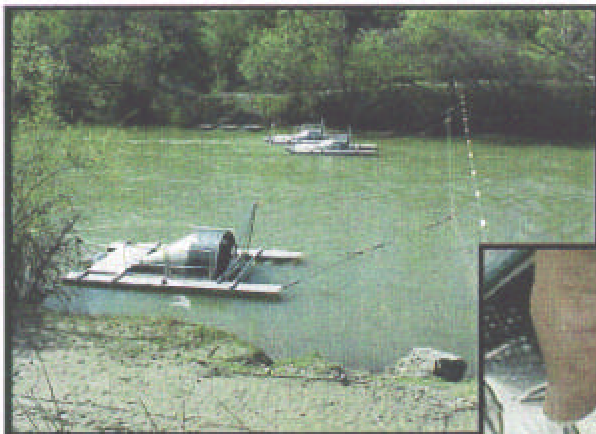
SONOMA COUNTY WATER AGENCY'S MIRABEL RUBBER DAM/WOHLER POOL FISH SAMPLING PROGRAM: YEAR 1 RESULTS 2000



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EXECUTIVE SUMMARY

The Sonoma County Water Agency (Agency) diverts water from the Russian River to meet residential and municipal demands. Water diverted is a combination of releases from upstream storage reservoirs and instream flow. The Agency's water diversion facilities are located near Mirabel and Wohler Road. The Agency operates five Ranney collector wells (large groundwater pumps) adjacent to the Russian River near Wohler Road and Mirabel that extract water from the aquifer beneath the streambed. The ability of the Russian River aquifer to produce water is generally limited by the rate of recharge to the aquifer through the streambed. To augment this rate of recharge, the Agency has constructed several infiltration ponds. The Mirabel Inflatable Dam (Inflatable Dam) raises the water level and submerges the intakes to a series of canals that feed infiltration ponds located at the Mirabel and Wohler facilities. The backwater created by the Inflatable Dam also raises the upstream water level and submerges a larger streambed area along the river. This increased depth and enlargement of the submerged area significantly increases infiltration to the aquifer.

Three species of fish (chinook salmon, coho salmon, and steelhead) listed as threatened under the federal Endangered Species Act (ESA) inhabit the Russian River drainage. In December 1997, the U.S. Army Corps of Engineers, NMFS, and the Agency entered into a Memorandum of Understanding (MOU) for consultation under Section 7 of the ESA to evaluate the effect of certain Russian River activities, including the Agency's water supply facilities and operations, on the three listed fish species. Section 7 of the ESA requires preparation of a Biological Assessment to evaluate these potential effects, and pursuant to the MOU the Agency is designated as the non-federal representative to prepare the Biological Assessment. The scope of this study is limited to assessing the potential for the Agency's Inflatable Dam to adversely affect chinook and coho salmon and steelhead. Results from this study will be incorporated into the Biological Assessment.

The three listed species are anadromous, meaning they spawn and rear in freshwater, then migrate to the ocean where they grow and mature. They then migrate back to their natal freshwater habitat where they spawn and complete their life cycle. Chinook salmon, coho salmon, and steelhead use the lower mainstem Russian River (including the study area) primarily as a migration corridor. Adults pass through the Mirabel Reach during their migration to upstream spawning and rearing habitat. Juveniles (smolts) emigrate through the area during their downstream journey to the ocean. Steelhead have been observed/captured in the study area throughout the summer period, indicating that either they migrate at low levels throughout the year, or that rearing occurs in the area, albeit at very low levels. Under current conditions, summer water temperatures limit salmonid rearing in the mainstem Russian River.

The Inflatable Dam has the potential to impact salmon and steelhead through; 1) altering habitat composition, 2) altering water temperature and water quality in the lower river, 3) impeding downstream migration of juveniles, 4) impeding upstream migration of adults, and 5) altering habitat to favor predatory fish. This study was developed in cooperation with the National Marine Fisheries Service and the California Department of Fish and Game to assess the potential for the dam to adversely impact listed species.

WATER TEMPERATURE

The average weekly water temperature at a depth of 0.5 m increased at a rate of approximately 0.1°C/km, June through August, through the lower two-thirds of the Wohler Pool. This rate of increase resulted in an overall increase in the temperature of water of approximately 0.4°C over this distance. The average weekly water temperature at a depth of 0.5 m from the Inflatable Dam downstream approximately 2.0 km increased at a rate of approximately 0.1°C/km, June through August. This rate of increase resulted in an overall increase in the temperature of water of approximately 0.2°C over this distance.

During the mid- to late-spring smolt emigration period (April 20 and June 30), mean weekly average water temperatures ranged from 16.1°C to 23.6°C (temperature collected at Inflatable Dam). During this same period, the maximum temperature recorded was 25.1°C. Based on the North Coast Regional Water Quality Control Board's criteria for water temperatures during the spring emigration period not to exceed 21.1°C, thermal conditions were suboptimal for salmonids from May 18 through the end of the migration period. The Sonoma County area experienced a heat wave during mid-May of 2000 that undoubtedly contributed to the suboptimal water temperatures. The weekly average water temperature increased from 16.9°C during the week of May 11 to 21.4°C during the following week. Minimum weekly temperatures remained below 20.0°C through the third week of June, and significantly, emigrating chinook and steelhead smolts were captured in the screw trap through the end of the study (June 29). All salmonid smolts captured in the screw traps appeared to be vigorous and healthy.

Water temperatures exceeded levels that are generally accepted as suitable for steelhead growth and survival from at least mid-June through mid-September 2000. Daily water temperatures rarely fell below 21.1°C from mid-June through mid-August. However, juvenile steelhead were captured in low numbers during the August electrofishing survey, and were observed during video monitoring entering and exiting the fish ladders throughout the summer. It is not known if these fish were rearing in the mainstem or late season emigrants. The fact that the fish were larger than comparably aged steelhead captured in Santa Rosa and Mark West creeks suggest that some rearing may have been occurring.

The chinook salmon upstream migration essentially began on September 7 and continued through December 30. The average daily water temperatures during this time-period ranged between 21.2°C in mid-September to <9.0°C in January. The mean weekly water temperatures recorded near the Inflatable Dam exceeded 19.0°C throughout September, peaking the week of the 14th at 20.4°C (Table 2.6). Chinook salmon continued to migrate past the dam on these days. Following the mid-September peak, water temperatures gradually declined throughout the rest of the migration period.

The shallow (approximately two to three meters) nature of Wohler Pool is not conducive to thermal stratification. As a result, the potential for the development of coldwater refugia in the Wohler Pool is low to non-existent under the conditions measured during the 1999 and 2000 sampling seasons.

SMOLT MIGRATION

Both juvenile chinook salmon and steelhead were captured in the rotary screw trap. Chinook salmon were captured throughout the study, but at greatly reduced numbers during the last two weeks of June. Steelhead were captured primarily in April and May. The capture of chinook and steelhead smolts after inflation indicates that the dam is not a complete barrier to emigration. However, the few marked fish that were recaptured suggest that the dam did delay at least some of the hatchery smolts released. The magnitude of the delayed was obscured by the low number of marked smolts recaptured, as well as factors such as differences in streamflow throughout the study, and time of year. A companion study, Manning et al. (2000), addresses this potential impact in detail.

Chinook salmon smolts ranged in size from 58 to 140 mm FL. The average length of chinook smolts increased from 81.3 during the second week in April to 104.1 during the last week in June. Steelhead emigrate primarily as two year old fish. Age 2+ steelhead ranged in length from 142 to 238 mm FL. The overall average length of steelhead smolts was 174.8 mm FL.

Average weekly water temperatures during the smolt emigration period ranged from 16.1 to 23.6°C, with maximum daily temperatures up to 25.6°C. Mean weekly water temperatures approached or exceeded 21.1°C during the final six weeks of the smolt emigration period. All smolts captured appeared to be healthy and vigorous, and the average size of chinook smolts increased (suggesting that growth occurred) despite temperatures above the levels that reportedly prevented growth in other river systems.

WOHLER POOL FISH COMMUNITY

Three potential salmonid predators inhabit the study area, Sacramento pikeminnow, smallmouth bass, and largemouth bass. Adults (>200 mm) of all three species were found in relatively low numbers. Although few adult pikeminnow were captured, they are capable of attaining a size large enough to feed on both chinook salmon and steelhead smolts (<400 mm fork length). Smallmouth bass are the most abundant species inhabiting the study area. The majority of smallmouth bass captured were young-of-the-year, however. No smallmouth bass large enough to prey on steelhead smolts and very few smallmouth bass large enough to feed on chinook smolts were captured. It is not known if the low numbers of older smallmouth bass is due to a high rate of mortality among YOY bass, or a high rate of dispersal by YOY bass to areas outside of the study area. Very few largemouth bass were captured. Abundance of largemouth bass was highest in below the dam. All three predator species attain a size sufficient to prey on chinook salmonids by the start of their third year of life (age 2+).

Three species of fish, smallmouth bass, Sacramento sucker, and hardhead dominated the fish community above the Inflatable Dam. The fish community in below the dam differed from the above dam community by having a greater abundance of sunfish and tule perch, and a reduction in the abundance of smallmouth bass and hardhead. Wild and hatchery salmonids were collected primarily in two reaches located immediately above the dam.

VIDEO MONITORING

Based on the results of video monitoring, chinook salmon and steelhead appear to have little problem finding and ascending the fish ladders around the Mirabel Inflatable Dam. Relatively large numbers of adult fish of both species have been documented successfully negotiating the ladders, and large numbers of fish milling at the base of the dam have not been observed. However, a satisfactory method of assessing fish populations at the base of the dam has not been identified. Direct observation (snorkel surveys) remains the best method of assessing fish populations at the base of the dam; however, this technique is limited by visibility, which tends to deteriorate in November when chinook and steelhead are most likely to be present in large numbers.

The entire chinook salmon run was monitored for the first time on the Russian River in 2000. The run appeared to be far larger than previously thought, with the estimated run of approximately 1,500 fish migrating above the Inflatable Dam. The chinook run essentially began in early September, peaked in late November, and ended in late December. In 1999, the first adult chinook salmon was observed in the fish ladder on August 26, and 16 adults were observed migrating through the fish ladder prior to the second week of October. The run peaked (in terms of the number of fish counted in 1999) during the last week of October. However, the dam was deflated on November 16, prior to the end of the 1999 run.

Steelhead began their upstream migration in late October, however, the majority of their run likely occurs after the dam is deflated. A few adult steelhead were observed in the spring and early summer, although only four of these fish were wild.

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1.0 INTRODUCTION

The Sonoma County Water Agency (Agency) diverts water from the Russian River in Sonoma County, California, to meet residential, municipal, and agricultural demands. Water diverted is a combination of releases from upstream storage reservoirs and instream flow. The Agency's water diversion is located near Mirabel (Figure 1-1). The Agency operates five Ranney collector wells (large groundwater pumps) adjacent to the Russian River that extract water from the aquifer beneath the streambed. The ability of the Russian River aquifer to produce water is generally limited by the rate of recharge to the aquifer through the streambed. To augment this rate of recharge, the Agency has constructed several infiltration ponds. An Inflatable dam raises the water level and submerges the intakes to three diversion pumps (Figure 1-2). The water is pumped through a dike into a system of canals that supply water to four infiltration ponds. Water is also diverted through two screened control gates that feed two additional infiltration ponds at the Wohler facility. The backwater created by the Inflatable dam also raises the upstream water level and submerges a larger streambed area along the river. This increased depth and enlargement of the submerged area significantly increases infiltration to the aquifer.

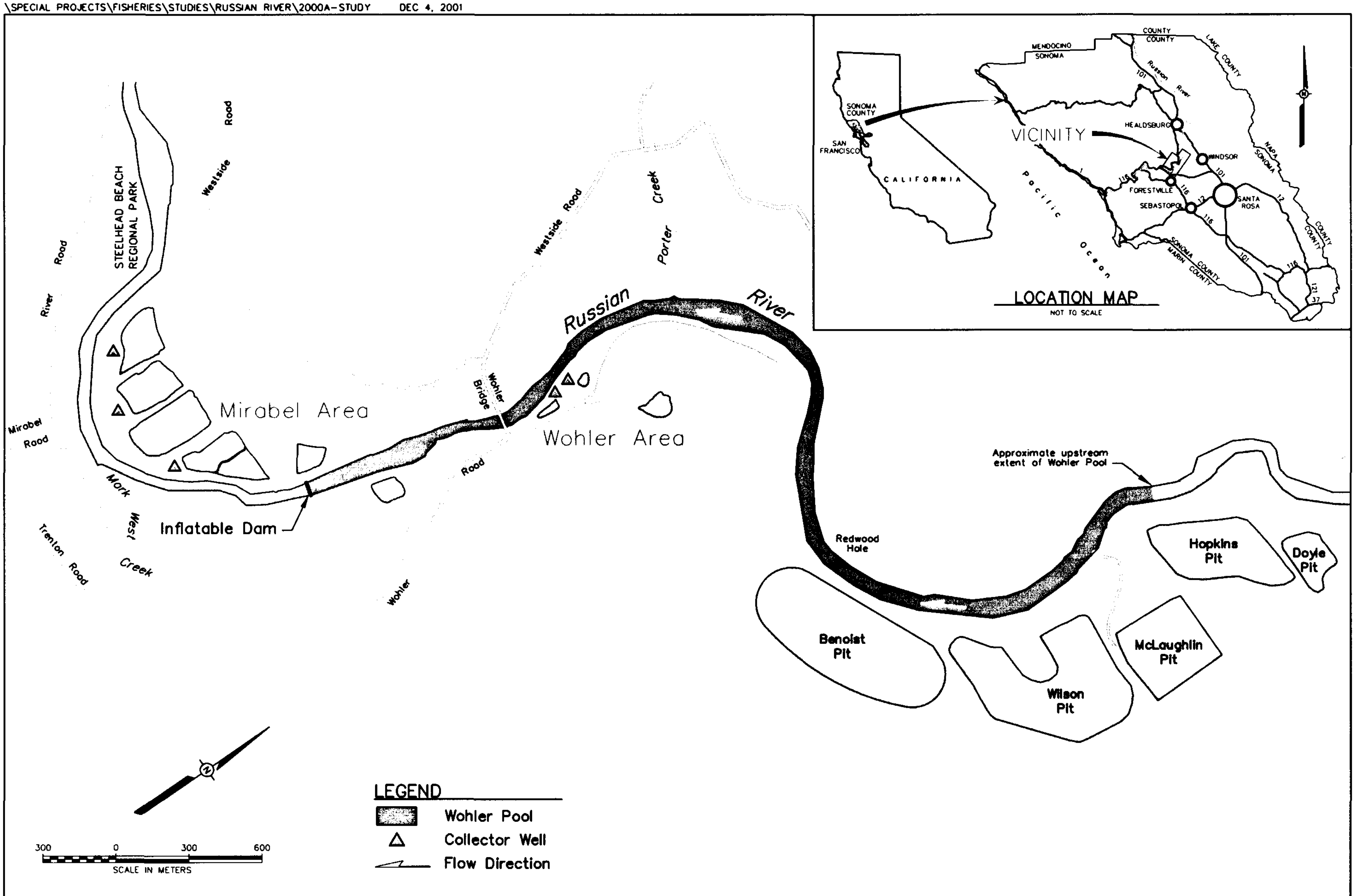
The dam is generally inflated between April and June and is deflated between late-September and mid-November of most years. However, the dam may be inflated during any month of the year, depending on conditions. The actual timing of dam inflation varies annually depending on a number of factors including water demand, air temperature, precipitation, and river flow. The Inflatable dam creates an impoundment that is approximately 5.1 kilometers in length (Wohler Pool). Within the impounded reach, water depth is increased and current velocity is decreased, compared to unimpounded conditions. These changes to the natural hydrology of the river have the potential to alter species composition, distribution, and abundance within the affected reach.

The Russian River provides habitat for several special status fish species, including three that are protected under the Federal Endangered Species Act (ESA). On October 31, 1996, the National Marine Fisheries Service (NMFS) listed coho salmon as threatened under the ESA within the Central California Coast Evolutionarily Significant Unit (ESU), which includes the Russian River. On August 10, 1997, NMFS listed steelhead as threatened under the ESA within the Central California Coast ESU, which includes the Russian River. On 16 September 1999, NMFS listed chinook salmon as threatened under the ESA within the California Coast ESU, which also includes the Russian River.

Chinook salmon, coho salmon, and steelhead use the lower mainstem Russian River (including the study area) primarily as a migration corridor. Adults pass through the Mirabel Reach of the river during their migration to upstream spawning and rearing habitat. Juveniles (smolts) emigrate through the area during their downstream journey to the ocean. Steelhead have been observed/captured in the study area throughout the summer period, indicating that either they migrate at low levels throughout the year, or that rearing occurs in the area, albeit at very low levels. Salmonid rearing habitat is likely limited by summer water temperatures under current river conditions.

In December 1997, the U.S. Army Corps of Engineers, NMFS, and the Agency entered into a Memorandum of Understanding (MOU) for consultation under Section 7 of the ESA to evaluate the effect of certain Russian River activities, including the Agency's water supply facilities and operations, on the three listed fish species. Section 7 of the ESA requires preparation of a Biological Assessment to evaluate these potential effects, and pursuant to the MOU the Agency is designated as the non-federal representative to prepare the Biological Assessment. The scope of this study is limited to assessing the potential for the Agency's Inflatable dam to adversely affect chinook and coho salmon and steelhead. Results from this study will be incorporated into the Agency's Biological Assessment.

There are several uncertainties regarding the potential for the Mirabel and Wohler facilities to adversely affect chinook and coho salmon and steelhead. The Inflatable dam has the potential to negatively impact several phases of the salmonid life history:



SONOMA COUNTY WATER

Figure 1-1 Map of Study Area

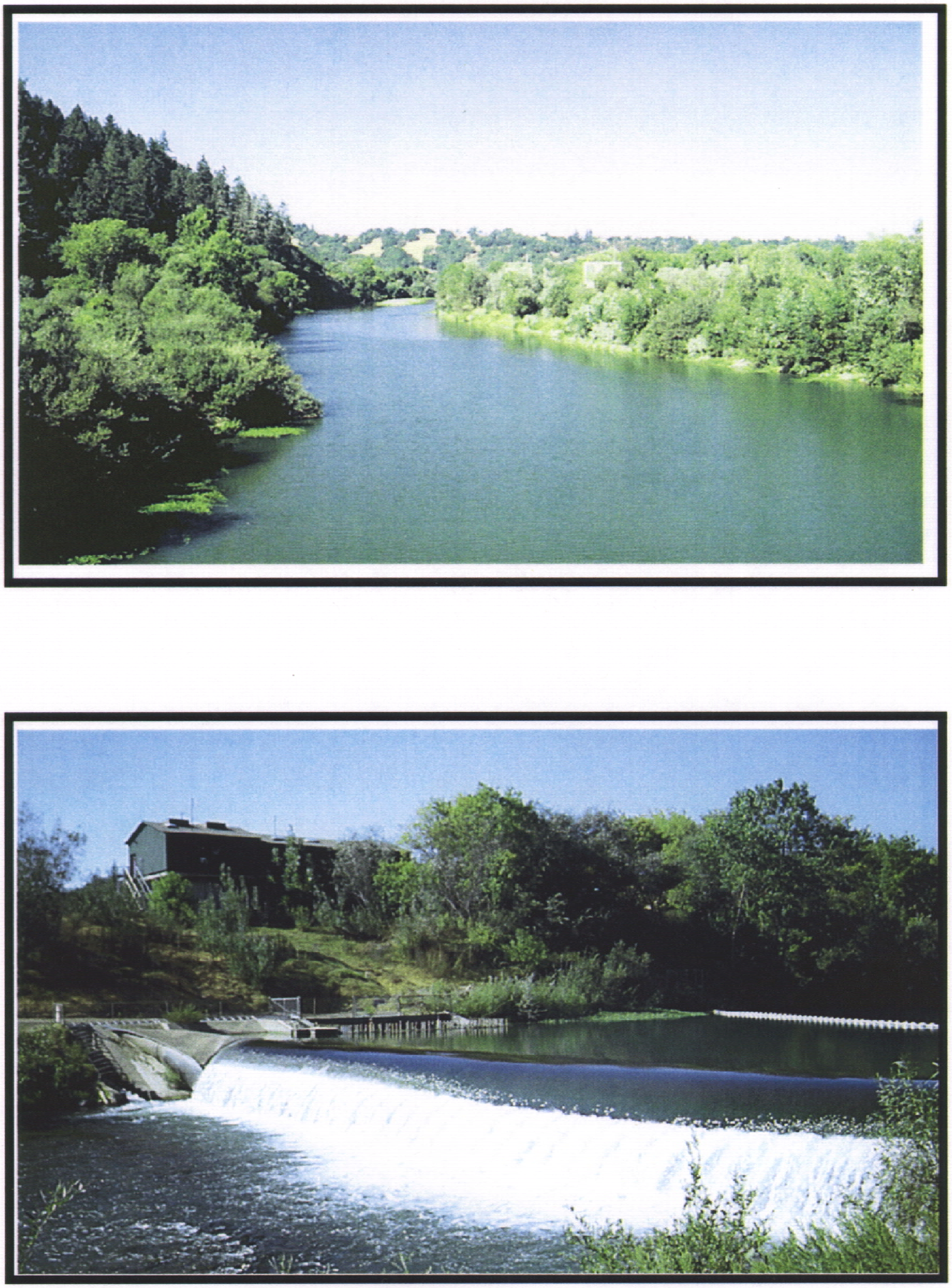


Figure 1. The Mirabel Rubber Dam (lower picture) and a portion of Wohler Pool (upper picture).

- The dam forms an 11-foot high barrier that effectively blocks upstream migrating adult salmonids. The dam is equipped with two denil type fish ladders to facilitate fish passage around the dam; however, the effectiveness of the ladders have not been evaluated prior to this study.

- The impoundment created by the dam affects approximately 5.1 km of river, essentially creating a long pool. The impoundment decreases current velocities which smolts use during their downstream migration to the ocean. The reduction of this tactile cue may result in smolts becoming disoriented while passing through the impoundment, and this may result in a delay in outmigration. Although there are three avenues for juvenile fish to pass by the dam (going over the dam and through the fish ladders and fish bypass facilities), fish that become disoriented may have difficulty finding these passage routes.

- The impoundment slows the flow of water through the basin, and may result in an increase in water temperatures downstream of the dam. An increase in temperature may degrade conditions if juvenile steelhead rear in the lower river.

- The combination of warmer, deeper, and lower velocity habitat may improve habitat conditions for predators such as Sacramento pikeminnow, smallmouth bass, and largemouth bass. Adults of these three species include small (smolt sized) fish in their diets. If the impoundment improves habitat conditions and leads to larger populations of the three predators, this could potentially increase mortality (through predation) on emigrating smolts.

Although the Inflatable dam has the potential to negatively impact adult and juvenile salmonids, no studies have been conducted to document which, if any, of these potential impacts are occurring. In light of these uncertainties, the Agency is conducting a five-year study to assess the potential impacts associated with the facilities, and to develop mitigation measures as appropriate.

Prior to initiating this 5-year study, the Agency conducted a study entitled "Sonoma County Water Agency's Mirabel Inflatable dam/Wohler Pool Reconnaissance Fish Sampling Program" (Chase *et al.* 1999). That program assessed the appropriateness of a variety of sampling methodologies to assess fish and aquatic habitat conditions in the Wohler Pool. The results of that study (Chase *et al.* 2000a) form the basis for the development of the study plan used for this project (Chase et al 2000b).

1.1 STUDY AREA

The study area encompasses the Russian River from approximately river kilometer (RK) 34.8 (approximately 1.6 kilometers downstream of the Inflatable dam (Steelhead Beach Regional Park) to approximately 5.1 km upstream of the dam (Figure 1-1). During the initial year of this 5-year study (2000), each sampling location was plotted on a base map using GPS coordinates.

Steelhead Beach Sampling location is a relatively large (approximate 620 meter long) natural pool located downstream of the dam. This is the only sampling habitat that is totally outside of the dam's influence. Wohler Pool is a 5.1 km long impoundment formed by the dam. The water surface elevation (depth) and current velocity in the lower 3.2 km of the impoundment is significantly influenced by the dam. The water surface elevation in the upper 1.9 km of the impoundment is only minimally influenced by the dam, ranging from approximately eight inches at the lower end of the reach to no influence at the upper end of the reach. Current velocity increases with distance upstream through the upper reach of the impoundment.

The following are landmarks and geographical names used throughout this study, and the types of sampling conducted at each location. River kilometer designations were taken from the aerial photographs taken for the County of Sonoma Aggregate Resources Hydrology Monitoring program.

1) *Steelhead Beach Regional Park: Located at RK 34.8*
    - *Boat electrofishing station*
    - *Continuous water temperature monitoring station*

2) *Rotary screw traps: Located at RK 36.4 (60 m downstream of the inflatable dam.*

3) *Mirabel Inflatable Dam (Inflatable Dam: Located at RK 36.4*
- *Boat electrofishing station*
- *Upstream (video) monitoring station*
- *Continuous water temperature monitoring station*
- *Water quality profile monitoring station*

4) *Lower Wohler Pool: Impoundment formed behind Inflatable Dam. RK 36.4 to RK 39.4*
- *Boat electrofishing station*
- *Continuous water temperature monitoring station*
- *Water quality profile monitoring station*

5) *Upper Wohler Pool Reach: RK 39.4 to 41.5*
- *Boat electrofishing Station*
- *Continuous water temperature monitoring station*
- *Water quality profile station*

1.2 HISTORICAL LOWER RUSSIAN RIVER FISH SURVEYS

The lower Russian River fish community has been surveyed on several occasions between 1954 and the present (e.g., CDFG 1954, 1955, 1984, Hopkirk and Northen 1980, Philip Williams Associates and Nielsen 1993). These surveys have generally been conducted during the summer (July through August) period. Sampling techniques were generally limited to beach seining.

To date, 27 species, including 14 native species, have been collected or observed in the lower Russian River during the 1999 and 2000 sampling seasons (Table 1-1). Four additional species of fish have also been reported in the Russian River. Coho salmon inhabit streams below the Inflatable Dam, and at least historically, inhabited a small number of streams upstream of the dam, however, they have not been observed during this study. White and green sturgeon *(Acipenser transmontanus and A. medirostris),* occasionally entered the Russian River, at least historically, although these species apparently did not spawn or rear their young in the river, and a third species, pink salmon *(O. gorbuscha)* is believed to be extirpated from the river. During historical surveys, native resident fish (Sacramento sucker and Sacramento pikeminnow), introduced sunfish (e.g., smallmouth bass and green sunfish), and juvenile American shad dominated the catch. Russian River tule perch were collected in low numbers during all surveys. It is important to note that beach seines are biased towards capturing smaller individuals, and are limited to sampling relatively shallow habitats that have smooth, unobstructed substrates, with moderately sloped contours. Beach seines are generally not effective at capturing species that are found in heavy cover (e.g., adult smallmouth bass), or fast swimming species (e.g. adult pikeminnow).

Young-of-the-year and age-1 or older steelhead were collected infrequently during the summer rearing period. Summertime water temperatures are believed to limit steelhead in the lower river. During a 1954 study, four juvenile steelhead were captured at one site (water temperature 24.4°C), ranging in length from 10.7 to 18.3 cm (CDFG 1954). All steelhead were infected with external parasites. No juvenile steelhead were observed or captured during a 1984 CDFG study (Cox 1984). However, in one study (CDFG 1955) 153 steelhead (mainly young-of-the-year) were captured in the lower Russian River at 30 sampling stations (generally one beach seine haul per site). Coho and chinook salmon have not been collected in the lower Russian River during the summer rearing period, although emigrating chinook salmon smolts have been collected during the spring and early summer in the river (this report) and in the estuary (MSG 1997).

Based on the 1999 and 2000 electrofishing surveys conducted in the Mirabel/Wohler Reach of the Russian River, three potential piscivorous predators inhabit the study area; the native Sacramento pikeminnow and introduced smallmouth and largemouth bass. A fourth potential predator, striped bass, also inhabits portions of the lower Russian River. However, only one has been captured in the study area during two years of sampling.

Table 1-1. Common and scientific names of species captured in the Russian River during 1999 and 2000 sampling efforts, including their status (native or introduced), life history strategy (anadromous or resident), and their regulatory status.

Common Name	Scientific Name	Status	Life history Strategy	Regulatory status[1]
American shad	*Alosa sapidissima*	Introduced	Anadromous	—
Sacramento sucker	*Catostomus occidentalis*	Native	Resident	—
California roach	*Lavinia symmetricus*	Native	Resident	CSC[1]
Hardhead	*Mylopharodon conocephalus*	Native	Resident	CSC
California blackfish	*Orthodon microlepidotus*	Native	Resident	
Hitch	*Lavinia exilicauda*	Native	Resident	—
Pikeminnow	*Ptychocheilus grandis*	Native	Resident	—
Fathead minnow	*Pimephales promelas*	Introduced	Resident	—
Golden shiner	*Notemigonus crysoleucas*	Introduced	Resident	—
Carp	*Cyprinus carpio*	Introduced	Resident	—
Threespine stickleback	*Gasterosteus aculeatus*	Native	Resident	—
Bluegill	*Lepomis macrochirus*	Introduced	Resident	—
Green sunfish	*Lepomis cyanellus*	Introduced	Resident	—
White crappie	*Pomoxis annularis*	Introduced	Resident	—
Smallmouth bass	*Micropterus dolomuieu*	Introduced	Resident	—
Largemouth bass	*Micropterus salmoides*	Introduced	Resident	—
Prickly sculpin	*Cottus asper*	Native	Resident	—
Riffle sculpin	*Cottus gulosus*	Native	Resident	—
Tule perch	*Hysterocarpus traski*	Native	Resident	CSC
Channel catfish	*Ictalurus punctatus*	Introduced	Resident	—
Bullhead	*Ameiurus spp.*	Introduced	Resident	—
Mosquitofish	*Gambusia affinis*	Introduced	Resident	—
Pacific lamprey	*Lampetra tridentata*	Native	Anadromous	—
Chinook salmon	*Oncorhynchus tshawytscha*	Native	Anadromous	FT[2]
Chum salmon	*Oncorhynchus keta*	Native/Stray	Anadromous	
Steelhead	*Oncorhynchus mykiss*	Native	Anadromous	FT
Striped bass	*Morone saxitalis*	Introduced	Anadromous	—

[1] California species of special concern
[2] Listed as Threatened under the Federal endangered Species Act

1.3 TARGET SPECIES

Six fish species of concern inhabit the study area: the three federally protected salmonids (chinook salmon, coho salmon, and steelhead), and three potential predators (the native Sacramento pikeminnow, and the introduced smallmouth and largemouth bass). Assessing the potential influences of the dam on these species requires an understanding of their life history requirements. The following section provides a brief discussion of the life histories of each of the six species of concern. The life history discussions are limited to the life stages of each species likely to be present in the study area during periods of the year when the dam is inflated. The discussions are further limited to the specific life history requirements likely to be affected by the operation of the Inflatable Dam. Discussion of salmonids was limited to the water temperature requirements (effects of flow on emigration is covered in Manning *et al.* 2001). The impoundment has the potential to provide spawning and rearing habitat for potential predators, therefore, a more detail discussion of life history requirements are presented for these species.

1.4 SELECTED LIFE HISTORY REQUIREMENTS FOR TARGET SPECIES

1.4.1 Chinook Salmon

Two life stages of chinook salmon are potentially affected by the Inflatable Dam; adults returning from the ocean, and smolts emigrating to the ocean. Adult chinook salmon migrate upstream through the study area to their spawning habitat, located primarily in mainstem Russian River above Asti and in selected tributaries such as Dry Creek. Upstream migration occurs from late August through December (primarily October and November). The primary concern for upstream migrating adults is passage around the Inflatable Dam and water temperature conditions in the river at the start of the upstream migration period. Juvenile chinook salmon in the Russian River emigrate as fingerlings from approximately late-February through June. Chinook salmon in the Russian River emigrate through the Wohler Pool at about 90 millimeters (mm) fork length (FL) (range 54 to 140 mm). Factors that stimulate downstream migration are not well known (Healy 1991), however, streamflow likely plays a role. The primary concerns for chinook smolts are water temperature, passage around the Inflatable Dam, and exposure to predation.

Water temperature and dissolved oxygen (DO) levels directly affect an organism's ability to survive, grow, and reproduce. Within a species-specific tolerance range, as water temperature increases, a fishes growth rate and swimming performance will increase. Water temperatures above this range will result in an increased susceptibility to disease, a reduction in swimming performance, and a reduction in growth. Ultimately, excessively high temperatures can result in direct mortality. Factors such as DO levels and food availability affect temperature tolerance of salmonids. Optimal and lethal water temperature tolerances also vary by life stage (e.g., embryos are less tolerant of high temperatures than juveniles).

The upper lethal water temperature for chinook salmon has been reported to be 25.0°C (Brett 1952 and Bell 1991), and 23.0°C (± 1.1°C) (Baker *et al.* 1995). The preferred temperature range for chinook salmon has been reported to range from 12.0 to 14.0°C (Brett 1952) and 7.2 to 14.4°C (Bell 1991). Excellent growth rates for juvenile chinook salmon have been reported to occur at temperatures ranging between 15.0 and 18.9°C (Brett *et al.* 1972, cited by Raleigh *et al.* 1984). The daily maximum temperature is approximately 23.3°C (North Coast Regional Water Quality Control Board (NCRWQCB 2000), citing data from EPA 1977). Water temperatures above 21.1°C have been reported to stop downstream migration of chinook salmon smolts (CDWR 1988 cited by NCRWQCB 2000.).

Fall chinook salmon reportedly migrate at temperatures ranging from 10.6 to 19.4°C (Bell 1991). Upstream migration by adult chinook salmon in the San Joaquin River was halted when temperatures exceeded 21.1°C, but resumed when temperatures declined below 18.3°C (Hallock 1970, cited by DW Kelly and Associates and ENTRIX (1992). The temperature of the water that the adults are exposed to prior to spawning can result in a reduction in survival of the subsequent embryos (Hinze 1959, cited by DW Kelly and Associates and ENTRIX (1992)). Eggs from salmon held for a prolonged time period at 15.6 to 16.7°C had a lower survival rate to hatching (70 percent) compared to eggs from salmon held at 12.8 to 15.0°C (80 percent survival).

1.4.2 Coho Salmon

Coho salmon have not been captured during the first two years of investigations. However, historically, coho salmon were known to inhabit tributaries upstream of the Mirabel/Wohler area. Coho spawn and rear in tributaries, thus the only life stages potentially affected by the dam are emigrating smolts and upstream migrating adults. Coho salmon, if present, are likely to be affected in much the same way as chinook salmon. Coho salmon emigration is affected by flow conditions, water temperature and day length (Shapovalov and Taft 1954).

The upper lethal temperature for coho fry ranges from 22.9 to 25.0°C, depending on the temperature that the fish were acclimated to (5.0 to 23.0°C, respectively) (Brett 1952, DeHart cited by Konecki *et al.* 1995), 25.6°C (Bell 1991), and 28.2 to 29.2°C (Konecki *et al.* 1995, Becker and Genoway (1979) cited by Konecti *et al.* 1995). Juvenile coho salmon were observed in a stream with maximum daytime temperatures of 29.5°C (although the daily minimum temperature was 12.5°C during this time, and food resources were plentiful, which may have increased the thermal tolerance of these fish) (Bisson *et al.* 1988).

Juvenile coho salmon rear at temperatures between 3.3 and 20.6°C (Bell 1991), but prefer water temperatures between 10.0 and 15.0°C (Hassler 1987) and 11.7 to 14.4°C (Bell 1991). Welsh *et al.* (2001) compared the distribution of juvenile coho salmon in 21 tributaries in the Mattole River Basin with the maximum weekly water temperature and the maximum weekly average water temperature. The warmest tributaries supporting coho salmon had a maximum weekly water temperature of 18.0°C, and a maximum weekly average water temperature of 16.7°C. Tributaries that had a maximum weekly water temperature of <16.3°C and a maximum weekly average temperature of >14.5°C contained juvenile coho salmon.

The maximum sustained cruising (swimming) speed of under yearling coho salmon occurred at 20.0°C; above this temperature, swimming speed decreased significantly (Griffiths and Alderice (1972) and Brett *et al.* (1958), cited by Bell (1991)). Growth of coho salmon fry was reported as high between 8.9 and 12.8°C, but decreased (from 55 mg/day to 35 mg/day) when temperature was increased to 18.1°C (Stein *et al.* 1972). Coho salmon growth apparently stops at temperatures above 20.3°C (Bell 1991). However, in a field study conducted in Washington, no differences in coho salmon growth rates where found between streams where the daily maximum water temperature exceeded 20.0°C during July and August and other nearby streams of similar size (Bisson *et al.* 1988). Thomas *et al.* (1986) examined the effects of fluctuating temperature on mortality, stress and energy reserves of juvenile coho salmon. Coho salmon held in a fluctuating environment of 6.5 to 20.0°C had higher levels of plasma cortisol (which may indicate that the fish were under stress), however, the fish did not exhibit common signs of stress, such as flashing, gasping at the surface, or disorientation. Thomas *et al.* (1986) also reported that all test fish survived when daily temperature fluctuation ranged from 5.0 to 23.0°C. Moyle *et al.* (1989) concluded that maximum water temperatures should not exceed 21.9 to 25.0°C for an extended period of time.

Holt *et al.* (1975) found that the percentage of coho salmon and steelhead dying after exposure to a bacterial infection increased with temperature from no mortality at a temperature of 9.4°C to 100 percent mortality at a temperature of 20.6°C. All control fish survived the maximum temperatures tested (23.3°C).

Coho salmon migration occurs at temperatures between 7.2 and 15.6°C (Bell 1991). McMahon (1983) recommended that water temperatures during the upstream migration period not exceed 12.8°C in order to minimize pre-spawning mortality. Coho salmon have been reported to spawn at temperatures ranging between 2.8 and 12.2°C (Burner 1951, cited by McMahon 1983). Preferred temperatures for egg incubation ranged from 4.4 to 13.3°C (Bell 91).

1.4.3 Steelhead

Steelhead may be adversely affected by the Inflatable Dam during the upstream and downstream migrations similar to chinook and coho salmon. In addition, low numbers of steelhead may rear in the Wohler Pool through summer. Low numbers of juvenile wild and hatchery steelhead have been observed in the study area during the fist two years of sampling. Steelhead smolts emigrate through the Wohler Pool at an average size of approximately 175 mm FL (range 83 to 250 mm).

The upper lethal water temperature for steelhead has been reported to be 23.9°C (Bell 1991). However, in the Eel River, juvenile steelhead were observed actively feeding in surface waters with ambient temperatures up to 23.9°C (Nielsen *et al.* 1994). Optimal water temperatures for rearing steelhead have been reported to be 10.0 to 12.8°C (Bell 1991) and 14.2°C (Bovee 1978). Steelhead streams should have summer water temperatures between 10.0 and 15.0°C, with maximum water temperatures below 20.0 °C (Barnhart 1986). Roelofs *et al.* (1993) classified water temperatures in the Eel River as: extremely stressful for steelhead above 26.0°C, causing chronic physiological stress that jeopardizes survival at temperatures between 23.0 and 26.0°C, and as having chronic effects at temperatures between 20.0 and 23.0°C. During the spring, smoltification has been reported to stop when temperatures reach 14.0 to 18.0°C (Barnhart 1986).

1.4.4 Summary of Critical Water Temperature Levels

The above review of water temperature requirements for chinook salmon, coho salmon, and steelhead demonstrates the wide variation in thermal tolerances of different populations of these fish. Site-specific temperature tolerance data are not available for salmonids in the Russian River Basin. The NCRWQCB is in the process of revising water temperature standards to protect aquatic life in the Russian River. This process includes an in-depth analysis of salmonid water temperature tolerances. This process is not complete, and their recommended standards are currently in draft form, only. The NCRWQCB (2000) standards are provided to give the reader an impartial summary of water temperature data with which to review the temperature data presented in this report.

- For emigrating smolts, water temperature should not exceed 21.1 °C.
- For upstream migrating adult salmonids, water temperatures between 15.6 and 18.3°C are likely to be suitable, while temperatures above 21.1 are likely to inhibit upstream migration.
- For rearing juvenile steelhead, the maximum weekly average water temperature should not exceed 17.6°C, and the maximum weekly water temperature should not exceed 23.9°C.

1.4.5 Sacramento Pikeminnow

The Sacramento pikeminnow is the largest member of the minnow family (Cyprinidae) inhabiting the Russian River. Pikeminnow are native to the Russian River, Sacramento-San Joaquin river systems, and the Pajaro and Salinas rivers (Moyle 1976). Prior to the introduction of other predators, pikeminnow were undoubtedly the top piscivore in the Russian River. Site-specific information on pikeminnow in the Russian River is limited, and most of what is known about their biology and life history comes from studies conducted in other river systems, primarily in the Sacramento and San Joaquin. In addition, a considerable amount of work has been conducted on northern pikeminnow *(P. oregonensis)* predation on salmonid smolts in the Columbia River Basin.

Historical observations of pikeminnow in the Russian River are limited to Taft and Murphy (1950), and CDFG reports, primarily during the late 1950s and early 1960s chemical treatment (rotenone) projects. Pikeminnow occupy pools throughout the Russian River and the lower reaches of the larger tributaries. Pikeminnow are native to the Study Area, and would be found in the area with or without the dam.

Pikeminnow prefer warm water streams with abundant pools (Taft and Murphy 1950, Moyle and Nichols 1973). Adult pikeminnow occupy deep pools with abundant cover, during the day they tend to be sedentary (Smith 1982, Brown 1990). Juveniles (70 to 120 mm standard length (SL) were found in riffles and runs (Smith 1982). Pikeminnow prefer relatively low velocity habitat (<15 cm/s), except when foraging or moving from one pool to another, moderate depths (0.5 to 2.0 meters), and a substrate of gravel to boulder (Knight 1985).

Pikeminnow prefer warm water compared to salmonids. Pikeminnow are seldom abundant where water temperature does not exceed 15°C (Moyle 1976), and showed a preference for a water temperature of 26.0°C (Knight 1985). The critical thermal maxima temperatures were 28.3°C for pikeminnow acclimated at 10°C and 37.2°C for pikeminnow acclimated to 25°C. (Knight). Pikeminnow survived temperatures of 30°C, but died when temperature was rapidly increased to 35°C (Cech *et al.* 1990). Pikeminnow are tolerant of low DO levels. Pikeminnow did not show a metabolic response to hypoxic conditions (DO levels at 25 percent of saturation for each temperature tested) at temperatures up to 25°C (Cech *et al.* 1990).

Adult pikeminnow feed primarily at dawn (Brown 1990), dusk and at night (Smith 1982, Brown 1990). Pikeminnow feed on aquatic insects as juveniles, switching to a diet primarily of fish as they grow (Moyle 1976). Taft and Murphy (1950) examined the stomach contents of 36 juvenile pikeminnow (ranging in length from 3.3 to 17.8 cm FL) captured in the Russian River near Cloverdale. The diet of these fish consisted entirely of aquatic insects. Merz and Vanicek (1996) compared the diets of juvenile pikeminnow and steelhead and chinook salmon in the lower American River. They concluded that juvenile pikeminnow fed primarily on corixids (water boatmen) and chironomids (larval gnats), and that their diet did not overlap with either steelhead or chinook salmon.

Adult Sacramento and northern pikeminnow are known to eat salmon and steelhead smolts (Moyle 1976, Vondracek and Moyle unpublished manuscript, Poe et. al 1991, Shively 1996, Vigg *et al.* 1991, Zimmerman 1999). Pikeminnow predation can be significant below large dams such as on the Columbia River where smolts can become disoriented or injured by passage past dams, and below hatcheries following large releases of smolts (Shively *et al.* 1996). However, salmonids seldom constitute a significant proportion of pikeminnow diet in free flowing sections of rivers (Buchanan *et al.* 1981, Vondracek and Moyle unpublished manuscript).

Pikeminnow generally begin to include fish in their diet after reaching a length of 165 to 230 mm. Pikeminnow have been reported to begin preying on fish and crayfish at a size of 180 mm SL (Falter 1969, cited in Brown and Moyle 1981), 230-250 mm FL (Thompson 1959, cited in Brown and Moyle 1981), and greater than 165 mm FL (Buchanan et al 1981). Moyle *et al.* (1979) reported a transition in the diet from mainly insects to fish and crayfish at a length of approximately 200 mm SL (cited in Vondracek and Moyle, unpublished manuscript). In the Buchanan *et al.* (1981) study, 75 percent of the salmonids consumed were eaten by pikeminnow greater than 300 mm FL. Smaller fish fed on insects. Brown (unpublished, cited by Vondracek and Moyle, unpublished manuscript) noted a change over to fish in the diet between 100 and 150 mm (primarily other juvenile pikeminnow, Sacramento sucker, and California roach).

Buchanan *et al.* (1981) examined northern pikeminnow diets in free flowing sections of the Willamette River basin in Oregon. The study fish were collected during spring smolt emigration period. Pikeminnow fed primarily on insects, crayfish, and sculpins. Juvenile salmonids were found in 2 percent of the 1,127 pikeminnow stomachs examined.

Both Buchanan (1981) and Thompson (1959) (cited in Brown and Moyle 1981) found that pikeminnow were opportunistic, and fed on whatever prey source was most abundant. This may explain why they are such active predators of salmonids below dams and after hatchery releases. A similar response to hatchery releases and an increase in salmonids in the diet has been reported by Vondracek and Moyle (unpublished manuscript).

Zimmerman (1999) developed a linear regression for the size of salmonids that could be consumed by northern pikeminnow between 250 and 550 mm FL (the northern pikeminnow is closely related and similar in morphology to the Sacramento pikeminnow) (Table 1-2). Based on this regression, northern pikeminnow ranging in size from 250 and 550 mm FL can consume salmonids ranging in length from 116 to 220 mm FL. The largest pikeminnow captured in this study was 710 mm FL, thus it could consume larger prey items than those studied by Zimmerman.

From the above review of the literature, there appears to be three significant size classes of pikeminnow in terms of the potential to prey on salmonids. Pikeminnow that are less than 200 mm FL (fish are an insignificant part of their diet), those between 200 and 300 mm FL (fish comprise a small portion of the diet), and those greater than 300 mm FL (fish comprise a significant part of their diet).

Growth rate is an important factor to consider when assessing the potential for a predator to impact a prey species. Until the predator becomes large enough to feed on the prey species, they are not a threat. Although Dettman (unpublished data cited by Moyle 1976) reported that pikeminnow in the Russian River grew very slowly, data collected in this study seems to refute that suggestion. Pikeminnow captured in the Russian River in 2000 (this study) were similar in size to fish captured in the Sacramento River (Table 1-3). Brown (1990) calculated the growth rate of pikeminnow from nine populations in the Sacramento River basin. Back-calculated lengths for the nine Sacramento River and tributary pikeminnow populations and the lengths of pikeminnow captured in August 2000 in the Russian River are as follows:

Table 1-2. Theoretical size of salmonids that can be consumed by Pikeminnow between 250 and 550 mm FL (based on Zimmerman 1999).

Size of pikeminnow (FL)	**Size of salmonid** (FL)
250	116
275	125
300	135
325	144
350	153
375	162
400	172
425	181
450	190
475	199
500	209
525	218
550	227

Table 1-3. Back-calculated lengths of Sacramento pikeminnow inhabiting the Sacramento River [1]and selected tributaries, and lengths of Sacramento pikeminnow captured in the Russian River in August 2000.

	Age 1+	**Age 2+**	**Age 3+**	**Age 4+**	**Age 5+**	**Age 6+**	**Age 7+**	**Age 8+**
Tributaries[2]	52-69	104-144	168-205	241-260	262-322	304-380	377-406	403-433
Sacramento River[2]	85-128	168-221	239-288	297-341	346-379	385-409	419-440	445-470
Russian River[3]	110-175	215-270	--	470-515	--	710	--	--

[1] From Brown 1990.

[2] Lengths back-calculated to size at the end of the previous year.

[3] Lengths of fish collected in August as part of the current study (i.e., the Russian River fish are approximately 8 months older than the fish in the Sacramento study.

The lengths of the pikeminnow captured in the Russian River are not back-calculated to the time of annulus formation (e.g., the end of the previous growing season). The Russian River fish have almost completed an additional year of growth, and are nearly old enough to be compared to the next year class. Still, Age 2+ pikeminnow in August were comparable in size to Age 3 pikeminnow in the Sacramento River, and age 4+ and older pikeminnow were larger than pikeminnow of the next comparable age group in the Sacramento River.

In the Russian River, pikeminnow spawning takes place in April and May (Taft and Murphy 1950). Eggs are adhesive and are attached to rocks or gravel. In larger rivers, groups of pikeminnow have been observed in behavior that appears to be spawning in pool tailouts. Pikeminnow inhabiting large rivers and reservoirs migrate upstream into smaller tributary streams to spawn during high flows (Moyle 1976, Mulligan 1975). Pikeminnow inhabiting smaller streams migrate either upstream or downstream to spawn (Grant and Maslin 1999).

Pikeminnow eggs hatch in 4 to 7 days at 18°C, and the young fish begin to swim around in schools approximately one week later (Moyle 1976). In the Russian River, larval pikeminnow were first captured in screw traps in late June 2000.

Adult pikeminnow make annual spawning migrations during the winter/spring (Harvey and Nakamoto 1999). Pikeminnow migrated anywhere from 2 to 92 km during spawning migration. Migration may be upstream or downstream. Pikeminnow tended to return to or near their home pool following the spawning migration. During the day, adult pikeminnow inhabit deep pools, only. During the night, they may move into riffles or runs to feed. Pikeminnow make local upstream migrations in the spring and downstream migrations in the fall (Taft and Murphy 1950). Pikeminnow were observed during video surveillance of the fish ladders (see Section 5.0) migrating upstream into the Wohler Pool during the spring.

The presence of adult pikeminnow can result in a shift in habitat used by other (prey) species (Brown and Moyle 1991, Brown and Brasher 1995, Gard 1994). Juvenile rainbow trout and Sacramento suckers shifted to shallower, higher velocity (riffle) habitat, and threespine stickleback and juvenile California roach shifted to nearshore, shallow water habitat in the presence of pikeminnow.

Pikeminnow were seldom abundant where centrarchids were common (Moyle and Nichols 1973). Pikeminnow abundance was limited by smallmouth bass predation in the South Fork Yuba River (Gard 1994). Pikeminnow were found in areas with rainbow trout and California roach, but they were seldom abundant when found together (Moyle and Nichols 1973).

1.4.6 Smallmouth Bass

Smallmouth bass are native to the eastern half of the United States and southern Canada, originally inhabiting streams and rivers from southern Quebec to the Tennessee River in Alabama, and west to eastern Oklahoma (Carlander 1977). Highly esteemed as a game fish, they have been widely stocked outside of their native range. Smallmouth bass appear to be widespread throughout the mainstem Russian River, with peak abundances reportedly occurring in the Alexander Valley. Smallmouth bass are widespread and abundant in the Study Area.

Edwards *et al.* (1983) describe optimal habitat for smallmouth bass in rivers as cool, clear streams with abundant shade and cover. Pools should be deep, with moderate currents and gravel or cobble substrate. Smallmouth bass have a strong preference for deep, dark hiding areas. Cover used includes boulders, stumps, rootwads, and large woody debris.

Optimal water temperatures for growth range from 26 to 29°C, and preferred temperatures range from 21 to 27°C (data cited by Edwards *et al.* 1983, Carlander 1977). Growth reportedly does not occur at temperatures below 10 to 14°C. Smallmouth bass prefer DO levels in excess of 6.0 parts per million (ppm).

Smallmouth bass will consume a wide variety of food items, including fish, crayfish, insects, and amphibians (Moyle 1976). Smallmouth bass have been documented to feed on salmonids, primarily under-yearling chinook salmon smolts (same life stage found in the Russian River). Underyearling chinook salmon comprised 59 percent of the diet of smallmouth bass in one Columbia River study (Tabor *et al.* 1993). However, in another study, also on the Columbia River, underyearling chinook accounted for only 4 percent of smallmouth bass prey items (Poe *et al.* 1991). Zimmerman (1999) reported that subyearling chinook salmon accounted for 12.4 to 25.8 percent of the diet of smallmouth bass collected in three sections of the Columbia River during a seven year study (smallmouth bass were collected during the spring and summer smolt emigration period).

Zimmerman (1999) developed a linear regression for the size of salmonids that could be consumed by smallmouth bass between 200 and 400 mm FL (Table 1-3). Based on this regression, a 200 mm smallmouth bass can consume a 100 mm salmonid, and a 383 mm FL smallmouth bass (largest smallmouth bass captured in this study) can consume a 134 mm salmonid.

Smallmouth bass are spring spawners, and spawning is generally initiated after water temperature increases to 12.8 to 15.5°C (range 4.4 to 21.1°C) (Emig 1966). Preferred spawning substrate is gravel, but silt and sand can be utilized. Nests are generally built at depths between 0.3 to 0.9 m (Edwards *et al.* 1983). Spawning generally occurs in quiet backwater areas of streams. Juvenile smallmouth bass (27 - 50 mm FL) were first captured in the screw trap in late May.

Table 1-4. The theoretical maximum sized salmonid that can be consumed by smallmouth bass between 200 and 400 mm FL (based on Zimmerman 1999).

Size of smallmouth bass (FL)	**Size of salmonid** (FL)
200	100
225	104
250	109
275	114
300	119
325	123
350	128
375	133
400	138

1.4.7 Largemouth Bass

Largemouth bass are native east of the Rocky Mountains from southern Quebec through the Mississippi River Basin to the Gulf of Mexico, east into the Carolinas and Florida (Carlander 1977). Largemouth bass have been introduced throughout the country because of their reputation as a game fish.

Little data are available on the abundance and distribution of largemouth bass in the Russian River. They are apparently confined to the lower sections of the river, but are not generally considered abundant. Largemouth bass were captured in low numbers during the 2000 sampling season, but were not captured during a similar study conducted in 1999 (Chase *et al.* 2000b).

In rivers, largemouth bass prefer low velocity habitats with aquatic vegetation (Stuber *et al.* 1982, Carlander 1977). Moyle and Nichols (1973) described habitat supporting largemouth bass in Sierra foothill streams as being warm, turbid pools with aquatic and floating vegetation. Substrate in these pools was typically sand or mud.

Stuber *et al.* (1982) reviewed the literature on largemouth bass, and concluded that optimal temperatures for growth of juvenile and adult largemouth bass range from 24 to 36°C. Little growth occurs below 15°C (Mohler 1966, cited by Stuber *et al.* 1982).

Largemouth bass feed primarily on fish and crayfish after reaching a size of 100 to 125 mm SL (approximately 125 to 150 mm FL). We are unfamiliar with any studies documenting largemouth bass predation on salmonids. This is likely because their habitats seldom overlap. Salmonids may become vulnerable to largemouth bass predation during the later half of the emigration period when stream flows decrease and water temperatures increase. Under these conditions, largemouth bass are more likely to become active. Largemouth bass will apparently consume any animal that it can fit in its mouth, including small mammals, waterfowl, frogs, and fish.

Largemouth bass typically spawn in April and May after the water warms to approximately 13.9 to 16.1°C (Emig 1966). Largemouth bass reportedly spawn at depths ranging from 0.15 to 7.5 meters in depth (Stuber *et al.,* 1982). However, the average depth which bass spawn is generally at the shallower end of this range. Largemouth bass nest were constructed at depths of 0.15 to 0.76 m, 1.2 to 1.8 m, and 0.15 to 2.0 m with an average of 0.6 m, in three studies cited by Carlander (1977), between 0.3 and 0.93 m (Stuber *et al.* 1982), and 1.0 to 2.0 m (Moyle 1976). Incubation (to hatching) of largemouth bass eggs is largely influenced by water temperature, and ranges from approximately 13 days at 10.0°C, to 1.5 days at 30.0°C (data cited by Carlander 1977).

2.0 WATER TEMPERATURE MONITORING

2.1 INTRODUCTION

During the typically warm summer period, water temperature tends to increase naturally as a river flows from its headwaters to the ocean. The rate of increase varies depending on climatic conditions, river morphology, and habitat quality. The impoundment formed by dams may degrade water quality, primarily by increasing the rate at which water temperature increases. Impoundments such as the Wohler Pool slow the flow of water through the basin. The longer the residence time, the greater the opportunity for water to be warmed by solar radiation. Therefore, the key consideration is to determine to what degree, if any, the impoundment increases the rate at which water warms compared to free flowing riverine conditions.

A second element of this study focused on the potential for the Wohler Pool to become thermally stratified during the summer. The density of water increases as the temperature decreases. When thermal stratification develops, a strong density gradient forms between the warmer surface water and the cooler water below. The density gradient prevents mixing between the two layers of water, and the bottom layer of water can remain several degrees cooler throughout the summer. The cooler layer of water, if present, could provide suitable temperatures for salmonids rearing in the mainstem river. Additional sampling was conducted using the portable YSI meter to determine if Porter Creek contributed cool water, either through surface water flow or ground water upwelling. Porter Creek enters the Wohler Pool near its mid point, in an area where steelhead smolts were captured during August fish sampling. The goal of this task was to determine if surface flow or ground water seepage from Porter Creek formed pockets of cold water in the Wohler Pool that steelhead could utilize as thermal refugia.

A third objective was to provide a general description of the spring through fall thermal regime within the study area, and compare this to temperature requirements of the target species (chinook salmon, coho salmon, steelhead, and the potential predators, Sacramento pikeminnow, smallmouth bass, and largemouth bass). Salmonid life stages of concern are: the spring emigration period, steelhead rearing (summer), and fall upstream migration period (there is essentially no salmonid spawning habitat in the study area). A number of different water temperature tolerance criteria have been developed for salmonids in various river systems. However, there are currently no site-specific water temperature criteria developed for salmonids inhabiting the Russian River. Most of the criteria developed to date are based on temperature requirements for salmonids inhabiting cooler stream systems (generally located north of the Russian River). Thus, these temperature criteria may be unrealistically low. The criteria used for analysis in this report will be based on temperature criteria developed by the NCRWQCB (see Section 1.4). The appropriateness of these criteria will be assessed based on site-specific data collected during this study.

2.2 METHODS

Five continuously recording water temperature monitoring stations were selected within the study area (Figure 2-1). Water temperature data were collected using a Hobo 8K data logger (Onset Computers, Inc.). At each station, two data loggers were placed in the water column: one at approximately 0.5 meters deep, and the second approximately 2.0 to 4.0 meters deep, depending on the maximum depth at each station. Data loggers were programmed to record temperature on an hourly basis, 24 hours a day. The temperature monitors were deployed on June 15, and were operated though October 25. Additional water temperature monitoring devices (Hydrolab Minisonde 4a and Hobo 8k loggers) were operated near the dam from May 17 through January 10, 2001.

Pre- and post-deployment, data loggers were calibrated to a National Institute of Standards and Technology (NIST) traceable thermometer. Data loggers were immersed in water at room temperature (approximately 20°C) and in an ice bath (approximately 0.2°C) for 20 minutes each. Data collected during calibration were compared to the NIST-traceable thermometer to determine accuracy. The standard set to determine the accuracy of each data loggers was set at ± 0.5°C.

Water quality profile (water temperature, dissolved oxygen, and conductivity) monitoring was conducted at four stations ranging from the Inflatable Dam upstream approximately 4.8 km (Figure 2-1). Water quality

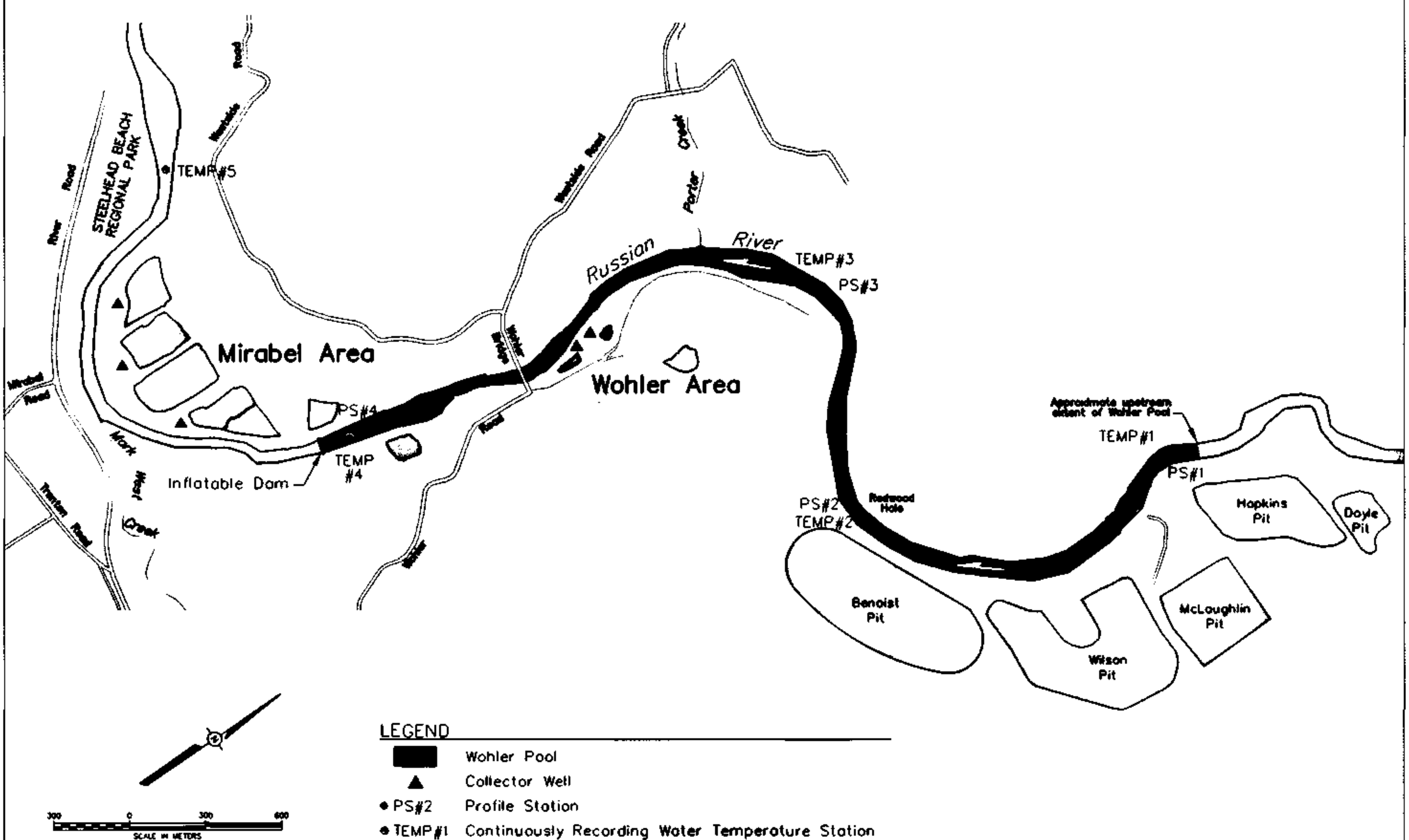


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Figure 2-1 Continuous water temperature and water quality profile stations - 2000 parameters were collected over the deepest section of each sampling station. Measurements were taken at a depth 0.1 ft. (surface) and 0.1 feet above the bottom. If a temperature difference of greater than 0.5°C was detected, additional measurements were taken at 0.5 to 1.0 meter intervals. Water quality profiles were collected on a biweekly schedule. Water temperatures were also recorded on the bottom of the pool in and around the mouth of Porter Creek. Data were recorded in a similar fashion to the profile data described above, except that only bottom temperatures were recorded. Water quality data was collected using a Yellow Springs, Inc., (YSI) 85 Portable Temperature/ DO/Conductivity meter. A table converting °C to °F is presented in Appendix A.

2.3 RESULTS

2.3.1 Continuous Temperature Recording

Water temperatures were recorded continuously at five locations within the study area; however, data loggers could not be recovered at sites #1 and #3. At site #1 (upstream most station), the data loggers were chained to a tree approximately six inches in diameter at the base. Sometime prior to the end of the sampling period, the tree was broken off at the base, and the data loggers were removed or lost. At site #3, the data loggers were chained to a tree partially submerged in the water. During a bank stabilization project constructed by the landowner, the tree was buried under several tons of rock (riprap). The loss of the data loggers prevented the comparison of the rate of change in water temperatures immediately above the project area with the rate of change within the project area.

2.3.1.1 Continuous water temperature monitoring station #1

The temperature probes at this site were not recovered. Water temperature recorded during bi-weekly water profile data collection found that the water temperature at this site ranged from 18.0°C in mid-October to 23.4°C in mid-June.

2.3.1.2 Continuous water temperature monitoring station #2

This station is situated in the upper two-thirds of the Wohler Pool, and is the deepest spot within the study area. The temperature probes were suspended from a chain attached to a submerged log in the middle of the channel. The shallow probe was positioned at a depth of 0.5 m, while the bottom probe was placed at a depth of approximately 4.0 meters. The weekly average and maximum water temperatures measured at 0.5 and 4.0 meters depth were essentially identical throughout the study period. Weekly average surface temperatures exceeded 21.1°C almost continuously from June 18 (when the temperatures probes were first set) through mid-August (Figures 2-2 and 2-3; daily and weekly summaries of water temperature data are presented in Appendix B-l). Average weekly temperatures peaked during the week of July 30 (22.7°C). The average weekly surface maximum temperature exceeded 23.9°C six times in 2000, and was within 0.3°C of this level during two additional weeks. The weekly maximum temperature also peaked during the week of July 30 (25.6°C). Graphs of the daily minimum, average, and maximum temperatures are provided in Appendix B-2.

2.3.1.3 Continuous water temperature monitoring station #3

The temperature probes at this station were buried under several tons of rock during a bank stabilization project. Water temperatures collected during bi-weekly water profile data collection found that the water temperature ranged from 17.3°C in mid-October to 24.0°C in mid-June.

2.3.1.4 Continuous water temperature monitoring station #4

This station was located at the Inflatable Dam. Maximum depth at Station #4 was 3.0 meters. The weekly average water temperatures between the surface and bottom probes were within 0.3°C throughout the study. Average weekly surface temperatures exceeded 21.1°C almost continuously from June 18 (when the temperatures probes were first set) through mid-August (Figures 2-4 and 2-5; daily and weekly summaries of data are presented in Appendix B-l). Maximum weekly temperatures exceeded 23.9°C three

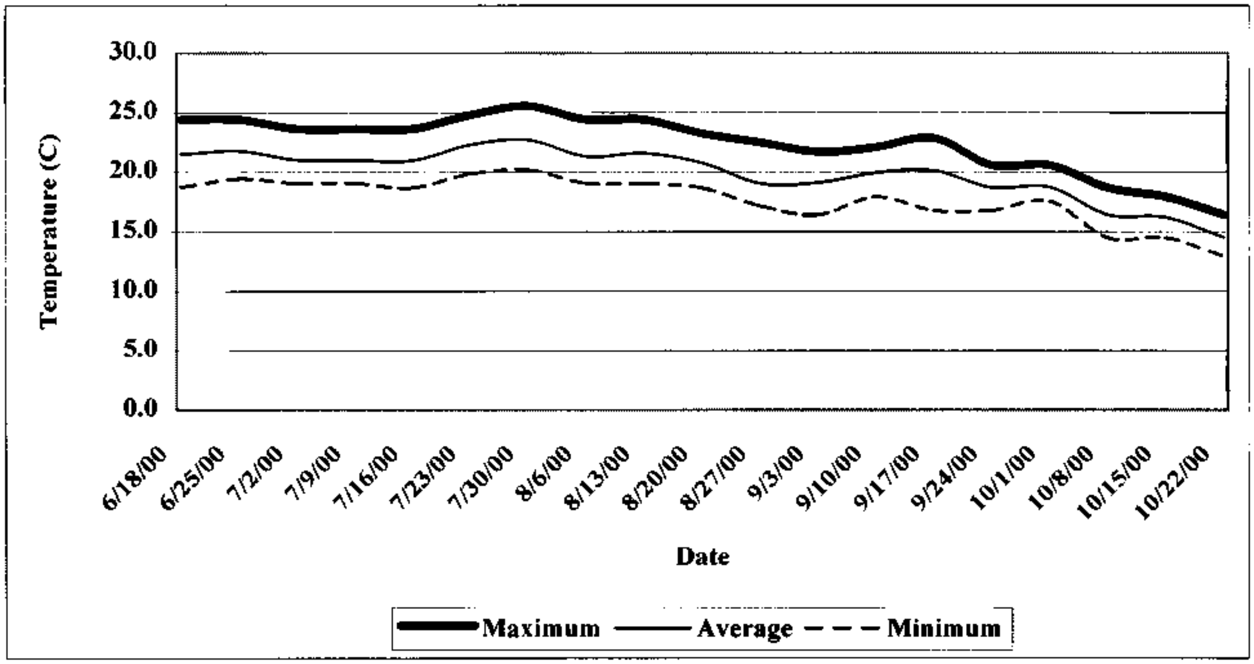


Figure 2-2 Weekly maximum, average, and minimum water temperatures recorded at a depth of 0.5 m Station #2, Mirabel Study Area, Russian River, June 18 through October 25, 2000.

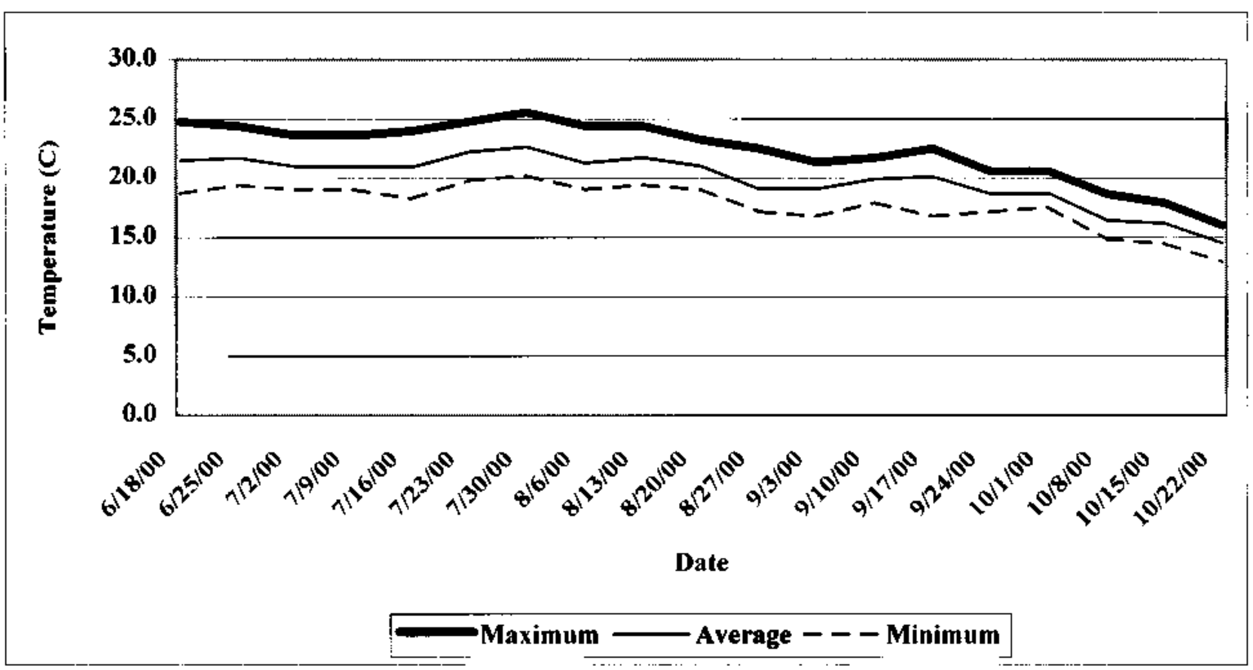


Figure 2-3 Weekly maximum, average, and minimum water temperatures recorded at a depth of 4.0 m Station #2, Mirabel Study Area, Russian River, June 18 through October 25, 2000.

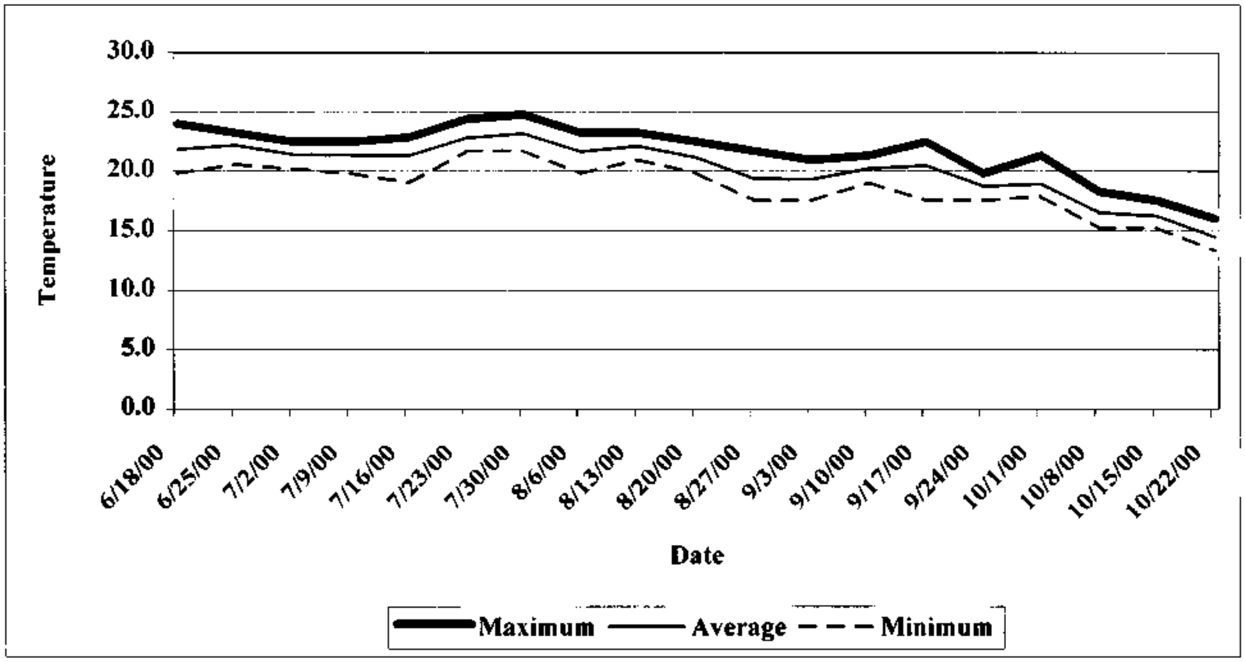


Figure 2-4 Weekly maximum, average, and minimum water temperatures recorded at a depth of 0.5 m Station #4, Mirabel Study Area, Russian River, June 18 through October 25, 2000.

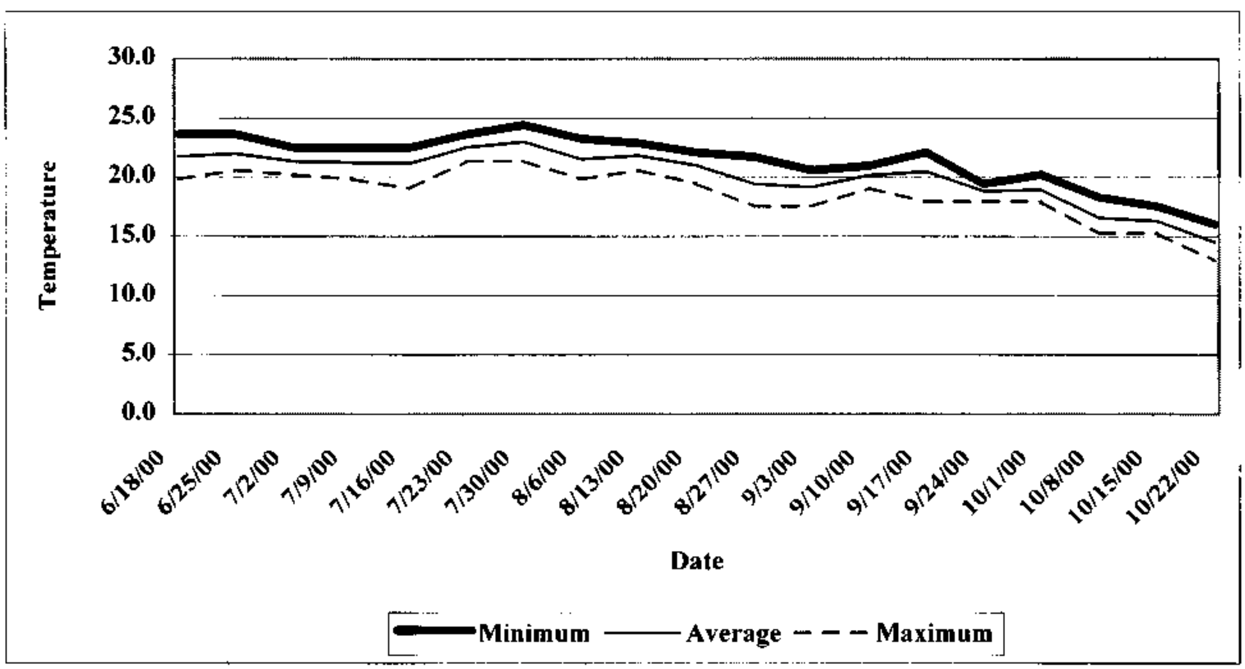


Figure 2-5 Weekly maximum, average, and minimum water temperatures recorded at a depth of 3.0 m Station #4, Mirabel Study Area, Russian River, June 18 through October 25, 2000.

times in 2000, and were within 0.7°C during three additional weeks. Graphs of the daily minimum, average, and maximum temperatures are provided in Appendix B-2.

Average weekly surface temperatures peaked the week of July 30 (23.2°C). The weekly maximum temperature also peaked during the week of July 30 (24.8°C). Graphs of the daily minimum, average, and maximum temperatures are provided in Appendix B-2.

2.3.1.5 Continuous water temperature monitoring Station #5

Station #5 was located at Steelhead Beach across from the boat ramp. Maximum depth at this station was 2.0 meters. The weekly average and maximum temperature at the surface (0.5 m depth) and bottom (2.0 meter depth) were essentially identical throughout the study. Weekly average water temperatures exceeded 21.1°C almost continuously from mid-June through mid-August (Figures 2-6 and 2-7; daily and weekly summaries of data are presented in Appendix B-l). Weekly maximum temperatures ranged from 23.2 to 25.6°C between mid-June and mid-August. Graphs of the daily minimum, average, and maximum temperatures are provided in Appendix B-2.

2.3.2 Rate of Water Temperature Change

The data loggers located at the upstream extent of the Wohler Pool were lost; therefore, a comparison of the rate of change in water temperature throughout the pool could not be made. Data loggers located approximately two-thirds of the way up the pool (Station #2) were recovered and these data were compared to water temperatures recorded below the Inflatable Dam. Two important factors to consider when analyzing these data are the <u>magnitude of the rate of change</u> in water temperature within and below the dam, and the <u>overall magnitude of the change in</u> water temperature.

2.3.2.1 Rate of change in water temperature between stations #2 and #4

The rate of change in the weekly average surface water temperature ranged from approximately 0.0 to 0.2°C/km between June 18 and October 19, 2000 (Table 2-4). The rate of change in water temperature resulted in an overall increase in temperature of water flowing through the Wohler Pool of 0.0 to 0.5°C during this time-span (Table 2-4). The highest temperatures were recorded from mid-June through mid-August. During this time-period, the rate of change in the average weekly surface water temperature was approximately 0.1°C/km, and the overall increase in water temperature of approximately 0.4°C.

The rate of change in the weekly average bottom water temperature ranged from approximately 0.0 and 0.1°C/km between June 15 and October 19, 2000 (Table 2-4). The rate of change in water temperature resulted in an overall increase in temperature of bottom water flowing through the lower two-thirds of the Wohler Pool of 0.0 to 0.4°C during this time-span (Table 2-4). The highest temperatures were recorded from mid-June through mid-August. During this time-period, the rate of change in the average weekly surface water temperature was approximately 0.1°C/km, and the overall increase in water temperature of approximately 0.3°C.

2.3.2.2 Rate of change in water temperature downstream of the Inflatable Dam (stations #4 and #5)

The rate of change in the average weekly surface water temperature ranged from approximately 0.0 and 0.1°C/km between June 18 and October 22, 2000, excluding two weeks when the temperature at Station #5 was less than Station #4 (Table 2-5). The rate of change in water temperature resulted in an overall increase in temperature of water flowing between the Wohler Pool and Steelhead Beach (approximately 1.6 km) of 0.0 to 0.2°C during this time-span (Table 2-5). The highest temperatures were recorded from mid-June through mid-August. During this time-period, the rate of change in the average weekly surface water temperature was approximately 0.1°C/km, and the overall increase in water temperature of approximately 0.2°C, excluding two weeks when the temperature at Station #5 was less than Station #4 (Table 2-5).

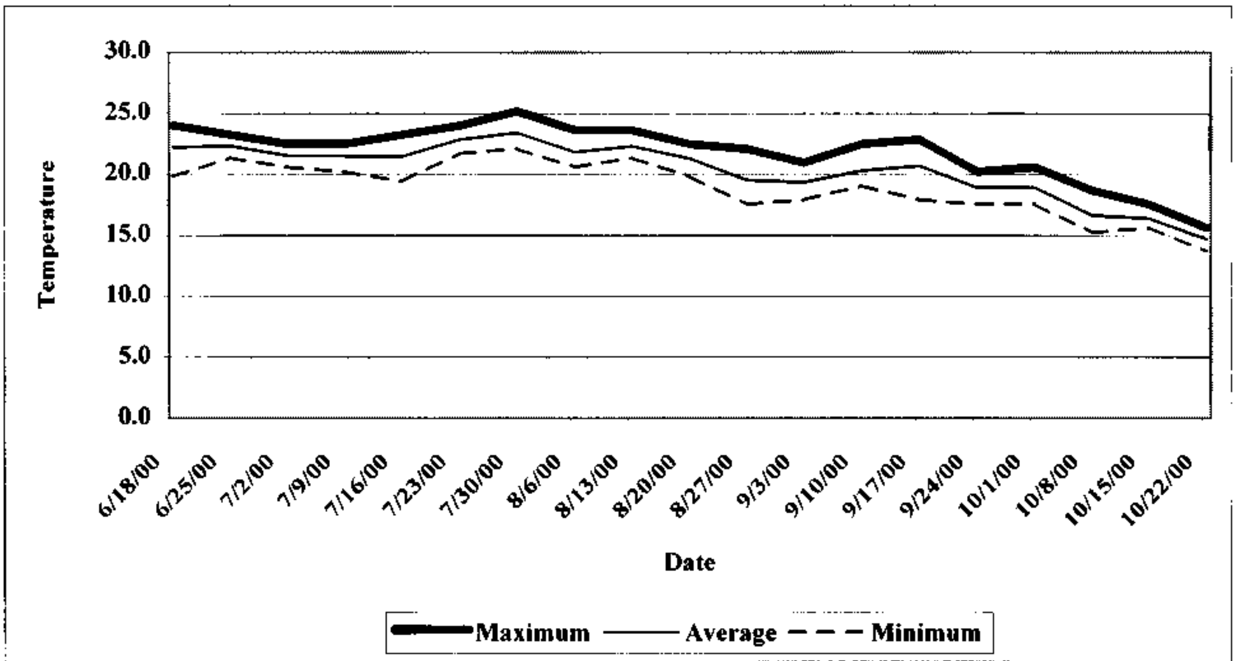


Figure 2-6 Weekly maximum, average, and minimum water temperatures recorded at a depth of 0.5 m Station #5, Mirabel Study Area, Russian River, June 18 through October 25, 2000.

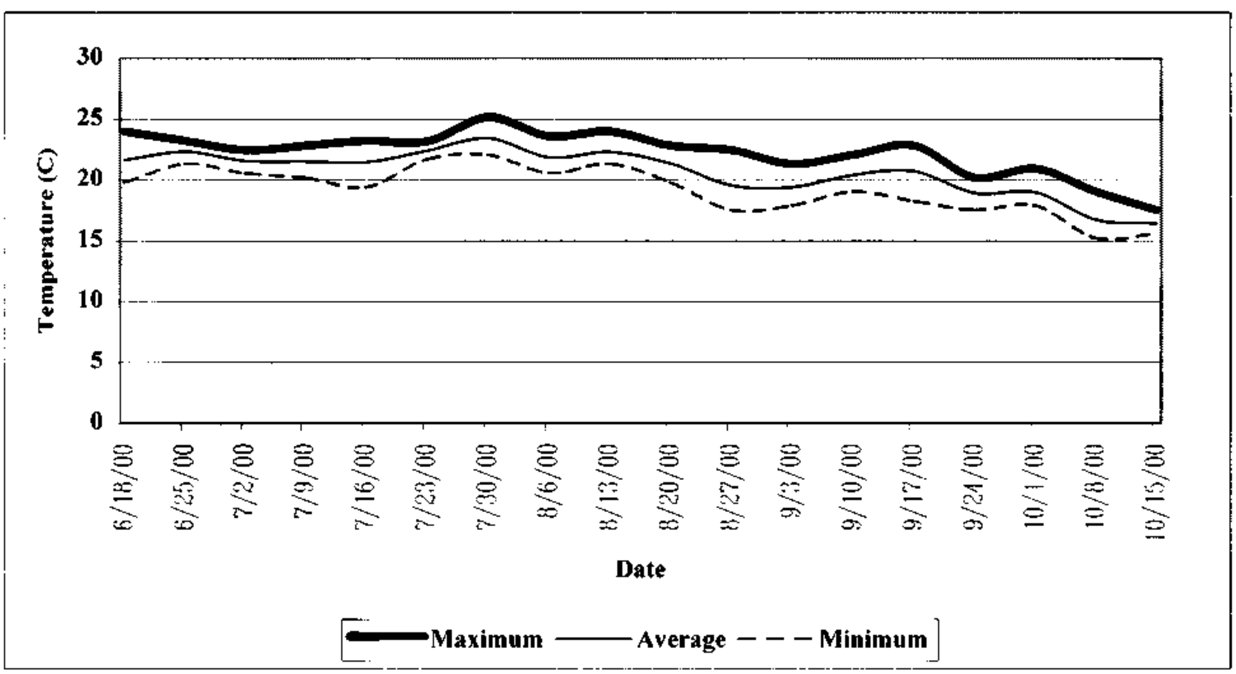


Figure 2-7 Weekly maximum, average, and minimum water temperatures recorded at a depth of 2.0 m Station #5, Mirabel Study Area, Russian River, June 18through October 25, 2000.

Table 2-1. The rate and magnitude of change in water temperatures (°C) recorded at Stations #2 and #4 (surface and bottom temperatures), Week of June 15 through October 19, 2000, Russian River.

	Surface		Bottom	
Date	Rate of change between Stations #2 and #4[1]	Magnitude of change between Stations #2 and #4[1]	Rate of change between Stations #2 and #4[1]	Magnitude of change between Stations #2 and #4[1]
18-Jun	—	—	—	—
25-Jun	0.1	0.4	0.1	0.3
2-Jul	0.1	0.4	0.1	0.4
9-Jul	0.1	0.4	0.1	0.2
16-Jul	0.1	0.4	0.1	0.2
23-Jul	0.2	0.5	0.1	0.3
30-Jul	0.2	0.5	0.1	0.3
6-Aug	0.1	0.4	0.1	0.3
13-Aug	0.2	0.5	0.0	0.1
20-Aug	0.1	0.4	0.0	0.0
27-Aug	0.1	0.3	0.1	0.3
3-Sep	0.1	0.2	0.0	0.1
10-Sep	0.1	0.3	0.1	0.2
17-Sep	0.1	0.4	0.1	0.4
24-Sep	0.0	0.1	0.0	0.1
1-Oct	0.1	0.2	0.1	0.2
8-Oct	0.0	0.1	0.0	0.1
15-Oct	0.0	0.0	0.0	0.1
22-Oct	0.0	0.0	0.0	0.0

[1] Numbers rounded to the nearest 0.1.

The rate of change in the average weekly bottom water temperature ranged from approximately 0.0 and 0.3°C/km between June 18 and October 22, 2000 (Table 2-5). The rate of change in water temperature resulted in an overall increase in temperature of bottom water flowing between the Wohler Pool and Steelhead Beach of 0.0 to 0.4°C during this time-span (Table 2-5). The highest temperatures were recorded from mid-June through mid-August. During this time-period, the rate of change in the average weekly surface water temperature was approximately 0.2°C/km, and the overall increase in water temperature of approximately 0.4°C.

2.3.3 Seasonal Water Temperature Regime at the Inflatable Dam

Additional water temperature data was also collected at the Inflatable Dam in connection with the downstream and upstream migrant studies (see Sections 3.0 and 5.0). Temperature data collection using the two continuously recording devices (Minisonde 4a and Hobo data loggers) overlapped at the dam from June 16 through October 25 at Station #4 bottom. The weekly average temperature recorded with the Hobo data logger at the bottom of Station #4 and the Minisonde that was located nearby were within 0.5°C of each other.

Weekly average water temperatures during the peak smolt emigration period (mid-April through mid-May) ranged between 16.1 and 17.4°C (Table 2-6). A heat wave (daytime temperatures approaching 42.0°C) resulted in a rapid increase in the average weekly water temperatures to over 20.0°C during mid- to late May. Chinook salmon and steelhead smolts emigrated through the Wohler Reach throughout June. The

Table 2-2. The rate and magnitude of change in water temperatures recorded at Stations #4 and #5 (surface and bottom temperatures), Week of June 18 through October 22, 2000, Russian River.

	Surface		Bottom	
Date	Rate of change between Stations #4 and #5[1]	Magnitude of change between Stations #4 and #5[1]	Rate of change between Stations #4 and #5[1]	Magnitude of change between Stations #4 and #5[1]
15-Jun	0.2	0.4	-0.1	-0.1
22-Jun	0.1	0.1	0.2	0.4
29-Jun	0.1	0.1	0.1	0.2
6-Jul	0.1	0.1	0.2	0.3
13-Jul	0.1	0.1	0.2	0.3
20-Jul	0.0	0.0	-0.1	-0.1
27-Jul	0.	0.2	0.3	0.5
3-Aug	0.	0.2	0.2	0.3
10-Aug	0.	0.2	0.3	0.5
17-Aug	0.	0.1	0.2	0.4
24-Aug	0.	0.1	0.1	0.2
31-Aug	0.0	0.0	0.2	0.3
7-Sep	0.0	0.1	0.2	0.3
14-Sep	0.1	0.2	0.2	0.3
21 -Sep	0.1	0.1	0.1	0.1
28-Sep	0.0	0.0	0.0	0.1
5-Oct	0.1	0.1	0.1	0.2
12-Oct	0.1	0.1	0.1	0.1
19-Oct	0.1	0.2	0.2	0.3

[1] Numbers rounded to the nearest 0.1.

average daily water temperature during June ranged from 20.9 to 23.6°C, with a maximum temperature of 25.0°C during the week of June 15.

The weekly average water temperature exceeded 17.6°C from mid-May through September. Weekly maximum temperatures approached or exceeded 23.9°C on several occasions. Although the Wohler Reach is generally not regarded as steelhead rearing habitat, wild and hatchery steelhead were captured/observed in the Wohler Pool throughout this time-period, albeit in very low numbers.

The first adult chinook salmon was observed at the Inflatable Dam in late August, although the main run did not begin until late October. Weekly average water temperatures began cooling in late August and generally remained below 20.0°C through the remainder of the year. By the first week of November, the average weekly water temperature had decreased to 14.4°C.

2.3.4 Water Temperature Profiles

Water and dissolved oxygen profiles were collected on nine occasions between May 26 and October 3, 2000. Two profile sampling dates scheduled for August were missed due to equipment failure. Data from the continuously recording temperature probes were used to evaluate conditions in August.

The Wohler Pool did not become thermally stratified during the 2000 sampling season (May 26 through October 3). The largest difference between the surface (0.1 m) and bottom (3.0 m) water temperatures recorded occurred at the Station #4 on September 12 (2.3°C) and June 15 (2.2°C) (Table 2-7). However, the greatest change in water temperature generally occurred within the upper 0.5 meters of the water

Table 2-3. Water quality profiles data, Wohler Pool - Russian River, May through October 2000.

Station #1									
Temperature									
Depth	26-May	15-Jun	29-Jun-	13-Jul	26-Jul	12-Sep	21-Sep	2-Oct	19-Oct
0.1	18.7	23.4	20.7	19.6	23.2	21.3	19.8	18.3	18.0
1.0			20.7			21.3	19.8		
2.0	18.7	23.4	20.7	19.6	23.0	21.3	19.8	18.3	17.9
Dissolved Oxygen									
0.1	8.8	8.3	8.6	19.6	23.2	9.7	8.4	8.5	10.0
1.0			8.6			9.8	8.5		
2.0	8.5	8.2	8.5	19.6	23.0	9.8	8.5	8.5	10.4
Conductivity									
1.0	260	253	234	226.0	228.0	232	215	229	217

Station #*2*									
Temperature									
Depth	26-May	15-Jun	29-Jun	13-Jul	26-Jul	12-Sep	21-Sep	2-Oct	19-Oct
0.1	19.2	23.5	20.8	19.9	22.5	20.3	20.0	18.3	17.7
1.0			20.8			20.3	20.0		
2.0			20.8			20.3	20.0		
3.0			20.8			20.3	20.0		
3.5			20.8		22.1	20.4	20.0		
4.0		23.6						18.3	
4.5	18.9			19.8					17.6
Dissolved Oxygen									
0.1	8.6	8.0	8.3	8.2	8.3	9.6	8.0	7.8	10.3
1.0			8.3			9.7	8.0		
2.0			8.3			9.8	8.1		
3.0			8.3			9.6	8.1		
3.5			8.3		8.5	9.8	8.1		
4.0		8.0		8.0				8.2	
4.5	8.4								10.2
Conductivity									
1.0	260	255	236	226	229	228	215	229	217

Table 2-3. Water quality profiles data, Wohler Pool - Russian River, May through October 2000 (concluded).

Station #3									
Temperature									
Depth	26-May	15-Jun	29-Jun	13-Jul	26-Jul	12-Sep	21-Sep	2-Oct	19-Oct
0.1	19.5	24.0	20.9	20.1	23.0	19.8	20.1	18.7	17.3
1.0			20.9			19.7			
2.0			20.9			19.7			
3.0	19.4		20.9			19.8			
3.7		23.9	20.9	19.9	22.5		20.1	18.5	17.3
Dissolved Oxygen									
0.1	8.6	7.9	8.0	7.9	8.1	9.2	7.6	7.9	9.4
1.0			8.1			9.2			
2.0			8.0			9.1			
3.0	8.4		7.9			9.1			
3.7		7.9	7.8	7.9	8.0		7.5	7.0	9.4
Conductivity									
1.0	260	255	237	227	225	225	215	227	217

Station #4									
Temperature									
Depth	26-May	15-Jun	29-Jun	13-Jul	26-Jul	12-Sep	21-Sep	2-Oct	19-Oct
0.1	20.4	26.5	21.5	20.5	24.1	22.0	20.8	19.4	18.4
1.0		24.7	21.4		22.3	19.8	20.8		17.9
2.0		24.4	21.4		22.5	19.7	20.8		17.3
3.0	19.8	24.3	21.4	19.9	22.3	19.7	20.7	18.8	17.0
Dissolved Oxygen									
0.1	8.2	7.3	7.9	7.5	7.4	8.3	7.1	7.5	8.8
1.0		7.2	7.8		7.5	8.7	7.1		8.4
2.0		7.2	7.8		7.4	8.8	7.1		9.0
3.0	8.0	7.2	7.8	7.4	7.4	8.9	7.2	7.9	9.1
Conductivity									
1.0	260	258	237	228	232	227	215	229	216

column. Water temperatures recorded at a depth of 0.5 to 1.0 meters were within 1.0°C of the bottom depth at all stations. During August, the largest variation in water temperature between the depths of 0.5 m and 3.0 m was recorded at Station #4 (0.8°C.). At the three upstream profiling stations, the maximum change in temperature between the surface (0.1 m) and the deepest spot for each profile was 0.5°C at Station #3, 0.4°C at station #2, and 0.2°C at station 1.

A secondary component of the water temperature profiling study included recording water temperatures in and around the mouth of Porter Creek which enters the Wohler Pool near Water Quality Station #3. Although several temperature measurements were recorded near the bottom of the pool in and around the mouth of Porter Creek, no pockets of cool water were located.

2.4 SIGNIFICANT FINDINGS

During the mid- to late-spring smolt emigration period (April 20 and June 30), mean weekly average water temperatures ranged from 16.1°C to 23.6°C (temperature collected at Inflatable Dam). During this same period, the maximum temperature recorded was 25.1°C. Based on the NCRWQCB's criteria for water temperatures during the spring emigration period not to exceed 21.1°C, thermal conditions were suboptimal for salmonids from May 18 through the end of the migration period. The Sonoma County area experienced a heat wave during mid-May of 2000 that undoubtedly contributed to the suboptimal water temperatures. The weekly average water temperature increased from 16.9°C during the week of May 11 to 21.4°C during the following week. Minimum weekly temperatures remained below 20.0°C through the third week of June, and significantly, emigrating chinook and steelhead smolts were captured in the screw trap through the end of the study (June 29). All salmonid smolts captured in the screw traps appeared to be vigorous and healthy.

The chinook salmon upstream migration essentially began on September 7 and continued through December 30 (see section 5.0). Water temperatures during this time-period ranged between 21.2°C in mid-September to < 9.0°C in January. The mean weekly water temperatures recorded near the Inflatable Dam exceeded 19.0°C throughout September, peaking the week of the 14th at 20.4°C (Table 2.6). Chinook salmon continued to migrate past the dam on these days (see Section 5.3.2.2 for additional discussion of chinook salmon and water temperatures). Following the mid-September peak, water temperatures gradually declined throughout the rest of the migration period.

Water temperatures exceeded levels that are generally accepted as suitable for steelhead growth and survival from at least mid-June through mid-September 2000. Daily water temperatures rarely fell below 21.1°C from mid-June through mid-August. However, juvenile steelhead were captured in low numbers during the August electrofishing survey (see Section 4.0), and were observed during video monitoring entering and exiting the fish ladders throughout the summer (See Section 5.0). It is not known if these fish were rearing in the mainstem or late season emigrants. The fish were larger than comparably aged steelhead captured in Santa Rosa and Mark West creeks that suggest that some rearing may have been occurring.

The weekly average temperature of water at a depth of 0.5 m flowing through the lower two-thirds of the Wohler Pool increased at a rate of approximately 0.1°C/km, June through August. This rate of increase resulted in an overall increase in the water temperature of approximately 0.4°C over this distance. The weekly average temperature of water flowing at a depth of 0.5 m from the Inflatable Dam downstream approximately 2.0 km increased at a rate of approximately 0.1°C/km, June through August. This rate of increase resulted in an overall increase in the temperature of water of approximately 0.2°C over this distance.

The shallow (approximately two to three meters) nature of Wohler Pool is not conducive to thermal stratification. As a result, the potential for the development of coldwater refugia in the Wohler Pool is low to non-existent under the conditions measured during the 1999 and 2000 sampling seasons.

3.0 SMOLT EMIGRATION

The impoundment formed by the Inflatable Dam can potentially impact juvenile salmonids as they migrate to the ocean. When in place, the Inflatable Dam impounds water upstream approximately 5.1 km. Salmonid smolts swim or drift downstream with the current during emigration. The impoundment decreases current velocities, and the smolts may become disoriented by the loss of the stimulus provided by moving water. The disoriented smolts may be delayed or unable to find their way downstream of the dam. Smolts have a seasonal "window of opportunity" to complete the physiological process (smoltification) necessary to survive in the marine environment. A substantial delay in migration may result in smolts revert to a "resident form," thus spending an additional year in freshwater. Depending on summertime conditions, this may greatly increase mortality of smolts failing to successfully migrate to the ocean.

Two sampling strategies were employed to collect data on emigrating smolts. A passive sampling methodology (rotary screw traps) was used to capture fish as they migrated past the trapping site (60 m downstream of the dam). Trapping data provided information on species composition, timing of emigration (past a particular point on the river), allowed for the collection of size and age data, plus allowed for the collection of tissue for DNA sequencing. The traps were also used to capture marked hatchery reared steelhead smolts released into the upper end of the Wohler Pool to determine travel time through the pool. An active sampling methodology (radio-telemetry) was used to determine the fate of hatchery steelhead smolts moving through the pool. Radio-telemetry provided information on the rate of emigration through the pool and past the dam, as well as providing some insight into the fate of smolts that do not pass the dam (i.e., what happened to the fish that did not pass the dam). The results of the radio-telemetry study are presented in the companion study, Manning *et al.* (2000).

3.1 METHOD

A mark and recapture study was employed to estimate the rate at which salmonids emigrate through the Wohler Pool Reach before and after the dam was inflated and to provide information on the timing and relative numbers of smolts emigrating past the dam. Hatchery reared steelhead smolts bearing distinguishing marks were released at the upstream end of the impounded reach, and were captured in a rotary screw trap (described below) downstream of the dam. The amount of time elapsing between release and recapture of the smolts was recorded.

3.1.1 Fish Marking

All steelhead released from the Warm Springs Fish Hatchery are "marked" by clipping the adipose fin, including those released for this study. In this report, the term "marked" refers to fish that received a mark in addition to the adipose fin clip as described below. All smolts used in the study were reared at the Warm Springs Fish Hatchery. Prior to marking, fish were anesthetized in water containing MS-222 (tricaine methanesulfonate). Anesthetized fish were then placed on a ceramic plate submerged in water. A commercially available micro-jet marker was used to inject a dye (Alcian Blue) into the fin rays of each fish marked. Thedinga and Johnson (1995) studied the effectiveness of marking juvenile salmonids (coho and sockeye salmon) with Alcian Blue. They reported that the mark provided by Alcian Blue remained visible for an extended period of time, and that this dye was suitable for marking studies greater than six weeks in duration. Marked fish were then placed in a tub containing freshwater and allowed to recover. After regaining equilibrium, fish were checked to insure that they were successfully marked, and released in a separate raceway. Marked fish were then held in the raceway (grouped together by lot) until released into the Russian River. Water in the tubs used to hold the smolts prior, during, and after marking was changed frequently to maintain suitable water temperature and dissolved oxygen levels.

Table 3-1. Number of marked hatchery steelhead released during mark-recapture study

Lot Number	Date Released	Fin Marked	Number Marked
Lot 1	April 7	Anal	5,000
Lot 2	April 14	Caudal	4,500
Lot 3	May 23	Left Pelvic	5,000
Lot 4	June 6	Right Pectoral	700
Total			15,200

Warm Spring Fish hatchery reserved 15,200 steelhead smolts for the study. The fish were divided into four uniquely marked Lots (Table 3-1). Smolts were transported to the release site in CDFG's fish transportation truck. The water tank on the truck is equipped with a refrigeration system to maintain suitably cool water temperatures and an oxygen (DO) injection system to maintain suitable DO levels Table during transportation. The release point was located at the Hanson Sand and Gravel facility (Figure 1-1). The site is near the upstream end of the Wohler Impoundment. This section of the river is bordered by a levee approximately 30 feet high. To facilitate the release of fish, three 20-foot long, 8-inch diameter, PVC pipes were fastened together to provide a chute for the fish to pass through from the truck to the river. The PVC pipe was set at an approximately 45° angle so that the smolts dropped no more than 1.5 feet before landing in the river. This system appeared to function adequately as there were no observed mortalities or injuries to the fish released.

3.1.2 Rotary Screw Trap

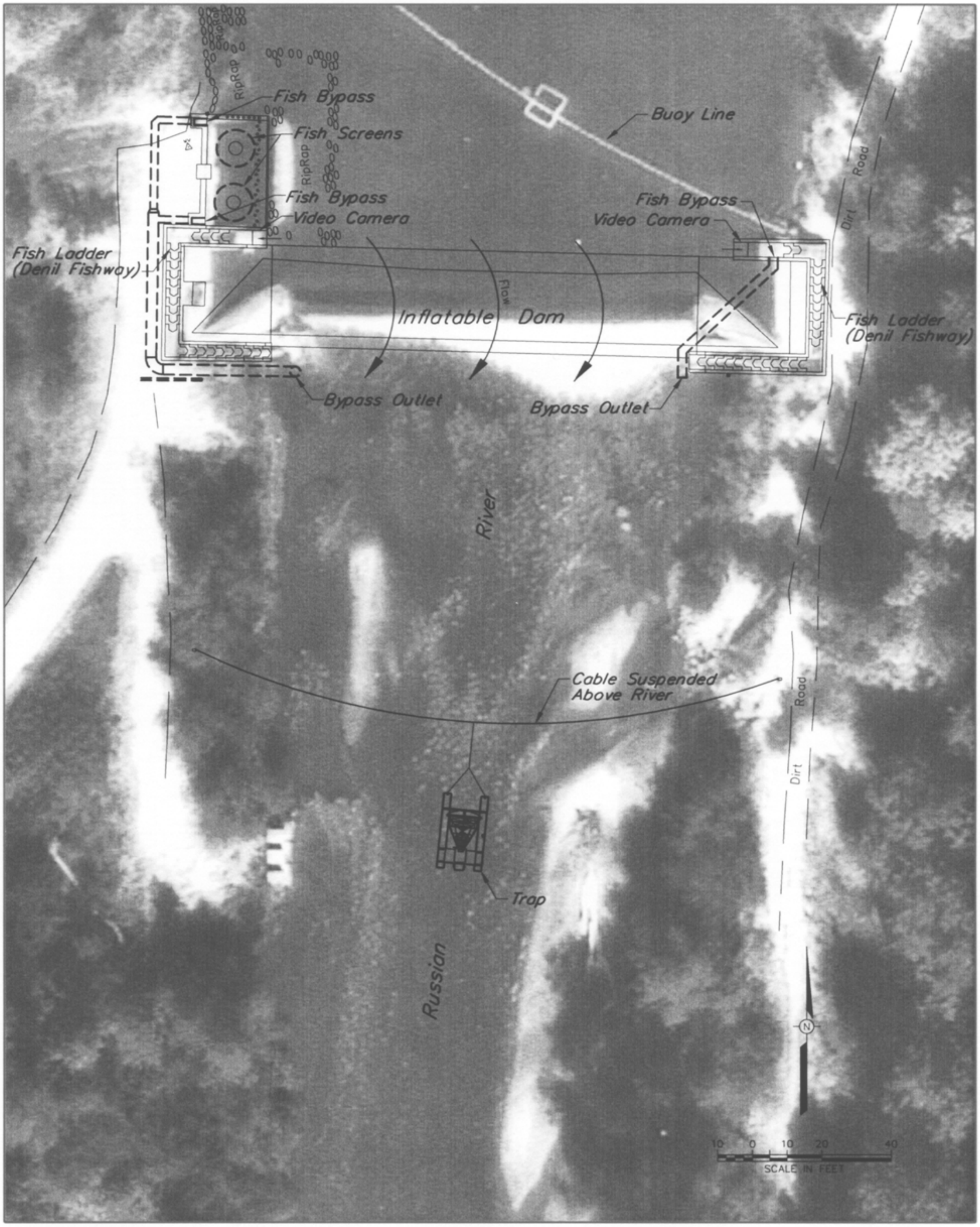
The rotary screw trap site was located approximately 60 m downstream of the Inflatable Dam site (Figure 3-1). Rotary screw traps are designed to capture downstream migrating juvenile fish. The screw traps are generally fished in the main channel where the water velocities are highest and the water column is the deepest (thalweg) since emigrating smolts are likely to be concentrated in these areas. Maintaining the trap in the desired location within the channel required a series of cables secured to the shoreline.

3.1.3 Rotary Screw Trap Infrastructure

The cable infrastructure and support system consisted of an anchor and a series of cables to maintain the trap in place as well as to move the trap across the channel. The cable system was anchored to two 30-foot by 10-inch H-beam piles driven approximately 27-feet (vertically) into the riverbank directly across from each other. The cabling system consisted of four components; the main line, the bridle, the lateral adjustment cable, and the visual barrier support cable.

The main line consisted of a 170-foot long, 0.75-inch steel cable. The cable was pulled across the river, stretched taunt, and secured to the piles with heavy equipment. The bridle consisted of a 20-foot length of 0.75-inch steel cable attached the rotary trap to the main line. The lateral adjustment cable consisted of a continuous length of 0.38 inch galvanized steel cable. The cable was run through two 4.0-inch blocks attached to the H-beam piles. The ends of the cable were attached to the block on the main line, creating a continuous loop (similar in theory to a clothes line). This looped cable was used to move the trap(s) into position and to adjust the trap(s) position when required. Once the trap was positioned appropriately, a cable clamp was used to secure the lateral cable in position. A 0.38-inch safety break-a-way cable was connected to the rear corner of the trap and to an anchor point on the shoreline.

Orange floats were attached to a cable stretched across the river above the other cables. The floats were strung out along this cable at 10-foot intervals to provide a warning for canoeist/kayakers (prior to the inflation of the dam) and low flying aircraft (e.g., helicopters) that a potential obstruction was placed across the river.



DATE OF PHOTOGRAPHY: SEPT 30, 1999

\SPECIAL PROJECTS\FISHERIES\STUDIES\RUSSIAN RIVER\2000A-TRAP SEPT 28, 2001

SONOMA COUNTY WATER AGENCY

Figure 3–1 Plan view of rotary screw fish trap, video cameras, and fish passage structures at Inflatable Dam

3.1.4 Operation of the Rotary Screw Fish Trap

Two different size rotary screw traps were used during the study. An 8-foot diameter trap was fished prior to the inflation of the dam, and two five-foot diameter traps were fished after the inflation of the dam (the first 5-foot trap was installed immediately after the dam was inflated, and the second 5-foot trap was installed six days later. The rotary screw fish trap is a cone consisting of perforated stainless steel panels which houses an internal Archimedes screw. Water striking the angled surface of the internal screw rotates the cone and screw assembly. As the assembly rotates, fish are trapped within the chambers formed by the screw and moved rearward into the live box at the back of the trap. The live box is constructed such that areas of very low water velocity are provided as resting areas for fish held in the box. Debris such as leaves and small twigs entering the live box are impinged on a rotating debris screen located at the back of the live box. As the screen rotates, debris is carried out of the box, maintaining a relatively clean environment for the fish held in the live box. The cone is mounted between two pontoons and is lowered and raised with a bipod and windlass located at the front of the cone.

Rotary screw traps are lowered into the water column until half of the cone is submerged (an 8-foot diameter trap requires a minimum depth greater than four feet to operate). The 8-foot diameter trap was operated until the river depth decreased below the minimum four-foot level. At this point, the 5-foot diameter traps (requiring a minimum depth of 2.5 feet) were fished.

The 8-foot rotary screw trap was operated continuously from April 7 through the morning of April 25, excluding April 18 and 19, when the trap was decommissioned during a high flow event. A single 5-foot (diameter) rotary screw trap was fished from April 25 through the morning of May 1. A second 5-foot trap was added in the afternoon of May 1, and both 5-foot traps were fished continuously through the morning of June 29.

Fish captured by the screw traps were netted and placed in five gallon buckets containing freshwater. Alka-seltzer was added to the bucket as an anesthetic. Fish captured were identified to species, measured to the nearest mm (FL) and placed in a recovery bucket containing fresh river water. Recovery buckets were equipped with a small aerator to maintain dissolved oxygen levels. Once the fish regained equilibrium, they were released into the river.

3.2 RESULTS

3.2.1 Results of Mark-Recapture Study

Recapture rates of marked steelhead were extremely low for all four releases (Table 3-2). Prior to dam inflation, 9,500 marked steelhead were released and 13 were recaptured. The majority (9 of 13) of the recaptures occurred the day after release (Table 3-3). Two hatchery fish released on April 7 (approximately 4 weeks prior to dam inflation) were recaptured 50 and 71 days after the release date.

After dam inflation, 25 of 5,700 marked steelhead were recaptured. More marked fish were recaptured during the third week after release (12 recaptures between days 21 and 28) compared to the first week (10 recaptures between days 1-7) following release (Table 3-3).

The capture of smolts downstream of the dam demonstrates that the dam is not a complete barrier to fish migration. However, the results of the mark-recapture study suggest that steelhead smolts may be delayed as they emigrate through the Wohler Pool/Inflatable Dam. A detailed analysis of the potential delay in smolt emigration is not possible from the mark-recapture data because of the low number of recaptures and the wide variation in the length of time between the releases and the capture of marked fish. A more detailed analysis of the potential affect of the dam on smolt emigration is provided in Manning et al (2001).

Table 3-2. Release and recapture statistics for marked hatchery steelhead releases.

Date Released	Fin Marked	Number Released	Dam Status	Number Recaptured	Percent Recaptured
April 7	Anal	5,000	Deflated	12	0.24
April 14	Caudal	4500	Deflated	1	0.02
May 23	Left pelvic	5,000	Inflated	22	0.44
June 6	Right pectoral	700	Inflated	4	0.57
		15,200		38	0.25

3.2.2 Rotary Screw Trapping Results

The capture of fish in the screw traps is influenced by the time of year, streamflow, size of trap in operation, and potentially whether the dam is inflated or deflated. Streamflow generally declined throughout the study, with a few exceptions. Significant events and average daily streamflow recorded at Hacienda Bridge are provided in Table 3-4.

3.2.2.1 Salmonids

Chinook: Chinook salmon smolts were captured from April 8 (first full day of sampling) through June 28 (second to last day of sampling). A total of 1,361 chinook smolts were captured during the study (Table 3-5). Numbers of chinook smolts captured remained relatively high through May before rapidly declining during the last two weeks of June (10 chinook were captured during the last six days of sampling) (Figure 3-2). The exact run timing for chinook salmon cannot be determined from the data collected for three reasons. First, the traps could not be deployed during the beginning of the season because of high streamflows. Second, the size and the number of traps used throughout the study changed during the season. Third, no effort was made to determine the sampling efficiency of the different traps, or to determine their sampling efficiency under different streamflow. Therefore, it was not possible to estimate the number of the chinook smolts emigrating past the dam site at any point in time to determine when the peak of the run occurred. Although it is not possible to determine if the dam has an affect on the rate of chinook emigration, the capture of smolts after the dam was inflated demonstrates that they are able to negotiate the dam.

Table 3-3. Length of time between date of release and capture of marked hatchery steelhead, data combined for both pre- and post- dam releases.

Number of days from release to recapture										
Dam Status	Totals	1 day	2-7 days	8-14 days	15-21 days	22-28 days	29-35 days	36-42 days	43-49 days	≥50 days
Deflated	9,500	10	1	0	0	0	0	0	1	1
Inflated	5,700	6	5	2	2	11	0	—[1]	—	—

[1] The screw trap was in operation for 38 and 23 days, respectively, following the two post-dam-inflation releases.

Table 3-4. Significant events during trapping season and average daily streamflow recorded at the Hacienda Bridge gage.

Date	Event	Flow (cfs)
April 8	First day of trapping	774
April 17	Peak flow associated with storm event	3,612
April 25	8-ft trap removed and 5-ft trap deployed	938
May 2	Dam inflated	≈700[1]
May 2	Second 5-ft trap deployed	≈700[1]
June 29	Trap removed for the season	225

[1] Streamflow (recorded downstream at the Hacienda Bridge) was artificially reduced as the reservoir filled behind the inflating dam.

Table 3-5. Anadromous species captured in the rotary screw trap catch, pre- and post-dam, 2000 sampling season.

Species	Pre-Dam	Post Dam	Totals
Chinook salmon - wild smolts	631	730	1,361
Wild Steelhead - wild smolts	69	65	134
Steelhead - hatchery smolts	61	7	68
Steelhead - marked smolts	11	28	39
Steelhead - young-of-the-year	61	702	763
Steelhead - adult	3	0	3
Pacific lamprey adult	22	2	24
Pacific lamprey - eyed	2	0	2
Pacific lamprey - ammocoetes	230	22	252

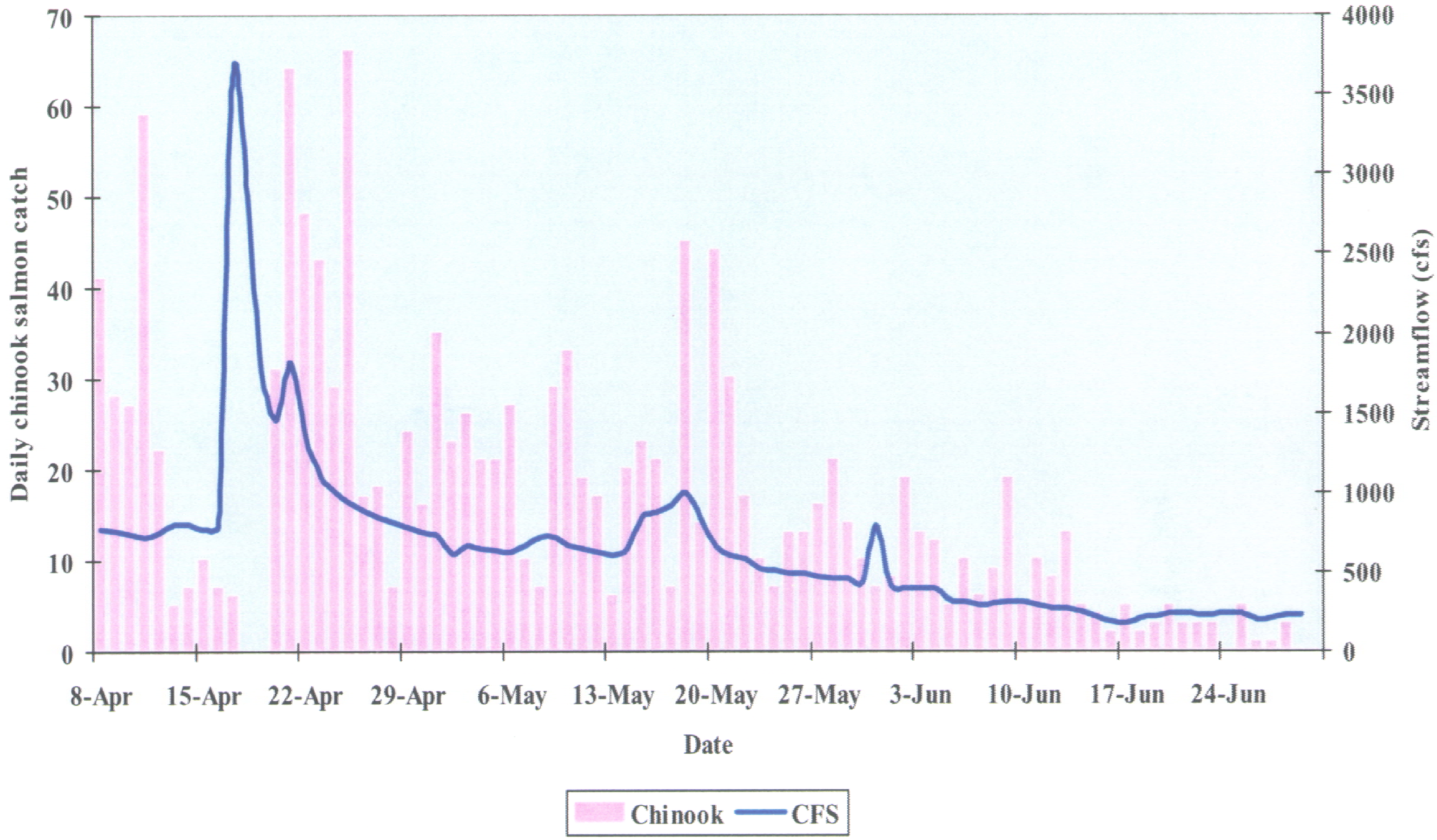


Figure 3-2. Daily catch of chinook salmon smolts in rotary fish screw trap and mean daily flow (cfs) in the Russian River (recorded at Hacienda Bridge, 8 April through 29 June 2000.

Water temperature was recorded at the screw trap site from April 18 through the end of sampling. Based on a literature review conducted by the Regional Water Quality Control Board, chinook salmon exhibit positive growth at temperatures between 4.4 and 18.9°C, are prevented from emigrating at 21.1°C, and have a maximum temperature tolerance of approximately 23.3°C. Water temperatures exceeded the daily maximum temperature during the spring emigration period. However, chinook smolts continued to emigrate even during periods when the mean daily temperature reached 25.1°C, and the daily maximum temperature reached 25.7°C. The numbers of smolts collected on a daily basis declined by about half after the daily average water temperature exceeded 22.0°C (Figure 3-3). The average daily catch of chinook smolts in the screw trap was 26.3 for the 7 days prior to the average daily temperature exceeded 22.0°C, compared to an average of 13.9 chinook smolts per day for the 7 days following the temperature exceeding 22.0°C. Although it is possible that the reduction in the numbers of chinook smolts captured in the trap was related to water temperature, it is also possible that the reduction in the catch was related to the smolt emigration period being nearly completed, and that there was just fewer fish in the river to be captured. Roelofs *et al.* (1993), working on the Eel River, found that the number of chinook smolts captured in a downstream trap did not increase following a significant drop in maximum daily water temperature during mid-June, indicating that the migration period was nearly completed by this time. Average daily dissolved oxygen (DO) levels were recorded from May 18 through the end of the trapping season ranged from 7.2 to 10.1 ppm.

The average size of chinook smolts captured in the screw trap increased during the trapping season (Table 3-6; Figure 3-4). Chinook smolts captured at Mirabel ranged in size from 47 to 140 mm FL, and the average size increased from 81.3 mm FL during the second week of April, to 104.8 mm FL at the end of June.

Wild Steelhead Smolts: Steelhead smolts were captured throughout the trapping season, but at lower numbers than chinook smolts. For the season, 134 wild steelhead smolts were captured in the rotary screw trap. Steelhead smolts are considerably larger than chinook smolts (thus they are stronger swimmers), and may be better able to avoid capture in the rotary screw traps. Therefore, it should not be assumed that chinook salmon are more abundant than steelhead based on the number of smolts of the two species captured in the screw traps. Steelhead smolts were captured primarily in April and May, with low numbers of wild smolts captured though mid-June.

Weekly minimum, average, and maximum lengths of chinook salmon smolts captured in the screw trap, 2000 sampling season.

Date (week of)	Minimum length (mm)	Average length (mm)	Maximum length (mm)	N =
April 8	58	81	96	185
April 15	64	87	102	113
April 22	57	89	105	227
April 29	67	93	105	164
May 6	47	96	120	142
May 13	54	98	117	134
May 20	48	96	114	134
May 27	72	99	117	94
June 3	74	98	114	73
June 10	89	103	119	47
June 17	88	99	135	24
June 24	89	105	140	10

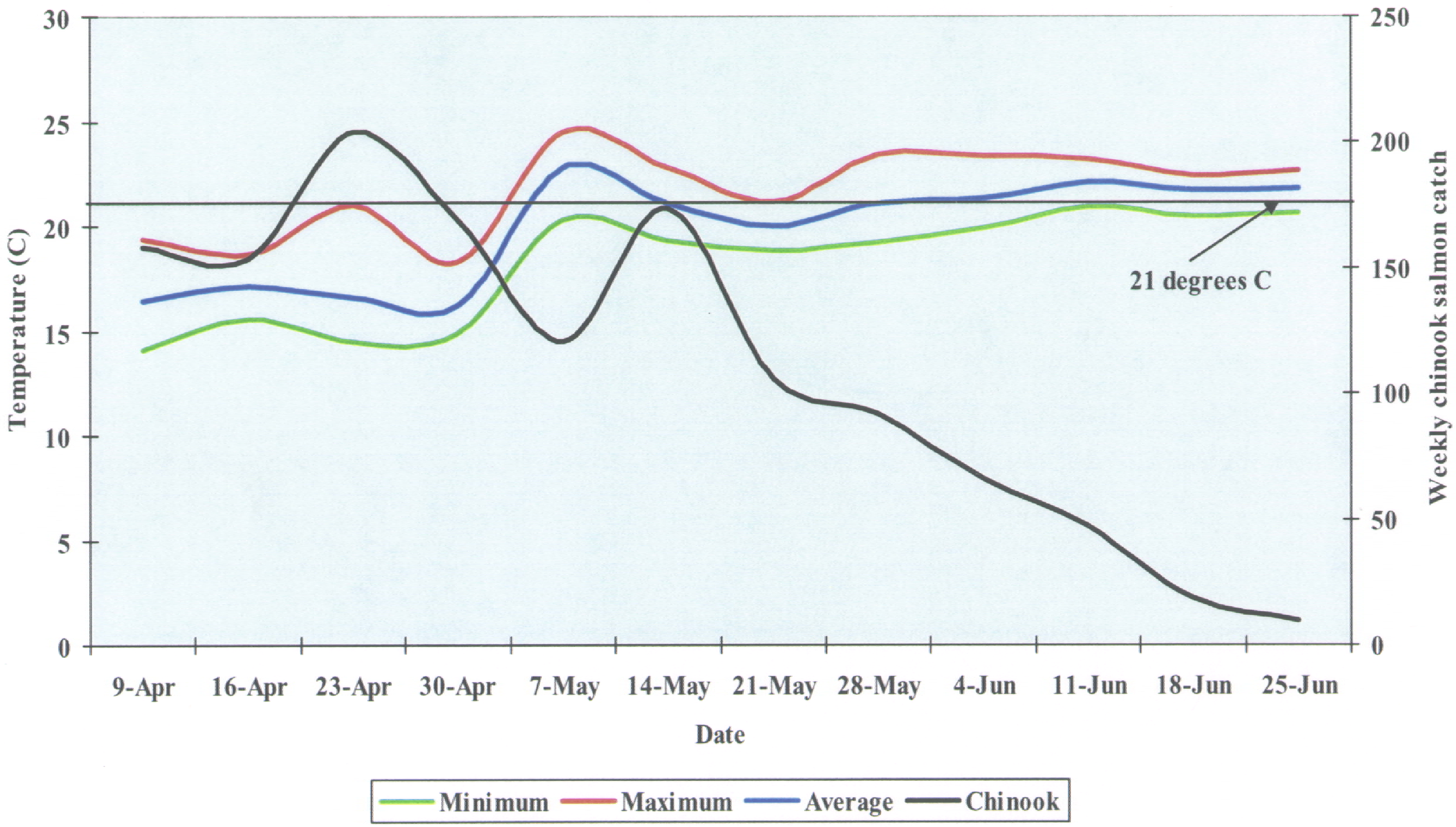


Figure 3-3. Weekly chinook salmon catch in rotary screw traps plotted against weekly maximum, average, and minimum water temperatures, April 20 - June 29, 2000.

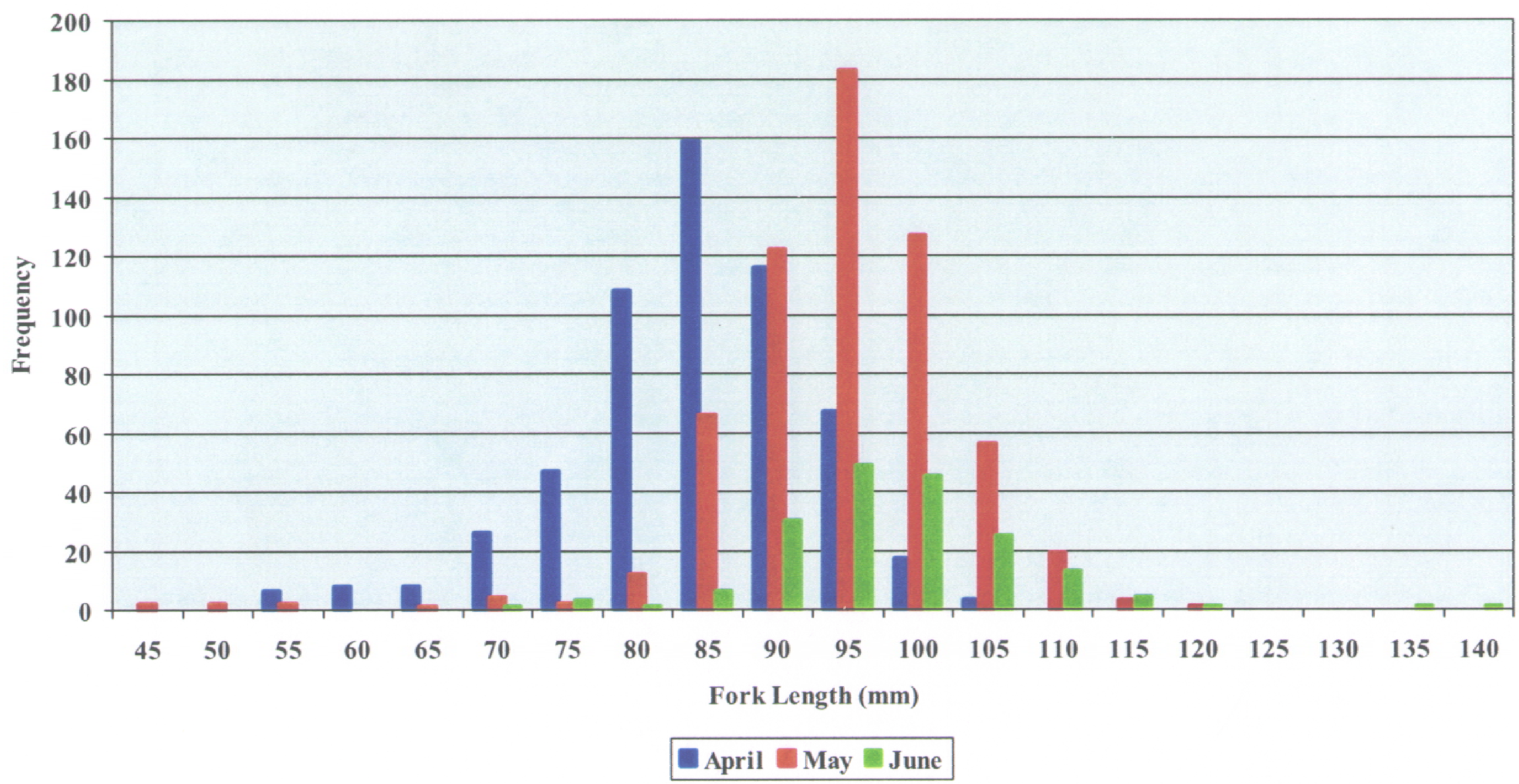


Figure 3-4. Length-frequency histogram for chinook smolts captured in the rotary fish screw trap, broken out by month of capture, spring 2000.

Wild Steelhead Young-of-the-Year (YOY): Steelhead YOY were captured from April 10 through June 29. The large number of steelhead YOY in the mainstem Russian River is surprising since little, if any, spawning habitat is available near the Inflatable Dam. It is possible that the YOY were washed out of upstream (mainstem and tributary) spawning habitat by the storm of April 16. It is not known if the YOY took up residence in the mainstem river, moved into tributary streams, emigrated to the estuary/ocean, or perished. A few YOY steelhead were captured in the Wohler Pool during August electrofishing surveys. These fish were generally larger than similar aged steelhead captured in Mark West and Santa Rosa creeks during fall surveys conducted by the Agency. The larger size suggests that some of these YOY were rearing in the mainstem river. However, it is also possible that the YOY captured during boat electrofishing surveys drifted downstream from more upstream mainstem rearing habitat.

Wild steelhead smolts in the Russian River emigrate primarily as 2-year-old fish. Scale samples were collected from 92 wild steelhead smolts captured in the screw trap. Of these, 47 (87.0 percent) of the 54 fish aged were two-year-old fish, three (5.6 percent) were aged as one-year-old fish, and four (7.4 percent) were aged as young-of-the-year fish (38 scale samples were unreadable due to re-absorption of scale tissue). Ages were assigned to all steelhead captured in the screw trap using both fish of known age (scales), and based on length frequency histograms. Since fish were captured over a three-month period, fish were grouped based on date of capture (one-week intervals). Second, the steelhead captured were produced in several different streams in the upper basin; each stream with potentially different rearing conditions. Thus, steelhead from one stream may be considerably larger than steelhead of the same age rearing in a different stream. Age 0+ steelhead ranged in length from 21 to 114 mm FL during the study (Figure 3-5, Table 3-7). The average length of YOY steelhead increased from 43.7 mm during the second week in April, to 84.0 mm during the last week in June. Few, if any, of the young-of-the-year steelhead captured were likely to be ocean bound migrants. Only eight steelhead were aged as one-year-old (Figures 3-5). Age 1+ fish ranged in length from 83 to 136 mm FL, and were primarily captured during June (6 of 8 age 1+ fish). Fish aged as one-year-old generally did not posses the characteristics associated with "smolting" fish (e.g., body shape and bright silver coloration), and may not have been ocean bound emigrants. Age 2+ smolts ranged in length from 142 to 238 mm.

3.2.2.2 Other species

In addition to salmonids, 20 species of fish were captured in the screw trap during the 2000 sampling season. Most of the species were captured in low numbers. With few exceptions, the fish captured were juveniles. The capture of larval fish indicates that the dam does not interfere with downstream dispersal of most species. Based on the time of capture of the larval fish, Sacramento suckers likely spawned in late April-early May, hardhead and pikeminnow in late May and early June, largemouth bass in early June, and smallmouth bass in mid-May. These estimated dates of spawning fit the general time trend observed in different systems for these species. Daily catches for each species are presented in Appendix C.

3.3 SIGNIFICANT FINDINGS

Juvenile chinook salmon and steelhead were captured in the rotary screw trap. Chinook salmon were captured throughout the study, but at greatly reduced numbers during the last two weeks of June. Steelhead were captured primarily in April and May.

Chinook salmon smolts ranged in size from 58 to 140 mm FL. The average length of chinook smolts increased from 81.3 during the second week in April to 104.1 during the last week in June. Steelhead emigrate primarily as two year old fish. Age 2+ steelhead ranged in length from 142 to 238 mm FL. The overall average length of steelhead smolts was 174.8 mm FL.

Average weekly water temperatures during the smolt emigration period ranged from 16.1 to 23.6°C, with maximum daily temperatures up to 25.6°C. Average weekly water temperatures approached or exceeded 21.1°C during the final six weeks of the smolt emigration period. All smolts captured appeared to be healthy and vigorous.

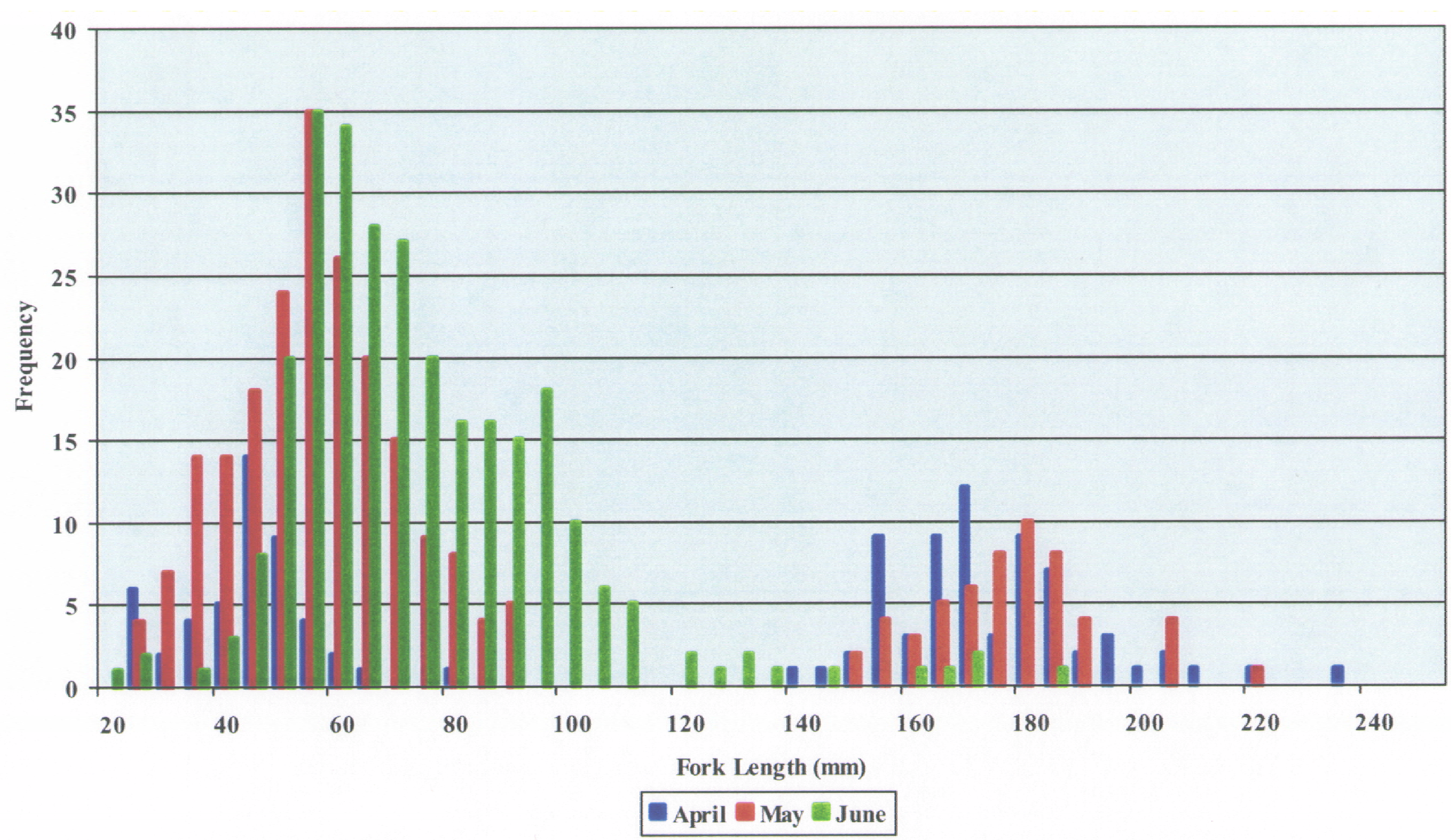


Figure 3-5. Length-frequency histogram for wild steelhead captured in the rotary fish screw trap, broken out by month of capture, spring 2000.

Table 3-7. Weekly minimum, average and maximum fork lengths of steelhead, separated by age class, captured in the screw trap during the 2000 sampling season.

Age 0+				
Week of	N	Average	Minimum	Maximum
April 8	3	43.7	42	46
April 15	5	47.0	39	54
April 22	31	46.0	28	67
April 29	223	41.8	21	70
May 6	35	43.6	25	66
May 13	46	52.5	28	79
May 20	75	57.1	32	90
May 27	81	70.0	23	92
June 3	93	63.3	26	104
June 10	47	70.6	45	100
June 17	50	82.1	56	112
June 24	58	84.0	54	114

Age 1+				
Week of	N =	Average length (mm)	Minimum length (mm)	Maximum length (mm)
April 8	—	—	—	—
April 15	1	83.0	83	83
April 22	—	—	—	—
April 29	1	94.0	94	94
May 6	—	—	—	—
May 13	—	—	—	—
May 20	—	—	—	—
May 27	—	—	—	—
June 3	—	—	—	—
June 10	1	120.0	120	120
June 17	3	128.0	125	132
June 24	2	128.5	136	121

Age 2+				
Week of	N =	Average length (mm)	Minimum length (mm)	Maximum length (mm)
April 8	19	174.4	148	238
April 15	14	183.0	165	220
April 22	33	173.9	142	206
April 29	19	180.1	153	220
May 6	10	172.1	156	194
May 13	13	179.2	156	207
May 20	7	188.1	178	207
May 27	8	171.1	150	180
June 3	2	167.0	160	174
June 10	3	167.8	147	185
June 17	—	—	—	—
June 24	—	—	—	—

The capture of chinook and steelhead smolts after inflation indicates that the dam is not a complete barrier to migration. However, the few marked fish that were recaptured suggest that the dam did delay at least some of the hatchery smolts released. The magnitude of the delayed was obscured by the low number of marked smolts recaptured, as well as factors such as trapping efficiency, differences in streamflow throughout the study, and time of year. A companion study, Manning *et al.* (2000), addresses this potential impact in detail.

4.0 WOHLER POOL FISH COMMUNITY

The Inflatable Dam impounds approximately 5.1 km of river, creating essentially a long pool. Since pools are the preferred habitat of adult predatory fish (e.g., pikeminnow and smallmouth bass - see section 1.4 for detailed discussions of predator life histories), the habitat created behind the Inflatable Dam may result in an increase in the populations of these predators. Concentrating numbers of adult predators may lead to an increase in predation on salmonid smolts. This may be particularly true if smolts have difficulty migrating through the impoundment (see Manning *et al.* 2000). In addition, the pool formed behind the dam may create suitable habitat for spawning and rearing of predator fish. If conditions created by the impoundment are favorable, this may lead to an increase in survival of predatory fish that may disperse to other sections of the river.

4.1 STUDY AREA

The study area was divided into four reaches. Reach #1 is located adjacent to Steelhead Beach Regional Park, and is located downstream of the Inflatable Dam. Reach #2 is located in the lower third of the Wohler Pool, Reach #3 is located in the middle third of the Wohler Pool, and the Reach 4 is located in the upper third of the Wohler Pool (Figure 4-1). Steelhead Beach is located approximately 1.6 kilometers downstream of the dam. Reach #4 is at the upstream end of the Wohler Pool, and is minimally affected by the dam, with the influence of the dam declining to virtually zero at the upstream end. Habitat in the Reaches 2 and 3 is significantly altered by the Inflatable Dam. Access along the Russian River just above and below the Inflatable Dam (outside the influence of the Dam) is limited. A shallow riffle at the upstream end of this reach was not passable in the electrofishing boat, and sites suitable for launching the electrofishing boat at other locations have not been identified at this point. These limitations prevented the expansion of the study into portions of the river that are not affected by the dam.

4.2 METHODS

4.2.1 Sampling Site Selection

Each Reach was divided into sampling stations of equal length, measuring 180 m. Depending on the length of the individual reaches, six or nine sampling stations were randomly selected. A "sampling station" constituted either the left bank, right bank, or mid channel of the river. Starting at the downstream end of a Reach, a starting "side" within the river was randomly selected (i.e., either the left bank, mid channel, or right bank). Once an initial starting point was selected, a distance of 180 m was measured upstream, and constituted sampling station #1. At the upstream end of sampling station #1, one of the two remaining "sides" was randomly selected, and a distance of 180 m measured upstream. This constituted sampling station #2 for that Reach. The remaining side was selected as sampling station #3. At the upstream end of sampling station #3, the station order was repeated with sampling station #4 being the same side as sampling station #1. This strategy for selecting sampling locations was repeated for each Reach.

4.2.2 Habitat Data

Habitat data were collected at each discrete sampling site prior to electrofishing. Habitat surveys were conducted by two biologists in kayaks. The 180 m long sampling sites were subdivided into 10 - 18m long segments, and within each segment a series of habitat variables were recorded. The data collected within each 18 m long segment was then averaged together to estimate the habitat variables within each 180 m long electrofishing unit. Habitat variables measured quantitatively included average and maximum depth, recorded as the average and maximum depth out to a distance of approximately 3 meters from shore, and average width of the river along a sampling unit. Habitat variables measured qualitatively included shoreline vegetative cover, instream cover (overhanging vegetation, aquatic vegetation, large woody debris, and large rocks), and substrate composition. Instream cover and substrate composition were estimated

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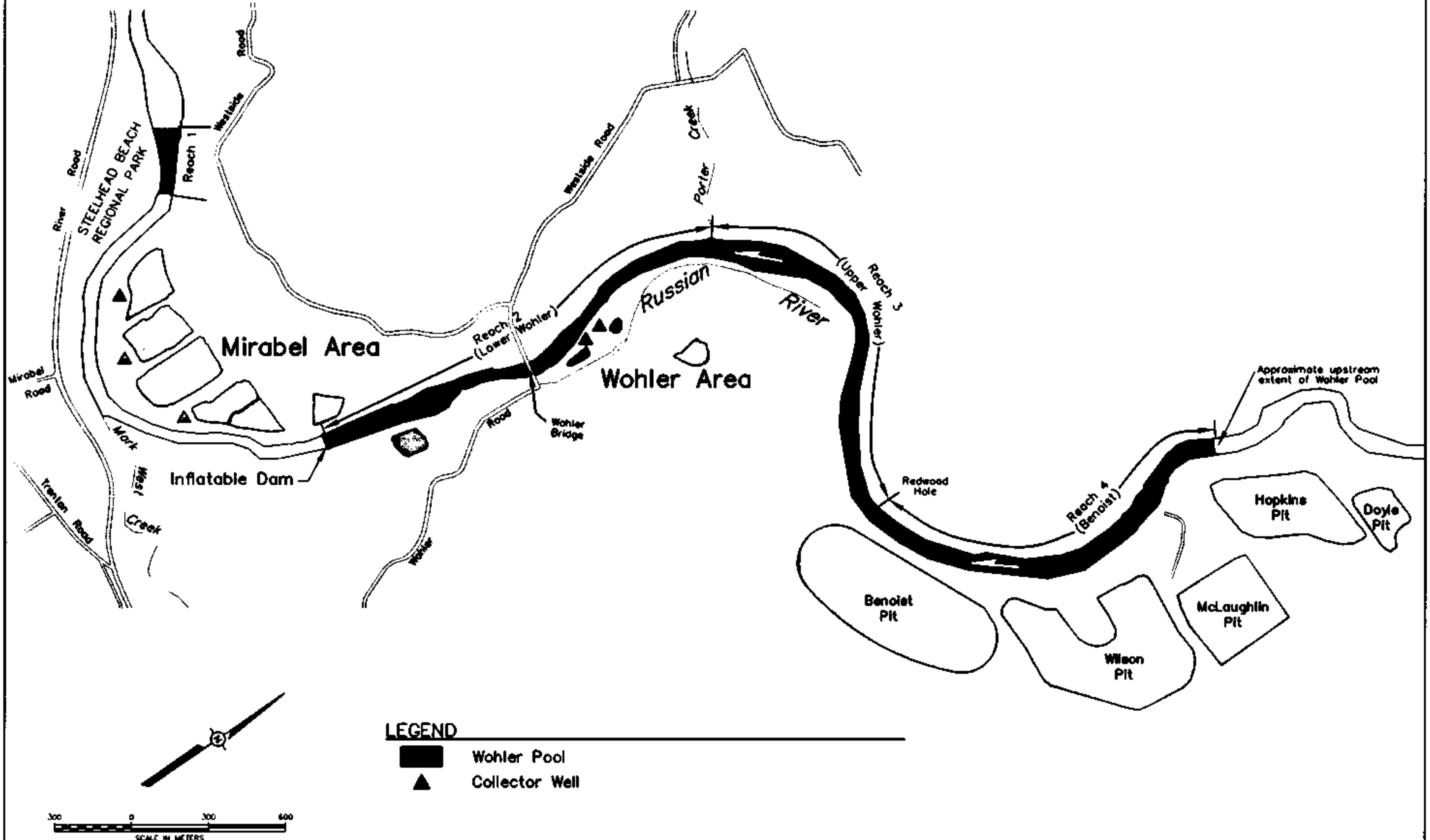

SONOMA COUNTY WATER AGENCY

Figure 4–1 Boat electrofishing reaches, August 2000 within 3 meters of the bank for shoreline sampling units. Variables were visually estimated to provide a general description of habitat characteristics between sampling units. Habitat data collected in the mid channel stations were collected along a straight line down the middle of the channel.

Vegetation hanging over the water provides shaded conditions that are preferred by predatory fish. Woody debris provides cover for predatory fish, and can take the form of downed trees, snags, or drowned vegetation. Aquatic vegetation can also provide cover for predators as well as for small fish. Aquatic vegetation in the study area was primarily water primrose *(Ludwigia peploides)*. Large boulders are a preferred habitat for smallmouth bass. Rocky shorelines in the Russian River are primarily the result of bank stabilization projects. In all cases, the amount of cover provided by the above categories was visually estimated based on the percentage of the shoreline, out to a distance of 3 meters, supporting each of the various types of cover.

4.2.3 Results of Boat Electrofishing

Fish were collected with a 16-foot electrofishing boat (Smith-Root, Inc. model 16S). The electrofishing boat uses an onboard generator that sends an electric current through two anodes mounted to the front of the boat. A series of cathodes mounted on the front of the boat complete the current. The strength of the current is controlled by the boat operator, and is maintained at the minimum level required to effectively capture fish. The front of the boat is designed as a flat platform enclosed on the front and sides with safety railing. The platform is large enough to allow two crewmembers to net fish stunned during electrofishing. Fish are collected using nets that measure 17" X 17", mounted on eight-foot long fiberglass handles. The motor is mounted on a transom jack which allows the engine to be raised or lowered depending on water depth. The transom jack combined with the shallow draft of the boat allows for the safe operation in water less than two feet deep. A series of floodlights mounted on the front and rear of the boat allow for safe operation during nighttime sampling efforts.

Electrofishing was conducted in early August to minimize the potential of encountering adult salmonids. Sampling was conducted during hours of darkness. Smallmouth bass have been shown to be more vulnerable to capture during electrofishing surveys conducted at night (Paragamian 1989). In addition, the potential to disrupt recreational user groups is greatly reduced. Electrofishing began at the downstream end of each sampling station, and proceeded upstream. Banks with cover (e.g., overhanging and aquatic vegetation) are sampled by maneuvering the boat such that the anodes are placed in the cover prior to the current being delivered to the water. This minimizes the potential of alerting fish to the presence of the current, and increases capture rates. Delivery of the current through the anode is controlled with a series of foot switches. One crewmember controlled the operation (on or off) of the electrofishing unit. In this way, the current was applied only when the anodes were in position to fish. A timer records the effort (i.e., number of seconds that the electrofishing unit was in operation) at each station.

During electrofishing, an attempt was made to net all fish stunned. However, special emphasis was placed on capturing target species (adult piscivorous fish) and juvenile salmonids. Fish captured were held in a live well. The live well was equipped with a recirculating pump and an aerator that supplied fresh, oxygenated water to the holding tank. Captured fish were identified to species and measured to the nearest 0.5 cm. FL. Scale samples were collected from representative fish to determine the age structure of the fish community.

4.3 RESULTS

4.3.1 Habitat Mapping

Habitat parameters, including average width, average and maximum depths, cover (overhanging vegetation, woody debris, aquatic vegetation, and large rocks), primary substrate composition, and primary bank vegetation composition, were recorded for each Reach (Table 4-1). Average widths and depths were similar between the four Reaches, with the exception of a relatively small hole at the upstream end of Reach #3 (maximum depth approximately 5.0 meters). Although the percentage of individual cover elements (e.g., overhanging vegetation and woody debris) varied between Reaches, the overall percentage of cover was similar in the three Reaches located above the dam (range 28.6 to 31.8 percent). Overall, habitat composition at Reach # 1 was 21.2 percent.

All four Reaches provide suitable habitat conditions for the three predatory species of concern. Based on a review of habitat requirements for smallmouth and largemouth bass, the lower half of the Wohler Pool provides the most suitable habitat in the study area. This area has the deepest water (excluding the small hole at the upstream end of Reach #3), the lowest current velocities, and abundant cover. However, based on the electrofishing results presented below, smallmouth and largemouth bass abundances were lowest in the lower half of Reach #2 compared to the rest of the Study Reach. A potential explanation for this is the observed lack of habitat during the late winter/early spring period when streamflows are decreasing, but prior to dam inflation (streamflow between approximately 800 and 1,500 cfs). During high flow events, fish move into heavy cover to avoid high velocities. As flow drops after the cessation of winter rains, low velocity habitat (relatively deep water with heavy cover) is still available in Reaches 1, 3, and 4. Reach #1 is a main channel pool under normal summer base flows, and as high winter flows subside, habitat returns to this condition (thus low velocity refuge remains available to fish throughout the winter to summer transition period). Reach #4 is also primarily pool habitat that is only slightly influenced by the dam, and habitat response in a manner similar to Reach #1 as winter flows decrease. Habitat at Reach #3 without the dam would be classified primarily as a run/glide habitat, however. The thalweg (deepest section of the channel) remains against the right hand bank throughout most of the Reach. As streamflow decreases from winter to summer flows, moderate depths and cover (mainly overhanging vegetation and large woody debris) provide velocity relief for fish. Habitat in lower half of Reach #2, however, becomes a series of relatively shallow riffle and glide habitats with moderately high current velocities. The thalweg shifts to the middle of the channel through this section of the river, eliminating the potential benefits provide by overhanging vegetation and woody debris associated with the riparian corridor. Refuge from the relatively high velocity currents is lacking during the winter to summer transition period in the lower 1/4 to 1/2 of the lower Wohler Pool. Although this theory is based on general observations made by biologist, and not on empirical data, the electrofishing results supports this conclusion.

4.3.2 Fish Sampling

Boat electrofishing surveys were conducted in August 2000. Four Reaches were sampled. Reach 1 was located downstream of the Inflatable Dam and consisted of four shoreline sampling units and two mid-channel sampling units. Reaches 2, 3 and 4 were located upstream of the Inflatable Dam and are contiguous. Reaches 2 and 4 consisted of nine sampling units each (six shoreline and three mid-channel units) and Reach 3 consisted of four shoreline sampling units and two mid-channel sampling units. Water surface elevation (thus depth) is directly influenced by the dam in Reaches 2 and 3. Reach 4 is located above a relatively shallow glide (maximum depth 1.5 to 2.0 feet). The influence of the Inflatable Dam on depth is approximately 20 cm at the lower end of Reach 4, and zero at the upper end of Reach 4.

4.3.2.1 Community composition

During the 2000 sampling season, 3,371 fish representing nine families and nineteen species were collected (Table 4-2, Appendix D). In addition, one species was observed but not captured in 2000, and another species was captured in 1999, but not in 2000. Juvenile Pacific lamprey were observed in most reaches in 2000, but are too small to be captured with the dip nets used for this study. In 1999, one adult striped bass was captured. Nine of the nineteen species are native to the Russian River. Native species comprised 54.2 percent (1,826) of the catch (hatchery steelhead were included in the non-native category). Overall, species composition in the study area was dominated by three species: smallmouth bass (34.4 percent), Sacramento suckers (22.6 percent) and hardhead (12.0 percent) (Table 4-3). The fish communities were similar in the three upstream Reaches. A measure of species richness was developed using the Alpha Diversity index to compare the fish communities inhabiting the four stations (see Li and Li 1996 for a discussion of this technique). The Alpha Diversity index has a low sensitivity to sample size that makes it useful for comparing the four Reaches in this study. Alpha increases as species richness increases. Alpha Scores were developed with all species captured and without bottom dwelling species (sculpin, channel catfish, and bullhead). Bottom dwelling species tend to remain on the river bottom after being stunned and are difficult to capture with boat electrofishing technique. Thus, these species were likely not captured in relationship to their abundance. Species richness was highest in Reach 1 (Table 4-4).

Table 4-1. Results of habitat mapping conducted in boat electrofishing stations, Mirabel Study Area, July 2000.

Reach 1										
Reach 1	Position	Average Width (m)	Average Depth (m)	Maximum Depth (m)	Overhanging Vegetation[1]	Woody Debris[1]	Aquatic Vegetation[1]	Rock[1]	Substrate	Bank Composition
Station 1-1	Left bank	48.5	1.9	2.9	14	13	<1	0	1	4
Station 1-2	Left bank	34.7	1.2	1.6	7	2	0	0	1	4
Station 1-3	Right bank	27.4	1.5	2.9	6	3	11	1	1	3
Station 1-4	Right bank	44.5	2.0	2.5	11	16	3	0	1	4
Station 1-5	Mid-channel	45.7	1.5	2.7	0	0	0	0	1	4
Station 1-6	Mid-channel	45.7	2.0	2.7	0	0	0	0	1	4
Average	Shoreline	41.1	1.7	--	9	8	4	<1	1	4
Average	Mid-channel	45.7	1.7	--	0	0	0	0	1	4

Reach 2										
Reach 2	Position	Average Width	Average Depth	Maximum Depth	Overhanging Vegetation[1]	Woody Debris[1]	Aquatic Vegetation[1]	Rock[1]	Substrate	Bank Composition
Station 2-1	Right Bank	51.2	2.1	2.6	46	9	<1	0	2	4
Station 2-2	Mid-channel	54.9	2.6	2.7	0	0	0	0	2	4
Station 2-3	Left bank	61.3	1.4	1.6	40	3	<1	0	2	4
Station 2-4	Right Bank	69.5	1.9	3.0	13	6	2	0	2	4
Station 2-5	Mid-channel	67.1	1.9	2.1	0	0	0	0	2	4
Station 2-6	Left bank	66.8	1.1	1.2	<1	0	2	0	2	4
Station 2-7	Right Bank	75.0	1.6	2.4	22	6	5	0	2	4
Station 2-8	Mid-channel	103.3	1.5	1.9	0	0	0	0	2	4
Station 2-9	Left bank	103.3	1.4	2.3	26	10	0	0	2	4
Average	Shoreline	72.5	1.6	--	25	6	2	0	2	4
Average	Mid-channel	75.1	2.0	--	0	0.0	0	0	2	4

[1] In all cases, the amount of cover provided by the above categories was visually estimated based on the percentage of the shoreline, out to a distance of 3 meters, that supported each of the various types of cover.

Table 4-1. Results of habitat mapping conducted in boat electrofishing stations, Mirabel Study Area, July 2000 (Concluded).

Reach 3										
Reach 1	Position	Average Width	Average Depth	Maximum Depth	Overhanging Vegetation[1]	Woody Debris[1]	Aquatic Vegetation[1]	Rock[1]	Substrate	Bank Composition
Station 3-1	Right bank	38.4	2.6	3.6	16	21	<1	12	1	3
Station 3-2	Mid-channel	48.5	1.8	2.5	0	0	0	0	1	4
Station 3-3	Left bank	45.1	1.1	2.1	14	6	0	0	1	4
Station 3-4	Right bank	58.5	1.5	1.7	31	8	0	0	2	4
Station 3-5	Mid-channel	53.0	1.1	1.1	0	0	0	0	2	4
Station 3-6	Left bank	20.1	1.7	3.1	4	2	0	0	2	5
Average	Shoreline	43.9	1.7	--	16	9	0	3	2	4
Average	Mid-channel	50.8	1.5	--	0	0	0	0	2	4

Reach 4										
Reach 1	Position	Average Width	Average Depth	Maximum Depth	Overhanging Vegetation[1]	Woody Debris[1]	Aquatic Vegetation[1]	Rock[1]	Substrate	Bank Composition
Station 4-1	Mid-channel	44.8	1.2	1.3	0	0	0	0	2	4
Station 4-2	Left bank	39.3	1.4	1.9	24	3	<1	0	2	4
Station 4-3	Right bank	39.3	1.9	2.3	6	20	8	1	2	3
Station 4-4	Mid-channel	37.5	1.4	1.5	0	0	1	0	2	3
Station 4-5	Left bank	39.3	.1	2.1	5	1	13	0	2	3
Station 4-6	Right bank	41.1	.4	2.8	8	12	15	4	2	3
Station 4-7	Mid-channel	43.9	.1	1.3	0	0	0	0	3	3
Station 4-8	Left bank	35.7	.6	2.4	<1	5	<1	7	3	3
Station 4-9	Right bank	28.3	0.9	1.3	6	4	41	0	3	4
Average	Shoreline	38.8	1.4	--	8	7	13	2	2	3
Average	Mid-channel	42.1	1.2	--	0	0	<3	0	2	3

[1] In all cases, the amount of cover provided by the above categories was visually estimated based on the percentage of the shoreline, out to a distance of 3 meters, that supported each of the various types of cover.

Table 4-2. Total number of fish captured during boat electrofishing sampling, Russian River, August 2000.

Species	Fish Status	Reach 1	Reach 2	Reach 3	Reach 4	TOTAL
Wild Steelhead	N	1	22	5	1	29
Hatchery Steelhead	I	0	19	7	4	30
Pikeminnow	N	5	37	25	35	102
Hardhead	N	20	143	154	123	440
Roach	N	4	22	70	100	196
Blackfish	N	15	0	2	0	17
Hitch	N	0	1	0	0	1
Tule Perch	N	82	41	56	108	287
Sucker	N	128	206	178	239	751
Sculpin	N	0	0	1	1	2
Smallmouth bass	I	104	331	429	358	1,222
Largemouth bass	I	16	7	1	1	25
Bluegill	I	63	10	5	4	82
Green sunfish	I	35	2	8	13	58
Redear sunfish	I	4	0	0	1	5
Crappie	I	4	0	0	0	4
Shad	I	11	38	14	10	73
Carp	I	13	5	7	14	39
Bullhead	I	1	1	2	2	6
Channel Catfish	I	0	0	0	1	1
TOTALS		507	885	964	1015	3,371

Table 4-3. Percentage composition of fish captured during boat electrofishing sampling, Russian River, August 2000.

Species	Reach 1	Reach 2	Reach 3	Reach 4	TOTAL
Wild Steelhead	0.20	2.49	0.52	0.10	0.20
Hatchery Steelhead	0.00	2.15	0.73	0.39	0.00
Pikeminnow	0.99	4.18	2.59	3.45	0.99
Hardhead	3.95	16.16	15.98	12.12	3.95
Roach	0.79	2.49	7.26	9.85	0.79
Blackfish	2.96	0.00	0.21	0.00	2.96
Hitch	0.00	0.11	0.00	0.00	0.00
Tule Perch	16.21	4.63	5.81	10.64	16.21
Sucker	25.30	23.28	18.46	23.55	25.30
Sculpin	0.00	0.00	0.10	0.10	0.00
Smallmouth bass	20.55	37.40	44.50	35.27	20.55
Largemouth bass	3.16	0.79	0.10	0.10	3.16
Bluegill	12.45	1.13	0.52	0.39	12.45
Green sunfish	6.92	0.23	0.83	1.28	6.92
Redear sunfish	0.79	0.00	0.00	0.10	0.79
Crappie	0.79	0.00	0.00	0.00	0.79
Shad	2.17	4.29	1.45	0.99	2.17
Carp	2.57	0.56	0.73	1.38	2.57
Bullhead	0.20	0.11	0.21	0.20	0.20
Channel Catfish	0.00	0.00	0.00	0.10	0.00
TOTAL	100.00	100.00	100.00	100.00	100.00

Table 4-4. Alpha Diversity Index for four sampling Reaches in the Mirabel Study Area, Russian River, August 2000.

	Reach 1	Reach 2	Reach 3	Reach 4
All Species	9.13	6.56	7.00	7.50
Minus Bottom Dwellers	8.46	5.98	5.88	5.82

Reaches 2, 3, and 4 had similar species compositions, with smallmouth bass, Sacramento sucker, and hardhead being the first, second, and third most abundant species, respectively. Russian River tule perch, California roach, and Sacramento Pikeminnow rank fourth, fifth, and sixth overall. In contrast, Sacramento suckers were the most abundance species in Reach 1, followed by smallmouth bass, tule perch, bluegill, green sunfish, and hardhead. The abundance of sunfish and tule perch, combined with the reduction in the percentage composition of hardhead and smallmouth bass, comprised the major difference in species composition between Reach 1 and the three upstream reaches.

4.3.2.2 Catch-per-unit-effort

Catch-per-unit-effort (CPUE) is a measure of a species relative abundance. It is also a way of comparing sampling sites where the effort exerted to capture fish is not equal (i.e., more effort is spent capturing fish at one station compared to another). The amount of effort spent at each site is dependent on several factors, including the number of fish present and the complexity of the habitat sampled. Unfortunately, the timer malfunctioned (dead battery) the first night of sampling. Therefore, comparisons of CPUE cannot be made on the six lowest sites in Reach #2. For this study, CPUE equals the average number of fish captured for every one-minute that the electrofishing unit was in operation at each site. Stations were separated into shoreline and mid-channel habitats, since species abundance and composition differ between the two.

Shoreline Stations: The CPUE varied widely between individual shoreline sampling stations within and between the Reaches. Catch-per-unit-effort ranged from 4.66 fish/minute at Station 1-1 to 21.09 fish/minute at Station 2-6 (Table 4-5 presents CPUE data by Reach, Appendix E provides a breakdown of the CPUE by stations within each Reach). For all shoreline-sampling stations combined, CPUE was similar between the three Reaches above the Dam (9.91 to 11.59 fish/minute). The CPUE at Reach #1 was lowest within the Study Area (6.05 fish/minute).

CPUE for predators followed a similar pattern at each station. For shoreline stations, CPUE was higher for pikeminnow and smallmouth bass as Reaches 2, 3 and 4, compared to Reach #1, while CPUE for largemouth bass was greater at Reach 1, compared to the three upstream Reaches (Table 4-5). CPUE at mid-channel stations was greatly reduced for all species (Table 4-6).

4.3.3 Steelhead

Both wild and hatchery steelhead were captured during the August 2000 sampling event. Wild steelhead were primarily concentrated in Reaches 2 and 3 (27 of 29 captured) (Table 4-2). Hatchery steelhead were similarly concentrated in Reach 2 and 3 (26 of 30 captured). One wild steelhead each was captured in Reaches 1 and 4, while four hatchery steelhead were captured in Reach 4, and none were captured in Reach 1.

Wild steelhead ranged in length from 90 to 215 mm FL (Figure 4-2. Appendix F presents length-frequency histograms for all species captured in each Reach). Four-year classes of steelhead were captured in 2000 (Figure 4-2). Steelhead averaged 109 mm FL (N = 8, all sites combined) in August of their first year (Age 0+) (Table 4-6). Age 1+, 2+ and 3+ steelhead averaged 143, 185.0, and 213 mm FL, respectively.

Table 4-5. Catch-Per-Unit-Effort in shoreline electrofishing stations, combined by Reach, Russian River, August 2000.

Species	Reach 1	Reach 2	Reach 3	Reach 4	Overall CPUE [1]
Wild Steelhead	0.00	0.12	0.03	0.01	0.03
Hatchery Steelhead	0.00	0.15	0.03	0.01	0.03
Pikeminnow	0.06	0.47	0.32	0.41	0.30
Hardhead	0.31	1.98	2.15	1.43	1.41
Roach	0.06	0.35	0.98	1.17	0.72
Blackfish	0.21	0.00	0.00	0.00	0.05
Hitch	0.00	0.00	0.00	0.00	0.00
Tule Perch	0.97	0.15	0.58	1.08	0.79
Sacramento sucker	1.01	1.86	1.11	1.91	1.45
Sculpin	0.00	0.00	0.01	0.01	0.01
Smallmouth bass	1.42	4.56	5.94	4.09	3.97
Largemouth bass	0.24	0.06	0.01	0.01	0.08
Bluegill	0.89	0.15	0.07	0.04	0.28
Green sunfish	0.51	0.03	0.11	0.15	0.22
Redear sunfish	0.06	0.00	0.00	0.01	0.02
Crappie	0.06	0.00	0.00	0.00	0.02
Shad	0.09	0.00	0.11	0.04	0.07
Carp	0.16	0.06	0.10	0.16	0.13
Bullhead	0.00	0.00	0.03	0.00	0.01
Channel Catfish	0.00	0.00	0.00	0.00	0.00
Total	6.05	9.91	11.59	10.53	9.58

Table 4-6. Catch-Per-Unit-Effort in mid channel electrofishing stations, combined by Reach, Russian River, August 2000.

Species	Reach 1	Reach 3	Reach 3	Reach 4	Overall CPUE [1]
Wild Steelhead	0.04	0.16	0.10	0.00	0.09
Hatchery Steelhead	0.00	0.08	0.16	0.08	0.10
Pikeminnow	0.04	0.16	0.06	0.00	0.07
Hardhead	0.00	0.08	0.03	0.03	0.07
Roach	0.00	0.00	0.00	0.00	0.02
Blackfish	0.04	0.00	0.06	0.00	0.03
Hitch	0.00	0.00	0.00	0.00	0.01
Tule Perch	0.63	0.72	0.48	0.44	0.53
Sacramento sucker	2.21	2.72	3.18	2.10	2.78
Sculpin	0.00	0.00	0.00	0.00	0.00
Smallmouth bass	0.33	1.44	0.23	0.22	0.50
Largemouth bass	0.00	0.00	0.00	0.00	0.00
Bluegill	0.11	0.00	0.00	0.00	0.03
Green sunfish	0.04	0.00	0.00	0.00	0.01
Redear sunfish	0.00	0.00	0.00	0.00	0.00
Crappie	0.18	0.00	0.00	0.00	0.05
Shad	0.00	0.32	0.19	0.19	0.36
Carp	0.07	0.00	0.00	0.00	0.03
Bullhead	0.04	0.00	0.00	0.06	0.04
Channel Catfish	0.00	0.00	0.00	0.03	0.01
Total	3.71	5.68	4.50	3.15	4.71

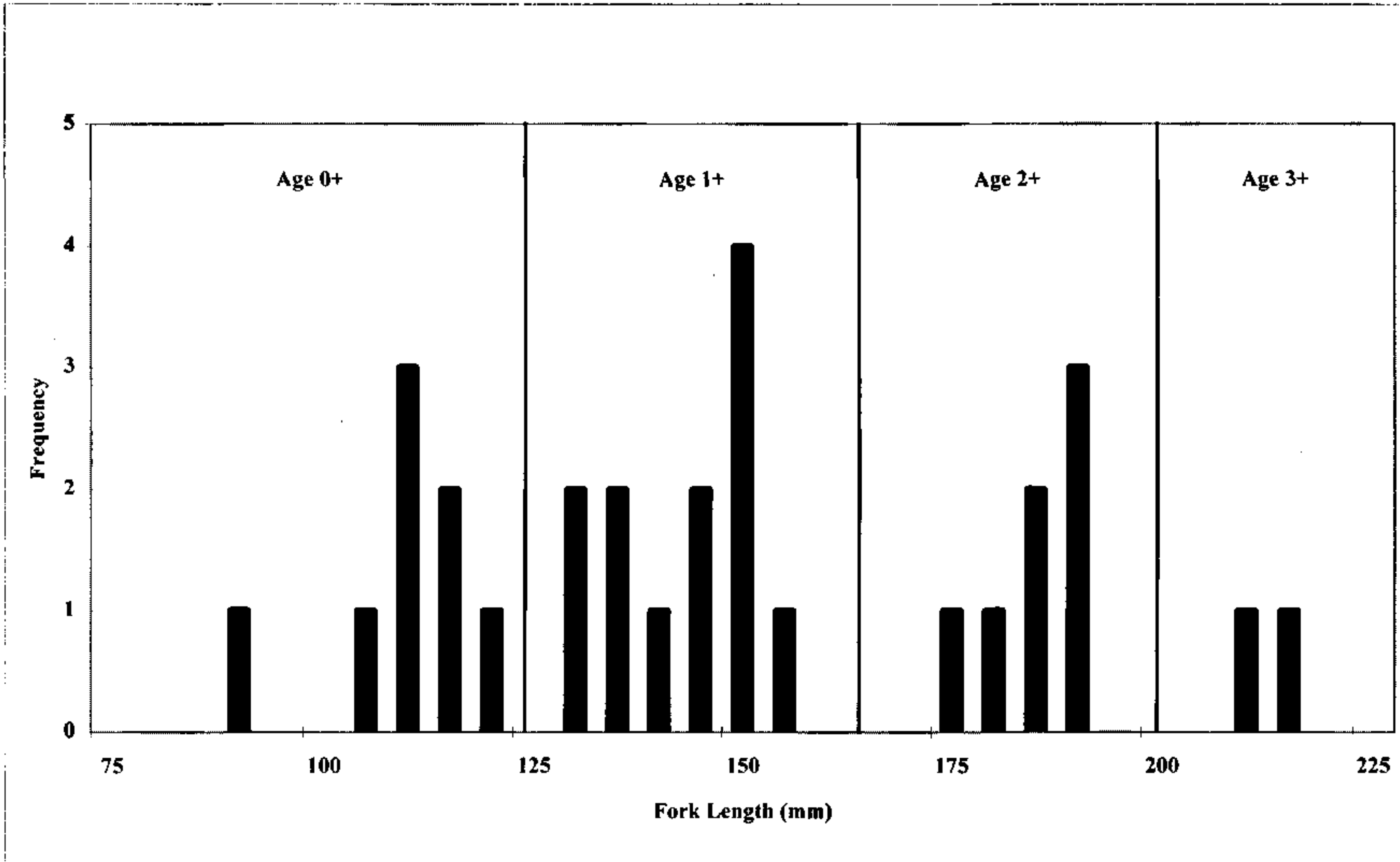

Figure 4-2. Wild juvenile steelhead length-frequency histogram, by age class (based on scale analysis), Mirabel Study Area, Russian River, all sites combined, August 2000 (N = 29).

4.3.4 Adult Predator Populations

Three potential predators of salmonids were captured during the study: Sacramento pikeminnow, smallmouth bass, and largemouth bass. In all, 40 percent (1,349) of all fish captured during electrofishing sampling fell in the predatory category. However, 85 percent (1,148) of the predators captured were young-of-the-year, and only 2.6 percent (35) of the predators were age 2+ or older (i.e., large enough to prey on juvenile salmonids).

4.3.4.1 Pikeminnow

Pikeminnow comprised 2.8 (N=102) percent of the fish captured in 2000 (Table 4-3). Within individual reaches, pikeminnow comprised between 1.0 (Reach #1) and 4.2 (Reach #2) percent of the populations. Seventy (69 percent) of the 102 pikeminnow captured were aged as young-of-the-year, and only eight fish (8 percent) were aged as two years old or more (Figure 4-3). Young-of-the-year pikeminnow were most abundant in Reach 4 (44.3 percent) and Reach 3 (32.9 percent). Young-of-the-year were least abundant in Reach #1 (4.3 percent). Pikeminnow large enough to prey on chinook smolts were found in the three upstream Reaches only. However, five of these fish were less than 300 mm FL (the size where fish become important in their diet) in August, and the smaller members of this group may have been too small to prey on chinook smolts during the salmonid emigration period. The three remaining pikeminnow ranged between 470 and 710 mm FL during August 2000, and are capable of consuming emigrating chinook and steelhead smolts. All three of the large pikeminnow were captured in Reach 4.

Based on the 1999 and 2000 electrofishing surveys, abundance of pikeminnow greater than 200 mm FL in the study area appears to be low (Table 4-7). In 1999, electrofishing was conducted in approximately the same locations as in 2000 (Chase *et al.* 2000b). During this survey, 13 pikeminnow were captured, three of which were large enough to prey on salmonid smolts. In spring of 2000, a spot electrofishing survey was conducted in an attempt to captured radio tagged steelhead smolts that remained in the Wohler Pool for an extended period of time (Manning *et al.* 2000). During the spring survey, two large pikeminnow were captured. Although all three studies were dissimilar in intent and design, the accumulative effort resulted in a relatively low number of pikeminnow captures in the study area. In total, 13 pikeminnow greater than 200 mm FL were captured during the three surveys combined.

Table 4-7. Total number of pikeminnow and total number of pikeminnow greater than 200 mm FL captured by boat electrofishing, three surveys combined.

Segment	Total number of Pikeminnow	Fork lengths of Pikeminnow > 200 mm	Number of Pikeminnow > 200 mm FL
Reach 1[1]	5	-	0
Reach 2[2]	41	240, 240	2
Reach 3	33	215, 255, 270, 385, 450, 530	6
Reach 4	40	470, 515, 525, 600, 710	5

[1] Station sampled in August 2000, only.
[2] Not sampled in spring of 2000.

Pikeminnow ranged in size from 35 to 710 mm FL (Figure 4-3). Pikeminnow averaged 138 mm FL (N = 24, all site combined) during August of their second year (age 1+), and 244 mm FL (N = 5, all sites combined) at age 2+ (Table 4-8). Thus, it appears that pikeminnow attain a size sufficient to prey on chinook salmon at the beginning of their third year of life (Age 2+). Pikeminnow aged as 4+ or older are large enough to prey on both chinook salmon and steelhead.

Pikeminnow can migrate long distances during their spawning migration (Harvey and Nakamoto 1999). Pikeminnow were observed moving upstream through the fish ladder in 2000 into the Wohler Pool (see section 5.0), possibly migrating to or from their spawning grounds. In addition, large pikeminnow were observed near the dam during early spring when smolts were present in the pool. Thus, additional sampling may be warranted during the spring salmonid emigration period to determine pikeminnow populations in the Study Area during this time-period.

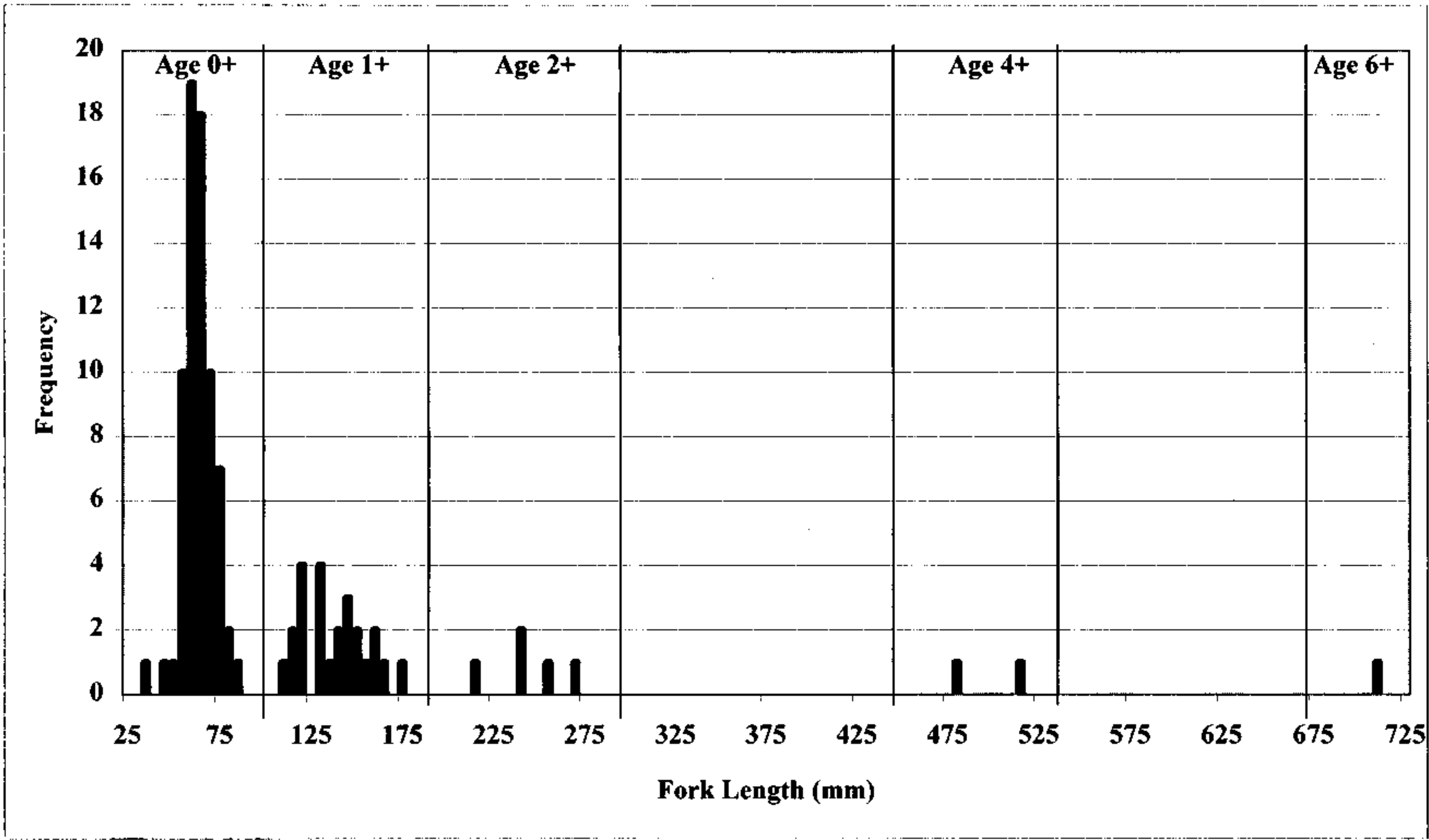

Figure 4-3 Pikeminnow length-frequency histogram, by age class (based on scale analysis), Mirabel Study Area, Russian River, all sites combined, August 2000 (N = 102).

Table 4-8. Average size and range by age class of Sacramento pikeminnow captured during boat electrofishing, August 2000, Russian River.

Segment	Average	Range	N =
Age 0+			
Reach 1	65	60-70	3
Reach 2	62	55-85	23
Reach 3	62	55-70	13
Reach 4	66	35-80	31
Overall	64	35-85	70
Age 1+			
	Average	Range	N =
Reach 1	138	130-145	2
Reach 2	138	115-175	12
Reach 3	140	110-165	9
Reach 4	120	120	1
Overall	138	110-175	24
Age 2+			
	Average	Range	N =
Reach 1	—	—	0
Reach 2	240	240	2
Reach 3	247	215-270	3
Reach 4	—	—	0
Overall	244	215-270	5
Age 3+			
	Average	Range	N =
Reach 1	—	—	0
Reach 2	—	—	0
Reach 3	—	—	0
Reach 4	—	—	0
Overall	—	—	0
Age 4+			
	Average	Range	N =
Reach 1	—	—	0
Reach 2	—	—	0
Reach 3	—	—	0
Reach 4	498	470-515	2
Overall	498	470-515	2
Age 6+ or older			
	Average	Range	N =
Reach 1	—	—	0
Reach 2	—	—	0
Reach 3	—	—	0
Reach 4	710	710	1
Overall	710	710	1

4.3.4.2 Smallmouth bass

Smallmouth bass comprised 34.4 percent (1,222) of the total catch during the August 2000 sampling event. Within individual reaches, smallmouth bass comprised between 20.5 (Reach 1) and 44.5 (Reach 2) percent of the fish captured. Approximately 87 percent of the smallmouth bass captured were aged as young-of-the-year, and 21 fish (1.7 percent) were age as two-years-old or more (Figure 4-4). Smallmouth bass were most abundant (based on CPUE) in Reach #3 (5.94 smallmouth bass/minute of sampling), followed by Reaches 2 and 4 (4.56 and 4.09 smallmouth bass/minute of sampling, respectively). Smallmouth bass were least abundant in Reach 1 (1.42 smallmouth bass/minute of sampling).

Overall, very few adult smallmouth bass were captured during the study (21 total). Relative abundance of adult smallmouth bass (Age 2+ and older) increased with distance upstream of the dam (Table 4-9). At Reach 1, one adult smallmouth bass was captured, compared to two, six, and twelve in Reaches 2, 3, and 4, respectively.

Smallmouth bass captured in August 2000 ranged in size from 50 to 370 mm FL (Figure 4-4). Smallmouth bass averaged 175 mm FL (N = 134, all site combined) during August of their second year (age 1+), and 252 mm FL (N = 17, all sites combined) at age 2+ (Table 4-9). Smallmouth bass likely attain a size sufficient to prey on chinook salmon at the beginning of their third year of life (Age 2 +). No smallmouth bass large enough to prey on age 1+ or older steelhead were captured.

4.3.4.3 Largemouth bass

Largemouth bass comprised 1.1 percent (26) of the catch during the August 2000 sampling event. Within individual Reaches, largemouth bass comprised between 0.1 percent of the catch in Reaches 3 and 4, to 3.2 percent in Reach 1. Eleven of the 26 largemouth bass were aged as 0+, and eight were aged as Age 2+ or older (Figure 4-5). Five of the eight adult largemouth bass (age 2+ or older) were captured in Reach 1, and one adult largemouth bass was captured in each of the three Reaches above the Inflatable Dam.

Largemouth bass appear to grow slower than smallmouth bass, possibly because of their thermal requirements (see Section 1.4.7). Largemouth bass captured in August 2000 ranged in length from 50 to 430 mm FL (Figure 4-5). Largemouth bass averaged 122 mm FL (N = 6, all sites combined) during August of their second year (age 1+), and 195 mm FL (N=5, all sites combined) during August of their third year (Age 2 +). Largemouth bass, based on their morphology, are able to feed on larger fish at a smaller size compared to smallmouth bass, thus, it is assumed that Age 2+ are large enough to feed on at least the smaller sized emigrating chinook smolts during the start of their third year (Age 2+).

4.4 SIGNIFICANT FINDINGS

Three species of fish (smallmouth bass, Sacramento sucker, and hardhead) dominated the fish community above the Inflatable Dam (Reaches 2, 3, and 4). The fish community in Reach #1 differed from the other Reaches by having a greater abundance of sunfish and tule perch, and a reduction in the abundance of smallmouth bass and hardhead. Wild and hatchery salmonids were collected primarily in Reaches 2 and 3 (Wohler Pool).

Three potential salmonid predators inhabit the study area, Sacramento pikeminnow, smallmouth bass, and largemouth bass. Pikeminnow were found in relatively low numbers. Although few adult pikeminnow were captured, they are capable of attaining a size large enough to feed on both chinook salmon and steelhead smolts. Smallmouth bass are the most abundant species inhabiting the study area. The majority of smallmouth bass captured were young-of-the-year, however. No smallmouth bass large enough to prey on steelhead smolts and very few smallmouth bass large enough to feed on chinook smolts were captured. It is not known if the low numbers of older smallmouth bass is due a high rate of mortality among YOY bass, or a high rate of dispersal by YOY bass to areas outside of the study area. Very few largemouth bass were captured. Abundance of largemouth bass was highest in Reach 1. All three predator species attain a size sufficient to prey on chinook salmonids by the start of their third year of life (age 2+).

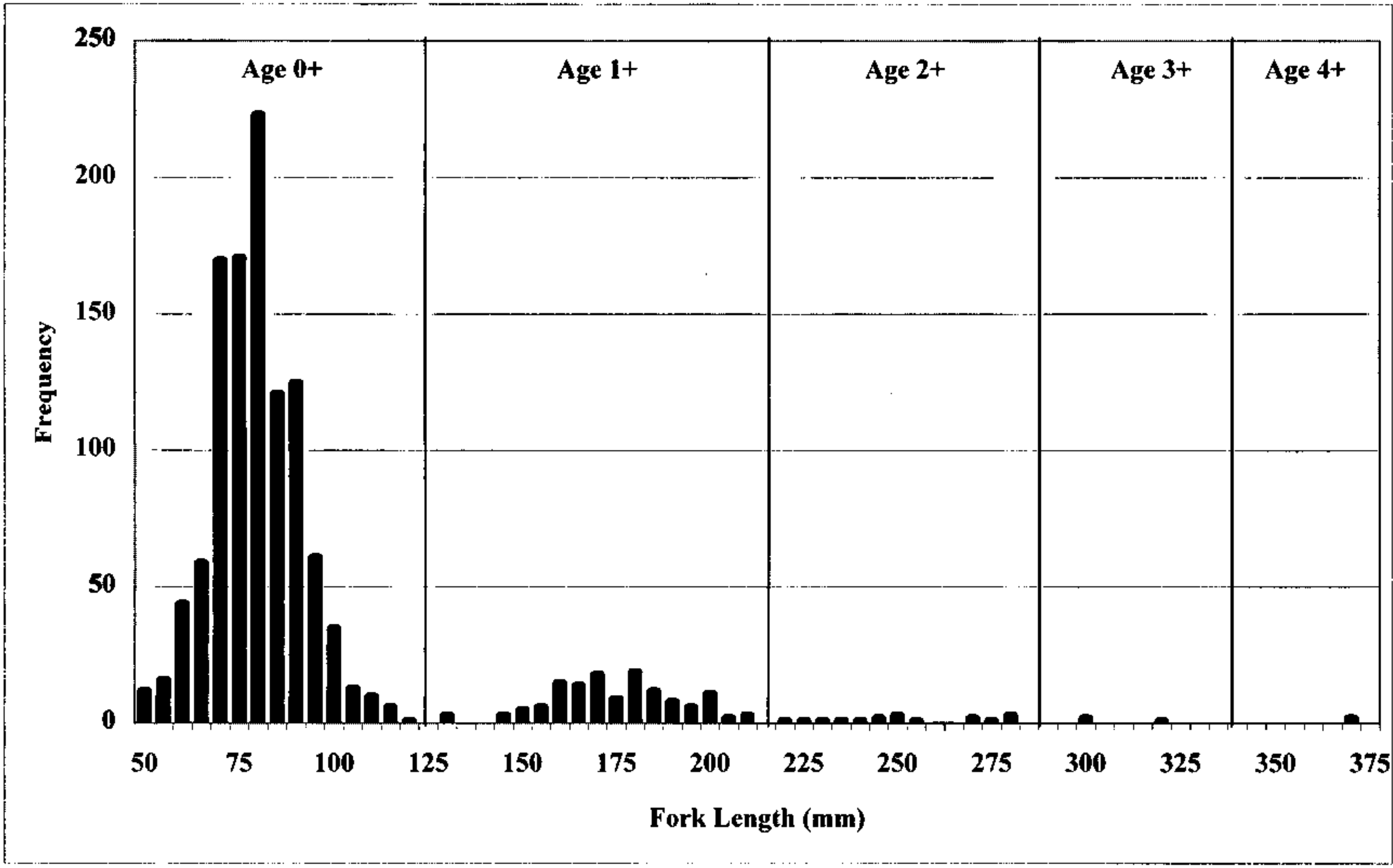

Figure 4-4 Smallmouth bass length-frequency histogram, by age class (based on scale analysis), Mirabel Study Area, Russian River, all sites combined, August 2000 (N = 1223).

Table 4-9. Average size and range by age class of smallmouth bass captured during boat electrofishing, August 2000, Russian River.

Age 0+			
Segment	Average	Range	N =
Reach 1	80	50-110	75
Reach 2	80	50-120	306
Reach 3	78	50-115	385
Reach 4	80	50-115	301
Overall	79	50-120	1,067

Age 1+			
	Average	Range	N =
Reach 1	174	145-210	28
Reach 2	178	130-205	23
Reach 3	173	130-200	38
Reach 4	176	130-210	45
Overall	175	130-210	134

Age 2+			
	Average	Range	N =
Reach 1	280	280	1
Reach 2	238	225-245	2
Reach 3	260	235-280	4
Reach 4	251	220-275	10
Overall	252	220-280	17

Age 3+			
	Average	Range	N =
Reach 1	—	—	0
Reach 2	—	—	0
Reach 3	300	300	2
Reach 4	320	320	1
Overall	307	300-310	3

Age 4+			
	Average	Range	N =
Reach 1	0	—	0
Reach 2	0	—	0
Reach 3	0	—	0
Reach 4	370	370	1
Overall	370	370	1

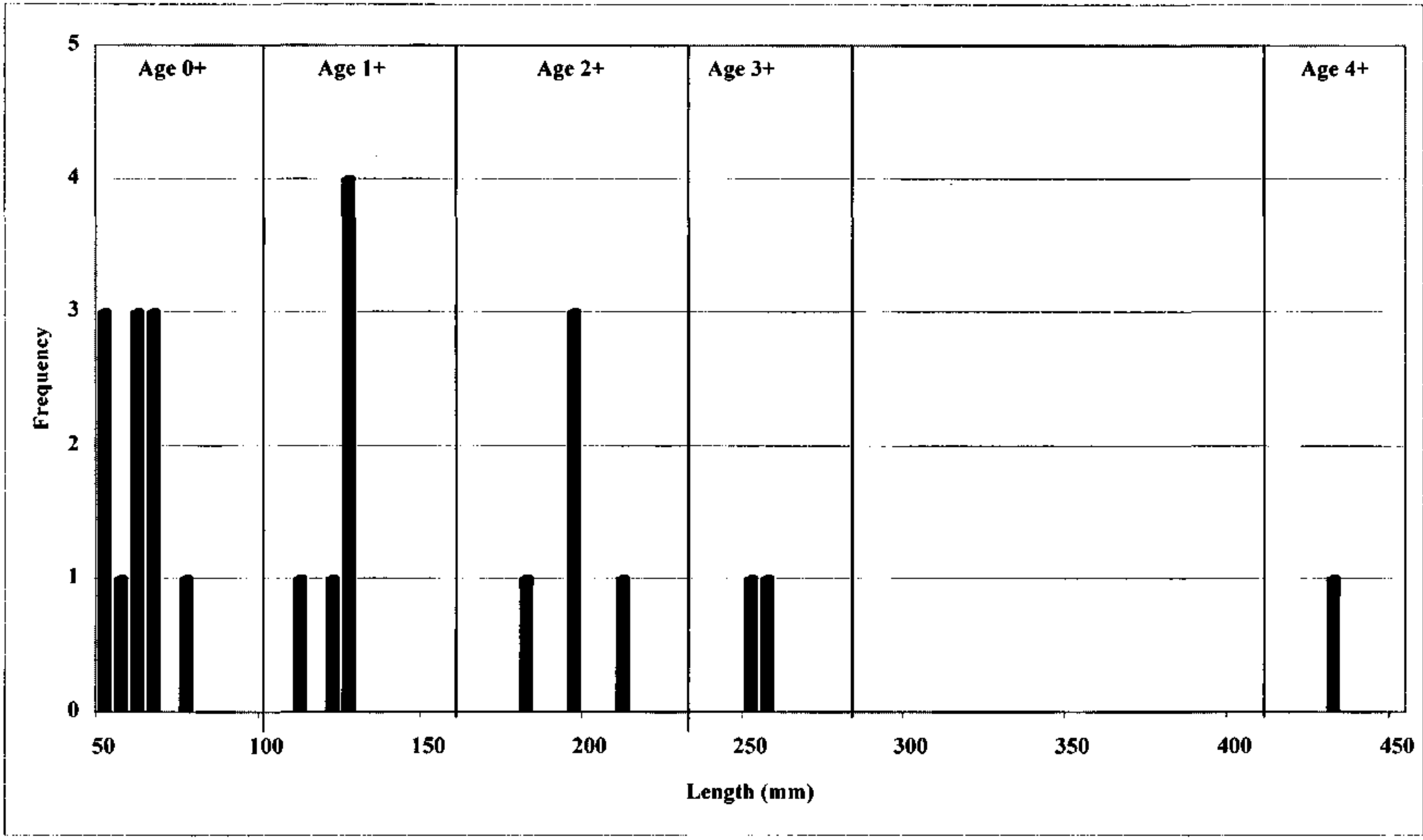

Figure 4-5 Largemouth Bass length-frequency histogram, by age class (based on scale analysis), Mirabel Study Area, Russian River, all sites combined, August 2000 (N = 25).

Table 4-10. Average size and range by age class of largemouth bass captured during boat electrofishing, August 2000, Russian River.

Age 0+			
Segment	Average	Range	N =
Reach 1	60	50-75	11
Reach 2			0
Reach 3	—	—	0
Reach 4	—	—	0
Overall	60	50-75	11

Age 1+			
	Average	Range	N =
Reach 1	—	—	0
Reach 2	122	110-125	6
Reach 3	—	—	0
Reach 4	—	—	0
Overall	122	110-125	6

Age 2+			
	Average	Range	N =
Reach 1	195	195	2
Reach 2	180	180	1
Reach 3	210	210	1
Reach 4	195	195	1
Overall	195	180-210	5

Age 3+			
	Average	Range	N =
Reach 1	253	250-255	2
Reach 2	—	—	0
Reach 3	—	—	0
Reach 4	—	—	0
Overall	253	250-255	2

Age 4+			
	Average	Range	N =
Reach 1	430	430	1
Reach 2	—	—	0
Reach 3	—	—	0
Reach 4	—	—	0
Overall	430	430	1

5.1 INTRODUCTION

The dam may be inflated during the salmon and steelhead upstream migration period. The Inflatable Dam is approximately 11-feet high when fully inflated, and may form a barrier to upstream migrating fish. The dam is equipped with two denil type fish ladders to provide for upstream passage, however, prior to this study, the effectiveness of the ladders had not been tested.

The main objective of this study was to verify that anadromous fish are able to ascend the fish ladders. A secondary objective assessed the timing of migration and relative numbers of anadromous fish utilizing the fish ladders while the dam was inflated. Several non-anadromous fish also passed through the fish ladders. Although several species of non-anadromous fish appeared at times to migrate both upstream and downstream through the fish ladders, at other times the fish entered and milled about (particularly Sacramento suckers) in the exit boxes, and it was often impossible to determine if there was any net upstream or downstream movements of these fish. Thus, counts of non-anadromous fish, excluding large pikeminnow and hardhead, were suspended after the first half of the study. Pikeminnow are a potential predator of juvenile salmonids that are known to migrate long distances during the spring spawning period. Counts were made of pikeminnow to determine their usage of the fish ladders. Hardhead were included because they are almost identical to pikeminnow in body shape, and the species could not be separated with a high degree of certainty in most cases. These fish were combined into the general category "large Cyprinids."

5.2 METHODS

Two methodologies were employed to evaluate fish passage through the fish ladders. Time-lapse video photography was used to document fish passage through the fish ladders. Direct (snorkel) observations were conducted to determine if large numbers of salmonids were holding below the dam.

5.2.1 Time-Lapse Video Photography

Adult salmonid passage through the fish ladders was assessed using underwater video cameras. The video system utilized at the fish ladders was designed specifically for this project. The system consists of two Sony™ ultra-high resolution monochrome video cameras with wide angle (105°) lenses housed in waterproof cases. The images captured by the cameras were recorded on two Sony S-VHS time-lapse videocassette recorders. The taped images were viewed on a Sony ultra-high resolution dual input monochrome monitor. Lighting for each video camera was provided by two 36 LED high intensity red illuminators in waterproof housings that were mounted directly onto the camera housings.

A square metal extension (exit box), measuring 4'x4'x7', was mounted to the upstream end of the each fish ladder. The exit boxes were smooth-sided, conformed to the sides of the fish ladders, and were designed such that the hydraulics of the ladders were not altered. To facilitate fish identification, a highly reflective background was attached to the back wall of the exit boxes. The cameras were mounted in custom manufactured boxes extending off the downstream side of the exit boxes. The boxes were constructed of 3/16" steel. A clear acrylic window was inserted between the exit boxes and the camera boxes. The cameras were in operation continuously while the dam was inflated.

The recording speed (number of images recorded per second) for the time-lapse photography was held constant, with only a few exceptions during the study. The time-lapse settings were set at one image recorded every 0.2 seconds, which equates to 24 hours coverage on a two-hour tape (on rare occasions the time-lapse setting was set on 0.6 seconds, or 72 hours to a two-hour tape). Every time the tapes were changed, the camera lens was cleaned with a soft rag, and the acrylic window and reflective background opposite the cameras were cleaned with a long handled squeegee.

Videotapes of the fish ladders were reviewed on high quality VCRs having a wide range of slow motion and freeze frame capabilities. When a fish was observed, tapes were reviewed frame by frame to determine the species and direction (upstream or downstream) of the fish. For each salmonid observed, the tape reviewer recorded the species (when possible), age class (juvenile or adult), direction (upstream or downstream), date, and time of passage out of the ladder. During periods of low visibility, it was not always possible to identify fish to species, although identification to Family (e.g., salmonidae) was often possible, and such fish were lumped into a general category called salmonid. All fish identified as an adult chinook salmon, steelhead, or salmonid were doubled checked by a senior biologist.

5.2.2 Direct Observation Surveys

Direct observation surveys were also conducted to determine if upstream migrants were present in the river below the dam. This was an important consideration because the observation of salmonids migrating through the ladder does not guarantee that all fish in the river are able to detect and ascend the ladder. Conversely, the lack of fish passing through the ladder may indicate a lack of fish in the river at that time, and not reflect the operation of the fish passage facilities. Direct observation (snorkel surveys) techniques were utilized to assess adult salmonid numbers below the dam. Survey teams consisted of two divers. The divers entered the river below the dam and searched for salmonids in the pool at the base of the structure.

5.3 RESULTS

Video monitoring and direct observation survey techniques demonstrated that adult salmon and steelhead were able to detect and ascend the fish ladders around the Inflatable Dam. Video monitoring provided conclusive evidence that salmonids plus a variety of other species were able to negotiate the ladders. Direct observation surveys were not as effective in determining if salmonids were delayed below the dam (that is, large numbers of fish holding below the dam prior to moving upstream through the fish ladders) as desired due to low water clarity. However, no large groups adult salmonid-sized fish were observed.

5.3.1 Video Monitoring

Video monitoring was conducted from May 12 through the morning of January 10, 2000. During this time-period, 432 videotapes were generated. Video monitoring was continuous throughout the study period with a few exceptions. On a few occasions, the end of a tape was reached prior to the tapes being changed, and on one occasion, the system malfunctioned, and one camera failed to record images for one day (Table 5-1).

Table 5-1. Dates that the video cameras were not in operation during the 2000 study period.

Camera	Dates of non-operation
B	May 12 through May 14
A	May 16 through May 23
A and B	July 4
A and B	September 23 and 24
A and B	November 17
A	December 8
A and B	December 20
A and B	December 25

Video monitoring demonstrated that adult chinook salmon, chum salmon, steelhead, Pacific lamprey, American shad, and pikeminnow are able to locate and ascend the Mirabel fish passage facilities. The total number of adult anadromous fish passing through the fish ladder can only be estimated from the data collected, however, owing to a few problems inherent in the current system. Turbidity was occasionally a problem, particularly during storm events, when turbidity levels occasionally increased to the point where the back wall of the exit boxes could not be observed, thus fish could have passed undetected. This is particularly troublesome because this limitation can only be minimally addressed by increasing the lighting in the exit boxes, and because salmon and steelhead tend to migrate during freshets which are associated with higher turbidity levels. However, the study objective was to determine if salmonids find and ascend the fish passage facilities, only. Data on the numbers of salmonids and the timing of upstream migration past the dam was a secondary objective. In addition, counts only represent numbers of fish migrating in the river during periods when the dam is inflated (mid-May to early-January in 2000).

5.3.2 Fish Counts

At least twelve species of fish were identified entering the fish ladders. Species observed included chinook and chum salmon, steelhead, Pacific lamprey, American shad, Sacramento pikeminnow, hardhead, Sacramento sucker, smallmouth bass, common carp, and channel catfish. Most of the non-anadromous species were noted as "milling about" in the exit boxes, as opposed to migrating upstream or downstream through the fish ladders. Detailed counts were made of anadromous fish and large Cyprinids (potential predators) only. These counts were broken out by species, with a general category defined as salmonid (fish could not be identified to species, but had identifiable characteristics (e.g., general body shape, adipose fin, etc.) of the family Salmonidae.

5.3.2.1 Salmonids

In 2000, 188 fish could be identified as a salmonid, but could not be identified to species (Table 5-2). Peak numbers of salmonids corresponded to peaks in the runs of chinook salmon and steelhead. Salmonids were partitioned into chinook or steelhead in an attempt to estimate the true number of each of these species observed in the fish ladders. Salmonids were partitioned by taking the percentage of chinook salmon to steelhead identified in the ladder each day, and multiplying the number of salmonids by these percentages. For example, on November 30, 36 chinook salmon, 8 steelhead, and 21 salmonids were identified in the fish ladders. Thus, 81 percent of the know fish (8/36) were identified as chinook and 19 percent were identified as steelhead. The number of salmonids was then multiplied by the percentage of chinook identified (21 times 0.81) to give an estimate of an additional 17 chinook salmon. The remaining four fish were classified as steelhead. Using this method, 123 of the salmonids were be classified as a chinook salmon, and the remaining 65 were classified as steelhead.

5.3.2.2 Chinook

In 2000, 1,322 chinook salmon were identified in the videos (Table 5-2). This number represents a minimum count for chinook salmon. One or both cameras did not record on five days during the chinook run, and on some days, turbidity levels reduced visibility to the point to the point where the back walls of the exit boxes could not be observed on the videotapes (as a result, some salmon may have migrated through the boxes undetected). However, the cameras were operated throughout the adult migration period (September through December), and usable images were recorded over approximately 95 percent of this time-period. Based on the results of video monitoring, a reliable "order-of-magnitude" estimate of the number of adult chinook salmon migrating through the Mirabel fish ladders in 2000, including salmonids reclassified above, is on the order of 1,500 fish.

The entire chinook salmon upstream migration period was monitored in 2000. Chinook salmon were observed in the fish ladders from August 24 through December 30, 2000, although only one chinook salmon was observed prior to September 7. The upstream migration increased slowly in September, with 6.7 percent of the chinook observed passing upstream by September 30 (Figure 5-1). The run peaked in late October, with 25 percent of the run passing by the 24th, and 56 percent of the run passing by the 30th. The run held strong through November (75 percent of the fish had passed upstream by November 20), and continued through the end of December, with the last fish observed on the 30th, 10 days prior to the end of video monitoring.

Table 5-2. Weekly counts of fish observed migrating upstream through the Inflatable Dam, 2000.

Date	Chinook	Chum	Wild Steelhead	Hatchery Steelhead	Unknown Steelhead	Unknown Salmonid	Pacific Lamprey	American Shad	Cyprinids
7-May	0	0	0	0	0	0	3	3	3
14-May	0	0	0	3	1	3	44	14	22
21-May	0	0	0	11	2	5	17	26	42
28-May	0	0	1	4	2	5	23	21	26
4-Jun	0	0	0	2	2	3	34	39	29
11-Jun	0	0	2	1	0	4	69	62	8
18-Jun	0	0	1	0	0	0	3	6	12
25-Jun	0	0	0	0	0	4	0	2	17
2-Jul	0	0	0	4	0	1	1	0	1
9-Jul	0	0	0	0	0	1	0	0	4
16-Jul	0	0	0	0	0	2	0	1	2
23-Jul	0	0	0	1	0	0	0	0	0
30-Jul	0	0	0	0	0	0	0	0	5
6-Aug	0	0	0	0	0	0	0	0	0
13-Aug	0	0	0	0	0	0	0	0	2
20-Aug	1	0	0	0	0	0	0	0	0
27-Aug	0	0	0	0	0	0	0	0	0
3-Sep	6	0	0	0	0	0	0	0	0
10-Sep	17	0	0	0	0	0	0	0	0
17-Sep	35	0	0	0	0	5	0	0	2
24-Sep	30	0	0	0	0	0	0	0	0
1-Oct	30	1	0	1	0	1	0	0	1
8-Oct	114	1	0	0	0	4	0	0	1
15-Oct	79	1	0	0	0	9	0	0	0
22-Oct	257	0	0	0	0	34	14	0	0
29-Oct	231	0	1	1	2	18	14	0	0
5-Nov	18	0	1	0	0	0	0	0	1
12-Nov	121	0	1	1	3	3	0	0	1
19-Nov	225	0	2	1	7	22	3	0	2
26-Nov	108	0	6	19	10	28	2	0	0
3-Dec	18	0	7	16	14	6	0	0	1
10-Dec	17	0	41	83	40	10	0	0	0
17-Dec	7	0	22	52	32	12	0	0	0
24-Dec	8	0	6	14	8	4	0	0	0
31-Dec	0	0	3	7	4	2	0	0	0
7-Jan	0	0	16	31	43	2	1	0	0
Totals	1,322	3	110	252	170	188	228	174	182

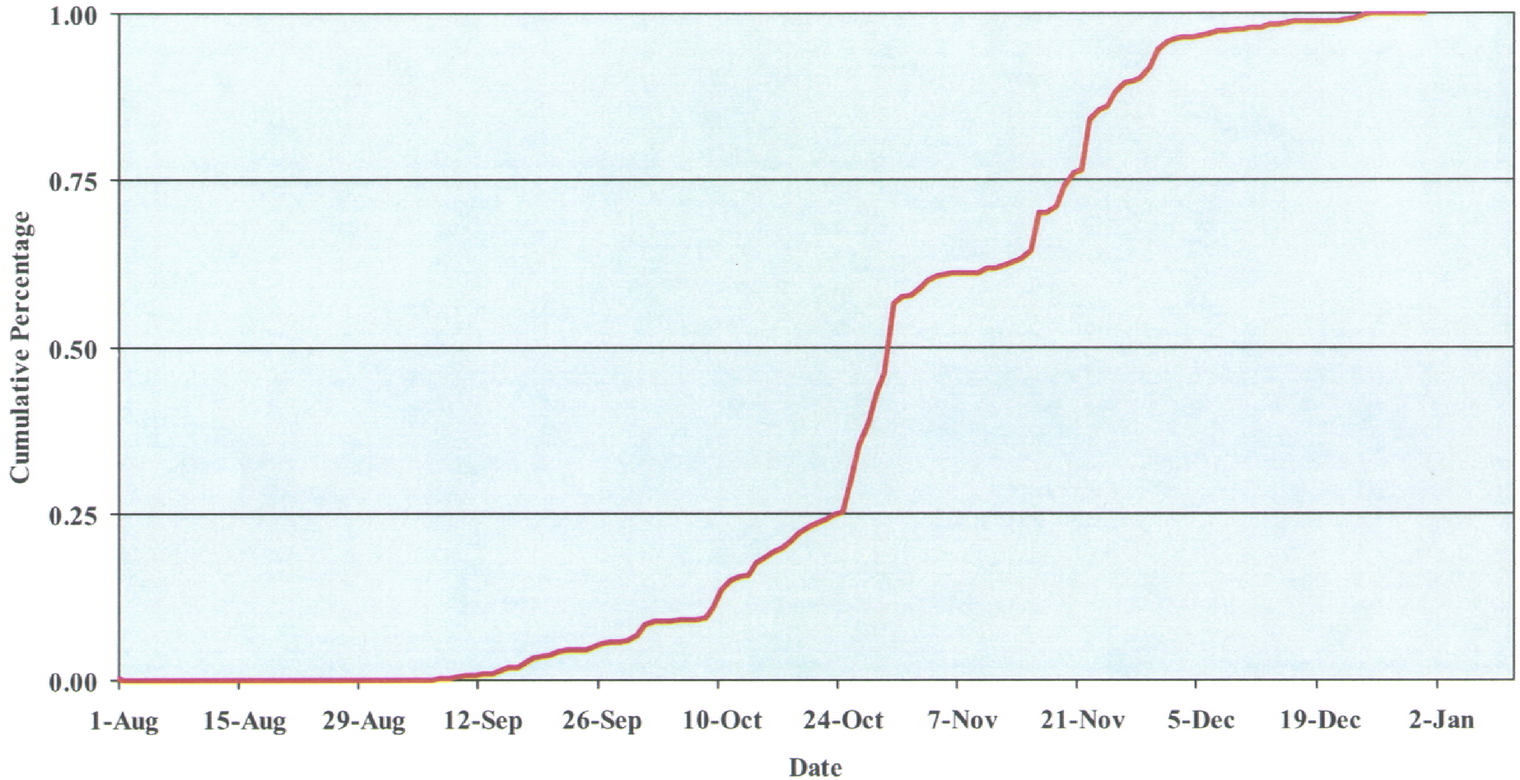

Figure 5-1. Timing of chinook salmon upstream migration through the Mirabel fish passage facilities, 2000 sampling season.

Chinook salmon were observed in the fish ladders at streamflows ranging from 132 to 555 cfs (Figure 5-2). A seven-day running average was used to evaluate streamflow conditions for chinook salmon upstream migration to the Inflatable Dam. During the 2000 upstream migration period (August 24 through December 30), the seven-day running average ranged from 141 to 369 cfs. Streamflows in this range apparently provide adequate conditions for adult chinook salmon to migrate through the lower Russian River.

Average daily water temperatures ranged from 20.4°C on August 24 (date the first chinook salmon was observed in the fish ladder) to 9.8°C during mid-November (Figure 5-3). Temperature on September 7 (the date that the run essentially began at the Inflatable Dam) was 19.5°C, and temperatures exceeded 20.0°C for seven consecutive days in mid-September. Thirty-six chinook were observed in the fish ladder during this time-period. The weekly average water temperature was 14.7°C during the peak of the chinook migration period (last week of October).

5.3.2.3 Chum

Chum salmon are found primarily in rivers north of California (Pauley *et al.* 1988, Moyle 1976), although small spawning populations may exist in some California rivers (Moyle 1976). The three chum salmon observed in the fish ladder were likely strays into the Russian River and do not represent a spawning population. The chum salmon migrated through the fish ladder between October 5 and October 21.

5.3.2.4 Adult steelhead

Winter run adult steelhead migrate to their spawning grounds from November through June, typically peaking between December and March. The dam is seldom inflated during much of this time period, as a result, the majority of the steelhead spawning migration occurs outside of the sampling period. The number of steelhead recorded in the fish ladders represents only those fish migrating when the dam was inflated, and cannot be used as an estimate of steelhead abundance. In 2000, 532 adult steelhead were observed in the fish ladders between May 15 and January 10 (Table 5-2). Steelhead were divided into three categories, wild fish (possessing an adipose fin), hatchery fish (adipose fin was clearly clipped), and unknown origin (could not be clearly determined if the adipose fin was clipped or not). Hatchery steelhead accounted for 70 percent of the adult steelhead that could be categorized as wild or hatchery (Table 5-2).

Adult steelhead were observed in the fish ladder in every month that the cameras were operated except August and September. The run of wild adult steelhead above the Inflatable Dam was essentially completed prior to the installation of the video cameras on May 6. After this date, four adult steelhead were identified as being wild. The numbers of steelhead identified in the ladders slowly increased during November, with relatively large numbers of steelhead migrating through the fish ladder beginning in December.

Steelhead were observed migrating upstream through the fish ladders at streamflows similar to those discussed for chinook salmon (figure 5-4). Adult steelhead were observed in the fish ladders when average daily temperatures exceeded 20.0°C on several occasions during the spring and early summer, with one fish ascending the ladder when the average daily temperature exceeded 24°C. However, water temperatures during mid-November when the upstream migration began in earnest ranged from approximately 10.0 to 12.0°C.

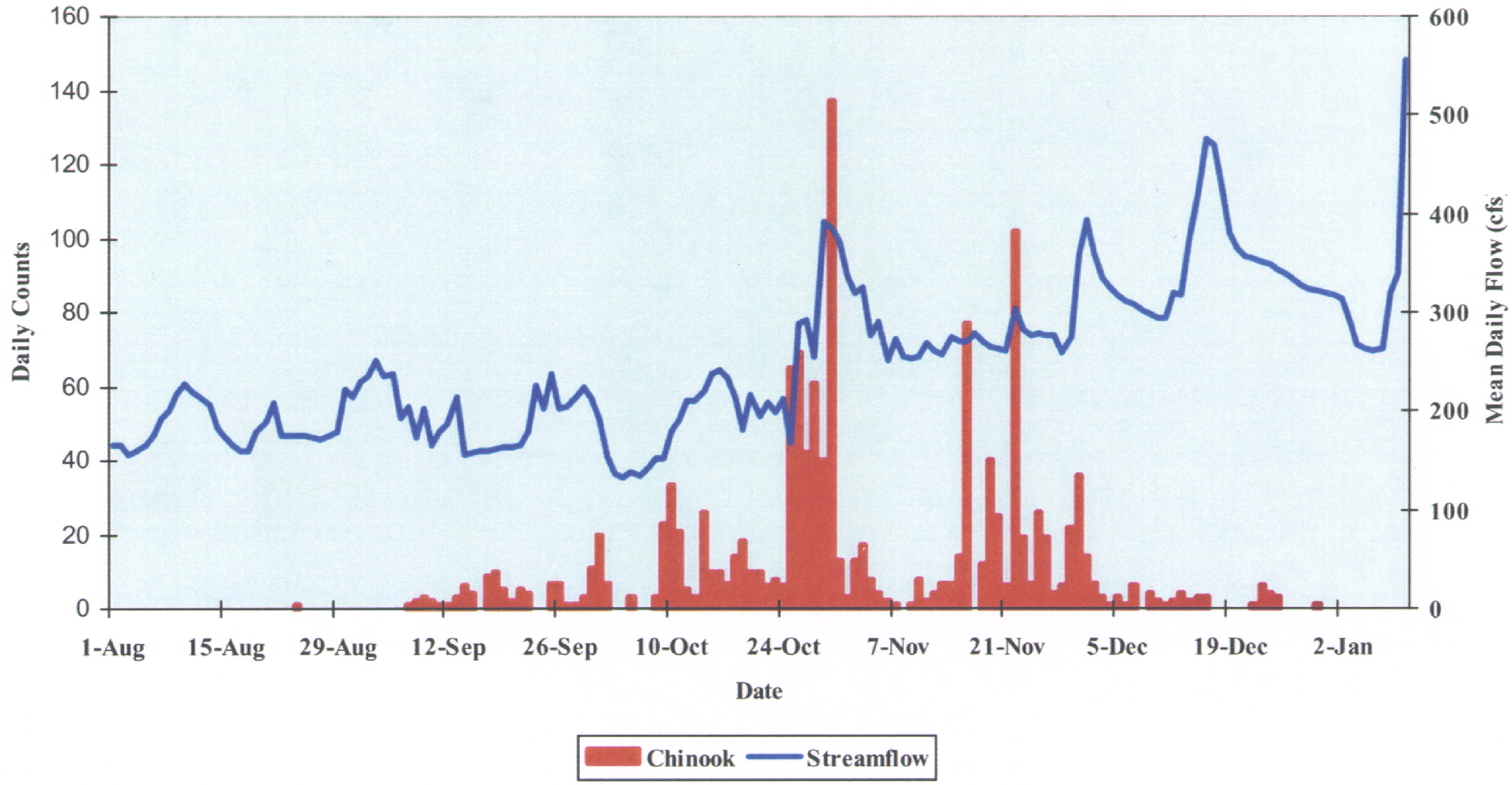

Figure 5-2. Daily counts of chinook salmon recorded during video monitoring and Mean daily streamflow recorded at Hacienda Bridge, 2000

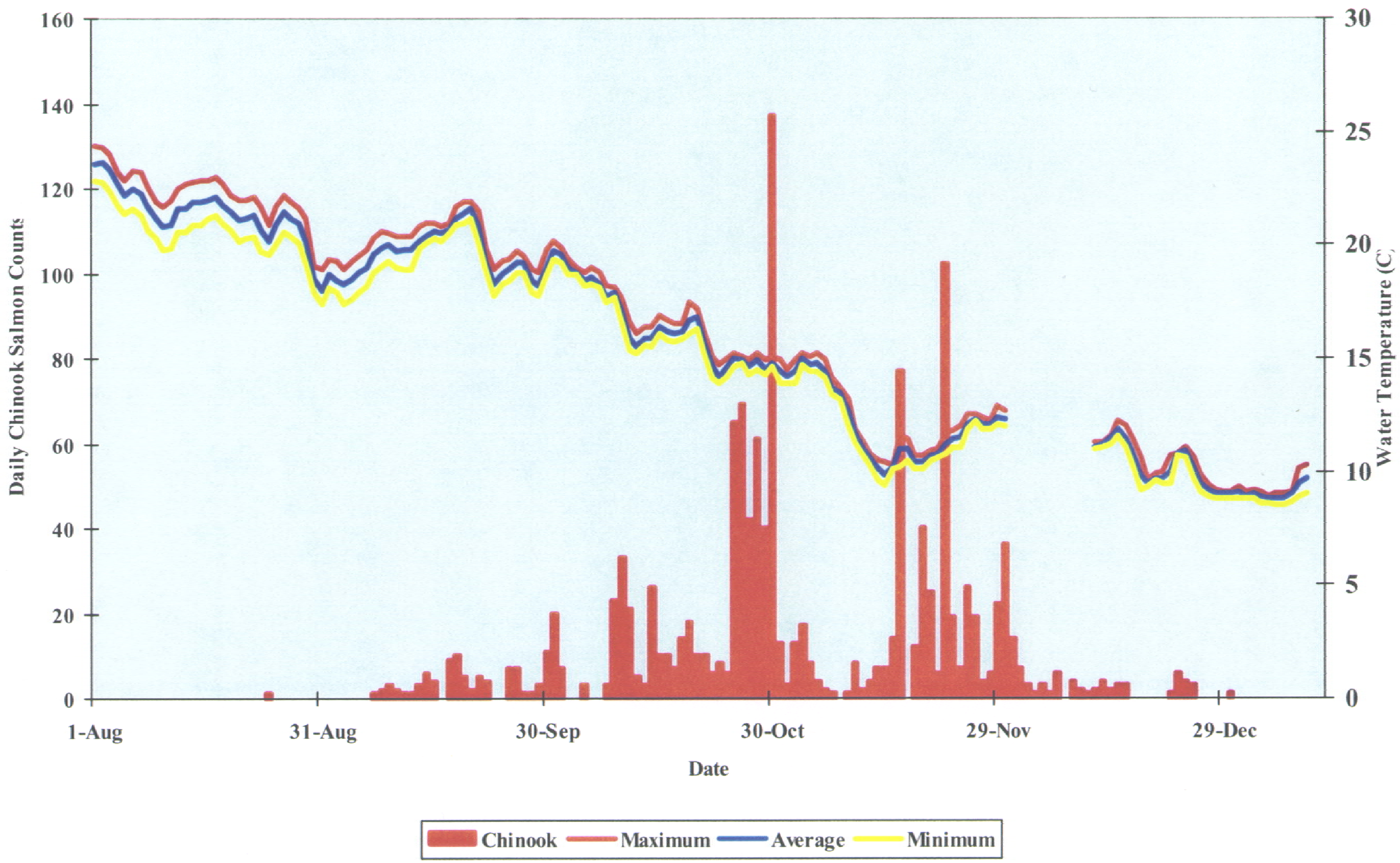

Figure 5-3. Daily counts of chinook salmon recorded during video monitoring and daily maximum, average, and minimum water temperatures recorded at the Inflatable Dam, 2000.

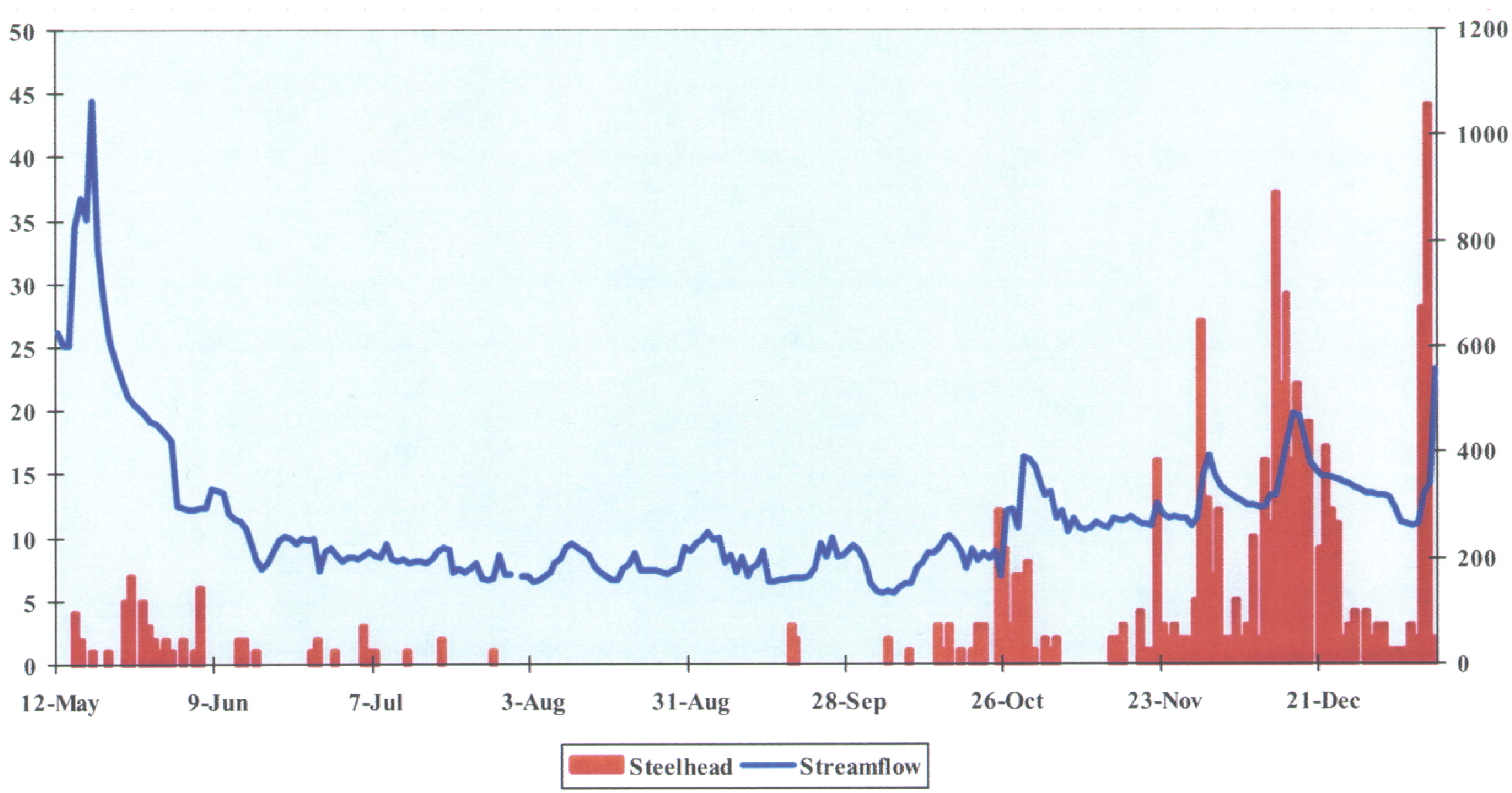

Figure 5-4. Daily counts of steelhead recorded during video monitoring and Mean daily streamflow recorded at Hacienda Bridge, 2000

5.3.2.1 Juvenile steelhead

Wild, hatchery, and smolts of undetermined origin were observed passing through the fish ladder throughout the sampling season (Table 5-3). In addition, several steelhead smolts were observed entering the exit boxes "milling about" and leaving the box in the same direction from which it originally entered. Since it was possible that at least some of the observations were the same fish passing upstream and downstream repeatedly through the boxes, it was not possible to estimate the number of fish moving past the dam during the year. The data does indicate that at least a few juvenile steelhead inhabit the Russian River in the vicinity of the Mirabel Dam throughout the summer.

Table 5-3. Number of steelhead smolts[1] observed passing upstream or downstream through the fish ladders by month.

	Wild smolts		Hatchery smolts		Undetermined smolts	
Month	UP	DOWN	Up	Down	Up	Down
May	4	1	19	0	29	6
June	23	18	124	8	21	7
July	13	29	38	10	26	3
August	4	3	36	23	18	1
September	0	0	6	6	26	11
October	0	0	2	0	13	1
November	1	0	1	1	9	13
December	1	6	4	3	67	35
January	0	0	11	23	38	45
Total	46	57	241	74	247	128

[1] Smolts were designated as wild if the adipose fin was readily apparent, and as hatchery if the adipose fin was obviously missing. If the presence or absence of the adipose fin could not be ascertained with certainty, the smolts origin was categorized as undetermined.

5.3.2.5 Pacific lamprey

In northern California rivers, Pacific lamprey migrate upstream to spawn between April and July (Moyle 1976, Wang 1986), although in the Trinity River, Moffett and Smith (1950, cited by Moyle 1976) reported lamprey migrating upstream in August and September. In 2000, 228 Pacific lamprey were observed in the fish ladders, primarily in May and June (Table 5-2). Interestingly, a small number of Pacific lamprey were also observed migrating upstream through the fish ladders in October and November. The average weekly water temperature ranged between 16.2 and 22.8°C during the spring migration period. During the apparently brief fall upstream migration period, the average weekly water temperatures were <14.6°C.

5.3.2.6 American shad

CDFG (1978) reported that American shad migrate upstream in the Russian River between the first-week of April through early August, although peak numbers of upstream migrants occur in May and early June. American shad are known to have difficulties ascending some types of fish ladders. Still, 174 shad were observed migrating upstream through the Mirabel fish ladders in 2000 (Table 5-2). However, no studies were conducted to determine how many shad migrated to the base of the dam so it is not possible to assess the impacts of the dam on American shad (shad are not native to the Russian River and are not a primary species of concern). The weekly average water temperature during the American shad upstream migration period ranged from 16.2 to 22.8°C. Water temperature during the peak of the observed migration was 21.1°C.

5.3.2.7 Large Cyprinids

Large Cyprinids (pikeminnow and hardhead approximately 250 mm or larger) were observed in the fish ladders throughout the study period (182 total). The majority (86 percent) of these observations occurred between the third week of May and the last week of June (Table 5-2). There are several species that have a body shape similar to pikeminnow, therefore, it is possible that some of the fish in this category are not pikeminnow. However, the large number of non-anadromous fish migrating through the fish ladders demonstrates that the dam likely does not form a barrier to upstream or downstream movement of these species.

5.3.3 Direct Observation Surveys

Five direct observation surveys were conducted in 2000. One survey was conducted each month from June through October. Visibility ranged from three to seven feet during surveys. Six species of fish were observed during surveys, including steelhead, hardhead, Sacramento sucker, smallmouth bass, and green sunfish, and carp. Steelhead observed included seven juvenile (parr), one hatchery smolt, and three steelhead between approximately 35 and 46 cm. One adult chinook salmon was observed jumping at the dam just prior to initiation of the October 19 survey. However, no chinook salmon were subsequently observed.

Snorkel surveys were generally found to be unreliable in determining if small numbers of chinook and/or steelhead adults were holding downstream of the dam. Poor water clarity and an increase in bubbles (entrained air) below the dam limited the usefulness of these surveys. During November, streamflow in the river increases (through increased rainfall or a reduction in water diversion. The increase in flow pouring over the dam increased turbulence and the entrainment of air in the water forming a sizable "bubble curtain" that further limited visibility. However, no other suitable sampling methods were identified during the study. Other methods available to sample fish below the dam include various fish traps. Traps would require the capture and handling of adult salmonids, which may be stressful to the fish. Based on the large numbers of adult salmon and steelhead observed in the fish ladder in 2000, it is recommended that direct observation surveys be suspended.

5.4 SIGNIFICANT FINDINGS

Based on the results of video monitoring, chinook salmon and steelhead appear to have little problem finding and ascending the fish ladders around the Inflatable Dam. Relatively large numbers of adult fish of both species have been documented successfully negotiating the ladders, and large numbers of fish milling at the base of the dam have not been observed. However, a satisfactory method of assessing fish populations at the base of the dam has not been identified. Direct observation (snorkel) surveys were limited by visibility which tends to deteriorate in November when chinook and steelhead are most likely to be present in large numbers.

The entire chinook salmon run was monitored for the first time on the Russian River in 2000. The number of chinook salmon spawning in the Russian River was far larger than previously thought, with an estimated run on the order of 1,500 fish migrating above the Inflatable Dam. The chinook run essentially began in early September, peaked in late November, and ended in late December. In 1999, the first adult chinook salmon was observed in the fish ladder on August 26, and 16 adults were observed migrating through the fish ladder prior to the second week of October. The run peaked (in terms of the number of fish counted in 1999) during the last week of October. However, the dam was deflated on November 16, prior to the end of the 1999 run.

Steelhead began their upstream migration in late October, however, the majority of their run occurs after the dam is deflated. A few adult steelhead were observed in the spring and early summer, although only four of these fish were wild.

Weekly average water temperature during the first five weeks of the chinook salmon upstream migration period ranged from 18.5 to 21.2°C. During the peak of the run, the weekly average water temperature was 14.6°C. Few adult steelhead were observed prior to November when water temperatures were ≤12.3°C.

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APPENDIX A

Common water temperatures found in the study area in Celsius and Fahrenheit

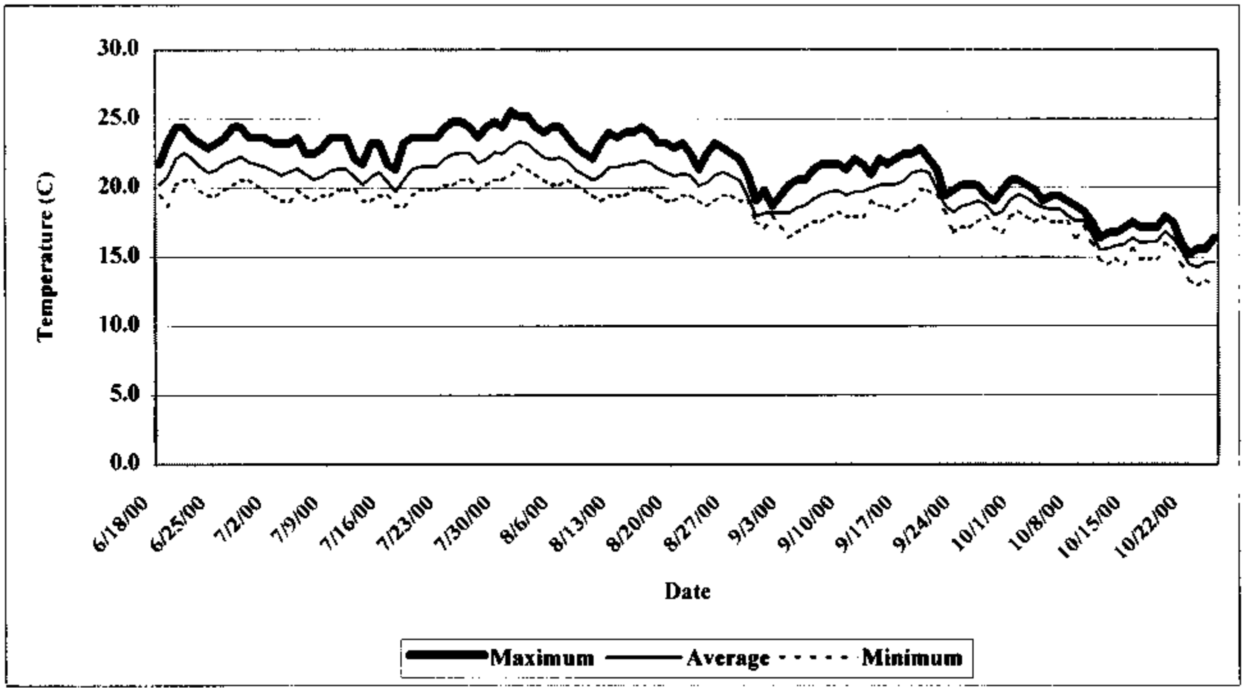
Appendix A. Common water temperatures found in the study area in °Celsius and °Fahrenheit.

°C[1]	°F
5.0	41.0
6.0	42.8
7.0	44.6
8.0	46.4
9.0	48.2
10.0	50.0
11.0	51.8
12.0	53.6
13.0	55.4
14.0	57.2
15.0	59.0
16.0	60.8
17.0	62.6
18.0	64.4
19.0	66.2
20.0	68.0
21.0	69.8
22.0	71.6
23.0	73.4
24.0	75.2
25.0	77.0
26.0	78.8
27.0	80.6
28.0	82.4
29.0	84.2
30.0	86.0

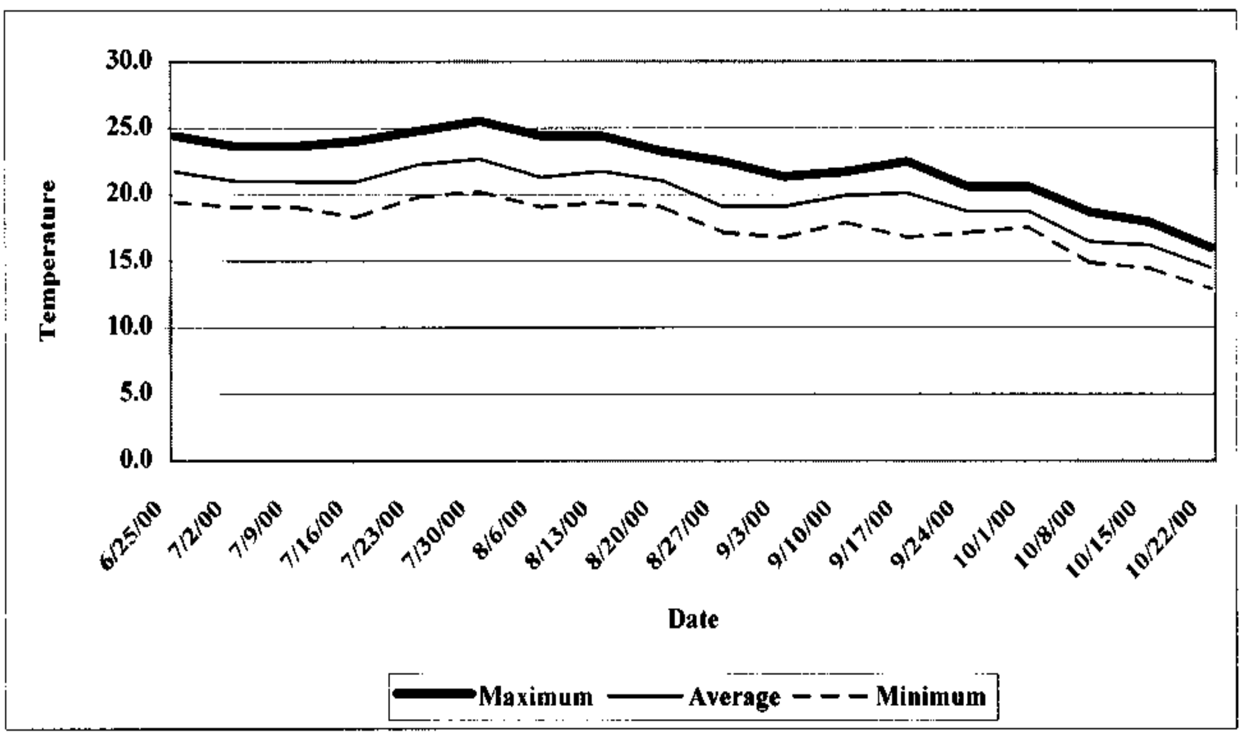
[1] The formula to convert °C to °F is:
(°C X 1.8) + 32

APPENDIX B-2

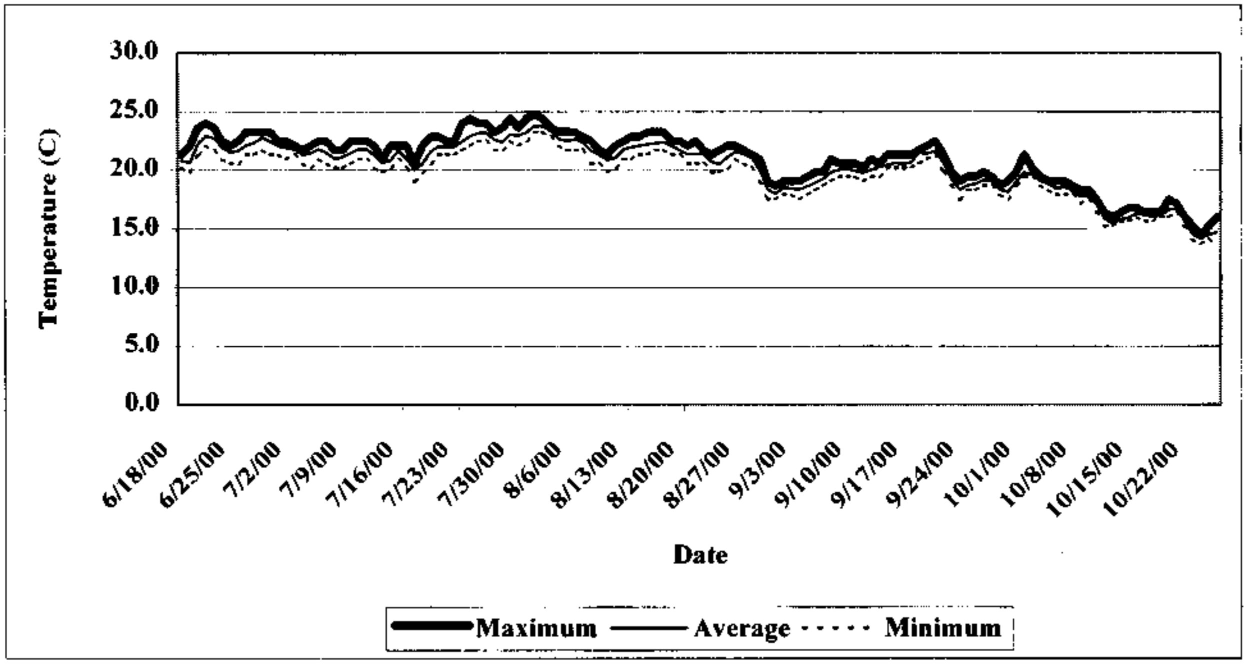
GRAPHS OF DAILY MAXIMUM, AVERAGE, AND MINIMUM WATER TEMPERATURES RECORDED NEAR THE RIVER'S SURFACE AND THE DEEPEST POINT AT EACH SAMPLING **Station within the Mirabel Study Area, 2000 Sampling Season**



Appendix B-2. Daily maximum, average, and minimum water temperatures recorded at a depth of 0.5 meters, Station #2, Mirabel Study Area, Russian River, June 18 through October 25,2000.

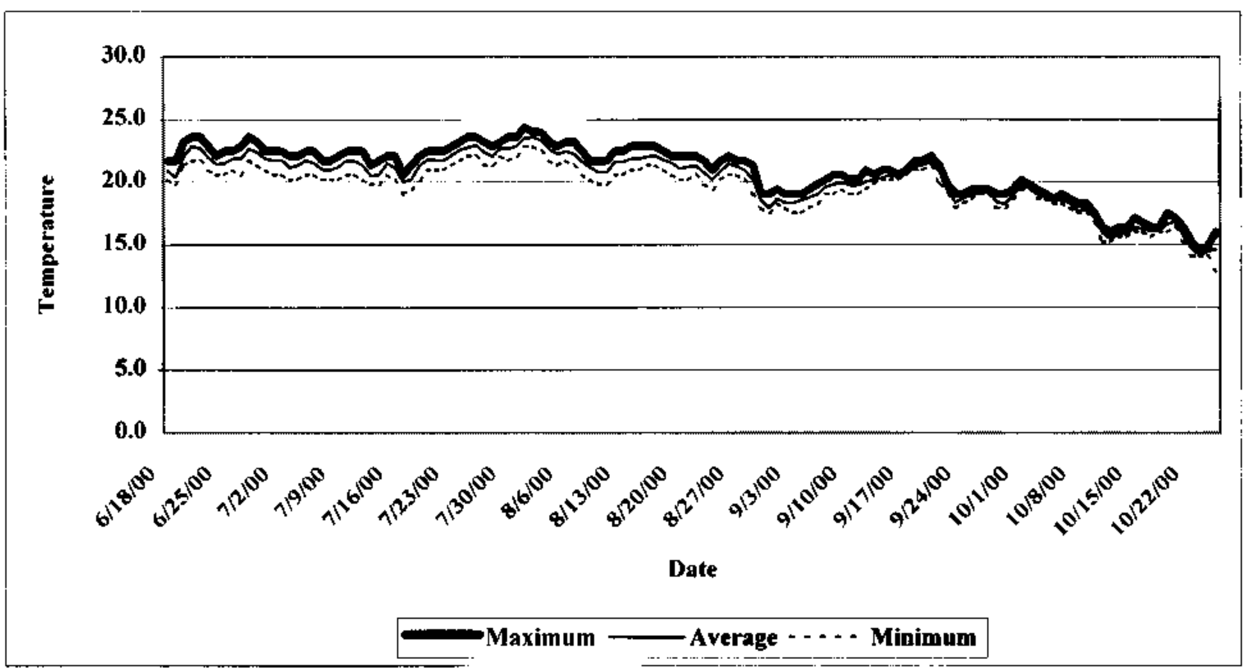


Appendix B-2. Daily maximum, average, and minimum water temperatures recorded at a depth of 4.0 meters, Station #2, Mirabel Study Area, Russian River, June 18 through October 25, 2000.

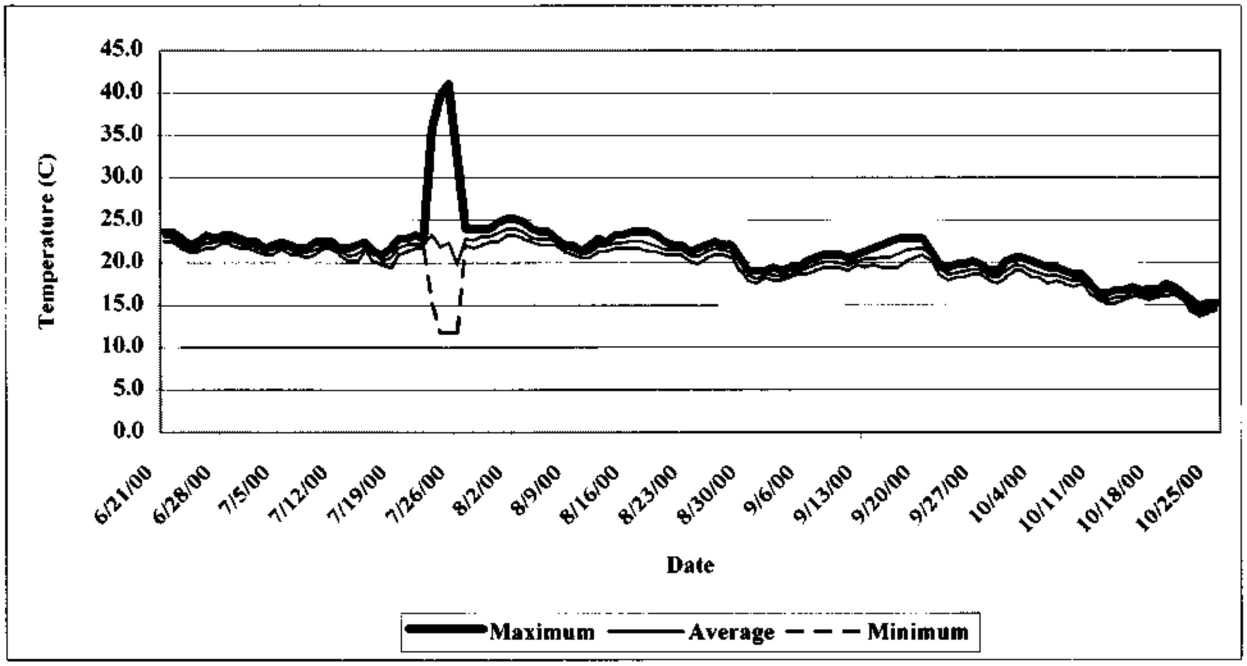


Appendix B-2. **Daily maximum, average, and minimum water temperatures recorded at a depth of 0.5 meters, Station #4, Mirabel Study Area, Russian River, June 18 through October 25,2000.**

Appendix B-2. Daily maximum, average, and minimum water temperatures recorded at a depth of 3.0 meters,

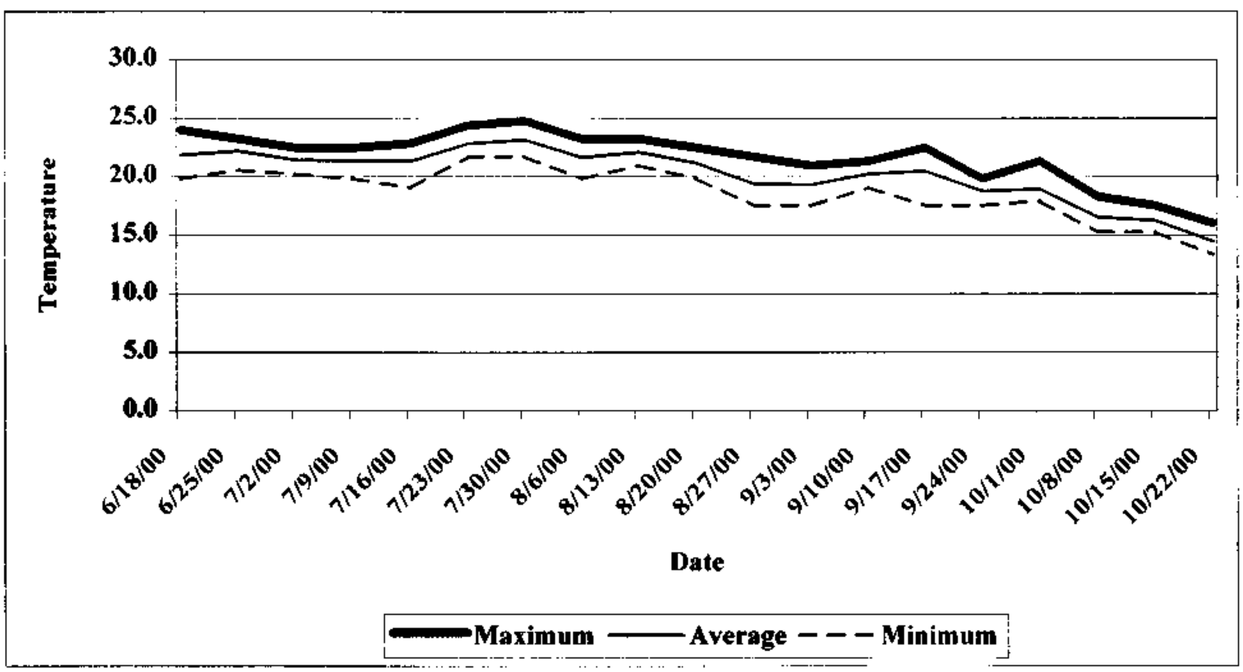


Station #4, Mirabel Study Area, Russian River, June 18 through October 25,2000.



Appendix B-2. Daily maximum, average, and minimum water temperatures recorded at a depth of 0.5 meters, Station #5, Mirabel Study Area, Russian River, June 18 through October 25, 2000.

Appendix B-2. Daily maximum, average, and minimum water temperatures recorded at a depth of 2.0

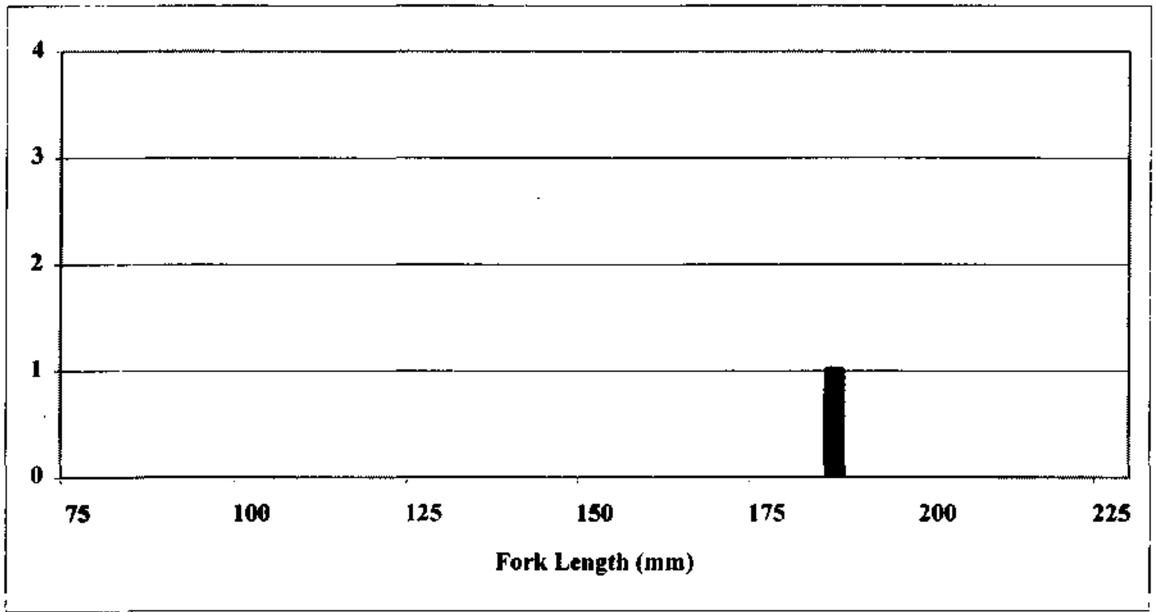


meters, Station #5, Mirabel Study Area, Russian River, June 18 through October 25,2000.

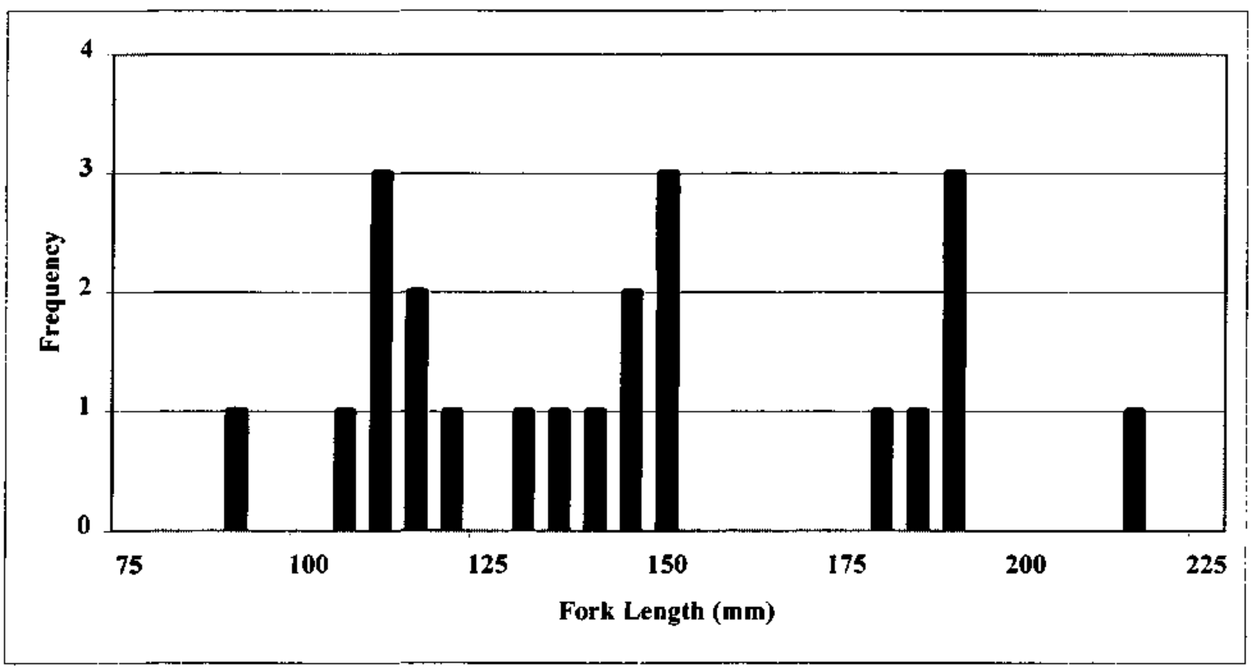
APPENDIX F

LENGTH-FREQUENCY HISTOGRAMS FOR EACH SPECIES BY REACH COLLECTED DURING BOAT ELECTROFISHING SAMPLING, AUGUST 2000, MIRABEL STUDY AREA

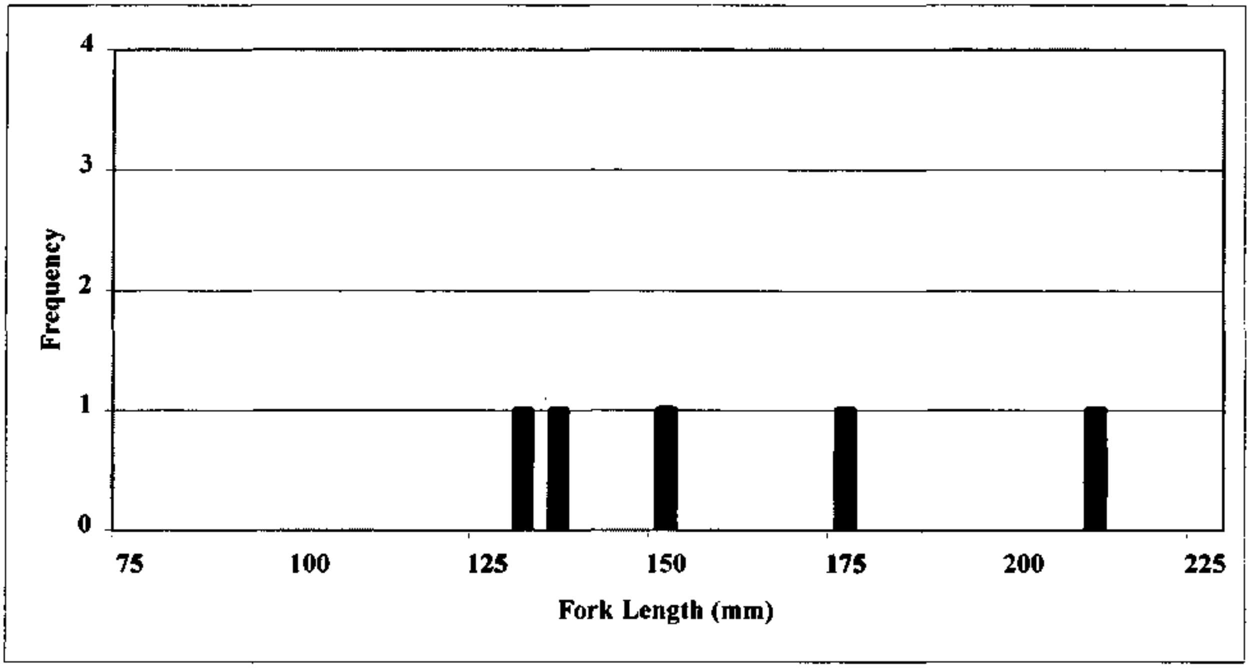
(FOR SPECIES WITH LESS THAN 10 INDIVIDUALS COLLECTED, RESULTS ARE PRESENTED IN TABLE FORMAT AT THE END OF THE APPENDIX)



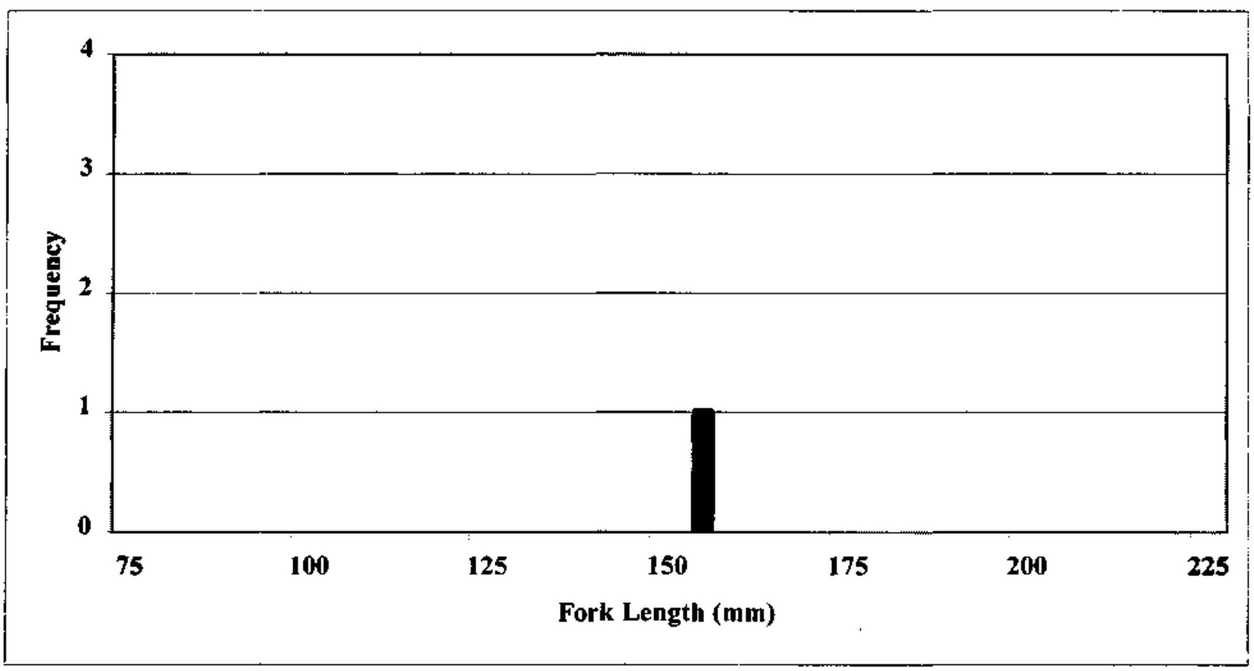
Appendix F. **Wild steelhead length-frequency histogram, Reach 1, August 2000**



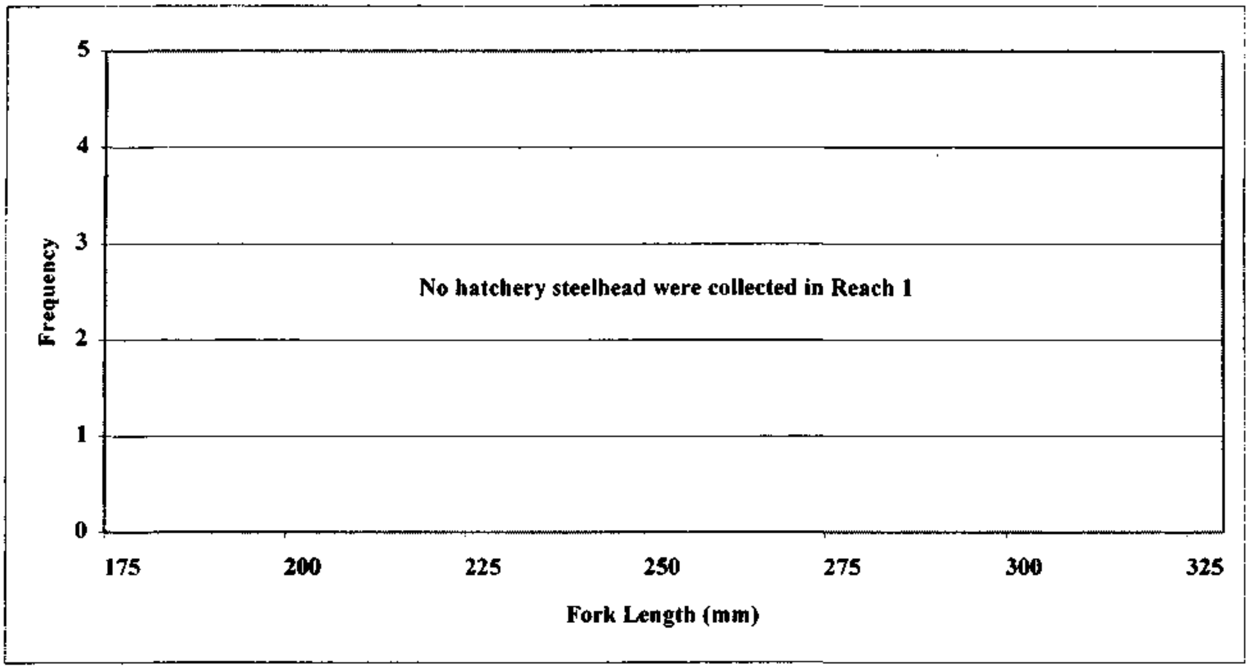
Appendix F. **Wild steelhead length-frequency histogram, Reach 2, August 2000**



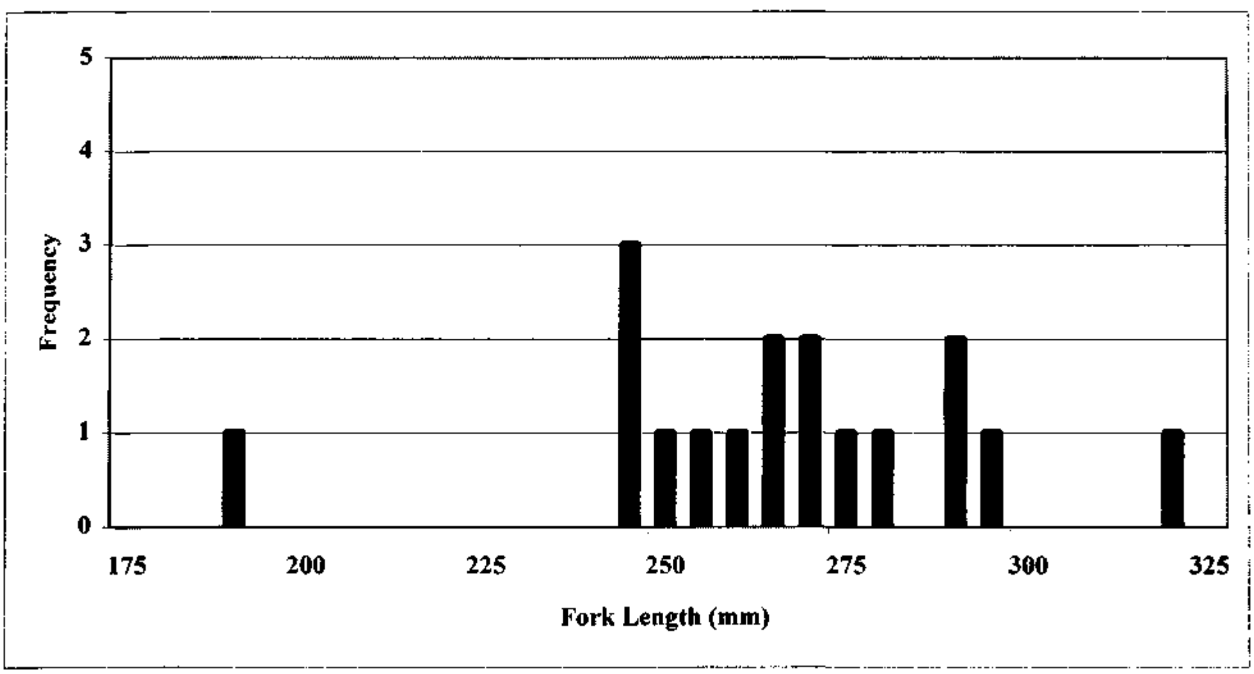
Appendix F. **Wild steelhead length-frequency histogram, Reach 3, August 2000**



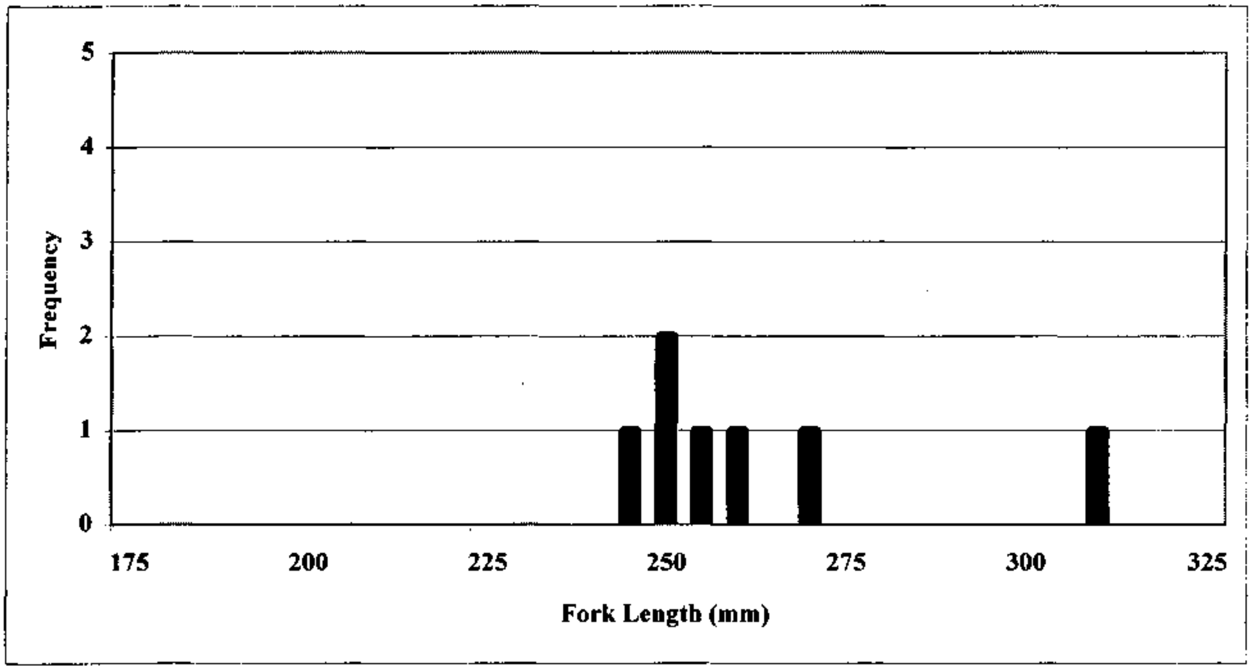
Appendix F. **Wild steelhead length-frequency histogram, Reach 4, August 2000**



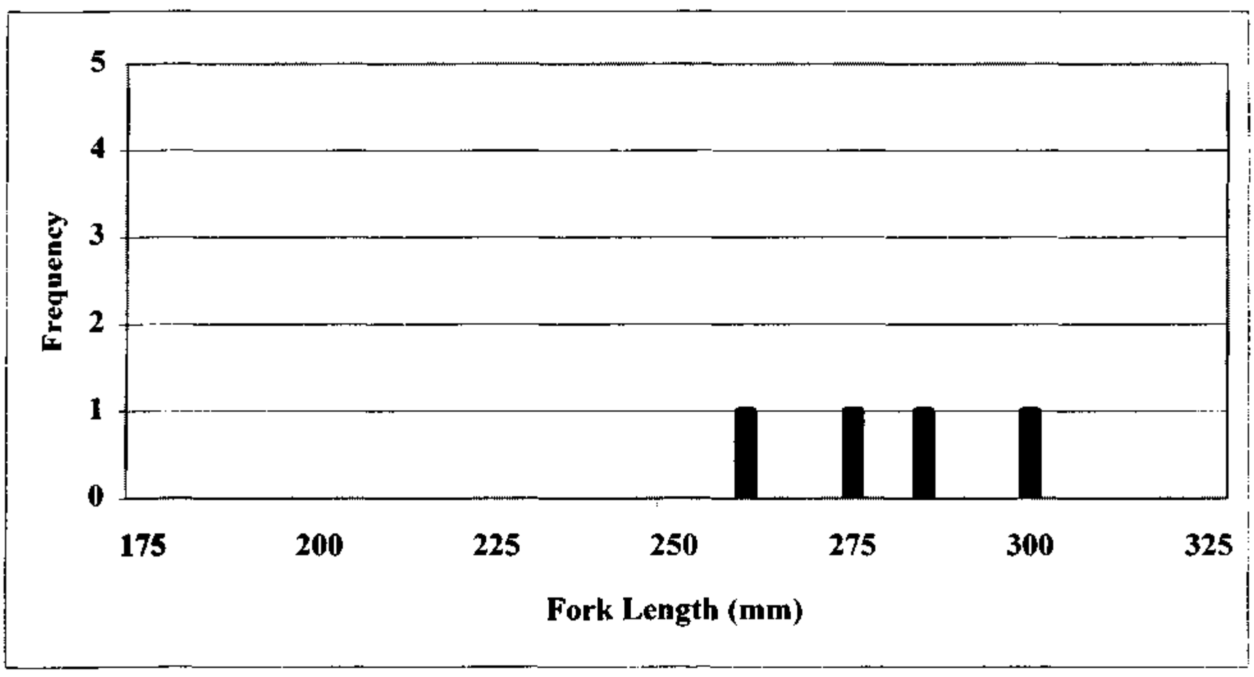
Appendix F. **Hatchery steelhead length-frequency histogram, Reach 1, August 2000**



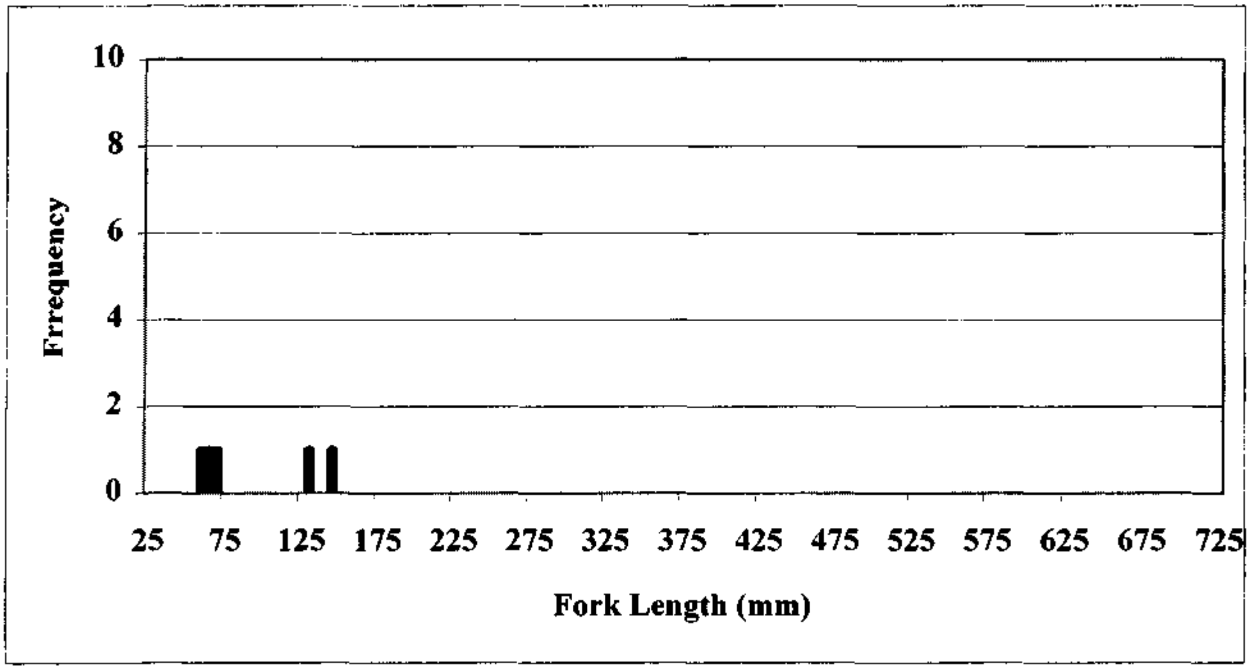
Appendix F. **Hatchery steelhead length-frequency histogram, Reach 2, August 2000**



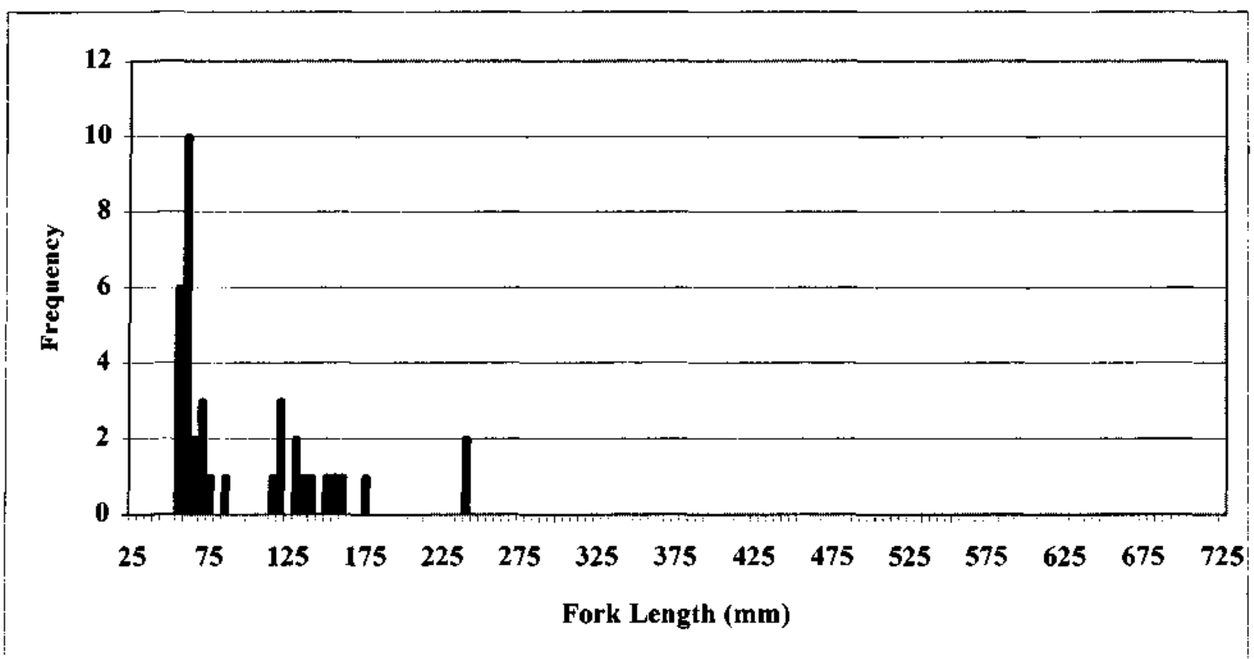
Appendix F. **Hatchery steelhead length-frequency histogram, Reach 3, August 2000**



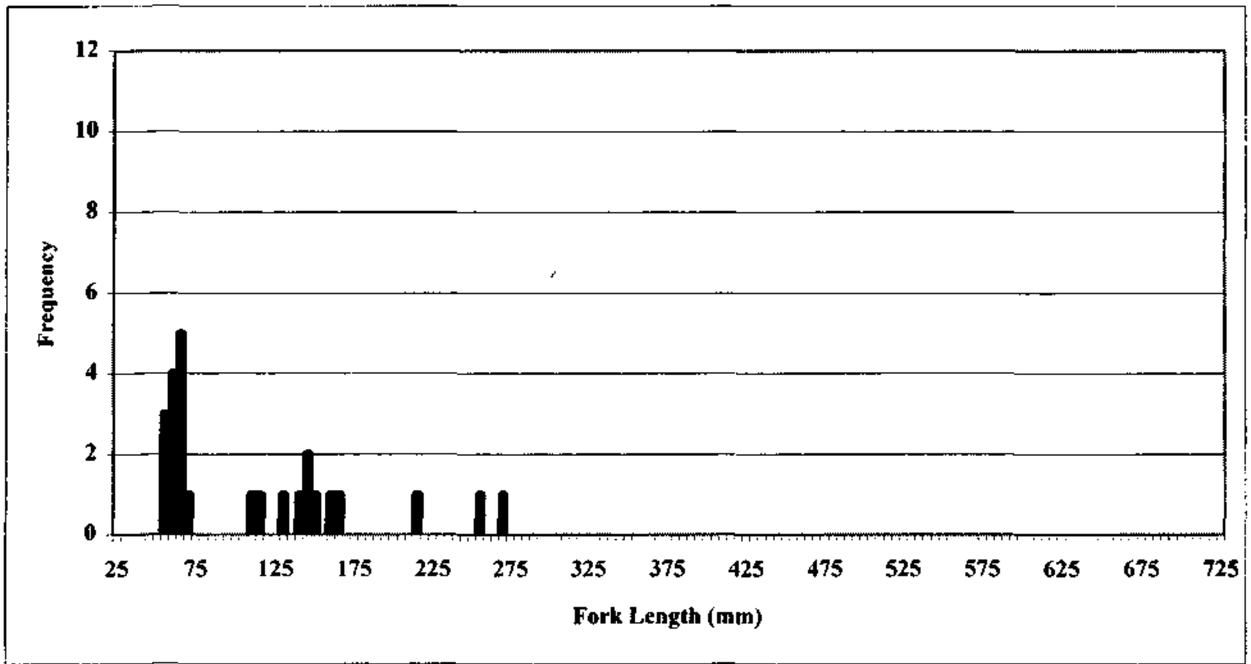
Appendix F. **Hatchery steelhead length-frequency histogram, Reach 4, August 2000**



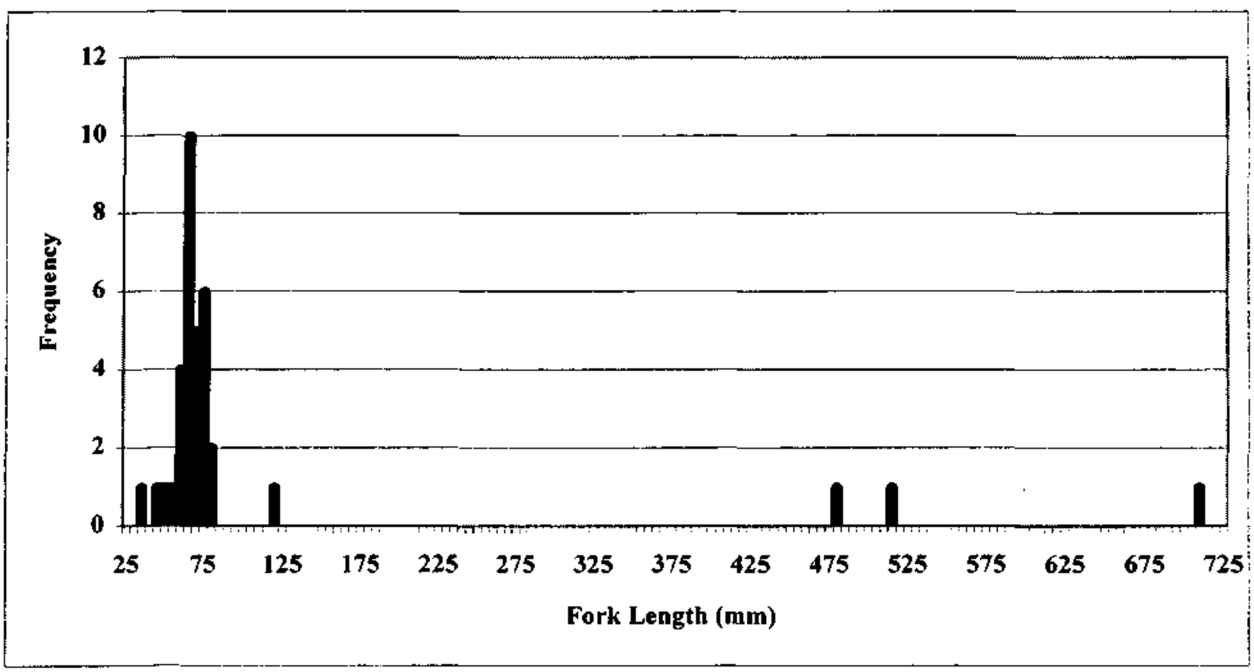
Appendix F. **Sacramento pikeminnow length-frequency histogram, Reach 1, August 2000.**



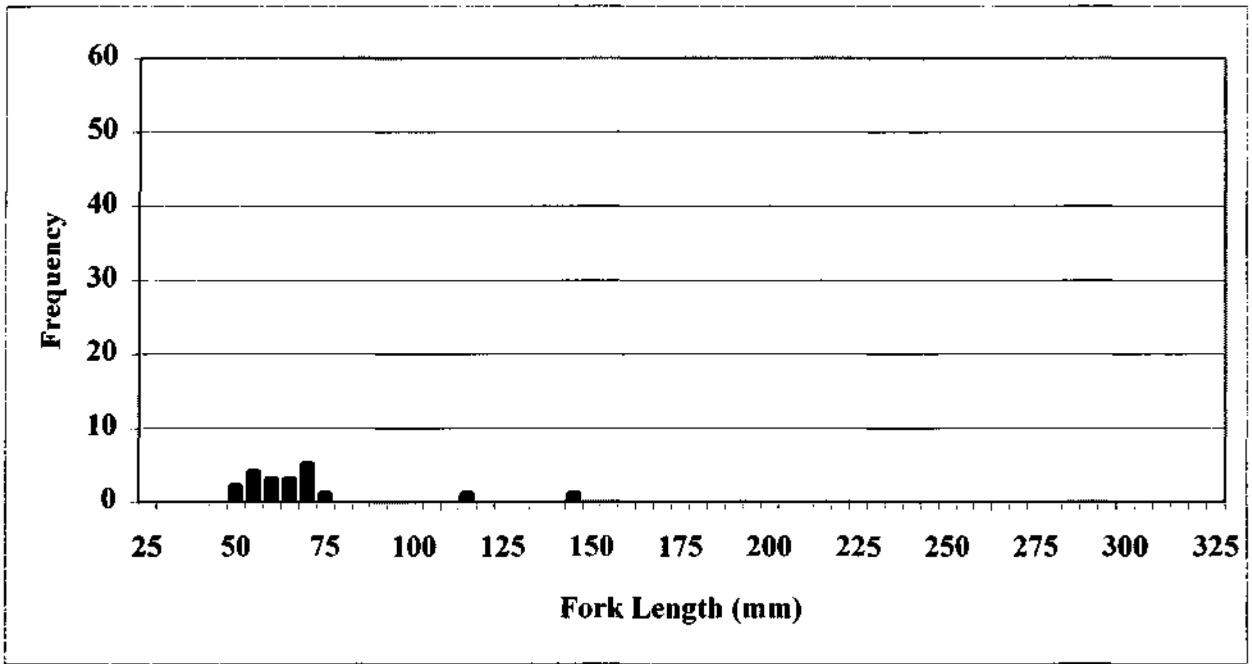
Appendix F. **Sacramento pikeminnow length-frequency histogram, Reach 2, August 2000.**



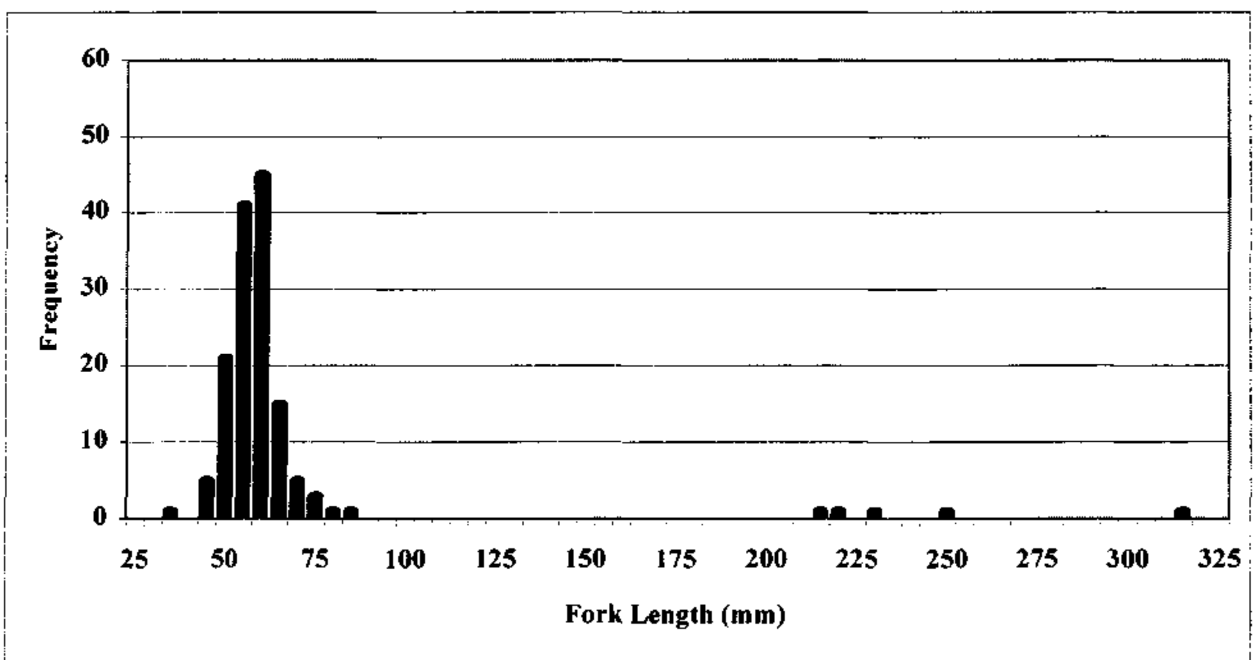
Appendix F. **Sacramento pikeminnow length-frequency histogram, Reach 3, August 2000.**



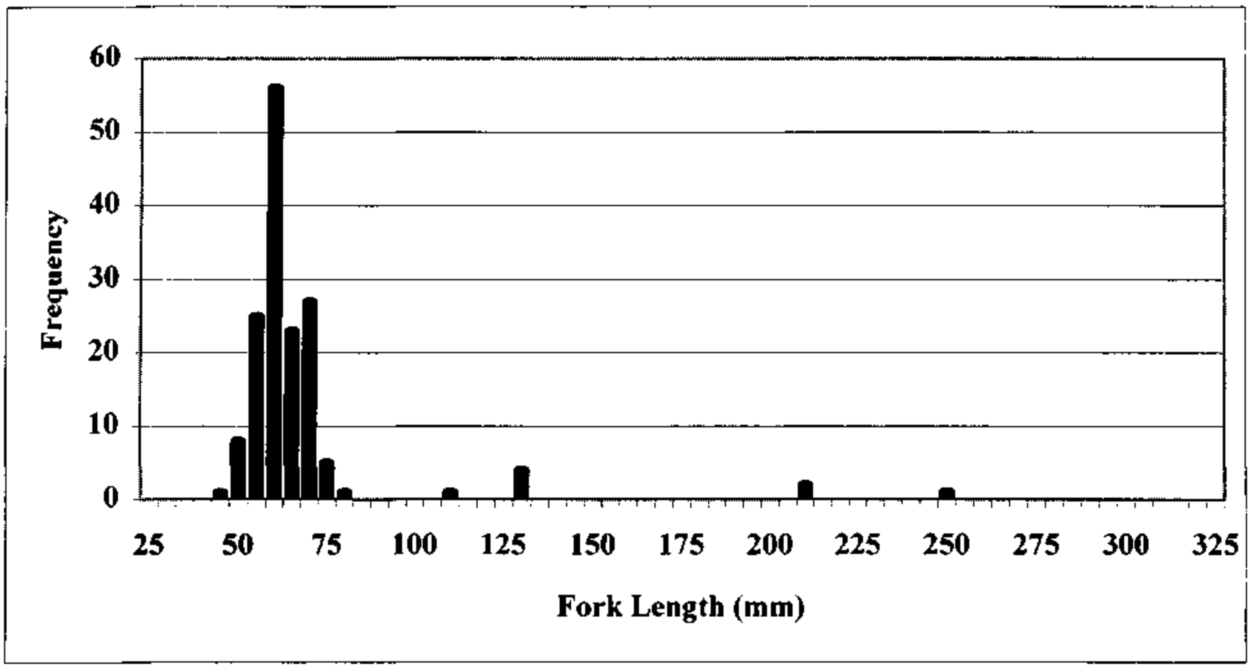
Appendix F. **Sacramento pikeminnow length-frequency histogram, Reach 4, August 2000.**



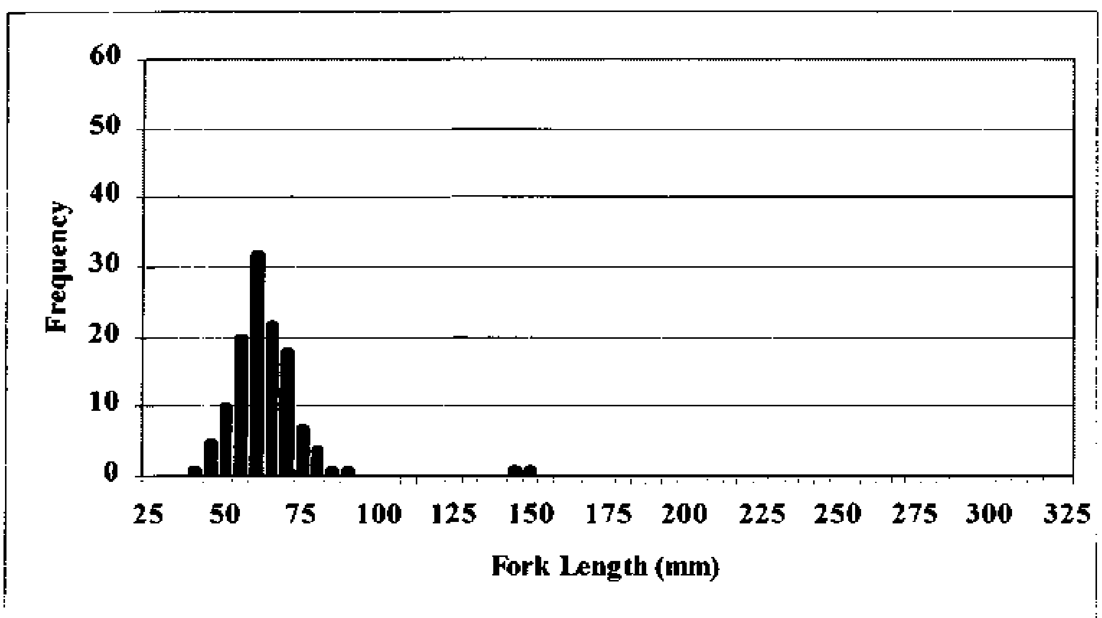
Appendix F. **Hardhead length-frequency histogram, Reach 1, August 2000.**



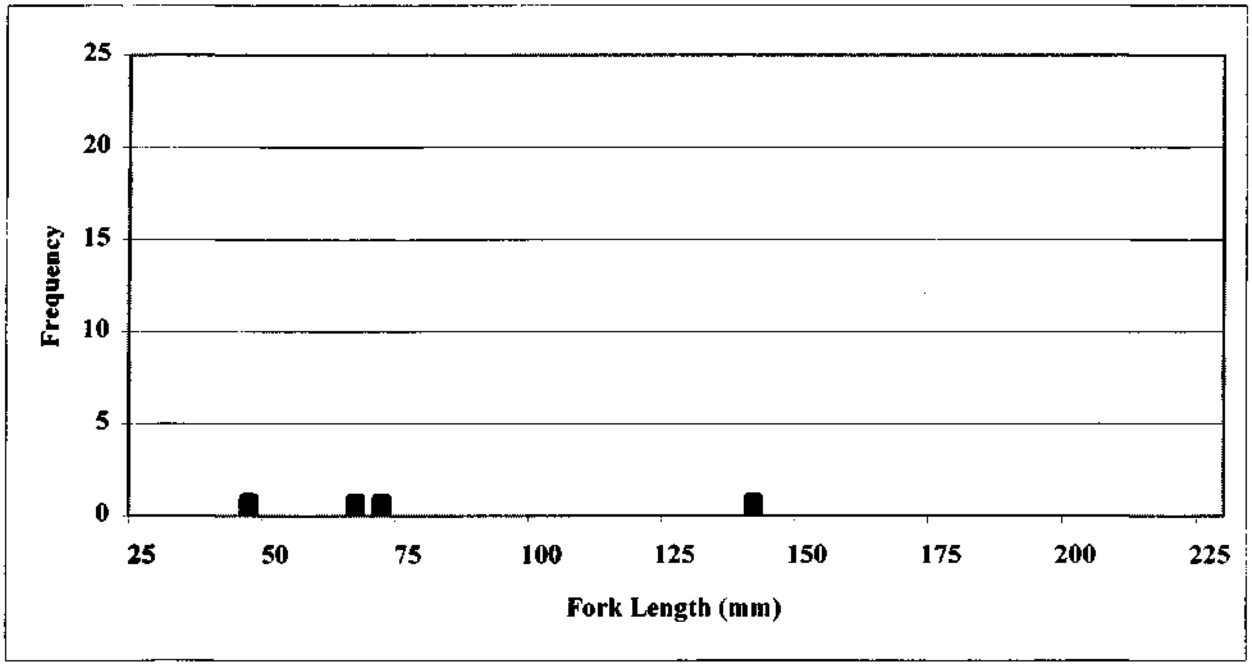
Appendix F. **Hardhead length-frequency histogram, Reach 2, August 2000.**



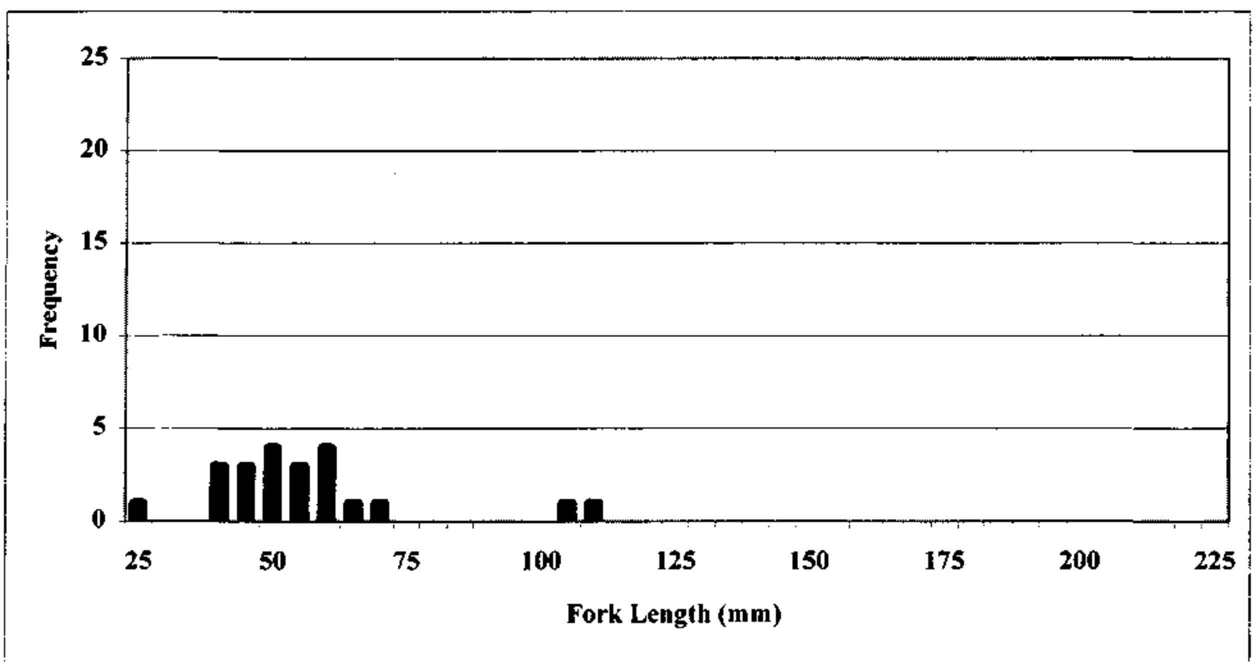
Appendix F. **Hardhead length-frequency histogram, Reach 3, August 2000.**



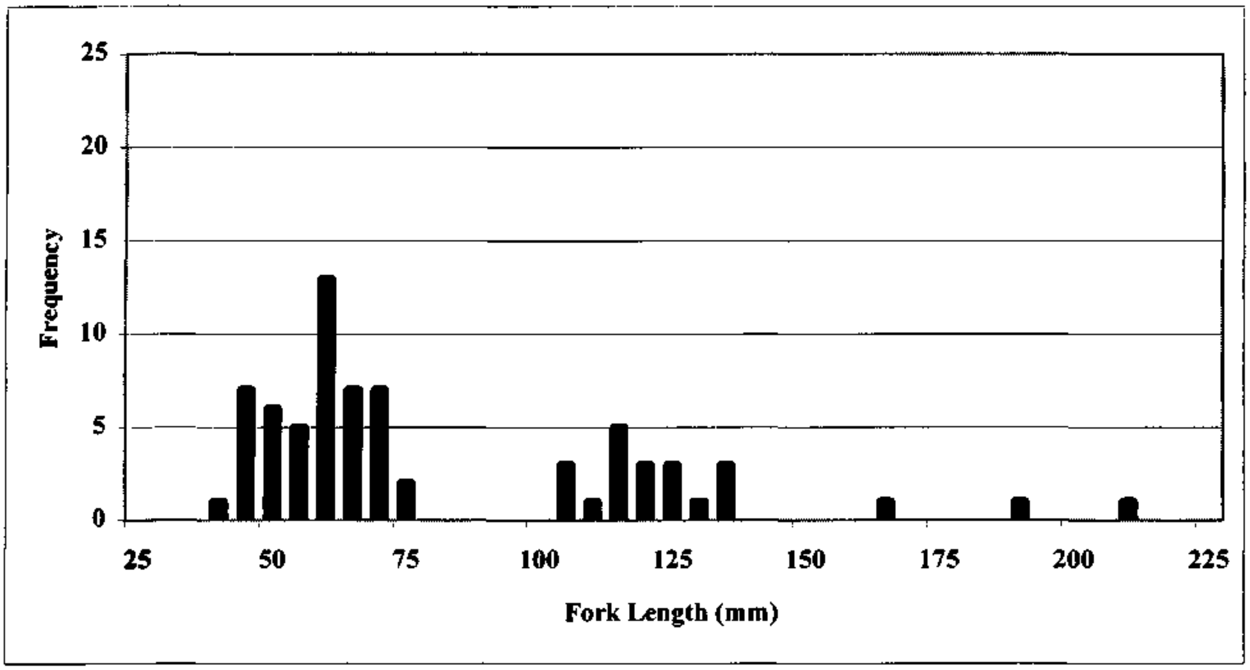
Appendix F. **Hardhead length-frequency histogram, Reach 4, August 2000.**



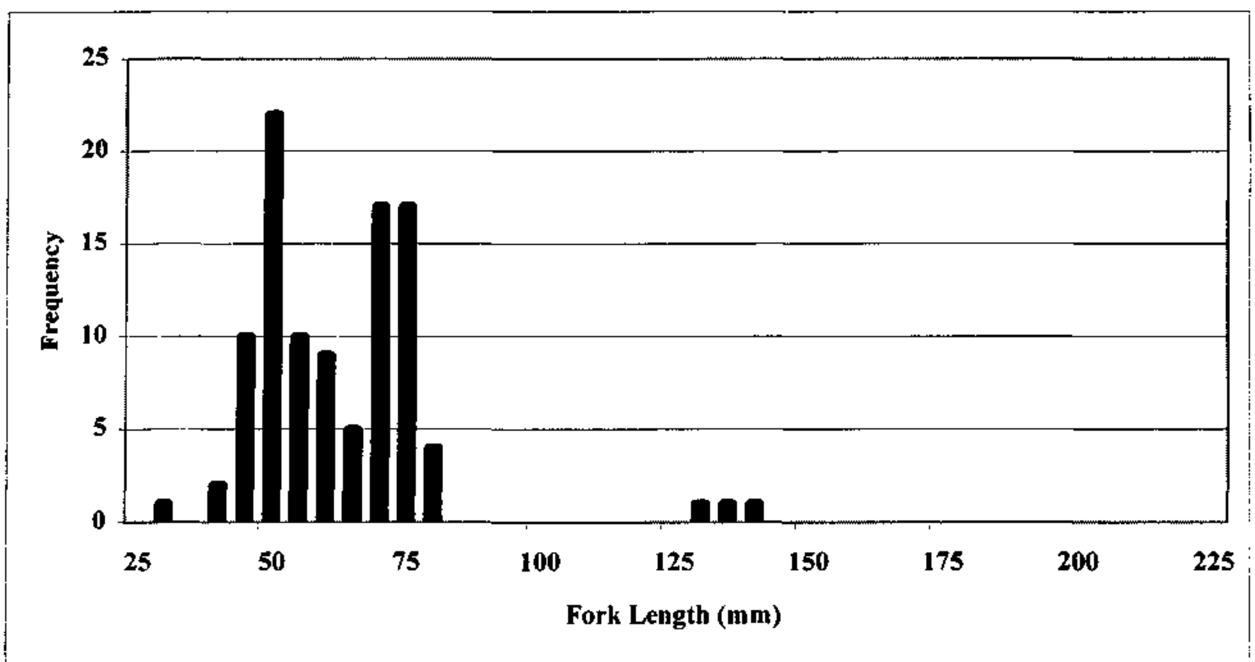
Appendix F. **California roach length-frequency histogram, Reach 1, August 2000**



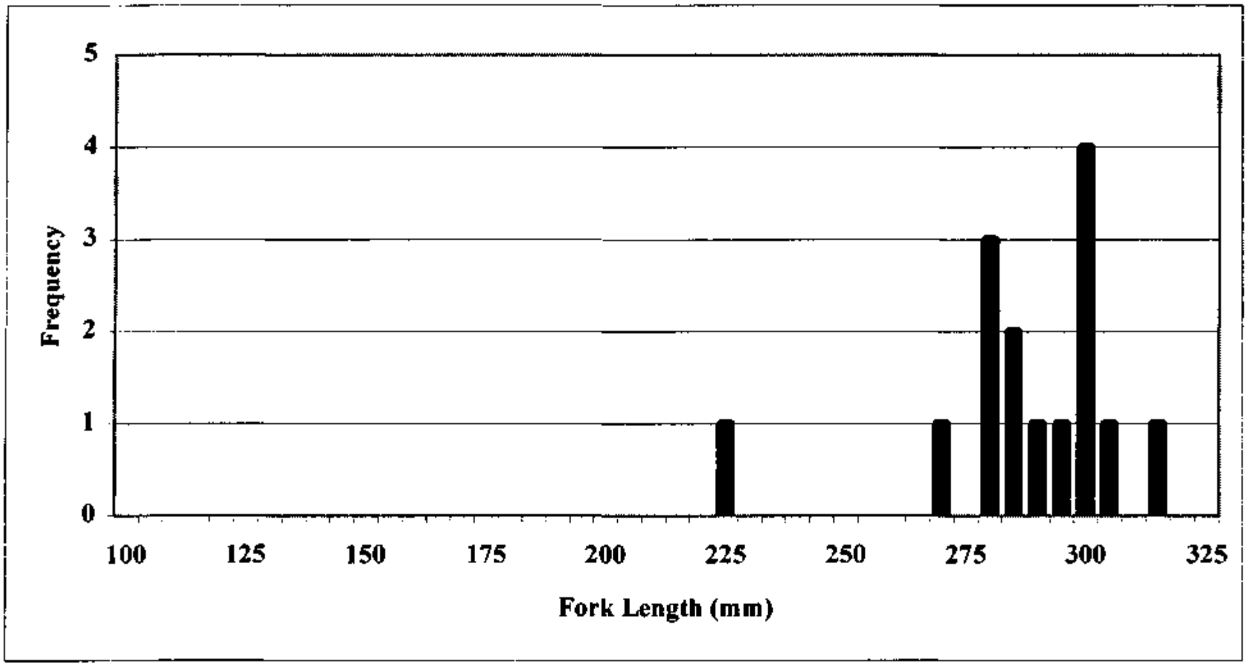
Appendix F. **California roach length-frequency histogram, Reach 2, August 2000**



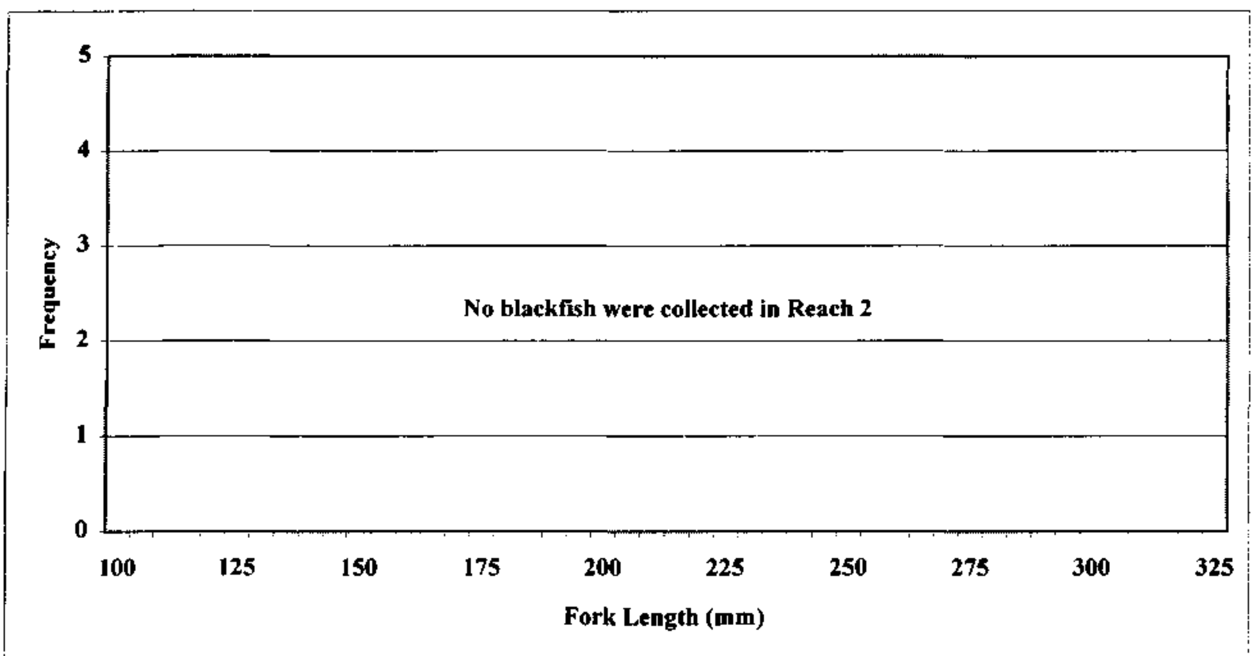
Appendix F. **California roach length-frequency histogram, Reach 3, August 2000**



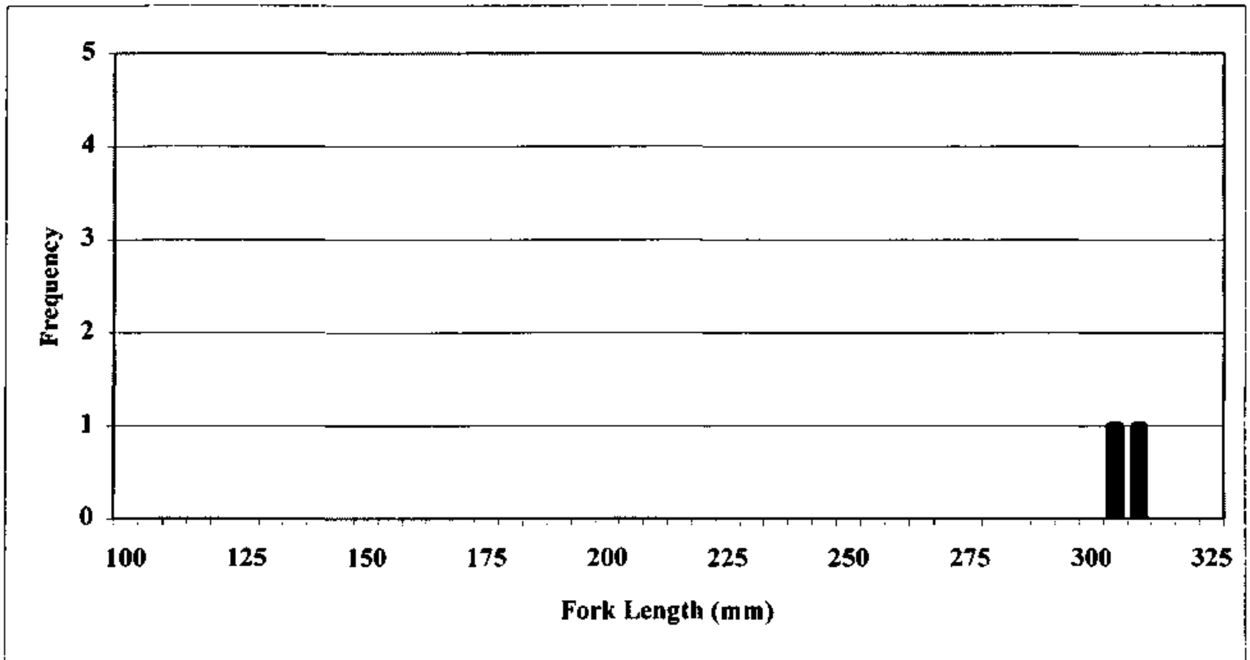
Appendix F. **California roach length-frequency histogram, Reach 3, August 2000**



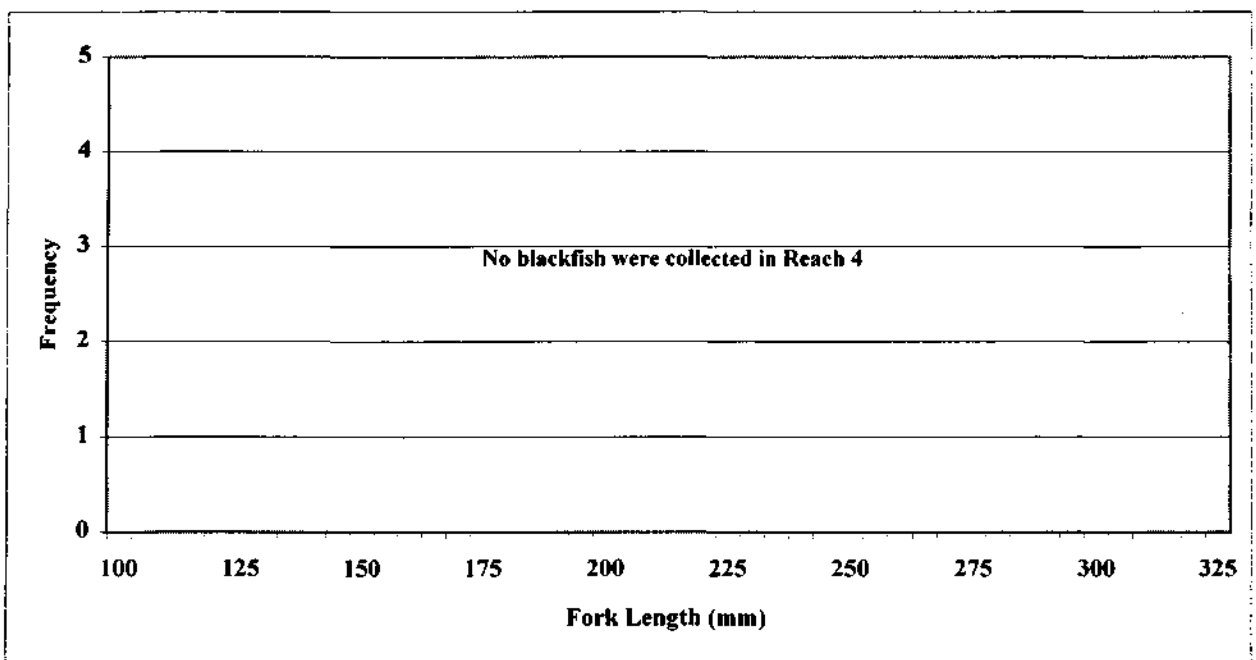
Appendix F. **Sacramento blackfish length-frequency histogram, Reach 1, August 2000**



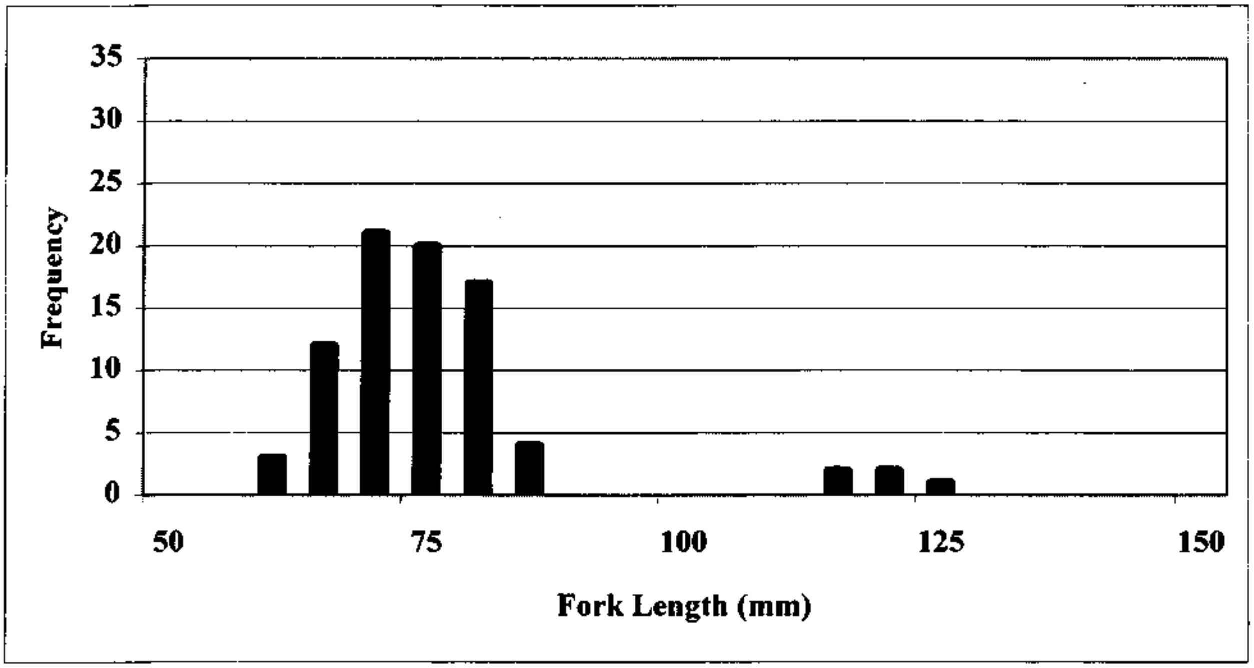
Appendix F. **Sacramento blackfish length-frequency histogram, Reach 2, August 2000**



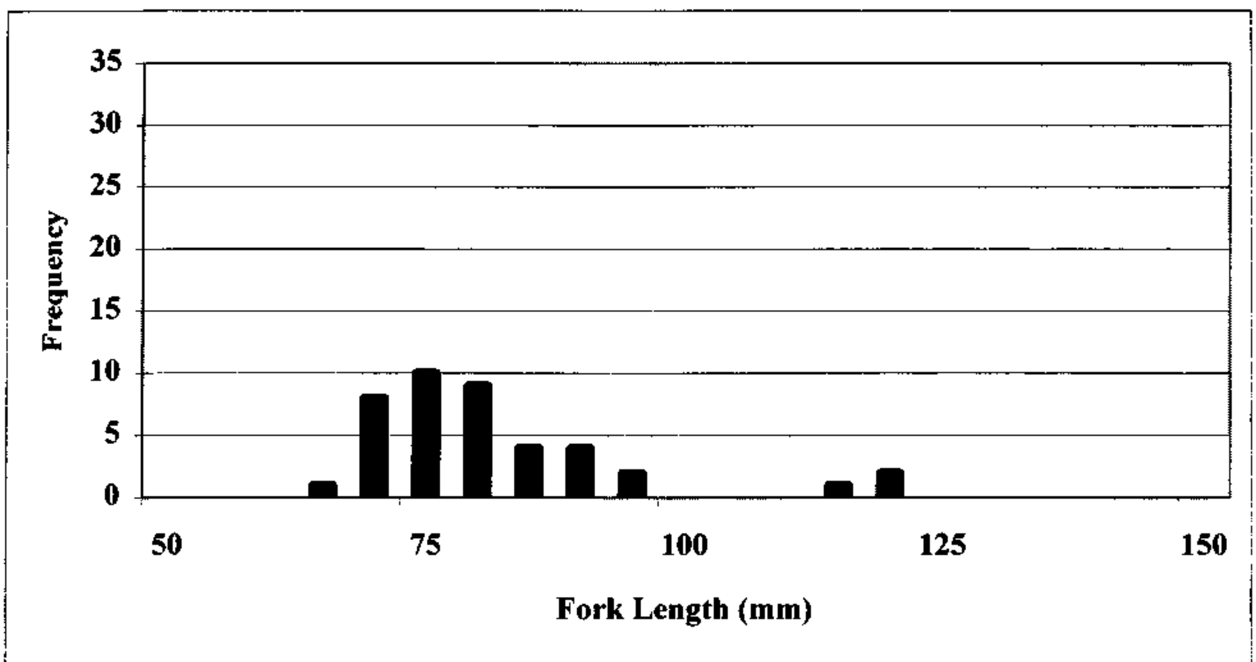
Appendix F. **Sacramento blackfish length-frequency histogram, Reach 3, August 2000**



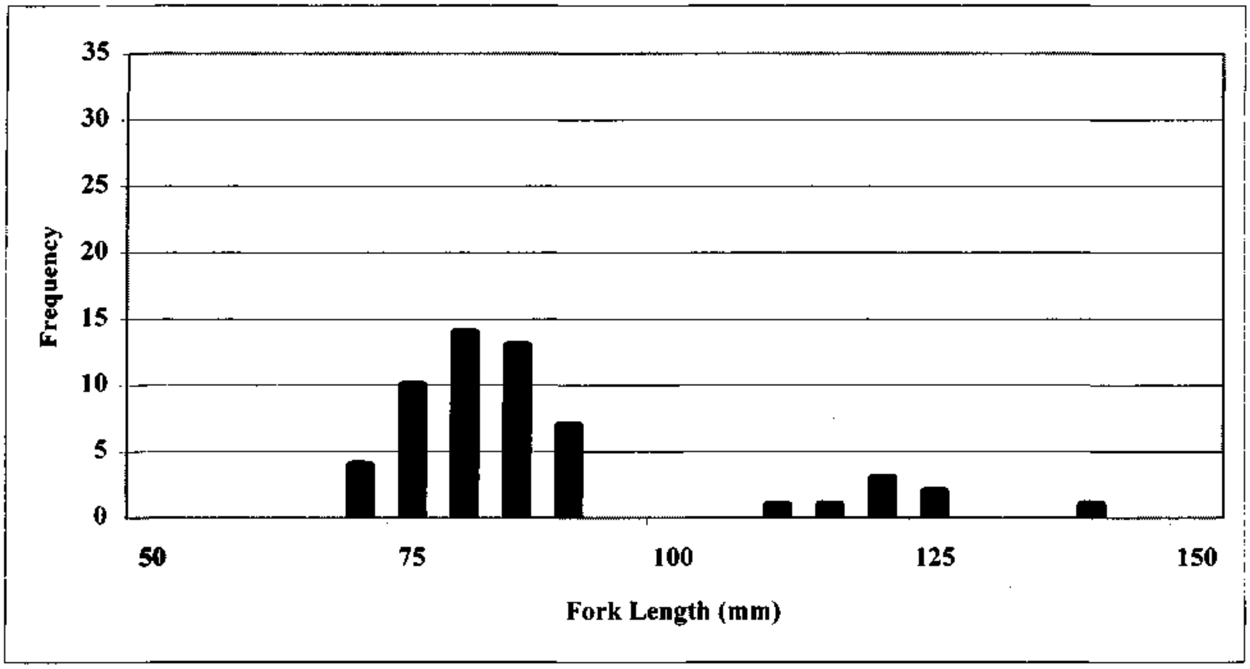
Appendix F. **Sacramento blackfish length-frequency histogram, Reach 4, August 2000**



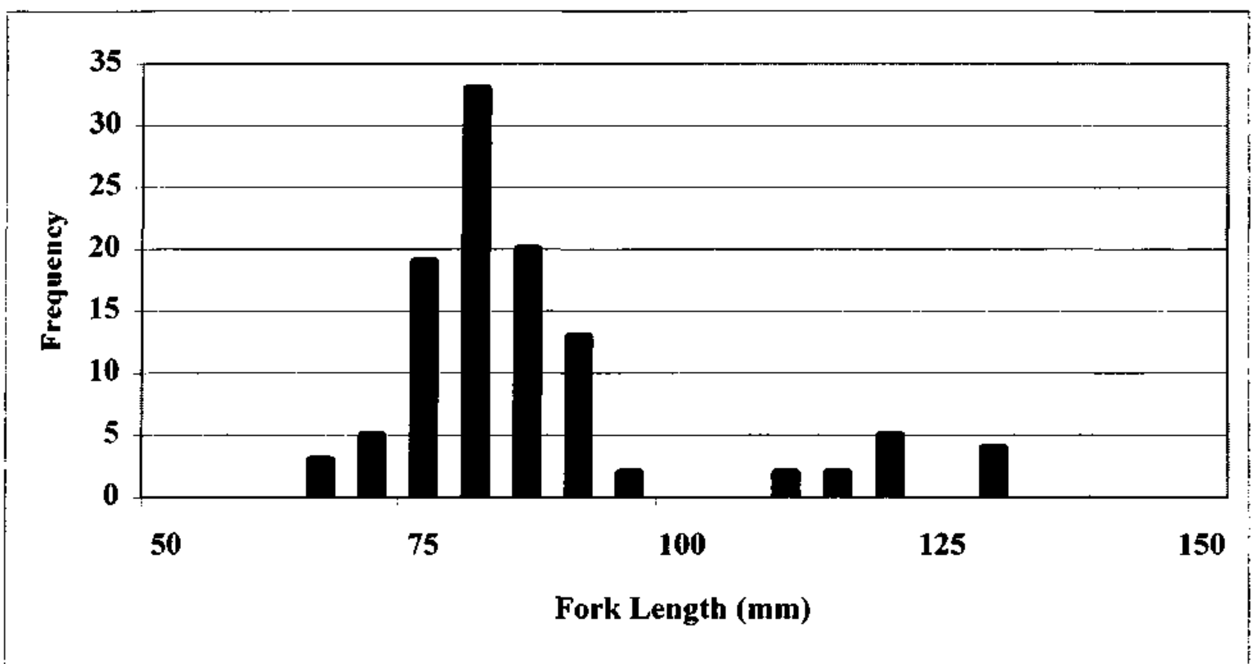
Appendix F. **Tule perch length-frequency histogram, Reach 1, August 2000**



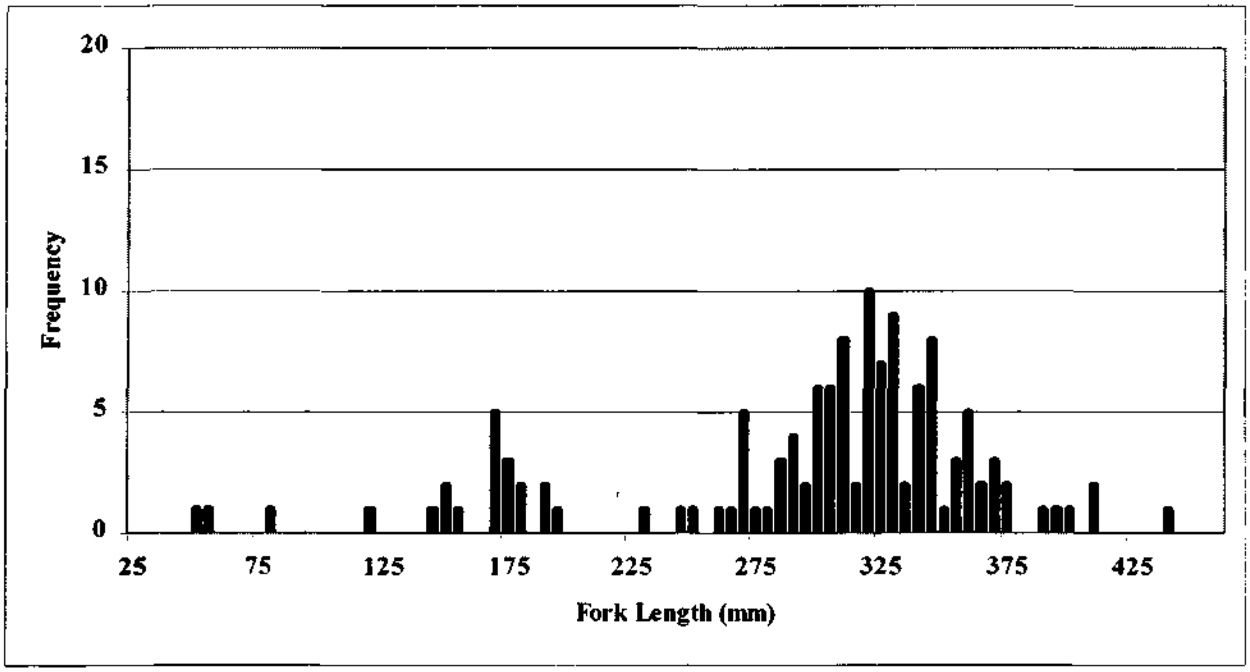
Appendix F. **Tule perch length-frequency histogram, Reach 2, August 2000**



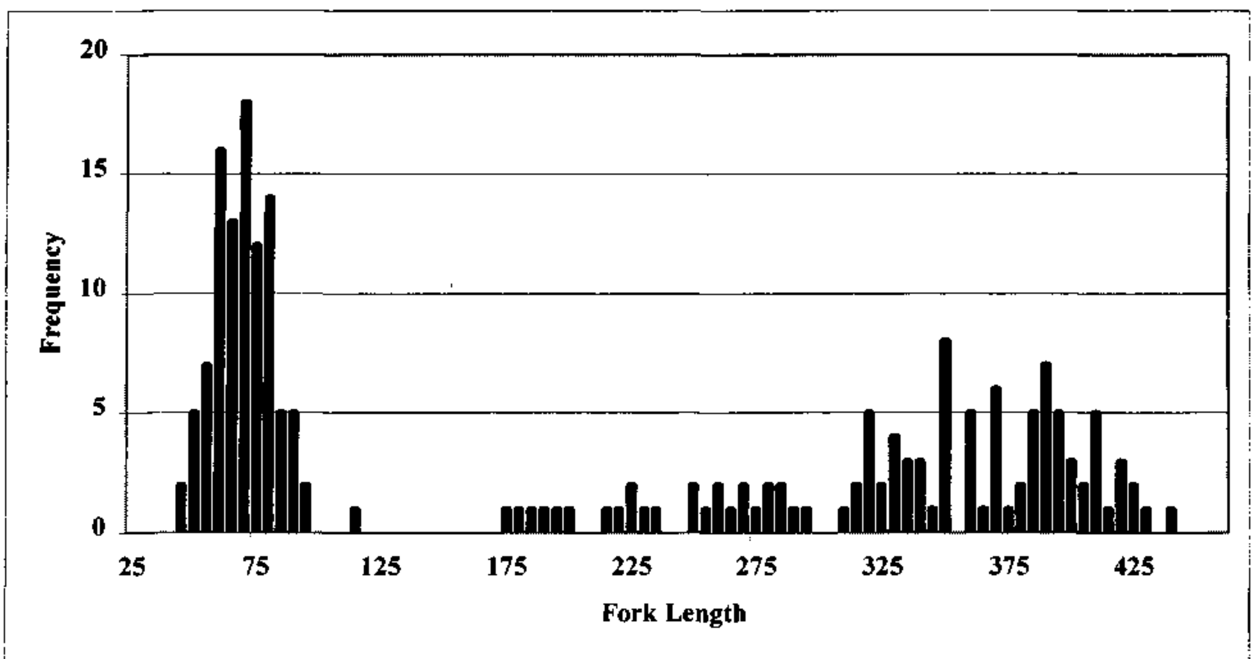
Appendix F. **Tule perch length-frequency histogram, Reach 3, August 2000**



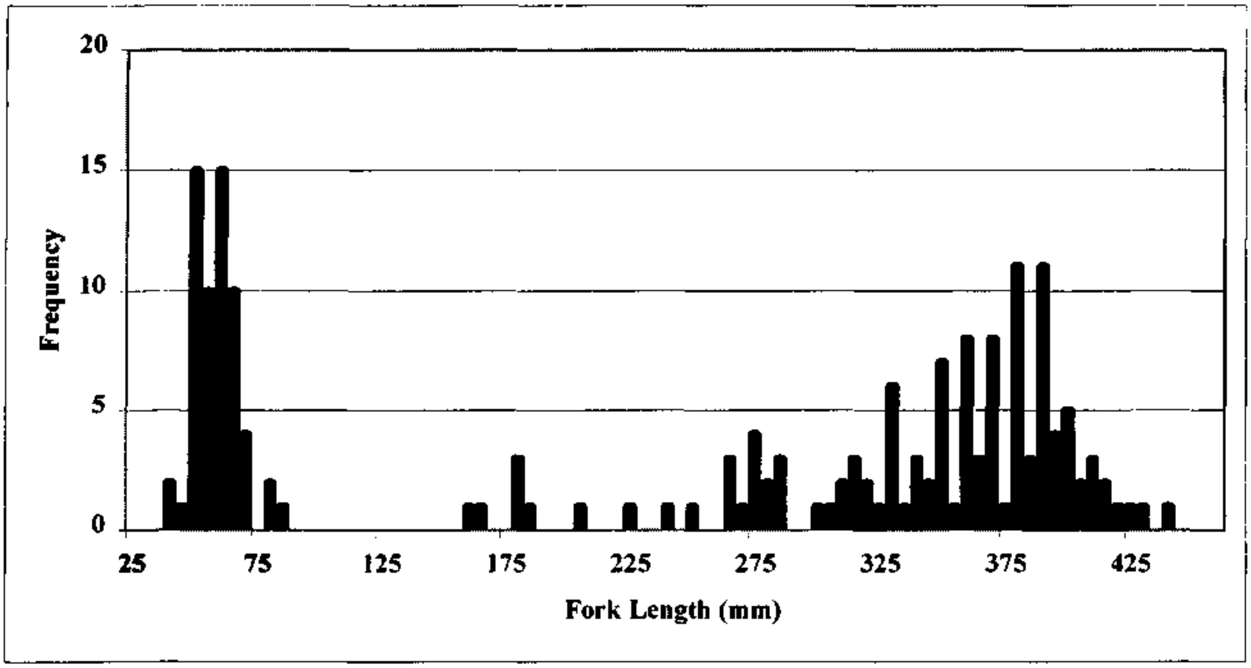
Appendix F. **Tule perch length-frequency histogram, Reach 4, August 2000**



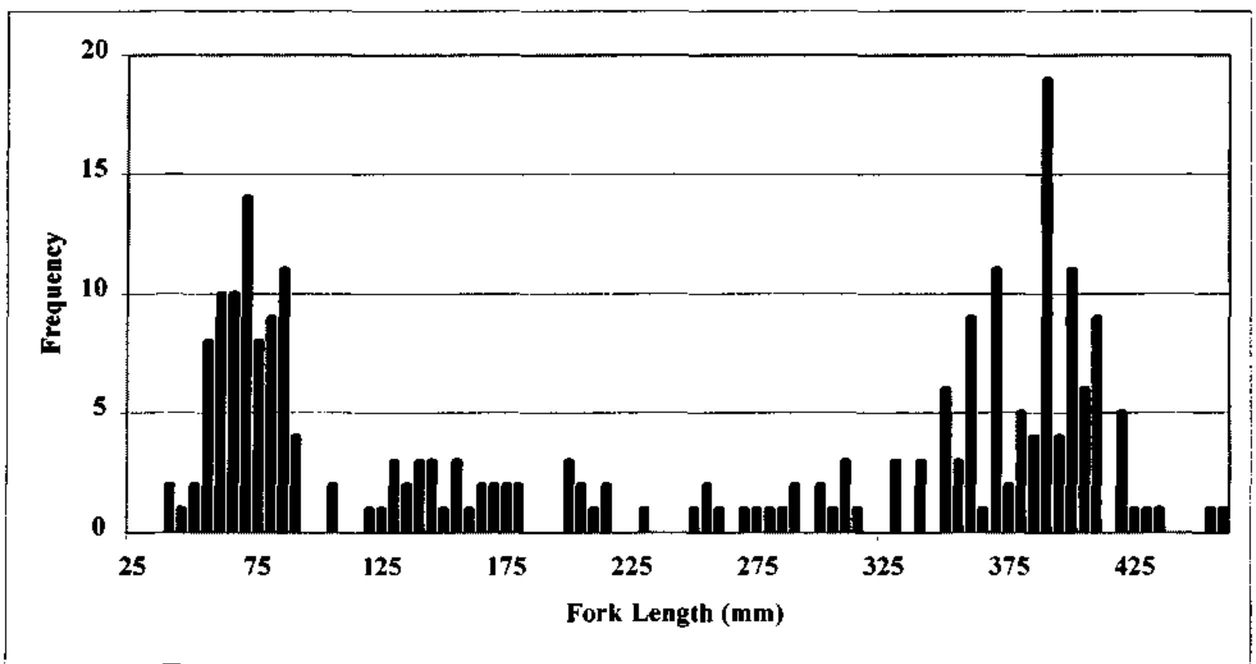
Appendix F. **Sacramento sucker length-frequency histogram, Reach 1, August 2000**



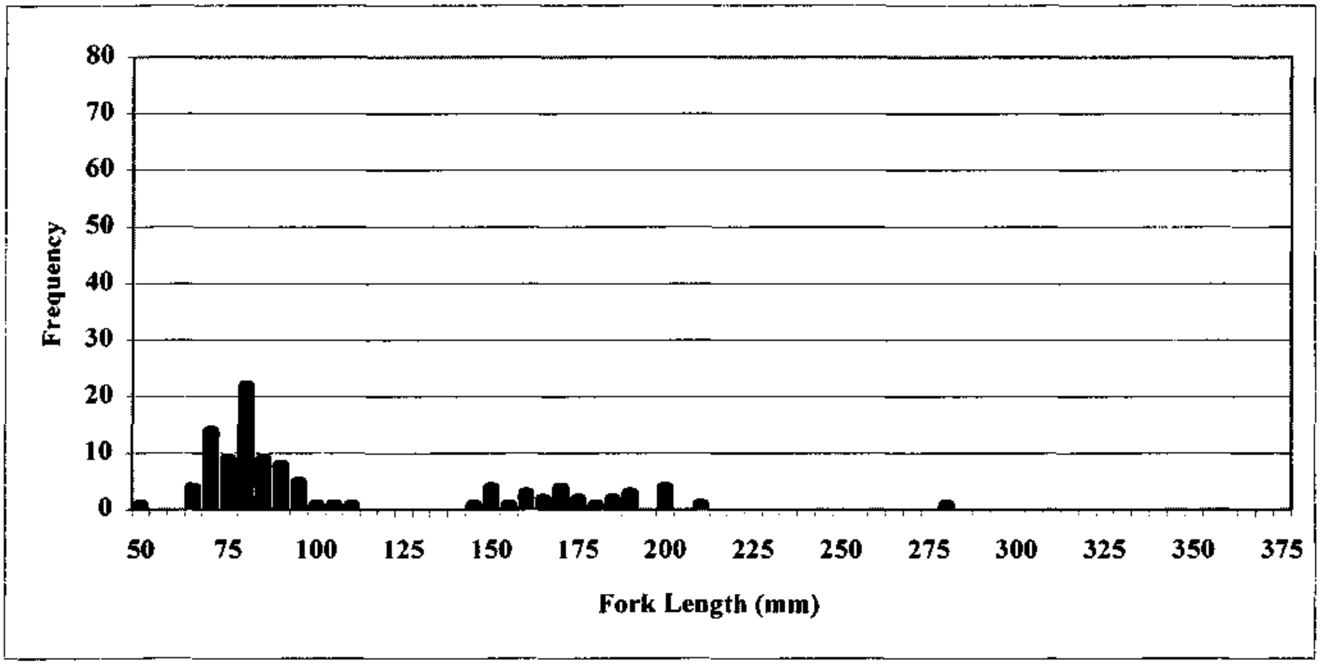
Appendix F. **Sacramento sucker length-frequency histogram, Reach 2, August 2000**



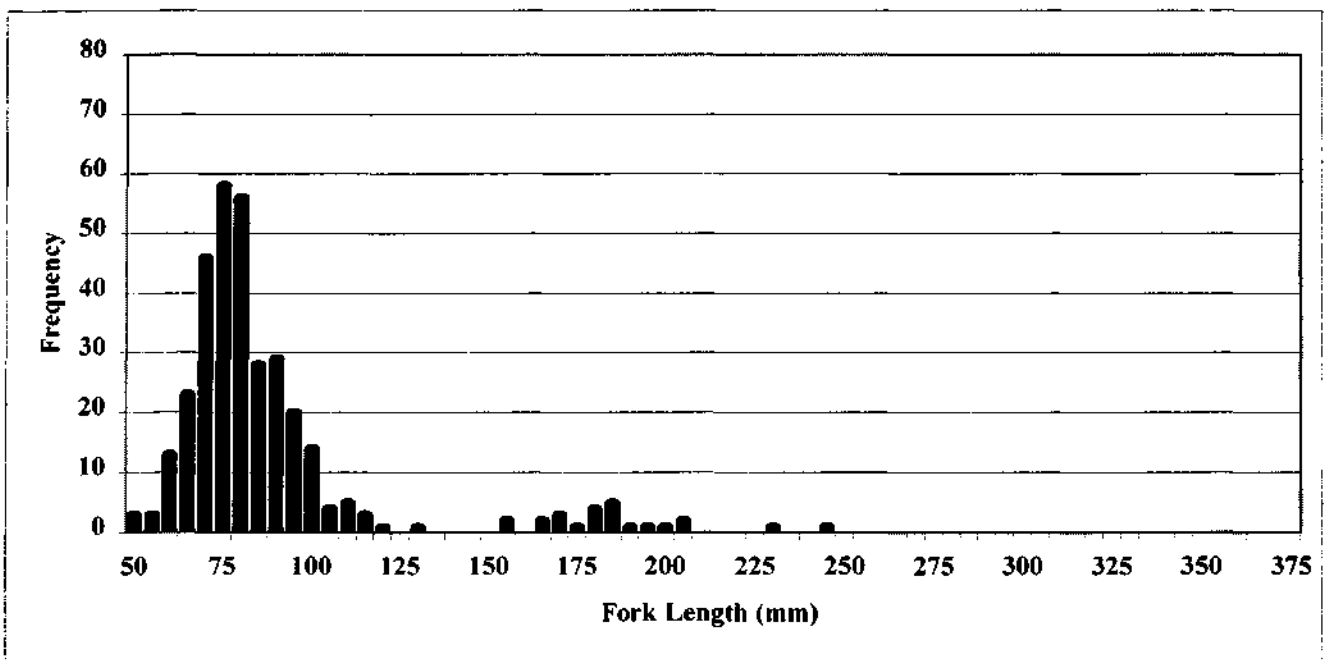
Appendix F. **Sacramento sucker length-frequency histogram, Reach 3, August 2000**



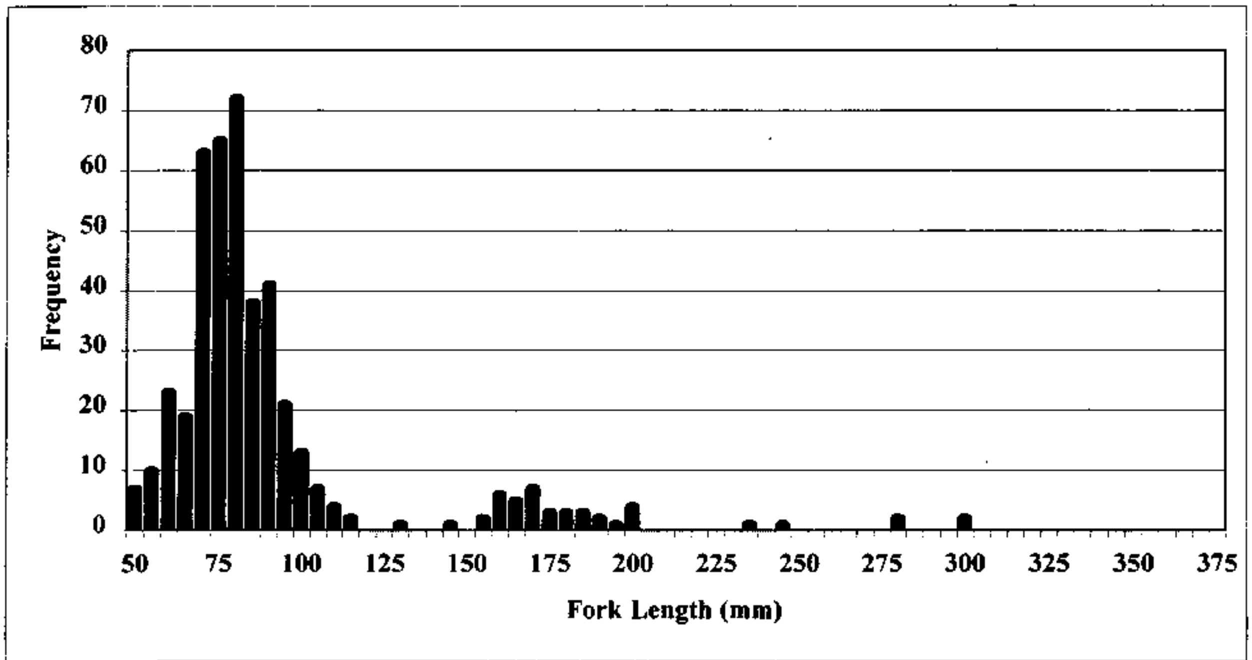
Appendix F. **Sacramento sucker length-frequency histogram, Reach 4, August 2000**



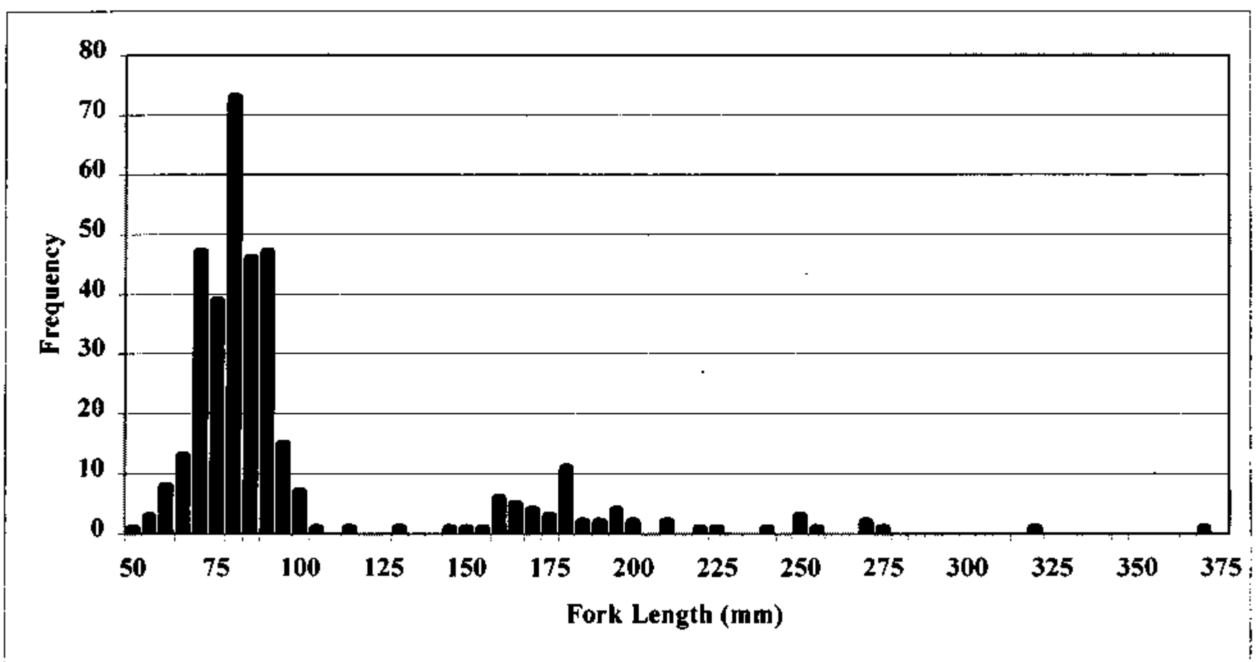
Appendix F. **Smallmouth bass length-frequency histogram, Reach 1, August 2000.**



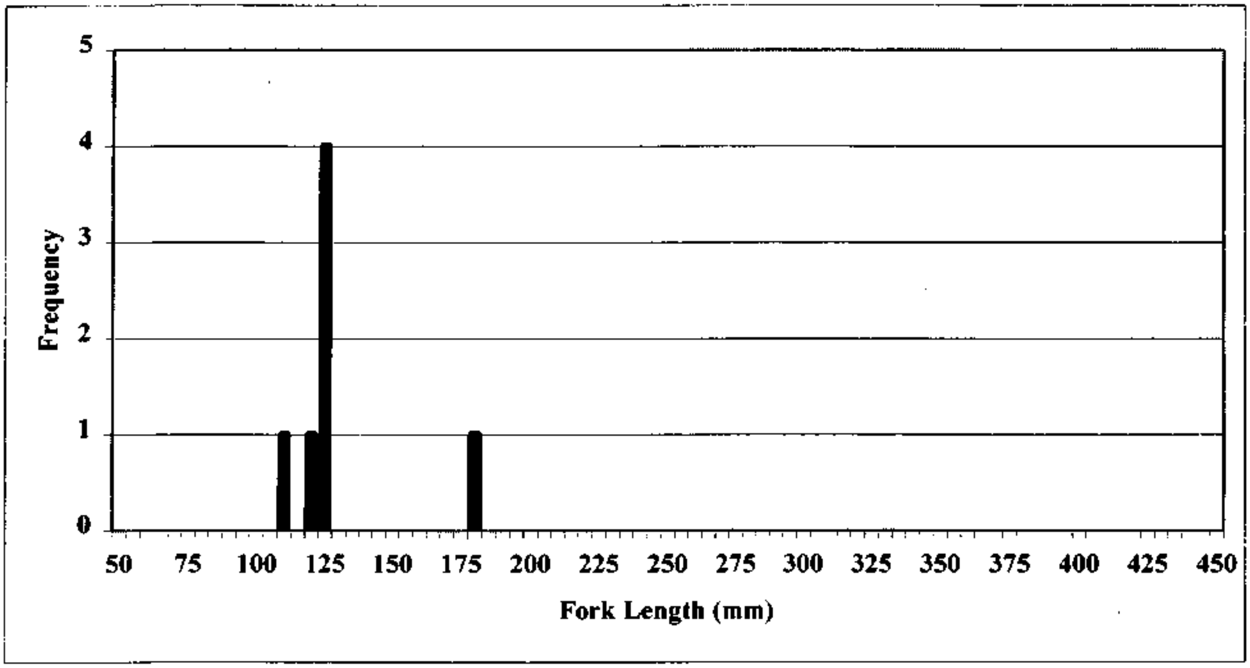
Appendix F. **Smallmouth bass length-frequency histogram, Reach 2, August 2000.**



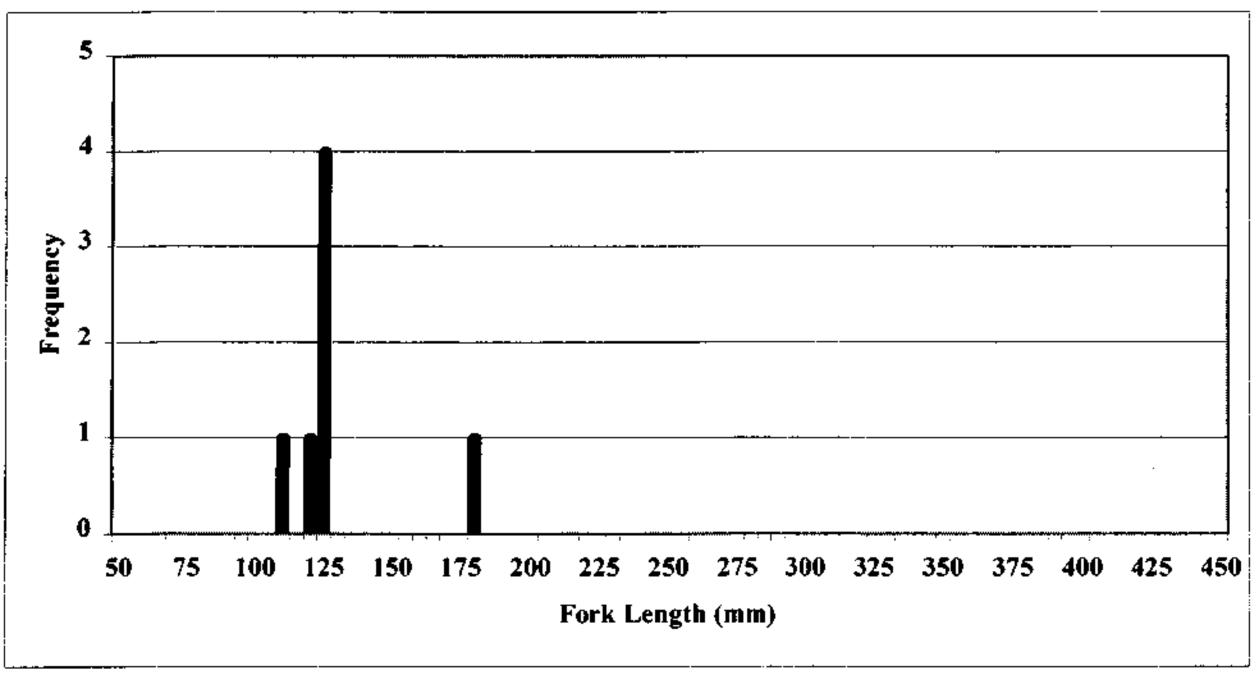
Appendix F. **Smallmouth bass length-frequency histogram, Reach 3, August 2000.**



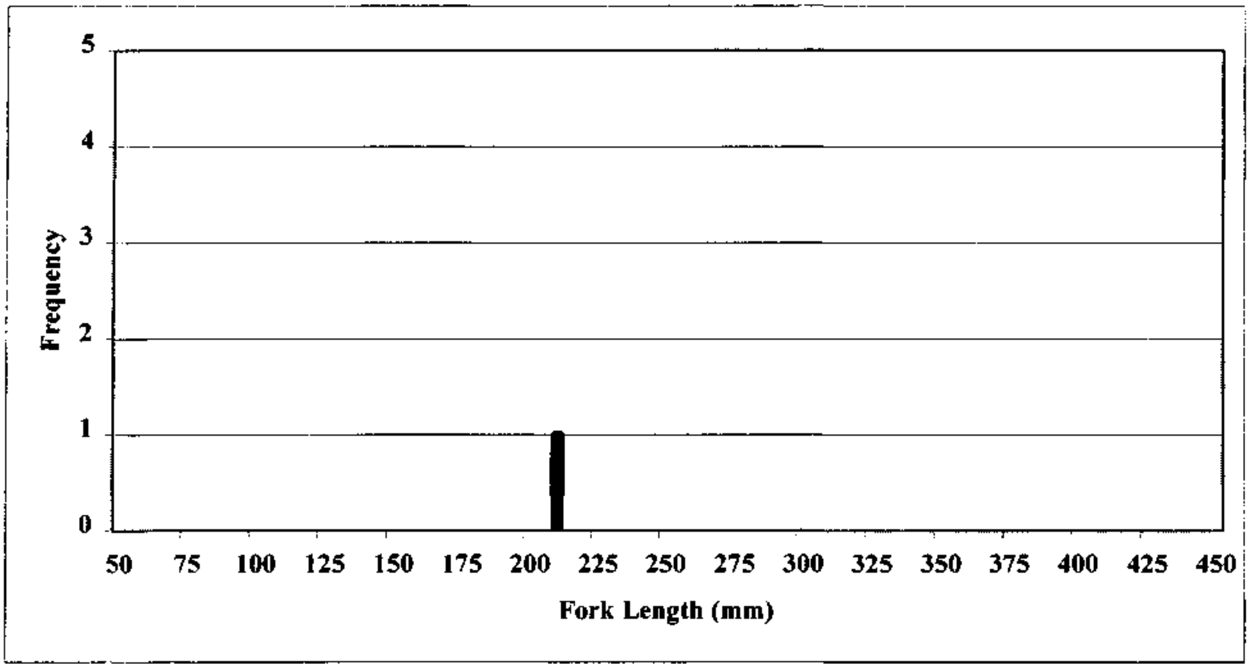
Appendix F. **Smallmouth bass length-frequency histogram, Reach 4, August 2000.**



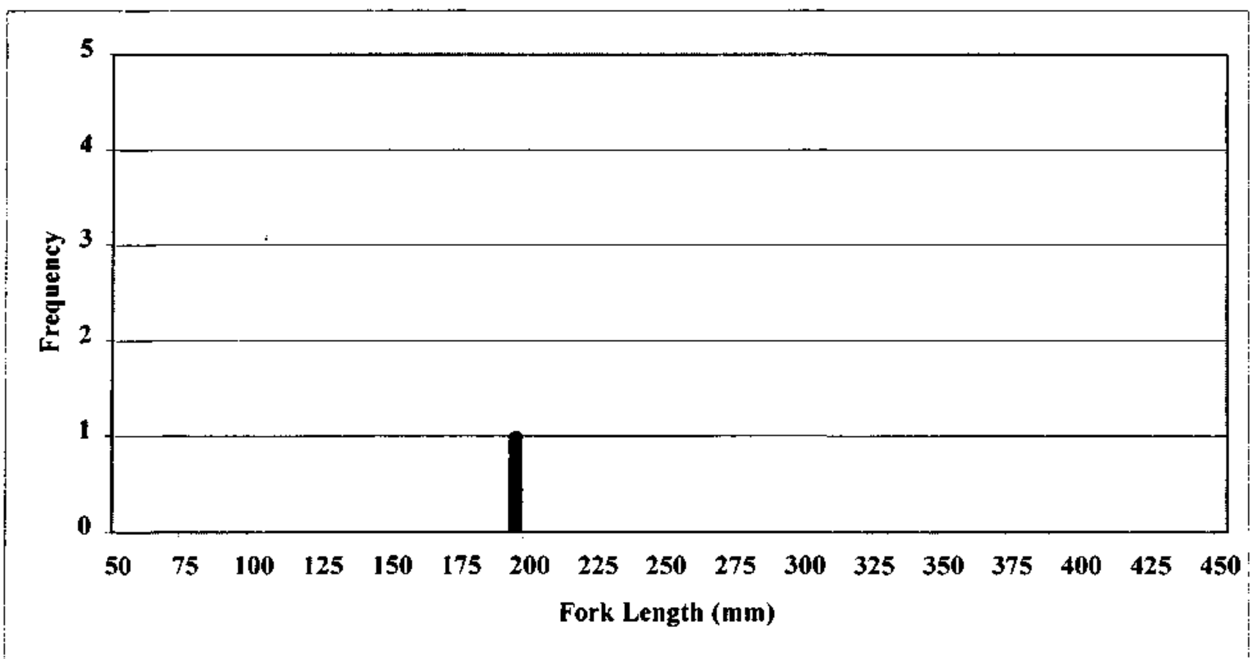
Appendix F. **Largemouth bass length-frequency histogram, Reach 1, August 2000.**



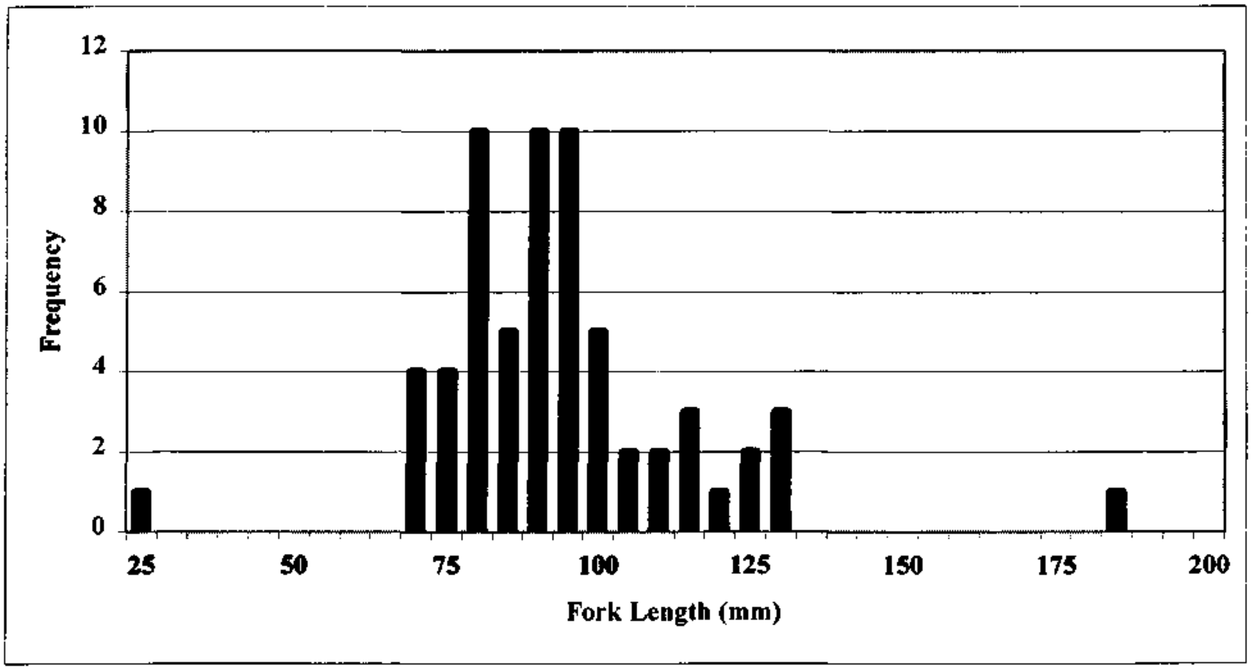
Appendix F. **Largemouth bass length-frequency histogram, Reach 2, August 2000.**



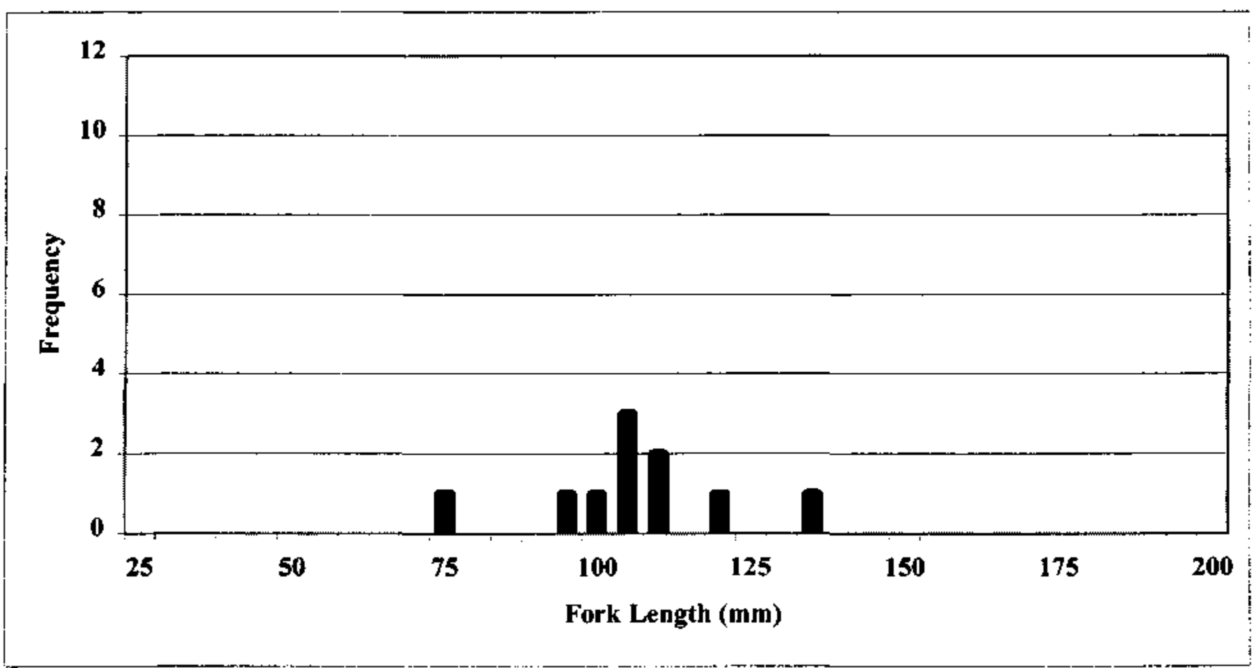
Appendix F. **Largemouth bass length-frequency histogram, Reach 3, August 2000.**



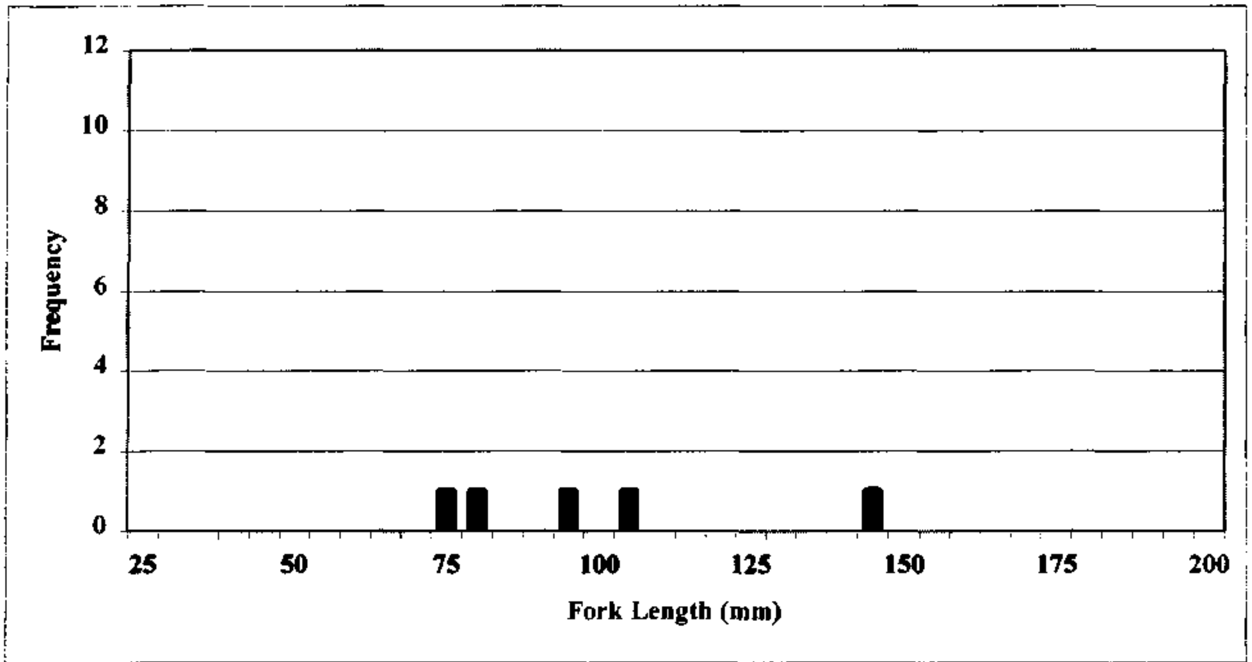
Appendix F. **Largemouth bass length-frequency histogram, Reach 4, August 2000.**



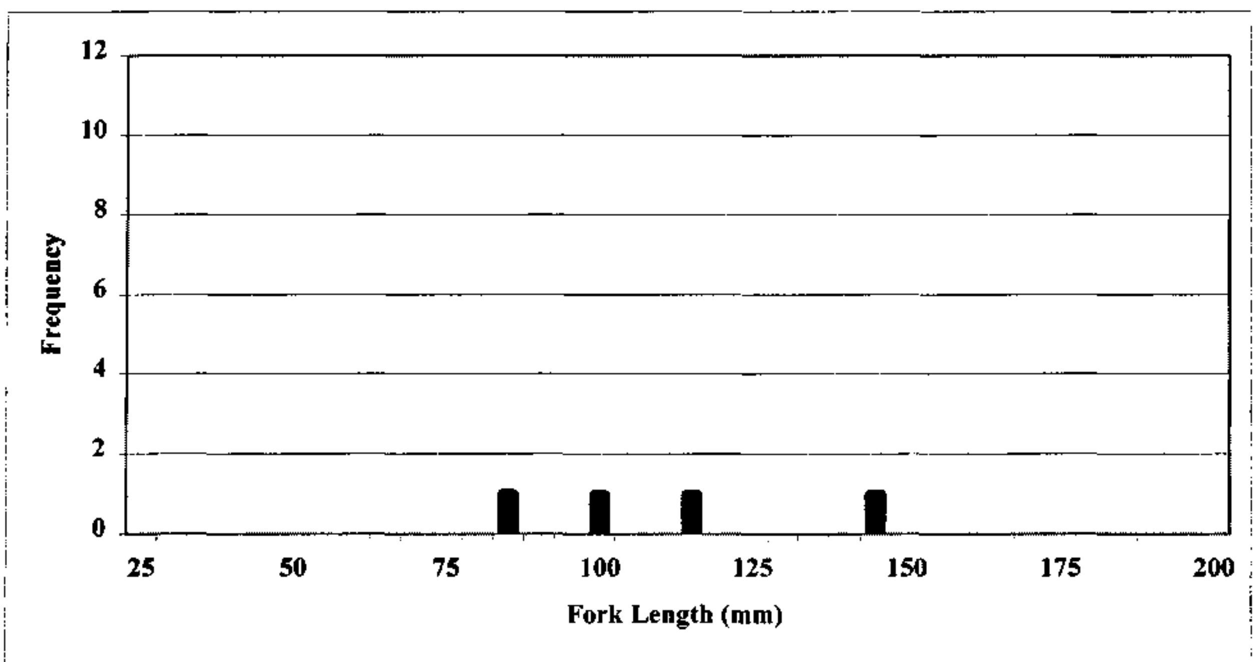
Appendix F. **Bluegill length-frequency histogram, Reach 1, August 2000.**



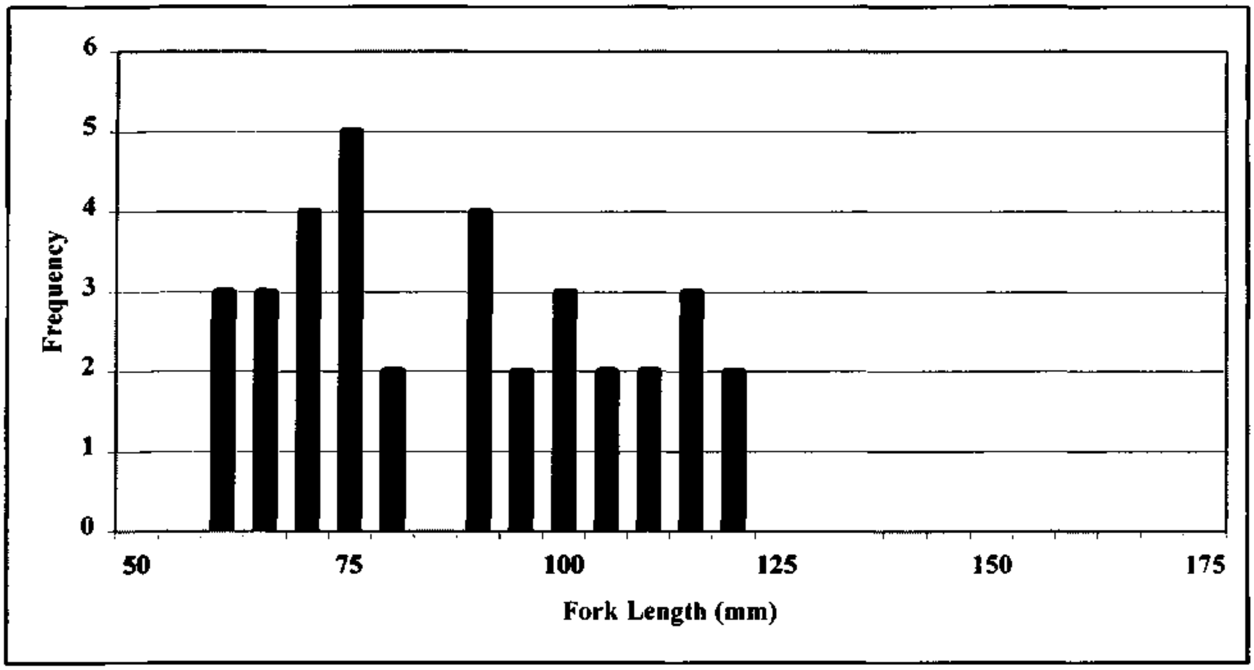
Appendix F. **Bluegill length-frequency histogram, Reach 2, August 2000.**



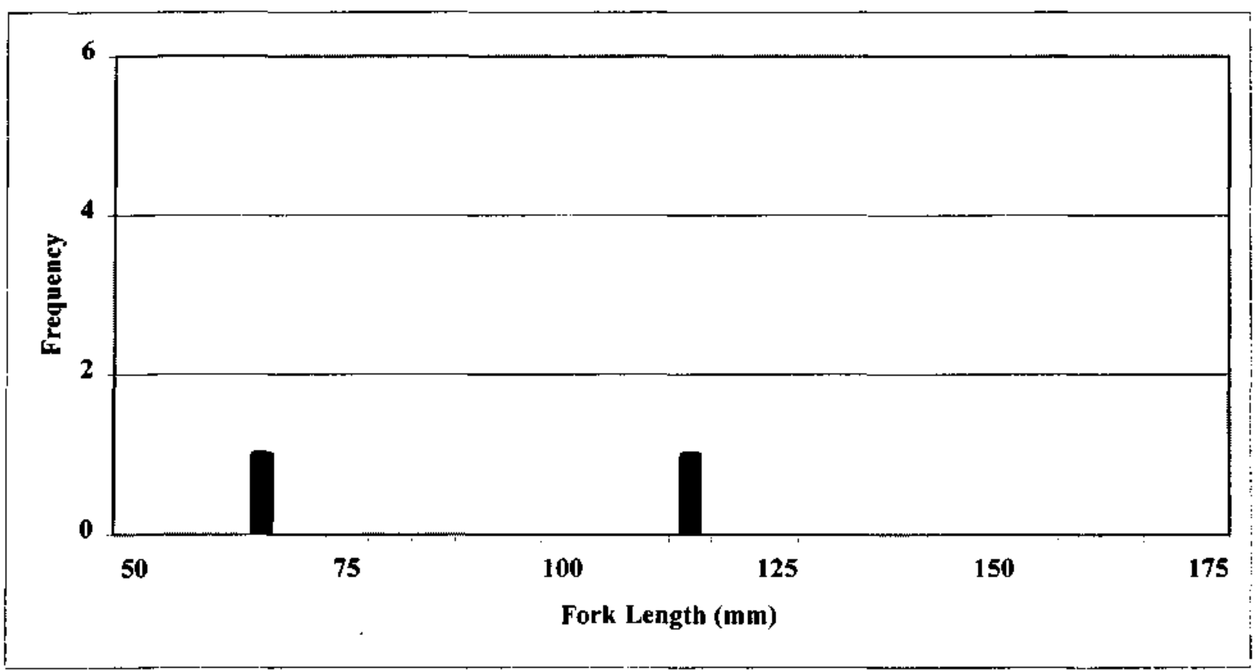
Appendix F. **Bluegill length-frequency histogram, Reach 3, August 2000.**



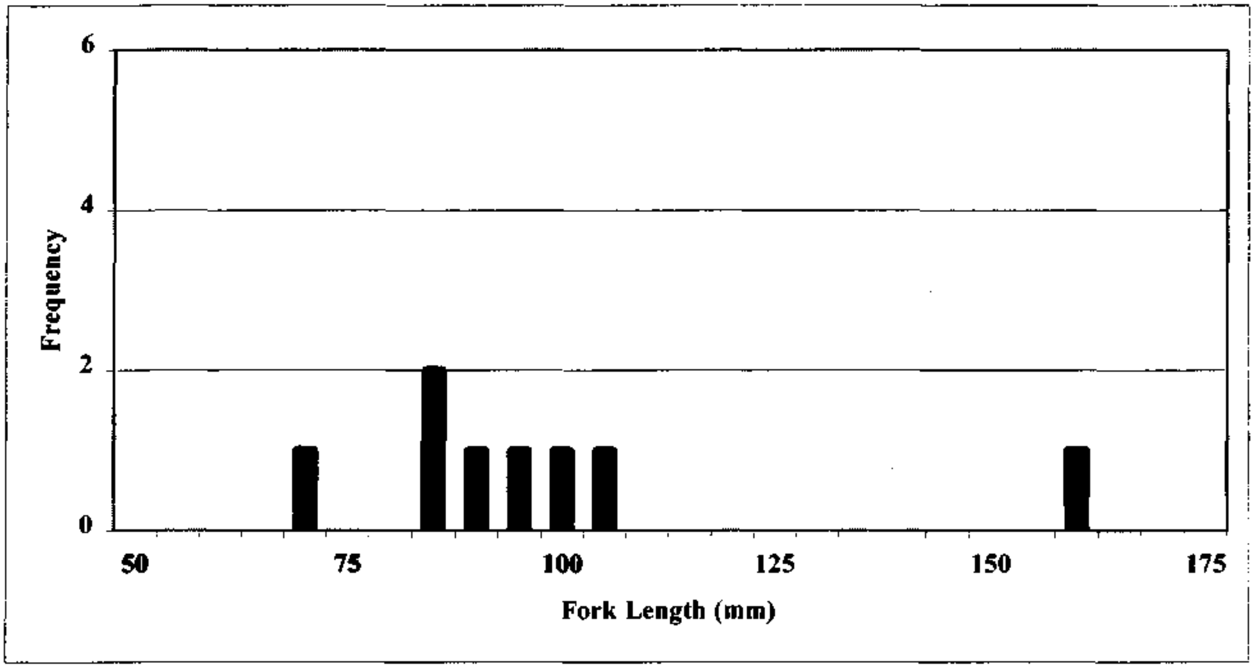
Appendix F. **Bluegill length-frequency histogram, Reach 4, August 2000.**



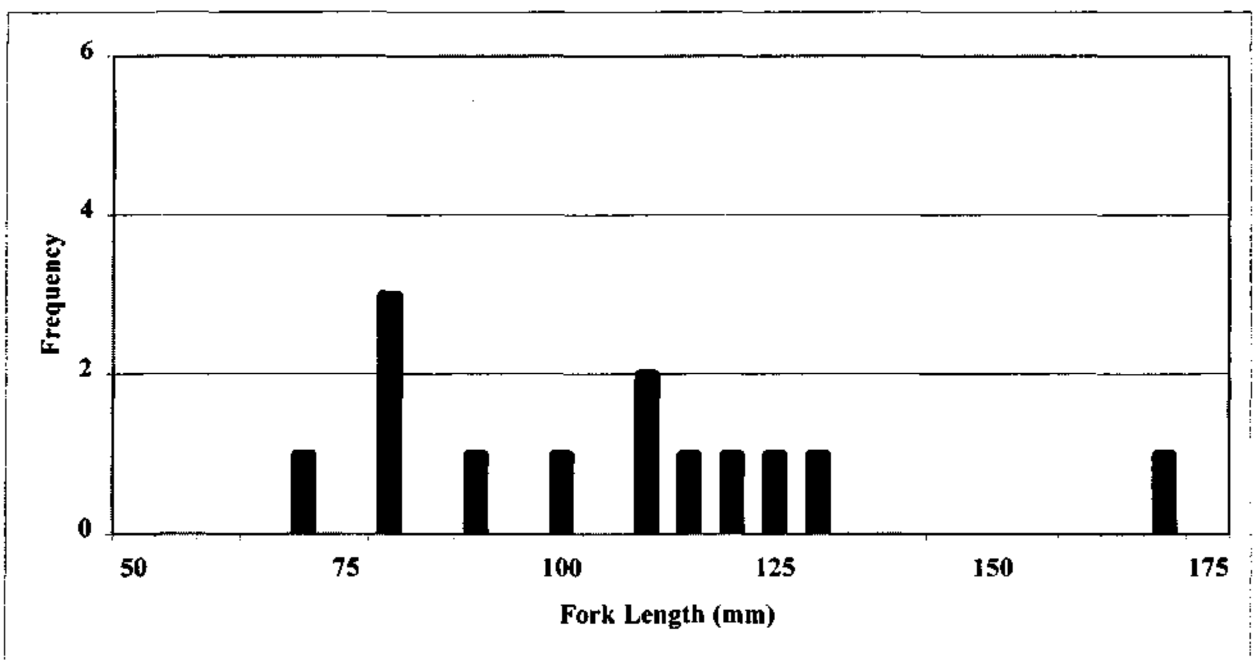
Appendix F. **Green sunfish length-frequency histogram, Reach 1, August 2000.**



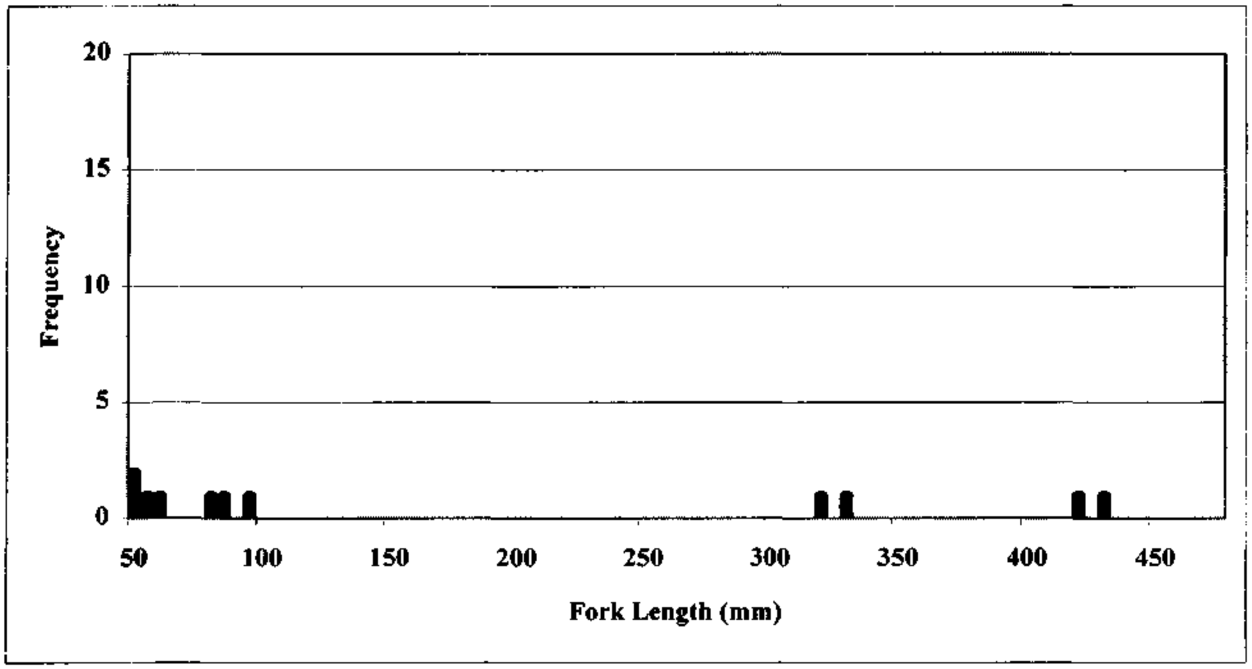
Appendix F. **Green sunfish length-frequency histogram, Reach 2, August 2000.**



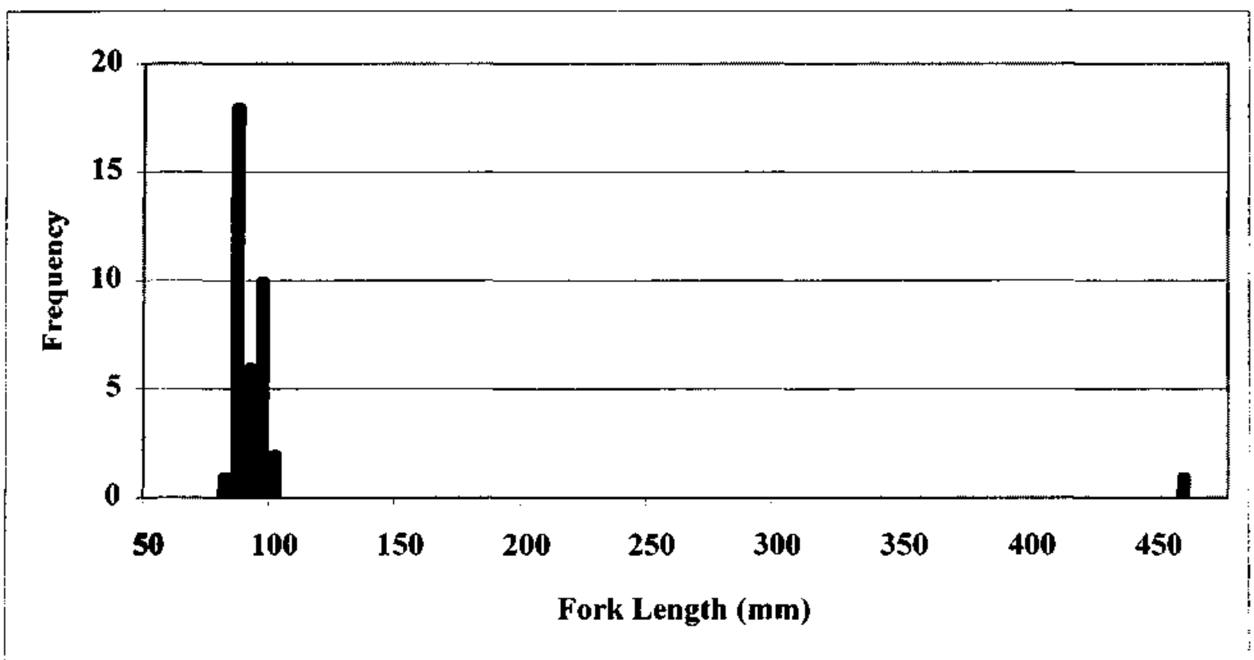
Appendix F. **Green sunfish length-frequency histogram, Reach 3, August 2000.**



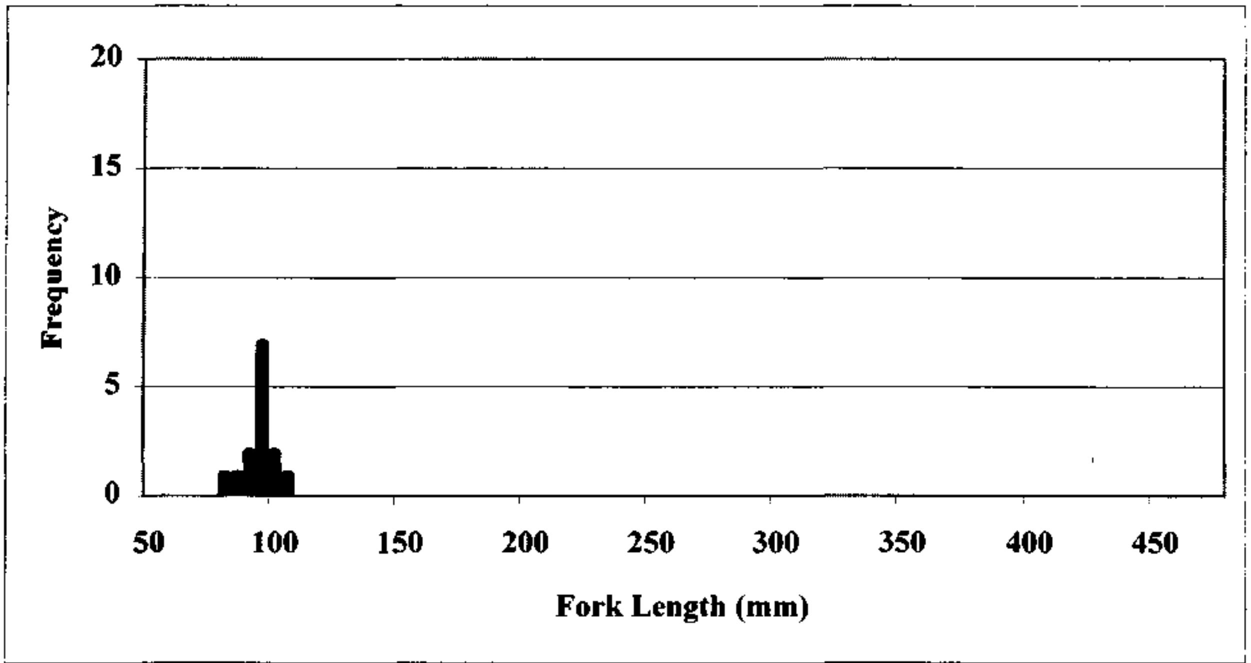
Appendix F. **Green sunfish length-frequency histogram, Reach 4, August 2000.**



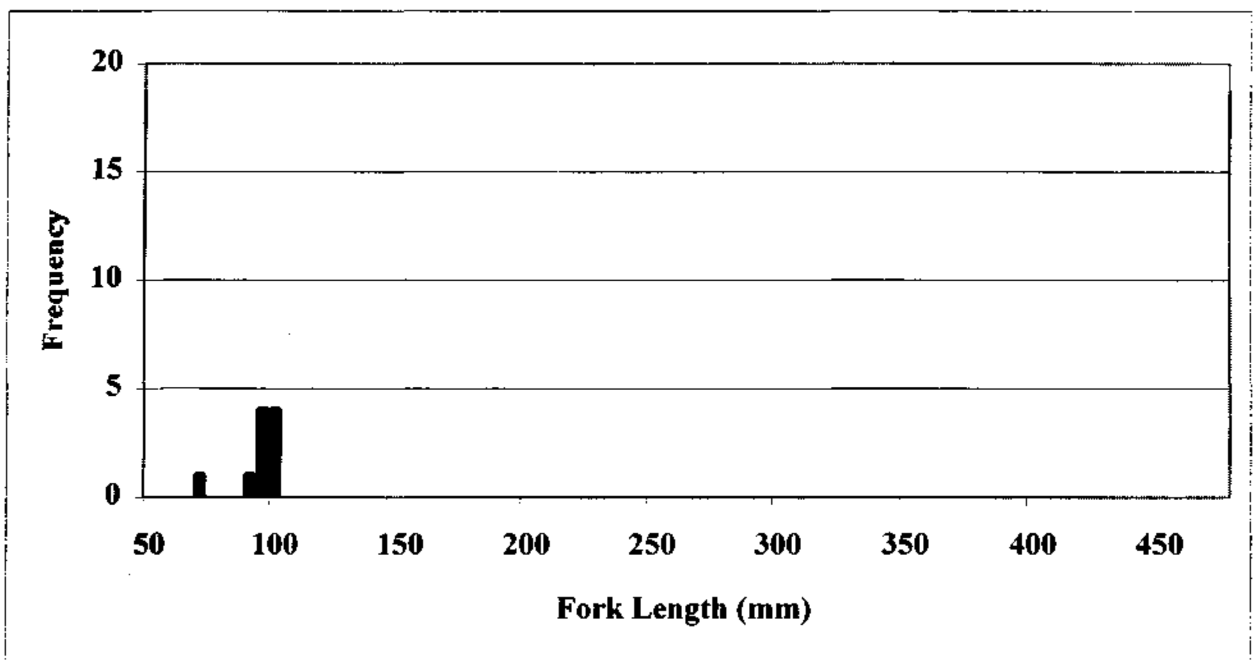
Appendix F. **American shad length-frequency histogram, Reach 1, August 2000.**



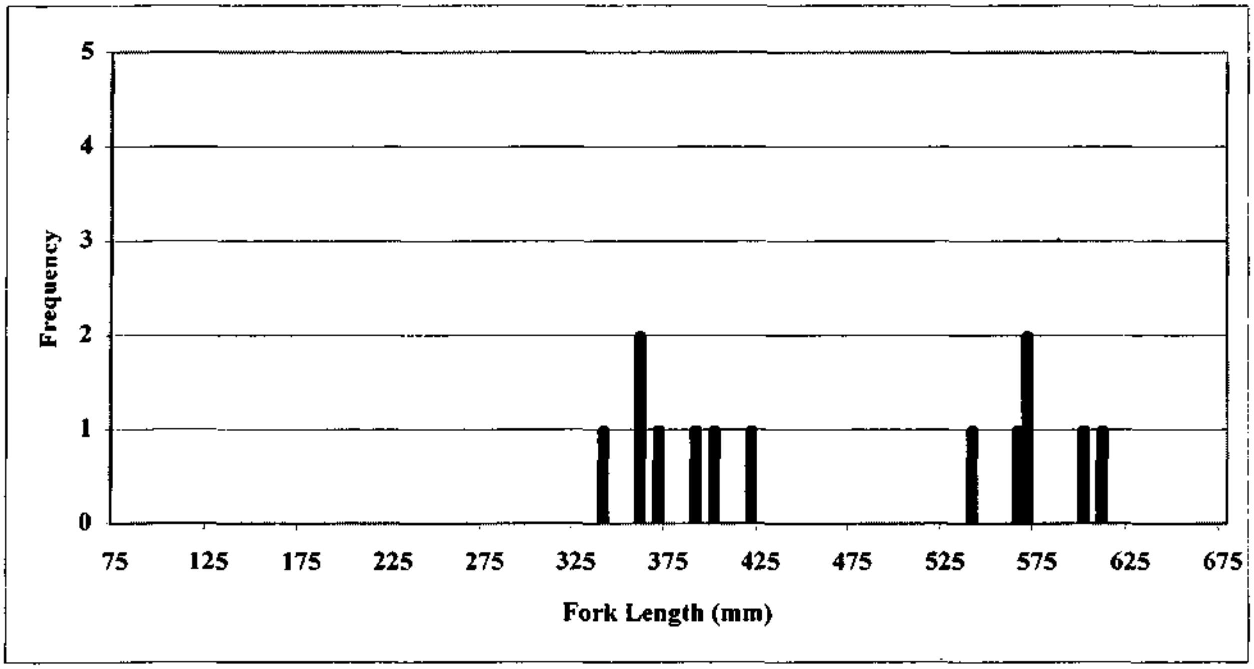
Appendix F. **American shad length-frequency histogram, Reach 2, August 2000.**



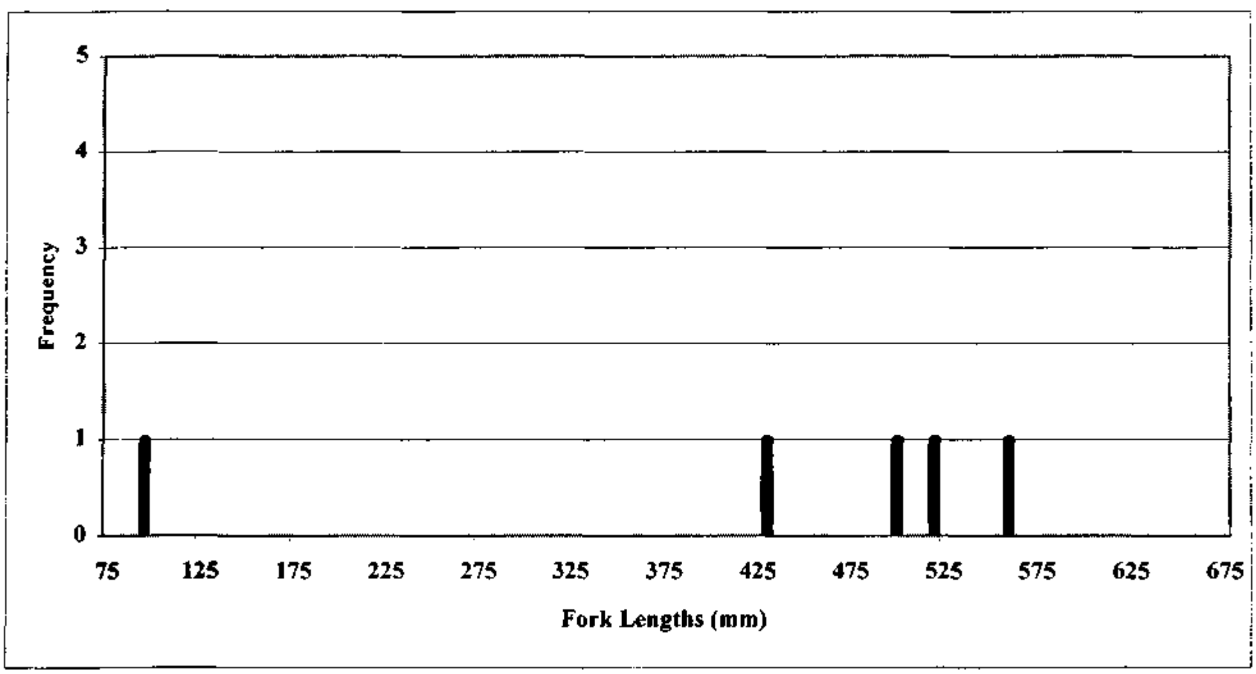
Appendix F. **American shad length-frequency histogram, Reach 3, August 2000.**



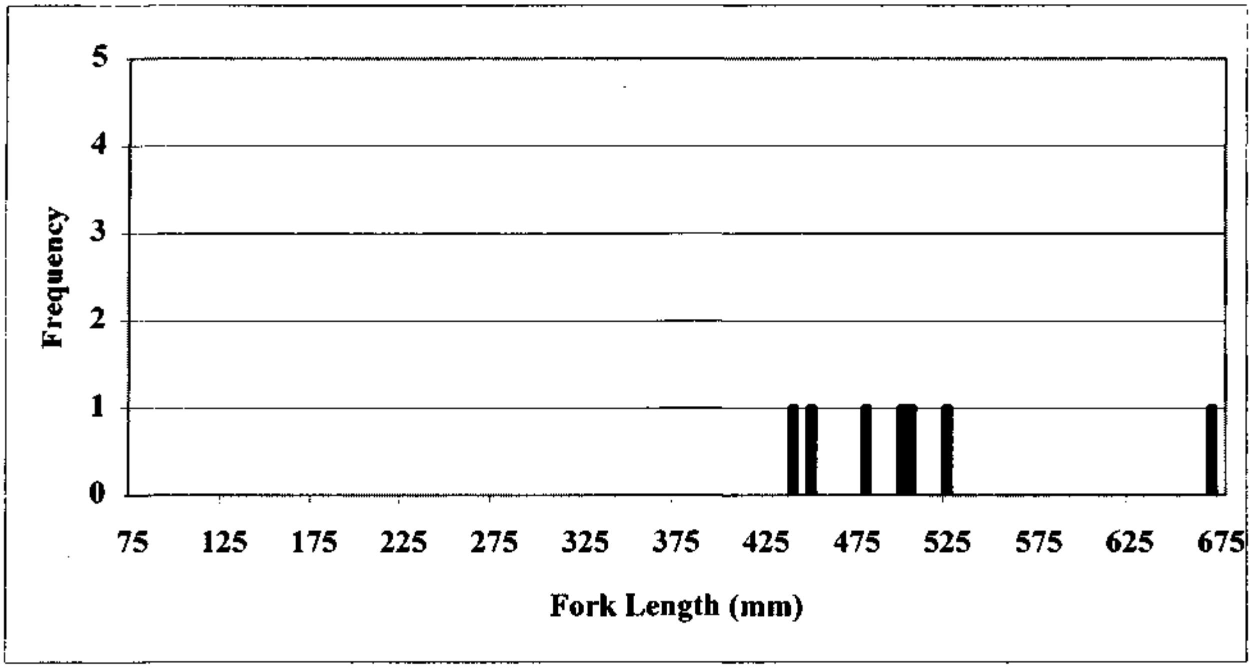
Appendix F. **American shad length-frequency histogram, Reach 4, August 2000.**



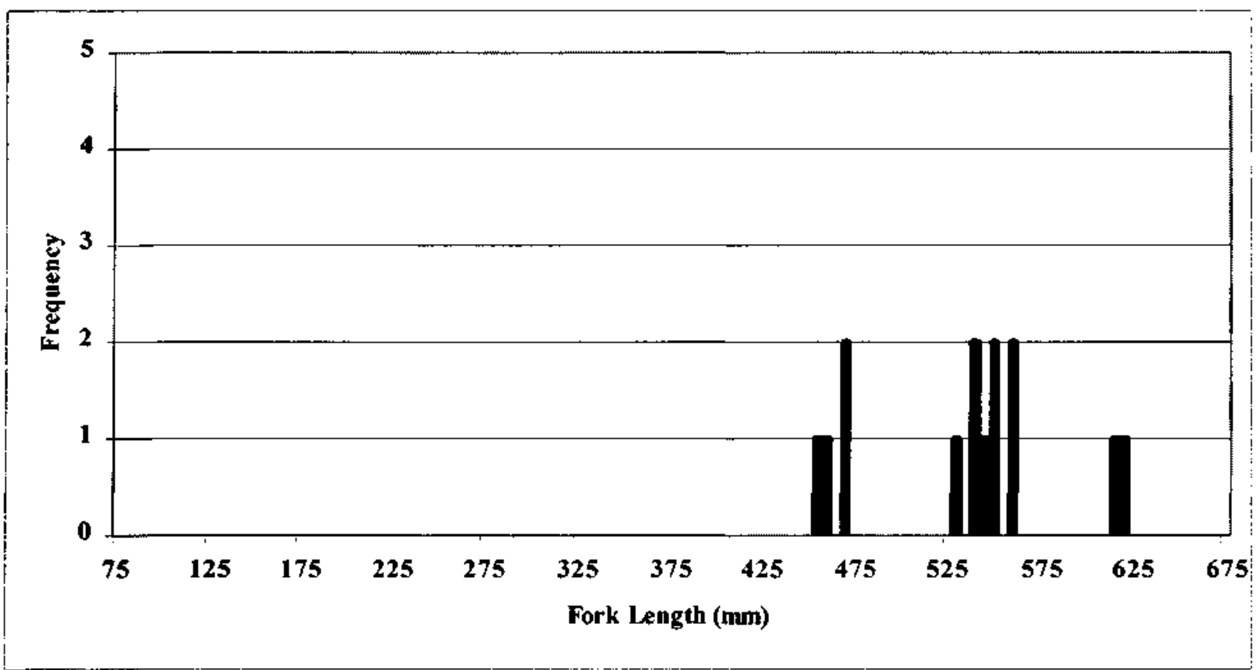
Appendix F. **Carp length-frequency histogram, Reach 1, August 2000.**



Appendix F. **Carp length-frequency histogram, Reach 2, August 2000.**



Appendix F. **Carp length-frequency histogram, Reach 3, August 2000.**



Appendix F. **Carp length-frequency histogram, Reach 4, August 2000.**

Appendix F. **Length data for species with fewer than 10 individuals captured, all Reaches combined, August 2000.**

Species	Reach	Fork Length (mm)
Hitch	**1**	**—**
	2	**120**
	3	**—**
	4	**—**
Sculpin	**1**	**—**
	2	**—**
	3	**90**
	4	**75**
Redear	**1**	**70, 75, 120, 130**
	2	**—**
	3	**—**
	4	**155**
White Crappie	**1**	**110, 115, 120, 140**
	2	**—**
	3	**—**
	4	**—**
Bullhead	**1**	**200**
	2	**240**
	3	**210, 230**
	4	**215**
Channel catfish	**1**	**—**
	2	**—**
	3	**—**
	4	**170**