type VI has very little

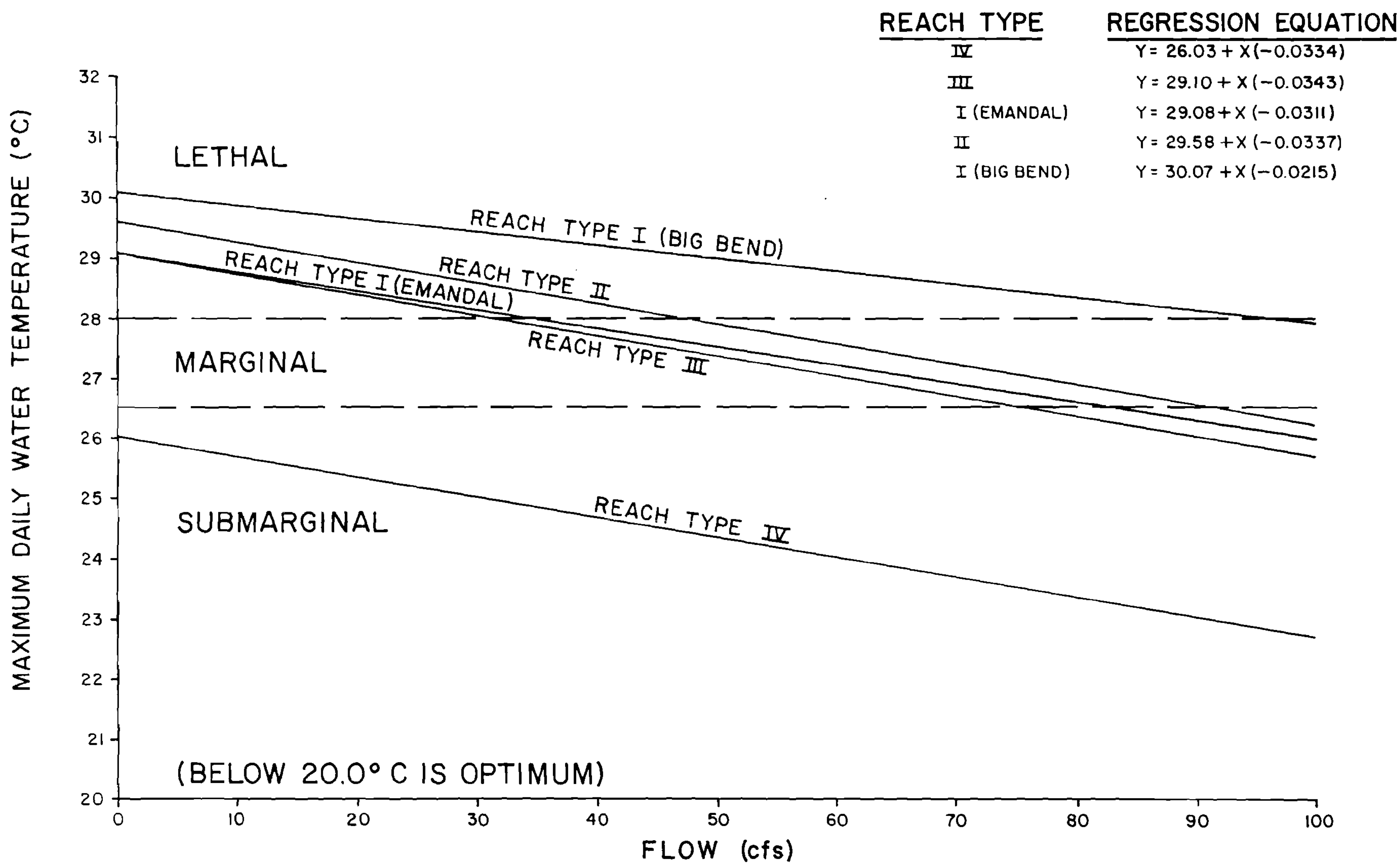

Figure 3.6-6. Relationship between streamflow and maximum daily water temperatures during midsummer for reach types in the Eel River from Cape Horn Dam to Outlet Creek.

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Table 3.6-4. Available habitat area (AHA) for each reach type and total AHA for all reach types combined for steelhead juveniles at various flows in the Eel River from Cape Horn Dam to Outlet Creek. AHA is modified for temperature in each reach type.

Flow Release at Cape Horn Dam (cfs)	Available Habitat Area (AHA)[a] for Steelhead Juveniles						
	Reach Type						
	IV (Cape Horn)	III (Todd)	I (Emandal)	II (Cavanaugh)	I (Big Bend)	Total	Percent of Peak Total AHA
8	15,011	481	200	111	22	15,825	0.8
12	23,842	768	395	196	71	25,272	1.2
15	28,437	1,154	686	274	93	30,644	1.5
20	35,680	2,008	1,196	484	194	39,562	1.9
25	44,946	3,443	2,152	757	374	51,672	2.5
30	55,348	4,595	3,547	1,025	639	65,154	3.1
40	74,424	11,516	10,240	2,255	1,384	99,819	4.8
50	93,720	19,114	17,560	3,772	2,297	136,463	6.5
60	115,651	29,090	30,078	6,734	4,066	185,619	8.9
75	136,976	67,619	57,345	13,590	8,164	284,144	13.6
85	155,233	91,400	97,911	18,074	12,354	374,972	17.9
100	170,992	143,916	153,086	30,652	28,793	527,439	25.2
125	193,774	250,447	295,052	55,134	72,521	866,928	41.5
150	211,024	342,977	446,126	72,703	141,905	1,214,635	58.1
175	226,985	377,534	531,543	80,740	287,427	1,504,229	72.0
200	236,251	377,630	554,331	79,373	446,436	1,694,021	81.0
225	245,640	357,366	544,584	74,240	658,387	1,880,217	89.9
250	250,517	332,339	512,524	69,805	839,827	2,005,012	95.9
300	250,278	293,856	449,411	64,145	1,032,812	2,090,502	100.0
350	248,091	269,931	400,705	62,993	1,040,052	2,021,772	96.7
400	241,613	262,723	368,042	64,263	985,125	1,921,766	91.9
500	234,520	257,841	318,931	72,126	862,294	1,745,712	83.5

[a] AHA in square feet.

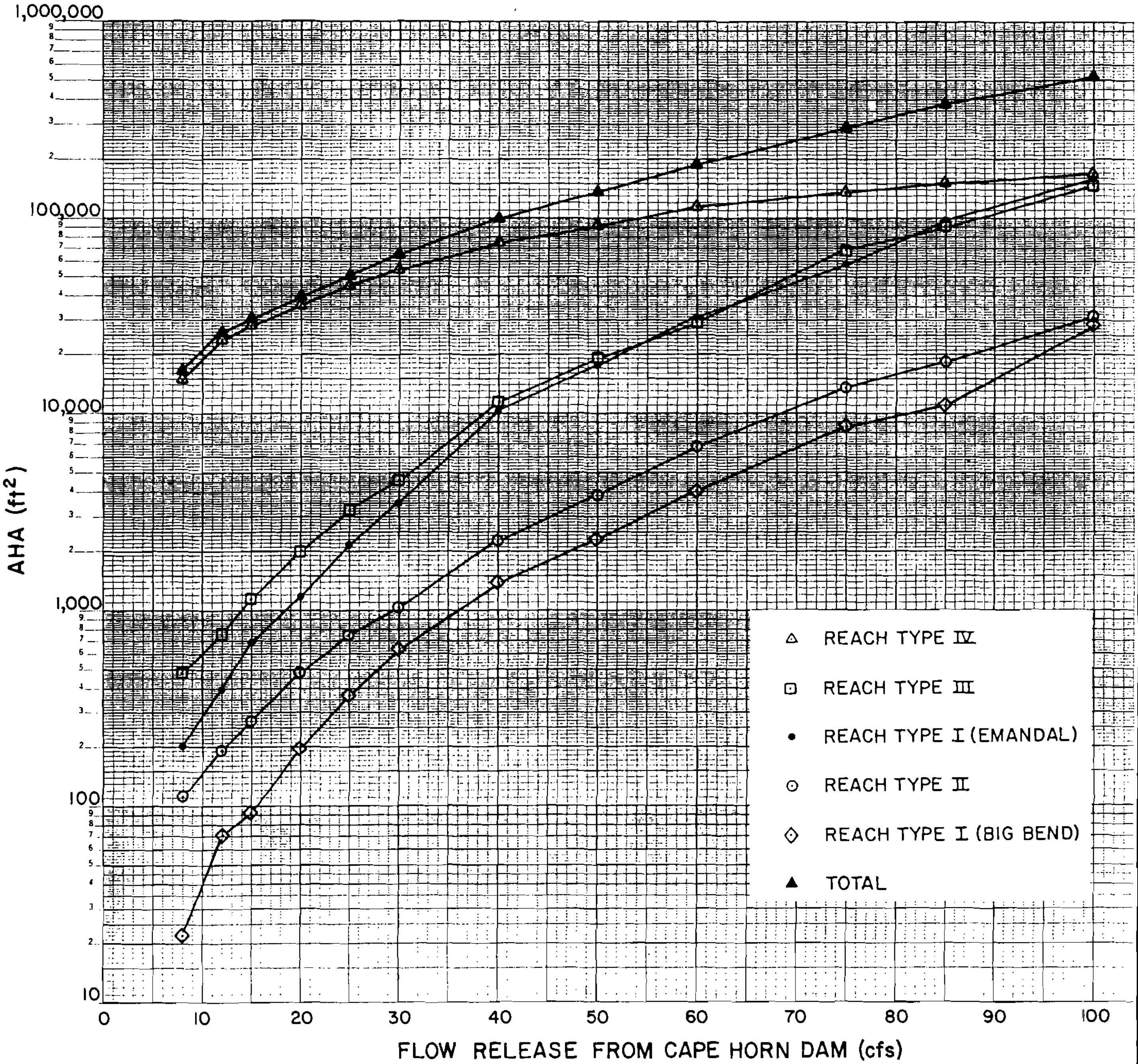

Figure 3.6-7. Temperature modified available habitat area for steelhead juveniles for each reach type and total AHA for all reach types combined from Cape Horn Dam to Outlet Creek.

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Table 3.6-5. Available habitat area (AHA) for each reach type and total AHA for all reach types combined for chinook salmon spawning at various flows in the Eel River from Scott Dam to Cape Horn Dam.

Flow Release at Scott Dam (cfs)	Available Habitat Area[a] (AHA) for Chinook Salmon Spawning: Reach Type V (Trout)	Reach Type VI (Slides)	Total	Percent of Peak Total AHA
68	8,018	0	8,018	22
100	17,509	0	17,509	49
125	25,781	44	25,825	72
170	35,579	139	35,718	100
200	30,929	211	31,140	87
230	29,586	276	29,862	84
265	30,627	324	30,951	87
300	28,650	321	28,971	81
400	26,452	249	26,701	75
500	23,598	170	23,768	67
600	21,847	97	21,944	61

[a] AHA in square feet.

Table 3.6-6. Available habitat area (AHA) for each reach type and total AHA for all reach types combined for steelhead trout spawning at various flows in the Eel River from Scott Dam to Cape Horn Dam.

	Available Habitat Area[a] (AHA) for Steelhead Trout Spawning			
	Reach Type			
Flow Release at Scott Dam (cfs)	V (Trout)	VI (Slides)	Total	Percent of Peak Total AHA
68	11,801	0	11,801	16
100	23,439	0	23,439	32
125	34,257	0	34,257	47
170	60,032	0	60,032	83
200	70,421	0	70,421	97
230	72,708	0	72,708	100
265	64,420	0	64,420	89
300	50,040	0	50,040	69
400	27,900	0	27,900	38
500	29,841	0	29,841	41
600	25,267	0	25,267	35

[a] AHA in square feet.

Table 3.6-7. Available habitat area (AHA) for each reach type and total AHA for all reach types combined for steelhead trout juveniles at various flows in the Eel River from Scott Dam to Cape Horn Dam.

Flow Release at Scott Dam (cfs)	Available Habitat Area[a] (AHA) for Steelhead Trout Juveniles: Reach Type V (Trout)	Reach Type VI (Slides)	Total	Percent of Peak Total AHA
68	400,721	257,548	658,268	86
100	481,936	264,436	746,372	98
125	507,964	257,392	765,356	100
170	508,211	240,007	748,218	98
200	477,691	205,873	683,564	89
230	435,691	216,989	652,680	85
265	383,327	226,957	610,285	80
300	335,785	226,760	562,545	74
400	275,588	223,707	499,295	65
500	230,827	204,334	435,161	57
600	204,149	187,314	391,463	51

[a] AHA in square feet.

spawning area for chinook salmon or steelhead trout due primarily to the absence of suitable substrate. AHA for Reach Type V for chinook salmon spawning peaks at 170 cfs, with over 80% of peak AHA available between 170 and 300 cfs; AHA declines rapidly below and moderately above this range. For steelhead spawning, AHA peaks at 230 cfs, with over 80% of peak AHA available between 170 and 265 cfs; AHA declines rapidly above and below this range.

Total AHA for juvenile steelhead for all reach types combined peaks at a flow release of 125 cfs, with nearly 80% of peak AHA available between 68 and 265 cfs; as flows increase above 265 cfs, AHA declines slowly. AHA for juvenile steelhead is higher in Reach Type V than in Reach Type VI. AHA for Reach Type V is greatest between 100 cfs and 230 cfs and declines gradually above and below this range. AHA for Reach Type VI shows relatively little change from 68 cfs to 600 cfs. Maximum daily water temperatures in the Eel River from Scott Dam to Cape Horn Dam are suitable for steelhead rearing ($\leq$23.5°C) (Appendix H); thus, AHA for juvenile steelhead in these reach types was not adjusted for temperature.

Eel River Water Temperatures

Daily maximum and minimum water temperatures recorded at four locations in the Eel River between Scott Dam and Outlet Creek from July through September 1980, at six Eel River stations from May to October 1981, and at five Eel River stations and one Tomki Creek station from March through September 1982 are presented in Appendix H and Figures 3.6-8 through 3.6-23. Water quality data collected periodically at each station during 1981 are also presented in Appendix H. Temperatures in the Eel River generally increase with distance from Scott Dam to Outlet Creek. Water is normally released at Scott Dam from the bottom of Lake Pillsbury and is relatively cool. As this water travels downstream, it warms in response to the warm summer climate, lack of shading and diversion of water at Cape Horn Dam.

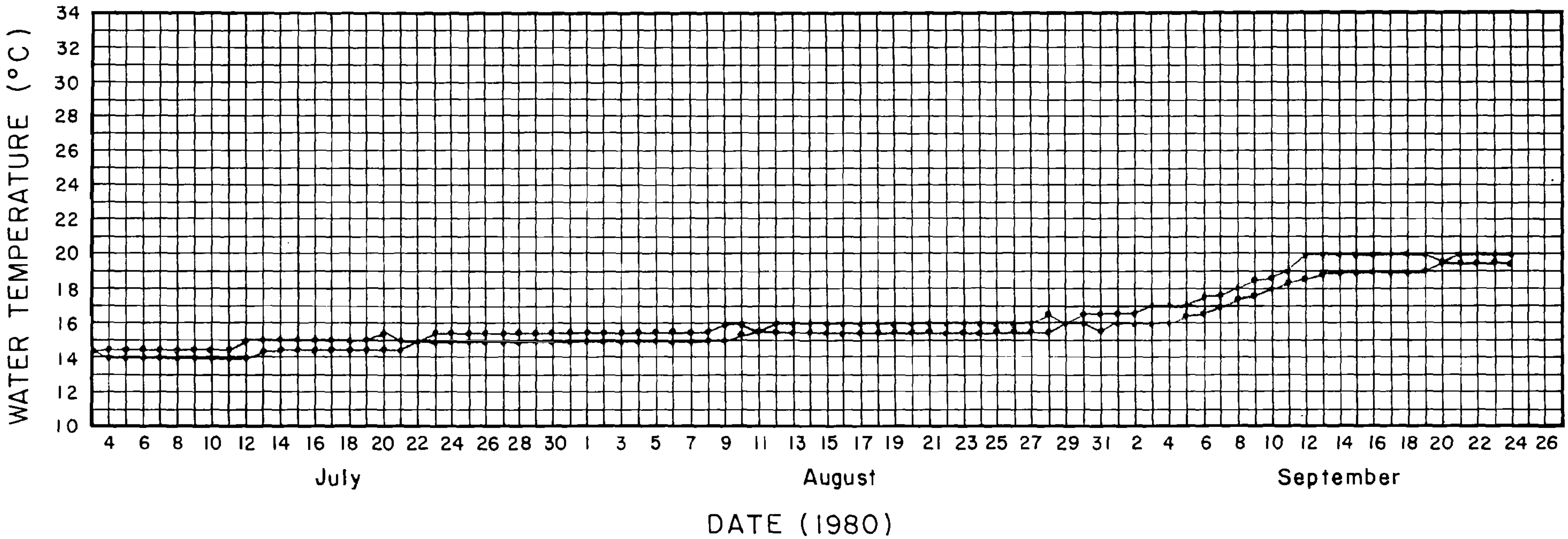

Figure 3.6-8. Daily maximum and minimum water temperatures recorded at Station 1 in the Eel River below Scott Dam in July, August, and September 1980.

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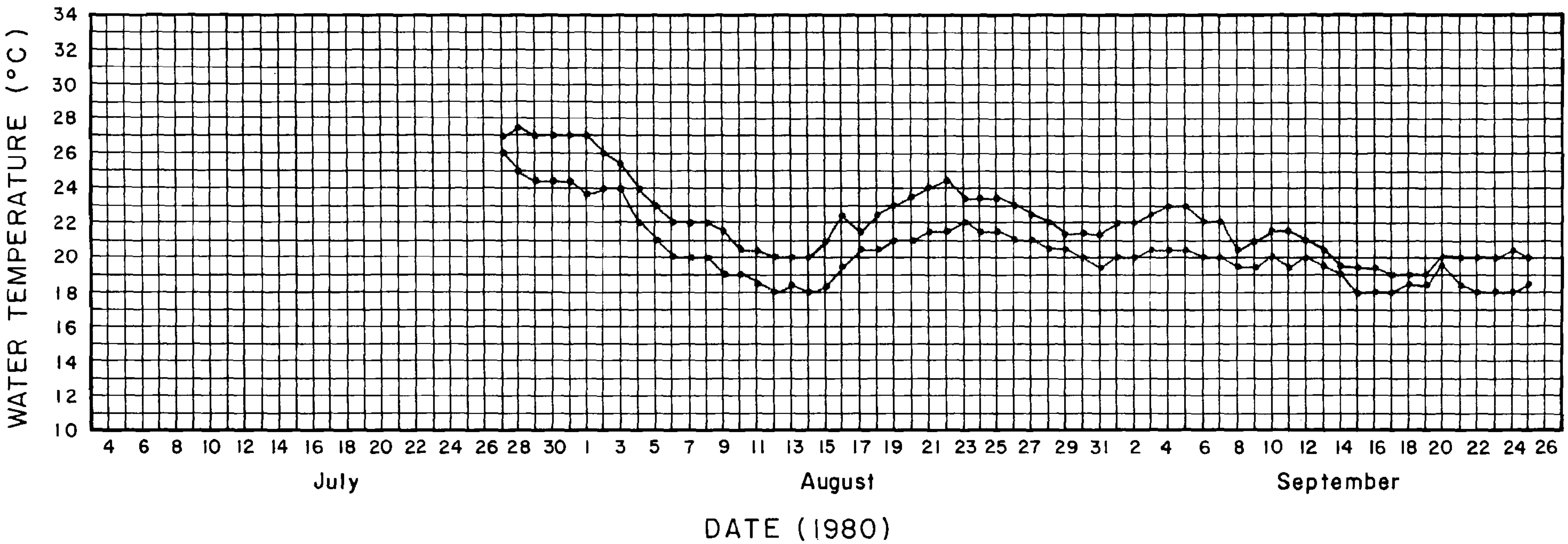

Figure 3.6-9. Daily maximum and minimum water temperatures recorded at Station 3 in the Eel River below Cape Horn Dam in July, August, and September 1980.

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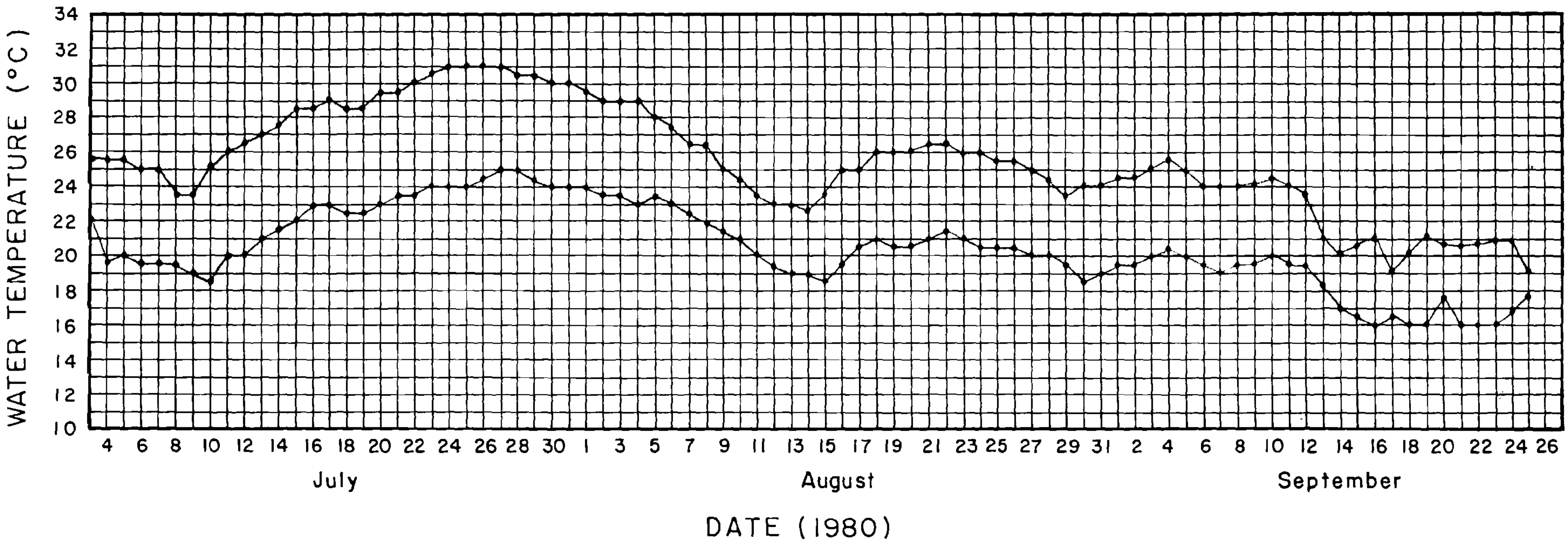

Figure 3.6-10. Daily maximum and minimum water temperatures recorded at Station 5 in the Eel River below Hearst Riffle in July, August, and September 1980.

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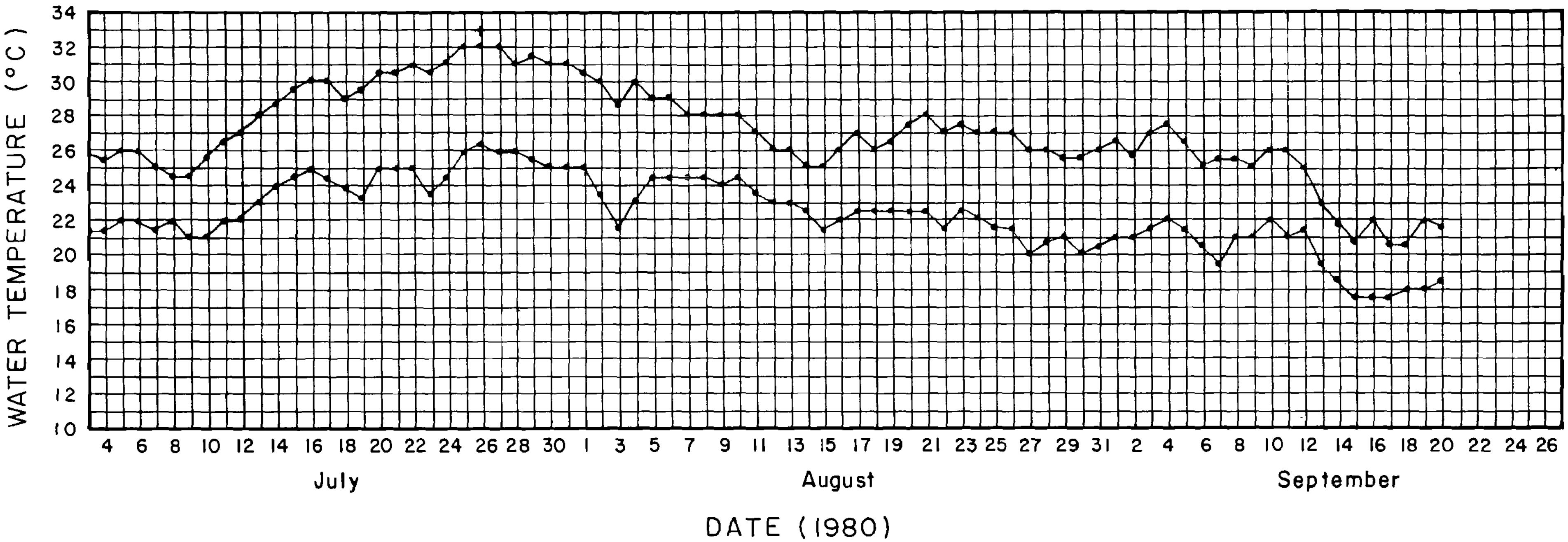

Figure 3.6-11. Daily maximum and minimum water temperatures recorded at Station 6 in the Eel River above Outlet Creek in July, August, and September 1980.

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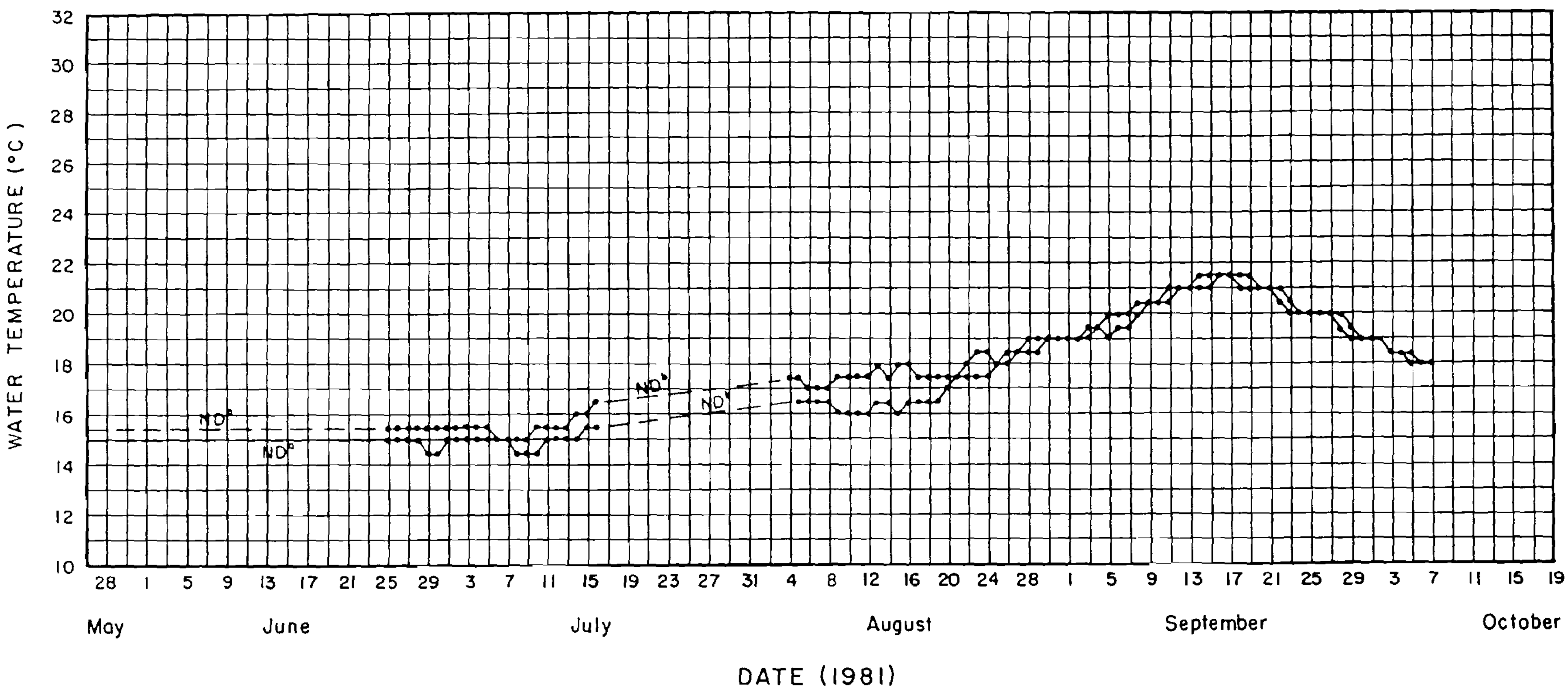

ND - No data
a - From May 27 through June 24, the maximum temperature was 15.0°C, and the minimum temperature was 12.0°C (see text).
b - From July 17 through August 3, the maximum temperature was 17.0°C, and the minimum temperature was 15.0°C (see text).

Figure 3.6-12. Daily maximum and minimum water temperatures recorded at Station 1 in the Eel River below Scott Dam from May to October 1981.

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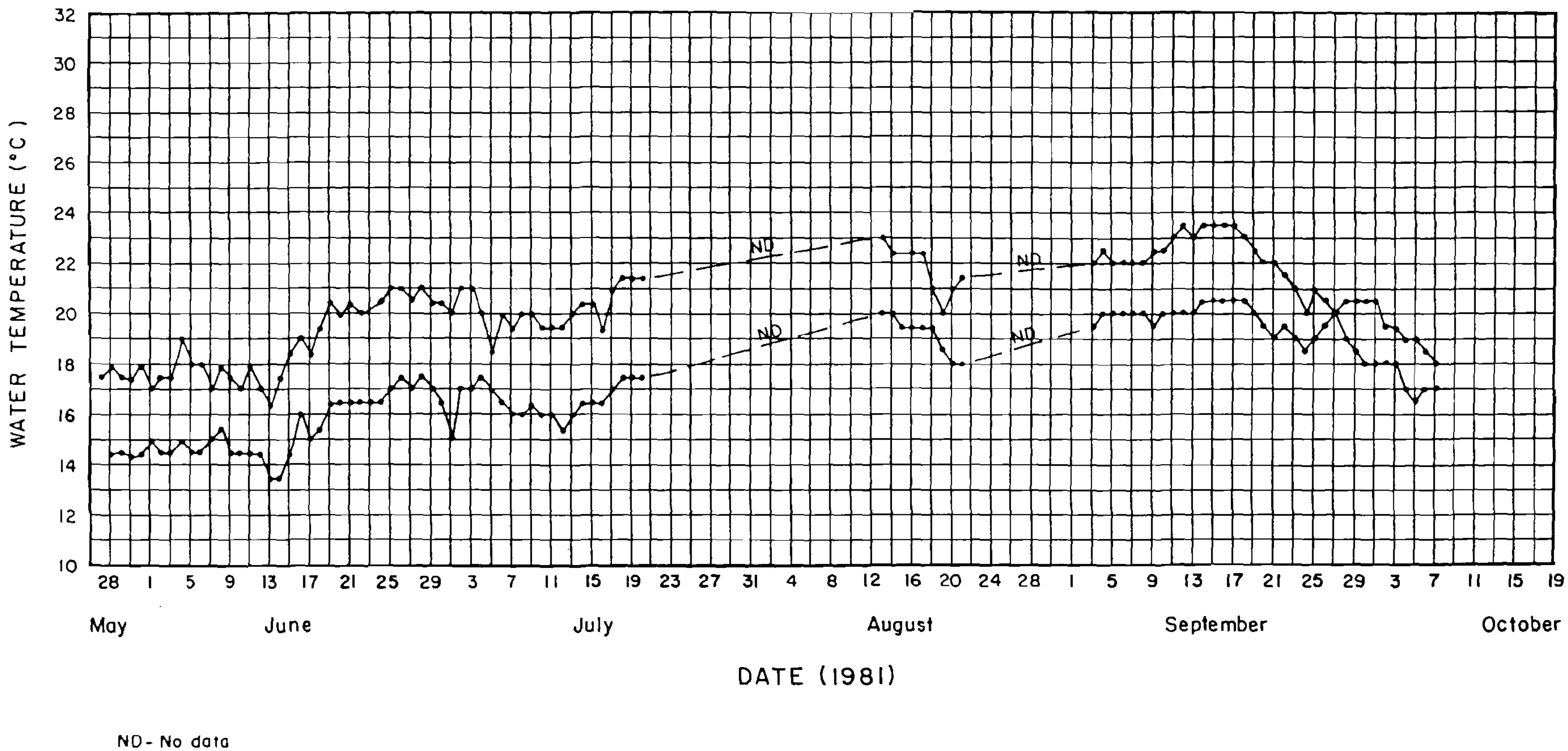

Figure 3.6-13. Daily maximum and minimum water temperatures recorded at Station 2 in the Eel River below Trout Creek from May to October 1981.

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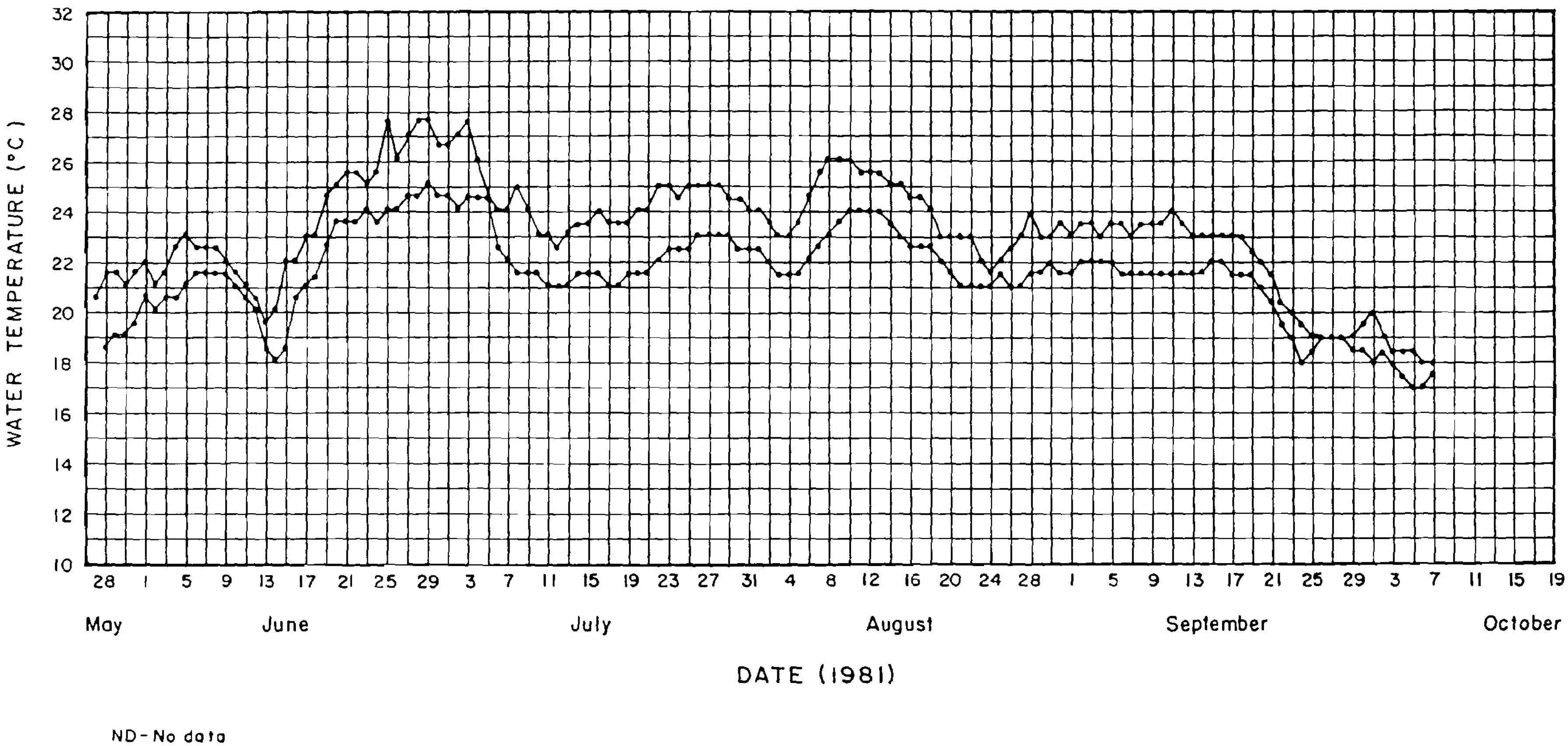

Figure 3.6-14. Daily maximum and minimum water temperatures recorded at Station 3 in the Eel River below Cape Horn Dam from May to October 1981.

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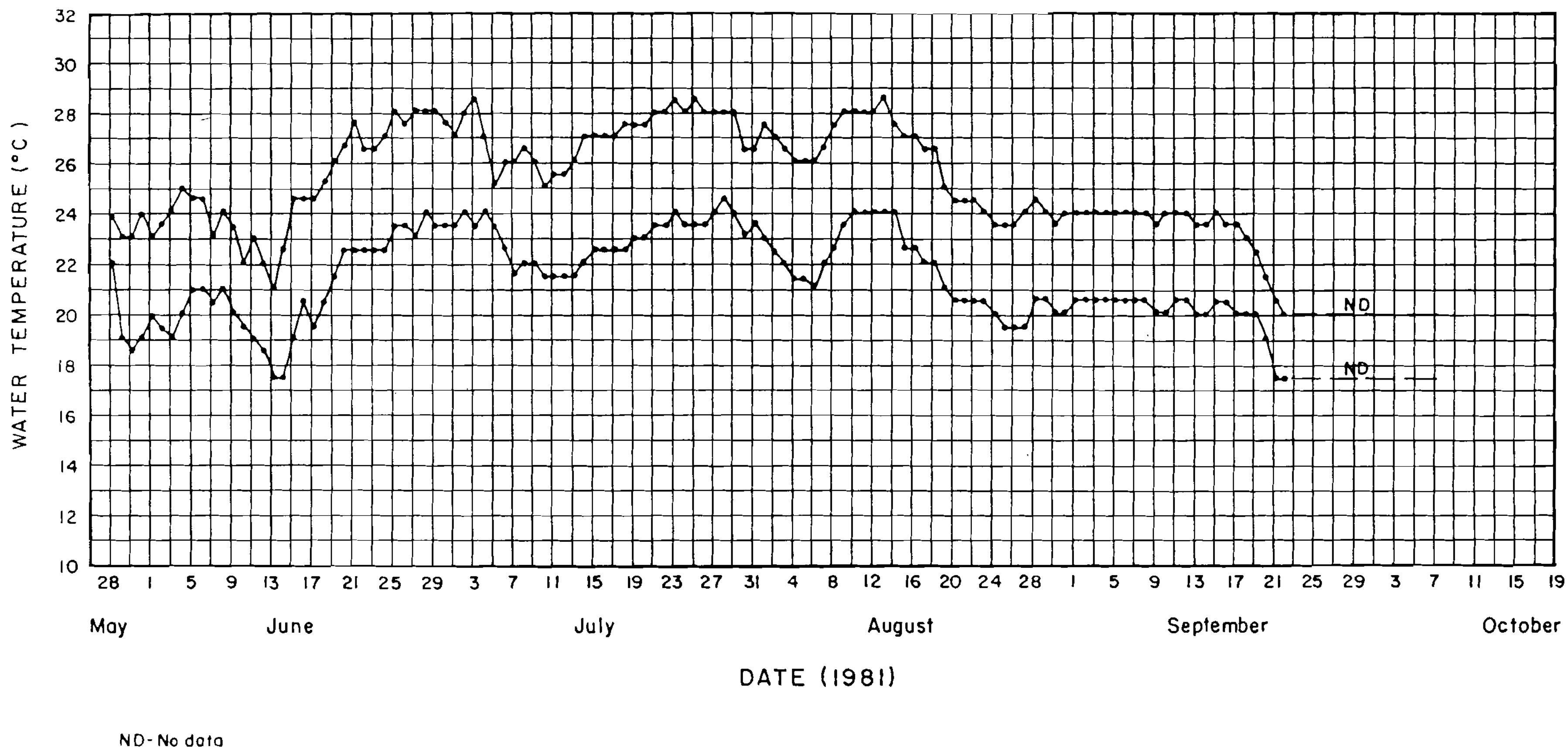

Figure 3.6-15. Daily maximum and minimum water temperatures recorded at Station 4 in the Eel River below Tomki Creek fom May to October 1981.

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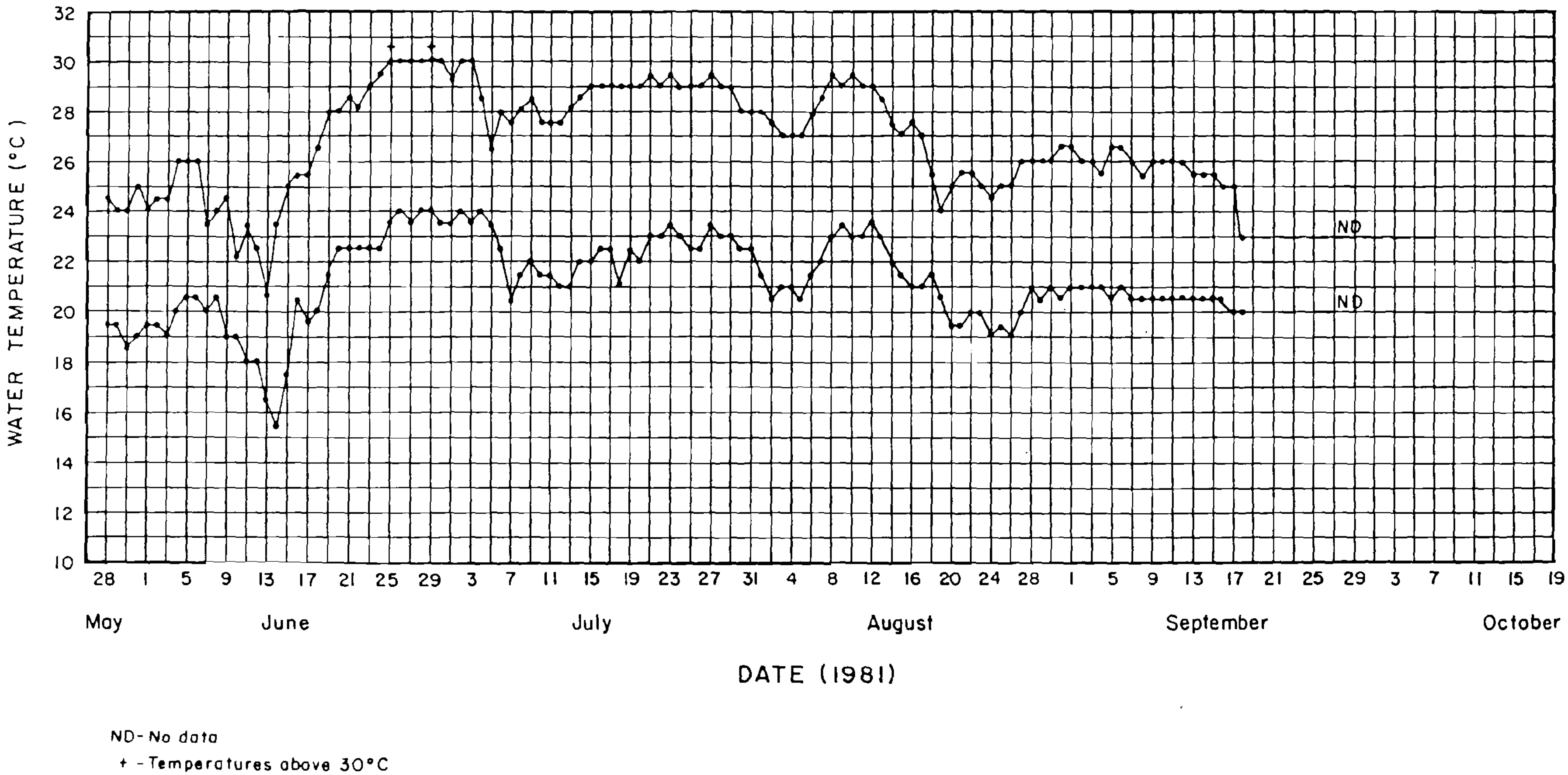

Figure 3.6-16. Daily maximum and minimum water temperatures recorded at Station 5 in the Eel River below Hearst Riffle from May to October 1981.

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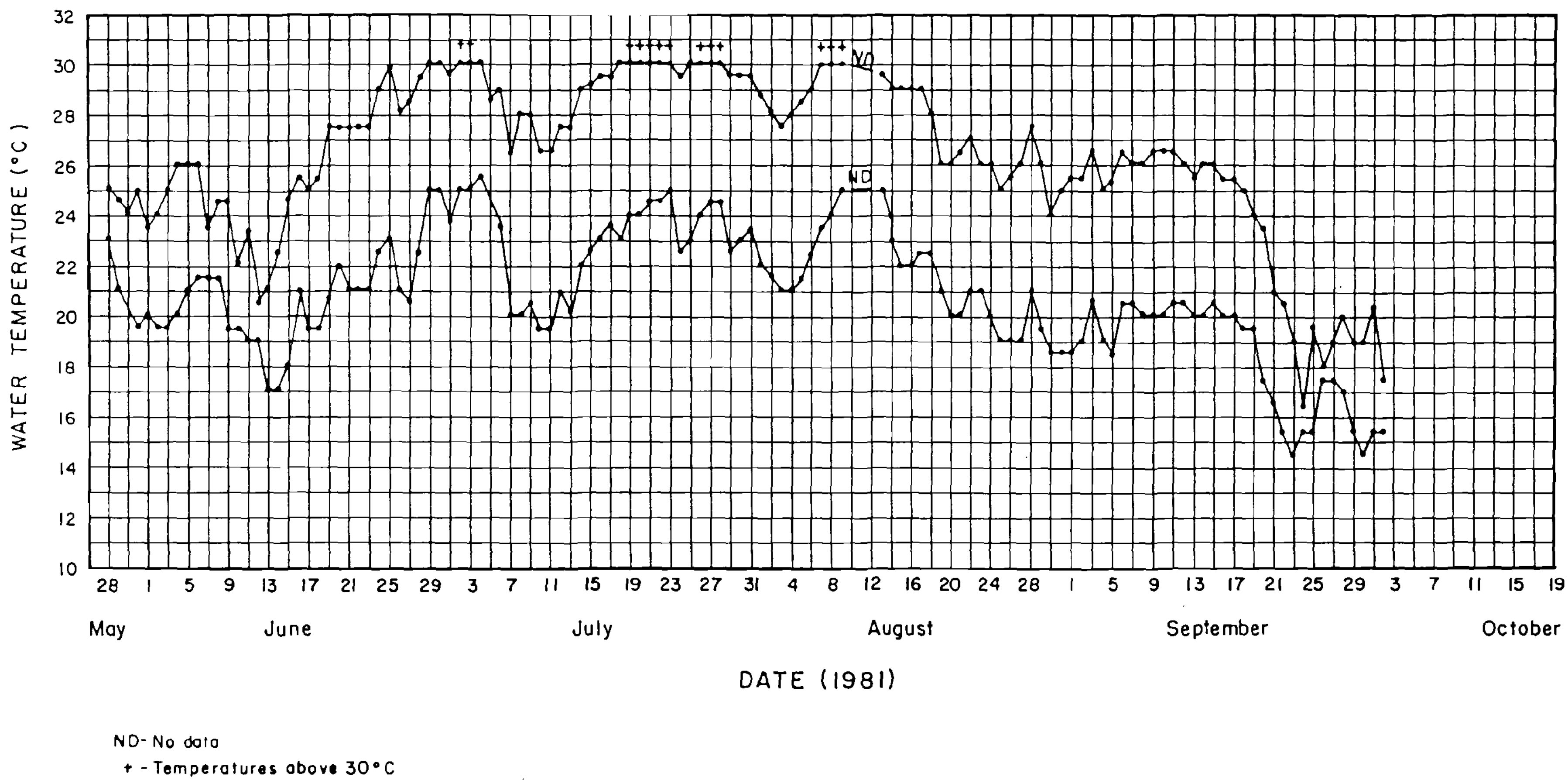

Figure 3.6-17. Daily maximum and minimum water temperatures recorded at Station 6 in the Eel River above Outlet Creek from May to October 1981.

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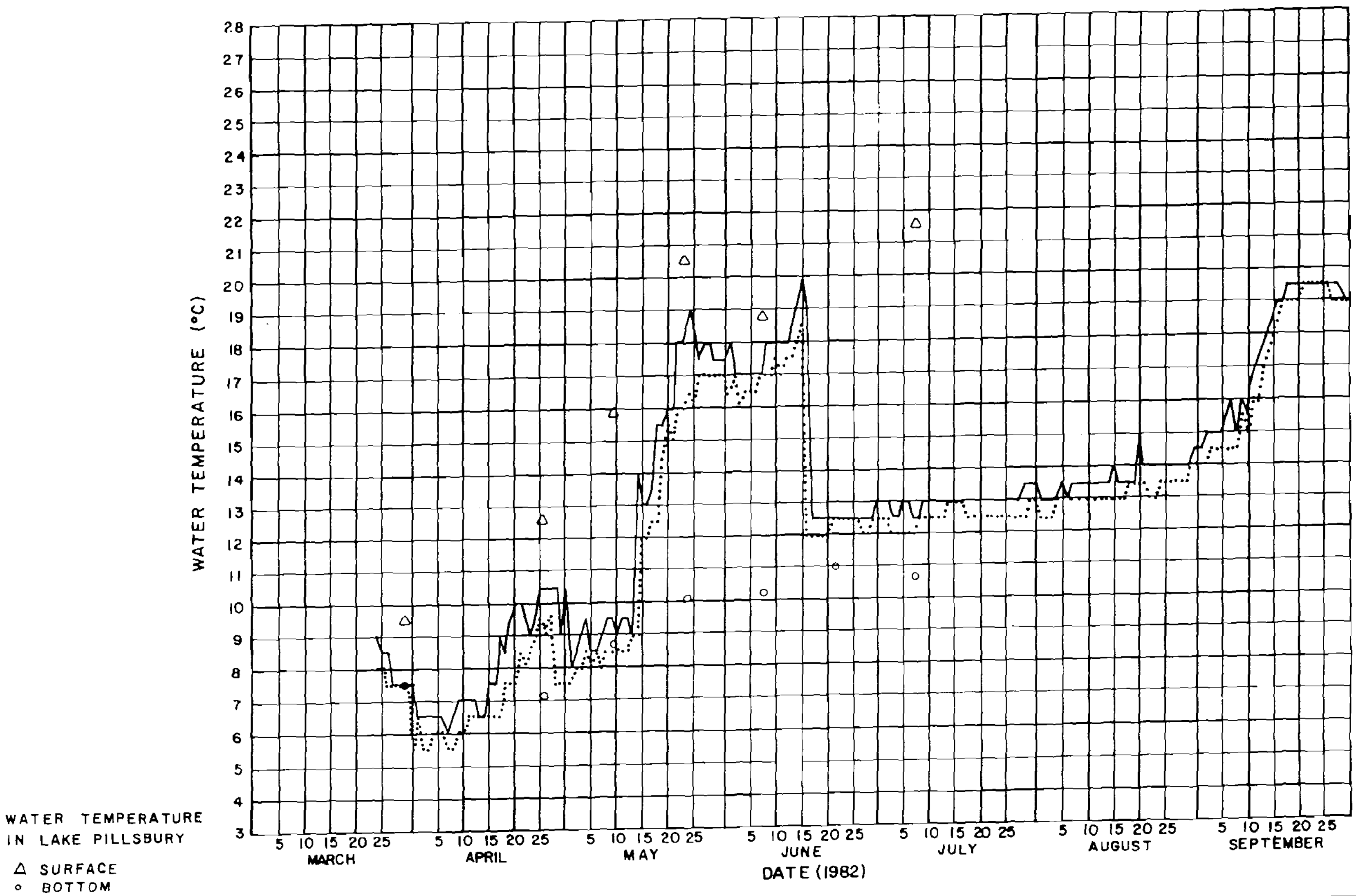

Figure 3.6-18. Daily maximum and minimum water temperatures recorded at Station 1 in the Eel River below Scott Dam from March through September 1982.

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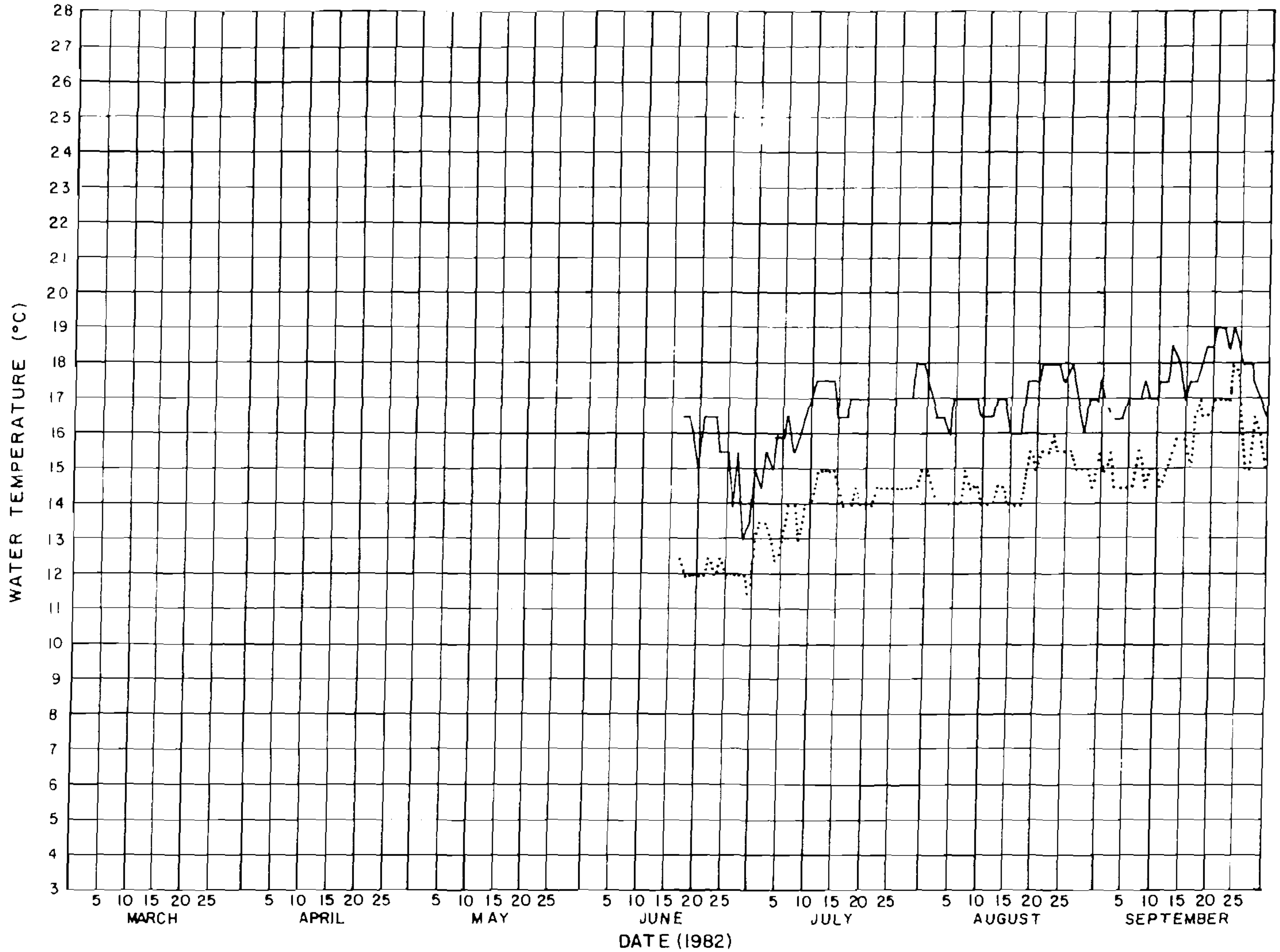

Figure 3.6-19. Daily maximum and minimum water temperatures recorded at Station 2 in the Eel River below Trout Creek from June through September 1982.

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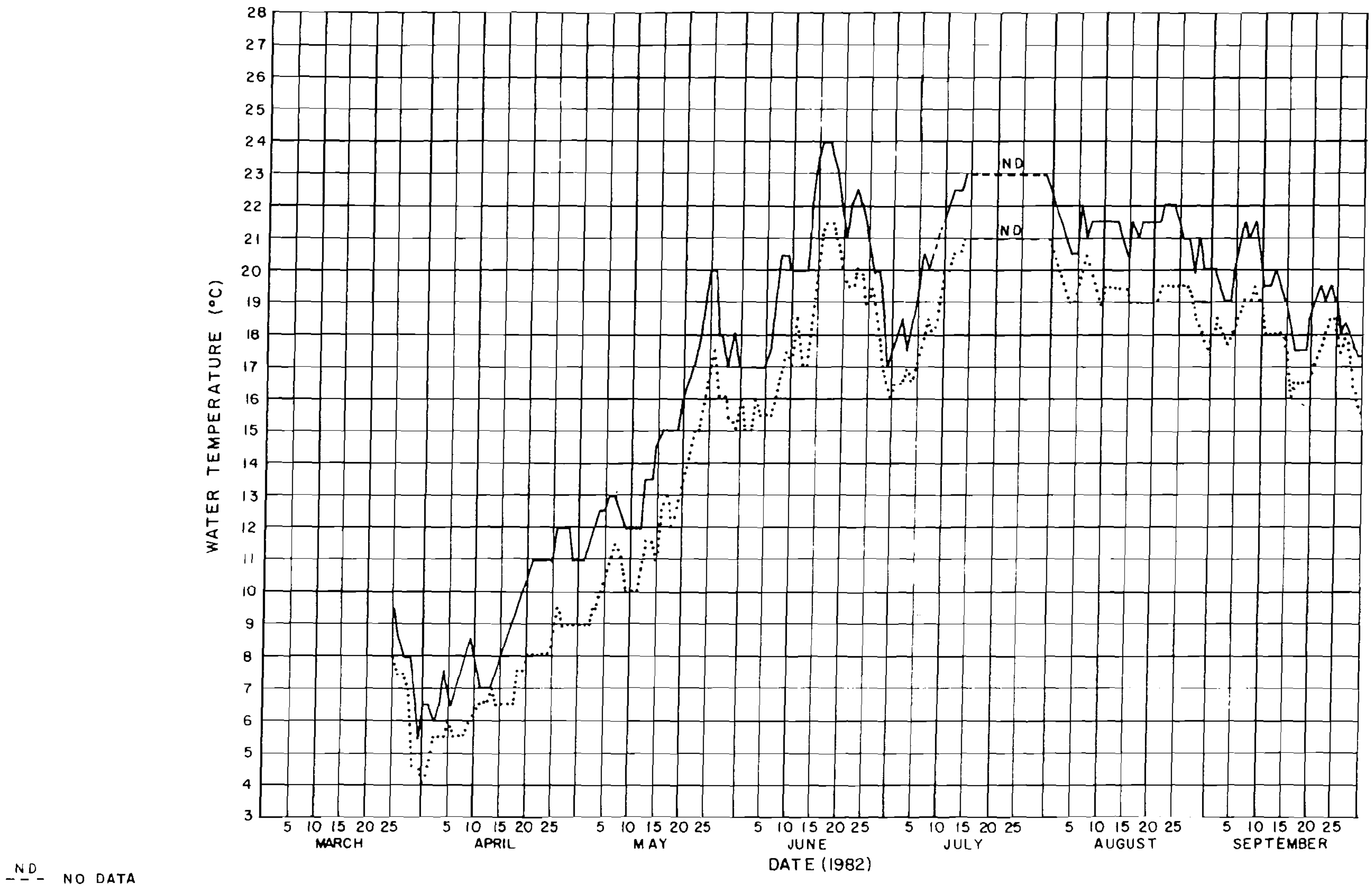

Figure 3.6-20. Daily maximum and minimum water temperatures recorded at Station 3 in the Eel River below Cape Horn Dam from March through September 1982.

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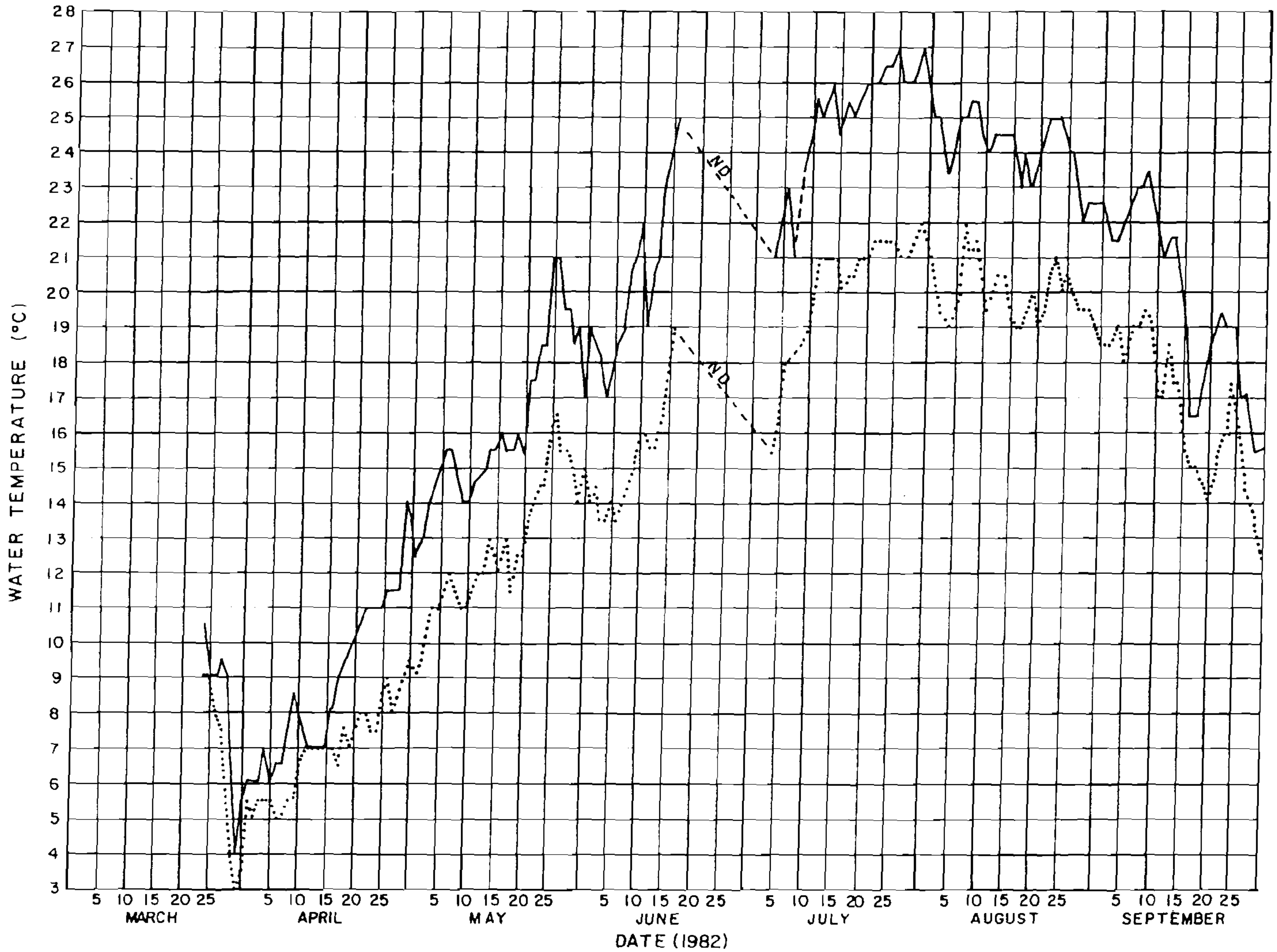

ND
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Figure 3.6-21. Daily maximum and minimum water temperatures recorded at Station 5 in the Eel River below Hearst Riffle from March through September 1982.

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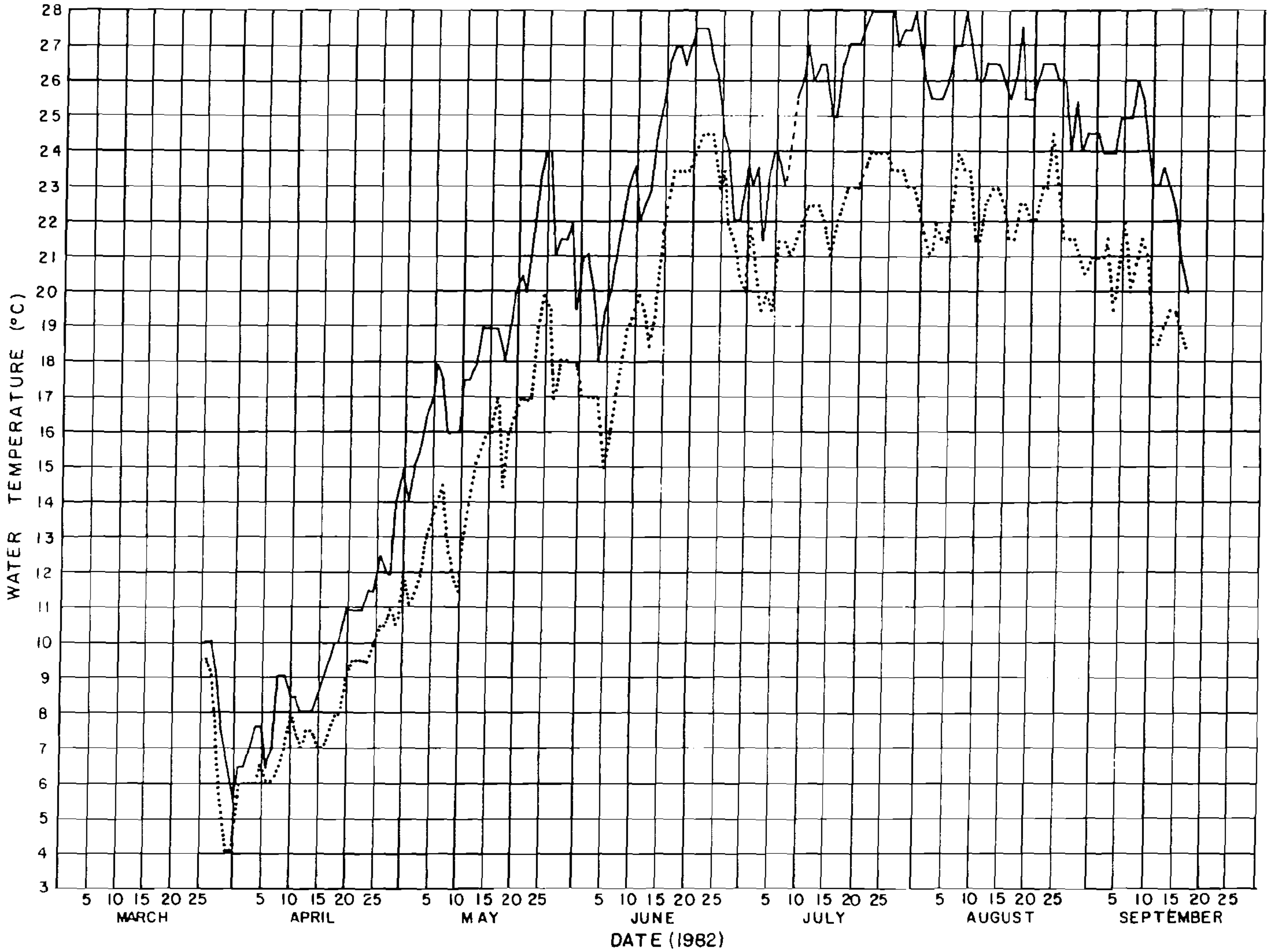

Figure 3.6-22. Daily maximum and minimum water temperatures recorded at Station 6 in the Eel River above Outlet Creek from March through September 1982.

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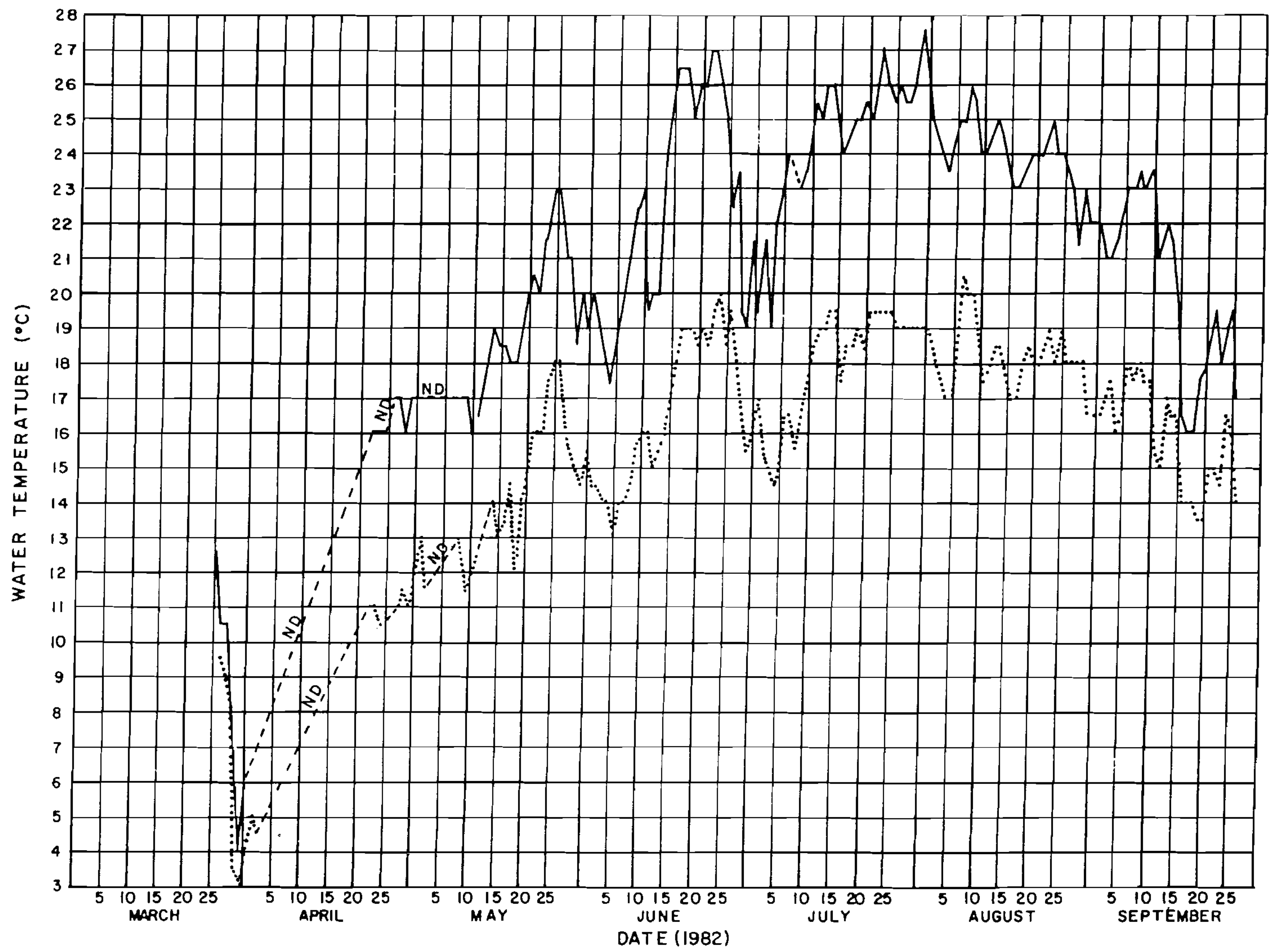

Figure 3.6-23. Daily maximum and minimum water temperatures recorded at Station 7 in Tomki Creek from March through September 1982.

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Temperatures in the Eel River between Scott Dam and Van Arsdale Reservoir increase gradually through summer to a peak in September. The maximum temperatures recorded in this stream section during the study were 21.5°C below Scott Dam and 23.5°C below Trout Creek. Maximum daily temperatures typically increase 2 to 5°C between Scott Dam and Van Arsdale Reservoir. Diurnal fluctuations in temperature are small due to the relatively large discharge from Scott Dam.

Thermal stratification in Lake Pillsbury is strong during the spring and summer and significantly affects downstream water temperatures. During the spring of 1982, surface temperatures ranged from 9.4°C on March 28 to 25.0°C on June 21, while bottom temperatures ranged from 7.4°C to 10.9°C; temperatures were strongly stratified by April 25, with a surface temperature of 12.5°C and a bottom temperature of 6.7°C (Figure 3.6-24 and Appendix H). Water released at Scott Dam normally is drawn from the bottom of Lake Pillsbury; thus, Eel River temperatures below Scott Dam normally reflect the temperature of the reservoir's lower levels. In 1982, however, surface water was released from Scott Dam from May 14 through June 16 to determine the effect of release level on temperature and on downstream migrating salmonids in the Eel River. On May 9, before release of surface water from Lake Pillsbury was begun, temperatures in the Eel River below Scott Dam were very close to bottom temperatures in Lake Pillsbury. Temperatures increased from 9.0°C to 14.0°C on May 14, when the change to the surface release was made, and then gradually increased to a maximum of 20.0°C on June 15. During release of surface water, temperatures below Scott Dam were 2 to 4°C lower than Lake Pillsbury surface temperatures and 6 to 8°C higher than bottom temperatures (Figure 3.6-24 and Appendix H). After June 16, when releases were resumed from the bottom of Lake Pillsbury, temperatures below Scott Dam dropped from 19.0°C to 12.0°C and were 1 to 2°C higher than bottom temperatures and 9 to 12°C lower than surface temperatures in Lake Pillsbury.

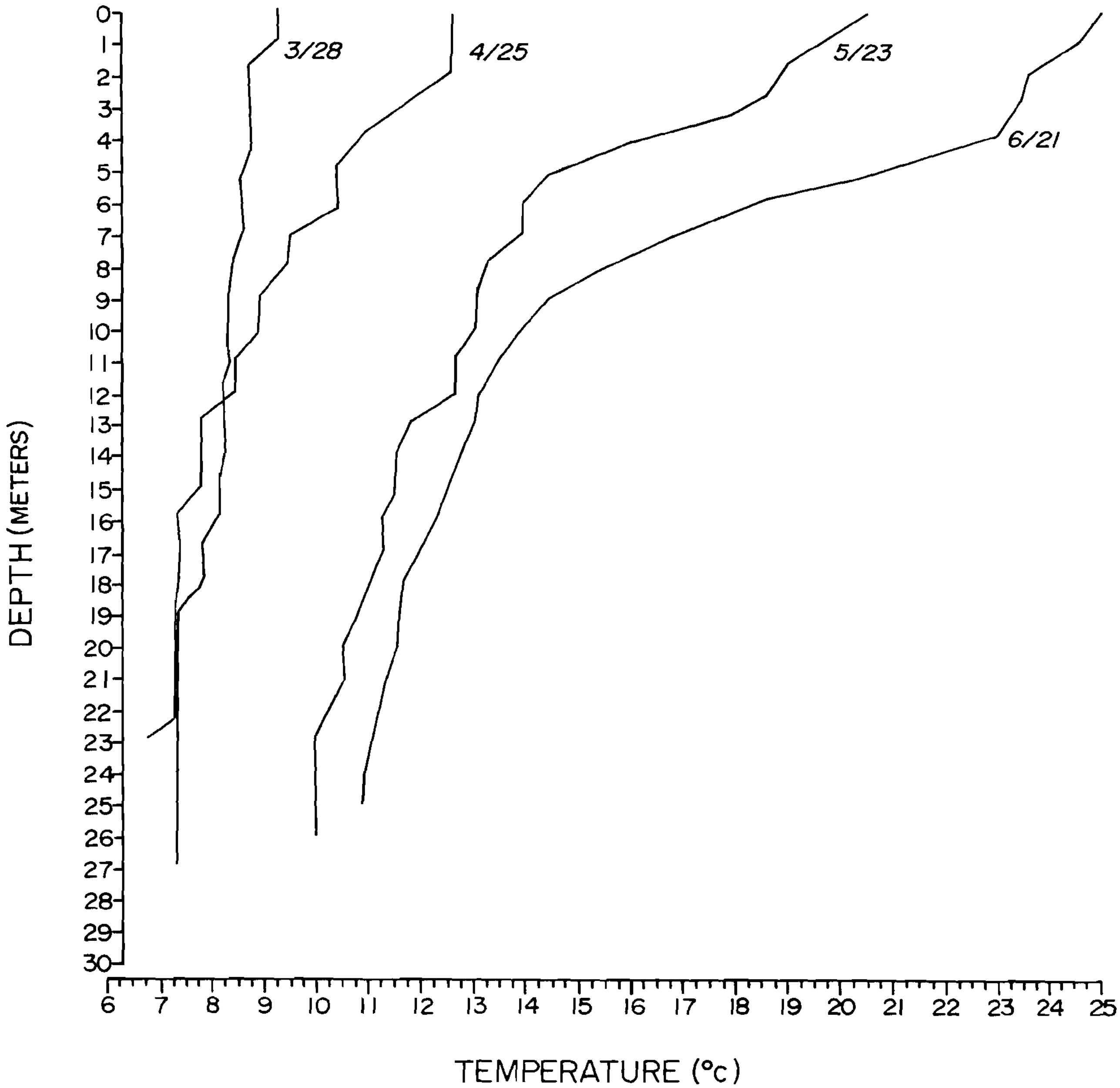

Figure 3.6-24. Temperature profile in Lake Pillsbury in the spring and early summer, 1982.

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Temperatures in the Eel River between Cape Horn Dam and Outlet Creek are influenced greatly by the reduction in flow that occurs at the Cape Horn Dam. Temperatures typically increase to peak levels in mid-June through August. The maximum temperatures recorded in this stream section during the study were 27.5°C below Cape Horn Dam, 28.5°C below Tomki Creek, and over 30.0°C below Hearst Riffle and above Outlet Creek. Maximum daily temperatures typically increase 3 to 6°C from Cape Horn Dam to Outlet Creek during mid-summer. Diurnal fluctuations in temperature are relatively large and increase with distance downstream from Cape Horn Dam.

Maximum daily temperatures in the study area were lower in 1982 than during the previous two summers (Table 3.6-8). The difference in temperatures between years was least immediately below Scott Dam (2.0°C) and greatest above Outlet Creek (4.5°C). The reduction in water temperature during the 1982 summer was probably in response to a combination of two factors: an exceptionally wet 1981/82 winter that recharged springs and tributaries and an unusually mild summer.

Table 3.6-8. Highest daily maximum water temperatures recorded at each station in the Eel River from Scott Dam to Outlet Creek during summer in 1980, 1981, and 1982, and in Tomki Creek in 1982.

Location	Station	Highest Daily Maximum Temperature		
		1980	1981	1982
Eel River Sites				
Below Scott Dam	1	20.0	21.5	19.5[a]
Below Trout Creek	2	-	23.5	19.0
Below Cape Horn Dam	3	27.5	27.5	24.0
Below Tomki Creek	4	-	28.5	-
Below Hearst Riffle	5	31.0	30 +	27.0
Above Outlet Creek	6	32.5	30 +	28.0
Tomki Creek	7	-	-	27.5

[a] Highest temperature recorded during bottom release from Lake Pillsbury. A maximum of 20.0°C was recorded on June 15, during release of surface water from Lake Pillsbury.

3.7 Downstream Juvenile Migration Study

The common and scientific names and location of fish captured during 1980, 1981, and 1982 are listed in Table 3.7-1. Numbers of fish captured for each sampling period, including physical and hydrological data are presented in Appendix I. Length-frequency tables for chinook salmon and steelhead trout captured during two-week intervals in 1980, 1981, and 1982 are also located in Appendix I.

Combined monthly summaries of fish species captured during standard sampling at PVPH and DFS (PVPH/DFS) in 1980 and 1981 are presented in Tables 3.7-2 and 3.7-3. Monthly summaries of fish species captured at PVPH and at DFS in 1982 are shown in Tables 3.7-4 and 3.7-5, respectively. Trapping at PVPH/DFS during standard sampling dates in 1980 resulted in the combined capture of 165 chinook salmon (4% of the total catch), 614 steelhead trout (13%), 316 California roach (7%), 967 golden shiner (21%), 132 Sacramento sucker (3%), 2,281 bluegill (49%), 134 green sunfish (3%), 24 Sacramento squawfish (<1%), and 59 lampreys (1%). Trapping during standard sampling dates during 1981 resulted in the combined capture of 6,106 steelhead trout (70%), 397 California roach (5%), 89 golden shiner (1%), 51 Sacramento sucker (<1%), 2,010 bluegill (23%), 43 green sunfish (<1%), 3 Sacramento squawfish (<1%), 6 threadfin shad (<1%), and 28 lampreys (<1%). No juvenile chinook salmon were caught in 1981 due to the absence of adult chinook salmon passing over Cape Horn Dam in the fall of 1980.

The monthly summaries of fish species captured at PVPH and at DFS in 1982 were not combined as in previous years. The breakdown of the fish pump at DFS resulted in no trapping for nearly six weeks during the main emigration periods of chinook salmon and steelhead trout. Therefore, it was felt that the combination of PVPH and DFS trapping data would not accurately reflect the timing and magnitude of juvenile salmonid emigration or the temporal species composition of the catch.

Table 3.7-1. List of common and scientific names and location of fish captured during trapping for downstream migrants in the Eel River during 1980, 1981, and 1982.

Common Name	Scientific Name	Potter Valley Powerhouse and Diversion Fish Screen			Cape Horn Dam Fishway			Eel River Above Outlet Creek			Tomki Creek
		1980	1981	1982	1980	1981	1982	1980	1981	1982	1982
Chinook salmon	*Oncorhynchus tshawytscha*	X		X	X		X	X	X	X	X
Steelhead trout	*Salmo gairdneri*	X	X	X	X	X	X	X	X	X	X
California roach	*Hesperoleucus symmetricus*	X	X	X	X	X	X	X	X	X	X
Golden shiner	*Notemigonus crysoleucas*	X	X	X	X	X	X	X	X		
Sacramento sucker	*Catostomus occidentalis*	X	X	X		X	X	X	X	X	X
Bluegill	*Lepomis macrochirus*	X	X	X	X	X	X		X		
Green sunfish	*L. cyanellus*	X	X	X		X	X		X	X	
Sacramento squawfish	*Ptychocheilus grandis*	X	X	X		X					
Brown bullhead	*Ictalurus nebulosus*							X	X	X	
Threadfin shad[a]	*Dorosoma petenense*		X	X			X				
Lampreys[b]		X	X	X	X	X	X	X	X	X	X

[a] Threadfin shad had never been caught before November 1981.
[b] Includes Pacific lamprey (*Lampetra tridentata*), Pacific brook lamprey (*Lampetra pacifica*), and lamprey ammocoetes.

Table 3.7-2. Combined monthly summary of fish species caught during standard sampling at the Potter Valley Powerhouse tailraces and the diversion fish screen from March through December 1980.

Common Name	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Chinook salmon	22	15	33	93	2	0	0	0	0	0	165
Steelhead trout	77	252	164	56	29	0	0	0	0	36	614
California roach	123	61	11	5	5	1	11	18	9	72	316
Golden shiner	522	385	35	19	0	0	1	4	1	0	967
Sacramento sucker	7	3	1	1	47	2	52	13	4	2	132
Bluegill	201	11	1	28	1	0	33	15	1,335	656	2,281
Green sunfish	7	9	5	6	1	0	1	0	104	1	134
Sacramento squawfish	1	1	0	0	0	0	15	2	0	5	24
Threadfin shad	0	0	0	0	0	0	0	0	0	0	0
Lampreys	5	7	20	21	0	0	0	0	2	4	59
TOTAL	965	744	270	229	85	3	113	52	1,455	776	4,692

Table 3.7-3. Combined monthly summary of fish species caught during standard sampling at the Potter Valley Powerhouse tailraces and the diversion fish screen from January through December 1981.

Common Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC.	TOTAL
Chinook salmon	0	0	0	0	0	0	0	0	0	0	0	0	0
Steelhead trout	28	103	300	388	2,180	2,616	277	46	42	45	66	15	6,106
California roach	44	79	74	17	5	14	14	1	15	21	31	82	397
Golden shiner	9	16	29	9	14	0	3	1	3	0	1	4	89
Sacramento sucker	2	10	15	3	10	1	2	2	5	1	0	0	51
Bluegill	444	433	455	28	5	20	2	1	281	129	195	17	2,010
Green sunfish	2	3	15	1	0	0	0	0	3	5	10	4	43
Sacramento squawfish	0	0	0	0	0	1	0	0	0	0	1	1	3
Threadfin shad	0	0	0	0	0	0	0	0	0	0	0	6	6
Lampreys	7	1	3	2	7	3	0	0	0	1	2	2	28
TOTAL	536	645	891	448	2,221	2,655	298	51	349	202	306	131	8,773

Table 3.7-4. Monthly summary of fish species caught during standard sampling at the Potter Valley Powerhouse tailraces from January through October 1982.

Common Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
Chinook salmon	0	0	0	0	23	3	1	0	0	0	27
Steelhead trout	2	17	7	57	216	47	5	0	0	0	351
California roach	33	38	17	43	26	3	8	2	10	2	182
Golden shiner	0	2	0	0	0	0	0	0	0	0	2
Sacramento sucker	0	0	0	0	0	0	0	2	4	2	8
Bluegill	0	2	4	12	13	0	0	0	0	0	31
Green sunfish	12	0	0	0	16	3	0	0	0	0	31
Sacramento squawfish	0	1	0	3	0	0	0	0	0	0	4
Threadfin shad	1	1	2	2	1	0	0	0	72	12	91
Lampreys	1	10	6	9	26	15	0	0	0	1	68
TOTAL	49	71	36	126	321	71	14	4	86	17	795

Table 3.7-5. Monthly summary of fish species caught during standard sampling at the diversion fish screen from January through October 1982.

Common Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
Chinook salmon	0	0	0	0	-	10	1	0	0	0	11
Steelhead trout	5	2	113	12	-	144	48	2	2	19	347
California roach	0	0	11	8	-	0	0	0	54	5	78
Golden shiner	0	0	1	0	-	0	0	0	0	0	1
Sacramento sucker	0	0	0	0	-	0	49	22	8	4	83
Bluegill	13	0	16	0	-	3	0	1	1	3	37
Green sunfish	1	1	1	0	-	0	0	0	0	0	3
Sacramento squawfish	0	0	2	1	-	0	0	0	0	0	3
Threadfin shad	0	0	0	0	-	0	0	0	123	71	194
Lampreys	0	0	0	0	-	2	0	0	0	0	2
TOTAL	19	3	144	21	-	59	98	25	188	102	759

In 1982, trapping at PVPH during standard sampling dates resulted in the capture of 27 chinook salmon (3%), 351 steelhead trout (44%), 182 California roach (23%), 2 golden shiner (<1%), 8 Sacramento sucker (1%), 31 bluegill (4%), 31 green sunfish (4%), 4 Sacramento squawfish (1%), 91 threadfin shad (11%), and 68 lampreys (9%). Trapping at DFS during standard sampling dates in 1982 resulted in the capture of 11 chinook salmon (1%), 347 steelhead trout (46%), 78 California roach (10%), 1 golden shiner (<1%), 83 Sacramento sucker (11%), 37 bluegill (5%), 3 green sunfish (<1%), 3 Sacramento squawfish (<1%), 194 threadfin shad (26%), and 2 lampreys (<1%).

Trapping conducted by Day (1964) at PVPH from April 12, 1961 through March 29, 1962 resulted in the capture of 716 steelhead trout (41%), 548 golden shiner (32%), 76 Sacramento sucker (4%), 193 green sunfish (11%), 128 lampreys (7%), 6 kokanee salmon (<1%), and 62 threespine stickleback (4%). Neither kokanee salmon or threespine stickleback were captured during the current study. Kokanee salmon fingerlings were planted in Lake Pillsbury in 1961 and apparently washed into the Eel River during spillage of Lake Pillsbury during the 1961/62 trapping period. Threespine stickleback are numerous in the irrigation canals below PVPH, but were not observed in the upper Eel River drainage during any phase of the current study.

Steelhead trout were not relatively abundant in catches during 1980, but were the most abundant species captured in 1981, probably because of the large numbers of adult steelhead that spawned above Cape Horn Dam during 1980/81 (Section 3.1, Cape Horn Dam Adult Fish Counts). The relatively large percentage of steelhead trout in the catches at PVPH and at DFS was probably also due to the relatively large number of adult steelhead that spawned above Cape Horn Dam during 1981/82. Although only 84 more steelhead were captured in 1982 than in 1980, it is likely that much larger numbers would have been present in the 1982 catch had the DFS fish pump been operated during the major emigration period. Large numbers of bluegill, golden shiner, and green sunfish were usually found in the catch only during the months when Lake Pillsbury was spilling. Resident species of the Eel River such as California roach, Sacramento sucker, Sacramento squawfish, and lampreys were usually found in similar numbers from month to month. Threadfin shad had never been captured in any of the downstream traps before November 1981. In 1982, threadfin shad accounted for 18% of the total combined catch at PVPH and DFS. This suggests that a population of threadfin shad has probably become established in Lake Pillsbury.

Monthly summaries of fish species caught in the CHDF during standard sampling dates in 1980, 1981 and 1982 are presented in Tables 3.7-6 through 3.7-8. During standard sampling in 1980, 2 chinook salmon (1%), 70 steelhead trout (40%), 14 California roach (8%), 18 golden shiner (10%), 70 bluegill (40%), and 3 lampreys (1%), were captured. During standard sampling in 1981, 3,158 steelhead trout (83%), 139 California roach (4%), 16 golden shiner (<1%), 11 Sacramento sucker (<1%), and 462 bluegill (12%) were captured. Standard sampling conducted during 1982 resulted in the capture of 9 chinook salmon (2%), 122 steelhead trout (33%), 32 California roach (9%), 2 golden shiner (1%), 5 Sacramento sucker (1%), 70 bluegill (19%), 22 threadfin shad (6%), and 104 lampreys (28%). Steelhead trout was the most abundant species captured in 1981 and 1982; bluegill and steelhead were concurrently the most abundant species captured in 1980. The exceptionally large number of steelhead juveniles captured in 1981 was probably due to the large number of adult steelhead that spawned above Cape Horn Dam during the 1980/81 migration season. As was the case for PVPH/DFS trapping, bluegill were numerous during spillage at Lake Pillsbury. Generally, lower numbers of fish were caught in the CHDF as compared with PVPH/DFS because a smaller portion of streamflow was sampled at the CHDF. Larger numbers of fish were captured in the CHDF during 1981 than in 1980 and 1982 for two reasons: 1) the CHDF was not trapped from July through October 1980 or in November and December 1982, and 2) steelhead trout were more abundant in 1981.

Table 3.7-6. Monthly summary of fish species caught during standard sampling at the Cape Horn Dam fishway from March through December 1980.

Common Name	MAR	APR	MAY	JUN	JUL[a]	AUG[a]	SEP[a]	OCT[a]	NOV	DEC	TOTAL
Chinook salmon	0	1	1	0	-	-	-	-	0	0	2
Steelhead trout	0	3	64	0	-	-	-	-	0	3	70
California roach	0	1	0	0	-	-	-	-	1	12	14
Golden shiner	6	11	1	0	-	-	-	-	0	0	18
Sacramento sucker	0	0	0	0	-	-	-	-	0	0	0
Bluegill	0	0	0	0	-	-	-	-	17	53	70
Lampreys	0	3	0	0	-	-	-	-	0	0	3
TOTAL	6	19	66	0	-	-	-	-	18	68	177

[a] No trapping was conducted during these months.

Table 3.7-7. Monthly summary of fish species caught during standard sampling at the Cape Horn Dam fishway from January through December 1981.

Common Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Chinook salmon	0	0	0	0	0	0	0	0	0	0	0	0	0
Steelhead trout	4	3	0	6	21	991	1,678	436	18	0	1	0	3,158
California roach	34	82	15	1	1	1	0	0	0	0	3	2	139
Golden shiner	0	9	1	1	0	0	0	0	0	0	5	0	16
Sacramento sucker	0	0	1	3	0	6	0	1	0	0	0	0	11
Bluegill	58	55	42	14	1	15	39	12	190	5	31	0	462
Lampreys	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	96	149	59	25	23	1,013	1,717	449	208	5	40	2	3,786

Table 3.7-8. Monthly summary of fish species caught during standard sampling at the Cape Horn Dam fishway from January through October 1982.

Common Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
Chinook salmon	0	0	0	0	2	1	6	0	0	0	9
Steelhead trout	0	6	6	0	10	6	82	0	3	9	122
California roach	3	3	10	1	1	1	0	0	4	9	32
Golden shiner	0	0	0	1	0	0	0	0	1	0	2
Sacramento sucker	0	0	0	0	0	2	1	1	0	1	5
Bluegill	0	0	0	2	2	1	0	3	44	18	70
Threadfin shad	0	1	0	0	0	0	0	0	1	20	22
Lampreys	0	0	0	0	0	103	0	1	0	0	104
TOTAL	3	10	16	4	15	114	89	5	53	57	366

Monthly summaries of fish species caught in Tomki Creek during 1982 are presented in Table 3.7-9. A total of 44,282 chinook salmon (87%), 5,735 steelhead trout (11%), 124 California roach (<1%), 278 Sacramento sucker (1%), and 211 lampreys (<1%) were captured during the single season of trapping. It should be noted that numbers reported for chinook salmon and steelhead trout juveniles are estimates due to extremely large numbers of fish captured during sampling in April and May. The relatively low species diversity found in Tomki Creek is characteristic of intermittent streams.

Monthly summaries of fish species caught in the Eel River above Outlet Creek during 1980, 1981 and 1982 are presented in Tables 3.7-10 through 3.7-12. Trapping conducted in 1980 resulted in the capture of 1,900 chinook salmon (92%), 4 steelhead trout (<1%), 67 California roach (3%), 7 golden shiner (<1%), 13 Sacramento sucker (<1%), 5 brown bullhead (<1%), and 66 lampreys (3%). Trapping conducted in 1981 resulted in the capture of 1,175 chinook salmon (61%), 92 steelhead trout (5%), 302 California roach (16%), 2 golden shiner (<1%), 225 Sacramento sucker (12%), 14 bluegill (<1%), 9 green sunfish (<1%), 85 brown bullhead (4%), and 8 lampreys (<1%). During 1982, trapping resulted in the capture of 3,667 chinook salmon (25%), 83 steelhead trout (1%), 713 California roach (5%), 10,068 Sacramento sucker (68%), 1 green sunfish (<1%), 28 brown bullhead (<1%), and 267 lampreys (2%). This was the only site at which chinook salmon were captured in 1981. During 1980 and 1981, chinook salmon was the most abundant species captured; however, during 1982, it was second in abundance to Sacramento sucker. The majority of these suckers were post larvae and were captured in low numbers during 1980 and 1981 due to their small size. The sucker catch greatly increased during 1982 when a finer-meshed netting was used in the live box to reduce the incidence of gilled salmonids. The trapping methodology was apparently inefficient for the capture of steelhead trout, based on the very low numbers of steelhead captured. Steelhead may be better able to avoid capture than salmon due to stronger swimming ability. Native fishes such as California roach, Sacramento sucker, and lampreys

Table 3.7-9. Monthly summary of fish species caught in Tomki Creek from February through July 1982.

Common Name	FEB	MAR	APR	MAY	JUN	JUL	TOTAL
Chinook salmon	0	11	20,354[a]	23,884[a]	26	7	44,282[a]
Steelhead trout	1	1	212[a]	5,299[a]	172	50	5,735[a]
California roach	1	3	29	28	15	48	124
Sacramento sucker	1	6	59	4	173	35	278
Lampreys	0	0	4	156	39	12	211
TOTAL	3	21	20,658	29,371	425	152	50,630
Days of trapping	2	6	4	12	9	9	

[a] Numbers are estimates due to large sample sizes.

Table 3.7-10. Monthly summary of fish species caught in the Eel River above Outlet Creek from April through July 1980.

Common Name	APR	MAY	JUN	JUL	TOTAL
Chinook salmon	295	1,462	143	0	1,900
Steelhead trout	0	0	2	2	4
California roach	27	30	9	1	67
Golden shiner	4	3	0	0	7
Sacramento sucker	11	0	2	0	13
Brown bullhead	3	1	1	0	5
Lampreys	33	33	0	0	66
	373	1,529	157	3	2,062

Table 3.7-11. Monthly summary of fish species caught in the Eel River above Outlet Creek from February through July 1981.

Common Name	FEB	MAR	APR	MAY	JUN	JUL	TOTAL
Chinook salmon	0	0	236	923	16	0	1,175
Steelhead trout	0	1	2	23	38	28	92
California roach	8	92	46	78	32	46	302
Golden shiner	1	0	1	0	0	0	2
Sacramento sucker	0	4	127	66	17	11	225
Bluegill	7	5	2	0	0	0	14
Green sunfish	0	0	0	1	2	6	9
Brown bullhead	1	2	9	14	16	43	85
Lampreys	0	0	5	2	1	0	8
TOTAL	17	104	428	1,107	122	134	1,912

Table 3.7-12. Monthly summary of fish species caught in the Eel River above Outlet Creek from March through July 1982.

Common Name	MAR	APR	MAY	JUN	JUL	TOTAL
Chinook salmon	6	184	3,433[a]	37	7	3,667[a]
Steelhead trout	0	0	3	57	23	83
California roach	2	4	8	11	688[a]	713
Sacramento sucker	0	2	0	8,630[a]	1,436[a]	10,068[a]
Green sunfish	1	0	0	0	0	1
Brown bullhead	0	0	0	0	28	28
Lampreys	9	111	59	71	17	267
TOTAL	18	301	3,503	8,806	2,199	14,827
Days of trapping	3	1	14	9	9	

[a] Numbers are estimates due to large sample sizes.

were usually more abundant than the introduced species such as golden shiner, brown bullhead, bluegill, and green sunfish.

Efficiencies of the trapping equipment varied between stations and with season. In particular, the percentages of fish trapped during high flows were lower than during low flows when much or all of the streamflow passed through the traps. Therefore, the catch rates probably do not represent the true relative abundances of chinook salmon and steelhead trout at particular locations in the Eel River during various times of the year.

Chinook Salmon

Juvenile chinook salmon were captured at PVPH/DFS from March through early July 1980; combined results indicate that peaks in catch rate occurred in late March (36 fish/24 hours) and late June (57 fish/24 hours) (Table 3.7-13 and Figure 3.7-1). Only two salmon were captured in the CHDF during standard sampling in 1980, probably because the ratio of streamflow to fishway flow is too great to adequately sample a small population. No juvenile chinook salmon were captured at PVPH, DFS, or CHDF in 1981 due to the absence of adult chinook salmon passage over Cape Horn Dam during the 1980/81 migration season (Table 3.7-14). Sampling conducted during the 1982 season at PVPH/DFS and CHDF suggests that a major period of emigration from above Cape Horn Dam began in mid-May and peaked in late May (31 fish/24 hours) (Table 3.7-15 and Figure 3.7-2). Chinook emigration continued in uniformly low numbers through the end of July with a slight pulse noted in mid-June; the catch rate was generally less than 5 fish/24 hours. No juvenile chinook salmon were captured at PVPH during Day's (1964) study in 1961/62, probably due to the low numbers of adult chinook salmon passing over Cape Horn Dam in the fall of 1960 and the total lack of passage in 1961.

Chinook salmon were present in large numbers from late March through early July 1982 during the single season of trapping at Tomki Creek.

Table 3.7-13. Combined catch rates (fish/24 hours) of steelhead trout and chinook salmon captured at Potter Valley Powerhouse and diversion fish screen during 1980.

Trapping Period	Catch Rate (fish/24 hours): Steelhead Trout PVPH[a]	Steelhead Trout DFS	Chinook Salmon PVPH[a]	Chinook Salmon DFS	PVPH + DFS Steelhead Trout	PVPH + DFS Chinook Salmon	Water[b] Temp. (°C)	Eel River[c] Flow Above Cape Horn Dam (cfs)	Turbidity (NTU)
Mar. 3-4	12	-	0	-	-	-	-	1,812	-
4-5	15	-	0	-	-	-	-	2,861	-
10-11	15	-	0	-	-	-	-	1,532	-
11-12	3	-	0	-	-	-	-	1,452	-
17-18	0	13	0	1	13	1	8.5	1,345	-
18-19	6	2	0	0	8	0	8.5	1,153	-
24-25	0	19	27	1	19	28	10.3	493	-
25-26	6	22	36	0	28	36	10.3	468	-
Mar. 31 - Apr. 1	8	23	3	0	31	3	11.4	451	-
1-2	16	33	5	0	49	5	11.4	447	-
7-8	49	0	3	0	49	3	10.6	431	-
8-9	30	0	11	0	30	11	10.6	433	-
14-15	7	25	0	0	32	0	11.8	427	-
15-16	9	31	0	0	40	0	11.8	433	-
21-22	3	29	6	0	32	6	9.7	435	-
22-23	3	18	3	0	21	3	9.7	442	-
28-29	4	11	0	1	15	1	11.4	307	15
29-30	7	17	4	0	24	4	11.4	425	15
May. 5-6	14	7	3	2	21	5	11.2	400	8.2
6-7	16	18	3	3	34	6	11.2	384	8.2
12-13	15	17	3	1	32	4	11.5	375	6.3
13-14	28	30	3	3	58	6	11.5	372	6.6
19-20	5	16	7	6	21	13	13.5	315	6.4
20-21	16	14	5	7	30	12	13.5	260	6.4
27-28	6	15[d]	0	2[d]	21	2	13.5	241	4.2
28-29	8	15[d]	0	2[d]	23	2	13.5	228	4.2
June 2-3	6	10	2	1	16	3	13.7	215	3.4
3-4	11	10	5	2	21	7	13.7	223	3.4
9-10	5	2	3	6	7	9	16.1	221	3.1
10-11	4	4	0	0	8	0	16.1	217	3.1
16-17	2	13	2	2	15	4	17.0	223	3.5
17-18	0	13[d]	37	2[d]	13	39	17.0	222	3.5
23-24	0	0	30	8	0	38	17.0	206	2.0
24-25	0	1	29	28	1	57	17.0	159	2.0
June 30 - July 1	0	-	0	-	-	-	17.8	153	1.3
1-2	2	-	4	-	-	-	17.8	154	1.3
21-22	0	20	0	0	20	0	20.4	156	1.2
22-23	2	7	0	0	9	0	20.4	164	1.2
Aug. 18-19	0	0[d]	0	0[d]	0	0	18.8	101	0.5
19-20	0	0[d]	0	0[d]	0	0	18.8	101	0.5
Sep. 22-23	0	0	0	0	0	0	18.2	306	2.1
23-24	0	0	0	0	0	0	18.2	311	2.1
Oct. 20-21	0	0	0	0	0	0	16.4	330	3.6
21-22	0	0	0	0	0	0	16.4	323	3.6
Nov. 17-18	0	0	0	0	0	0	9.8	270	9.6
18-19	0	0	0	0	0	0	9.8	265	9.6
Dec. 16-17	15	17	0	0	32	0	7.2	322	9.4
17-18	10	11	0	0	21	0	7.2	320	9.4

[a] Daily estimate of fish passing through the Potter Valley Powerhouse.
[b] Water temperatures from PVPH/DFS are an average of spot checks taken at the beginning and ending of each trapping period.
[c] Eel River flows are an average of mean daily flows throughout each trapping period.
[d] Estimated from CDF&G total sampling periods.

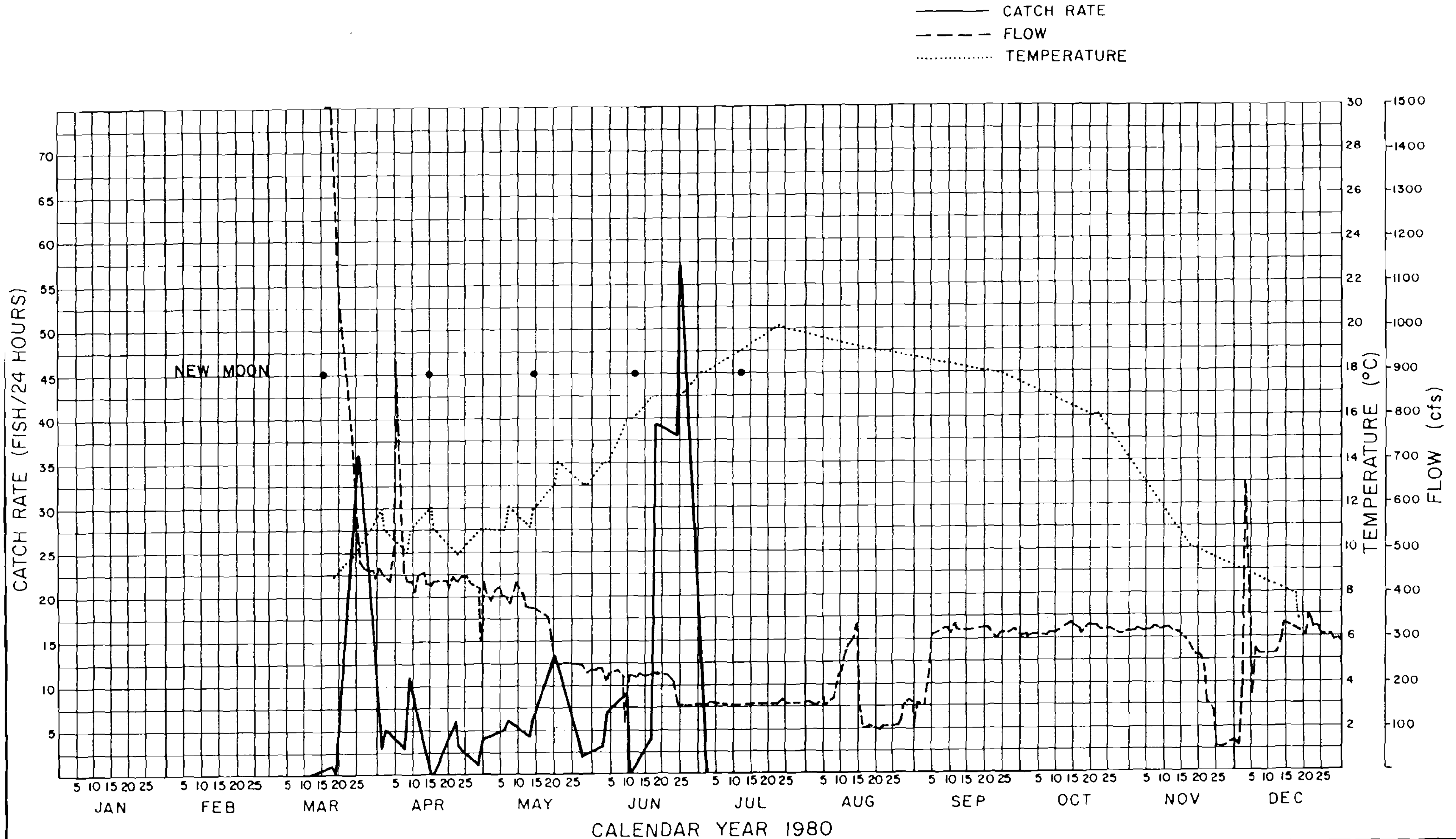

Figure 3.7-1. Combined catch rate (fish/24 hours) of chinook salmon and daily water temperature and discharge at the diversion (PVPH/DFS) in 1980.

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Table 3.7-14. Combined catch rates (fish/24 hours) of steelhead trout and chinook salmon captured at Potter Valley Powerhouse and diversion fish screen during 1981.

Trapping Period	Catch Rate (fish/24 hours): Steelhead Trout PVPH[a]	Steelhead Trout DFS	Chinook Salmon PVPH[a]	Chinook Salmon DFS	PVPH + DFS Steelhead Trout	PVPH + DFS Chinook Salmon	Water[b] Temp. (°C)	Eel River[c] Flow Above Cape Horn Dam (cfs)	Turbidity (NTU)
Dec. 31'80 -Jan. 1'81	0	0	0	0	0	0		279	
27-28	16	23	0	0	39	0	7.8	2,024	89
Feb. 5-6	35	36	0	0	71	0	5.7	409	265
9-10	8	11	0	0	19	0	6.2	410	79
12-13	3	9	0	0	12	0	7.1	886	52
17-18	0	7[d]	0	0	7[d]	0	-	1,439	-
19-20	15	5	0	0	20	0	7.8	949	45
22-23	4	7	0	0	11	0	8.3	594	42
24-25	3	11	0	0	14	0	7.1	822	43
Mar. 3-4	3	19	0	0	22	0	7.3	836	33
5-6	6	9	0	0	15	0	7.3	784	33
9-10	16	21	0	0	37	0	7.7	532	28
11-12	6	27	0	0	33	0	8.1	476	28
16-17	13	60	0	0	73	0	7.6	506	18
19-20	9	28	0	0	37	0	8.2	503	22
24-25	6	67	0	0	73	0	8.8	623	62
26-27	36	36	0	0	72	0	9.1	2,111	21
30-31	5	6[d]	0	0	11[d]	0	8.3	463	61
Apr. 2-3	37	6[d]	0	0	43[d]	0	8.7	395	8
6-7	0	54	0	0	54	0	9.3	414	10
9-10	7	31	0	0	38	0	9.3	397	10
13-14	5	13	0	0	18	0	9.7	282	8
16-17	0	25	0	0	25	0	10.5	256	8
20-21	14	19	0	0	33	0	10.5	241	7
23-24	133	24	0	0	157	0	14.0	234	5
28-29	171	51	0	0	222	0	14.0	157	5
Apr. 30 - May 1	179	47	0	0	226	0	14.0	226	6
5-6	234	37[d]	0	0	271[d]	0	12.0	214	5
7-8	268	41[d]	0	0	309[d]	0	12.0	203	5
11-12	93	220	0	0	313	0	14.0	205	6
13-14	40	87[d]	0	0	127	0	14.0	184	5
18-19	26	339	0	0	365	0	13.0	165	6
21-22	40	196	0	0	236	0	13.0	173	5
25-26	177	251	0	0	428	0	16.0	171	4
27-28	98	134[d]	0	0	232	0	16.0	156	4
June 1-2	176	491	0	0	667	0	17.0	151	2.6
4-5	155	124	0	0	284	0	16.0	161	2.5
8-9	433	435	0	0	686	0	17.0	156	-
11-12	158	264	0	0	422	0	16.0	156	1.7
16-17	51	100[d]	0	0	151	0	17.0	156	1.1
18-19	33	221	0	0	254	0	18.0	158	0.6
22-23	83	189[d]	0	0	272	0	19.0	161	1.9
25-26	160	271	0	0	431	0	20.0	161	2.3
29-30	163	266	0	0	429	0	20.0	153	1.1
July 1-2	117	16[d]	0	0	133	0	19.0	153	0.8
6-7	73	16[d]	0	0	89	0	18.0	149	1.5
9-10	34	16[d]	0	0	50	0	18.0	158	1.8
13-14	8	16[d]	0	0	24	0	18.0	160	0.9
16-17	13	68	0	0	81	0	19.0	160	0.9
20-21	11	33	0	0	44	0	19.0	95	0.6
22-23	0	9	0	0	9	0	-	102	-
27-28	7	33	0	0	40	0	21.0	113	0.8
30-31	6	36	0	0	42	0	21.0	111	0.7
Aug. 10-11	5	69	0	0	74	0	22.0	103	1.3
24-25	4	22	0	0	26	0	22.0	102	1.0
Sep. 14-15	3	11	0	0	14	0	21.0	228	1.9
28-29	7	26	0	0	43	0	19.0	315	2.5
Oct. 14-15	0	45	0	0	45	0	14.0	311	5.8
28-29	-[e]	303	-[e]	0	303	0	12.0	341	-
Nov. 12-13	19	36	0	0	55	0	13.0	308	25
Nov. 30 - Dec. 1	14	21	0	0	35	0	8.0	1,248	56
11-12	10	10[d]	0	0	20	0	8.0	1,501	28
15-16	0	7	0	0	7	0	8.0	2,930	87
28-29	5	2	0	0	7	0	9.0	2,093	91

[a] Daily estimate of fish passing through the Potter Valley Powerhouse.
[b] Water temperatures from PVPH/DFS are an average of spot checks taken at the beginning and ending of each trapping period.
[c] Eel River flows are an average of mean daily flows throughout each trapping period.
[d] Estimated from CDF&G total sampling periods.
[e] Trapping at the Potter Valley Powerhouse was not conducted due to a heavy debris load.

Table 3.7-15. Combined catch rates (fish/24 hours) of steelhead trout and chinook salmon captured at Potter Valley Powerhouse and diversion fish screen during 1982.

Trapping Period	Catch Rate (fish/24 hours) Steelhead Trout PVPH[a]	Steelhead Trout DFS	Chinook Salmon PVPH[a]	Chinook Salmon DFS	PVPH + DFS Steelhead Trout	PVPH + DFS Chinook Salmon	Water[b] Temp. (°C)	Eel River[c] Flow Above Cape Horn Dam (cfs)	Turbidity (NTU)
Jan. 18-19	0	1	0	0	1	0	5.0	1,500	69
25-26	5	4	0	0	9	0	5.5	1,865	59
Feb. 8-9	0	2	0	0	2	0	5.0	1,534	18
25-26	43	-	0	-	43	0	7.8	1,257	66
Mar. 4-5	-	35	-	0			6.7	2,354	
8-9	-	25	-	0			8.3	1,534	
11-12	9	12	0	0	21	0	8.9	2,276	35
15-16	-	10	-	0			8.3	1,400	
18-19	-	8	-	0	8	0	7.8	1,146	
22-23	-	7	-	0			8.9	816	
25-26	12	13	0	0	25	0	8.3	679	19
29-30	-	0	-	0			6.7	775	
Apr. 1-2	-	4	-	0	4	0	6.7	3,325	
5-6	-	2	-	0			6.7		
8-9	12	4	0	0	16	0	6.7	1,626	24
12-13	-	2	-	0			7.8	10,925	
15-16	-	0	-	0			7.8	5,982	
19-20	31	-	0	-	31	0	9.4	3,443	51
22-23	13	-	0	-	13	0	9.4	2,917	33
26-27	32	-	0	-	32	0	11	1,993	22
29-30	88	-	0	-	88	0	10	558	35
May 3-4	102	-	0	-	102	0	10	408	24
6-7	67	-	0	-	67	0	11	388	19
10-11	43	-	10	-	43	10	10	378	17
13-14	68	-	0	-	68	0	11	370	16
17-18	126	-	9	-	126	9	13	364	9
20-21	68	-	12	-	68	12	14	404	5
24-25	101	-	31	-	101	31	18	347	4
27-28	84	-	9	-	84	9	16	376	3
28-31	-	47	-	4	47	4	17	339	-
May 31 - Jun. 1	9	27	0	2	36	2	17	325	1.0
1-2	7	25[d]	3	3[d]	32	6	17	324	1.3
3-4	-	12	-	2	12	2	16	321	
7-8	4	22	0	0	26	0	17	319	1.8
10-11	-	9	-	1	9	1	17	321	
14-15	18	10	7	1	18	8	19	323	1.0
17-18	-	19	-	0	19	0	16	327	
21-22	27	40	0	3	67	3	15	333	3.1
24-25	-	6	-	1			17	337	
28-29	80	65[d]	0	1[d]	145	1	13	304	1.8
Jul. 1-2	-	34	-	0	34	0	16	199	
12-13	7	13	2	1	20	3	18	161	1.6
26-27	5	2[d]	0	1[d]	7	1	20	164	1.7
Aug. 9-10	0	1	0	0	1	0	18	169	0.7
23-24	0	1	0	0	1	0	16	170	1.0
Sep. 9-10	0	1	0	0	1	0	17	350	
23-24	-	1	-	0			19	359	
26-27	0	-	0	-	0	0	18	274	0.4
27-28	0	0	0	0	0	0	18	122	0.3
28-29	0	0	0	0	0	0	17	46	0.3
Oct. 11-12	0	0	0	0	0	0	15	166	0.3
25-26	0	19	0	0	19	0	14	250	24

[a] Daily estimate of fish passing through the Potter Valley Powerhouse.
[b] Water temperatures from PVPH/DFS are an average of spot checks taken at the beginning and ending of each trapping period.
[c] Eel River flows are an average of mean daily flows throughout each trapping period.
[d] Estimated from CDF&G total sampling periods.

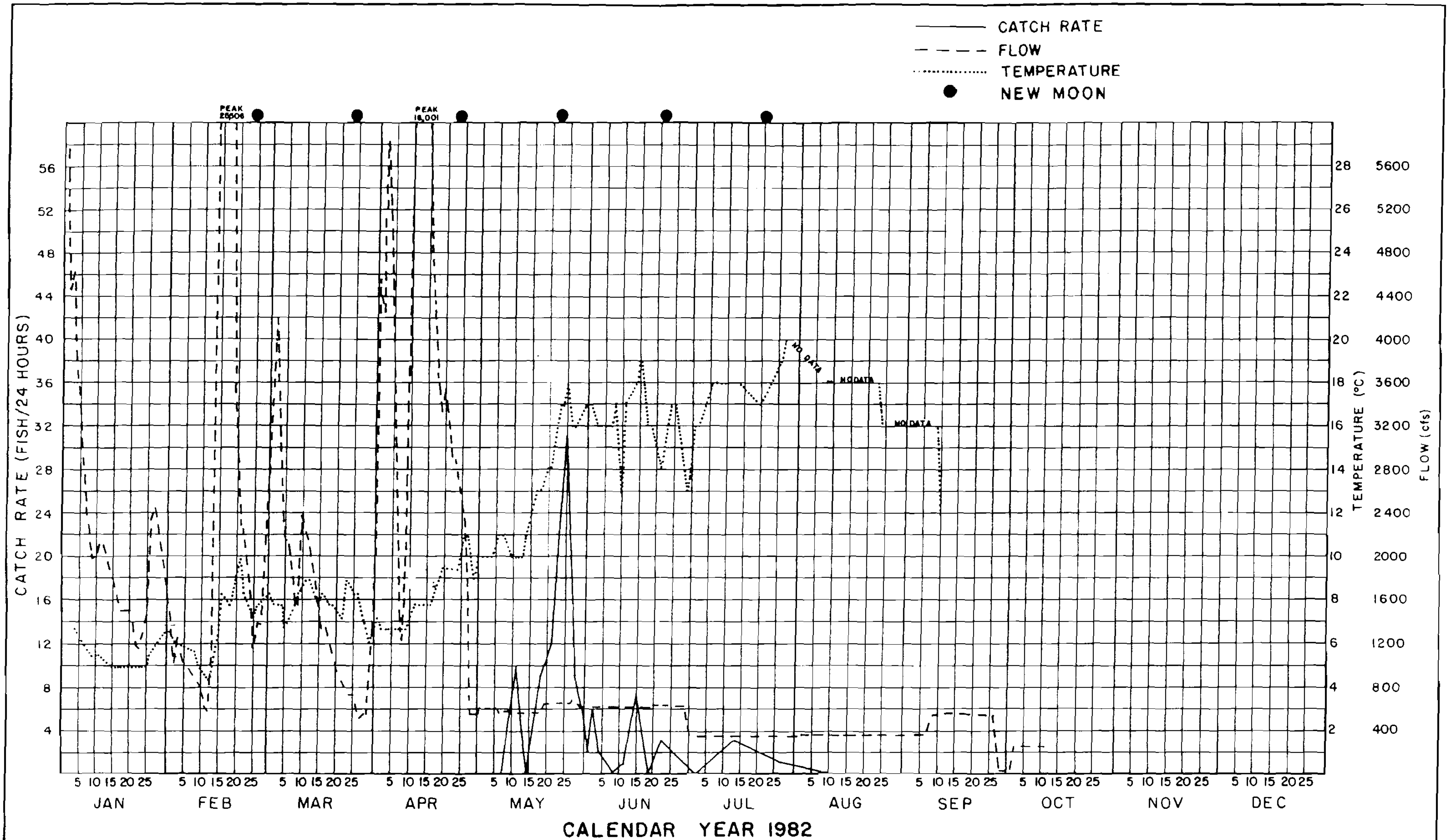

Figure 3.7-2. Combined catch rate (fish/24 hours) of chinook salmon and daily water temperature and discharge at the diversion (PVPH/DFS) in 1982.

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Three major peaks of catch rate were observed (Table 3.7-16 and Figure 3.7-3). The first peak was also the largest observed peak for all stations throughout the entire study; an estimate of 12,326 fish/24 hours was noted in late April. Two latter peaks, also of substantial size, occurred in mid-May (8,730 fish/24 hours) and late May (3,108 fish/24 hours).

In the Eel River above Outlet Creek, juvenile chinook salmon were caught from early April through mid-June 1980 (Table 3.7-17 and Figure 3.7-4). The catch rate remained high during the first two weeks of May with the peak occurring in mid-May (420 fish/24 hours); smaller peaks were observed in mid-April (80 fish/24 hours) and early June (88 fish/24 hours). During 1981, chinook salmon were trapped from early April through mid June; one major peak occurred in late April/early May (352 fish/24 hours) (Table 3.7-17 and Figure 3.7-5). In 1982, chinook salmon were first found in the catch in late March and were present through mid-July (Table 3.7-16 and Figure 3.7-6). Three major peaks of catch rate were observed, the largest of which occurred in early May (1,140 fish/24 hours). The two subsequent peaks were observed in mid-May (561 fish/24 hours) and late May (587 fish/24 hours). In late June, a smaller pulse of 14 fish/24 hours was noted. The three major peaks observed in 1982 were larger than those which occurred in 1980 and 1981. Also, chinook salmon were present in the 1982 catch over a longer time range than was observed in 1980 and 1981.

Timing of Peaks in Catch Rate of Juvenile Chinook Salmon Compared between Trapping Sites

The first major peak in catch rate of juvenile chinook salmon in 1980 was observed at PVPH (late March); it consisted exclusively of emergent fry less than 41 mm in length. This peak did not appear at DFS apparently due to the inability of the fish screen to effectively retain small fish (Appendix I). The second major peak occurred at the Eel River site (mid-May), followed by a final major peak at PVPH/DFS

Table 3.7-16. Catch rates (fish/24 hours) of steelhead trout and chinook salmon captured in Tomki Creek and the Eel River above Outlet Creek in 1982.

Trapping Period	Tomki Creek: Catch Rate (fish/24 hours) Steelhead	Tomki Creek: Catch Rate (fish/24 hours) Chinook	Tomki Creek: Water[a] Temp. (°C)	Tomki Creek: Flow[b] (cfs)	Tomki Creek: Turbudity (NTU)	Eel River above Outlet Creek: Catch Rate (fish/24 hours) Steelhead	Eel River above Outlet Creek: Catch Rate (fish/24 hours) Chinook	Eel River above Outlet Creek: Water[a] Temp. (°C)	Eel River above Outlet Creek: Flow[c] (cfs)	Eel River above Outlet Creek: Turbudity (NTU)
Feb. 24-25	1	0	8	-	5	-	-	-	1,450	-
25-26	0	0	8	-	5	-	-	-	1,550	-
Mar. 8-9	0	0	9	304	7	-	-	-	1,480	-
11-12	0	0	10	282	6	-	-	-	1,870	-
15-16	0	0	6	251	5	-	-	-	1,205	-
18-19	0	0	7	-	5	0	0	10	963	13
22-23	1	3	8	146	2	0	0	12	693	13
25-26	0	8	10	109	2	0	6	11	562	10
Apr. 19-20	11	199	13	216	6	-	-	-	3,350	-
22-23	0	212	11	165	4	-	-	-	2,785	-
26-27	101	12,326	18	93	2	-	-	-	2,180	-
29-30	109	8,307	18	86	3	0	232	14	1,030	10
May 3-4	39	2,253	19	79	1.4	0	1,140	13	490	7
6-7	2	610	20	70	0.9	0	152	16	394	5
10-11	223	3,036	15	62	0.9	0	7	18	332	5
13-14	186	1,245	16	58	0.7	0	27	19	274	2
17-18	522	8,730	15	54	0.4	0	19	19	214	1.2
18-20	-	-	-	-	-	0	34	19	240	1.8
20-21	180	51	18	50	0.7	0	561	20	307	1.7
21-22	-	-	-	-	-	1	133	21	277	1.5
21-23	178	261	19	-	0.6	-	-	-	-	-
22-23	-	-	-	-	-	0	4	22	175	1.4
23-24	663	813	21	42	0.5	0	1	23	130	1.0
24-25	996	1,475	21	42	0.4	0	293	24	147	0.7
25-26	1,934	3,108	22	40	0.4	0	219	25	132	0.5
26-27	530	1,828	19	40	0.6	0	264	23	125	0.7
27-28	179	948	17	40	0.8	2	587	22	141	0.6
May 31 - June 1	10	8	17	35	0.4	0	0	20	85	0.4
3-4	3	5	16	35	0.3	0	0	19	68	0.3
7-8	0	3	18	35	0.7	0	2	22	58	0.8
10-11	13	12	17	31	0.5	0	2	22	50	0.5
14-15	11	0	19	28	0.4	0	0	24	48	0.3
17-18	36	8	20	24	0.3	1	1	25	41	0.4
21-22	14	0	21	21	0.4	33	14	27	40	0.4
24-25	47	0	18	20	0.8	23	11	23	37	1.0
28-29	37	0	17	19	0.4	2	9	22	43	0.5
July 1-2	9	5	17	21	0.4	0	2	21	51	0.3
6-7	4	2	23	21	0.5	0	3	20	38	0.5
8-9	0	0	24	16	0.4	2	1	21	33	0.5
12-13	9	0	20	13	0.4	1	1	26	28	0.3
15-16	10	10	22	10	0.3	3	0	20	22	0.3
19-20	9	0	24	10	0.3	5	0	23	22	0.2
22-23	5	0	25	5	0.2	1	0	24	19	0.2
26-27	3	0	20	1	0.3	3	0	27	16	0.2
29-30	1	0	26	0	0.4	8	0	22	17	0.3

[a] Water temperatures from Tomki Creek and Eel River above Outlet Creek are an average of spot checks taken at the beginning and ending of each trapping period.

[b] Tomki Creek flows are from spot checks taken sometime during the trapping period at Gage E-19 located near Cave Creek.

[c] Eel River flows are averages of mean daily flows throughout the trapping period.

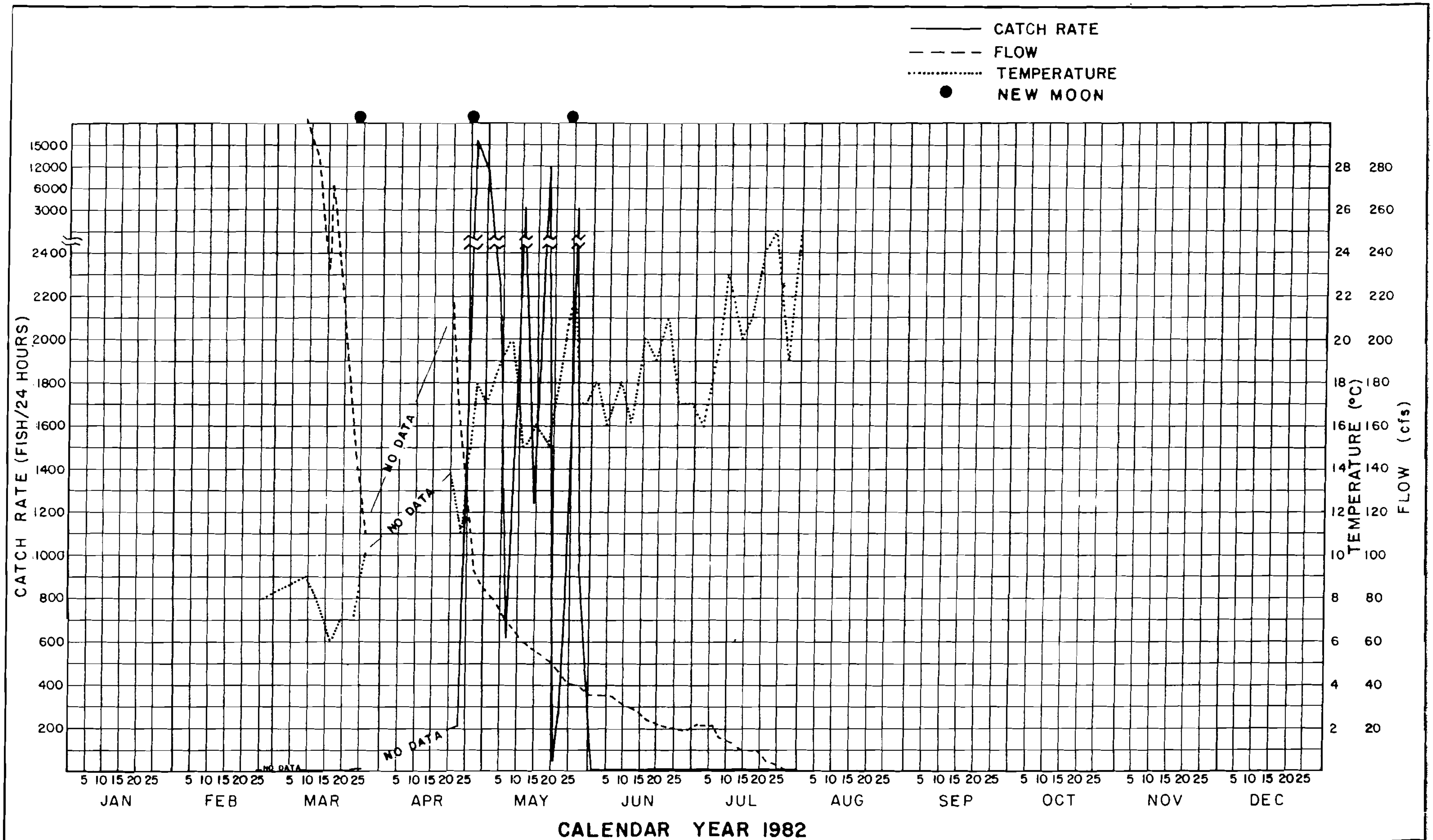

Figure 3.7-3. Catch rate (fish/24 hours) of chinook salmon and daily water temperature and discharge at Tomki Creek in 1982.

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Table 3.7-17. Catch rates (fish/24 hours) of steelhead trout and chinook salmon captured in the Eel River above Outlet Creek in 1980 and 1981.

	1980[a]					1981				
	Catch Rate (fish/24 hours)		Water[b] Temp.	Flow[c]	Turbudity	Catch Rate (fish/24 hours)		Water[b] Temp.	Flow[c]	Turbudity
Trapping Period	Steelhead	Chinook	(°C)	(cfs)	(NTU)	Steelhead	Chinook	(°C)	(cfs)	(NTU)
Feb. 11-12	-	-	-	-	-	0	0	10	315	17
22-23	-	-	-	-	-	0	0	9	585	25
24-25	-	-	-	-	-	0	0	8	1,200	30
Mar. 3-4	-	-	-	-	-	0	0	10	1,110	58
5-6	-	-	-	-	-	0	0	9	1,200	23
9-10	-	-	-	-	-	0	0	11	730	16
11-12	-	-	-	-	-	0	0	12	585	13
16-17	-	-	-	-	-	1	0	10	460	16
19-20	-	-	-	-	-	0	0	10	536	17
24-25	-	-	-	-	-	0	0	11	1,090	19
Mar. 31-Apr. 1	-	-	-	-	-	1	0	9	647	-
2-3	-	-	-	-	-	0	1	12	498	5
3-4	0	53	11	329	-	-	-	-	-	-
4-5	-	-	-	-	-	0	4	13	418	5
6-7	-	-	-	-	-	0	0	13	373	3.9
8-9	-	-	-	-	-	0	5	14	338	3.2
10-11	-	-	-	-	-	0	2	13	350	3.2
12-13	-	-	-	-	-	1	2	12	269	3.2
14-15	0	70	17	378	-	0	5	15	268	2.8
15-16	0	44	16	361	-	-	-	-	-	-
16-17	-	-	-	-	-	0	4	16	256	2.7
20-21	-	-	-	-	-	0	18	16	276	3.1
21-22	0	80	14	401	-	-	-	-	-	-
22-23	0	18	15	349	-	-	-	-	-	-
23-24	-	-	-	-	-	0	65	17	219	1.6
28-29	0	6	18	282	-	0	128	21	186	1.3
29-30	0	31	18	272	3.2	-	-	-	-	-
Apr. 30-May 1	-	-	-	-	-	1	352	21	160	1.0
5-6	0	316	20	217	2.0	3	111	16	151	0.9
6-7	0	284	19	211	1.9	0	189	17	147	0.8
7-8	-	-	-	-	-	6	117	17	139	0.7
8-9	-	-	-	-	-	0	40	19	131	0.7
11-12	-	-	-	-	-	2	55	20	120	0.6
12-13	0	206	18	167	1.5	-	-	-	-	-
13-14	0	190	19	159	1.3	2	10	20	106	0.5
14-15	0	420	18	147	1.3	-	-	-	-	-
18-19	-	-	-	-	-	3	4	16	179	4.0
19-20	0	4	24	104	0.8	-	-	-	-	-
20-21	0	2	24	108	0.7	0	0	0	0	0
21-22	-	-	-	-	-	0	15	16	98	1.0
25-26	-	-	-	-	-	0	13	21	75	0.3
26-27	-	-	-	-	-	2	14	22	75	0.3
27-28	0	85	19	80	0.4	2	7	23	70	0.2
28-29	0	7	21	76	0.5	-	-	-	-	-
Jun. 1-2	-	-	-	-	-	3	6	24	39	0.9
2-3	0	88	20	57	0.4	-	-	-	-	-
3-4	0	7	19	58	0.4	-	-	-	-	-
4-5	-	-	-	-	-	3	0	22	31	0.2
8-9	-	-	-	-	-	5	0	20	34	-
9-10	1	40	24	48	0.5	-	-	-	-	-
10-11	0	1	22	47	0.5	-	-	-	-	-
11-12	-	-	-	-	-	1	0	21	29	0.2
16-17	1	0	24	39	1.0	1	4	23	26	1.0
17-18	0	0	24	38	1.0	-	-	-	-	-
18-19	-	-	-	-	-	3	6	23	24	0.1
22-23	-	-	-	-	-	2	0	22	20	0.2
23-24	0	0	23	33	0.3	-	-	-	-	-
24-25	0	0	24	35	0.3	-	-	-	-	-
25-26	-	-	-	-	-	10	0	25	19	0.5
29-30	-	-	-	-	-	12	0	28	17	0.7
Jun. 30-Jul. 1	0	0	26	31	0.4	-	-	-	-	-
1-2	2	0	26	28	0.3	9	0	29	16	0.4
6-7	-	-	-	-	-	5	0	22	16	0.5
9-10	-	-	-	-	-	1	0	22	16	0.5
13-14	-	-	-	-	-	2	0	25	17	0.3
16-17	-	-	-	-	-	2	0	26	17	0.5
20-21	-	-	-	-	-	1	0	27	16	0.4
22-23	-	-	-	-	-	7	0	29	16	0.3
27-28	-	-	-	-	-	2	0	27	14	0.3
30-31	-	-	-	-	-	0	0	27	14	0.2

[a] During 1980, trapping was begun on March 3 and was terminated for the season on July 2.
[b] Water temperatures from the Eel River are an average of spot checks taken at the beginning and ending of each trapping period.
[c] Eel River flows are an average of mean daily flows throughout each trapping period.

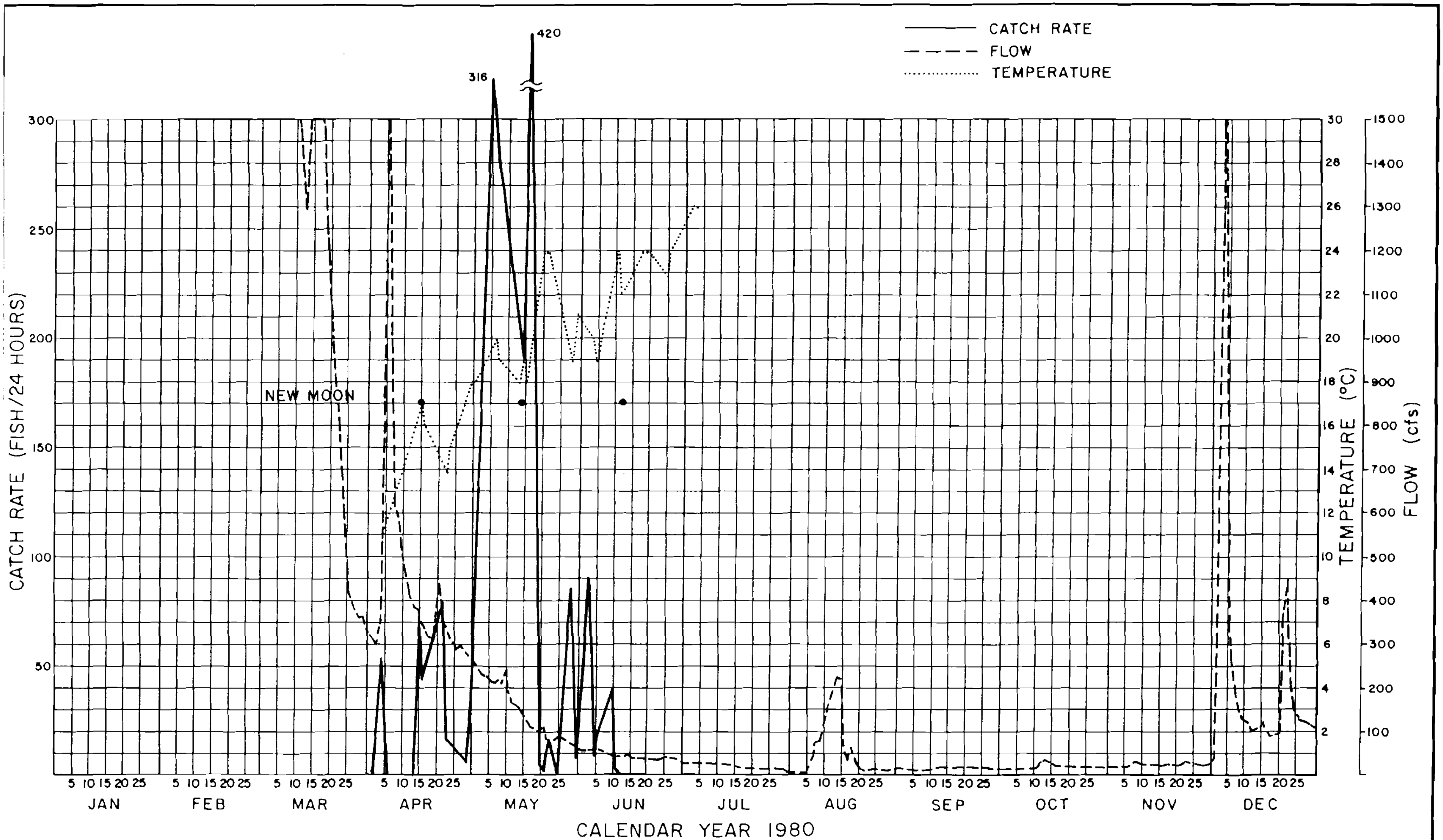

Figure 3.7-4. Catch rate (fish/24 hours) of chinook salmon and daily water temperature and discharge in the Eel River above Outlet Creek in 1980.

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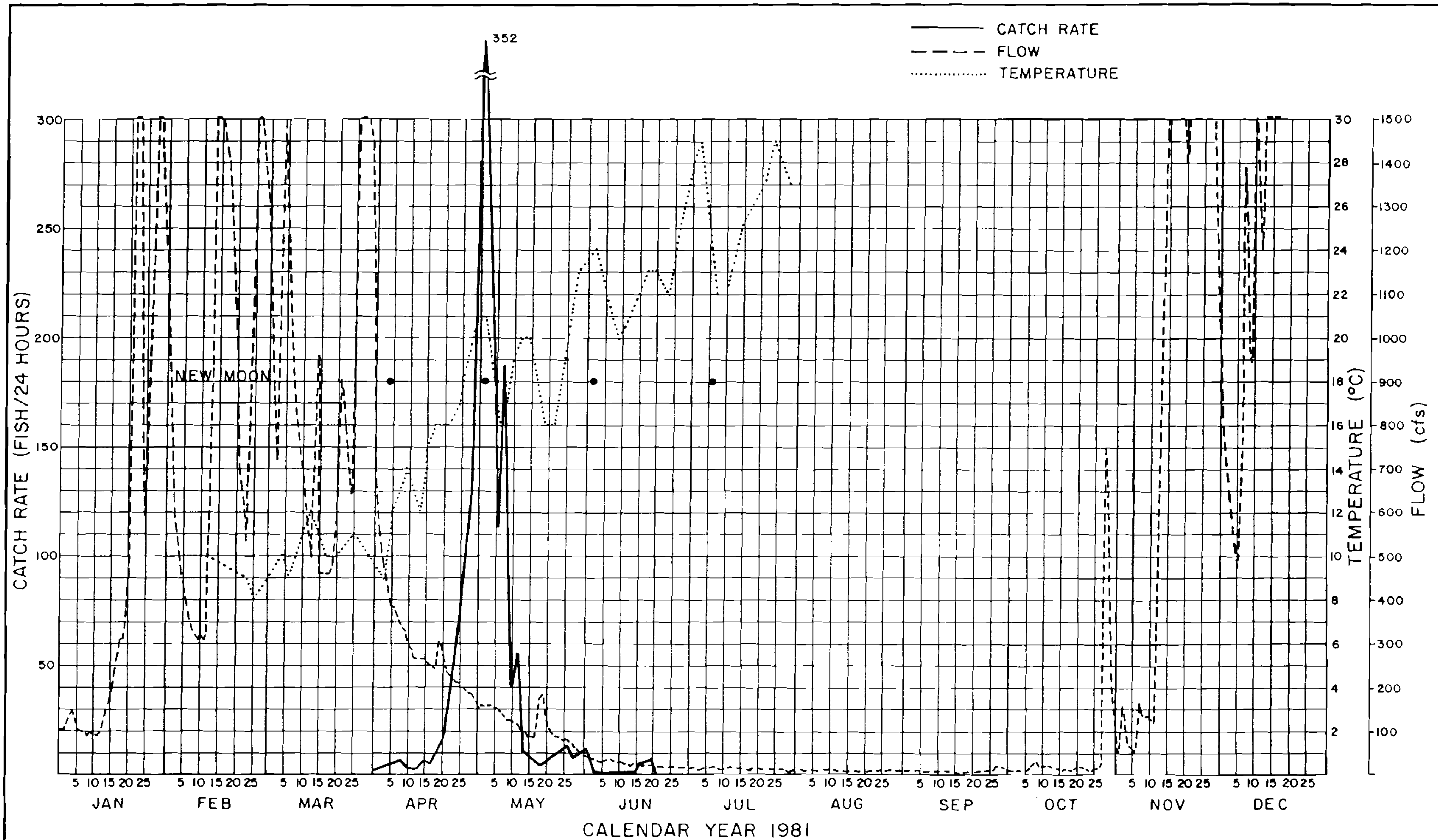

Figure 3.7-5. Catch rate (fish/24 hours) of chinook salmon and daily water temperature and discharge in the Eel River above Outlet Creek in 1981.

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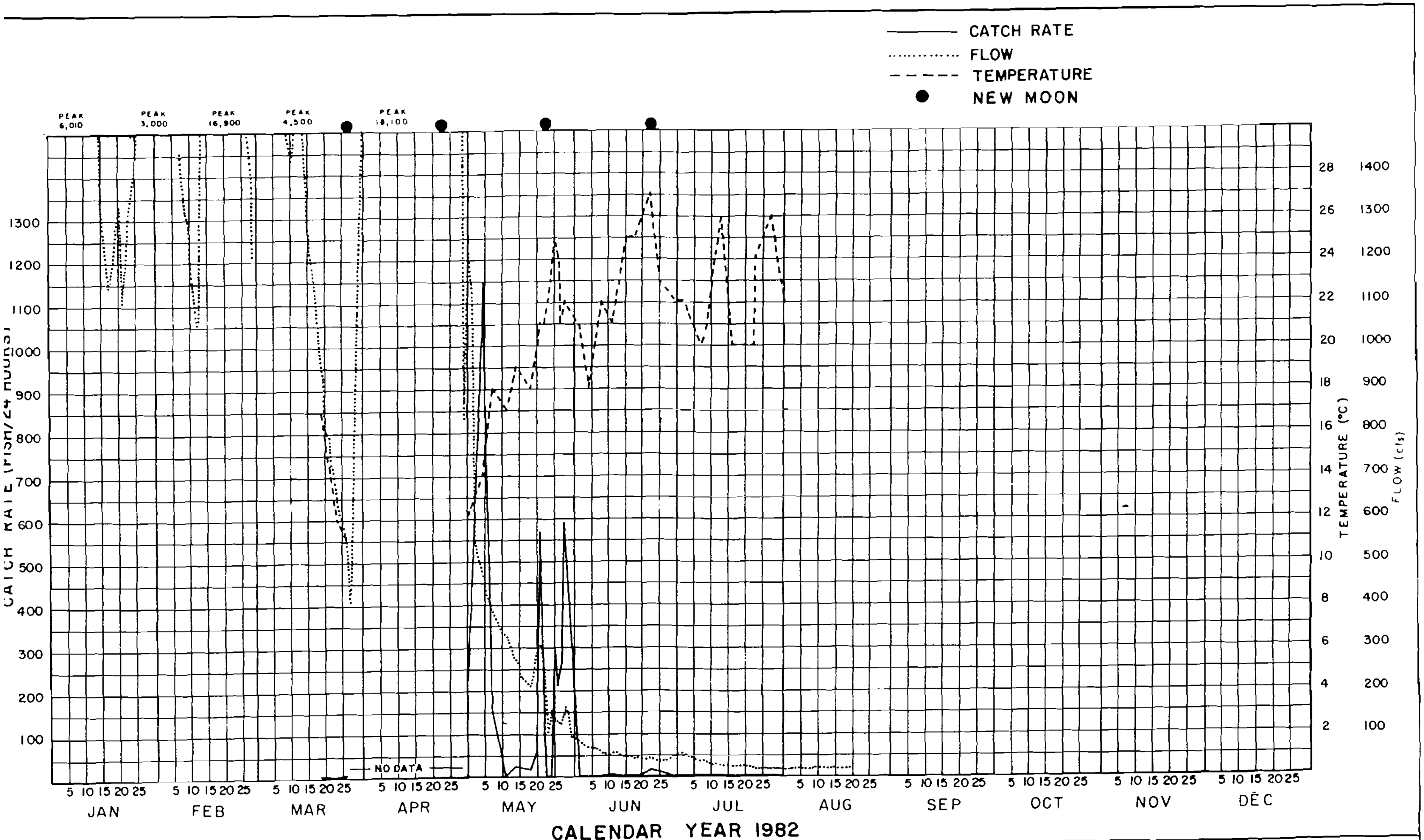

Figure 3.7-6. Catch rate (fish/24 hours) of chinook salmon and daily water temperature and discharge in the Eel River above Outlet Creek in 1982.

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approximately five weeks later (late June). In 1981, only one large peak was evident at the Eel River site; small increases in catch rate occurred before and after the major peak. This one major peak in emigration was about two weeks earlier (late April/early May) and smaller in magnitude than the main emigration peak in 1980. As reported above, no juvenile chinook salmon were captured at PVPH, DFS, or CHDF in 1981.

Greater numbers of juvenile salmon were captured at the Eel River site in 1982 than were captured in 1980 or 1981. A small number of newly emerged chinook salmon were first captured at the Eel River site during two sampling periods in late March 1982. However, high flows precluded further trapping for three weeks until flows had dropped to a workable level. When sampling was resumed, large numbers of chinook salmon were present in the catch. The first major peak was observed in Tomki Creek (late April) followed one week later by a major pulse at the Eel River site; these two peaks contained fish ranging in length from 35 to 65 mm indicating that some of these fish had hatched a number of weeks earlier and were rearing in Tomki Creek. This pattern was repeated about three weeks later (mid-May) with a peak in catch rate at Tomki Creek followed three days later by another peak at the Eel River site; these fish also ranged in length from 35 to 60 mm suggesting that many fish were still emerging. The first observed emigration peak at PVPH/DFS occurred concurrently (late May) with the final sequence of peaks at the Tomki Creek and Eel River sites; these fish were generally larger, exhibiting lengths up to 80 mm. The earlier peak of emergent fry which was observed at PVPH in 1980 was not observed in 1982. This was probably a result of extremely high flows during the suspected emergence period in 1982, thereby reducing trapping efficiency.

Environmental Factors Associated with Downstream Migration of Juvenile Chinook Salmon in the Eel River and Tomki Creek

For all three years of trapping, the downstream migration patterns of juvenile chinook salmon were similar and seemed to depend primarily on water temperature. The major peaks of emigration occurred when water temperature reached 17 to 20°C at PVPH/DFS in 1980 and 1982, at Tomki Creek in 1982, and at the Eel River site in 1980, 1981, and 1982 (Figures 3.7-1 through 3.7-6). When water temperatures exceeded 22°C, major emigration tended to decline. In 1980 and 1982, the catch rate at the Eel River site dropped sharply to near zero when water temperatures approached 24°C and then increased substantially when water temperatures dropped below 22°C. At the Eel River site in 1981, very few fish were captured when water temperatures rose above 22°C. Other studies have also indicated the importance of temperature to downstream migration of chinook salmon. McPherson and Cramer (1981) stated that water temperatures approaching 19°C stimulated chinook salmon emigration in the Rogue River. Additionally, Thomas (1975) found that a sudden increase of stream temperature caused an increase of chinook salmon emigration in Washington.

Emigration of chinook salmon reared above Cape Horn Dam occurs later than elsewhere in the study area apparently due to cool water releases from the bottom of Lake Pillsbury during spring. Temperatures necessary to stimulate migration (17-20°C) did not occur above Cape Horn Dam until late May to mid-July during the three years of study; in contrast, temperatures in Tomki Creek and the Eel River above Outlet Creek reached the 17-20°C level by mid-April to early May. The delay in migration for chinook reared above Cape Horn Dam can expose them to lethal temperature conditions downstream and reduce or eliminate the likelihood of successful passage to the ocean. For example, the major peak of emigration above Cape Horn Dam in late June 1980 did not appear at the Eel River site; in fact, no juvenile chinook salmon were caught at the Eel River site after June 12 during the 1980 migration season. This may be explained by the differences in water temperatures at the two locations. At the time peak emigration occurred above Cape Horn Dam in 1980 (late June), water temperatures in the Eel River downstream from Cape Horn Dam were approaching or exceeding lethal levels (24°C) as defined experimentally by Brett (1952).

Results from 1982 contrasted with the 1981 results. In 1982, the major period of emigration from above Cape Horn Dam occurred in late May and juvenile chinook salmon were present in the catch at the Eel River site until mid-July. The presence of chinook salmon in the Eel River above Outlet Creek during mid-summer was probably a direct result of cooler water temperatures downstream of Cape Horn Dam in 1982. The earlier emigration of chinook salmon from above Cape Horn Dam in 1982 may have been due to the experimental release of water from the surface of Lake Pillsbury. Surface releases were made from May 14 to June 15 to determine the effect of release level on temperature and on downstream migrating salmonids in the river between Scott and Cape Horn Dams. River temperatures were increased about 5 to 7°C as a result of the surface releases and reached the 17 to 20°C level much earlier than under normal operating conditions (Section 3.6, Instream Flow Study and Appendix H). It appears that manipulation of water release from Scott Dam can affect the timing of emigration of chinook salmon from the Eel River above Cape Horn Dam, and is an effective tool for improving the timely emigration of salmon from the study area.

Temperature differences within the study area may also affect growth rates of juvenile chinook salmon. The apparent growth rates of juvenile chinook salmon, as indicated by mean length per two-week interval (Appendix I), differ between the PVPH/DFS, Tomki Creek and the Eel River trapping sites and between years. Cooler water temperatures upstream of Cape Horn Dam may be more conducive to growth as compared to the warmer water temperatures downstream of Cape Horn Dam. In 1980, juvenile chinook salmon appeared to grow faster above Cape Horn Dam than at the Eel River site. Mean lengths of juvenile salmon above Cape Horn Dam increased from 47 to 83 mm from mid April through late June, a growth rate of approximately 4.5 mm per week. At the Eel River site above Outlet Creek, mean lengths increased from 47 to 66 mm during the same time period, a growth rate of approximately 2.4 mm per week. Water temperatures above Cape Horn Dam varied from 10 to 17°C between mid April and late June, roughly averaging 14°C. Water temperatures at the

Eel River site varied from 14 to 30°C during the same time period, roughly averaging 21°C.

In 1982, mean lengths of emigrating salmon from above Cape Horn Dam increased from 49 to 107 mm from mid-May through early July, a growth rate of approximately 8.3 mm per week. Tomki Creek fish showed an apparent growth rate of 2.0 mm during the same time period, indicating that these fish were probably emigrating soon after hatching. The catch from the Eel River site showed an increase in mean length from 42 to 73 mm during the same time period, a growth rate of 4.4 mm per week. Water temperatures above Cape Horn Dam from mid-May through early July varied between 13 and 19°, roughly averaging 16°C. Tomki Creek water temperatures varied between 15 and 24°C, averaging 19°C. Eel River water temperatures near Outlet Creek varied between 13 and 27°C, roughly averaging 20°C.

Satterthwaite (1981) reported that Rogue River chinook salmon grew faster when water temperatures were 16 to 17°C as compared to 18 to 19°C. Additionally, McPherson and Cramer (1981) found that the body condition of juvenile salmon decreased when water temperature exceeded 21.6°C. During the present study, the greatest growth rate was observed above Cape Horn Dam in 1982. According to Satterthwaite's criteria, the fish from above Cape Horn Dam were reared in optimum temperatures in 1982; water temperatures above Cape Horn Dam were lower than optimum in 1980, thus producing the slower growth rate. Growth rates at Tomki Creek and the Eel River site were much slower, apparently due to the higher than optimum water temperatures.

Downstream movement of juvenile chinook salmon may also be dependent on the timing of lunar phases. Figures 3.7-1 through 3.7-6 show the position of the new moon with catch rates. Generally, the major peaks in catch rate at Tomki Creek and at the Eel River site above Outlet Creek occurred during periods of low light intensity associated with lunar periodicity. Usually, lower catch rates were evident when the moon was nearing the full phase. Catch rates increased as light levels decreased in association with the waning moon. In 1980 and 1981, the greatest catch rates were concurrent with the new moon occurring in May. In 1982, the greatest catch rates occurred in proximity to the new moon in late April. Wertz (1981) reported that investigators have found high levels of thyroxin in the blood plasma of smolting salmon during the new moon; thyroxin is believed to initiate hormone production in conjunction with the smoltification process, thereby physiologically readying juvenile salmon to migrate.

In 1980, salmon emigration from above Cape Horn Dam did not demonstrate an apparent response to lunar periodicity. However, in 1982, the main peak of emigration occurred near the new moon. This may be due to the difference in water temperatures above Cape Horn Dam between the two years. It is possible that water temperatures must reach a threshold level of around 17 to 20°C before major emigration occurs. In 1980, peak emigration did not begin until water temperatures approached 17°C in mid-June, about one week later than the occurrence of the new moon. In 1982, major emigration of juvenile chinook salmon began in mid-May. This earlier response may have been due to the fact that water temperatures also approached 17°C in mid-May. The occurrence of the new moon during this same time period possibly enhanced the downstream movement of juvenile salmon. The fact that peaks in catch rate above Cape Horn Dam and downstream from Cape Horn Dam did not always occur during the new moon phase suggests that water temperature may be the main influencing factor stimulating emigration with light intensity being a secondary factor.

Factors other than temperature and light intensity may also affect the pattern of chinook salmon downstream migration. During emergent fry dispersal, some downstream movement was evident, usually in association with peaks in streamflow. This occurred at PVPH and at the Eel River site in 1980 and at Tomki Creek and the Eel River site in 1982; water temperatures at all sites during fry emergence in 1980 and 1982 were 10 to 11°C. In 1981, this early peak was not evident at the Eel River site. Flows were in excess of 2,500 cfs at the expected time of emergence and the proportion of streamflow which was fished by the fyke net was extremely small. McGie (1969) found that most salmon fry emerge from the gravel at night resulting in disorientation. This causes the newly emergent fry to drift downstream until increasing light levels during the next day allow the fry to orientate themselves to the environment. Early season peaks in chinook salmon migration may also result from decreases in streamflow. Initial migration peaks each season generally followed major reductions in flow from high spring levels (Figures 3.7-1 through 3.7-6). Decreasing spring flows may affect migration directly by stimulating movement or indirectly by helping to increase temperature, which in turn stimulates movement.

Steelhead Trout

Juvenile steelhead trout were captured at all locations during 1980, 1981, and 1982. The catch rates of juvenile steelhead trapped at PVPH/DFS during 1980 and 1981 are shown in Tables 3.7-13 and 3.7-14 and Figures 3.7-7 and 3.7-8. As previously stated, catch results from these two sites were combined, since they represent a single group of fish. The catch rates of juvenile steelhead trapped at PVPH/DFS during 1982 are shown in Table 3.7-15 and Figure 3.7-9. The breakdown of the DFS fish pump resulted in fewer trapping periods at DFS in 1982. Therefore, fewer data points were available to define the catch curve, and the magnitude of the catch rates may be negatively biased. However, the pattern of emigration can be discerned from the data. Catch rates of juvenile steelhead trapped at the CHDF during 1980, 1981 and 1982 are presented in Figures 3.7-10 through 3.7-12. Catch rates of steelhead trapped in Tomki Creek during 1982 are shown in Table 3.7-16 and Figure 3.7-13. Catch rates of steelhead trapped in the Eel River above Outlet Creek during all three years are shown in Tables 3.7-16 and 3.7-17 and Figures 3.7-14 and 3.7-15. The timing of emergence and migration, as well as approximate growth rates of juvenile steelhead in the Eel River, can be derived from the data presented in the length frequency table in Appendix I and Figures 3.7-7 through 3.7-15.

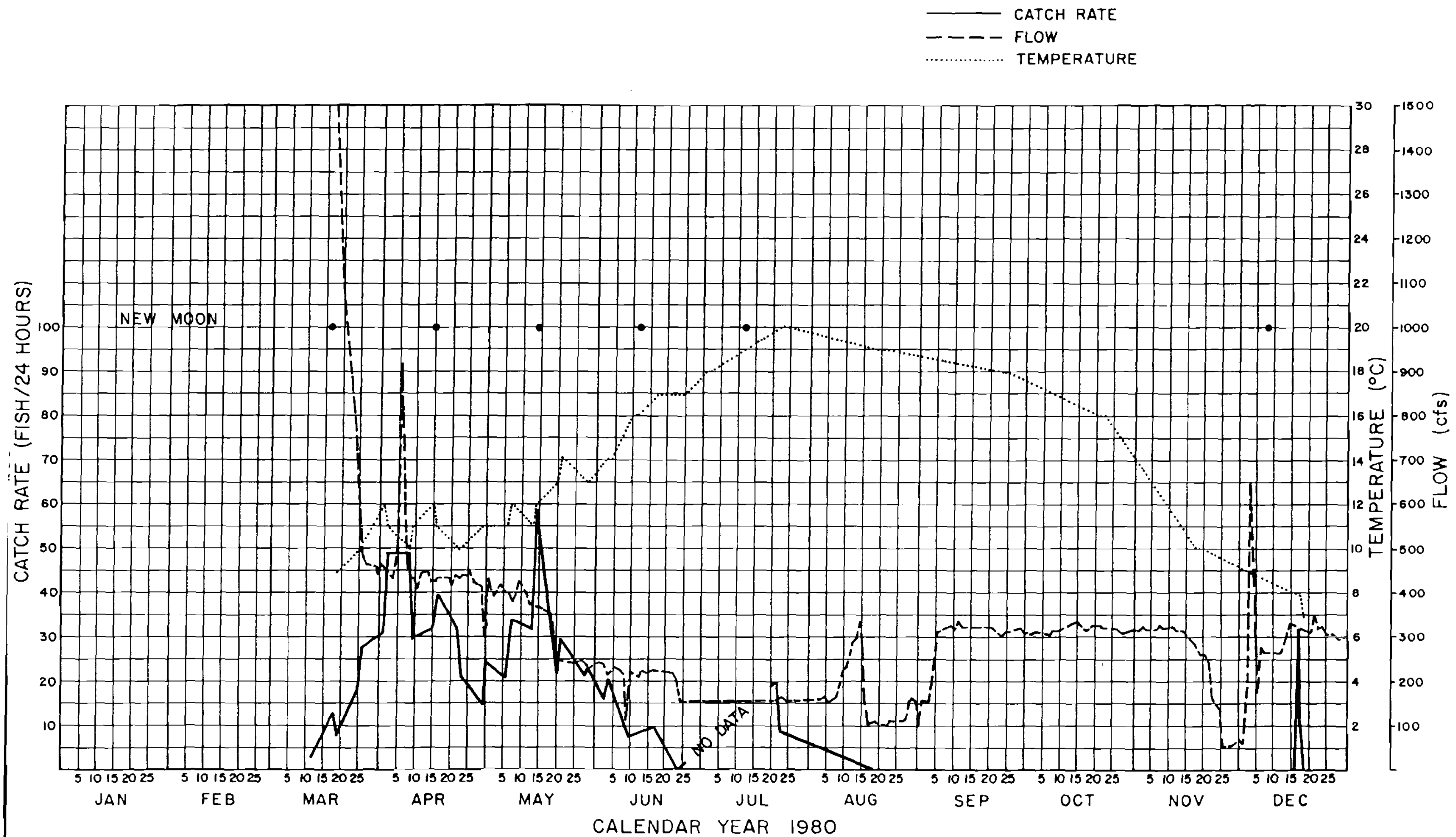

Figure 3.7-7. Combined catch rate (fish/24 hours) of steelhead trout and daily water temperature and discharge at the diversion (PVPH/DFS) in 1980.

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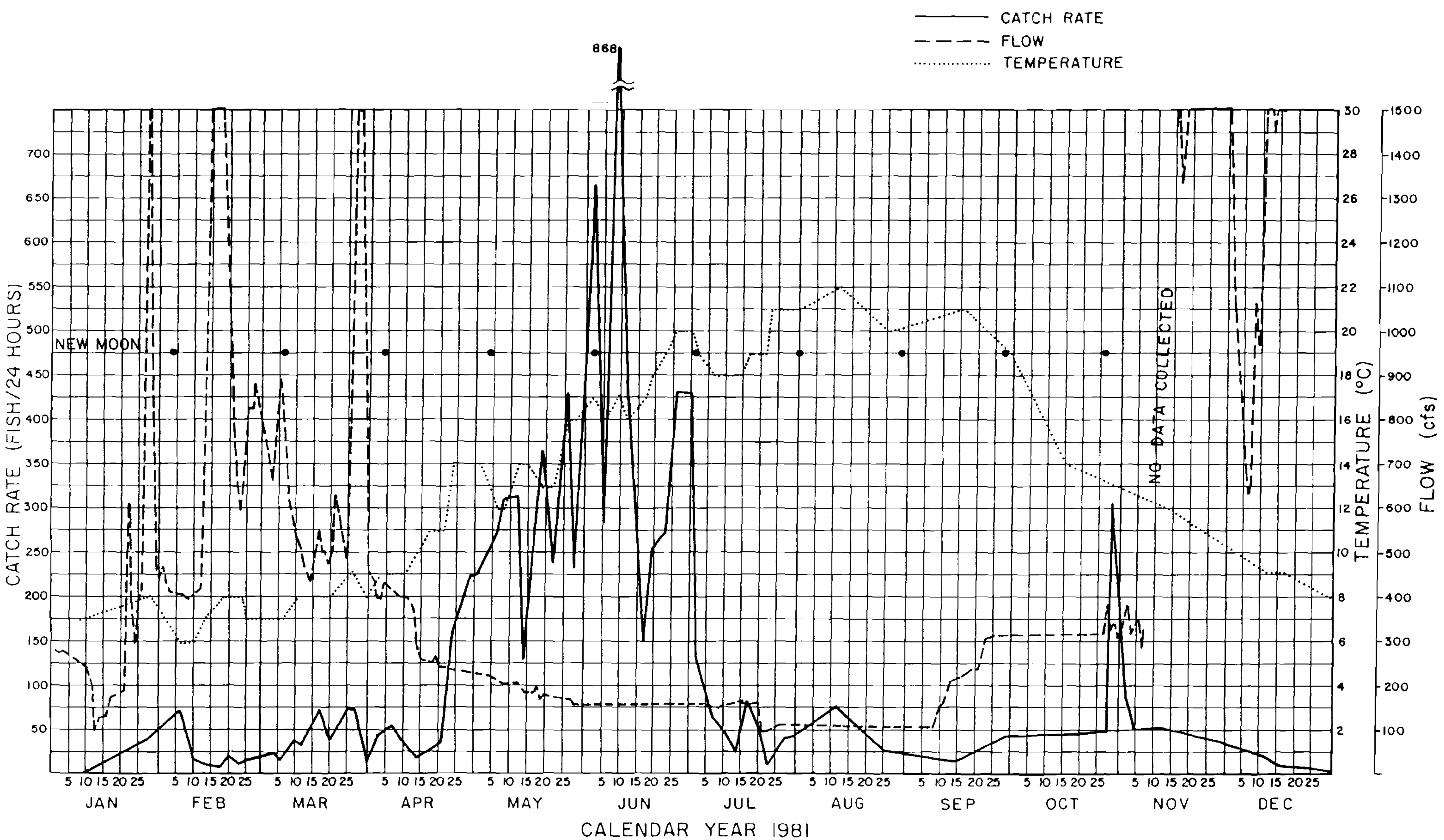

Figure 3.7-8. Combined catch rate (fish/24 hours) of steelhead trout and daily water temperature and discharge at the diversion (PVPH/DFS) in 1981.

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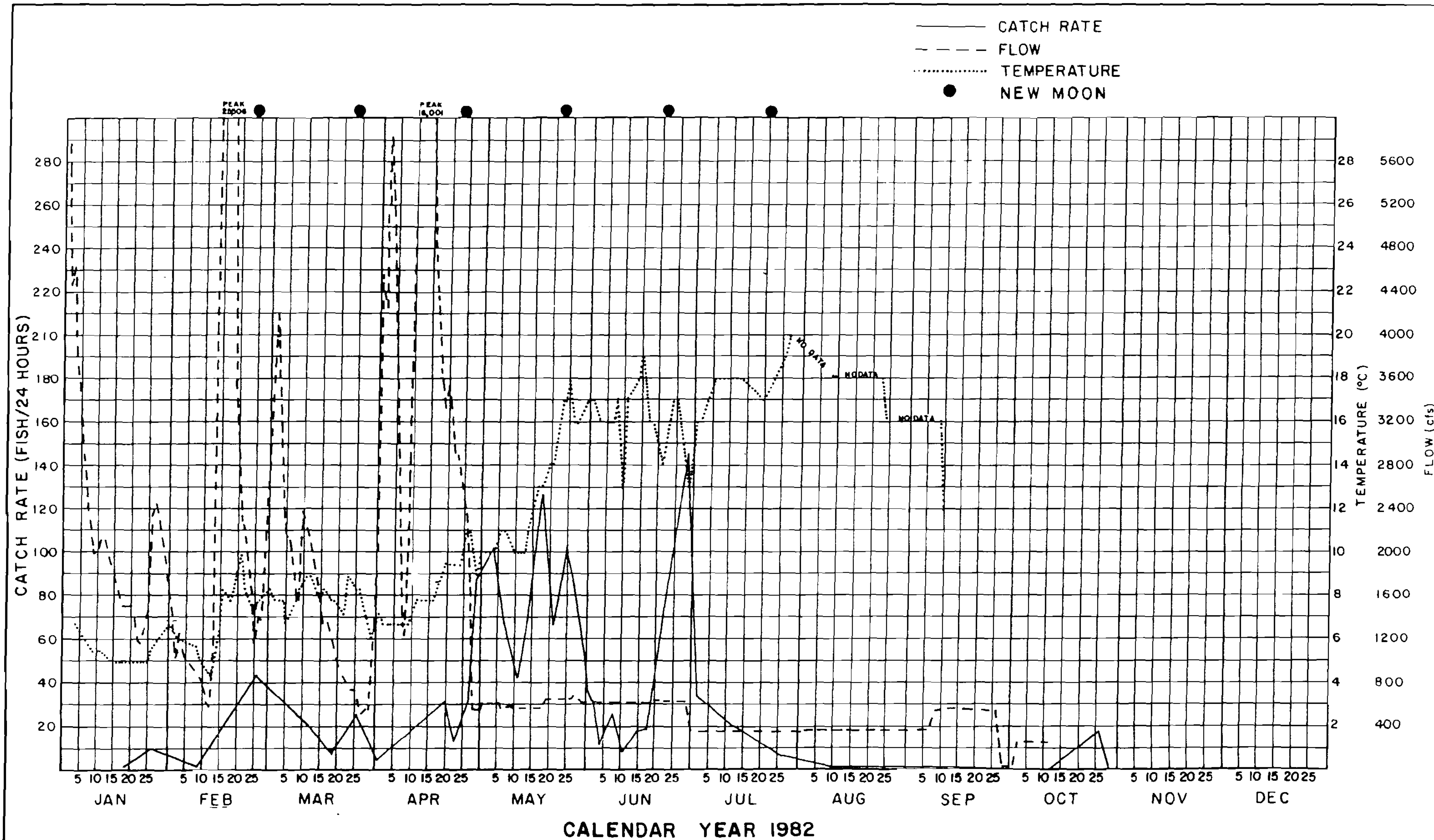

Figure 3.7-9. Combined catch rate (fish/24 hours) of steelhead trout and daily water temperature and discharge at the diversion (PVPH/DFS) in 1982.

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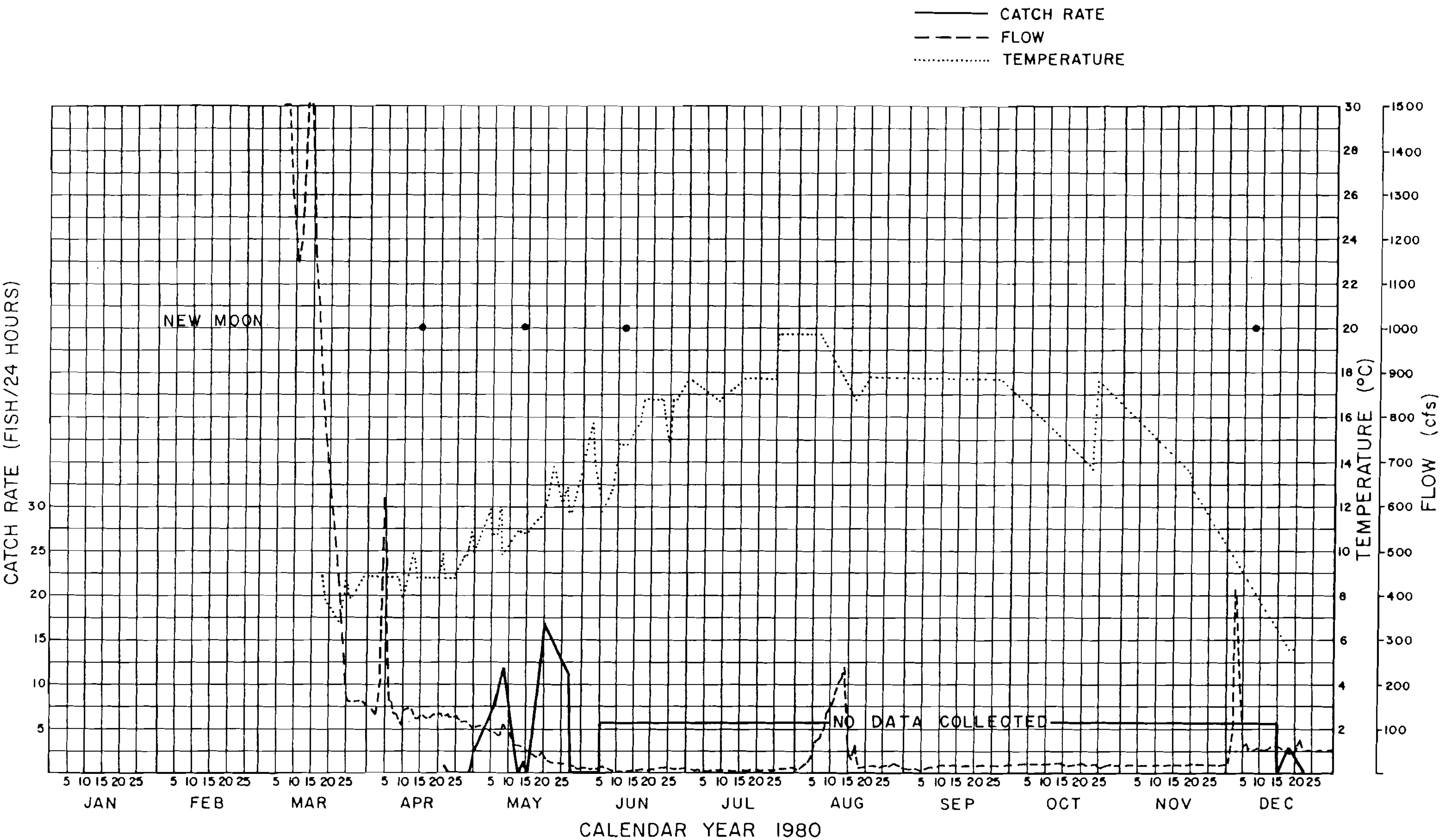

Figure 3.7-10. Catch rate (fish/24 hours) of steelhead trout and daily water temperature and discharge at the Cape Horn Dam fishway in 1980.

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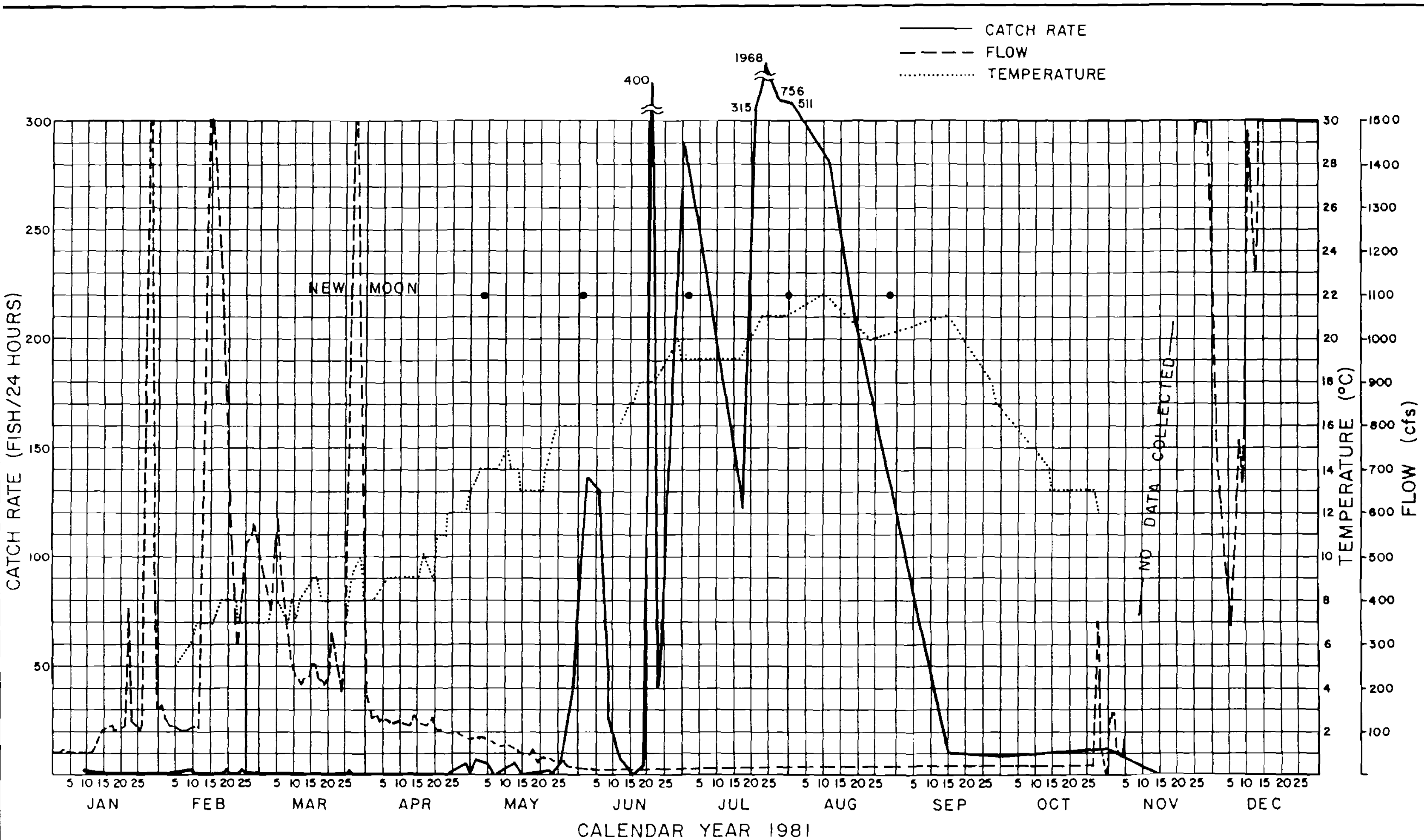

Figure 3.7-11. Catch rate (fish/24 hours) of steelhead trout and daily water temperature and discharge at the Cape Horn Dam fishway in 1981.

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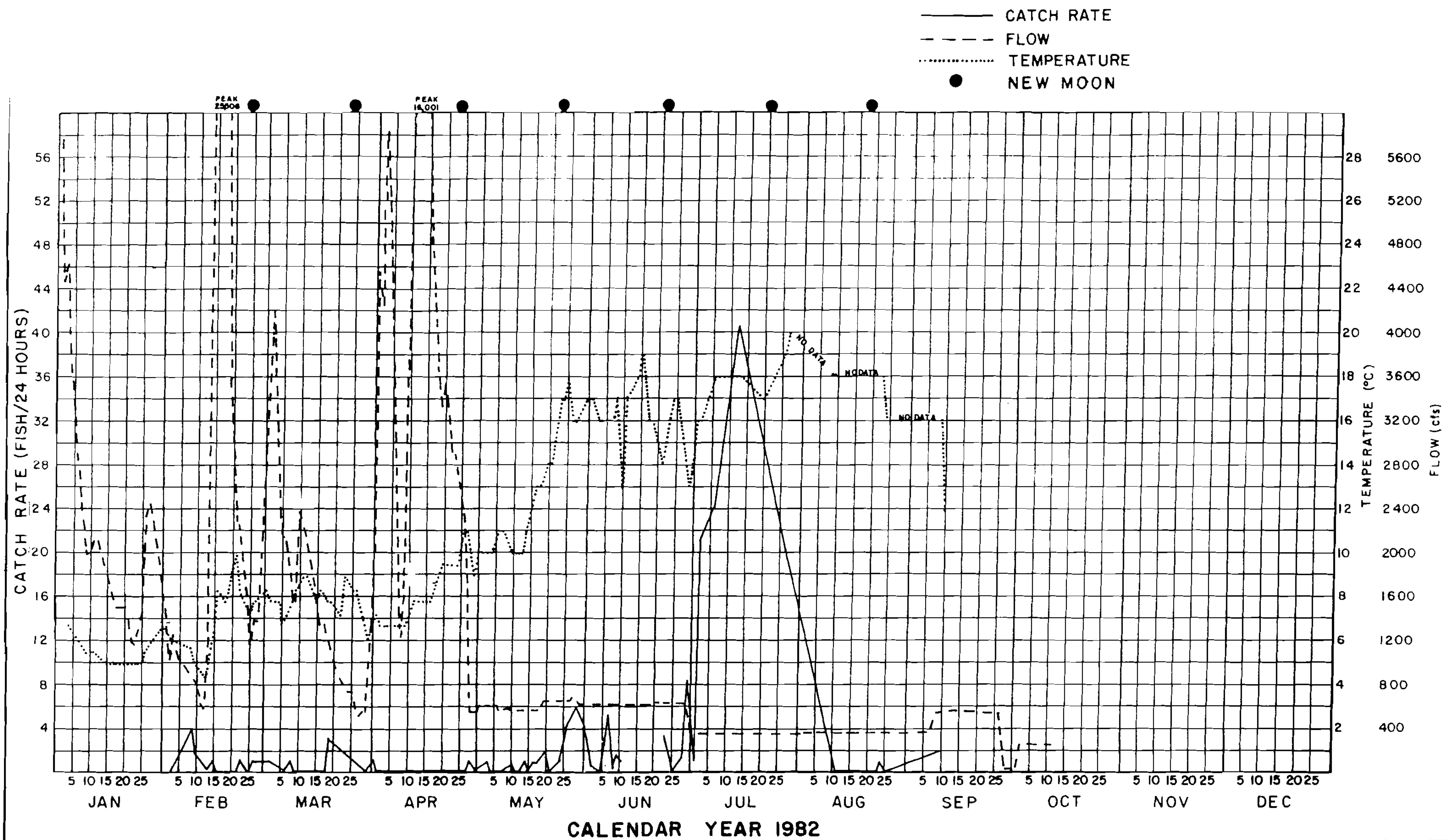

Figure 3.7-12. Catch rate (fish/24 hours) of steelhead trout and daily water temperature and discharge at the Cape Horn Dam fishway in 1982.

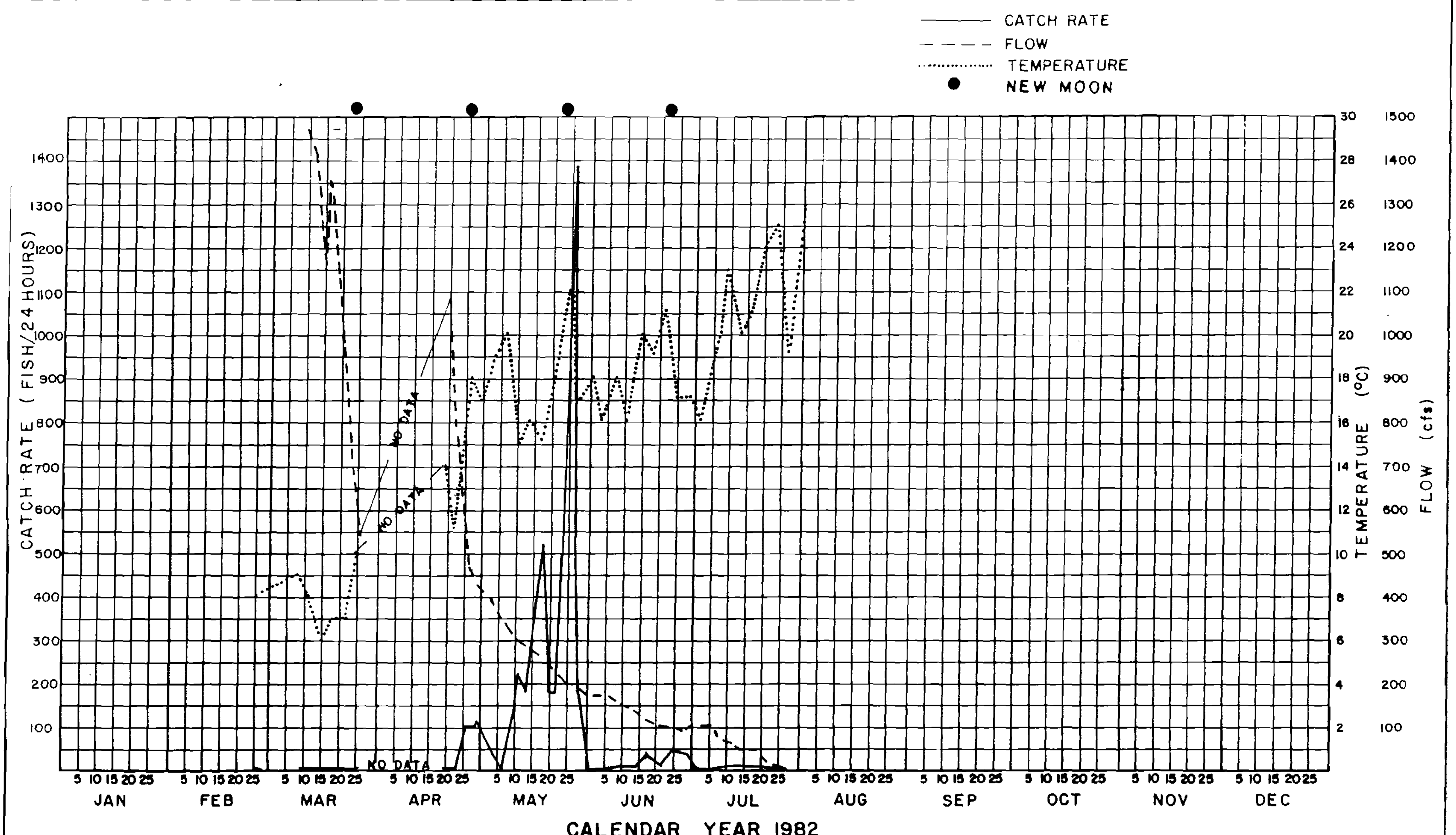

Figure 3.7-13. Catch rate (fish/24 hours) of steelhead trout and daily water temperature and discharge at Tomki Creek in 1982.

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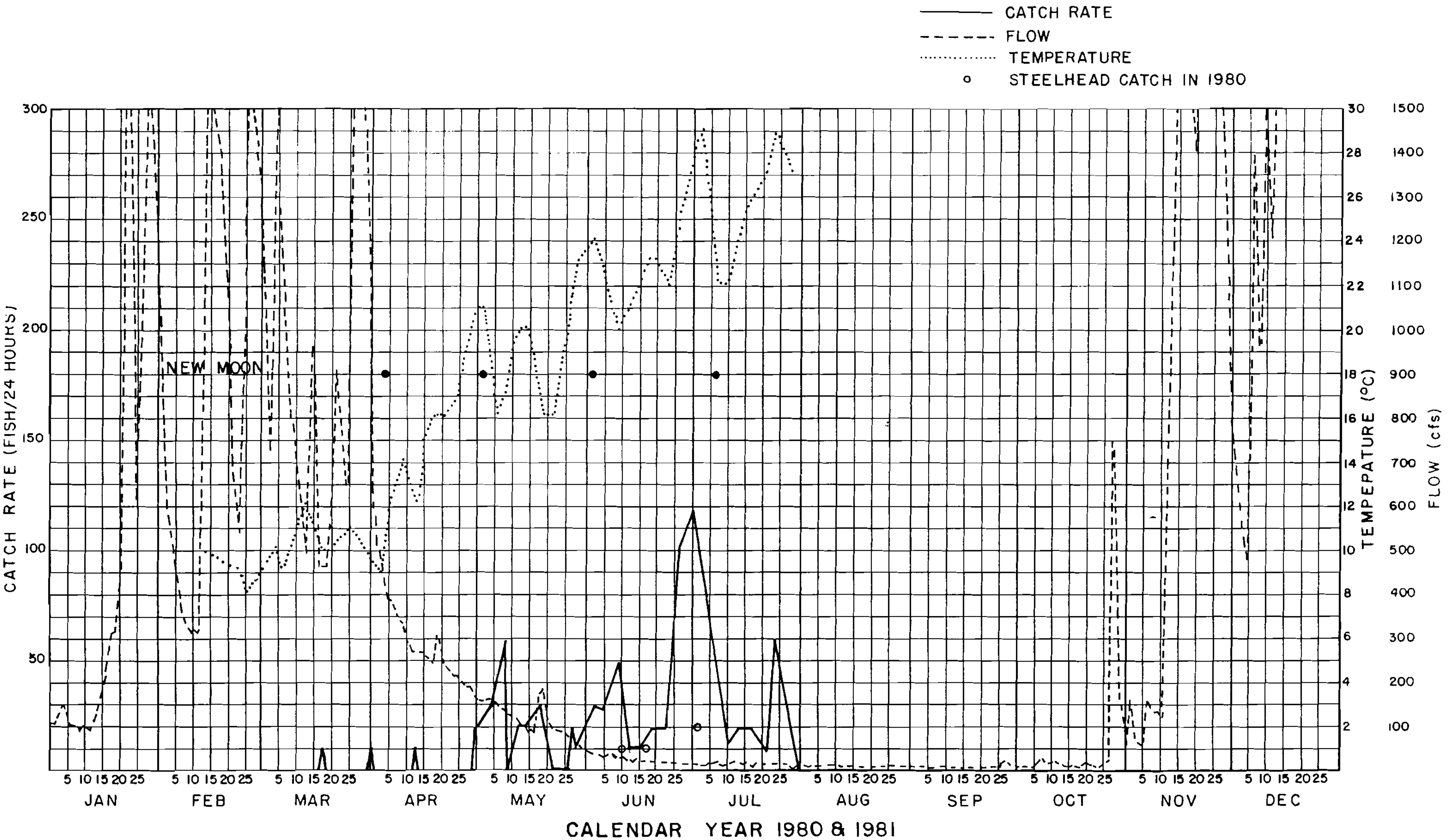

Figure 3.7-14. Catch rate (fish/24 hours) of steelhead trout and daily water temperature and discharge in the Eel River above Outlet Creek in 1981 and catch rate only of steelhead trout in 1980.

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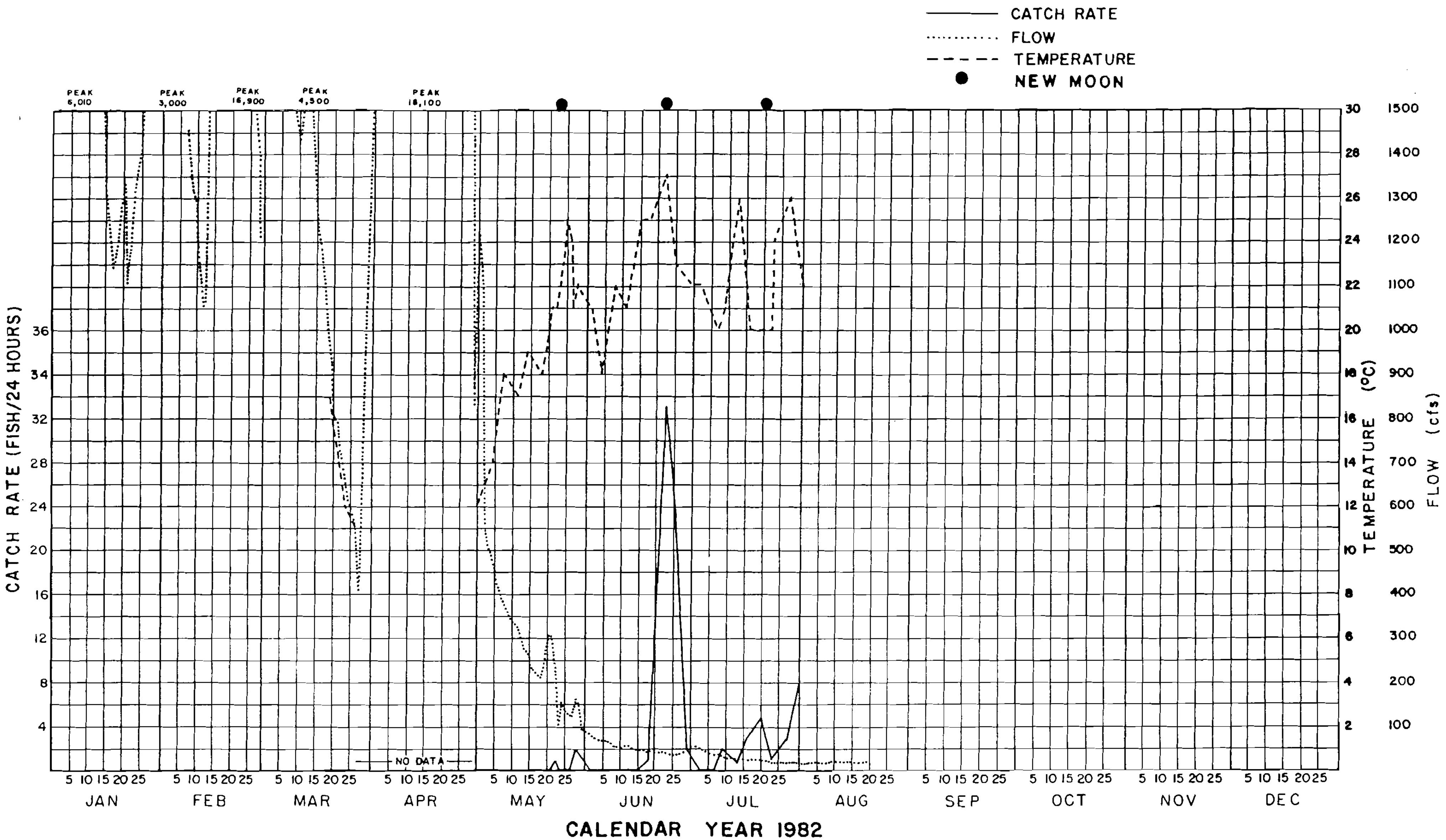

Figure 3.7-15. Catch rate (fish/24 hours) of steelhead trout and daily water temperature and discharge in the Eel River above Outlet Creek in 1982.

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The same general seasonal pattern of juvenile steelhead migration was observed during all three years of trapping. However, considerably more fish were trapped over a greater portion of the year in 1981 and 1982, due to the larger runs of adult steelhead during the 1980/81 and 1981/82 seasons. The trapping effort was also greater during the latter two years. For these reasons, data from 1981 and 1982 are more representative of the downstream migration pattern and will be discussed in greater detail than the 1980 data.

The juvenile steelhead collected each year in this study represent at least three emigrating groups: age 0+, age 1+, and age 2+. For this analysis, all fish older than age 0+ were considered as one group for the following reasons: age 1+ and 2+ (and possibly older fish) overlap in length; smolts of a given age are longer than non-smolts of the same age (McPherson and Cramer 1981); and smolts were not identified in this study. In the following text, young-of-the-year fish will be defined as age 0+ until the following January when the changeover to age 1+ occurs.

Migration Pattern at Potter Valley Powerhouse and Diversion Fish Screen, Age 1+ and Older Fish

Age 1+ and older steelhead began migrating in substantial numbers from above Cape Horn Dam in late January 1981 and in relatively low numbers in late January 1982 (Appendix I). For both years, age 1+ fish averaged about 80 mm in January; the older fish ranged in size up to 250 mm. Most age 1+ and older fish were trapped from January through the middle of June in 1981 and from January to the middle of July in 1982. In 1981, the peak of emigrating age 1+ fish occurred in late March, one month before the major migration period began. It was primarily the 2+ and 3+ fish that defined the first half of the major 1981 migration period (late April-late May) shown in Figure 3.7-8, while the second half (late May-late June) represents the very large numbers of newly emerged 0+ fish. In 1982, however, the peak movements of age 2+ fish occurred in early March while the major movement of age 1+ fish occurred throughout May and June; newly emerged 0+ fish defined the second major peak (early June - mid-July) shown in Figure 3.7-9. For both years, from the middle of June to the end of the year, very few fish older than 0+ were trapped at PVPH/DFS. Age 2+ and older fish outnumbered age 1+ fish in 1981, possibly the result of a relatively weak 1980 year class and the combining of age 2+ and 3+ fish into one group. However, in 1982 the numbers of age 2+ and older fish were less than the numbers of age 1+ fish; this would be expected due to the relatively strong 1981 year class.

Migration Pattern at Potter Valley Powerhouse and Diversion Fish Screen, Age 0+ Fish

Juvenile steelhead measuring 20 to 50 mm in length were trapped at PVPH/DFS beginning in mid-April 1981 and late March 1982 (Appendix I). By extrapolation, hatching of fry upstream of Cape Horn Dam can be estimated to have begun around the beginning of March and to have lasted until about mid-April. In 1981, age 0+ steelhead increased in numbers from mid-April to a peak in early June (Figure 3.7-8). In 1982, this same pattern was apparent but occurred one month later, with numbers increasing from mid-May to a peak in late June (Figure 3.7-9). For both years, numbers declined sharply in early July, ending the peak migration period. In 1981, age 0+ fish continued to migrate in low numbers into October, when a sharp increase in migration occurred in association with the first major rainfall of the season; few fish were trapped during November and December (Figure 3.7-8). In 1982, very few steelhead were captured from late July through mid-October, but a sharp peak was observed in late October, once again associated with the first storm of the season (Figure 3.7-9).

Migration Pattern at Cape Horn Dam Fishway

The timing of juvenile steelhead migration at the CHDF appears to be later than at PVPH/DFS for both 1981 and 1982 (Figures 3.7-11 and

3.7-12); however, this may be the result of extreme seasonal variation in the efficiency of the fish trap. Relatively constant flows of about 12-25 cfs pass through the CHDF throughout the year; flows in excess of 12-25 cfs spill over Cape Horn Dam. From early June to early September, the entire release from Cape Horn Dam flows through the CHDF; however, during the rest of the year, an extremely small percentage of the flow passes through the CHDF. Trapping efficiency varied inversely with the total flows past Cape Horn Dam. During the period from early June to early September 1981 and June to late July 1982, a high percentage of the fish migrating downstream past Cape Horn Dam were counted; however, during the rest of the trapping period, most fish may have gone over the dam. This would explain why very few juvenile steelhead were collected before June even though the peak migration period began in late April as indicated by the PVPH/DFS trapping. For both years, the majority of fish trapped at CHDF were age 0+ fish.

It is not known why large numbers of fish were trapped at CHDF in July and August 1981 when few fish were trapped at PVPH/DFS (Figures 3.7-8 and 3.7-11). However, it should be noted that the large numbers of fish were trapped right after the flow release at Scott Dam was reduced by approximately 60 cfs. It is possible that the flow reduction triggered the migration response in fish that were in the river above Van Arsdale Reservoir or in the reservoir itself. Whatever was the case, there is no explanation as to why the fish entered the CHDF but not the PVPH/DFS, other than that phenomenon may also be related to the reduction in flow.

Migration Pattern at Tomki Creek

The catch from Tomki Creek exhibited a minor peak of age 1+ fish in late April 1982 (Figure 3.7-13). Approximately one week later, major emigration of exclusively newly emergent steelhead fry began; numbers generally increased to a peak in late May. Numbers then declined fairly rapidly to relatively low levels by early June. The catch rate further declined until trapping was terminated at the end of July; numbers had dropped to less than 1 fish/24 hours indicating that emigration had probably ceased. The pattern of older fish emigrating in April with young-of-the-year fish moving out immediately afterward is similar to the emigration pattern observed at PVPH/DFS.

Migration Pattern at the Eel River Site Above Outlet Creek

The numbers of fish captured at the Eel River site are affected by low trapping efficiency resulting from variable flows and the apparent ability of juvenile steelhead to avoid the traps. Only a few fish were trapped during the peak months (May, June, and July), and no fish were trapped at other times. Several of the fish trapped in late June and July 1981 were dead or noticeably stressed when the traps were checked. Summer fish inventories indicated that this section of stream did not provide suitable summer habitat for steelhead in 1981 due to high water temperatures (Section 3.8, Summer Fish Inventory). In contrast, the larger numbers of steelhead trapped in June 1982 appeared to be in relatively good condition. Summer fish inventories in 1982 showed the presence of more steelhead downstream of Cape Horn Dam than in 1981, apparently due to lower water temperatures.

Environmental Factors Associated with Downstream Migration of Juvenile Steelhead Trout in the Eel River

The major emigration of age 0+ fish from above Cape Horn Dam was associated with changes in stream temperatures, decreasing streamflows and near maximum photoperiod. Emigration began when streamflow decreased from high spring levels and rising stream temperatures approached 12 to 14°C; emigration ended when temperatures were at their summer maximum of 20 to 22°C (Figures 3.7-7 through 3.7-9). Substantially larger numbers of fish migrated on certain days. These "peaks" were commonly associated with one or more of the following: 1) rapid changes in water temperature relative to surrounding days, 2) sudden drops in streamflow during spring and summer, 3) sudden increases in streamflow during fall, and 4) a new moon.

Age 1+ and older fish began their migration from above Cape Horn Dam when temperatures were at their minimum (7°C), flows were high and unstable, and photoperiod was short. However, numbers of migrating fish remained fairly low until April when temperatures were above 10°C and rising quickly and flows had dropped and stabilized considerably (Figures 3.7-7 through 3.7-9). Peaks in migration of older fish were less extreme than those of the 0+ fish and did not appear to be strongly associated with specific environmental factors.

Numerous studies have looked at the influence of various environmental factors on the downstream migration of juvenile steelhead. Shapovalov and Taft (1954) found rising temperature to be important in triggering the beginning of major emigration. During the present study, rising stream temperatures in April appeared to be a primary factor initiating the major migration period from above Cape Horn Dam. Adams, et al. (1975) and Zaugg (1981) observed a reduction of smolt transformation at temperatures over 15°C. This may partially explain the cessation of emigration of age 1+ and older fish in mid-June of 1981 and 1982 at Cape Horn Dam, while age 0+ fish continued to migrate. Kerstetter and Keeler (1976) found that water temperatures over 17°C caused a major decline in emigration. This may explain the cessation of emigration of the age 0+ fish in late July 1982, when water temperatures had risen to 17 or 18°C.

Kerstetter and Keeler (1976) also found that declining water temperatures brought about an extension of steelhead emigration. This was observed during the present study in mid-June 1982, when a sudden drop in water temperature associated with the change from surface to bottom water release from Lake Pillsbury apparently brought about a large peak in age 0+ emigration. These large numbers of age 0+ steelhead may have been readied for this emigration by the experimental release of warmer surface water from Lake Pillsbury earlier in the spring; increases in temperature may increase the percentage of fish that smolt at age 1 by shortening the incubation period and increasing growth (McPherson and Cramer 1981).

Past studies have also indicated the importance of streamflow changes on the downstream migration of juvenile steelhead. Shapovalov and Taft (1954) found that earlier migrations occurred in low flow years; they felt that the rate of change in flow may have been an important factor. During the present study, the first major seasonal peaks in emigration usually occurred following large and rather rapid decreases in flow from high spring levels. Additionally, a sudden flow reduction at Scott Dam in mid-July 1981 triggered a sudden migration of age 0+ steelhead downstream past Cape Horn Dam. Unfortunately, because of the limited rearing habitat below Cape Horn Dam due primarily to high water temperatures, most of these fish probably did not survive through the summer (Section 3.8, Summer Fish Inventory). Sudden increases in flow may also affect downstream migration. Shapovalov and Taft (1954) and McPherson and Cramer (1981) observed that peaks in the fall migration of age 0+ fish were associated with freshets; this pattern was observed in 1981 and 1982 between Scott and Cape Horn Dams when a peak in migration occurred during the first fall storm in October.

The response of the age 0+ steelhead to sudden changes in flow and temperature below Scott Dam indicates that the manner in which flow releases are made can have a major impact on the timing of the juvenile steelhead migration and ultimately on the successful passage of these fish to the ocean. Depending on the time of year, and therefore the quality of the rearing habitat below Cape Horn Dam, stimulation of migration could be either beneficial or deleterious to juvenile steelhead. Through proper manipulation of the magnitude and temperature of releases at Scott Dam, steelhead populations above Cape Horn Dam could be greatly benefited.

Environmental factors other than flow and temperature may also affect the migration pattern of juvenile steelhead in the Eel River. Day length and light intensity have been found to be factors in other studies (Wagner 1969 and 1974; Shapovolov and Taft 1954; and Wertz 1981). Wagner (1969 and 1974) found photoperiod to be the most important factor controlling smolt transformation, with temperature acting as a modifying factor. Shapovalov and Taft (1954) found that most steelhead migrated at night. In addition, Wertz (1981) reviewed studies that indicate the smolt transformation in chinook and coho salmon is triggered by the new moon phase. During the present study, there was often an increase in migration of age 0+ steelhead immediately before or during the new moon. However, these fish were not experiencing smolt transformation, so the relationship (if causal) may be different than that reported by Wertz (1981). It may have been just the low levels of light during the new moon that prompted migration.

Estimated Numbers of Salmonids Diverted from the Upper Eel River

Total numbers of downstream migrating chinook salmon and steelhead trout diverted from the upper Eel River through PVPH for 1980, 1981, and 1982 have been estimated: 854, 0 and 350 chinook salmon and 1,568, 13,139 and 5,145 steelhead trout, respectively (Tables 3.7-18 through 3.7-20). Numbers of diverted steelhead trout in 1961/62 were estimated by Day (1964) to be 24,766. This number is considerably larger than the current estimates even though greater numbers of adult steelhead passed over Cape Horn Dam in 1980/81 than in 1960/61. This apparent reduction in numbers of fish diverted is probably a result of the installation of a fish screen since 1961/62. Based on a representative sample of 5,314 fish captured at PVPH/DFS, 4,498 were caught at the DFS and 816 were caught at PVPH. Length-frequency distributions (Figures 3.7-16 through 3.7-18) show that fish caught in PVPH/DFS represent a single group of fish physically divided by the retainment of most of the larger fish by the fish screen; only a small percentage of age 1+ and older steelhead were present in the catch at PVPH while over half of the steelhead captured at DFS were age 1+ or older. The same pattern was observed for non-salmonid species also; relatively few large fish were trapped at PVPH.

Table 3.7-18. Estimated daily, weekly, and monthly numbers of steelhead trout and chinook salmon passing through the Potter Valley Powerhouse in 1980.

Trapping Periods	Average Daily Catch		Estimated Number of Fish Passed through Powerhouse					
			Daily		Weekly		Monthly	
	Steelhead	Chinook	Steelhead	Chinook	Steelhead	Chinook	Steelhead	Chinook
Mar. 3-4	12	0						
4-5	15	0	14	0	98	0		
10-11	15	0						
11-12	3	0	9	0	63	0		
17-18	0	0						
18-19	6	0	3	0	21	0		
24-25	0	27						
25-26	6	36	3	32	21	224	203	224
Mar. 31-Apr. 1	8	3						
1-2	16	5	12	4	84	28		
7-8	49	3						
8-9	30	11	40	7	280	49		
14-15	7	0						
15-16	9	0	8	0	56	0		
21-22	3	6						
22-23	3	3	3	5	21	35		
28-29	4	0						
29-30	7	4	6	2	42	14	483	126
May 5-6	14	3						
6-7	16	3	15	3	105	21		
12-13	15	3						
13-14	28	3	22	3	154	21		
19-20	5	7						
20-21	16	5	11	6	77	42		
27-28	6	0						
28-29	8	0	7	0	49	0	385	84
June 2-3	6	2						
3-4	11	5	9	4	63	28		
9-10	5	3						
10-11	4	0	5	2	35	14		
16-17	2	2						
17-18	0	37	1	20	7	140		
23-24	0	30						
24-25	0	29	0	30	0	210	105	392
June 30-July 1	0	0						
1-2	2	4	1	2	7	14		
21-22	0	0						
22-23	2	0	1	0	7	0	28	28
Aug. 18-19	0	0						
19-20	0	0	0	0	0	0	0	0
Sep. 22-23	0	0						
23-24	0	0	0	0	0	0	0	0
Oct. 20-21	0	0						
21-22	0	0	0	0	0	0	0	0
Nov. 17-18	0	0						
18-19	0	0	0	0	0	0	0	0
Dec. 16-17	15	0						
17-18	10	0	13	0	91	0	364	0
TOTAL							1,568	854

Table 3.7-19. Estimated daily, weekly, and monthly numbers of steelhead trout and chinook salmon passing through the Potter Valley Powerhouse in 1981.

Trapping Periods	Average Daily Catch		Estimated Number of Fish Passed through Powerhouse					
			Daily		Weekly		Monthly	
	Steelhead	Chinook	Steelhead	Chinook	Steelhead	Chinook	Steelhead	Chinook
Dec. 31/80 Jan 1/81	0	0	0	0	0	0		
27-28	16	0	16	0	112	0	224	0
Feb. 5-6	35	0	35	0	245	0		
9-10	8	0						
12-13	3	0	6	0	42	0		
17-18	0	0						
19-20	15	0	8	0	56	0		
22-23	4	0						
24-25	3	0	4	0	28	0	371	0
Mar. 3-4	3	0						
5-6	6	0	5	0	35	0		
9-10	16	0						
11-12	6	0	11	0	77	0		
16-17	13	0						
19-20	9	0	11	0	77	0		
24-25	6	0						
26-27	36	0	21	0	147	0	336	0
30-31	5	0						
Apr. 2-3	37	0	21	0	147	0		
6-7	0	0						
9-10	7	0	4	0	28	0		
13-14	5	0						
16-17	0	0	3	0	21	0		
20-21	14	0						
23-24	133	0	74	0	518	0	714	0
28-29	171	0						
April 30- May 1	179	0	175	0	1,225	0		
5-6	234	0						
7-8	268	0	251	0	1,757	0		
11-12	93	0						
13-14	40	0	57	0	469	0		
18-19	26	0						
21-22	40	0	33	0	231	0		
25-26	177	0						
27-28	98	0	138	0	966	0	4,648	0
June 1-2	176	0						
4-5	155	0	166	0	1,162	0		
8-9	433	0						
11-12	158	0	296	0	2,072	0		
16-17	51	0						
18-19	33	0	42	0	294	0		
22-23	83	0						
25-26	160	0	122	0	854	0		
29-30	163	0						
July 1-2	117	0	140	0	980	0	5,362	0
6-7	73	0						
9-10	34	0	54	0	378	0		
13-14	8	0						
16-17	13	0	11	0	77	0		
20-21	11	0						
22-23	0	0	6	0	42	0		
27-28	7	0						
30-31	6	0	7	0	49	0	546	0
Aug. 10-11	5	0	5	0	35	0		
24-25	4	0	4	0	28	0	126	0
Sep. 14-15	3	0	3	0	21	0		
28-29	7	0	7	0	70	0	140	0
Oct. 14-15	0	0	0	0	0	0	0	0
Nov. 12-13	19	0	19	0	133	0		
Nov. 30- Dec 1	14	0	14	0	98	0	462	0
11-12	10	0	10	0	70	0		
28-29	5	0	5	0	35	0	210	0
TOTAL							13,139	0

Table 3.7-20. Estimated daily, weekly, and monthly numbers of steelhead trout and chinook salmon passing through the Potter Valley Powerhouse in 1982.

Trapping Periods	Average Daily Catch		Estimated Number of Fish Passed through Powerhouse					
			Daily		Weekly		Monthly	
	Steelhead	Chinook	Steelhead	Chinook	Steelhead	Chinook	Steelhead	Chinook
Jan. 18-19	0	0	0	0	0	0		
25-26	5	0	5	0	35	0	70	0
Feb. 8-9	0	0	0	0	0	0		
25-26	43	0	43	0	301	0	602	0
Mar. 11-12	9	0	9	0	63	0		
25-26	12	0	12	0	84	0	294	0
Apr. 8-9	12	0	12	0	84	0		
19-20	31	0	31	0	217	0		
22-23	13	0	13	0	91	0		
26-27	32	0						
29-30	88	0	60	0	420	0	812	0
May 3-4	102	0						
6-7	67	0	85	0	595	0		
10-11	43	10						
13-14	68	0	56	5	392	35		
17-18	126	9						
20-21	68	12	97	11	679	77		
24-25	101	31						
27-28	84	9	93	20	651	140	2,317	252
May 31- Jun. 1	9	0						
1-2	7	3	8	3	56	21		
7-8	4	0						
14-15	18	7	11	7	77	49		
21-22	27	0	27	0	189	0		
28-29	80	0	80	0	560	0	882	70
Jul. 12-13	7	2	7	2	49	14		
26-27	5	0	5	0	35	0	168	28
Aug. 9-10	0	0	0	0	0	0		
23-24	0	0	0	0	0	0	0	0
Sep. 9-10	0	0	0	0	0	0		
26-27	0	0	0	0	0	0		
27-28	0	0	0	0	0	0		
28-29	0	0	0	0	0	0	0	0
Oct. 11-12	0	0	0	0	0	0		
25-26	0	0	0	0	0	0	0	0
TOTAL							5,145	350

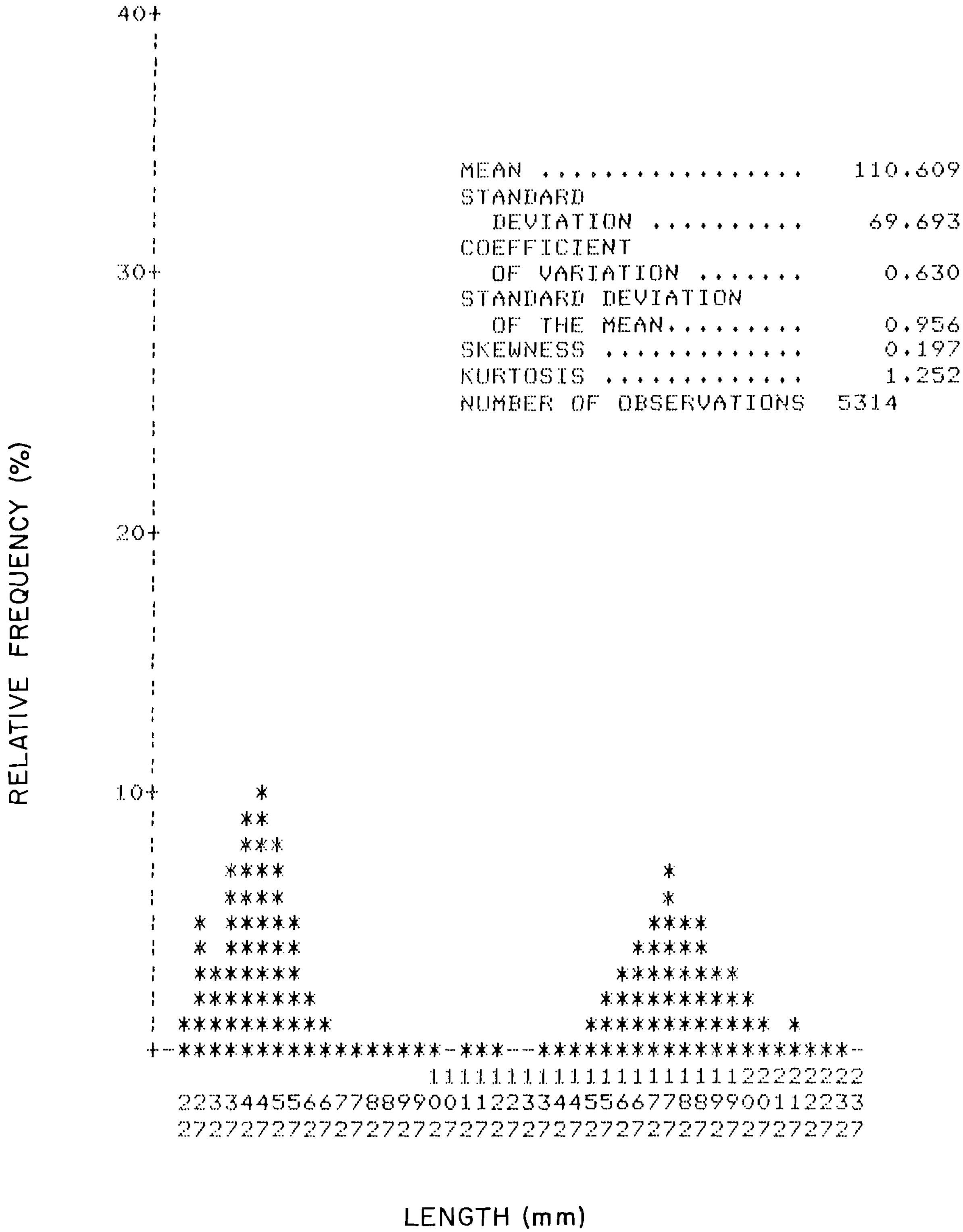

Figure 3.7-16. Length-frequency distribution of steelhead trout captured in the diversion fish screen and Potter Valley Powerhouse from April 15 to July 15, 1981.

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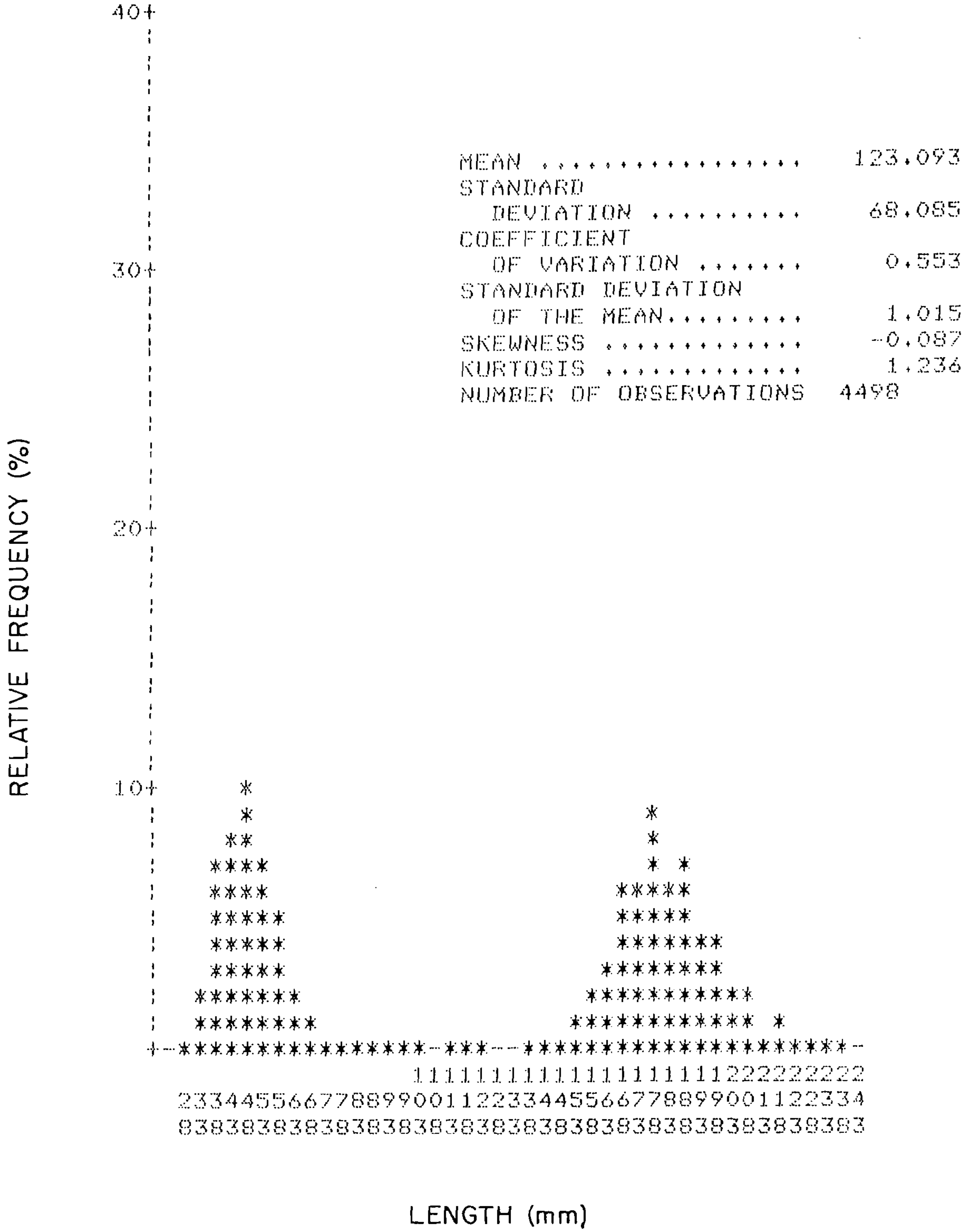

Figure 3.7-17. Length-frequency distribution of steelhead trout captured at the diversion fish screen from April 15 to July 15, 1981.

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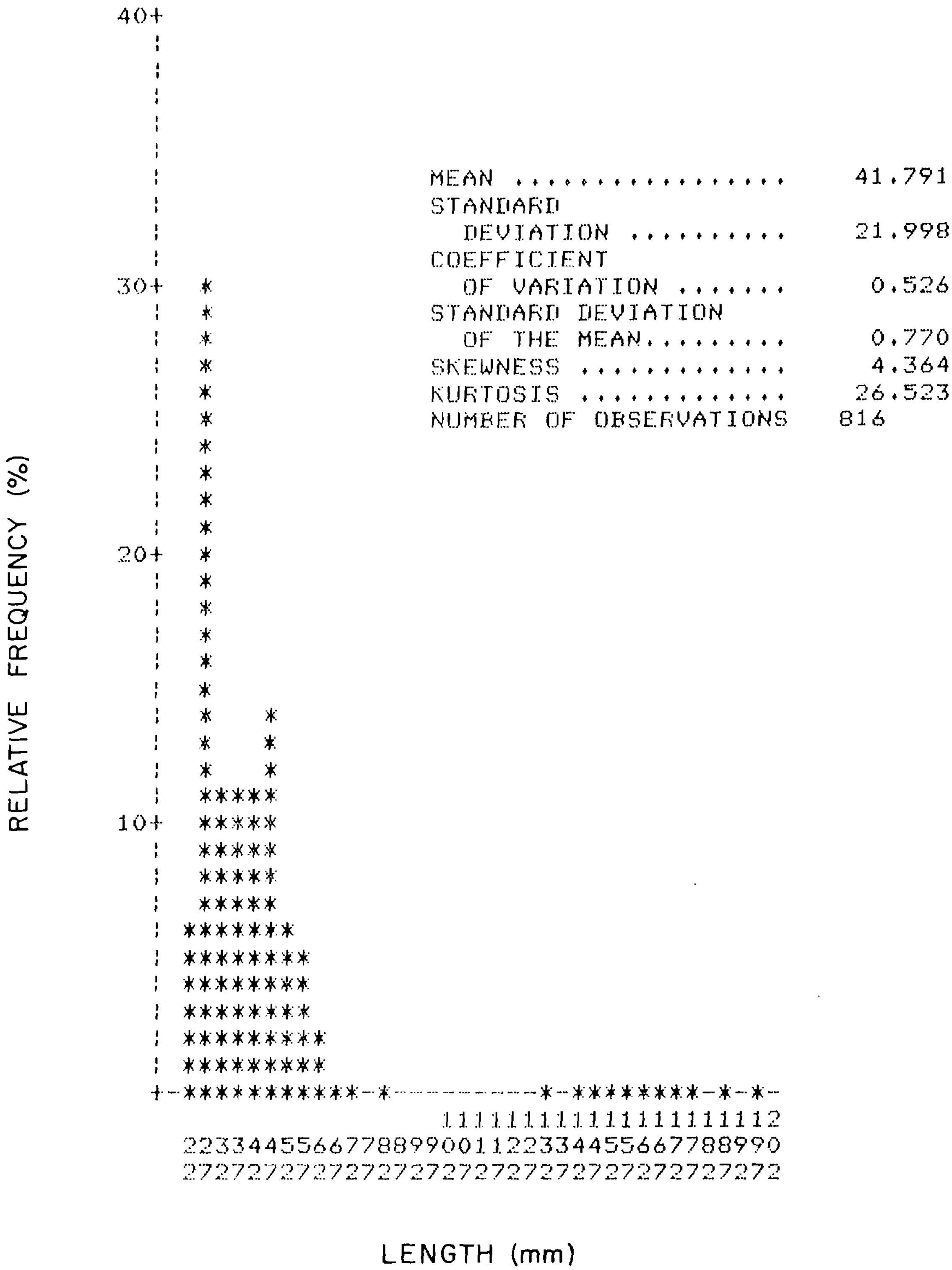

Figure 3.7-18. Length-frequency distribution of steelhead trout captured at the Potter Valley Powerhouse from April 15 to July 15, 1981.

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3.8 Summer Fish Inventory

Mainstem Eel River

Four species of fish were consistently captured in the mainstem Eel River from Cape Horn Dam to Outlet Creek during summer fish inventories in 1980, 1981, and 1982: Pacific lamprey, steelhead trout, California roach, and Sacramento sucker (Tables 3.8-1 through 3.8-4 and Appendix J). Other species caught incidentally were brown bullhead in July 1980, green sunfish in July 1980 and June and August 1981, and Sacramento squawfish in August 1982. Chinook salmon were not collected or observed during electrofishing in the mainstem Eel River. Most juvenile chinook had emigrated from the study area prior to electrofishing in each year (Section 3.7, Downstream Juvenile Migration Study).

Fish abundance and distribution between Cape Horn Dam and Outlet Creek were similar in July 1980 and August 1981. The most abundant species was California roach (>90%), followed by Sacramento sucker (≤5%) and steelhead trout (≤4%). The most abundant species in June 1981 was steelhead trout (64%), followed by California roach (36%) and Sacramento sucker (<1%). The shift in dominance from steelhead trout in June to California roach in August was due to an overall decline in steelhead numbers and an increase in the number of California roach. The pattern of fish abundance and distribution differed slightly in August 1982 from previous late summer samples, although limited sampling prevents a complete comparison. California roach (81%) was again the most abundant species, but was followed by steelhead trout (17%) rather than Sacramento sucker (2%). The greater overall abundance of steelhead trout in 1982 as suggested by one sample at the Emandal site appears to be the result of lower summer water temperatures in the Eel River system (Section 3.6, Instream Flow Study).

Juvenile steelhead trout were collected at three of the five sites below Cape Horn Dam in July 1980 (Table 3.8-1), at all five sites in June 1981

Table 3.8-1. Summary of fish captured during electrofishing of 98-foot (30-meter) riffle sections in the Eel River from Cape Horn Dam to Outlet Creek, July 24-30, 1980.

		REACH TYPE									
		Cape Horn Dam to Outlet Creek[a]									
		1				2		3		4	
		Emandal		Big Bend		Cavanaugh		Todd		Cape Horn	
Species		1	2	3	4	1	2	1	2	1	2
Pacific lamprey	N[b]	0	4	0	0	2	0	0	0	0	9
	FL[c]	-	103	-	-	106	-	-	-	-	110
	B[d]	0	13	0	0	5	0	0	0	0	27
Steelhead trout	N	9	3	0	0	0	0	0	10	145	106
	FL	52	53	-	-	-	-	-	50	62	62
	B	27	3	0	0	0	0	0	13	720	437
California roach	N	1,247	311	487	245	326	203	394	847	284	323
	FL	35	32	34	36	30	34	45	38	59	56
	B	810	173	315	105	125	107	420	637	794	955
Sacramento sucker	N	72	28	19	2	23	33	0	6	35	27
	FL	42	43	53	43	44	42	-	46	46	48
	B	78	30	130	5	27	34	0	8	44	36
Brown bullhead	N	1	0	0	0	0	0	0	0	0	0
	FL	47	-	-	-	-	-	-	-	-	-
	B	2	0	0	0	0	0	0	0	0	0
Green sunfish	N	0	0	0	0	0	0	0	0	1	0
	FL	-	-	-	-	-	-	-	-	62	-
	B	0	0	0	0	0	0	0	0	5	0

[a] The first station listed at each location (i.e. #1 or #3) is the upstream riffle. The second station listed (i.e. #2 or #4) is the downstream riffle.

[b] N = total number collected.

[c] FL = mean fork length in millimeters.

[d] B = total biomass in grams.

Table 3.8-2. Summary of fish captured during electrofishing of 98-foot (30-meter) riffle sections in the Eel River from Scott Dam to Outlet Creek, June 9-16, 1981.

		REACH TYPE								
		Cape Horn Dam to Outlet Creek[a]					Scott Dam to Cape Horn Dam[b]			
		1		2	3	4	5			
Species		Emandal(2)[c]	Big Bend(3)	Cavanaugh(1)	Todd(2)	Cape Horn(2)	1[d]	2	3	4
Pacific lamprey	N[e]	0	0	0	1	27	1	2	1	0
	FL[f]	-	-	-	495	116	111	96	124	-
	B[g]	0	0	0	1,000	69	2	10	5	0
Steelhead trout	N	497	543	216	582	174	509	297	167	172
	FL	46	61	47	52	54	46	46	48	38
	B	600	1,780	290	1,295	455	550	370	240	110
California roach	N	404	16	72	271	533	1	14	312	231
	FL	49	52	53	53	53	77	56	60	54
	B	705	35	160	540	1,025	5	40	945	350
Sacramento sucker	N	0	0	1	0	2	7	20	4	10
	FL	-	-	89	-	88	186	72	63	55
	B	0	0	7	0	22	1,790	110	12	15
Green sunfish	N	0	1	0	0	0	1	0	0	0
	FL	-	91	-	-	-	95	-	-	-
	B	0	15	0	0	0	20	0	0	0

[a] Stations between Cape Horn Dam and Outlet Creek were accurately measured, block netted, and thoroughly electrofished (see text, Section 2.8).
[b] Stations between Scott Dam and Cape Horn Dam were not measured or block netted, and only limited portions of each riffle were electrofished (see text, Section 2.8).
[c] Number in parenthenses refers to the station number.
[d] Station number.
[e] N = total number collected.
[f] FL = mean fork length in millimeters.
[g] B = total biomass in grams.

Table 3.8-3. Summary of fish captured during electrofishing of 98-foot (30-meter) riffle sections in the Eel River from Scott Dam to Outlet Creek, August 25 - September 2, 1981.

		REACH TYPE								
		Cape Horn Dam to Outlet Creek[a]					Scott Dam to Cape Horn Dam[b]			
		1		2	3	4	5			
Species		Emandal(2)[c]	Big Bend(3)	Cavanaugh(1)	Todd(2)	Cape Horn(2)	1[d]	2	3	4
Pacific lamprey	N[e]	1	0	0	2	8	0	8	1	0
	FL[f]	100	-	-	-	122	-	119	129	-
	B[g]	2	0	0	1	45	0	20	2	0
Steelhead trout	N	4	6	0	10	87	181	157	138	25
	FL	60	89	-	70	71	67	66	63	56
	B	9	45	0	60	515	695	630	505	70
California roach	N	682	1,156	309	1,291	884	3	33	82	68
	FL	47	46	43	44	49	99	55	54	54
	B	1,130	1,935	350	2,015	1,590	30	65	190	145
Sacramento sucker	N	3	25	6	1	7	4	3	1	0
	FL	64	60	60	59	116	268	100	238	-
	B	7	90	15	5	130	1,110	50	155	0
Green sunfish	N	0	0	0	0	0	4	1	0	0
	FL	-	-	-	-	-	>5	61	-	-
	B	0	0	0	0	0	30	3	0	0

[a] Stations between Cape Horn Dam and Outlet Creek were accurately measured, block netted, and thoroughly electrofished (see text, Section 2.8).
[b] Stations between Scott Dam and Cape Horn Dam were not measured or block netted, and only limited portions of each riffle were electrofished (see text, Section 2.8).
[c] Number in parentheses refers to the station number.
[d] Station number.
[e] N = total number collected.
[f] FL = mean fork length in millimeters.
[g] B = total biomass in grams.

Table 3.8-4. Summary of fish captured during electrofishing of 98-foot (30-meter) riffle sections in the Eel River from Scott Dam to Outlet Creek, August 24 - September 30, 1982.

		REACH TYPE				
		Cape Horn Dam to Outlet Creek[a]		Scott Dam to Cape Horn Dam[b]		
		1	4	5		
Species		Emandal(2)[c]	Cape Horn(2)	Above Soda Creek(1)	Above Benmore Creek(2)	Below Trout Creek(3)
Pacific lamprey	N[d]	0	4	1	6	3
	FL[e]	-	112	138	122	114
	B[f]	0	15	5	12	5
Steelhead trout	N	36	47	116	181	237
	FL	56	82	114	102	101
	B	88	380	2,265	2,620	3,280
California roach	N	342	414	25	129	342
	FL	36	49	54	47	50
	B	267	620	55	230	570
Sacramento sucker	N	6	15	18	36	427
	FL	54	56	60	60	66
	B	16	45	90	225	2,020
Sacramento squawfish	N	0	1	1	0	0
	FL	-	48	52	-	-
	B	0	1	2	0	0

[a] Stations between Cape Horn Dam and Outlet Creek were accurately measured, block netted, and thoroughly electrofished (see text, Section 2.8), August 24-28, 1982. Reach Types 2 and 3 were not sampled.
[b] Stations between Scott Dam and Cape Horn Dam were accurately measured, block netted, and thoroughly electrofished (see text, Section 2.8), September 28-30, 1982. Reach Type 6 was not sampled.
[c] Number in parentheses refers to the station number.
[d] N = total number collected.
[e] FL = mean fork length in millimeters.
[f] B = total biomass in grams.

(Table 3.8-2), at four of the five sites in August 1981 (Table 3.8-3) and at the two sites sampled in August 1982 (Table 3.8-4). Station population estimates of steelhead were largest at the Todd site and smallest at the Cape Horn site in June (Table 3.8-5). In July 1980 and August 1981, however, the Cape Horn site had the largest population estimate of steelhead and contained 96% and 82% of the steelhead collected from the five sites in July and August, respectively. Steelhead population estimates decreased in a downstream direction from the Cape Horn site in both July and August apparently due to increasing water temperature. Steelhead populations at the four sites below the Cape Horn site dropped 98-100% from June to August 1981; estimates at the Cape Horn site dropped 50% during the same period. While steelhead populations dropped at all sites below Cape Horn Dam between June and August, the Cape Horn site maintained a much higher population in August than the other sites.

This pattern of relatively large steelhead populations in the Cape Horn site compared to populations in the Todd, Emandal, and Cavanaugh sites was not followed in August 1982 (Table 3.8-5). Although only the Cape Horn and Emandal sites were sampled in 1982, station population estimates indicate a more uniform distribution of juvenile steelhead trout in the Eel River below Cape Horn Dam. Lower maximum water temperatures, by as much as 5.0°C, in 1982 probably resulted in greater survival of steelhead and less of a stimulus to seek cooler temperatures, and probably accounts for the distribution pattern observed in 1982.

Reach type and total stream population estimates for steelhead trout in the Eel River between Cape Horn Dam and Outlet Creek are shown in Tables 3.8-6 through 3.8-9. Reach Type I had the largest steelhead population in June 1981 and August 1982, while Reach Type IV had the largest population in July 1980 and August 1981. Total stream steelhead population estimates were 7,758 in July 1980, 162,066 in June 1981, and 3,949 in August 1981; this amounted to a drop of 98% from June to August 1981. This large decline may be due to temperature-related

Table 3.8-5. Station population estimates of steelhead trout for mainstem Eel River sites from Scott Dam to Outlet Creek in 1980, 1981, and 1982.

		Station Population Estimates			
Reach Type[a]	Station	July 1980	June 1981	August 1981	August 1982
I	Big Bend	0	600	6	-[c]
	Emandal	9	556	6	76
II	Cavanaugh	0	298	0	-[c]
III	Todd	5	761	13	-[c]
IV	Cape Horn	356[b]	222	112	77
V	Soda Creek	-[c]	-[d]	-[d]	125
	Benmore Creek	-[c]	-[d]	-[d]	196
	Trout Creek	-[c]	-[d]	-[d]	271

[a] Reach Type VI was not sampled.
[b] This population estimate is considered unreasonably high due to low catchability of steelhead at this site in 1980 (VTN 1981).
[c] Not sampled.
[d] Qualitative sampling only.

Table 3.8-6. Fish population estimates, percent species composition, and standing crop estimates for the Eel River from Outlet Creek to Cape Horn Dam, July 24-30, 1980.

Species		REACH TYPE 1	2	3	4	STREAM TOTAL
Pacific lamprey	PE[a]	215	69	0	105	389
	%[b]	<1	<1	-	1	<1
	kg[c]	<1	<1	0	<1	1
Steelhead trout	PE	669	0	320	6,769	7,757
	%	1	-	1	45	4
	kg	1	0	<1	11	13
California roach	PE	98,134	25,652	45,647	7,323	176,756
	%	94	89	99	49	91
	kg	53	8	34	17	112
Sacramento sucker	PE	5,150	3,082	192	792	9,215
	%	5	11	<1	5	5
	kg	9	2	<1	1	12
Brown bullhead	PE	38	0	0	0	38
	%	<1	-	-	-	<1
	kg	<1	0	0	0	<1
Green sunfish	PE	0	0	0	10	10
	%	-	-	-	<1	<1
	kg	0	0	0	<1	<1

[a] PE = Population estimate.
[b] % = Percent species composition.
[c] kg = Standing crop estimate in kilograms.

Table 3.8-7. Fish population estimates, percent species composition, and standing crop estimates for the Eel River from Cape Horn Dam to Outlet Creek, June 9-16, 1981.

Species		REACH TYPE 1	2	3	4	STREAM TOTAL
Pacific lamprey	PE[a]	0	0	64	521	585
	%[b]	-	-	<1	3	<1
	kg[c]	0	0	64.4	1.3	65.7
Steelhead trout	PE	88,045	20,760	48,967	4,294	162,066
	%	62	78	72	25	64
	kg	181.3	20.2	83.4	8.8	293.7
California roach	PE	54,232	5,804	19,128	12,503	91,667
	%	38	22	28	72	36
	kg	56.3	11.2	34.8	19.8	122.1
Sacramento sucker	PE	0	70	0	39	109
	%	-	<1	-	<1	<1
	kg	0	0.5	0	0.4	0.9
Green sunfish	PE	76	0	0	0	76
	%	<1	-	-	-	<1
	kg	1.1	0	0	0	0

[a] PE = Population estimate.
[b] % = Percent species composition.
[c] kg = Standing crop estimate in kilograms.

Table 3.8-8. Fish population estimates, percent species composition, and standing crop estimates for the Eel River from Cape Horn Dam to Outlet Creek, August 25-September 2, 1981.

Species		REACH TYPE 1	2	3	4	STREAM TOTAL
Pacific lamprey	PE[a]	76	0	129	201	406
	%[b]	<1	-	<1	<1	<1
	kg[c]	0.2	0	0.1	0.9	1.2
Steelhead trout	PE	939	0	848	2,162	3,949
	%	<1	-	<1	9	1
	kg	4.1	0	3.9	9.9	17.9
California roach	PE	158,087	21,547	95,804	20,350	295,788
	%	98	98	99	89	98
	kg	23.4	24.4	129.7	30.7	418.8
Sacramento sucker	PE	2,259	418	64	135	2,876
	%	1	2	<1	<1	<1
	kg	7.4	1.0	0.3	2.5	11.2

[a] PE = Population estimate.
[b] % = Percent species composition.
[c] kg = Standing crop estimate in kilograms.

Table 3.8-9. Fish population estimates, percent species composition, and standing crop estimates for the Eel River from Scott Dam to Outlet Creek, August 24 - September 30, 1982.

Species		REACH TYPE[a] 1	4	5	STREAM[b] TOTAL
Pacific lamprey	PE[c]	0	76	190	-
	%[d]	-	1	1	-
	kg[e]	0	0.2	0.3	-
Steelhead trout	PE	11,496	1,468	9,359	-
	%	18	14	34	-
	kg	13	7	129	-
California roach	PE	51,984	8,468	10,545	-
	%	81	82	38	-
	kg	41	12	14	-
Sacramento sucker	PE	912	293	7,648	-
	%	1	3	28	-
	kg	2	1	37	-
Sacramento squawfish	PE	0	19	16	-
	%	-	<1	<1	-
	kg	0	<0.1	<0.1	-

[a] Reach Types 2, 3, and 6 were not sampled.
[b] Stream Total cannot be determined due to incomplete reach type sampling.
[c] PE = Population estimate.
[d] % = Percent species composition.
[e] kg = Standing crop estimate in kilograms.

mortality or movement of fish out of the stream section between Cape Horn Dam and Outlet Creek. Movement into tributaries or upstream areas does not appear likely, as steelhead abundance also declined in these areas from June to August and streamflow at the mouth of tributaries was quite low (<1 cfs). The larger population in Reach Type 1 than Reach Type 4 in August 1982 also appears to be temperature related. Cooler than normal temperatures during the summer of 1982 allowed greater survival of juvenile steelhead in stream reaches that normally attain lethal temperatures (e.g., Stream Type 1). The population estimate for Reach Type 1 alone in August 1982 exceeds the stream total estimates (between Cape Horn Dam and Outlet Creek) for the previous two years, and is a reflection of the potential production of the upper Eel River if temperatures were not limiting.

Population estimates of fish in the mainstem Eel River between Scott Dam and Cape Horn Dam were not calculated for 1981 data due to the qualitative nature of the sampling in this section. Consequently, comparisons between stations are limited to differences in total catch in 1981. Steelhead catch at the four sites above Cape Horn Dam was highest at site 5-1 (above Soda Creek) and declined downstream in both June and August (Tables 3.8-2 and 3.8-3). Like the sites below Cape Horn Dam, steelhead catches declined at all sites between the June and August sample periods, although not as dramatically. The decline was highest at site 5-4 (85%) and least at site 5-3 (17%). Overall steelhead numbers declined an average of 56% at the four sites above Cape Horn Dam between June and August, which was much less than the decline at the sites below Cape Horn Dam (95%).

Results of quantitative sampling at three sites between Scott Dam and Cape Horn Dam in 1982 indicated a much larger population density of steelhead than downstream (Tables 3.8-4, 3.8-5 and 3.8-9). The population estimate for riffle areas in the 6 miles of Reach Type 5 was 9,359 (1,560/mile), compared to 11,496 in 14 miles of Reach Type 1 (821/mile) and 1,468 in 4 miles of Reach Type 4 (367/mile) (Table 3.8-9). Even greater differences in density would be expected during years of more normal temperature conditions. As discussed elsewhere in this section of the report, high water temperatures severely limit steelhead populations below Cape Horn Dam in normal years; however, in 1982, unusually cool temperatures allowed much greater survival of steelhead. In contrast, temperatures above Cape Horn Dam are highly suitable for steelhead in both normal and cooler than normal years; thus, population levels above Cape Horn Dam are expected to fluctuate little from year to year, based solely on summer water temperatures. In comparison to the mainstem below Cape Horn Dam, the river upstream is normally inhabited by much larger numbers of juvenile steelhead during the summer (July/August).

During snorkel surveys conducted in pools of the mainstem Eel River from Cape Horn Dam to Outlet Creek, California roach was the overwhelming dominant species observed (Tables 3.8-10 through 3.8-13). Steelhead trout were observed at all five sites in June 1981; they were most numerous at Emandal (108) and sparsest at Big Bend (9). In July 1980 surveys, steelhead trout were observed at Emandal (5), Todd (5), Cavanaugh (3), and Cape Horn (5). Steelhead were observed only at the Cape Horn site (6) in August 1981. Steelhead were observed at both sites sampled in August 1982, Emandal (8) and Cape Horn (12). Snorkel survey results followed a similar pattern as electrofishing results with numbers of steelhead decreasing downstream from the Cape Horn site in July and August and declining in numbers between June and August at all sites.

Pool depths at all sites were shallow (5 to 8 feet) except a small area in the Todd site, which was approximately 11 feet deep. This deeper area was the only pool area within the sampling sites to thermally stratify. An additional snorkel survey of a 0.5-mile length of Reach Type 2 below the Cavanaugh site was conducted August 3, 1980. Most pools were shallow, approximately 6 to 10 feet deep, but a few deeper pools up to 26 feet were found. Varying degrees of thermal stratification were evident in these pools. Some pools as shallow as 6 feet were

Table 3.8-10. Numbers of fish observed during snorkel surveys of one pool at each electrofishing site on the Eel River between Cape Horn Dam and Outlet Creek, July 24-28, 1980.

	Steelhead Trout			California Roach	Sacramento Sucker	Green Sunfish
	0-150 (mm)	150-300 (mm)	>300 (mm)			
Emandal	5	0	0	200	35	0
Big Bend	0	0	0	450	10	0
Cavanaugh	0	2	1	1,050	165	0
Todd	1	4	0	2,000	275	0
Cape Horn	0	0	5	600	35	19

Table 3.8-11. Numbers of fish observed during snorkel surveys of one pool at each electrofishing site on the Eel River between Cape Horn Dam and Outlet Creek, June 9-16, 1981.

	Steelhead Trout			California Roach	Sacramento Sucker	Green Sunfish
	0-150 (mm)	150-300 (mm)	>300 (mm)			
Emandal	98	10	0	300	0	0
Big Bend	8	1	0	895	0	0
Cavanaugh	82	3	0	234	0	0
Todd	65	1	0	365	0	0
Cape Horn	17	1	0	350	1 (200 cm)	7 (100-150 cm)

Table 3.8-12. Numbers of fish observed during snorkel surveys of one pool at each electrofishing site on the Eel River between Cape Horn Dam and Outlet Creek, August 25-September 2, 1981.

Location	Steelhead Trout 0-150 (mm)	Steelhead Trout 150-300 (mm)	Steelhead Trout >300 (mm)	California Roach	Sacramento Sucker	Green Sunfish
Emandal	0	0	0	1,200	0	0
Big Bend	0	0	0	1,440	6	0
Cavanaugh	0	0	0	840	0	0
Todd	0	0	0	985	15 (90-120 mm)	0
Cape Horn	6	0	0	1,770	15 (180-560 cm)	2 (15 cm)

Table 3.8-13. Numbers of fish observed during snorkel surveys of one pool at each electrofishing site on the Eel River between Cape Horn Dam and Outlet Creek, August 24-28, 1982.

	Steelhead Trout			California Roach	Sacramento Sucker
	0-150 (mm)	150-300 (mm)	>300 (mm)		
Emandal	8	0	0	2,000	55
Big Bend[a]	-	-	-	-	-
Cavanaugh[a]	-	-	-	-	-
Todd[a]	-	-	-	-	-
Cape Horn	11	1	0	1,150	3

[a] Not sampled.

thermally stratified, while other pools up to 16 feet deep were not. Surface water temperature was 29°C, while bottom temperatures of stratified pools ranged from 23 to 26°C. The cooler stratified areas appeared stagnant, lacked cover, and generally contained no fish. For example, the largest pool surveyed, which was approximately 200 yards long and up to 26 feet deep, was well stratified with a temperature of 23°C at the bottom, but no fish were seen in this pool.

Tributary Sites

Four species of fish were collected from tributary sites in June and August 1981 and August 1982: Pacific lamprey, steelhead trout, California roach, and Sacramento sucker. In June 1981, one juvenile chinook salmon was also collected from the lower site on Tomki Creek. One green sunfish was collected from Tomki Creek in August 1982.

Steelhead trout were collected in all tributaries and was the most abundant species collected at nine of the ten sites in June 1981 (Table 3.8-14). Of the seven tributary sites containing fish in August 1981, steelhead was the most abudant species at three sites, and California roach was most abundant at four (Table 3.8-15). In 1982, steelhead trout was the most abundant species at all tributary sites except Tomki Creek and was the only species in Thomas Creek (Table 3.8-16). Sacramento suckers and Pacific lampreys were only rarely collected from tributaries in both 1981 and 1982.

Population estimates based on total tributary length showed Tomki Creek with the largest steelhead population in June (215,002) and Garcia Creek with the largest steelhead population in August 1981 (17,405) and August 1982 (23,301) (Table 3.8-17). Steelhead population estimates dropped at all tributary sites from June to August 1981. The average decline between June and August for all tributaries was 90%. Tomki Creek showed the largest decline, dropping from 215,002 in June to 0 in August; however, some steelhead no doubt survived through the summer in

Table 3.8-14. Summary of fish captured during electrofishing of 98-foot (30-meter) sections of tributaries to the Eel River from Scott Dam to Outlet Creek, June 9-16, 1981.

SPECIES		Soda Creek		Benmore Creek	Bucknell Creek	Tomki Creek		String Creek	Thomas Creek	Garcia Creek	Brushy Creek
		1	2			1	2				
Pacific lamprey	N[a]	0	0	0	0	1	4	8	0	0	0
	FL[b]	-	-	-	-	87	92	113	-	-	-
	B[c]	0	0	0	0	1	10	22	0	0	0
Steelhead trout	N	347	437	310	303	56	229	104	270	225	106
	FL	47	36	44	46	60	50	45	59	55	50
	B	585	220	565	490	280	440	130	1,025	750	240
California roach	N	5	0	0	21	32	109	213	8	0	0
	FL	57	-	-	48	61	50	55	64	-	-
	B	9	0	0	39	100	190	565	40	0	0
Sacramento sucker	N	0	0	0	0	0	4	0	0	0	0
	FL	-	-	-	-	-	32	-	-	-	-
	B	0	0	0	0	0	2	0	0	0	0
Chinook salmon	N	0	0	0	0	0	1	0	0	0	0
	FL	-	-	-	-	-	45	-	-	-	-
	B	0	0	0	0	0	1	0	0	0	0

[a] N = Total number collected.
[b] FL = Mean fork length in millimeters.
[c] B = Total biomass in grams.

Table 3.8-15. Summary of fish captured during electrofishing of 98-foot (30-meter) sections of tributaries to the Eel River from Scott Dam to Outlet Creek, August 25-September 2, 1981.

SPECIES		Soda Creek 1	Soda Creek 2[a]	Benmore Creek	Bucknell Creek	Tomki Creek 1[a]	Tomki Creek 2	String Creek[a]	Thomas Creek	Garcia Creek	Brushy Creek	Fish Creek
Pacific lamprey	N[b]	0	0	0	0	0	9	0	1	0	1	19
	FL[c]	-	-	-	-	-	80	-	67	-	50	84
	B[d]	0	0	0	0	0	15	0	2	0	1	32
Steelhead trout	N	132	0	0	38	0	0	0	61	70	11	39
	FL	54	-	-	67	-	-	-	69	76	69	52
	B	290	0	0	206	0	0	0	358	566	82	85
California roach	N	79	0	0	7	0	619	0	217	95	0	132
	FL	58	-	-	59	-	41	-	61	67	-	66
	B	195	0	0	27	0	740	0	620	350	0	565
Sacramento sucker	N	0	0	0	0	0	0	0	0	0	0	1
	FL	-	-	-	-	-	-	-	-	-	-	80
	B	0	0	0	0	0	0	0	0	0	0	5

[a] Not sampled; site dry or contained very little water.
[b] N = Total number collected.
[c] FL = Mean fork length in millimeters.
[d] B = Total biomass in grams.

Table 3.8-16. Summary of fish captured during electrofishing of 98-foot (30-meter) sections of tributaries to the Eel River from Scott Dam to Outlet Creek, August 24-28, 1982.

SPECIES		Soda Creek 1	Soda Creek 2[a]	Benmore Creek	Bucknell Creek	Tomki Creek 1[a]	Tomki Creek 2[a]	Tomki Creek 3	String Creek[a]	Thomas Creek	Garcia Creek	Brushy Creek[a]	Fish Creek[a]
Pacific lamprey	N[b]	0	-	0	0	-	-	12	-	0	0	-	-
	FL[c]	-	-	-	-	-	-	91	-	-	-	-	-
	B[d]	0	-	0	0	-	-	26	-	0	0	-	-
Steelhead trout	N	75	-	106	80	-	-	5	-	126	93	-	-
	FL	61	-	52	69	-	-	63	-	57	65	-	-
	B	230	-	190	375	-	-	19	-	305	428	-	-
California roach	N	13	-	3	4	-	-	150	-	0	45	-	-
	FL	85	-	88	79	-	-	39	-	-	49	-	-
	B	104	-	30	28	-	-	142	-	0	95	-	-
Sacramento sucker	N	1	-	0	0	-	-	22	-	0	0	-	-
	FL	123	-	-	-	-	-	50	-	-	-	-	-
	B	25	-	0	0	-	-	45	-	0	0	-	-
Green sunfish	N	0	-	0	0	-	-	1	-	0	0	-	-
	FL	-	-	-	-	-	-	123	-	-	-	-	-
	B	0	-	0	0	-	-	35	-	0	0	-	-

[a] Not sampled.
[b] N = Total number collected.
[c] FL = Mean fork length in millimeters.
[d] B = Total biomass in grams.

Table 3.8-17. Summary of station and total tributary population estimates of steelhead trout for tributaries to the Eel River from Scott Dam to Outlet Creek in June and August 1981 and August 1982.

	1981					1982	
	June		August			August	
Site	Site Est.	Total Tributary Estimate	Site Est.	Total Tributary Estimate	% Decrease From June To August	Site Est.	Total Triburary Estimate
Soda Cr.	412[a]	76,785	134	12,825	83	79	9,768
Benmore Cr.	364	38,794	0	0	100	110	11,700
Bucknell Cr.	338	57,722	41	6,980	88	86	14,668
Tomki Cr.[b]	145[c]	215,002	0	0	100	5	1,152
Thomas Cr.	321	17,125	63	3,353	80	135	7,143
Garcia Cr.	288	69,209	73	17,405	75	97	23,301
Fish Cr.	-	-	40	6,378	-	-	-
Brushy Cr.	114	763	11	74	90	-	-
	1,982	475,400	362	47,015	90	512	67,732

[a] Mean of two sites.
[b] Includes String Creek.
[c] Mean of three sites.

scattered portions of the drainage. A reduction in suitable habitat because of low streamflows and increased water temperatures probably accounts for this decline in steelhead populations.

Higher streamflows and lower summer water temperatures in 1982 may largely account for the higher tributary populations of juvenile steelhead trout in August 1982 than in August 1981. The abundance of spawning adult steelhead trout was actually higher in 1981 than in 1982, based on counts at Cape Horn Dam (1,966 versus 650). Winter and spring streamflows were generally higher in 1982 than in 1981, possibly facilitating more successful migration, spawning and incubation in 1982; however, based on juvenile steelhead abundance in June 1981, spawning and incubation were quite successful that year. Higher summer streamflows and lower summer water temperatures in 1982 probably provided more suitable rearing habit than in 1981, carrying a larger percentage of available steelhead through the summer and resulting in larger populations in nearly all tributaries sampled (Table 3.8-17).

Mainstem population estimates downstream of Cape Horn Dam were generally low compared to the mainstem above Cape Horn Dam and to tributaries (Table 3.8-18). Direct comparison of all areas and years is not possible; however, it is clear that the mainstem Eel River between Cape Horn Dam and Outlet Creek usually supports far fewer steelhead through summer than either the mainstem Eel River between Scott Dam and Cape Horn Dam or all tributaries combined from Scott Dam to Outlet Creek. The mainstem Eel River between the two dams appears to be an important summer rearing habitat for juvenile steelhead trout, as are tributaries in the study area.

Although the age of most juvenile steelhead trout collected during electrofishing surveys appeared to be young-of-the-year (age 0+) at all sites, considerably larger numbers of steelhead over 100 mm (probably age 1+ and older) were collected in the mainstem between Scott and Cape Horn Dams in 1982 (Table 3.8-19). Steelhead over 100 mm comprised 9% or

Table 3.8-18. Steelhead trout population estimates for reach types in the Eel River in 1980, 1981, and 1982.

	Reach Type	July 1980 Pop. Est.	July 1980 %	June 1981 Pop. Est.	June 1981 %	August 1981 Pop. Est.	August 1981 %	August 1982 Pop. Est.	August 1982 %
Mainstem Eel River from Cape Horn Dam to Outlet Creek	4	6,769	87	4,294	1	2,162	4	1,468	-
	3	320	4	48,967	8	848	2	-	-
	2	0	0	20,760	3	0	0	-	-
	1	669	9	88,045	14	939	2	11,496	-
Total		7,758	100	162,066	25	3,949	8	12,964	-
Mainstem Eel River from Scott Dam to Cape Horn Dam[a]	5	-	-	-	-	-	-	9,359	-
Tributaries	7 & 8	-	-	475,400	75	47,015	92	67,732	-
TOTAL				637,466		50,964		-	

[a] Sampled in September 1982

Table 3.8-19. Number and location of steelhead trout greater than 100 mm collected during electrofishing surveys in 1980, 1981, and 1982.

Site	July 1980	June 1981	August 1981	August 1982
EEL RIVER				
Above Soda Creek	-	2[b]	1[b]	82
Above Bucknell Creek	-	0[b]	4[b]	60
Below Trout Creek	-	1[b]	1[b]	94
Above Van Arsdale	-	0[b]	0[b]	-
Cape Horn site	4[a]	8	2	6
Todd site	0	8	0	-
Cavanaugh site	0	0	0	-
Emandal site	0	2	0	0
Big Bend site	0	4	0	-
	4	25	8	242
TRIBUTARIES				
Soda Creek	-	3[a]	1	3
Benmore Creek	-	7	0	0
Bucknell Creek	-	10	6	7
Tomki Creek	-	2[a]	0	0
String Creek	-	0	0	-
Thomas Creek	-	22	8	2
Garcia Creek	-	14	15	10
Brushy Creek	-	1	1	-
Fish Creek	-	-	1	-
		59	32	22
		84	40	264

[a] Mean of two sites.
[b] Nonquantitative samples.

less of the total steelhead collected from mainstem sites below Cape Horn Dam and from tributaries; this contrasts sharply with 33 to 71% steelhead over 100 mm collected at mainstem sites above Cape Horn Dam in 1982 using similar quantitative sampling techniques. Large young-of-the-year populations in 1981 may have contributed a more-than-usual number of yearling steelhead to the 1982 populations. Nontheless, these 1982 data further indicate the importance of the Eel River between Scott and Cape Horn Dams as the prime steelhead rearing habitat in the study area. Low numbers of steelhead over 100 mm collected at mainstem sites above Cape Horn Dam in 1981 (Table 3.8-19) are probably the result of non-quantitative sampling techniques and probably do not reflect true population size; since no block nets were used and only one pass was made during electrofishing in 1981 at these mainstem sites, many steelhead over 100 mm probably avoided capture. Larger numbers of steelhead over 100 mm collected in tributary streams as compared to the mainstem below Cape Horn Dam (Table 3.8-19) further indicates the importance of tributaries within the study area (primarily Garcia, Thomas and Bucknell Creeks) as permanent summer rearing habitat for steelhead trout.

Habitat characteristics of each sample site were evaluated to help explain observed fish distribution and abundance patterns. Appendix J lists the results of the physical habitat and water quality parameters measured or estimated at each site. Physical habitat characteristics differ between the mainstem Eel River above Cape Horn Dam, the mainstem below the dam, and tributary streams; characteristics within each of these groupings are similar. The mainstem above Cape Horn Dam contains large, sustained summer flows that provide more living space than either the mainstem below the dam or tributary streams; tributaries provided the least living space due to small streamflows during late summer. In general, the mainstem both above and below the dam is characterized by large pool areas connected by relatively short riffles and runs; due to higher flows and somewhat steeper gradient, the mainstem above the dam has higher riffle and run to pool ratios than below the dam. Tributaries are characterized by steeper gradient and higher riffle and run to pool ratios than both mainstem areas. Substrate in the mainstem and tributaries is dominated by rubble, with lesser amounts of boulder and gravel; tributaries generally contain a greater variety of substrate types. Cover and canopy are sparse in most of the mainstem; tributaries had larger amounts of both with few exceptions.

The water chemistry was similar among all sites, and no obvious pattern was observed between tributary or mainstem sites. All water chemistry parameters were within acceptable limits for a productive salmonid fishery with the possible exception of dissolved oxygen (DO) in some areas. DO appeared to be at or near saturation levels (>90%) at most sites and was usually over 8 mg/l; however, values less than 7.0 mg/l were measured at four sites in late summer (Big Bend, July 1980; Cape Horn, July 1980; Tomki Creek, August 1981; Fish Creek, August 1981).

Juvenile steelhead trout abundance and water temperatures recorded in the mainstem Eel River and tributaries during 1980 and 1981 correspond well with the classification of Kubicek (1977). He classified the Eel River between Scott Dam and Cape Horn Dam as "satisfactory" with respect to temperature conditions for steelhead trout during summer, between Cape Horn Dam and Tomki Creek as "marginal", and between Tomki Creek and Outlet Creek as "lethal." A maximum daily temperature of 28.0°C or greater for at least 100 continuous minutes was considered lethal to steelhead trout; temperatures from 26.5°C up to, but not including, 28.0°C were considered marginal; and temperatures less than 26.5°C were considered satisfactory.

In 1980, temperatures below Scott Dam were well within the satisfactory classification; the maximum temperature recorded was 20.0°C. Temperatures recorded at the site between Cape Horn Dam and Tomki Creek reached marginal levels on six days; the maximum temperature was 27.5°C. Temperatures recorded at the two sites between Tomki Creek and Outlet Creek (below Hearst Riffle and above Outlet Creek) reached lethal levels on 22 and 30 days, respectively; maximum temperatures were over 30°C at both sites.

In 1981, temperatures recorded at the two sites above Cape Horn Dam were satisfactory; maximum temperatures were 21.5°C below Scott Dam and 23.5°C below Trout Creek. Temperatures at the site between Cape Horn Dam and Tomki Creek reached marginal levels on eight days; the maximum temperature was 27.5°C. Temperatures recorded at the three sites between Tomki Creek and Outlet Creek (below Tomki Creek, below Hearst Riffle, and above Outlet Creek) reached lethal levels on 20, 46, and 47 days, respectively; maximum temperatures were 28.5°C at the upper site and over 30.0°C at the two lower sites. Temperature data for tributaries for 1981 are available only during electrofishing surveys. No temperatures were recorded greater than 26.5°C; however, some sites (e.g., lower Tomki Creek) probably reach marginal or lethal temperatures during the summer for short periods of time.

In 1982, water temperatures were cooler than during the previous two summers (Table 3.6-8). Temperatures recorded between Scott Dam and Cape Horn Dam were well within the satisfactory classification; maximum temperatures were 20.0°C below Scott Dam and 19.0°C below Trout Creek. Temperatures recorded at the site between Cape Horn Dam and Tomki Creek did not reach marginal levels as they had during the previous two summers; the maximum temperature recorded (24.0°C) was well within the satisfactory classification, although data were missing for late July, which is typically the period of highest temperature. Temperatures below Hearst Riffle reached marginal levels on 5 days but never attained lethal levels as in 1980 and 1981; the maximum temperature recorded was 27.0°C. Temperatures recorded above Outlet Creek reached lethal levels on only 6 days; the maximum temperature was 28.0°C. Temperatures in Tomki Creek reached marginal levels on 7 days; the maximum recorded was 27.5°C.

Temperature appears to be the major factor controlling the abundance and distribution of juvenile steelhead in the Eel River during the summer. The largest numbers of steelhead were caught in the Eel River above Cape Horn Dam where temperatures remain satisfactory. In late summer of both

1980 and 1981, steelhead numbers decreased with distance downstream from Cape Horn Dam, coincident with an increase in temperatures to marginal levels between Cape Horn Dam and Tomki Creek and lethal levels below Tomki Creek. The Cape Horn site, which had the lowest temperatures of the mainstem sites below Cape Horn Dam, generally maintained the largest population of steelhead below the dam during summer (July/August). Lethal temperatures below Tomki Creek were coincident with very low numbers of juvenile steelhead. The lack of complete mortality at temperatures considered lethal may be due to the presence of cool water in stratified pools, to cool water inflow from tributaries and springs, or to thermal adaption of Eel River steelhead stocks.

In late summer of 1982, steelhead were more abundant below Cape Horn Dam and their distribution was more uniform than in previous summers, reflecting the more suitable temperature conditions in 1982. The greater abundance of steelhead downstream of Tomki Creek in 1982 also corresponds well with the criteria for "marginal" and "lethal" temperature conditions and indicates that habitat conditions in the Eel River are strongly dependent on water temperature.

A comparison of summer water temperatures and streamflows below Cape Horn Dam during the 1980 Instream Flow Study and during studies by DWR in 1973 (DWR 1973, unpublished data), shows a decline in water temperatures with increasing flows (Figure 3.6-6); however, the decline is small with moderate flow increases, and temperatures still increase with distance below Cape Horn Dam. Variation from the regression lines shown in Figure 3.6-6 may occur due to the effects of changing air temperature and temperature of water being released at Cape Horn Dam. Temperature variability is greatest at low flows. Figure 3.6-6 indicates that water temperatures in Reach Type IV remain below 26.5°C at all flows, although the highest measured temperature in this reach was actually 27.5°C (Appendix H). Water temperatures in Reach Type III remain above 28°C up to 35 cfs and do not drop below 26.5°C until 83 cfs. Water temperatures in Reach Type II remain above 28°C up to 47 cfs and do not drop below 26.5°C until 91 cfs. The Big Bend subreach of Reach Type I maintains the highest water temperature, remaining above 28°C up to 96 cfs and does not drop below 26.5°C until 166 cfs. Increased summer flow releases from Cape Horn Dam would apparently extend the area of satisfactory or marginal water temperatures for steelhead rearing further downstream, but the distance extended would depend on: a) magnitude of flow being released; b) temperature of water being released at Cape Horn Dam; and c) weather conditions. The expected increase in area of suitable habitat would be very small with moderate increases in flow (20-30 cfs). Even at flows above 30 cfs, high summer water temperatures would remain the major limiting factor to steelhead survival in the mainstem below Cape Horn Dam.

The available habitat area (AHA) for juvenile steelhead trout was calculated for 22 different flows for each reach type using the IFG HABTAT Program (Section 3.6, Instream Flow Study). Modified AHA values were then calculated for each reach type based on the streamflow/temperature relationship at each reach type. Reach Type I was separated into two subreaches, Big Bend and Emandal, because of the different temperature characteristics of those sites. Table 3.8-20 shows a ranking of the reach types based on the amount of unmodified AHA, temperature modified AHA, and population estimates of steelhead for July 1980, June and August 1981, and August 1982.

Table 3.8-20 shows that in June 1981, when stream temperatures below Cape Horn Dam had not yet reached marginal ($\geq$26.5°C) or lethal ($\geq$28.0°C) levels, and in August 1982 when lethal levels did not occur in the two reach types sampled, reach type rankings based on steelhead population estimates closely followed the rankings of the unmodified AHA values. However, in July 1980 and August 1981, when stream temperatures often reached lethal levels, reach type rankings based on steelhead population estimates followed the temperature modified AHA values. These results show that the unmodified AHA values best represent the reach types during the cool parts of the year and years of below normal summer water

Table 3.8-20. Comparative rankings of reach types by AHA (Available Habitat Area) values and steelhead population estimates.

			Steelhead Population Estimates			
Ranking	AHA[a] Unmodified	AHA[b] Modified	July 1980	August 1981	June 1981	August[c] 1982
Highest value	I (Big Bend)	IV	IV	IV	I (Big Bend)	I (Emandal)
	III	III	III	III	III	IV (Cape Horn)
	II	I (Emandal)	I (Emandal)	I (Big Bend)	I (Emandal)	
	I (Emandal)	II	I Big Bend)	I (Emandal)	II	
Lowest value	IV	I (Big Bend)	II	II	IV	

[a] AHA values before temperature correction.
[b] AHA values with temperature correction.
[c] Reach Types II and III were not sampled.

temperatures. When temperatures are high (July/August), the temperature modified AHA values best represent the rearing area for juvenile steelhead in each reach type.

AHA values cannot be used to predict actual fish populations because of yearly variation in escapement, spawning success, and egg and fry survival. The AHA values do provide a useful relative estimate of the rearing area available at different flows for each reach type. Generally, during the summer, Reach Type IV (Cape Horn) has the largest area of suitable rearing habitat up to a flow of 100 cfs (Table 3.6-4). At flows greater than 100 cfs, temperature becomes less of a factor affecting rearing habitat.

3.9 Hearst Riffle Channelization Feasibility Study

Three major alternatives for constructing and maintaining a channel of adequate depth and velocity to ensure upstream passage of adult chinook salmon and steelhead trout over Hearst Riffle were identified: Alternative 1 - Modification of streambed on an annual basis, or as required; Alternative 2 - Installation of gabions to narrow the stream channel; and Alternative 3 - Construction of permanent instream structure to define the stream channel. Each alternative is discussed below.

Alternative 1 - Modification of Streambed on An Annual Basis, or As Required

Due to the constantly changing streambed morphology at Hearst Riffle, it is possible that an adequate fish passage channel may form with no cost expenditure. For example, the gravel bar that formed during the spring of 1980 reduced the critical nature of this riffle. If this channel does not meet all of the design criteria or becomes blocked with sediment, the streambed would be modified by earth-moving equipment each year as required. The advantage of of this scheme is that it provides time to determine the best course of action once the gravel bars have stabilized; disadvantages are the recurring maintenance and instream work that may be detrimental to the fishery. This plan should not be greatly affected by the choice of a flow release within the range studied.

Alternative 2 - Installation of Gabions to Narrow the Stream Channel

Installation of gabions, rock-filled wire cages, could be completed in two phases as shown in Appendix K. In Phase I, gabions would be extended from the right bank to narrow the riffle. Additional gabions may be required on the left bank in two to three years (Phase II), depending on the movement of the gravel bar. The design for this plan is based on the existing cross-sections as of January 1981 and assumes the gravel bars can provide the required fill. Maintenance is expected to be negligible. This plan should not be greatly affected by the choice of a flow release within the range studied.

Alternative 3 - Construction of Permanent Instream Structure to Define the Stream Channel

A concrete channel meeting the design criteria would be constructed within the streambed. This alternative is not considered to be feasible, because the large streambed transport may make the channel ineffective or require maintenance similar to that of Alternative 1. The design and construction of a channel to meet the proposed criteria and remain functional with limited maintenance is a major undertaking with relatively high costs and a low probability of success.

The alternatives are recommended in the order they are listed. Alternative 1 seems to be the best choice due to its relatively low costs and the possibility that streambed modification may actually be unnecessary for adequate fish passage. Alternative 2, the second choice, would require major riffle modification and larger costs, but would meet the design criteria with a flexible scheme involving maintenance free gabions. Alternative 3 is not recommended due to its relatively high costs and low probability of success.

Based on the results of the Hearst Riffle Passage Study (Section 3.4) and the Critical Riffle Study (Section 3.5), channelization of riffles critical to the upstream passage of adult chinook salmon and steelhead trout appears unnecessary and impractical. Flow releases from Cape Horn Dam meeting passage requirements discussed as part of the Hearst Riffle Passage Study and Critical Riffle Study should provide adequate passage without riffle modification. Channelization of the critical riffles appears impractical due to streambed instability, and poor access to three of the five identified critical riffles.

3.10. Mitigation Study

Habitat

Aerial and ground surveys of current habitat conditions in the Eel River system upstream of Scott Dam, conducted in the last five years, indicate that chinook salmon and steelhead trout are blocked from spawning and rearing in approximately 25 miles of major channels above Lake Pillsbury and 10.5 miles of channels inundated by Lake Pillsbury (Table 3.10-1 and Figure 3.10-1). Steelhead trout have been blocked from an additional 23 miles of minor channels that may have been used above Lake Pillsbury (Table 3.10-2). Major channels include 8 miles of the mainstem Eel River, 11 miles of the Rice Fork, and 6 miles in Salmon and Smokehouse Creeks. Minor channels include tributaries to the Eel River, Rice Fork, and Salmon Creek. It is possible that chinook salmon could migrate into some of the tributaries included as minor channels, but the length of accessible stream cannot be determined with available data.

The mainstem Eel River upstream of Lake Pillsbury contains mainly rubble, boulder, and gravel substrates (Table 3.10-1). Gravels suitable for spawning occur as isolated pockets (5-20% of streambed area) among the dominant rubble and boulders. Extensive gravel bars, characteristic of the Eel River downstream of Scott Dam, are absent except immediately upstream of Lake Pillsbury. During the 1981 ground surveys, a major barrier falls was observed in the mainstem Eel River, approximately 0.1 mile downstream of Cold Creek. It consists of an old landslide of large boulders, forming a series of falls and multiple channels. Two consecutive, vertical drops of approximately 8 feet form an impassable barrier for all fish migrating upstream. Other barriers may exist in the mainstem, although none were observed during the aerial survey.

The Rice Fork contains extensive gravel bars (60% of streambed area) of apparently good quality for spawning in the lower and middle sections (6-8 miles). The channel is constricted in the upper section, and

Table 3.10-1. Summary of current habitat conditions and accessibility to chinook salmon and steelhead trout in major channels of the Eel River and tributaries upstream of Scott Dam.

STREAM NAME	DISTANCE (miles) Total	DISTANCE (miles) Estimated Accessible	Potential Barriers	SUBSTRATE Dominant Type	SUBSTRATE Spawning Quality	Rainbow Trout Present	SOURCE Surveyor, Survey Type	River Mile
Eel River, mainstem								
Headwaters to Trout Cr.	9.9	0	-	-	-	-	River mile index 1973	197.0-187.1
Trout Cr. to Corbin Cr.	0.8	0	-	Rubble, boulder	<5% marginal	2-10 in in pools	PGandE/VTN 1982 (0.1 mi-foot, 0.8 mi-aerial)	187.1-186.3
Corbin Cr. to Anderson Cr.	1.5	0	-	Silt	-	None	CDF&G 1978 (0.25 mi-foot)	186.3-184.8
same			-	Sand, silt, cobble, rubble, (0.3 mi)	<5% marginal	Fairly abundant	PGandE/VTN 1982 (0.3 mi-foot, 1.5 mi-aerial)	
Anderson Cr. to Cold Cr.	3.4	0	None	Gravel, rubble (2.5mi)	-	Abundant	CDF&G 1979 (2.5 mi-foot)	184.8-181.4
Cold Cr. to Lake Pillsbury	8.2	8.1	Two 8 ft falls approx. 0.1 mi below Cold Cr.	Rubble, boulders	<10% (marginal in upper section, 20% marginal in lower section)	A few 2-10 in in most pools	PGandE/VTN 1982 (1.0 mi-foot, 8.2 mi-aerial)	181.4-173.2
	23.8	8.1						
Rice Fork, mainstem								
Headwaters to French Cr.	8.0	1.0	Log jams in upper section	Sand, gravel, rubble	-	Common, 5-10 in	CDF&G 1978 (foot)	18.0-10.0
Salt Cr. to French Cr.	(1.0) (included in above)	(1.0)	-	Cobble, rubble, boulder	5% marginal	Young-of-year and adults in pools	PG&E/VTN 1982 (0.1 mi-foot 1.0 mi-aerial)	11.0-10.0
French Cr. to Parramore Cr.	2.8	2.8	None	Gravel, rubble, boulder	60% good	-	PGandE/VTN 1982 (aerial)	10.0-7.2

Table 3.10-1. (continued)

STREAM NAME	DISTANCE (miles) Total	Estimated Accessible	Potential Barriers	SUBSTRATE Dominant Type	Spawning Quality	Rainbow Trout Present	SOURCE Surveyor, Survey Type	River Mile
Rice Fork, mainstem (continued)								
Parramore Cr. to Bear Cr.	0.6	0.6	None	Gravel, rubble, boulder	60% good	-	PGandE/VTN 1982 (aerial)	7.2-6.6
Bear Cr. to Rice Cr.	2.6	2.6	None	Gravel	60% good	Abundant (6-12 in)	PGandE/VTN 1982 (0.2 mi-foot, 2.1 mi aerial)	6.6-4.0
Rice Cr. to Willow Cr.	3.2	3.2	None	Gravel	60% good	-	PGandE/VTN 1982 (aerial)	4.0-0.8
Willow Cr. to Lake Pillsbury	0.8	0.8	None	Gravel	60% good	-	PGandE/VTN 1982 (aerial)	0.8-0.0
	18.0	11.0						
Salmon Creek								
Mill Cr. to Lake Pillsbury	2.3	2.3	None	Gravel	Good	-	PGandE/VTN 1982 (aerial)	-
Smokehouse Cr.	>3.8	3.8	None	-	-	-	Estimated from topo map	-
	>6.1	6.1						
TOTAL MAJOR CHANNELS	>47.9	25.2						
Inundated by Lake Pillsbury								
Eel River	4.7	4.7	-	-	-	-	River Mile Index 1973	173.2-168.5
Rice Fork	2.3	2.3	-	-	-	-	Estimated from topo map	-
Salmon Cr.	2.0	2.0	-	-	-	-	Estimated from topo map	-
Squaw Valley Cr.	1.5	1.5	-	-	-	-	Estimated from topo map	-
	10.5	10.5						

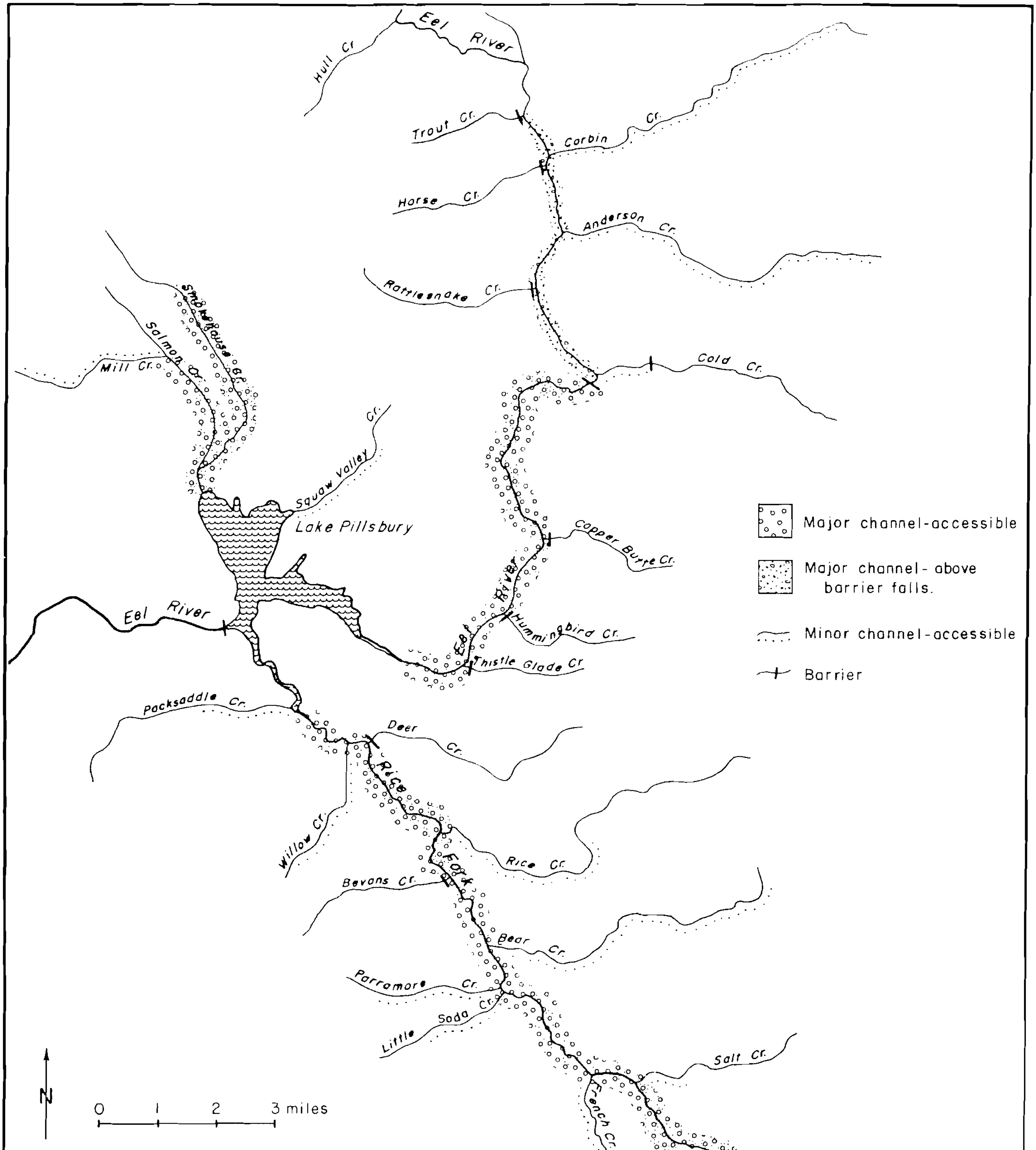

Figure 3.10-1. Chinook salmon and steelhead trout spawning and rearing habitat in major and minor channels of the Eel River and tributaries blocked by Scott Dam.

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1982

Table 3.10-2. Summary of current habitat conditions and accessibility to steelhead trout in minor channels of the Eel River and tributaries upstream of Scott Dam.

STREAM NAME	DISTANCE (miles) Total	DISTANCE (miles) Estimated Accessible	Potential Barriers	SUBSTRATE Dominant Type	SUBSTRATE Spawning Quality	Rainbow Trout Present	SOURCE Surveyor, Survey Type	River Mile
Eel River Tributaries								
Trout Cr.	3.0	0	150 ft upstream from Eel River	Rubble, boulder	None	None	CDF&G 1978, 1979 (1.5 mi-foot)	187.1
Corbin Cr.	12.0	(5.7)[a]	Boulder falls in middle section. Log jams throughout	Silt in lower section Rubble, boulder in upper section	-	A few (6 in.) in middle section	CDF&G 1977 (foot)	186.3
same			-	Cobble, rubble,	<10% marginal	Abundant in pools	PGandE/VTN 1982 (1.5 mi-foot, 6.0 mi-aerial)	
Horse Cr.	3.0	0	Log jams and slides abundant	Gravel, rubble, boulders	-	Present	CDF&G 1978 (1.0 mi-foot)	186.0
Anderson Cr.	>5.5	(5.0)[a]	-	-	-	-	Estimated from topo map	184.8
Rattlesnake Cr.	4.7	0	-	-	-	-	Estiamed from topo map	183.5
Cold Cr.	>4.5	(1.0)[a]	20 ft boulder falls in lower section	Rubble, boulders	-	Lower and middle sections	CDF&G 1978 (4.0 mi-foot)	181.4
Copper Butte Cr.	3.0	0	None[b]	Gravel	-	None	CDF&G 1938 (3.0 mi-foot)	176.6
Hummingbird Cr.	3.0	0	None[b]	Boulder	-	None	CDF&G 1938 (3.0 mi-foot)	174.9
Thistle Glade Cr.	5.0	0	4 ft falls, 50 ft upstream of Eel River	Gravel	-	None	CDF&G 1938 (5.0 mi-foot)	173.7
	>43.7	0 (11.7)[a]						

[a] Not currently accessible due to barrier on the Eel River downstream of Cold Cr. (Table 3.10-1).
[b] Stream gradient at mouth too great for chinook or steelhead passage, estimated from topo map.

Table 3.10-2. (continued)

STREAM NAME	DISTANCE (miles) Total	DISTANCE (miles) Estimated Accessible	Potential Barriers	SUBSTRATE Dominant Type	SUBSTRATE Spawning Quality	Rainbow Trout Present	SOURCE Surveyor, Survey Type	River Mile
Squaw Valley Cr. (Lake Pillsbury to headwaters)	3.5	2.0	None	Gravel, bedrock	-	-	CDF&G 1978 (2.5 mi-foot)	-
Salmon Creek Triburtaries								
Mill Cr. (tributary to Salmon Cr.)	5.0	3.0	-	-	-	-	CDF&G 1938 (foot)	
Rice Fork Tributaries								
Salt Cr.	3.5	1.0	None	Gravel, rubble	-	Lower section	CDF&G 1978 (foot)	11.0
same				Cobble, rubble	0%	-	PGandE/VTN 1982 (foot)	
French Cr.	3.0	2.0	None	Gravel, rubble	-	None	CDF&G 1978 (2.7 mi-foot)	10.0
Little Soda Cr.	3.5	1.4	10 ft falls in middle of stream	Rubble, boulder	-	None	CDF&G 1978 (2.7 mi-foot)	7.4
Parramore Cr.	4.0	1.9	Several falls in upper section	Gravel, rubble	-	None	CDF&G 1978 (3 mi-foot)	7.2
Bear Cr.	8.0	5.3	-	-	Good	Abundant (1-2 in.)	CDF&G 1938 (6.0 mi-foot)	6.6
same			6 ft falls in upper section	Sand, gravel, rubble	-		CDF&G 1978 (6.0 mi-foot)	
same			-	Gravel cobble, rubble	60% good	Young-of-year abundant	PGandE/VTN 1982 (0.1 mi-foot)	

Table 3.10-2. (continued)

STREAM NAME	DISTANCE (miles) Total	Estimated Accessible	Potential Barriers	SUBSTRATE Dominant Type	Spawning Quality	Rainbow Trout Present	SOURCE Surveyor, Survey Type	River Mile
Bevans Cr.	3.2	0	Log jam and debris (4 ft)	Sand, gravel, rubble	-	None	CDF&G 1978 (0.5 mi-foot)	4.9
Rice Cr.	6.0	3.2	None	Gravel	Excellent	Common (1 1/2-2 1/2 in) Occasional (3-5 in)	CDF&G 1938 (foot)	4.0
same			-	Gravel, rubble	-	Present	CDF&G 1978 (0.5 mi-foot)	
same				Cobble, rubble, boulder	5% marginal	Few (1-6 in)	PGandE/VTN 1982 (0.1 mi-foot)	
Deer Cr.	6.5	0	-	-	Excellent	Occassional (2-3 in)	CDF&G 1938 (foot)	1.1
same			Log jam and 10 ft falls	Sand, gravel, rubble	-	None	CDF&G 1978 (0.75 mi-foot)	
Willow Cr.	4.8	2.0	Log jam in lower section	Sand, gravel, rubble	-	None	CDF&G 1978 (2 mi-foot)	0.8
Packsaddle Cr.	3.4	0.9	-	-	-	-	Estimated from topo map	
	45.9	17.7						
	>98.1	22.7						

boulder substrates are more prevalent. The upper limit of accessibility is estimated to be Salt Creek, although no barriers were observed during the 1981 surveys.

Salmon and Smokehouse Creeks are tributaries to the north side of Lake Pillsbury. The lower reaches of these streams spread out in braided channels over an extensive gravel and rubble flood plain and contain good quality spawning gravel. Upstream areas were not examined; however, judging from topographic maps, each stream is probably accessible to migrating salmonids for several miles upstream of Lake Pillsbury. The greatest potential for a migration barrier is the low gradient multi-channel gravel flood plain that may disperse the streamflow to the extent that there is not adequate water depth for fish to pass.

Summer rearing conditions for steelhead trout appear to be fair in the mainstem Eel River. Streamflows were estimated to be 2-3 cfs. Midday water temperatures in August 1981 were 21.5°C near Trout Creek, 24.0°C below Corbin Creek, and 26.0°C above Cold Creek. Cold Creek entered the Eel River at 19.0°C, lowering the Eel River temperature to 22.5°C; however, the river temperature rose to 26.5°C less than 1/2 mile downstream. Resident rainbow trout (2-10 inches) were present in most pools, but rarely exceeded more than 5-10 fish in any single pool. The fish observed did not appear stressed by the relatively high water temperatures. Streamside shading by vegetation or large boulders was sparse (<10% of streambed area).

Rearing conditions in the Rice Fork appear to be slightly better than in the mainstem Eel River. Estimated streamflows ranged from <1 cfs near Salt Creek to about 2 cfs near Bear Creek. Water temperature was 23.0°C at both locations. Riffle and run areas were more abundant (60-90% of streambed area) than in the Eel River (40-80%), as was streamside shading by riparian vegetation (10-60%). Rainbow trout were more abundant and larger (up to 12 inches).

Cold Creek, Anderson Creek, and Corbin Creek, the three principle tributaries to the mainstem Eel River upstream of Lake Pillsbury, have generally good summer habitat conditions with water temperatures from 15 to 26°C, moderate to dense shading, and rainbow trout common. These tributaries are not accessible, however, due to the barrier falls downstream of Cold Creek. Tributaries downstream of the barrier falls have not been surveyed recently, but due to steep gradients and barriers near the Eel River, they are considered to be unimportant as summer rearing habitat for steelhead trout. Summer habitat conditions in most of the tributaries accessible to steelhead in the Rice Fork appear fair to good with temperatures from 15 to 26°C, sparse to dense shading, and rainbow trout common.

Historical habitat conditions in the Eel River upstream of Scott Dam are difficult to evaluate due to the lack of data. Stream surveys conducted by CDF&G in late August of 1938 in Copper Butte, Hummingbird, and Thistle Glade Creeks indicated generally good conditions with flows of 1-4 cfs, water temperatures of about 13°C, and rainbow trout present. There are no recent survey data, however, to compare with these historical data.

Stream surveys conducted in 1938 by CDF&G in the Rice Fork tributaries; Bear, Rice, and Deer Creeks; indicated fair to good conditions with flows of 2-6 cfs, water temperatures of 16 to 20°C, and rainbow trout present. Recent surveys indicate poor to good conditions with less flow (<1 cfs), higher water temperatures (18-25°C), and rainbow trout less abundant. Habitat quality and fish abundance in these streams is evidently lower now than in 1938. If this is typical of general habitat conditions throughout the drainage above Lake Pillsbury, the total carrying capacity has probably declined since the 1930s and since construction of Scott Dam. The magnitude or degree of change cannot be determined, however, due to the lack of adequate historical data.

Aquatic habitat conditions in the major channels of the Eel River drainage upstream of Scott Dam vary widely from a narrow, steep, largely rubble and boulder channel in the mainstem Eel River to a broad, low gradient, extensively gravel channel in the Rice Fork. The mainstem Eel River upstream of Scott Dam has no comparable counterpart downstream of Scott Dam. Reach Type 6 of the Eel River (Figure 2.8-1) may have been very comparable under natural flow conditions; however, this reach now receives high sustained flow releases from Scott Dam. The Rice Fork is most comparable to Tomki Creek from Cave Creek to Wheelbarrow Creek. Each has a broad, low gradient channel, and extensive gravel deposits; the major difference is the lack of sustained summer streamflow and slightly less riparian vegetation in Tomki Creek. Salmon Creek, the other major channel area upstream of Scott Dam, is probably most comparable to Soda Creek, just downstream from Scott Dam. The broad, open gravel flood plain in the downstream section of each typically dries up during summer.

Adult Fish Abundance

Estimates of present day adult chinook salmon and steelhead trout abundance in the upper Eel River are available based on several different types of data (Table 3.10-3). The four-year average for chinook salmon escapement into Tomki Creek is probably the best indicator of current salmon abundance (35 fish/mile). Given the apparent degradation of habitat since construction of Scott Dam, the highest recorded chinook escapement into Tomki Creek (2,410 in 1979) may be a better indicator of previous abundance (70 fish/mile). Estimates of chinook salmon abundance in the mainstem Eel River downstream of Cape Horn Dam are probably poor indicators of previous abundance above Scott Dam due to the difference in habitat characteristics between the two areas.

Annual counts of steelhead trout passing over Cape Horn Dam since 1933/34 are the most accurate and complete estimates of steelhead escapement in the upper Eel River. Estimates of steelhead numbers in

Table 3.10-3. Density (fish per mile) of adult chinook salmon and steelhead trout from various areas in the Eel River.

Species	Stream	Number of Fish	Distance (miles)	Density (fish/mile)	Source
Chinook salmon	Tomki Creek (carcass survey, 4-year average)	1,210	34.5	35	Hinton 1976, Brown 1977, and present study
	Tomki Creek (highest known escapement, 1979/80)	2,410	34.5	70	Present study
	Eel River near Emandal (carcass survey, 1979/80)	766	4	192	Present study
	Eel River, Tomki Cr. to Outlet Cr. (aerial survey, 1979)	3,500	27	130	Present study
	Eel River, upstream of English Ridge damsite	6,210	64	97	Anderson 1972
	Eel River, upstream of the South Fork	16,500	257	64	USFWS unpublished
	Eel River, total drainage	69,000	802	86	Anderson 1972
Steelhead trout	Eel River, Scott to Cape Horn Dams (1933/34-1939/40 average)	4,394	23	191	Present study
	Eel River, Scott to Cape Horn Dams (1970/71-1979/80 average)	721	23	31	Present study

Table 3.10-3. (continued)

Species	Stream	Number of Fish	Distance (miles)	Density (fish/mile)	Source
Steelhead trout	Eel River, Scott to Cape Horn Dams (highest recent escapement, 1980/81)	1,966	23	85	Present study
	Eel River, upstream of English Ridge damsite	11,860	82	145	Anderson 1972
	Eel River, total drainage	115,000	1,269	91	Anderson 1972
	Soda Creek (1980/81)	106[a]	2.5	42	Present study

[a] Based on 53 redds counted during February and March surveys and assuming two fish per redd.

the total drainage and upstream of the English Ridge damsite by Anderson (1972) are the only other data available on steelhead abundance. Neither of these estimates is particularly useful for comparison to the Eel River upstream of Scott Dam. The Eel River between Scott Dam and Cape Horn Dam is subjected to a vastly different flow regime than upstream of Scott Dam. Flows are regulated during all but peak flow periods creating more abundant, stable conditions for all life stages. Because of the sustained high summer flows and low water temperatures, summer rearing conditions between the two dams are considerably better than in any other section of the upper Eel River. Presumably, this would result in substantially greater smolt production and, subsequently, a greater return of adult steelhead to this section. Although the extent of losses of steelhead smolts through the diversion at Cape Horn Dam are not known, it is unlikely that any single area historically supported as many steelhead, per mile of stream, as the section between Scott and Cape Horn Dams currently supports. Estimates of steelhead abundance for the total Eel River drainage and for the area upstream of the English Ridge damsite suffer the same drawbacks as similar estimates of chinook abundance (i.e., great dissimilarity of overall habitat characteristics).

Tributaries to the Eel River between Scott and Cape Horn Dams are not regulated, and adult steelhead abundance in Soda Creek (42 steelhead/mile in 1981) may be a reasonable indicator of potential steelhead abundance upstream of Scott Dam. Return of steelhead trout to the Eel River between the two dams in 1980/81 (1,966) was 44.7% of the average return during the 1930 decade (4,394). If a similar decline has occurred in returns to Soda Creek, the 1981 density of 42 steelhead per mile can be multiplied by 2.23 to represent the average return during the 1930 decade: 94 steelhead per mile.

Estimates of Fish Lost

Habitat survey results suggest that chinook salmon and steelhead trout could currently spawn in 25.2 miles of the Eel River and tributaries upstream of Lake Pillsbury. Addition of approximately 10.5 miles inundated by Lake Pillsbury brings the total loss of available spawning area due to construction of Scott Dam to 35.7 miles. Steelhead trout might have access to an additional 22.7 miles of minor channels in tributaries.

Estimates of historical run size and the length of stream available prior to construction of Scott Dam are: 70 chinook/mile, 94 steelhead/mile, and 35.7 miles of stream. Estimates of the number of fish lost are: 2,499 chinook salmon and 3,356 steelhead. The estimate derived here for chinook salmon lost due to construction of Scott Dam compares favorably with the estimate made by CDF&G of 2,300, but the estimate for steelhead trout is one and one-third times higher than the CDF&G estimate of 2,500 (CDF&G 1979, unpublished).

Salmon and steelhead runs in streams throughout the north coastal area of California have declined from historical levels for a number of reasons (Section 3.1, Cape Horn Dam Adult Fish Counts). It is extremely unlikely that the Eel River drainage above Scott Dam could support runs as large as it did historically, even without the existence of the Potter Valley Project.

The best available estimates of current run sizes of chinook salmon and steelhead trout in the upper Eel River are 35 chinook/mile and 42 steelhead/mile. Applying these densities to estimates of currently available spawning habitat upstream of Lake Pillsbury (25.2 miles) and habitat that is currently inundated by Lake Pillsbury (10.5 miles), yields estimates of 1,250 chinook salmon and 1,499 steelhead trout that could be presently returning to the Eel River upstream of the Scott Dam site. Additional steelhead trout might be supported in some of the tributaries not included in the calculation.

4.0 CONCLUSIONS

4.1 Cape Horn Dam Adult Fish Counts

Chinook salmon spawning escapement to the Eel River above Cape Horn Dam is a minor component of the total spawning population within the study area. During four years of comparable data, salmon ascending Cape Horn Dam comprised 0 to 4% of the estimated populations in Tomki Creek. Also, during the 1979/80 season, 3,500 salmon were estimated to have spawned in the Eel River between Tomki Creek and Outlet Creek, while only 84 salmon passed over Cape Horn Dam. During the last 27 seasons of record, salmon counts at Cape Horn Dam have ranged from 0 to 175; in ten of the those seasons, no salmon ascended the dam. Chinook salmon, as a self-sustaining population, may have been eliminated from the Eel River above Cape Horn Dam; the salmon ascending Cape Horn Dam being strays from downstream populations.

Steelhead trout spawning escapement to the Eel River above Cape Horn Dam appears to be a major component of the total spawning population within the study area. The river between Scott and Cape Horn Dams is the primary steelhead rearing habitat area within the study area during summer. During the 45 seasons of record, steelhead counts at Cape Horn Dam have ranged from 39 to 9,528; mean annual counts of steelhead for each decade of record show a decline from 4,394 in the 1930's to 721 in the 1970's. The high quality permanent summer rearing habitat that exists between Scott Dam and Cape Horn Dam is one of the primary factors contributing to the maintenance of this run.

Timing of chinook salmon arrival at the dam is dependent on the pattern and magnitude of flow in the Eel River drainage below Cape Horn Dam from late October through December. The first salmon usually arrive at the dam during or following the first or second major high flow event of the season. Peaks in arrival at the dam generally are associated with peak flows. Salmon have arrived at Cape Horn Dam following peak flows as low as 100 cfs at the dam and 235 cfs above Outlet Creek. Peak releases from Cape Horn Dam of 135 cfs during periods of normal storm activity and 205 cfs in the absence of normal storm activity appear necessary for chinook migration. Upstream migration of steelhead trout is also dependent on peak streamflows from November to April; however, peak releases necessary for steelhead migration appear to be less.

4.2 Tomki Creek/Eel River Salmon Carcass Survey

Chinook salmon spawning escapement to the Tomki Creek drainage is a major component of the total spawning population within the study area. During the 1979/80 season, 2,410 salmon were estimated to have spawned in the Tomki Creek drainage, compared to 3,500 in the Eel River between Tomki Creek and Outlet Creek and 84 in the Eel River between Scott and Cape Horn Dams. Excellent spawning habitat is found throughout most of the Tomki Creek drainage.

The size and composition of the chinook salmon spawning run in the Tomki Creek drainage varies greatly from year to year. During four years of record, estimates of spawning escapement to Tomki Creek ranged from 317 to 2,410.

Movement of chinook salmon up to Tomki Creek is dependent on Eel River flows during fall. Salmon generally reach Tomki Creek during the second major high flow event of the season. Movement of chinook salmon and distribution of spawning activity within the Tomki Creek drainage are dependent on natural runoff conditions. During fall/early winter seasons of high runoff, salmon are able to migrate higher into the drainage and spawning activity is spread over an expanded area.

The 1.2-mile section of the Eel River downstream of Hearst Riffle provides good spawning habitat for chinook salmon as indicated by the large numbers that spawned there during the 1979/80 season. An estimated 766 salmon spawned in 4 miles of stream below Hearst Riffle; approximately 80% of these fish spawned in the upper 1.2-mile section.

A majority of steelhead trout that ascend Cape Horn Dam spawn in the mainstem Eel River rather than in tributary streams. During the 1980/81 season, a total of 1,530 steelhead ascended Cape Horn Dam by the second week of February; during that week, only 75 steelhead and 41 redds were observed in tributaries above Cape Horn Dam, and approximately one month later, even fewer fish and redds were observed.

4.3 Aerial Redd Survey

Chinook salmon spawning escapement to the Eel River between Tomki Creek and Outlet Creek is a major component of the total spawning population within the study area. During the 1979/80 season, an estimated 3,500 chinook salmon spawned in the Eel River between Tomki Creek and Outlet Creek, compared to 84 in the Eel River between Scott and Cape Horn Dams and 2,410 in the Tomki Creek drainage.

Chinook salmon may spawn more heavily in the Eel River between Tomki Creek and Hearst Riffle than between Hearst Riffle and Outlet Creek. During the 1979/80 season, salmon redd densities in these two stream sections were 28 and 10 redds per mile, respectively.

4.4 Hearst Riffle Passage Study

Timing of chinook salmon and steelhead trout upstream migration depends on the occurrence of fall storms that cause pulses in the Eel River flow regime. Chinook salmon were observed passing over Hearst Riffle following the first or second storms in November and December during the three years of study. Steelhead trout typically migrate through April and are less dependent on early fall flows than are chinook salmon.

Streamflows of 60 cfs and greater appear to be adequate for upstream passage of chinook salmon and steelhead trout; however, passage was greatest during or following natural or artificial peak flows that cause flows at Hearst Riffle to rise above 200 cfs. Passage during the day under stable flow conditions was relatively low at all flows up to 274 cfs; passage at flows over 500 cfs was not readily observable but is assumed to be high. Unsuccessful passage attempts were low in all three years of observation with the highest frequencies associated with peak successful attempts and with spawning on and below the riffle.

Fish passage patterns on Hearst Riffle were more dependent on depth and velocity downstream of the riffle than on the riffle itself. As fish approached the riffle, they followed the deepest channel along the left bank and then swam directly over the riffle parallel to the current, rather than seeking areas of greatest depth. Passage patterns at high flow levels (>400) parallel the direction of flow over the riffle, irrespective of depths on or below the riffle.

A minimum depth of 0.6 ft was consistently used by chinook salmon passing over Heart Riffle; however, a preference for depths over 0.8 ft was indicated by the data. This is probably the direct result of higher passage associated with peak flows and concurrently greater depths on Hearst Riffle and may result from responses to stimuli, other than depth, related to peak flows.

Adequacy of various streamflows for passage over Hearst Riffle and other shallow riffles cannot be determined solely on a knowledge of depth conditions on the riffle; other data such as channel morphology below the riffle, riffle length, and normal variations in flow magnitude must also be considered.

4.5 Critical Riffle Study

Data collected during three years of observation on Hearst Riffle indicate that at least two elements of the Thompson criteria for upstream fish passage may not be valid for chinook salmon in the Eel River: minimum depth (0.8 ft) and usable width (25% of stream width, 10% of which must be continuous). A minimum depth of 0.6 ft was found to be adequate for successful upstream passage of chinook salmon. Salmon passed in large numbers and with little apparent difficulty at depths down to 0.6 ft; depths of 0.5 ft and less were used infrequently. Although the selected transect across each critical riffle accurately represented the shallowest depths on the riffle, usable widths determined according to the Thompson criteria did not necessarily represent areas and depths used by fish for passage. Passage patterns on Hearst Riffle were primarily dependent on channel morphology below the riffle and flow magnitude rather than depth on the riffle.

Hearst Riffle passage data also indicate that changes in streamflow stimulate much greater movement than stable flows. This information and the dynamic nature of the gravel bars suggest that a single, stable release flow based on passage criteria may not achieve the desired goal of providing adequate transportation conditions for chinook salmon or steelhead trout. Instead, a release schedule based on flows required for spawning and incorporating regulated pulse releases to supplement naturally occurring peak flows would probably better achieve both goals.

4.6 Instream Flow Study

Streamflows in the Eel River between Scott Dam and Outlet Creek need to be regulated and maintained for several key activities and life stages of chinook salmon and steelhead trout, separated both seasonally and geographically. During the fall and winter seasons, streamflows adequate for upstream migration, spawning, and egg incubation for both species should be maintained. Upstream passage of chinook salmon and steelhead trout in the fall is largely dependent on peak flows associated with major storm events. Spawning and incubation of eggs are more dependent on minimum flows and should be emphasized in establishing flow releases for the fall and winter seasons. Flows adequate for spawning should also be adequate for incubation, narrowing the basis for streamflow selection to spawning. Rearing of juvenile steelhead trout is the principal life stage and biological activity occurring during the remainder of the year on which selection of summer streamflows should be based.

Geographical separation of chinook salmon and steelhead trout is evident; chinook salmon spawn principally in Tomki Creek and the mainstem Eel River from Tomki Creek to Outlet Creek, while steelhead trout spawn and rear mainly in the Eel River between Scott and Cape Horn Dams and in tributaries. Steelhead are dependent on summer rearing conditions, restricting them to the areas of suitable water temperatures found between the dams and in some tributaries. Summer water temperatures are unsuitable in the Eel River downstream of Tomki Creek, in most of Tomki Creek, and in some other tributaries. Juvenile chinook salmon emigrate in the spring shortly after emerging from the gravel and thus are not limited by summer rearing conditions in the upper Eel River. Chinook salmon returns to the Eel River above Cape Horn Dam have been consistently low during the period of record. Historically low streamflows released from Cape Horn Dam have limited upstream migration; however, steelhead trout have successfully migrated in large numbers under these conditions, and in many years when no salmon arrived at Cape Horn Dam, ample water for upstream passage existed. The general absence of chinook salmon from this section of river may be due to a variety of project and non-project related problems.

All habitat simulations for the instream flow study except chinook salmon spawning were based on unmodified IFG habitat suitability index curves; insufficient data specific to Northern California coastal rivers were available to support modifications for most curves. A modified depth curve was used in habitat simulations for chinook salmon spawning.

Chinook salmon spawning habitat in the Eel River from Cape Horn Dam to Outlet Creek, adjusted for tributary inflow, is greatest (>90% of optimum) at flow releases of 175 to 250 cfs. Weighting the habitat areas for the reach types used most by spawning chinook salmon indicates that the "optimum" flow range is probably 175 to 200 cfs. Cape Horn Dam flow releases of 125 to >400 cfs provide at least 50% of the maximum spawning area available in the two reach types used most heavily.

Steelhead trout spawning habitat in the Eel River from Scott Dam to Cape Horn Dam is greatest (>80% of optimum) at flow releases from Scott Dam of 170 to 280 cfs. At least 50% of maximum spawning area is available in the approximate flow range of 125 to 360 cfs.

An evaluation of summer rearing habitat for steelhead trout, modified for temperature suitability, indicates that the most important rearing area exists between Scott and Cape Horn Dams. Summer rearing habitat available in this section is greatest (>80% of optimum) at flow releases of 68 to 265 cfs. Summer rearing habitat in the Eel River below Cape Horn Dam (and particularly below Tomki Creek) is limited by high water temperature. Moderate summer flow releases of 20-30 cfs from Cape Horn Dam would have minimal effects on reducing stream temperatures to suitable levels; releases ranging from 76 to 166 cfs would be required to achieve suitable temperature conditions between Tomki Creek and Outlet Creek.

4.7 Downstream Juvenile Migration Study

The timing of juvenile chinook salmon emigration differed above and below Cape Horn Dam. In 1980, peak salmon emigration below the dam occurred in late April and May, while peak emigration above the dam occurred in late June. In 1982, peak salmon emigration below the dam also occurred in late April and May, but peak emigration above the dam occurred in May. Water temperature appears to be the primary factor influencing emigration; the major periods of downstream movement occurred when temperatures reached 17 to 20°C. In 1980, water temperautes above Cape Horn Dam approached 17°C in late June, while in 1982, water temperatures reached 17°C in mid-May due to the experimental release of warmer surface water from Lake Pillsbury.

Relatively cool temperatures in the Eel River between Scott and Cape Horn Dams, due to the usual release of water from the bottom of Lake Pillsbury, apparently cause a delay in emigration from this stream section. This has a profound adverse effect on salmon emigrating from above Cape Horn Dam; by the time water temperatures above Cape Horn Dam approach emigration-stimulating levels (around 17°C), temperatures downstream approach lethal levels (over 24°C), probably resulting in the loss of these later emigrating fish.

Water temperature differences above and below Cape Horn Dam may also contribute to different growth rates for salmon in these two sections. Cooler water temperatures between Scott Dam and Cape Horn Dam are apparently more conducive to growth than downstream temperatures. Juvenile chinook salmon appeared to grow faster between the dams based on catch rates per two-week intervals.

Other factors influencing chinook salmon emigration may include streamflow and light intensity associated with lunar phases. Initial peaks in salmon emigration each season usually followed large declines in streamflow from high spring levels. Peak movement below Cape Horn Dam appeared to coincide with the reduction of light associated with the new moon.

Emigrating juvenile steelhead trout consisted of two discernible groups: age 0+, and age 1+ and older fish. Age 1+ and older fish appear to emigrate in large numbers earlier in the year than age 0+ fish. In 1981, peak catch rates of age 1+ and older fish occurred from late April to late May; peak catch rates of 0+ fish occurred from late May through mid-July. In 1982, age 1+ and older fish emigrated from March through June while age 0+ emigration occurred mainly from early June to mid-July.

Factors influencing juvenile steelhead emigration appear to include: rising water temperatures and decreasing flows during spring, rapid changes in water temperatures during early summer, sudden decreases in flow during summer, sudden increases in flow during fall, and reduced light intensity associated with the new moon.

In most years, steelhead emigrating as late as June are apparently lost to the fishery. Water temperature data and summer fish inventories indicate that there is little habitat available to juvenile steelhead during the summer months below Cape Horn Dam.

Estimates of juvenile chinook salmon diverted from the upper Eel River in 1980, 1981, and 1982 were 854, 0 and 350, respectively; estimates of steelhead diverted were 1,568, 13,139 and 5,145. A comparison of the 1981 steelhead estimates with data collected in 1961/62, prior to installation of a fish screen, indicates that the screen is partially effective. During a year of trapping in 1961/62, an estimated 24,766 steelhead were diverted; this is nearly twice as many fish as were diverted in 1981, despite a larger adult run over Cape Horn Dam in 1980/81 (1,966 fish) than in 1960/61 (1,130 fish). The screen is most effective for age 1+ and older steelhead.

4.8 Summer Fish Inventory

The Eel River between Scott and Cape Horn Dams provides the most important summer rearing habitat for juvenile steelhead trout in the study area; higher densities occur in this section than in other portions of the study area. Tributary streams between Scott Dam and Outlet Creek provide fair to good quality rearing habitat and are important components of the total available rearing habitat within the study area. The Eel River between Cape Horn Dam and Tomki Creek provides some additional rearing habitat, but of lower quality than in the Eel River upstream of Cape Horn Dam and in most tributaries. The Eel River between Tomki Creek and Outlet Creek provides little or no rearing habitat that can be considered suitable during most summers due to high temperatures. During the 1982 summer, however, water tempeatures were significantly lower than usual, providing suitable rearing habitat in most stream sections. Consequently, steelhead populations in the Eel River from Tomki Creek to Outlet Creek showed a significant improvement.

High water temperature is the major factor limiting the abundance and distribution of juvenile steelhead trout during summer. The various stream sections listed above were classified as either satisfactory, marginal, or lethal with respect to suitability of temperature conditions for juvenile steelhead during most summers: Eel River between Scott and Cape Horn Dams, satisfactory; Eel River between Cape Horn Dam and Tomki Creek, marginal; Eel River between Tomki Creek and Outlet Creek, lethal; and tributary streams, satisfactory to marginal. During the unusually mild 1982 summer, the Eel River between Cape Horn Dam and Tomki Creek was classified as satisfactory and between Tomki Creek and Outlet Creek classified as marginal to lethal.

4.9 Hearst Riffle Channelization Feasibility Study

Three alternatives for constructing and maintaining a channel of adequate depth and velocity to ensure upstream passage of adult chinook salmon and steelhead trout over Hearst Riffle were identified and evaluated. Alternative 1, modification of streambed on an annual basis, is considered the best choice due to its relatively low cost and the possibility that streambed modifications may actually be unnecessary for adequate fish passage. Alternative 2, installation of rock-filled gabions to narrow the stream channel, would require major riffle modification and larger costs, but would meet the design criteria with flexible, maintenance-free structures. Alternative 3, construction of permanent instream structure to define the stream channel, is not recommended due to its relatively high cost and low probability of success.

Channelization of the critical riffles appears unnecessary; flow releases from Cape Horn Dam meeting passage requirements addressed as part of other study elements should provide adequate passage without riffle modification. Channelization also appears impractical due to streambed instability and poor access to three of the five identified critical riffles.

4.10 Mitigation Study

Estimates of the number of returning adult chinook salmon and steelhead trout lost due to construction of Scott Dam are 2,499 chinook and 3,356 steelhead. Habitat survey data indicated that 25.2 miles of currently usable major channels exist upstream of Lake Pillsbury and that 10.5 miles of channel are inundated by Lake Pillsbury, totalling 35.7 miles of lost spawning and rearing habitat. Estimates of historical run size were based on current escapement of chinook and steelhead into streams below Scott Dam having comparable habitat characteristics to streams above Scott Dam. The highest recorded escapement into Tomki Creek (70 chinook/mile) was used for chinook salmon. Estimated escapement into Soda Creek in 1981 (42 steelhead/mile), adjusted to the 1930 decade levels (94 steelhead/mile), was used for steelhead trout.

The estimate derived here for chinook salmon (2,499) compares favorably with the estimate made by CDF&G of 2,300, but the estimate for steelhead trout (3,356) is one and one-third times higher than the CDF&G estimate of 2,500.

Salmon and steelhead runs in streams throughout the north coastal area of California have declined from historical levels for a number of reasons. It is extremely unlikely that the Eel River drainage above Lake Pillsbury could support runs as large as it did historically, even without the existence of the Potter Valley Project.

The best available estimates of current run sizes of salmon and steelhead are 35 chinook/mile and 42 steelhead/mile. Applying these densities to estimates of currently available spawning habitat above Lake Pillsbury and areas inundated by Lake Pillsbury yields estimates of 1,250 chinook and 1,499 steelhead that could presently be returning to the Eel River above Scott Dam.

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