SONOMA COUNTY WATER AGENCY'S MIRABEL RUBBER DAM/WOHLER POOL FISH SAMPLING PROGRAM: YEAR 5 RESULTS 2004

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Prepared by

Shawn Chase - Project Manager, Senior Environmental Specialist – Fisheries

Ron Benkert and David Manning - Senior Environmental Specialist – Fisheries

Sean White – Principal Environmental Specialist

Sonoma County Water Agency
P. O. Box 11628
Santa Rosa, CA 95406

EXECUTIVE SUMMARY

The Sonoma County Water Agency (Agency) diverts water from the Russian River to meet residential and municipal demands. Water diverted results from releases from upstream storage reservoirs. Water is stored in Lake Sonoma and Lake Mendocino, and releases are made to meet downstream demands and minimum instream flow requirements. 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, NOAA-Fisheries, 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. This study was initiated to provide information regarding the potential for the Agency's Inflatable Dam to adversely affect Chinook and coho salmon and steelhead. Results from this study were 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. After spending approximately one to four years growing and maturing in the ocean, adult salmonids migrate back to their natal streams 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) migrate 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.

Although the operation of the Inflatable Dam has the potential to negatively impact adult and juvenile salmonids, no studies had been conducted to assess the actual effects of the dam's operations on salmonid populations. In light of these uncertainties, the Agency conducted a five-year study to assess the potential impacts associated with the facilities, and to develop mitigation measures as appropriate. This report documents the results of the fifth year of study.

WATER TEMPERATURE

Water temperatures measured in the study area were likely stressful for salmonids for at least the last month of the smolt emigration period, the entire summer juvenile steelhead rearing period, and the beginning of the adult upstream migration period. The limiting conditions were similarly found above the influence of the impoundment, within the impoundment, and below the impoundment. Although the temperatures were often well above established temperature criteria, healthy appearing Chinook salmon and steelhead smolts were captured during periods when maximum daily surface temperatures ranged to >23.0ºC. In addition, juvenile steelhead were captured and observed in the Wohler Pool throughout the summer months. Water temperatures were sub-standard during the first few weeks of the adult migration period, but steadily improved as the migration season progressed.

Between 2001 and 2004, the monthly average temperature of water flowing through the Wohler Pool was estimated to increase by generally less than 0.5ºC above what would have been expected without the dam in place during June, July, and August. The data collected indicates that the Inflatable Dam results in a slight increase in the water temperature within the Wohler Pool over what would occur without the dam in place. However, at the temperatures measured, the increase is likely to be biologically insignificant. The temperature regimes during the summer months are marginal for salmonids, and it is unlikely that the steelhead population would increase in the absence of the dam (based on changes to the water temperature regime).

SMOLT EMIGRATION

This section of the study evaluated Chinook smolt passage at the Inflatable Dam. As part of the mark-recapture study instituted to estimate Chinook smolts abundance, Chinook smolts were marked with an alternating upper and lower caudal clip on a weekly basis, then transported approximately 0.8 km upstream of the dam. On the day following a change in the clip used, Chinook smolts captured in the screw traps almost invariably possessed the new clip. Few Chinook smolts were recaptured bearing the previous week's clip, which would indicate that they had required more than 24 hours too pass the dam. At emigration, Chinook smolts are two to four months old. Chinook salmon smolts were captured in the traps between March 1 and July 3 (the earliest and latest dates that the traps were fished during the 5-year study). Peak emigration generally occurred from mid April through mid May. Emigrating smolts average between 80 and 90 mm FL during the peak emigration period.

Steelhead smolts were captured in the trap from the first week in March through the last week in June during the 5-years studied. Peak emigration appears to occur from mid March through mid May. Steelhead emigrate to the ocean at (primarily) age 2.

Steelhead smolt emigration passed the dam was addressed in a companion study (Manning et al. 2004, Manning et al. 2005). There are three routes for fish to move downstream of the dam; through the fish bypass, down the ladders, and passing directly over the dam. Manning et al. (2003) found that 80 percent of the steelhead smolts in their study passed over the dam. However, at full inflation, the dam forms a flat surface and water passing over the dam is typically a few inches deep. Observations at the dam indicated that steelhead smolts were reluctant to pass over the dam when fully inflated. Manning *et al* (2005) reported that at least some hatchery steelhead smolts with surgically implanted radio tags did experience a delay, ranging from a few hours to a few days. The radio tagged steelhead appeared to negotiate the slack water behind the dam with little difficulty, however, the smolts were delayed in negotiating the dam. Steelhead smolts apparently were inhibited by the nature of the shallow water sheeting over the dam. Steelhead smolts were observed beginning to pass over lip of the dam, before hitting a critical spot where they would swim against the current and move back upstream of the dam.

The Agency has the ability to manipulate the shape of the dam to a small degree. By carefully filling the dam with water and air, the dam operators were able to form a notch in the dam which concentrated the flow through a relatively narrow section of the dam (Figure 3-5). The flow through the notch produced a relatively deep, high velocity passage route over the dam. Radio tagged steelhead encountering the dam after the formation of the notch passed the dam at a significantly faster rate compared to the flat crest configuration (see Manning et al. 2005 for a detailed discussion of the Notch).

WOHLER POOL FISH COMMUNITY

This section of the study assessed the fish assemblage in the study area, and in particular, the predator population. Three primary salmonid predators inhabit the study area, Sacramento pikeminnow, smallmouth bass, and largemouth bass. Although few adult pikeminnow were captured, they are capable of attaining a size large enough to feed on both Chinook salmon and steelhead smolts, and are a longed lived species, possibly up to 16 years (Scoppettone 1988). 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 an average size steelhead smolt and relatively few smallmouth bass large enough to feed on 80 mm FL Chinook smolts were captured. It is not known if the low number 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. Winter habitat conditions (i.e., when the dam is deflated) may a least partially explain the poor recruitment of smallmouth bass to older age classes. Very few largemouth bass were captured. Abundance of largemouth bass was highest in Reach 1 in all years sampled. Smallmouth bass, pikeminnow, and possibly largemouth bass attain a size sufficient to prey on Chinook salmonids by the start of their third year of life (age 2+).

All five study Reaches provide suitable habitat conditions for the three predatory species of concern. Based on a review of habitat requirements for smallmouth and largemouth bass, Reach 1 and Reach 2 should provide the most suitable habitat in the study area when the dam is inflated. Stream gradient in the Russian River declines below the dam, and there is a higher frequency of pool type habitats compared to the above dam habitat (Chase *et al.* 2000). The greater depth and lower current velocity associated with pool habitats is preferred by centrarchids (which include smallmouth and largemouth bass). Not surprisingly, centrarchids dominate the fish population in Reach 1.

During six years of sampling, four species of fish, smallmouth bass, Sacramento sucker, hardhead, and tule perch have dominated the fish community above the Inflatable Dam (Reaches 2, 3, and 4). Smallmouth bass and Sacramento sucker dominated the catch, when all years and sites are combined (28.5 and 27.9 percent of the catch, respectively). Tule perch and hardhead ranked 3 (12.6 percent of the catch) and 4 (12.0 percent of the catch), respectively. Pikeminnow were the 7th most abundant species captured during six years of sampling, accounting for 3.0 percent of the total catch. Largemouth bass comprised 0.5 percent of the fish captured during the study. Wild and hatchery salmonids have been collected in relatively low numbers, primarily in Reaches above the dam ("Wohler Pool").

All three predator species would inhabit the study reach with or without the dam in place, and populations of these species did not appear to be higher than those in upstream sections of the river based on snorkel surveys conducted by the Agency (Cook 2003). However, one potential impact that could not be directly assessed with the sampling techniques employed during this study was the potential for predators to occupy the reservoir just upstream of the dam, and prey on smolts as they negotiate passage by the dam.

ADULT MIGRATION

Based on the results of video monitoring from 2000 through 2004, Chinook salmon and steelhead appear to be highly successful in finding and ascending the fish ladders around the Inflatable Dam. Relatively large numbers of adult fish of both species have been documented negotiating the ladders, and large numbers of fish milling at the base of the dam have not been observed. Direct observation (snorkel) surveys are limited by visibility, which tends to deteriorate in October and November when Chinook salmon are most likely to be present in large numbers. However, if large numbers of salmonids had been present below the dam they would likely have been detected.

In 2004, approximately 4,788 adult Chinook salmon were counted ascending the fish ladders at the Mirabel Dam. During the five year study, the number of adult Chinook salmon counted at the Mirabel fish ladders has ranged from 1,383 to 6,081. These counts are likely underestimates of the true population size in the river. The Russian River often becomes highly turbid with during even moderate rainfall events. The poor visibility associated with these events precluded observing adult Chinook salmon on the video tapes resulting in days where no data could be collected. Based on the sampling effort to date, the Chinook salmon run pass the inflatable dam begins in September, peaks during October and November, and slowly diminishes through December.

Adult steelhead began their upstream migration in late October; however, the majority of their run occurs after the dam is deflated. Thus, little run information is available for this species. However, based on the data collected at the Warm Springs Fish Hatchery, at least the hatchery run peaks between December and March.

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1.0 INTRODUCTION

The Sonoma County Water Agency (Agency) operates the Mirabel/Wohler water diversion facility on the mainstem Russian River near the town of Forestville (Figure 1-1). The Agency supplies water to meet residential, municipal, and agricultural demands. Water diverted primarily results from releases from upstream storage reservoirs. Water is stored in Lake Sonoma and Lake Mendocino, and releases are made to meet downstream demands and minimum instream flow requirements. The Agency operates six 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 (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 five 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.

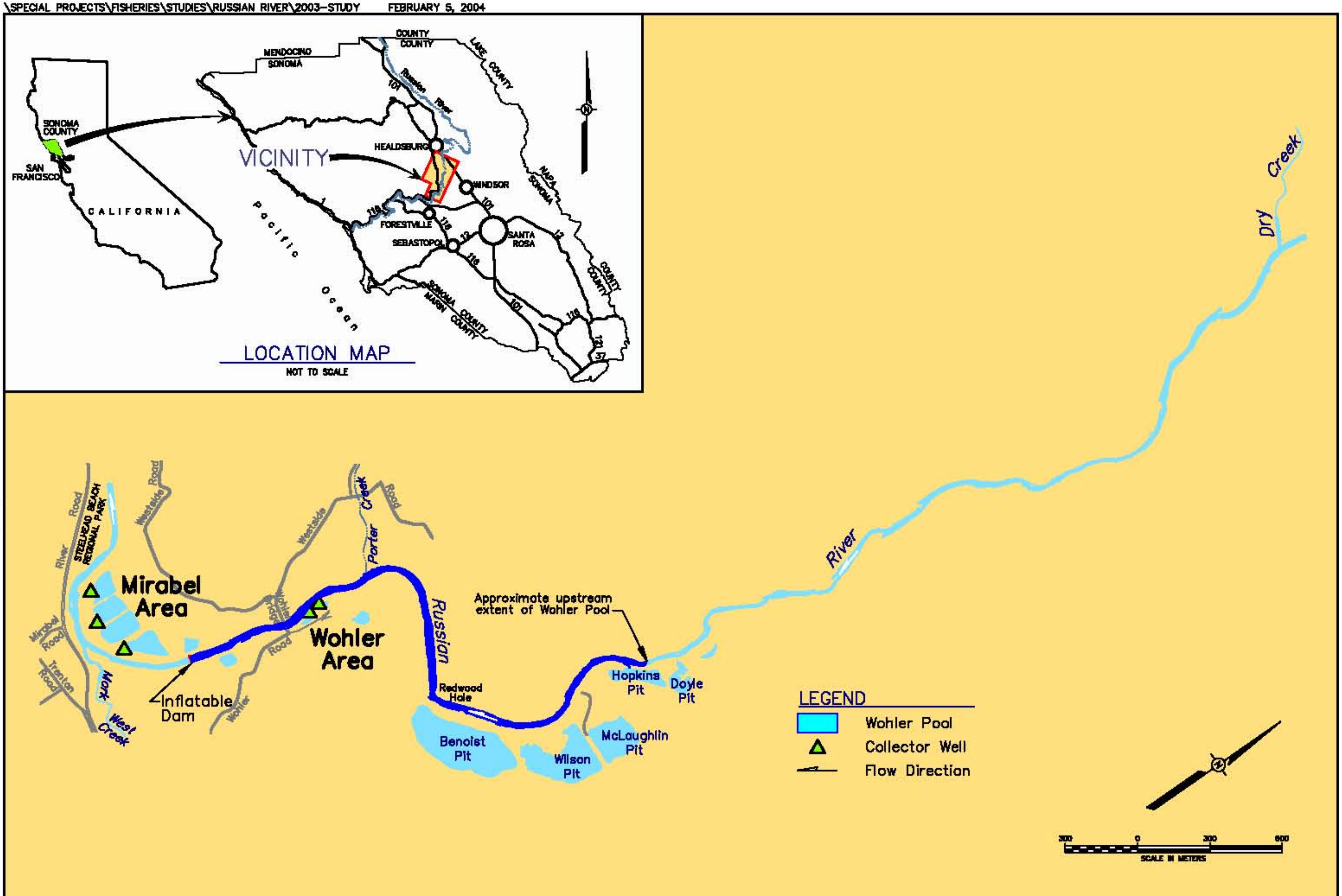
The dam is generally inflated between April and June and is deflated between late-September and mid-December of most years. However, the dam may be inflated during any month of the year, depending on conditions. The actual timing of dam inflation and deflation varies annually depending on a number of factors including, water demand, air temperature, precipitation, and river flow. The Inflatable Dam creates an impoundment that is approximately 5.1 kilometers (km) 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 (FESA) and one that is also listed as Endangered under the California Endangered Species Act (CESA). On October 31, 1996, the National Oceanic and Atmospheric Administration-Fisheries (NOAA-Fisheries) listed coho salmon as threatened under the FESA within the Central California Coast Evolutionarily Significant Unit (ESU), which includes the Russian River (Federal Register 1996). In addition, coho salmon inhabiting streams south of Punta Gorda (which includes the Russian River) have been listed by the Department of Fish and Game as endangered under the CESA. On August 10, 1997, NOAA Fisheries listed steelhead as threatened under the FESA within the Central California Coast ESU ((Federal Register 1997), which includes the Russian River. On September 16, 1999, NOAA Fisheries listed Chinook salmon as threatened under the FESA within the California coastal ESU ((Federal Register 1999), 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) migrate through the area during their downstream journey to the ocean. However, small numbers of 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 low levels.

In accordance with Section 7(a)(2) of the ESA, federal agencies must consult with either the USFWS and/or the NOAA Fisheries to "insure that any action authorized, funded, or carried out by such an agency is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat.…" In the present case, the endangered species are anadromous salmonids, which are managed by the NOAA Fisheries. The U.S. Army Corps of Engineers (USACOE), as the federal sponsor, and the Agency, as the local sponsor, entered into a Memorandum of Understanding (MOU) with the NOAA Fisheries to begin the consultation process in December 1997. The MOU covers the Agency's flood control and water supply projects throughout the Russian River Basin.

\SPECIAL PROJECTS\FISHERIES\STUDIES\RUSSIAN RIVER\2003-STUDY FEBRUARY 5, 2004



SONOMA COUNTY WATER AGENCY

Figure 1–1 Map of Study Area

Figure 1-2. **The Mirabel Inflatable Dam (lower picture) and a portion of Wohler Pool (upper picture).**

The Agency has prepared a Biological Assessment of its operations and facilities to assess potential impacts to ESA protected species. 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 were incorporated into the Agency's Biological Assessment.

The Inflatable Dam has the potential to negatively impact several phases of the salmonid life history:

- The impoundment slows the flow of water through the basin, and may result in an increase in water temperatures within the impoundment and downstream of the dam. An increase in temperature may degrade conditions if juvenile steelhead rear in the lower river. An increase in water temperature may also negatively affect smolts during the later stages of emigration period and during the early stages of the adult upstream migration period.
- The Inflatable Dam impounds 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 loss of this tactile cue may result in smolts becoming disoriented while passing through the impoundment, which could delay outmigration. Although there are three avenues for juvenile fish to pass by the dam (going over the dam, through the fish ladders, or through the fish bypass facilities), fish that become disoriented may have difficulty finding these passage routes. This potential impact is only partially addressed in this study. A companion study (Manning *et al.* 2001, 2003, and 2005) covers this topic in detail.
- 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.
- The dam forms an 11-foot high barrier that effectively blocks upstream migrating adult salmonids. Although the dam is equipped with two denil type fish ladders; the effectiveness of the ladders has not been evaluated prior to this study.

Although the operation of the Inflatable Dam has the potential to negatively impact adult and juvenile salmonids, no studies had been conducted to assess the actual effects of the dam's operations on salmonid populations. In light of these uncertainties, the Agency initiated a five-year study to assess the potential impacts associated with its diversion facilities at Wohler and Mirabel, 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). This report documents the final results of the five year study.

1.1 STUDY AREA

The study area encompasses the Russian River from approximately 2.3 river kilometers (RK) downstream of the Inflatable Dam (Steelhead Beach Regional Park) to approximately 12.7 RK upstream of the dam (just above the confluence with Dry Creek) (Figure 1-1).

The Steelhead Beach Sampling location (Reach 1) is a relatively large (approximate 620 meter long) pool located downstream of the dam. Steelhead Beach was the only location found where an electrofishing boat could be launched and operated in the river within the first few miles downstream of the dam. This site was used to characterize the fish community in the river below the impoundment (under the constraint of the limited sampling area).

Wohler Pool is a 5.1 km long impoundment formed by the dam. The water surface elevation (depth) and current velocity in the lower 3.0 km of the impoundment is significantly influenced by the dam. The water surface elevation in the upper 2.1 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. Reaches 2, 3 and 4 represent the lower 1/3, middle 1/3, and upper 1/3 of the impoundment. Reach 2 was characterized as being the main body of the impoundment, and was pond-like in habitat. This reach had the greatest overall average depth and lowest water velocity. This reach undergoes the greatest change in habitat when the dam is deflated. During the spring when the river flow in decreasing, but prior to inflation of the dam, this section of river becomes a series of riffle and run habitats (see discussion in Section 4.4 for potential affects on fish). Reach 3 was characterized as being a relatively shallow (excluding a deep pool at both the downstream and upstream ends of the reach), low velocity habitat. Reach 4 transitioned from the impoundment to free flowing river. The downstream end of the reach was characterized by long, moderately deep (1 to 2 meter deep pools). The upper end of this Reach is marked by a run habitat with a relatively high current velocity.

A relatively short reach of the river was accessible to the electrofishing boat in some years (Reach 5). This reach is above the influence of the dam, and is representative of riverine habitat under the current flow regime. In addition, three water temperature monitoring stations were located approximately 6.4, 6.9, and 7.1 RK above the upstream extent of the pool. The upstream most temperature station was located approximately 200 meters upstream of Dry Creek, and represented temperatures above the influence of this major tributary. A second temperature station was located in the mouth of Dry Creek, and the final temperature station was located downstream of Dry Creek, and was used to assess the rate at which water temperature changed above and within the influence of the Wohler Pool.

1.2 HISTORICAL FISH SURVEYS

The fish community in the study area (Steelhead Beach and the Wohler Pool) has been surveyed by various sampling techniques over the past 5 years. In addition, the lower Russian River fish community has been previously surveyed on several occasions between 1954 and 1993 (Johnson 1954, Johnson 1955, Johnson 1957, Cox 1984, Hopkirk and Northen 1980, Nielsen and Light 1994). These surveys have generally been conducted during the summer (July through August) period. Sampling techniques were generally limited to beach seining and the application of the fish toxicant, Rotenone.

To date, 32 species, including 17 native species, have been collected or observed during fish sampling programs conducted between 1999 and 2004 (Table 1-1). Four additional species of fish have also been reported in the Russian River. Coastrange sculpin inhabit tributaries located primarily downstream from the Inflatable Dam. River lamprey are also occasionally observed/captured in the river and larger tributaries (Moyle 2002). White and green sturgeon, at least historically, entered the Russian River, although these species apparently do not spawn or rear their young in 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).

Table 1-1. Common and scientific names of species captured in the Russian River during 1999 through 2004 sampling efforts, including their status (native or introduced), life history strategy (anadromous or resident), and their regulatory status.

Common Name	Scientific Name	Status	Resident - Anadromous	Regulatory status
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*	Uncertain[2]	Resident	--
Hitch	*Lavinia exilicauda*	Native	Resident	--
Pikeminnow	*Ptychocheilus grandis*	Native	Resident	--
Fathead minnow	*Pimephales promelas*	Introduced	Resident	--
Golden shiner	*Notemigonus crysoleucas*	Introduced	Resident	--
Common carp	*Cyprinus carpio*	Introduced	Resident	--
Threespine stickleback	*Gasterosteus aculeatus*	Native	Resident	--
Bluegill	*Lepomis macrochirus*	Introduced	Resident	--
Green sunfish	*Lepomis cyanellus*	Introduced	Resident	--
Redear sunfish	*Lepomis microlophus*	Introduced	Resident	--
Black crappie	*Pomoxis nigromaculatus*	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	--
White catfish	*Ameiurus catus*	Introduced	Resident	--
Bullhead	*Ameiurus melas*	Introduced	Resident	--
Mosquitofish	*Gambusia affinis*	Introduced	Resident	--
Pacific lamprey	*Lampetra tridentata*	Native	Anadromous	--
Western brook lamprey	*Lampetra richardsoni*	Native	Resident	--
Steelhead	*Oncorhynchus mykiss*	Native	Anadromous	FT
Chinook salmon	*Oncorhynchus tshawytscha*	Native	Anadromous	FT[3]
Coho salmon	*Oncorhynchus kisutch*	Native	Anadromous	FE[4]
Chum salmon	*Oncorhynchus keta*	Native/Stray	Anadromous	--
Pink salmon	*Oncorhynchus gorbuscha*	Native/Stray	Anadromous	
Striped bass	*Morone saxitalis*	Introduced	Anadromous	--

[1]California species of special concern
[2]Status of this species is uncertain. Although they are native to the Sacramento River, their status in the Russian River is not clear (Hopkirk 1973).
[3]Listed as Threatened under the Federal Endangered Species Act
[4]Listed as Endangered under the State and Federal Endangered Species Acts

In the early 1950's, CDFG treated the mainstem Russian River and several tributaries with the fish toxicant Rotenone in an attempt to reduce non-salmonid fish from the river (under the false assumption that competition with these species was responsible for limiting salmonid populations) (Pintler and Johnson 1956). Sacramento sucker accounted for 90 percent of the fish killed during the chemical treatments. Roach, carp, and pikeminnow ranked 2 through 4 in terms of abundance. Few "game fish" (presumably sunfish) were collected, the most abundant of which were smallmouth bass. In the lowest reaches of the river, juvenile shad were the most abundant species. Pintler and Johnson (1956) provide anecdotal information on the distribution and relative abundance of several species of fish collected after the application of Rotenone to the Russian River. Juvenile steelhead were collected in low numbers throughout the river ("the total count being estimated at about 500"). Approximately 150 adult coho salmon were killed in the Monte Rio to Jenner reach. Pacific lamprey ammocoetes were abundant throughout the treated reach ("The number of ammocoetes in those areas of the river where counted exceeded the total of all the other fishes present by as much as sixteen times"). "Brook lamprey" were found only at the Vichy Springs Bridge (Ukiah). Sacramento sucker were the most abundant species collected, and were noted as being very abundant at all locations sampled (second dam below the PG&E powerhouse in Potter Valley downstream to the Duncan Mills area). Tule perch were "fairly abundant" throughout the drainage from the lower end of Potter Valley to the mouth. Pikeminnow were distributed throughout the river. Large pikeminnow were noted as being abundant in the lower end of Potter Valley, near Ukiah, and near Duncan Mills. Juvenile pikeminnow ("6 to 10 inches long") were most abundant above Healdsburg. Hardhead were found in low numbers above Healdsburg. Smallmouth bass comprised 0.5 percent of the fish collected and were captured from the East Branch downstream to "the mouth of the Russian River." "Several" largemouth bass were killed in a post treatment of two sloughs near Geyserville. Green sunfish were found in low numbers, primarily in sloughs near Geyserville and Healdsburg, while bluegill (6 total) were found near Geyserville. A follow up study in 1958, conducted by CDFG using Rotenone, found that non game species (primarily "minnows" and "suckers") comprised 84 percent of the fish in the Russian River Basin (Holman 1968a). The study concluded that "… benefits from past chemical rough fish control programs are short-lived."

Young-of-the-year and age-1 or older steelhead were collected infrequently during the summer rearing period. Summertime water temperatures were 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 (Johnson 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 (Johnson 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). Only four juvenile coho have been collected during the present study (all in the downstream migrant traps fished below the Mirabel Dam in 2004). Two juvenile Chinook salmon have been collected in the lower Russian River during the late summer (August), although emigrating Chinook salmon smolts have been collected during the spring in the river (this report) and in the estuary (Merritt Smith Consulting 1997).

Based on six years of 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 predator, striped bass, also inhabits portions of the lower Russian River. However, only two adult (and a small number of sub adult) striped bass have been captured or observed in the study area.

Fish communities in the Russian River Basin form analogous aggregations to those described by Moyle and Nichols (1973) and Moyle (2002). Fish populations change in response to habitat conditions. Two important factors affecting the distribution of fish are water temperature and stream gradient. The borders between fish zones are not distinct, but gradually shift from one zone to another in response to changes in habitat. The five freshwater zones described by Moyle and Nichols (1973) and Moyle (1976) are; the Rainbow Trout Zone (RTZ), the California Roach Zone (CRZ), the Pikeminnow - Sucker - Hardhead Zone (PSHZ), the Deep-bodied Fish Zone (DFZ), and the Estuarine Fish Zone (EZ). The RTZ is found in headwater streams with relatively high gradients, cool well-oxygenated water. Fish communities are dominated by rainbow trout, although sculpin are often found in the lower portions of the zone. Examples of the RTZ include the upper reach of Mark West and Santa Rosa creeks. The CRZ is typified by warm, intermittent streams. California roach are the dominant species in the middle section of Mark West Creek and below Highway 12 on Santa Rosa Creek. The PSHZ is found in the mainstem Russian River near Mirabel.

1.3 HISTORICAL SALMONID POPULATION ESTIMATES

Four species of salmonids inhabited the Russian River, historically. Steelhead, Chinook salmon and coho salmon maintain populations within the basin, while pink salmon are believed to be functionally extinct, although adult pink salmon are occasionally observed in the river. A fifth salmonid species, chum salmon, are occasionally observed in the river as well, but they are likely strays from other river systems. The historical populations of steelhead, coho, Chinook, and pink salmon were never quantitatively estimated (Hinton 1963, Prolysts and Beak 1984, Steiner 1996, CDFG 2002, NCRWQCB 2004). Nevertheless, many documents (including those cited above) have provided "historical estimates" for these species. We reviewed the source documents to evaluate the validity of these estimates.

1.3.1 Pre 1900 Fisheries Information

Chinook salmon in the Russian River are an enigma. There are no records indicating whether or not Chinook salmon inhabited the Russian River prior to stocking efforts initiated during the 1880's. Fisheries data from Sonoma County prior to 1900 are sparse. The United States Commission of Fish and Fisheries (USCFF) produced annual reports on commercial fishing activities, hatchery operations, and research efforts throughout the United States, and sometimes the world. The few references to the fisheries of Sonoma County, although lacking in specific details, provide an intriguing glimpse into historical fish populations. The earliest mention of Chinook salmon in the Russian River is a reference to stocking 30,000 juveniles into the basin in 1881 (USCFF 1910). The earliest record of a commercial fishery found for Sonoma County was from 1888 (USCFF 1892). The 1892 document briefly described a commercial fishery consisting of 19 men gillnetting "salmon" from the Russian River. The commercial catch ranged from approximately 21,000 and 36,000 pounds of salmon (Table 1-2) in the Russian River annually, and that the catch by local fisherman ranged from 75,000 to 100,000 pounds of salmon (salmonids were not identified to species). In 1888, 33,597 pounds of salmon were captured by commercial fisherman and shipped to San Francisco. In addition, "…local consumption of fish was estimated at 150,000 pounds…" However, it was noted that all of the commercial fisherman in 1888 were cited and fined for using illegal gill nets (mesh size of nets smaller that the legal limit for California). Table 1-3 was presented in USCFF (1892) details the number of fish captured by month during 1888.

The size of the fish captured in 1888 (8 to 20 pounds) is consistent with the size of three of the salmonids commonly found in the Russian River. In addition, the run timing of the three salmonids species overlaps with the time of year of the reported catch (Chinook enter the river primarily in October and November (range September through December), coho salmon run primarily in November and December (range October through January), and steelhead run primarily December through March (range November though May). Thus, it is possible that all three species of salmonids contributed to the catch in 1888. Pink salmon average approximately 2 to 6 pounds in weight and in California, spawn during September and October (Moyle 2002). Pink salmon are not mentioned in the USCFF reports concerning Sonoma County. Thus, pink salmon likely did not contribute significantly to the commercial catch.

Catch records are also available for the years 1890 to 1892 (USCFF1893 and 1896). In those years, the commercial catch ranged between 21,375 to 36,656 pounds (Table 1-2). The species given for these years was Chinook salmon. Unfortunately, the site description for the fishery in the 1890 to 1892 period was not specific, noted only as being "… in the shore or boat fishery…." Included in the commercial totals were flounder and rockfish suggesting that a marine fishery existed in Sonoma County, thus, an ocean fishery for the salmon can not be ruled out. However, the gear used (gillnets and trammel nets) and the number of fisherman involved in the fishery was identical to that of 1888 when the fishery were located in the river. The time of year that the fish were captured is also not provided for the 1889 to 1892 era. In 1888, a significant portion of the catch was made in January through May suggesting that steelhead likely comprised a significant portion of the catch.

Table 1-2. Pounds of commercially caught salmon in the Russian River prior to 1900 (data from USCFF 1892, 1893, 1896).

Year	Chinook salmon	Salmon
1888		33,597
1889	26,81	
1890	21,375	
1891	36,656	
1892	28,839	

Table 1-3. Pounds of commercially caught "salmon" by month in the Russian River near Duncan Mills and shipped to San Francisco in 1888 (data from USCFF 1892).

Month	Pounds
January	14,677
February	3,785
March	0
April	250
May	650
October	8,485
November	6,150
December	0
Total	**33,597**

Other references to Sonoma County prior to 1900 included a USCFF (1895) comment that trout and black bass were abundant in the river. The noted ichthyologist David Starr Jordan (1896) observed that the Sonoma County coastline had no bays especially suitable for fishing. And that "salmon run in the Russian river in the fall and are taken in some number the total annual catch cannot exceed 10,000 pounds."

1.3.2 Fisheries Information – 1900 to present

1.3.3 Chinook salmon

During the 1940's and 50's, the general consensus among biologists familiar with the river was that few Chinook inhabited the river, and those that did were the results of stocking activities. Chinook salmon were first stocked into the basin in 1881, when 15,000 fry were planted in the Russian River, and additional 15,000 Chinook fry were stocked into "Skaggs Springs." An additional 25,000 Chinook fry were stocked into the Russian River in 1907 (USCFF 1910). Plantings occurred sporadic from that time through 1959. Between 1959 and 1960, 2.25 million fry and 500,000 eyed eggs were planted in the river by CDFG. In 1964, CDFG planted late winter run Chinook fry from the Green River in Washington in an attempt to produce a run of Chinook that would return the river later in the fall after the water temperature cooled to more appropriate levels. In 1982 CDFG attempted to establish a run at the Warm Springs Fish Hatchery. Approximately 2 million fry and smolts were released from the hatchery between 1982 and 1996. Adult returns to the hatchery ranged between 0 and 304 fish during this time. CDFG ended its Chinook hatchery program in 1996.

The historical records of Chinook salmon in the Russian River that do exist are sparse, but most indicate that the population was never very large. Sources in the 1940's and 1950's stated that few, if any, Chinook inhabited the river. Rich et al. (1944) and Shapovalov (1955) stated that Chinook salmon did not in habitat the Russian River. Murphy (1946) noted that “other” salmon (other than coho) occasionally enter the Russian River. However, pink salmon inhabited the Russian River during the 1940’s. Thus, this statement could refer to either Chinook or pink salmon. Pintler and Johnson (1956) reported that although Chinook salmon were occasionally caught in the lower river, they were rare. Day (1961) attempted to document Chinook salmon spawning in the Russian River. The methods for the study did not entail a systematic search of potential spawning areas, and appears to have been limited to observations made by a biologist taking temperature readings at two locations on the river (one at the base of Coyote dam, and the second at Talmage Road bridge in Ukiah, and by wardens making observations in the Cloverdale to Jenner Reach). Although several adult Chinook salmon were observed in the river during September and October, no spawning was observed. A rain event in mid November reduced water clarity, and observations were not made after this point. The report concluded that little spawning took place in the river in1960, and that high water temperatures likely prohibited Chinook from spawning. Day (1961) did report that approximately 75 to 100 Chinook salmon were caught in the mainstem by anglers. Hinton (1963) stated that the Chinook salmon runs were increasing in response to heavy stocking practices between 1956 and 1960. Hinton (1963) reported that angler catch of Chinook salmon was approximately 25-50 in 1959, 200 to 250 in 1960, and 500 to 600 in 1961. He concluded that the Chinook run in the Russian River in 1961 was 1,000. Jensen (1973) in an internal memo reported that CDFG plants of Chinook salmon resulted in a minor fishery, but that the fish were unable to reproduce successfully. CDFG (1991) stated that it is not known if Chinook maintained a self-sustaining population in the Russian River. But if it did, then there was “likely only about 100 spawners.” A few sources provide estimates for Chinook salmon in the Russian River (e.g., CDFG 1965 – 1,000; Winzler and Kelly 1978 – 500, Jones 1993 – 40 to 125).

Steiner (1996) concluded that very few Chinook were presently in the Russian River basin. Moyle (2002), states that the Chinook salmon in the Russian River disappeared due to the advent of agriculture and water projects in the river, and that attempts to reestablish Chinook salmon through stocking did not appear to have been successful.

Similarly to the 1940’s and 50’s, the general consensus among fishery biologists in 1999 was that few Chinook salmon inhabited the river. However, between 2000 and 2004, approximately 1,400 to 6,100 adult Chinook salmon counted passing the dam annually. Genetics analysis of Chinook salmon was conducted by the Bodega Marine Lab (BML) under a funding agreement with SCWA. BML completed microsatellite analyses on 449 fish to assess the affinity of Russian River Chinook with Warm Springs Hatchery, Central Valley, and other coastal populations of Chinook. Genetic analysis concluded that the Russian River Chinook population is not a remnant of the Warm Springs Hatchery population, nor are they closely related to the Central Valley populations. The Russian River Chinook did cluster closely with Eel River Chinook; however, the two populations are distinct from one another with a bootstrap value of 919. Further, Hedgecock et al. (2002) states that “Chinook in the Russian River do appear to belong to a diverse set of coastal Chinook populations.” Although samples from Russian River Chinook smolts deviated from Hardy-Weinberg equilibrium in some cases, there was no evidence of linkage disequilibrium.

1.3.4 Steelhead

The historical estimate for steelhead in the Russian River has been cited in a number of reports ranging from 50,000 to 57,000 fish (CDFG 1965, Vestal and Lassen 1969, Prolysts and Beak 1984, Steiner 1996, CDFG 1996, CDFG 2002). The estimate of 50,000 steelhead has its origins in Evans (1959) and Hinton (1963). Evans (1959) conducted a fish rescue operation at the base of Coyote Dam on March 26, 1959, and captured 375 adult steelhead. Several additional steelhead were observed below the dam but not captured. From this one day of fish rescue work, Evans stated that “It indicates in all probability perhaps 2,000 or more steelhead may be present at the base of the dam in the course of a normal annual run.” No additional supporting data were provided to support this claim. Hinton (1963) also uses the same 2,000 estimate in the East Branch in 1959, and 800 to 1,000 steelhead in 1960. CDFG’s estimates were based on one-half hour counts of steelhead jumping at the dam made by local wardens in 1959 and 1960 and the rescue of adult steelhead at the dam on one day in each year. CDFG personnel also participated in "brief surveys" of Dry and Santa Rosa creeks, and came up with a figure of 8,000 steelhead in Dry Creek, and 5,000 in Santa Rosa Creek. No data or other supporting information were provided in the source documents to validate these numbers. The numbers used for the run size for these three creeks (East Branch of the Russian River, Dry, and Santa Rosa) were then expanded to the entire Russian River on the basis of proportionate stream mileage and drainage area to arrive at the estimate of 50,000 steelhead in the Russian River.

Several documents cite the steelhead sports catch in 1957 at 25,000 fish and the total run in 1957 as 57,000 fish. NCRWQCB (2000) cites these numbers, but did not reference a source. CDFG 2002 cites Steiner (1996), while Steiner (1996) cited Christensen (1957) for the sport catch (25,000) and Prolyst (1984) for the source of the estimated 57,000 steelhead in the Russian River. Prolyst (1984) cites Christensen (1957) as the source for the 25,000 steelhead caught be sports anglers, but cites Vestal and Lassen (1969) as the source of the 57,000 steelhead. Vestal and Lassen (1969) state "57,000 steelhead and 5,500 salmon use this drainage annually for spawning and nursery grounds" but provide no supporting data to substantiate these numbers. The Christensen citation is a newspaper article where the author estimated the number of fish he believed were caught in 1956/57 steelhead run. A point stressed by the article was that the rainfall pattern that year allowed the mouth of the river to remain open during the upstream migration period for steelhead, but that the flow in the tributaries was too low for steelhead to migrate into their spawning tributaries, and that the fish were concentrated in the mainstem for an extended period of time. The river remained low and clear, and open to fishing essentially the entire time that steelhead were in the river. The catch of steelhead was sufficient that the author was concerned that a significant portion of the spawning population was being removed and that lower runs might result in following years. The 25,000 and 57,000 figures cited to illustrate the size of the historical steelhead population are not based on scientifically defensible data. The estimate of 57,000 adult steelhead returning annually to the Russian River is based on a dead end source, that is, the number is cited with no supporting information to validate the number. The 25,000 sports caught fish is based on a guess by a newspaper reporter, and occurred under conditions that may have lead to the overexploitation of the steelhead population that year.

Although no comprehensive surveys have been conducted across the basin, steelhead appear to be widely distributed throughout the watershed. Relatively healthy populations have been documented in Mark West, Santa Rosa, and Millington creeks (Cook and Manning 2002). Steelhead have also been documented in Sheephouse, Austin, Ward, Green Valley and Mill creeks (CDFG unpublished data). The anecdotal information presented in the literature does suggest that the historical steelhead populations were likely very large, and although steelhead are presently widely distributed in the basin, the overall population is likely depressed compared to historically levels.

1.3.5 Coho salmon

There are no historical estimates for coho salmon prior to 1975. Although some researchers (Steiner 1996) theorized that the commercial fishery in the lower Russian River during the late 1800's was composed primarily of coho salmon, the time of year that many of the fish were captured argues against this. In 1888, 58 percent of the fish shipped to San Francisco were captured January through May, suggesting that steelhead were a large portion of the catch. Although the information from 1889 through 1892 states that only Chinook salmon were captured in Sonoma County, these data do not specifically state that the catch was in-river (tables displaying catch data use the qualifier "…in the shore or boat fisheries…." Thus, it does not rule out that coho were part of the in-river catch.

Few other reports of coho salmon were found in the literature. Rich et al. (1944) stated that runs of coho salmon were small and sporadic. Conversely, in 946 good catches of coho salmon near Duncans Mills (Murphy 1946). Shapovalov (1947) observed that coho salmon enter the river in "appreciable numbers." Lee and Baker (1975) cite CDFG (1965) as the source for their estimate of 7,000 coho in the river with an annual harvest of 2,000 fish. CDFG (1965) does not provide supporting data for their numbers. Anderson (1972) placed the average annual run of coho salmon at 5,000 fish. The ACOE (1982) reported that 300 coho salmon inhabited Dry Creek prior to the construction of Warm Springs Dam, but again, no supporting data are provided to validate the numbers.

Currently, coho salmon in the Russian River are believed to be threatened with extinction. Several agencies, including the CDFG, NOAA-Fisheries, USACOE, and SCWA, are involved in a captive broodstock program designed to increase the number of coho returning to basin streams. Wild coho salmon are captured and taken to the Warm Springs Fish Hatchery were they are reared to maturity and spawned at the hatchery. The young are reared in the hatchery for several months then released into streams that historically supported coho salmon, where they will hopefully emigrate to the ocean and return to spawn. Although surveys for the captive broodstock program found that coho salmon are more widely distributed than was previously thought, there numbers are likely very low compared to historical levels.

1.3.6 Pink salmon

Few reports are available documenting the presence of pink salmon in the Russian River. Wilson (1954) stated that humpback (pink) salmon enter the Russian River from late August through October, and spawn in the river from Duncan Mills to Monte Rio. Numbers of fish were noted as being "quite large one year and very small the next year." Since 1955, few pink salmon have been observed in the river. They are currently believed to be functionally extinct.

1.4 SYNTHESIS OF HISTORICAL POPULATION DATA

The literature on the Russian River abounds with "salmonid population estimates." However, we reviewed the source documents for the "estimates," commonly cited in the Russian River literature, and in every case found to date, the population estimates were based, at best, on anecdotal information, and not on actual counts of fish. Thus none of the historical estimates for salmonid abundance can be defended as scientifically valid. Currently, the only valid estimates for adult salmonids are the Chinook salmon counts made during video monitoring conducted by the Agency from 2000-2004. There are no current estimates for steelhead or coho salmon.

Assessing the decline of salmonids in the Russian River in a scientifically valid manner is impossible because of the lack of historical as well as recent surveys. However, enough information, even as anecdotal in nature as it is, does exist to make a compelling argument that steelhead and coho populations have declined significantly since the turn of the century.

The overall weight of the historical information on Chinook salmon suggests that they are native to the Russian River. However, it is not possible to suggest a size to the historical runs. The fact that few Chinook salmon were observed in the river during the 1940's to 1990's would suggest that the runs during this time frame were small. However, the current experience leading up to the initiation of video monitoring in 2000 shows that a relatively large population of Chinook can go relatively unnoticed in the Russian River. Based on the heavy planting of out of basin Chinook stocks, the genetics of the Chinook presently spawning in the Russian River may differ significantly from the pre-1900 population (J. Garza, NOAA Fisheries, Pers. Com. 2005)

Steelhead are widespread throughout the basin, and likely occupy a significant proportion of their historical habitat. However, based on the popularity of the historical fishery, and the reports of angler success, it is apparent that the wild steelhead fishery is substantially reduced from historical levels. This becomes even more apparent in light of the fact that the fishery is now, to a large degree, support by hatchery production.

Coho salmon are poorly documented in the historical literature. Based on the fact that they traditionally inhabited 20 to 30 relatively small tributaries, their population in the basin was likely small compared to steelhead. Although comprehensive studies are lacking, coho currently appear to be limited to a relatively small proportion of their historical range.

1.5 TARGET SPECIES

The focus of this study is the three federally protected salmonids (Chinook salmon, coho salmon, and steelhead), and three potential predators (the native Sacramento pikeminnow, and the introduced smallmouth bass and largemouth bass). Other species such as green sunfish and crappie are also known to include fish in their diet. However, the species tend to be small and are not well established in the Russian River. Thus, there potential to be a serious predator on salmonids is slight. 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.

For an organism to persist over time, it must be able to survive, grow and reproduce. The operation of the Inflatable Dam alters the physical habitat of the Russian River over an approximately 5.1 km reach of the river. Depending on the life history requirements of each species, the changes brought about by the Inflatable Dam may result in an increase or decrease in the population levels of individual species.

1.6 SALMONID LIFE HISTORY REQUIREMENTS

All three salmonids inhabiting the Russian River exhibit a similar life history characteristic known as anadromy. An anadromous life style can be thought of as a circle, where the juveniles live in freshwater, then migrate to the marine environment where they grow and mature, then return to freshwater to lay their eggs and begin the lifecycle anew. Although there are specific differences between the species, they all share several life history traits. After growing and maturing in the ocean, the adults of all three species return (generally) to the stream where they were born. The eggs are laid in a nest, called a redd. The eggs are deposited in the redd and fertilized, and are subsequently buried with gravel by the female. The eggs remain in the gravel for several weeks before hatching. The resulting sac fry remain in the gravel for 3 to 6 more weeks (depending on the species and water temperature) before emerging from the gravel. The freshwater residency is highly variable between the three species, but is marked by rapid growth and a physiological change known as smoltification. The smolting process is necessary for fish to convert from a physiology adapted to living in freshwater to a physiology adapted to living in salt water. In short, in freshwater, the fish's body has a higher salt content than the surrounding environment. The fish must prevent the loss of salts across the semipermeable gills and the kidneys by conserving salts while pumping out large quantities of water from their body. In the marine environment, the process is reversed, where the salt content of the environment is much higher than in the fish, and the fish must excrete excess salts from the body while conserving water.

Because of their differences in life history strategies, the potential effects of the Inflatable dam/Wohler Pool will vary by species. A general description of the life history of each of the three salmonids is provided below to highlight the potential for the project to impact each species. Water temperature is a crucial parameter controlling salmonid populations and warrants special consideration. A detailed discussion of water temperature requirements will be presented in Section 1.7.

1.6.1 Chinook Salmon

Chinook salmon is the largest species of salmonids inhabiting the Russian River, and is limited to the mainstem and larger tributaries with sufficient flow to allow upstream migration and spawning during the fall/early winter time frame. Spawning habitat is located primarily in the mainstem, primarily upstream of Healdsburg, in the West Fork Russian River (with the construction of the fish passage facility over Mumford Dam), and in Dry Creek. Spawning also apparently occurs in Mill (tributary to Dry Creek), Austin, and Green Valley creeks, based on the capture of juvenile fish during out migrant trapping studies (NOAA, CDFG and Agency unpublished data). Chinook salmon were observed spawning in Santa Rosa Creek in 2002 and YOY were captured in 2004 (S. Brady, City of Santa Rosa, Pers. Comm. 2005). Chinook salmon may spawn in other streams when appropriate conditions exist.

Upstream migration occurs from the last week in August through December (primarily October and November) (Chase *et al*. 2004). Spawning begins in November (Cook 2003), and likely continues through early January. Juvenile Chinook salmon display two life history strategies; ocean type, where the fish emigrate at 2 to 4 months of age, and stream type, where they spend a full year in freshwater before emigrating. In the Russian River, juvenile Chinook display the ocean type strategy almost exclusively. Emigration through the study area occurs from approximately late-February through June.

Based on their life history, adult Chinook salmon are likely to be present in the Wohler Study Reach from Late August through December and juvenile Chinook salmon from late February though at least the first week of July (Figure 1-3).

1.6.2 Coho salmon

Coho salmon appear to be the most sensitive of the three salmonid species inhabiting the Russian River. Coho prefer cold (≤16.3˚C), low gradient stream reaches that typically include dense riparian canopy. Since coho are restricted to a relatively small number of streams, they are at a greater risk from localized disturbances compared to the other salmonids. Coho salmon primarily inhabit streams in the lower basin (downstream of the project), including, Austin, Willow, Dutch Bill, Green Valley creeks, and possibly Mark West Creek. Coho salmon also inhabit a few tributaries upstream of the Project area, including Dry Creek as well as some of its tributaries, including Mill and Palmer creeks. At least historically, populations of coho were also documented in the Maacama and Forsythe creek basins. Coho are only present in the study area during their upstream and downstream migrations.

Coho have a fairly rigid life history, where they spend approximately one year in freshwater and two years in the ocean, although juveniles occasionally spend two years in freshwater, and a few adults return after one year in the ocean (mostly male fish). Coho migrate upstream in November and December and spawning occurring primarily between December and January (Shapovalov and Taft 1954). Since coho spawn in relatively small tributaries, they are dependant on rain to provide sufficient streamflow to allow for passage and spawning. Smolts emigrate March through May (Figure 1-3). The three coho smolts captured during outmigration surveys conducted at the Mirabel Dam in 2004 were captured in late April.

1.6.3 Steelhead

Steelhead are the most widely distributed salmonid in the watershed, inhabiting most permanent streams in the basin. Relatively healthy populations have been documented in Mark West, Santa Rosa, and Millington creeks (Cook and Manning 2002). Steelhead have also been documented in Sheephouse, Austin, Ward, Green Valley and Mill creeks (CDFG unpublished data). Steelhead also utilize the upper mainstem Russian River as spawning and rearing habitat. Spawning habitat overlaps with Chinook salmon (mainly above Cloverdale). Limited steelhead rearing occurs in the mainstem with peak abundances recorded in the Canyon Reach located between Cloverdale and Hopland and near Ukiah (Cook 2003). Limited rearing has been observed in the mainstem above the Wohler Dam. Steelhead have also been documented rearing in the lower river near the confluence with Austin Creek and in the Estuary (SCWA, unpublished data). Although steelhead are widely distributed in the basin, the overall population is likely depressed compared to historically levels.

Steelhead have a highly flexible life in their life history strategies and habitat that they live in. Adult steelhead enter the Russian River from at least November through May, although based on hatchery returns peak migration occurs in January through March (Figure 1-3). Steelhead may be adversely affected by the Inflatable Dam during the upstream and downstream migrations similar to Chinook and coho salmon. Adult steelhead migrate through the study area during the winter when the dam is generally not inflated. Steelhead smolts, however, emigrate during the spring (March through early June) and may be negatively impacted by the dam. In addition, low numbers of steelhead may rear in the Study Area throughout the summer. Low numbers of juvenile wild and hatchery steelhead have been observed in the study area during all five years of sampling. Steelhead smolts emigrate through the Wohler Pool at an average size of approximately 175 mm FL (range 83 to 259 mm). Young-of-the-year steelhead have been captured below the dam, measuring between 29 mm and approximately 130 mm FL, depending on the time of year.

Figure 1-3. Likelihood of occurrence by life history stage for salmonids in the Wohler Pool Study Area, Russian River.

Chinook salmon

	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July
Upstream Migration												
Spawning												
Rearing												
Smolt emigration												

Coho salmon

	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July
Upstream Migration												
Spawning												
Rearing												
Smolt emigration												

Steelhead

	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July
Upstream Migration												
Spawning												
Rearing												
Smolt emigration												

Legend

Unlikely to be present	
Likely present in low numbers	
Likely present in moderate numbers	
Peak occurrence of species	

1.7 WATER TEMPERATURE REQUIREMENTS FOR SALMONIDS

Water temperature within the study reach warrants special consideration. Water temperature levels directly affect an organism's ability to survive, grow, and reproduce. Within a species' specific tolerance range, as water temperature increases, its growth rate and other metabolic activities will increase. Water temperatures above or below 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 (excessively low temperatures likely never occur in Russian River and will not be discussed). Factors such as dissolved oxygen 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).

Under natural conditions, water temperatures vary on a diel and seasonal basis, and are seldom within the optimal range for a particular species for extended periods of time. Further, habitat conditions vary depending on the position in the watershed that is studied. The significance of this fact on the distribution of fish communities within a river system is that some reaches of the Russian River likely would not provide suitable habitat for salmonids under natural conditions. The question is does the presence of the Inflatable Dam negatively impact salmonid populations compared to conditions if the dam and diversion did not exist.

Stream temperatures that restrict salmonids vary with species and by geographical region. Critical temperatures that limit production and survival of salmonids vary widely in the literature. As a result, establishing a single set of criteria that describes the suitability of a particular stream's thermal regime to support salmonids is difficult. For example, Bell (1986) states that the upper lethal temperature of steelhead is 23.9°C, while Nielsen et al. (1994) reported steelhead in the Eel River feeding at water temperatures of 24.0°C. Brett (1956) developed a generalized concept of the effects of temperature on salmonids. He used four categories to relate the effects of temperature on growth and survival; the upper lethal limit where death occurs rapidly, zone of resistance where death can occur depending on the length of exposure, zone of tolerance where there is no mortality but zero growth as well, and the zone of preference where growth occurs proportional to food availability. Sullivan *et al.* (2000) illustrated this concept graphically (Figure 1-4). There are no site-specific temperature data to assess the effects of temperature on steelhead, Chinook, and coho salmon in the Russian River. The critical thresholds used to assess thermal ranges of these species in the Russian River are based on the following review of the pertinent literature.

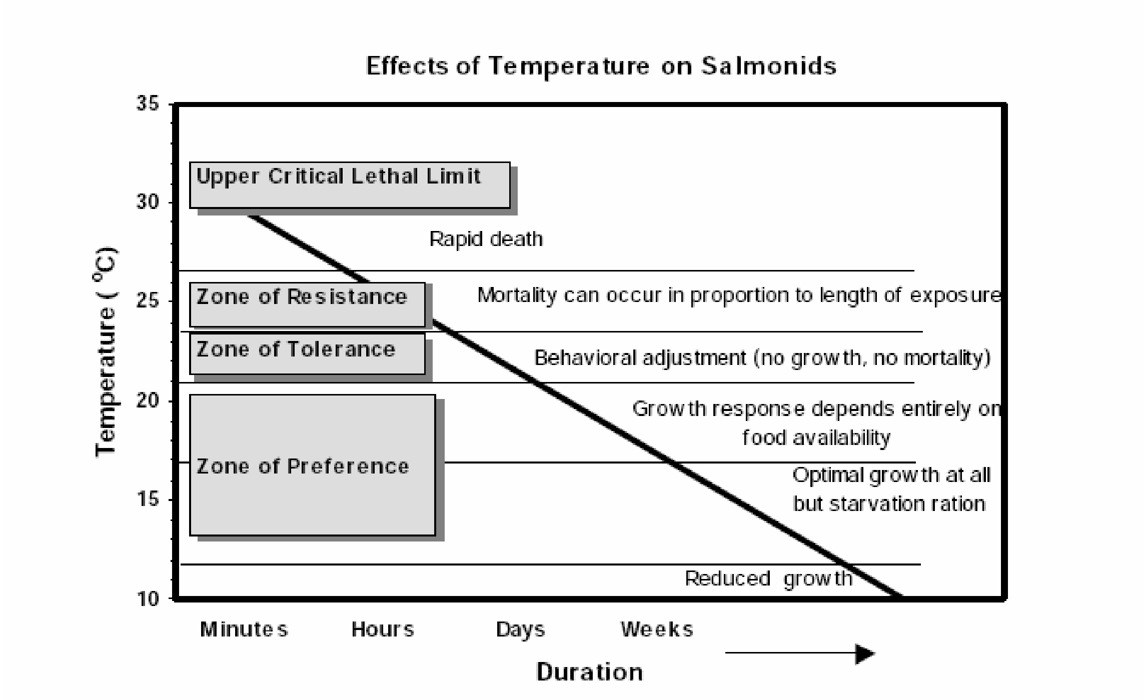


Figure 1-4. General environmental effects of temperature on salmonids in relation to duration and magnitude of temperature (from Sullivan *et al.* 2000, page 2-2).

1.7.1 Chinook Salmon

Chinook salmon (Figure 1-5) are vulnerable to effects of the dam during their upstream (Adult spawning) migration and downstream (smolt emigration) periods. Adult Chinook salmon migrate upstream through the study area to their spawning habitat, located primarily in mainstem Russian River upstream of the city of Healdsburg and in larger tributaries such as Dry Creek (Cook 2004). Upstream migration occurs from the last week in August through December, peaking in 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 display two life history strategies; ocean type, where the fish emigrate at an age of 2 to 4 months, and stream type, where they spend a full year in freshwater before emigrating. In the Russian River, juvenile Chinook display the ocean type strategy. Emigration through the study area occurs from approximately late-February through June (one to four months of age). Chinook salmon in the Russian River emigrate through the Wohler Pool at about 90 millimeters (mm) fork length (FL) (range 32 to 140 mm). Factors that stimulate downstream migration are not well known (Healey 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.

The upper lethal water temperature for Chinook salmon has been variously reported to be 26.0°C (Hansen 1999, cited in Myrick and Cech 2000), 25.0°C (Brett 1952 and Bell 1986), and 23.0°C (± 1.1°C) (Baker *et al.* 1995). Chinook salmon can tolerate brief exposure to temperatures of 28.8°C when acclimated to a temperature 19.0°C (Myrick and Cech 2000). The upper chronic thermal limit (temperature survived for at least 7 days) is similar to the upper lethal temperatures (24.0 to 25.1°C) (Myrick and Cech 2000). 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 1986).

Figure 1-5. Russian River Chinook salmon smolt.

Juvenile Chinook salmon reportedly grow at temperatures up to 25°C (Brett et al. 1982). 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.* 1982, cited by Raleigh *et al.* 1986). Myrick and Cech (2000) reviewed several studies analyzing the effects of temperature on growth of Chinook salmon, and found that growth was maximized at temperatures ranging between 15.3 and 20.5°C, when food was not limiting. Brett et al. 1982 reported growth was maximized between 18.9 and 20.5°C (when fed to satiation), depending on the stocked used, but when rations were cut to 60 percent of satiation, maximum growth occurred at 14.8°C. Rich 1987 reported 15.3°C, but water quality may have been a factor in the reducing growth rates in this study. Cech and Myrick 2000 reported that maximum growth occurred at 19.0°C (all studies cited in Myrick and Cech 2000). Marine and Cech (2004) reported that Chinook smolts reared at fluctuating temperatures between 17 and 20˚C grew at rates similar to Chinook smolts reared at 13 to 16°C, and that Chinook smolts survived and grew at temperatures up to 24˚C at ration levels found in the wild. However, the rate of growth decreased for fish reared at temperatures above 20°C. McCullough (1999) concluded that optimal temperature range for Chinook salmon fed at 60 percent rations would be between 10.0 and 15.6°C.

Water temperatures above 21.1°C have been reported to stop downstream migration of Chinook salmon smolts (CDWR 1988 cited by NCRWQCB 2000). Chinook reared at temperatures greater than 17°C had impaired hypoosmoregulatory capability (ability to adapt to seawater) compared to fish reared between 13.0 and 16.0°C (Myrick and Cech 2000). However, smolts reared at temperatures between 17 and 20°C did not experience a statistically significant decrease in survival during acute seawater test compared to fish reared at 13 to 16°C. Compared to smolts reared at 13 to 16°C, smolts reared at temperatures between 17 and 20°C were more vulnerable to predation during test held at temperatures ranging between 15.0 and 17.0°C, but were not more vulnerable to predation when the test were held at temperatures ranging from 18 to 21.0°C). Marine (1997) demonstrated that Chinook salmon can successfully smolt at temperatures up to 20.0°C, however, they did exhibit some impaired patterns compared to fish reared at lower temperatures. Clarke and Shelbourn (1985) and Clarke et al. (1981) reported that optimal temperatures for smolting Chinook salmon range between 10.0 and 17.5°C.

Fall Chinook salmon reportedly migrate at temperatures ranging from 10.6 to 19.4°C, with an optimal temperature of 12.2°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 ENTRIX (in Kelly and Associates 1992)). Adults exposed to sufficiently high temperatures to prior to spawning can result in a reduction in survival of the subsequent embryos (Hinze 1959, cited by ENTRIX (in Kelly and Associates 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). Eggs incubated at temperatures above 16.7 experienced 100 percent mortality (Hinze 1959, cited by ENTRIX (in Kelly and Associates 1992**)**.

1.7.2 Coho Salmon

Coho salmon may be affected by the dam in a similar manner as Chinook. Coho salmon were captured only once during the study; four smolts and one young-of-the-year were captured in the screw traps in 2004. Coho salmon spawn primarily in tributaries located downstream of the study area. However, historically, coho salmon were known to inhabit a small number of tributaries upstream of the Mirabel/Wohler area. Young-of-the-year smolt sized coho salmon were captured in Mill Creek (tributary to Dry Creek) during the Spring of 2005 (Obedinski pers. comm. 2005). Coho migrate upstream during the fall (November and December), and juvenile emigration occurs during the spring (March through May). Coho salmon spawn and rear in tributaries, thus the only life stages potentially affected by the dam are emigrating smolts and upstream migrating adults. Coho salmon emigration is affected by flow conditions, water temperature and day length (Shapovalov and Taft 1954).

The upper lethal temperature for coho fry has been reported to range from 22.9 to 25.0°C, depending on the temperature that the fish were acclimated to (5.0 and 23.0°C, respectively) (Brett 1952, DeHart cited by Konecki *et al.* 1995), 25.6°C (Bell 1986), and 28.2 to 29.2°C (Konecki *et al.* 1995, Becker and Genoway (1979) cited by Konecki *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). Moyle *et al.* (1989) concluded that maximum water temperatures should not exceed 21.9 to 25.0°C for an extended period.

Juvenile coho salmon rear at temperatures between 3.3 and 20.6°C (Bell 1986), but reportedly prefer water temperatures between 10.0 and 15.0°C (Hassler 1987) and 11.7 to 14.4°C (Bell 1986). Bell (1986) gives the preferred range of temperatures for emigrating juvenile coho salmon as 7.2 to 16.7°C. The Environmental Protection Agency (EPA 1977) developed the concept of the "Maximum Weekly Average Temperature" (MWAT). A MWAT is the highest temperature that an organism can survive over the long term and maintain a healthy population (the MWAT is based on a 7-day moving average, and is the warmest seven consecutive days recorded annually). The EPA determined that the MWAT for coho salmon was 17.7°C. Welsh *et al.* (2001) compared the distribution of juvenile coho salmon in 21 tributaries in the Mattole River Basin with the maximum weekly maximum temperature (MWMT), defined as the highest average maximum temperature over a seven day period, and the MWAT. The warmest tributaries supporting coho salmon had a MWMT of 18.0°C, and a MWAT of 16.7°C. All tributaries that had a MWMT of less than 16.3°C and a MWAT of less than 14.5°C supported 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 (1986)). 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 1973, cited by McMahon 1983). However, in a field study conducted in Washington, no differences in coho salmon growth rates were 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), although food was not limiting in that study. Sullivan *et al.* (2000) concluded that setting an upper threshold for the 7-day maximum temperature at 16.5°C would minimize growth loss for coho salmon. 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.

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).

1.7.3 Steelhead

Steelhead (Figure 1-6) 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 Study Area throughout the summer. Adult steelhead migrate through the study area during the winter (December through March), when the dam is generally not inflated. Steelhead smolts, however, emigrate during the spring (March through early June) and may be negatively impacted by the dam. Low numbers of juvenile wild and hatchery steelhead have been observed in the study area during all five years of sampling. Steelhead smolts emigrate through the Wohler Pool at an average size of approximately 175 mm FL (range 83 to 259 mm). Young-of-the-year steelhead have been captured below the dam, measuring between 29 mm and approximately 130 mm FL, depending on the time of year.

Figure 1-6. Russian River steelhead smolt

The upper lethal water temperature for steelhead has been reported to be 23.9°C (Bell 1986). Myrick and Cech (2000) reported that various strains of rainbow trout/steelhead can withstand temperatures near 30.0°C for short periods of time. In the Eel River, juvenile steelhead were observed feeding in surface waters with ambient temperatures up to 24.0°C (Nielsen *et al.* 1994). Optimal water temperatures for rearing steelhead have been reported to be 10.0 to 12.8°C (Bell 1984) and 14.2°C (Bovee 1978). In general, steelhead streams should have summer water temperatures between 10.0 and 15.0°C, with maximum water temperatures below 20.0°C (Barnhart 1986). Myrick and Cech (2000) reported a preferred temperature for wild Feather River steelhead of approximately 17°C under both fed and food deprived conditions, even though the fish were collected from water with temperatures below 15.°C. Myrick and Cech (2000) also reported that hatchery reared steelhead from the American River reared at a constant temperature selected temperatures between 18 and 19.0°C. Werner et al. (2005) detected significant increases in the heat shock protein (hsp 72) in wild steelhead parr collected in the Navarro River Watershed when the short- and long term daily average temperatures were 18 to 19°C, and daily maximum temperatures were 20.0 to 22.5°C. The study did not report on the ecological consequences of juvenile steelhead rearing at temperatures above 18.0°C (e.g., reduced growth, survival, etc.).

Reese and Harvey (2002) found that the growth of and the size of the territory defended by dominant steelhead was reduced in the presence of juvenile pikeminnow at temperatures between 20.0-23.0˚C, but growth was not reduced when the two species were held in treatment water ranging between 15.0 and 18˚C. Nielsen *et al.* (1994) reported an increase in agonistic behavior and a decrease in foraging as stream temperatures increased above 22°C. Harvey et al. (2002) found that pikeminnow depressed growth of dominant juvenile steelhead at temperatures between 20 and 23°C Harvey et al. (2002) found steelhead in relatively high densities in some tributaries to the Eel River where MWAT's ranged between 20.0-22.0°C.

Steelhead were not observed to move into thermally stratified pools at temperatures below 22°C. Wurtsbaugh and Davis (1977) reported that for fish fed to satiation, an increase in temperature led to an increase in the maximum consumption rates. The high feeding rates decreased the negative effects of increased water temperatures, up to 22.5°C for rainbow trout. Above 22.5°C, feeding rates decreased, possibly due to temperature related stress (Nielsen *et al* 1994).

Sullivan *et al.* (2000) concluded that setting an upper threshold for the 7-day maximum temperature at 20.5°C would minimize growth loss for steelhead. 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. A MWAT has not been calculated for steelhead.

1.7.4 Summary of Critical Water Temperature Levels

The above review of water temperature requirements for Chinook and coho salmon and steelhead demonstrates the wide variation in thermal tolerances reported in the literature. These differences are likely a result of the local conditions that the test fish were adapted to. Site-specific temperature tolerance data are not available for salmonids in the Russian River Basin. A series of threshold temperatures were developed based on the reviewed literature. The terms used to discuss the results of this study are similar, and can be confusing at first glance. Table 1-4 presents the terminology and their definitions used in this report, while Table 1-5 presents the criteria and supporting citations. The temperature regimes described do not necessarily represent absolute thresholds where impacts will occur to Chinook and coho salmon and steelhead inhabiting the Russian River. The thresholds do provide a framework to assess the overall suitability of the thermal regimes within the study area to support salmonids. Temperature thresholds used are divided into two classes; long term (chronic) affects, and short term (acute) affects. Salmonids can survive short-term exposure to relatively high temperatures without appreciable mortalities occurring. However, long-term exposure to moderately high temperatures can result in adverse affects (e.g., reduction in growth). At a sufficiently high temperature, mortality can occur over the short term. For example, Sullivan *et al.* (2000) estimated a 10 percent mortality rate for yearling rainbow trout exposed to a temperature of 26.5°C for six hours, and that the same rate of mortality would be expected to occur during a one-hour exposure to a temperature of 28.3°C. Water temperatures were evaluated primarily using a 7-day running average temperature and daily maximum temperatures.

Table 1-4. Terminology and definitions used to discuss the results of water temperature monitoring.

Terminology	Definition
Maximum Weekly Average Temperature (MWAT)	Highest average of mean daily temperatures over any consecutive 7-day period, recorded annually
Weekly average temperature	7-day moving average of the average daily temperature
Maximum Weekly Maximum Temperature (MWMT)	Highest average of maximum daily temperatures over any consecutive 7-day period, recorded annually
Weekly maximum temperature	7-day moving average of the daily maximum temperatures
Maximum daily average temperature	Highest average daily temperature recorded annually
Maximum annual temperature	Highest hourly temperature recorded annually

Table 1-5. Threshold temperature criteria and supporting citations used to assess thermal regimes in Mirabel reach of the Russian River.

Temp	7-day running averages and MWAT thresholds	Source
14.5	Coho found in all Mattole River tributaries with MWATs below this threshold	Welsh *et al.* 2001
15.5	Reduced survival of eggs when gravid female Chinook salmon were exposed to temperatures above this level (fish from the American River).	Hinze et al. 1959.
16.7	MWAT of Mattole River tributaries supporting coho salmon.	Welsh *et al.* 2001
17.0	Chinook experience variable hypoosmoregulation, and potentially an increased risk of predation. Growth occurred proportional to food availability.	Marine and Cech 2004. Sullivan et al. 2000..
19.0	Growth rate for steelhead reduced 20 percent from optimal conditions	Sullivan et al. 2000
20.0	Temperatures above this threshold result in chronic effects to steelhead and Chinook; upper range at which coho growth occurs	Roelofs *et al.* 1993; Marine and Cech 2004, Bell 1973
21.1	Chinook smolt emigration and adult salmonid upstream migration inhibited	Hallock 1970 CDWR 1988
23.0	Chronic stress, survival jeopardized at temperatures above threshold for steelhead	Roelofs *et al.* 1993
Temp	**MWMT thresholds**	**Source**
16.3	Coho found in all Mattole River tributaries with MWMT less than this threshold. Approximates the recommended MWMT (16.5°C) to protect coho growth.	Welsh *et al.* 2001 Sullivan *et al.* 2000
18.0	MWMT of Mattole River tributaries supporting coho.	Welsh *et al.* 2001
20.0	Maximum recommended temperature for steelhead streams. Approximates the recommended MWMT (20.5°C) to protect steelhead growth.	Barnhart 1986 Sullivan *et al.* 2000
22.0	Salmonids utilization of cool water refuge begins to increase, feeding decreases	Nielsen *et al.* 1994 Sullivan *et al.* 2000
Temp	**Daily temperature thresholds**	**Source**
25.0	Lethal temperature range for Chinook salmon	Brett 1952
26.0	Approximate lethal temperature range for salmonids (time of exposure measured in hours). Extremely stressful for steelhead.	Sullivan *et al* 2000 Roelofs *et al.* 1993

1.8 LIFE HISTORY REQUIREMENTS FOR PREDATOR SPECIES

1.8.1 Sacramento Pikeminnow

The Sacramento pikeminnow (Figure 1-7) 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 2002). Prior to the introduction of other predators, pikeminnow were 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 the closely related northern pikeminnow (*P. oregonensis*) predation on salmonid smolts in the Columbia River Basin.

Historical observations of pikeminnow in the Russian River are generally limited to Taft and Murphy (1950), and a few CDFG reports, primarily during the late 1950s/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 Russian River, and would be found in the area with or without the inflatable dam. Large pikeminnow are apparently widespread in the mainstem above the Wohler Pool, and were observed in most large pools sampled during a snorkel survey in 2002 (Cook 2003).

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 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).

Figure 1-7. Pikeminnow (with streamer tag) captured in the Wohler Pool, Russian River

Pikeminnow prefer warmer water than salmonids. Pikeminnow are seldom abundant where water temperature does not exceed 15°C (Moyle 2002), 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 1985). 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 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.

In the Russian River, spawning takes place in April and May (Taft and Murphy 1950). Eggs are adhesive and are attached to rocks or gravel. Pikeminnow inhabiting large rivers and reservoirs migrate upstream into smaller tributary streams to spawn during high flows (Moyle 2002, Mulligan 1975). Pikeminnow inhabiting smaller streams migrate either upstream or downstream to spawn (Grant and Maslin 1999).

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 2002). 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 feed on fish, including salmon and steelhead smolts (Moyle 2002, 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 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).

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.

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 sculpin, and salmonids did not constitute a significant proportion of pikeminnow diet in free flowing sections of rivers. 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).

From the above review of the literature, there appear 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).

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 1-6). Based on this regression, northern pikeminnow ranging in size from 250 and 550 mm FL can consume salmonids ranging in length from 116 to 227 mm FL. The largest pikeminnow captured in this study was 730 mm FL, thus it could consume larger prey items than those studied by Zimmerman.

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. Lengths of pikeminnow captured in August (average between 1999 - 2004) in the Russian River Range in length from 35 to 725 mm FL (Table 1-7):

Table 1-6. 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 1-7. Average fork lengths and numbers of Sacramento pikeminnow, by age class, captured in the Russian River during August electrofishing surveys (1999 – 2004 sampling seasons combined).

	Age 0+	Age 1+	Age 2+	Age 3+	Age 4+	Age 5+ up
Number	**229**	**118**	**36**	**15**	**7**	**32**
Average	**67**	**140**	**252**	**354**	**440**	**615**
Range	**35 - 100**	**105 - 200**	**195 - 300**	**320 - 385**	**410 - 455**	**515 - 725**

It should be noted that aging older (age 4+ or greater) pikeminnow by scale analysis is unreliable (Scoppetone (1988, Moyle 2002). Growth of older fish slows considerably, and the annuli are laid too close together to accurately age fish by this method. This point was highlighted by the capture of a pikeminnow tagged in 2001. This individual measured 615 mm FL in August of 2001, and 655 mm FL in August of 2003. The fish was aged as 5 years old in 2001, but would have only been aged as a 5 or 6 year old fish based on scale analysis in 2003. Clearly, the age of this fish would have been underestimated. Pikeminnow are a long lived species, with fish as old as 16 years old being aged from otoliths (a much more reliable, but lethal, technique to age older fish) (Scoppetone 1988). 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 were found in areas with rainbow trout and California roach, but they were seldom abundant when found together. Pikeminnow abundance was limited by smallmouth bass predation in the South Fork Yuba River (Gard 1994).

1.8.2 Smallmouth Bass

Smallmouth (Figure 1-8) 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.

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 ppm. Edwards *et al.* (1983) cite data showing that adult smallmouth bass seek cover when temperatures drop to 15 to 20°C, and become inactive at approximately 10°C.

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.

Figure 1-8. **Smallmouth bass captured in the Russian River.**

Smallmouth bass will consume a wide variety of food items, including fish, crayfish, insects, and amphibians (Moyle 2002). Smallmouth bass have been documented to feed on salmonids, primarily Chinook salmon less than a year old (life stage found in the Russian River). Subyearling 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, subyearling 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). Fritts and Pearson (2004) reported smallmouth bass consuming approximately 4 percent of the hatchery production in a given year. However, hatchery reared Chinook salmon are larger than their wild counterparts, and predation on wild fish is likely higher.

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 1-8). 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.

Table 1-8. 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

1.8.3 Largemouth Bass

Largemouth (Figure 1-9) 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 in this study.

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.

Figure 1-9. Largemouth bass captured in the Russian River

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 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).

Largemouth bass feed primarily on fish and crayfish after reaching a size of 100 to 125 mm SL (approximately 125 to 150 mm FL). Bolding et al. (2005) found largemouth bass Age 1 and older to be a significant predator on juvenile and smolt sized coho salmon in three shallow lakes in Washington.

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2.0 WATER TEMPERATURE MONITORING

2.1 INTRODUCTION

During the 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. Impoundments such as Wohler Pool may degrade water quality, primarily by increasing the rate at which water temperature increases. Impoundments slow the flow of water through the basin. The longer that water resides in the pool, the greater the opportunity for warming through solar radiation. The primary objective of this study is to determine to what degree, if any, the impoundment increases the rate at which water warms compared to free flowing riverine conditions.

A secondary objective of this study is to provide a general description of the spring through fall thermal regime within the study area, and compare this to the temperature requirements of the target species (Chinook salmon, coho salmon, steelhead). All three species use the Wohler Pool Reach of the river during their upstream and downstream migrations, and juvenile steelhead rear in the study reach during the summer, albeit at very low levels. Thus, these life stages may potentially be affected by an increase in water temperature associated with the Wohler Pool. There would be no salmonid spawning habitat within the footprint of the Wohler Pool even in the absence of the dam.

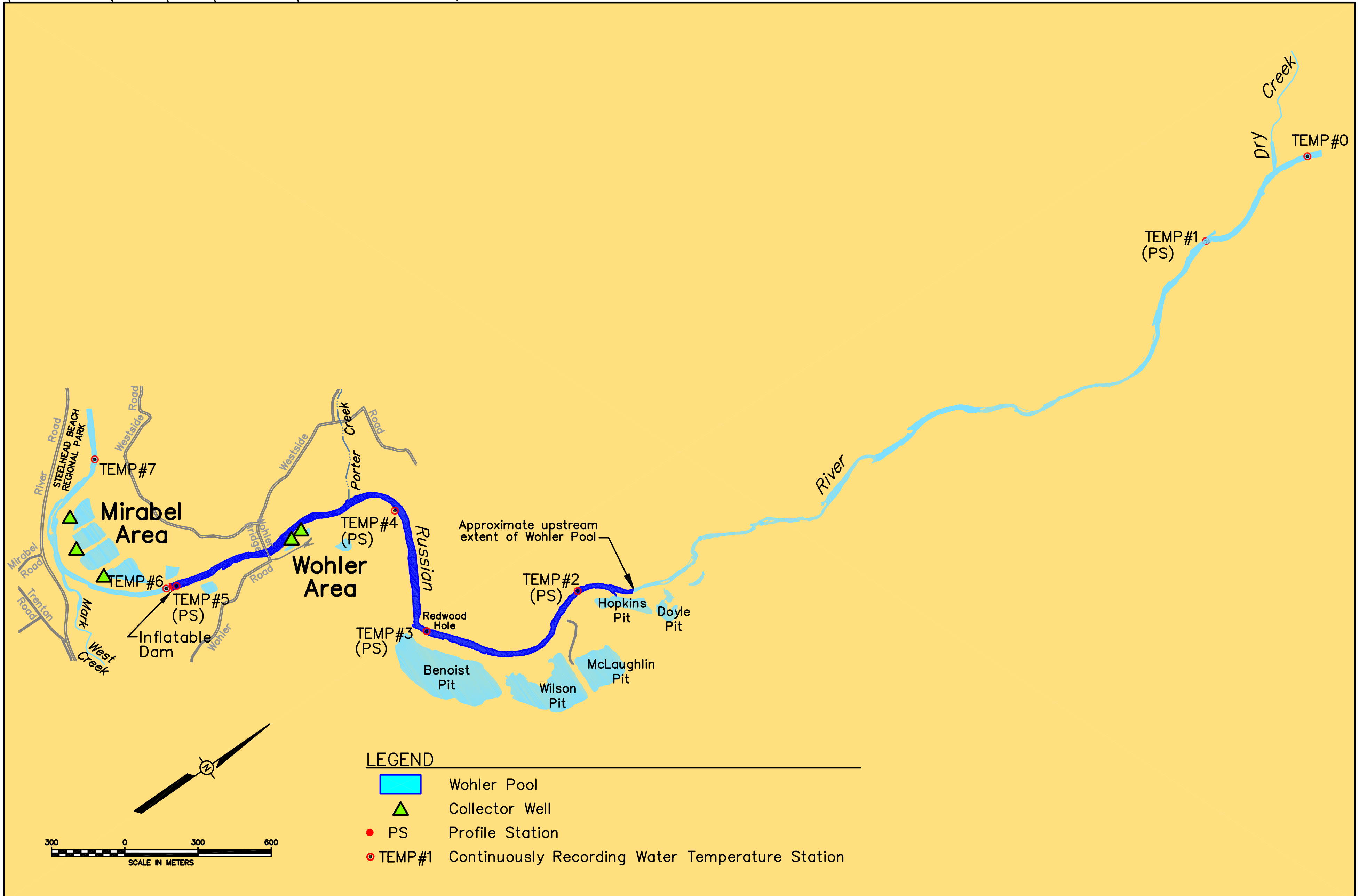
The final objective of this study was to determine the potential for the Wohler Pool to become thermally stratified during the summer. The density of water decreases as the temperature increases (thus, warm water “floats” on top of cold water). Thermal stratification develops when a strong density gradient 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 Wohler Pool.

2.2 METHODS

Up to nine continuously recording water temperature-monitoring stations were selected within the study area between 2000 and 2004 (Figure 2-1). Water temperature data were collected using Hobo 8K data loggers (Onset Computers, Inc.). At stations 3 through 5, 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. At the remaining stations, one data logger was deployed at a depth of approximately 1 meter (these were relatively shallow stations with moving water, therefore the temperatures at these stations was uniform top to bottom). Data loggers were programmed to record temperature on an hourly basis, 24 hours a day. Data loggers were downloaded in the field (using an Onset Shuttle) on a roughly biweekly schedule. Occasionally, a data logger failed or was vandalized. When this occurred, the data logger was replaced with a calibrated unit.

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 at least and hour and allowed to reach equilibrium with the temperature of the test water prior to calibrating. During the calibration process, the dataloggers were programmed to collect a water temperature once every two minutes. The temperatures recorded were compared to similar temperatures collected with the NIST thermometer for 20 minutes. Data collected during calibration exercise were then compared to the NIST-traceable thermometer to determine accuracy. The standard set to determine the accuracy of each data loggers was ± 0.5°C.

From 1999 through 2003, water quality profile (water temperature, dissolved oxygen, and conductivity) monitoring was conducted at four stations ranging from the Inflatable Dam (Station #5) upstream approximately 5.1 km (Station #2) (Figure 2-1). Water quality parameters were collected over the deepest section of each sampling station. Measurements were taken at 0.5 to 1.0 meter intervals. Water quality



SONOMA COUNTY WATER AGENCY

Figure 2-1 Continuous water temperature and water quality profile stations - 2003 profiles were collected on a biweekly schedule. Water quality data was collected using a Yellow Springs, Inc., (YSI) 85 Portable Temperature/ DO/Conductivity meter. A table converting ºC to ºF is presented in Appendix A.

2.3 RESULTS

Temperature criteria used to assess the suitability of water temperatures in the project area are presented in Section 1.4.5. As discussed in that section, site-specific water temperature criteria are not available for fish inhabiting the Russian River. General temperature guidelines have been established based on data collected on the three species inhabiting rivers outside (and generally north) of the Russian River. However, the appropriateness for their use in the Russian River has not been verified in the field. These criteria provide a conservative framework for assessing the suitability of the thermal conditions in the Russian River to support the three listed salmonids.

2.3.1 Streamflow

Flow releases in the Russian River are controlled by the State Water Resources Control Board's Decision 1610 (SWRCB 1986), which stipulates that the annual minimum summer low flow in the Russian River downstream of Dry Creek as:

- 125 cfs during normal water supply conditions
- 85 cfs during dry water supply conditions
- 35 cfs during critical water supply conditions

Although streamflows above and below the Inflatable Dam are typically greater than the minimum required flow, the flow above and below the dam differs by the amount diverted by the Agency and other diverters (Table 2-1). Low flow discharges measured above and below the Inflatable Dam have varied significantly during the study. The 2004 water year qualified as a Dry Spring year. Flows released from Lake Mendocino were reduced below normal year releases August through mid October to preserve the cool water pool in the lake for release later in the fall during the Chinook salmon upstream migration period.

In addition to flow, channel morphology is also different above and below the Inflatable Dam. Above the Wohler Pool is approximately 70 percent run, compared to habitat below the dam that is approximately 70 percent pool (Chase *et al.* 2000b). The difference in streamflow and channel morphology undoubtedly affects residence time of the water flowing through these reaches. The differences in streamflow and channel morphology affect the rate at which water temperature changes above and below the dam, thus, the above and below reaches are not comparable. The above reach was used to assess the effects of the dam on water temperature because the streamflow and channel morphology between the two reaches are similar.

Table 2-1. Average monthly flow (June through September) in 2000 (normal flow year), 2001 (dry year), and 2002 (dry spring), and 2003 (normal) and 2004 (dry spring).

Month	Average monthly flow (cfs) in 2000		Average monthly flow (cfs) in 2001		Average monthly flow (cfs) in 2002		Average monthly flow (cfs) in 2003		Average monthly flow (cfs) in 2004	
	HB[1]	AW[2]	HB	AW	HB	AW	HB	AW	HB	AW
June	267	347	114	246	191	268	442	501	229	335
July	196	287	111	196	144	267	241	380	172	286
Aug	184	301	113	219	152	280	208	302	109	239
Sept	202	290	151	274	153	277	184	282	112	242

[1]HB = Hacienda Bridge
[2]AW = Above Wohler Pool

2.3.2 Continuous Temperature Recording

Water temperatures were recorded continuously at nine locations within the study area for varying lengths of time (Table 2-2) (see Appendix B for graphs of the daily maximum, average, and minimum temperatures recorded at each station). Water temperatures at Station #0 represent temperatures above the influence of Dry Creek. A new station added in 2004 was in Dry Creek approximately 20 meters upstream of the confluence with the Russian River. Station #1 represents temperatures 6.5 RK above the influence of the impoundment, but below Dry Creek. Station #2 is located at the upstream end of the impoundment and represents the temperature of the river as it enters the Wohler Pool. The difference in the temperatures between Stations #1 and #2 represents the natural heating/cooling of the river just above the influence of the impoundment. Stations #3, #4 and #5 are located in approximately the upstream third, middle, and downstream end of the pool, respectively. Temperatures at these stations describe the thermal conditions within the impoundment. The differences in water temperatures between Stations #2 and #5 represent the cooling/heating of the river as it passes through the 5.1 km long Wohler Pool. Station #6 was located immediately below the dam, and is a mixture of surface and mid column water flowing both over the dam and through the fish ladders and fish bypass facilities. Station #7 is located approximately 2.3 RK downstream of the dam. The difference in temperature between Stations #6 and #7 represents the natural heating/cooling of the river just below the influence of the impoundment. However, water is diverted at Mirabel, and the streamflow between the dam and Station #7 is generally less than the streamflow at Stations #1 and #2. Therefore, the change in temperature between the dam and Station #7 are not directly comparable to the change in temperature above and within the impoundment.

Table 2-2. Dates of operation for data loggers at seven continuous temperature recording Stations, 2004.

Station	Date deployed	End date	Periods of non operation
MDC[1]	May 7	October 17	Continuous
0	April 13	October 17	Continuous
1	May 6	October 17	July 14 – September 2[2]
2	April 13	October 17	Continuous
3 (bottom)	June 16	October 17	Continuous
3 (surface)	April 13	October 17	May 29 – June 15[3]; August 12 – August 31
4 (bottom)	April 13	August 29	May 7 – June 15[3]; Logger failed after August 29
4 (surface)	April 13	October 17	May 7 – June 15[3];August 30 – 31[4].
5 (bottom)	April 13	October 17	Continuous
5 (surface)	April 13	October 17	Continuous
6	April 8	October 17	May 18 – 19[4]; May 25 – June 2[3]; June 16 – 30[3]; Sept 3 - 9[3]
7 (bottom)	June 17	October 26	August 30, 31[4]

[1]MDC = Mouth of Dry Creek
[2]Data logger not recovered
[3]Data logger failed
[4]Data logger returned to office for data download

2.3.3 Rate and Magnitude of Change in Water Temperature between Stations

Two important factors to consider when analyzing the temperature data are the <u>rate of change</u> in water temperature and the <u>overall magnitude of the change</u> in water temperature within and outside of the influence of the dam. Water temperature will increase or decrease naturally depending on climatic conditions. Therefore, the critical element of this study was to analyze the rate at which water heated or cooled as it passed through the Wohler Pool, compared to the river immediately above the impoundment. Streamflow below the dam was less than the streamflow above the dam due to the diversion at Mirabel. The decreased streamflow would affect the rate at which water temperature changed in the river below the dam. All things being equal, the rate of change in water temperature would be higher below the dam, compared to the within pool and above pool reaches, based solely on streamflow (using the below dam rate would underestimate the impact of the influence of the Wohler Pool on water temperature).

If the impoundment does contribute to an increase in the rate at which the temperature of the water warms compared to the above reach, the influence of the dam can be estimated by subtracting the rate of increase in the above reach from the rate of increase within the Wohler Pool. The overall increase in the magnitude of the change in water temperature caused by the Wohler Pool can then be estimated by multiplying the difference in the rate of change between the above reach and the Wohler Pool Reach by the length of the Wohler Pool.

2.3.3.1 Rate and magnitude of change in water temperature between Stations #1 and #2 (Above Reach)

The rate of change in the average monthly water temperature could only be developed for June in 2004 (Data logger at Station 1 was not recovered after July 15). The rate at which the June 2004 temperatures increased between Stations #1 and #2 was 0.06°C/km, leading to an overall increase in the temperature between the two stations of 0.4°C (Table 2-3). The June 2004 rate of increase between Stations #1 and #2 was similar to the rates of increased found during the June through August period of 2001 through 2003 (0.04 to 0.11°C/km) leading to an increase in the average monthly temperature of 0.3 to 0.7°C over the 6.4 km stretch of river (changes in temperature rounded to the nearest tenth of a degree).

2.3.3.2 Rate and magnitude of change in water temperature between Stations #2 and #6 (Wohler Pool)

The rate of change in the average monthly water temperature in June 2004 was 0.10°C/km over the 6.5 km distance between Stations #2 and #6 (Table 2-3). The rate of change in water temperature resulted in an overall increase in Magnitude of the average monthly temperature of water flowing between the two stations of 0.5°C (Table 2-3). The average monthly rate of increase throughout the length of the pool has ranged from 0.10 to 0.20°C/km during June, July, and August between 2001 and 2004. This rate of increase has equated to an increase in the overall water temperature of 0.5 to 1.0°C during this time period.

2.3.4 Overall Influence of the Inflatable Dam on Water Temperature.

The crux of this portion of the study was to determine whether the water flowing out of the study area would be cooler without the dam. Without the dam in place, the rates at which water warms during the low flow period within the Wohler Pool reach would likely be similar to the above impoundment rates. The water temperature regime in the Wohler Pool without the influence of the impoundment can be estimated by applying the monthly average rates of change in water temperature developed for the above Reach to the Wohler Pool Reach. Using the monthly average rate of change in water temperatures developed for the Above Pool Reach the average monthly water temperatures during June through August were estimated to increase from 0.2 to 0.5°C, compared to what would have been expected without the dam (Table 2-3).

2.3.5 Seasonal Water Temperatures within the Study Area.

Spring (emigration) thermal conditions providing adequate protection for juvenile salmonids should be good below an MWAT of 17ºC and an MWMT of 20.0ºC, and acceptable with MWAT below 20.0ºC and MWMT below 21.1ºC. Juvenile Chinook and coho salmon do not rear in the river past June, while low numbers of steelhead rear in the study area throughout the year. Adult Chinook enter the river from late August through December (primarily October and November), while the coho salmon spawning run is primarily from October through January. Adult steelhead migration begins in mid November and continues through at least March.

Table 2-3. **The minimum and maximum daily and the average monthly rate of change in temperatures (°C/km) and the magnitude of change in temperatures (°C) between Stations #1 and #2, July and August, 2004, Russian River.**

June							
	Δ Station 1-2			Δ Station 2-6			
Year	**Rate (˚C/km)**	**Change (˚C)**		**Rate (˚C/km)**	**Change (˚C)**	**Estimated Increase w/o dam (˚C)**	**Increase due to dam (˚C)**
2001	0.10	0.6		0.19	1.0	0.5	0.5
2002	0.06	0.4		0.14	0.7	0.3	0.4
2003	N/A	N/A		N/A	N/A	N/A	N/A
2004	0.06	0.4		0.10	0.5	0.3	0.2

July							
	Station 1-2			Station 2-6			
Year	**Rate (˚C/km)**	**Change (˚C)**		**Rate (˚C/km)**	**Change (˚C)**	**Estimated Increase w/o dam (˚C)**	**Increase due to dam (˚C)**
2001	0.11	0.7		0.20	1.0	0.6	0.4
2002	N/A	N/A		0.12	0.6	N/A	N/A
2003	0.04	0.3		0.10	0.5	0.23	0.3
2004	N/A	N/A		0.10	0.5	N/A	N/A

August							
	Station 1-2			Station 2-6			
Year	**Rate (˚C/km)**	**Change (˚C)**		**Rate (˚C/km)**	**Change (˚C)**	**Estimated Increase w/o dam (˚C)**	**Increase due to dam (˚C)**
2001	0.10	0.7		0.16	0.8	0.5	0.3
2002	N/A	N/A		0.10	0.5	N/A	N/A
2003	0.05	0.3		0.10	0.5	0.2	0.3
2004	N/A	N/A		0.14	0.7	N/A	N/A

In general, water temperatures were limiting during at least a portion of the time for life stages ranging from juvenile through adult upstream migrants at all stations (Figures 2-2 – 2-9). The suitability of water temperatures during the spring juvenile emigration period generally declined as the season progressed. The limiting conditions were recorded at all stations, although the general trend was for the downstream stations (within and below the Inflatable Dam/Wohler Pool complex) to have less desirable conditions compared to the two upstream sites (Stations #1 and #2). Conditions are generally poor for rearing steelhead during July and August, before improving in late September to early October. Conditions for upstream migrating adults (primarily Chinook salmon) were poor during the first few weeks of the upstream migration period, but quickly improved during October when the majority of the fish began entering the river. Steelhead migration begins in late November/December, after temperatures have declined to acceptable levels.

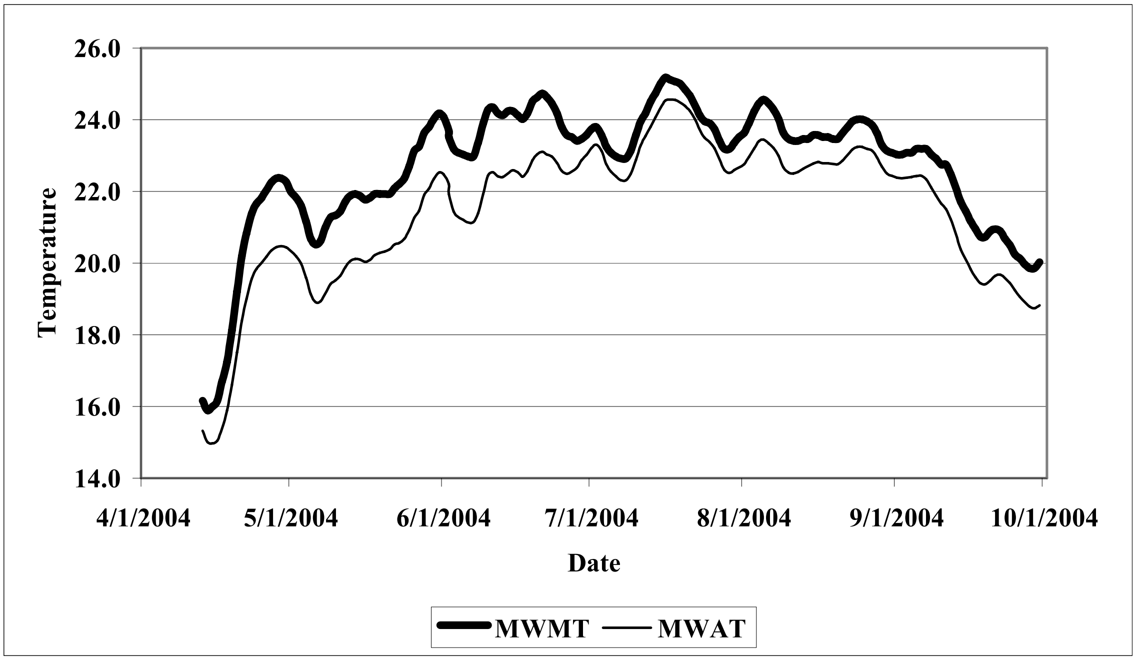


Figure 2-2. **Weekly maximum and weekly average water temperatures recorded at a depth of 1.0 meters, Station #0, Russian River Above Dry Creek, 2004.**

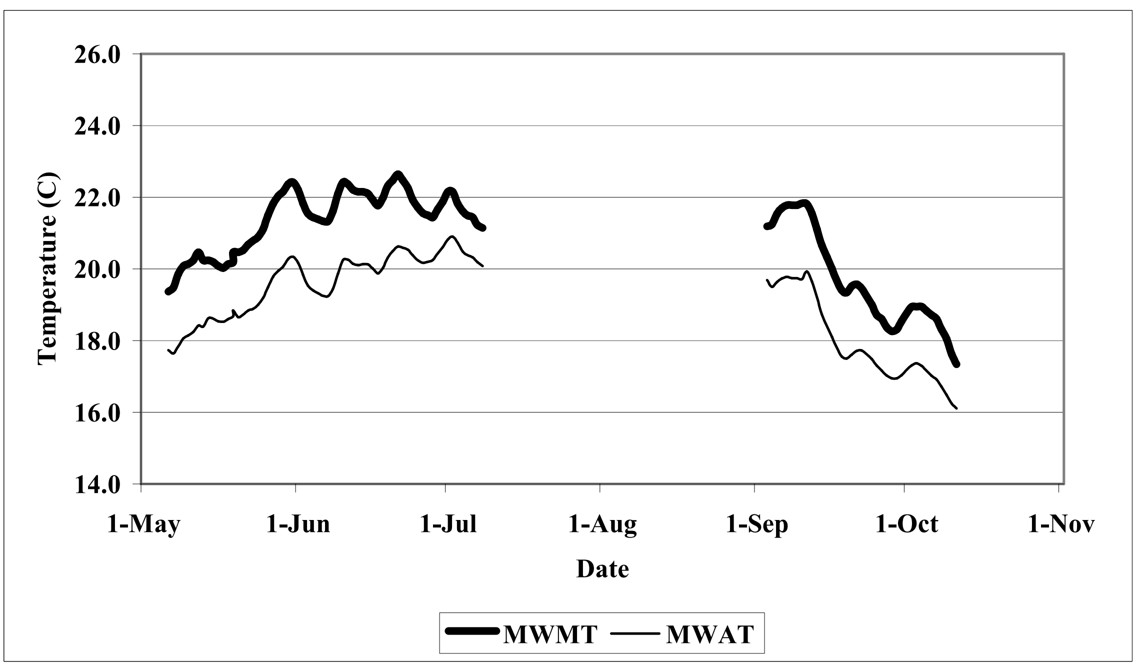


Figure 2-3. **Weekly maximum and weekly average water temperatures recorded at a depth of 1.0 meters, Station #1, Russian River 1 km downstream of Dry Creek, 2004.**

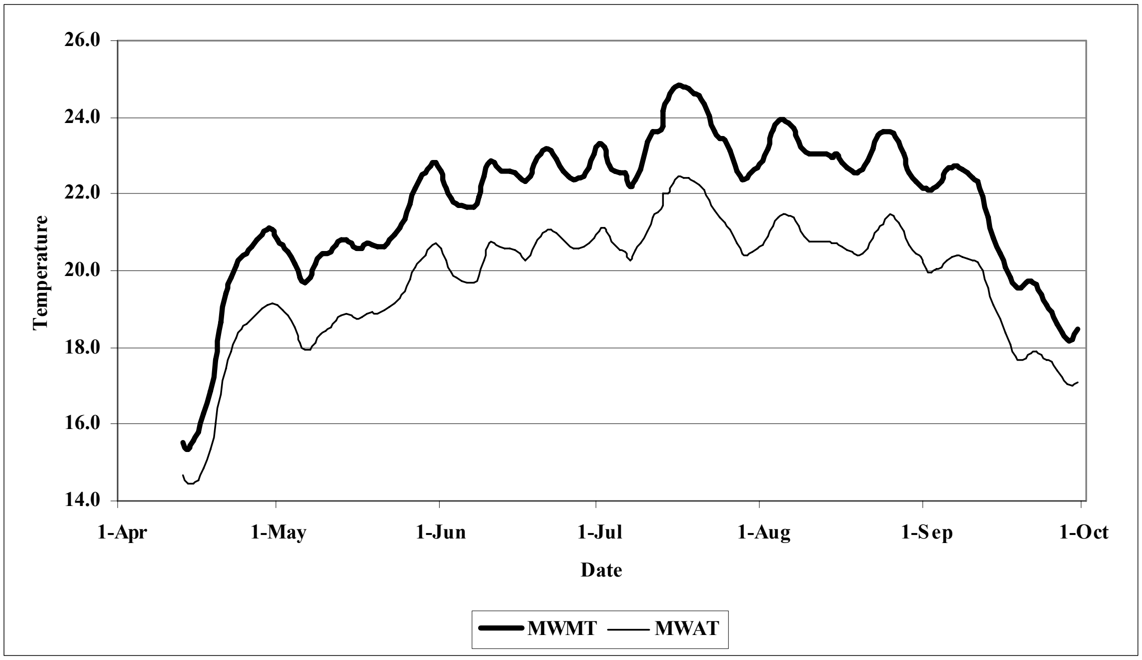


Figure 2-4. Weekly maximum and weekly average water temperatures recorded at a depth of 1.0 meters, Station #2, Russian River at the upstream end of the Wohler Pool, 2004.

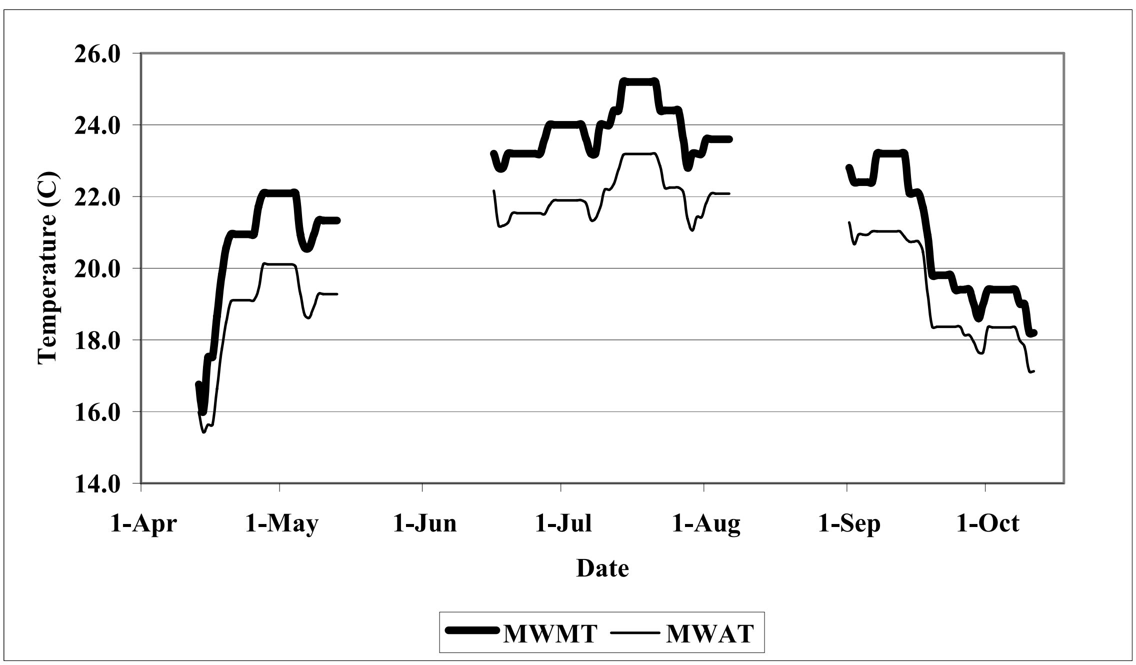


Figure 2-5. Weekly maximum and weekly average water temperatures recorded at a depth 4.0 meters, Station #3, Mirabel Russian River, upper 1/3 of the Wohler Pool 2004.

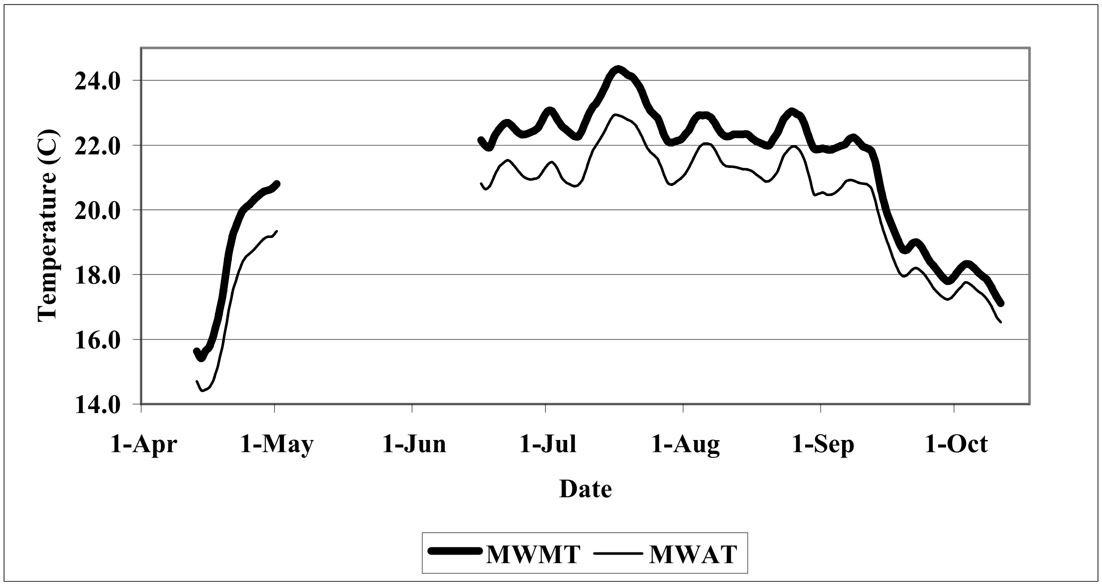


Figure 2-6 **Weekly maximum and weekly average water temperatures recorded at a depth of 1.0 meters, Station #4, Russian River, lower 1/3 of the Wohler Pool, 2004.**

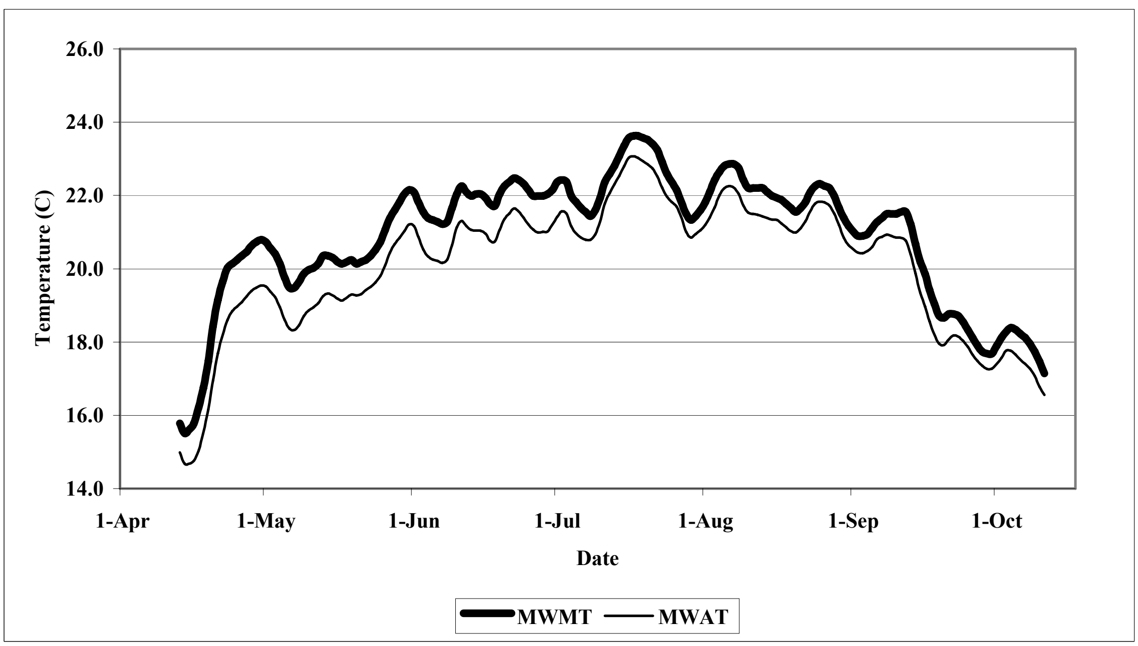


Figure 2-7. **Weekly maximum and weekly average water temperatures recorded at a depth of 3.0 meters, Station #5, Russian River at the Mirabel Inflatable Dam, 2004.**

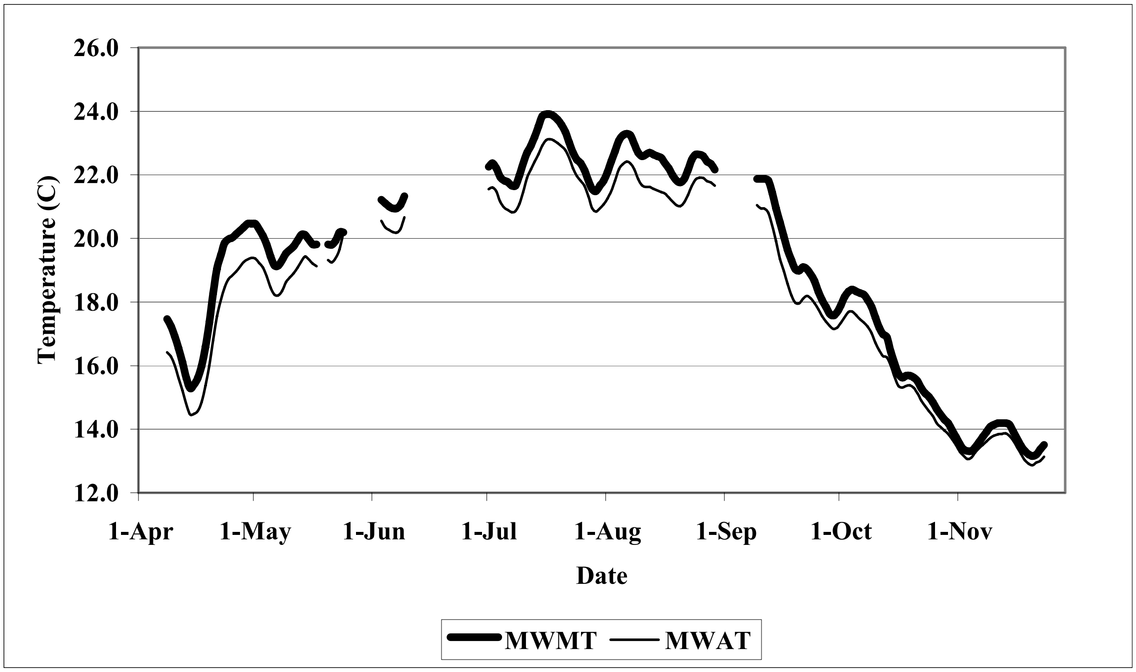


Figure 2-8. Weekly maximum and weekly average water temperatures recorded at a depth of 2.0 meters, Station #6, Russian River at Mirabel Dam fish ladder outlet, 2004.

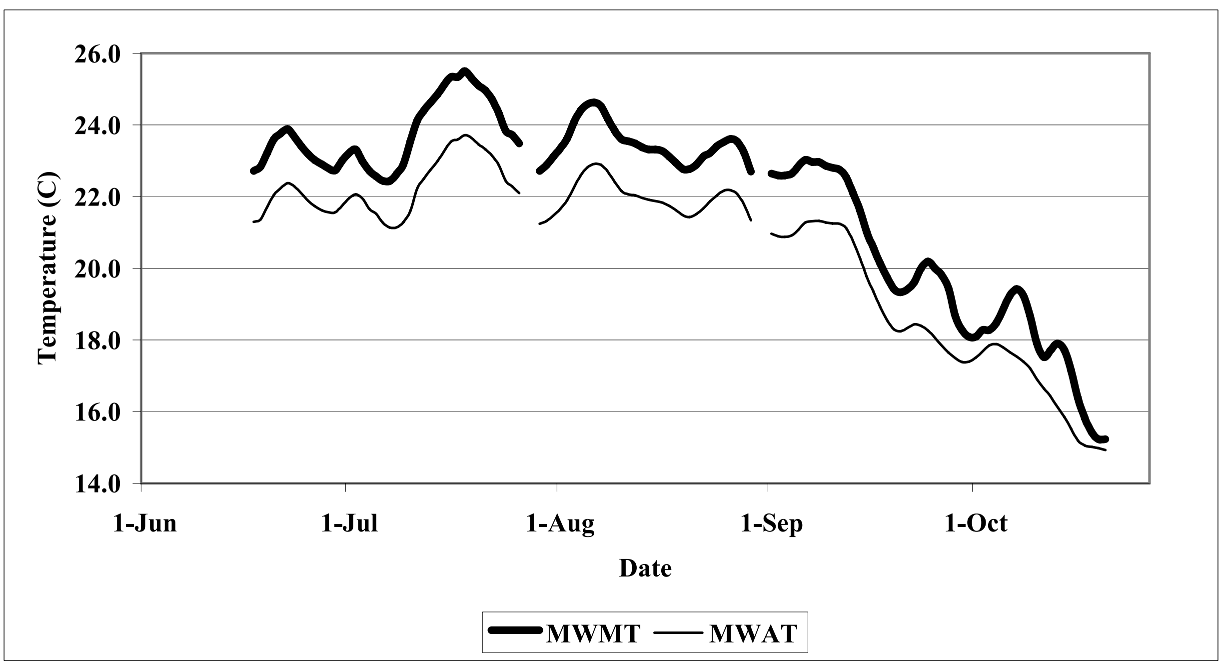


Figure 2-9. Weekly maximum and weekly average water temperatures recorded at a depth of 2.0 meters, Station #7, Russian River at Steelhead Beach County Park, 2004.

2.3.5.1 Seasonal water temperatures during the smolt emigration period.

Water temperatures began to deteriorate during late April, and reached levels considered stressful to rearing smolts by late May (Table 2-4). The weekly average water temperature surpassed 21.1ºC on June 11, 2004, a level that has reportedly blocked migration in other river systems. Water temperatures during the spring emigration period were excellent through the first half of the emigration period and degraded to potentially stressful levels by late May in most years (Table 2-4). Although temperatures exceeded levels thought to inhibit smolt migration in all years, Chinook smolts were captured in low numbers when the daily average temperature exceeded 22.5ºC in all years sampled. The maximum daily temperature recorded on a day that Chinook salmon were captured in the outmigrant traps was 25.2ºC. See Section 3.2.2.4 for a discussion of water temperatures and fish observations during the smolt emigration period.

Table 2-4. Dates that water temperatures first exceeded selected water temperature criteria, 2000- 2004 (temperatures measured at the Inflatable Dam).

Year	≥17.0 (WAT)	≥20.0 (WAT)	≥21.1 (WAT)	≥22.0 (WMT)
2000	N/A[1]	N/A	N/A	N/A
2001	April 20	May 7	May 14	May 17
2002	May 1	May 24	May 29	May 28
2003	May 13	May 27	June 22	June 21
2004	April 21	May 24	June 11	June 14

[1]N/A = Temperature criteria exceeded prior to the onset of sampling (June 18, 2000)

2.3.5.2 Seasonal water temperatures during the summer (June through September) rearing period.

The 7 day average water temperature recorded at the four Wohler Pool stations were generally ≥20.5ºC from approximately mid June through approximately mid September, with a maximum daily average temperature (bottom) ranging between 21.0 and 23.5ºC within the impoundment, June through September (Table 2-5). The MWAT for 2004 at Station 2 (near where the majority of the steelhead where captured during the August fish sampling event) was 22.4ºC. The stressful rearing conditions for juvenile steelhead observed in 2004 were similar to conditions reported in all five years of the study.

2.3.5.3 Water temperature conditions during the fall adult migration period.

Water temperatures were limiting during the first three to four weeks during the adult upstream migration period (September). The MWAT first declined below 21.1ºC on September 9, 2004, and remained above 15.5ºC through October 15 (Table 2-6). This pattern was fairly typical over the 5-year study, with temperatures unsuitable for maturing Chinook salmon prior to mid October. See Section 5.3.3.2 for a detailed discussion of water temperatures during the fall migration period.

Table 2-5. Maximum daily average, daily maximum, maximum weekly average, and maximum weekly maximum temperatures, by month, at 8 water temperature monitoring stations, Wohler Pool, 2004.

Maximum Daily Average Temperature (by month) (°C)								
Month	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
April	20.7	N/S	19.1	N/S	19.1	19.3	19.3	N/S
May	22.2	20.3	20.6	DLF	DLF	DLF	20.4	DLF
June	23.9	21.4	21.9	22.2	22.5	22.8	21.9	22.8
July	25.0	21.5	23.0	23.0	23.5	23.8	23.7	24.1
August	24.0	DLF	22.3	21.8	22.7	23.1	22.7	23.2
September	23.0	20.2	21.0	21.1	21.4	21.5	21.6	21.8
October 13	19.8	18.0	18.2	18.1	18.4	18.2	18.2	18.4

Daily Maximum Temperature (by month) (°C)								
Month	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
April 8	22.5	N/S	21.0	N/S	20.9	20.6	20.6	N/S
May	24.4	22.5	22.9	DLF	DLF	DLF	21.3	DLF
June	25.6	23.6	24.0	23.6	23.6	24.0	22.1	24.4
July	26.0	22.9	25.6	25.6	24.8	25.2	24.8	25.9
August	25.2	DLF	24.4	24.4	23.2	24.4	23.6	24.8
September	23.6	22.1	23.2	22.8	22.8	22.5	22.1	23.6
October	21.3	19.8	19.8	19.0	19.0	19.4	19.0	19.4

Maximum Weekly Average Temperature (by month) (°C)								
Month	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
April	20.5	N/S	19.2	N/S	17.0	17.2	19.5	N/S
May	22.5	18.8	20.7	DLF	DLF	DLF	20.2	DLF
June	23.1	20.6	21.1	21.3	21.5	21.9	21.9	22.4
July	24.6	20.9	22.4	22.4	22.9	23.2	23.1	23.7
August	23.5	DLF	21.5	21.5	22.0	22.6	22.4	22.0
September	22.4	19.9	20.4	20.5	20.9	21.0	21.0	21.3
October	19.2	17.4	17.5	17.5	17.8	17.7	17.7	17.9

Maximum Weekly Maximum Temperature (by month) (°C)								
Month	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
April	22.4	N/S	21.1	N/S	18.5	18.4	20.6	N/S
May	24.2	20.7	22.8	DLF	DLF	DLF	20.7	DLF
June	24.7	22.6	23.3	23.0	22.8	23.0	22.1	23.9
July	25.2	22.2	24.8	24.8	24.3	24.3	24.6	25.5
August	24.6	DLF	24.0	24.0	23.0	23.7	23.6	23.6
September	23.2	21.8	22.8	22.2	22.2	21.9	21.9	22.9
October	20.4	18.9	19.0	18.5	18.3	18.5	18.4	19.4

1 NS = Not sampled
[2] DLF = Data logger failed

Table 2-6. Dates that seasonal water temperature remained below selected water temperature criteria, 2000- 2004 (temperatures measured at the Inflatable Dam).

Year	≤21.1 (MWAT)	≤16.7 (WAT)	≤15.5 (WAT)
2000	September 17	October 16	October 20
2001	August 7	October 14	October 21
2002	August 10	October 9	October 13
2003	September 25	October 14	October 26
2004	September 9	October 11	October 16

2.4 WATER TEMPERATURE PROFILES

Water temperature and dissolved oxygen profiles were collected at up to four locations within the Wohler Pool during the summer period between 1999 and 2003 (Chase *et al*. 2003). Temperature stratification requires a fairly large, deep section of river with minimal flow. With one exception, the entire 5.1 km of the Wohler Pool has a maximum depth of approximately 3.4 meters. The one relatively deep section of river (the "Redwood hole"), has a maximum depth of approximately 5 meters, but is relatively small, and does not have sufficient area for stratification to develop. This site was essentially isothermic during all surveys conducted during the 5-year study period. The Wohler Pool did not become thermally stratified during any of the sampling season. Temperatures top to bottom were generally very similar at all stations with the exception of Station 5 near the dam. Occasionally a modest (1.0 to 1.5°C) difference in temperature between the surface and the bottom was recorded at Station 5 during the July and August profiles. However, the heating was primarily limited to the upper meter of the water column, and a cooler thermal layer did not develop at depth.

2.5 WATER TEMPERATURES AND FISH OBSERVATIONS

The above discussion of seasonal water temperatures provides an overview of the thermal conditions present during part of three different life history phases for Chinook salmon and steelhead. These observations, combined with the corresponding water temperatures, provide site-specific data relevant to the Russian River. However, to persist through time, a species must be able to survive, grow, and reproduce. Observations of fish at any particular time (and temperature regime) do not mean that they are meeting all of the above criteria. Observations of fish must be tempered by the fact that the present day thermal regimes in the river likely do not represent natural (historical) conditions and that although salmonids may be surviving under the present thermal regime, conditions may be limiting, and may negatively affect the long-term survival of current population levels of the three salmonid. Conversely, water temperature is only one of many factors that control fish populations in rivers. Populations may also be limited by factors unrelated to water temperature. Specific fish observations and water temperatures are discussed in related sections.

2.6 SIGNIFICANT FINDINGS

The monthly average temperature of water flowing through the Wohler Pool was estimated to increase by generally less than 0.5ºC above what would have been expected without the dam in place during the June through August period, 2001-2004. This portion of the study was often compromised by the loss/theft of data collection equipment. The data collected, however, indicates that the Inflatable Dam results in a slight increase in the water temperature within the Wohler Pool over what would occur without the dam in place. However, at the temperatures measured, the increase is likely to be biologically insignificant. The temperature regimes during the summer months are marginal for salmonids, and it is unlikely that the steelhead population would increase in the absence of the dam (based on changes to the water temperature regime).

Water temperatures measured in the study area were likely stressful for salmonids for at least the last month of the smolt emigration period, the entire summer juvenile steelhead rearing period, and the beginning of the adult upstream migration period. The limiting conditions were similarly found above the influence of the impoundment, within the impoundment, and below the impoundment. Although the temperatures were often well above established temperature criteria, healthy appearing Chinook salmon and steelhead smolts were captured during periods when maximum daily surface temperatures ranged to >23.0ºC. In addition, juvenile steelhead were captured and observed in the Wohler Pool throughout the summer months. Water temperatures were sub-standard during the first few weeks of the adult migration period, but steadily improved as the migration season progressed.

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 though 2003 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. Emigrating smolts swim or drift downstream with the current. The impoundment decreases current velocities, and the smolts may become disoriented by the loss of the tactile stimulus provided by moving water. 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 reverting 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. Of equal importance, the dam itself may impede smolt passage by forming a barrier to downstream movement.

Two sampling strategies (rotary screw traps and radio-telemetry) were employed to collect data on emigrating smolts. Rotary screw traps were used to capture fish as they migrated past the trapping site (60 m downstream of the dam). Trapping data provides information on species composition, timing of emigration (past a particular point on the river), allows for the collection of size and age data, plus the collection of tissue for DNA sequencing. Tissue samples collected during the study are provided to the NOAA-Fisheries for analysis and reporting. Radio-telemetry provides information on the rate of emigration of hatchery steelhead smolts through the Wohler Pool, and their success at passing the dam when it is inflated, as well as providing some insight into the fate of those that did not pass the dam. The results of the radio-telemetry program will be briefly covered in the Significant Findings section (Section 3.4). A detailed discussion of the results are presented in Manning *et al. (*2001), Manning *et al.*(2003) and Manning. *et al.* (2005).

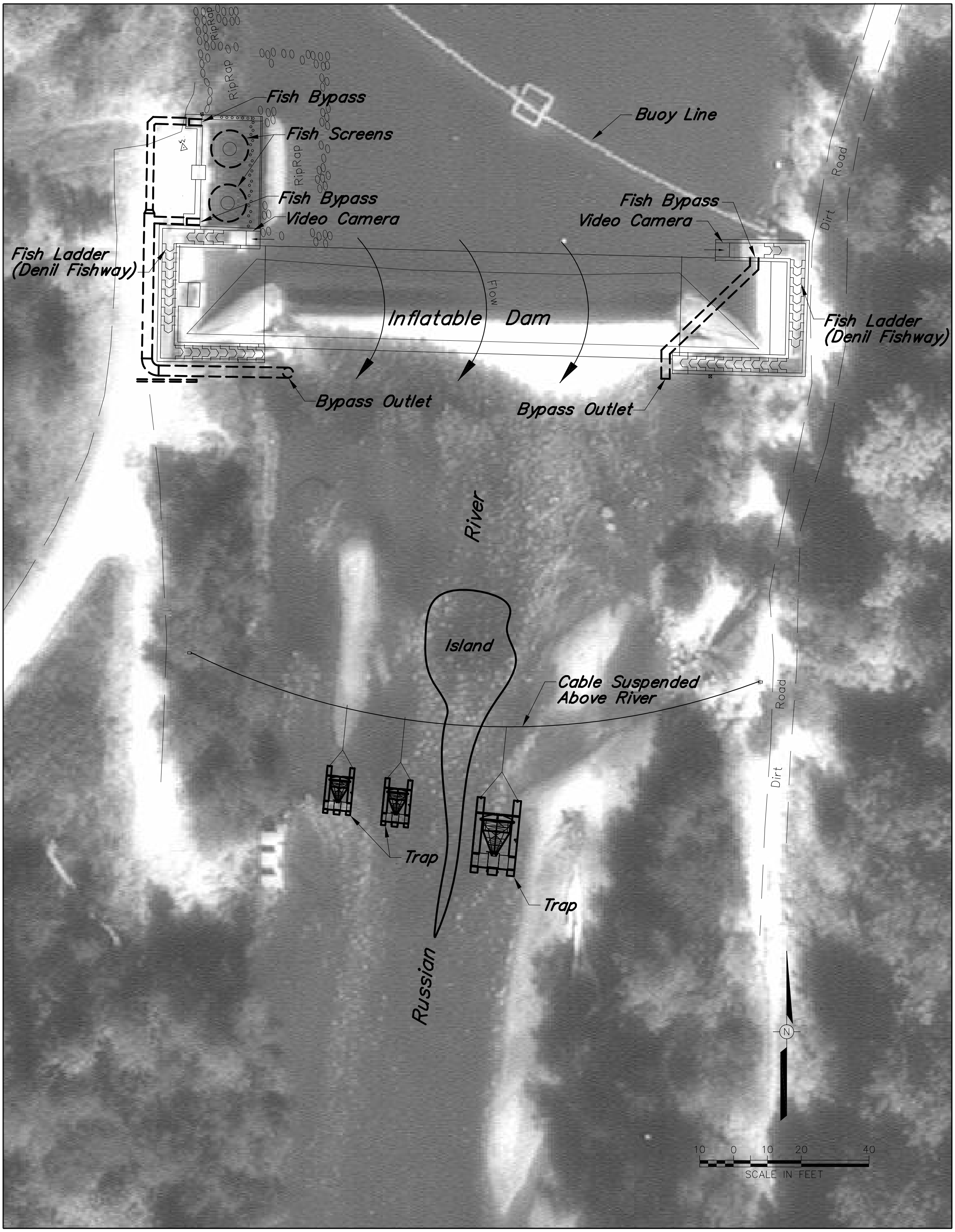
3.1 METHODS

3.1.1 Rotary Screw Trap

Rotary screw fish traps consist of a cone of perforated stainless steel panels which houses an internal Archimedes screw assemblage. 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 4.0-feet to operate).

The rotary screw trap site is located approximately 60 m downstream of the Inflatable Dam (Figure 3-1). Rotary screw traps are designed to capture downstream migrating juvenile fish (Figure 3-2). 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.

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 parallel 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.



DATE OF PHOTOGRAPHY: SEPT 30, 1999

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SONOMA COUNTY WATER AGENCY

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

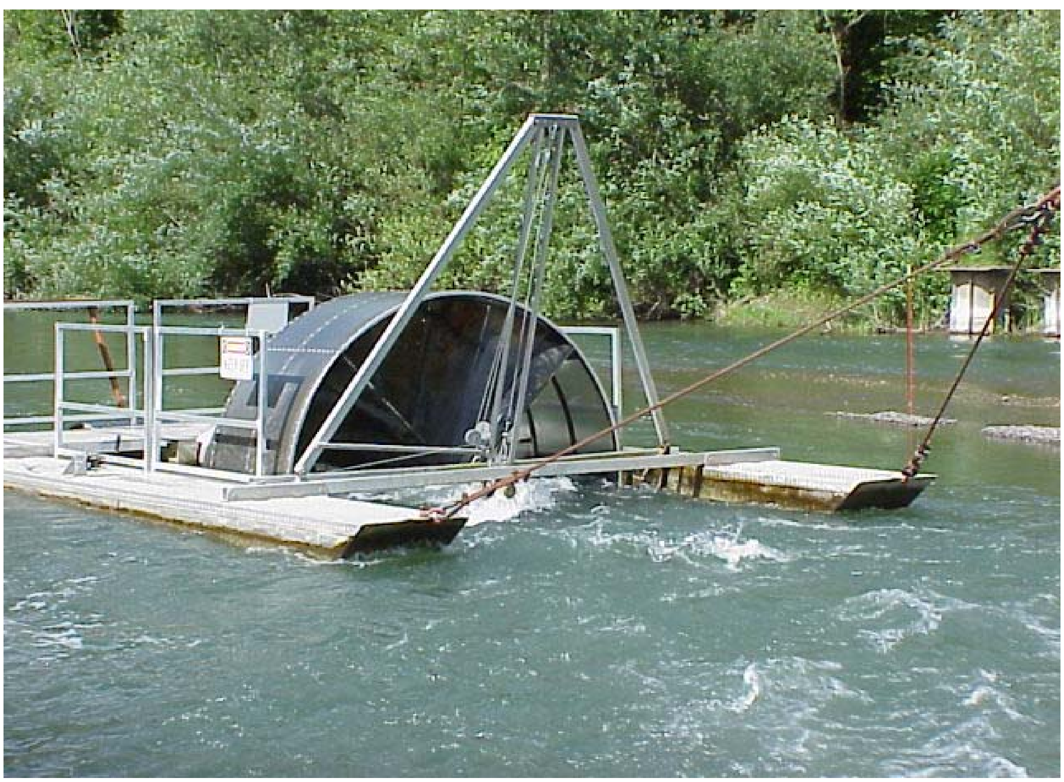

Figure 3-2. Rotary Screw Traps (under relatively high flow conditions) in the Russian River below the Inflatable Dam.

The main line consisted of a 170-foot long, 0.75-inch steel cable. The cable was pulled across the river, stretched tight, and secured to the piles with heavy equipment. The bridle consisted of a 20-foot length of 0.75-inch steel cable attaching 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.

Yellow 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 boaters and low flying aircraft (e.g., helicopters) that an obstruction was placed across the river.

3.1.2 Operation of the Rotary Screw Fish Trap

Two rotary screw traps (one 5-feet in diameter and one 8-feet in diameter) were operated throughout the 2003 sampling season. This is in contrast to the last two years when two 5-ft diameter traps were fished in tandem (the second trap was deployed in a tributary to collected data on salmonid smolt emigration from that creek). The rotary screw traps were installed in the river on the afternoon of March 31 and fished through the morning of July 1, excluding April 8 when the dam was inflated. Fish captured by the screw traps were netted out of the live well and placed in an insulated ice chest (approximately 3.0' X 2.0') supplied with freshwater. Aerators were operated to maintain DO levels in the ice chest. Prior to data collection, fish were transferred to a five-gallon bucket containing water and Alka-seltzer, which was used as an anesthetic. Fish captured were identified to species, measured to the nearest mm (FL), scales were collected from wild steelhead smolts, and tissue samples (an approximately 1 mm^2 section clipped from the caudal fin) were taken from a sub sample of Chinook and steelhead smolts. After data collection, fish were placed in a bucket containing fresh river water. Dissolved oxygen levels in the recovery buckets were also augmented with aerators to insure that the DO level remained near saturation. Once equilibrium was regained, the fish were released into the river downstream of the screw traps. In accordance with the Agency's Section 10 Permit, once water temperatures exceeded 21.1°C, fish were not handled, but were netted from the live well, identified and enumerated, and released without being measured.

3.1.3 Mark-Recapture Study

A mark-recapture study was initiated in an attempted to estimate the number of juvenile Chinook salmon emigrated past the dam. The study was conducted from April 16 through May 24. Chinook salmon captured in the trap were sub sampled, and up to 50 fish daily (depending on the number of fish captured) were marked with a caudal clip (identical to the clip used to collected tissue samples). Only Chinook salmon >60 mm FL were included in the marking process. Marked fish were held in container of water equipped with aerators, and transported and released approximately 0.8 km above the dam. The proportion of marked to unmarked fish captured in the traps was then used to calculate a weekly estimate of the number of Chinook smolts emigrating past the dam (Bjorkstedt 2000).

3.2 RESULTS

3.2.1 Rotary Screw Trapping Results

The capture of fish in the screw traps was influenced by the time of year, streamflow, and potentially whether the dam was inflated or deflated. In 2004, the screw traps were operated from the afternoon of March 31 through the morning of July 1, excluding April 8, when the dam was inflated. The river configuration remained almost unchanged between 2001and 2004 trapping seasons. An island formed in the river between the traps between the 2000 and 2001 trapping seasons. The split channels concentrate streamflow in to two relatively small channels (compared to conditions in and 2000), creating excellent conditions for fishing the screw traps. As a result, the trapping efficiencies in 2001 through 2004 were superior to those experienced during the 2000 trapping season.

During the 2004 trapping season, 12,520 fish (excluding larval cyprinids and larval Sacramento suckers) including 25 species were captured (Appendix C provides daily catch data for all species). Chinook smolts were the most abundant species collected, followed by young-of-the-year steelhead, juvenile smallmouth bass, and threespine stickleback.

3.2.2 Salmonids

3.2.2.1 Juvenile Chinook salmon

Chinook smolts were captured throughout the trapping season (April 1 – July 1, 2004). For the season, 7,386 Chinook smolts were captured in the traps (Table 3-1). Chinook were captured in the traps throughout the trapping season. Peak catches of Chinook smolts occurred between mid April and mid May as in previous years sampled.

The mark-recapture study was conducted from April 16 through May 24. During the study period, 1,631 Chinook smolts were marked with a caudal clip and released approximately 0.8 km upstream of the traps: 120 marked smolts were subsequently recaptured. Weekly capture efficiencies averaged 7 percent for the 11-week period (range from 5.1 to 11.5 percent) (Table 3-2). For the mark-recapture study period (all catch data combined), the capture efficiency was 7.1 percent. Estimates of the number of smolts emigration past the trap during the periods sampled was 90,724 ± 17,652 (Table 3-2).

During the first few weeks of the trapping season, Chinook captured in the traps were generally less than 50 mm FL. The average size of Chinook smolts captured in the screw trap increased from 61.1 mm FL during the first week of April to 103 mm FL between June 25 – 27 (The water temperature exceeded 21.1 C on June 28, and per NOAA Fisheries requirements, no length data were recorded after this date) (Table 3-3). Individual Chinook smolts ranged in length from 39 to 118 mm FL throughout the 2004 sampling period.

3.2.2.2 Juvenile coho salmon

Juvenile coho salmon were captured in the rotary screw traps for the first time during the 5 year study. Three smolts were captured between April 24 and 26, and a YOY coho salmon was captured on May 24. The three coho smolts ranged in length between 127 and 140 mm FL, and the YOY measured 29 mm FL.

3.2.2.3 Juvenile steelhead

Steelhead smolts were captured throughout the trapping season, but at lower numbers than Chinook smolts. Wild steelhead smolts in the Russian River emigrate primarily as 2-year-old fish (Chase *et al.* 2003). Steelhead captured in 2004 were classified into age classes based on length at age data collected during the first three years of this study. In 2004, 1,493 wild steelhead were captured; including 1,411 YOY, 19 Age 1+ parr, and 63 Age 2+ smolts. The average size of Age 0+ steelhead increased from 39 mm FL in early April to 59 mm FL in late June (Table 3-4). Age 1+ fish ranged in length from 74 to 142 mm FL. 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 were likely not ocean bound emigrants. Age 2+ smolts ranged in length from 143 to 219 mm FL (Table 3-5, Figure 3-3).

Table 3-1. Weekly salmonid catch in the rotary screw trap, 2004 sampling season.

Week	Chinook	Wild steelhead smolts	Steelhead parr	Young-of-the-year steelhead	Hatchery steelhead
1-Apr	82	3	0	16	5
9-Apr	115	14	0	119	54
16-Apr	672	11	1	54	269
23-Apr	1,911	14	2	108	95
30-Apr	1,845	10	0	42	4
7-May	1,631	3	0	192	4
14-May	552	1	0	322	2
21-May	158	1	0	320	0
28-May	150	1	1	63	0
4-Jun	125	2	0	62	0
11-Jun	31	1	0	47	1
18-Jun	88	2	8	51	0
25-Jun	26	0	7	15	0
Total	7,386	63	19	1,411	434

Table 3-2. Results of the Chinook smolt mark-recapture study, spring 2004.

Week of	Smolts marked	Smolts recaptured	Weekly efficiency	Catch (not marked)	Seasonal estimate DARR Analysis N ± (Std. Dev.)
16-Apr	294	19	6.1	672	
23-Apr	350	18	5.1	1516	
30-Apr	321	37	11.5	1524	
7-May	350	25	7.1	1281	
14-May	273	16	5.9	279	
21-May	94	5	5.3	85	
Sampling Total	**1,631**	**120**	**0.074**	**5,357**	**90,724 ± 17,652**

Table 3-3. Weekly minimum, average, and maximum lengths of Chinook salmon smolts captured in the rotary screw trap, 2004 sampling season.

Week of	Number	Minimum length	Average length	Maximum length
April 2 – April 8	83	39	61.1	77
April 9 – April 15[1]	115	61	78.3	95
April 16– April 22[1]	664	51	83.2	98
April 23– April 29[1]	887	53	85.3	96
April 30– May 6[1]	832	51	85.5	108
May 7 – May 13[1]	923	56	88.9	110
May 14 – May 20	320	60	88.8	113
May 21 – May 27[1]	160	61	91.1	108
May 28– June 3	100	73	95.8	115
June 4 – June 10[2]	65	82	98.2	118
June 11 – June 17	18	94	100.6	108
June 18 – June 24	68	82	99.4	114
June 25 – June 27	3	102	103.0	104

Table 3-4. Size range (mm) of young-of-the-year steelhead captured in the screw trap, 2004

Week of	N	Minimum	Average	Maximum
2-Apr	16	28	39	47
9-Apr[1]	103	25	41	56
April 16[1]	53	27	48	58
April 23[1]	97	24	43	68
April 30[1]	33	27	48	76
May 7[1]	170	23	50	83
May 14	96	24	49	85
May 21[1]	157	22	48	88
May 28	45	30	52	101
June 4[2]	33	35	51	88
11-Jun	12	36	51	72
18-Jun	36	42	59	105
25-Jun[3]	0	--	--	--

Table 3-5. Weekly average, minimum and maximum lengths of steelhead smolts captured in the screw trap, 2004

Week of	N	Minimum	Average	Maximum
2-Apr	3	167	168	168
9-Apr[1]	14	150	172	194
April 16[1]	11	150	180	203
April 23[2]	14	150	184	219
April 30[2]	10	172	195	216
May 7[2]	3	178	179	182
May 14	1	130	130	130
May 21	1	178	178	178
May 28	1	200	200	200
June 4	2	185	195	205
11-Jun	1	187	187	187
18-Jun	2	143	152	160
25-Jun[3]	0	--	--	--

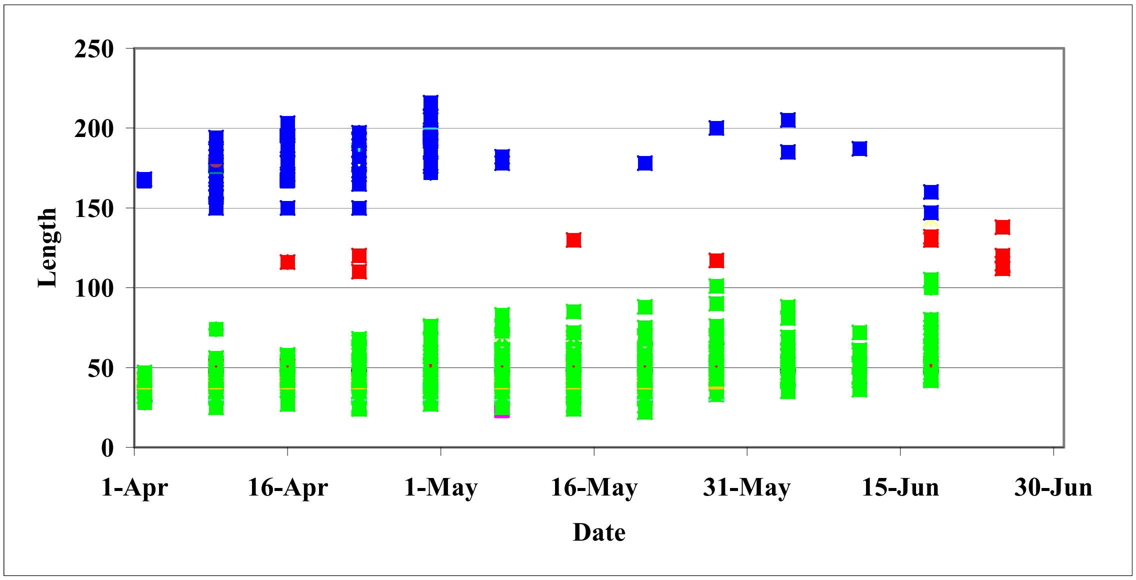

Figure 3-3. Scatter plot of steelhead lengths captured in 2004, grouped by week of capture. Green squares = young-of-the-year, red squares = parr, blue squares = smolts.

3.3 COMPARISON BETWEEN YEARS

Rotary screw traps were operated primarily during the second half of the spring emigration period during the first two years of this study (2000 - 2001) and again in 2004. In 2002 and 2003, the traps were deployed on March 1, and in the case of 2002, operated throughout the majority of the emigration period (though June 27). Since several operational factors vary between years (time of year that the traps are operated, size and number of traps deployed, and the efficiency of the traps); only limited comparisons can be made between sampling seasons.

3.3.1 Chinook Salmon

Small (34 to 52 mm FL) Chinook salmon were captured in relatively low numbers starting on March 1 in 2002 and 2003 (indicating that Chinook begin to emerge from the gravel by at least late February). In 2002, Chinook smolt numbers slowly increased during March and early April, peaked during the last two week in April and first two week in May, then slowly declined through May into early June, and approached zero by the end beginning of July (Table 3-6, Figure 3-4). The timing of the Chinook emigration period in 2003 followed a similar pattern to trends observed in the other years sampled. Smolts were captured as late as July 3, the last day sampled in 2003, indicating that the Chinook emigration period extends into at least early July, albeit at extremely reduced numbers.

The size of the Chinook smolt run was estimated over a 29 day period in 2001, over a 74 day period in 2002, sporadically for 25 days in 2003 (when flows permitted), and over a 38 day period in 2004 (Table 3-7). The estimates represent the numbers of Chinook smolts migrating during the mark-recapture study period, only. Excluding 2001, the onset of the mark-recapture study was predicated by the majority of the smolts exceeding 60 mm FL and by streamflow (primarily in the case of the 2003 season). Sampling was discontinued when sampling efficiencies approached zero. Suitable conditions (streamflow and size of smolts) necessary to sample the majority of the emigration period (primarily April and May) occurred during the 2002 sampling season. An estimated 215,875 Chinook smolts emigrated past the traps during the sampling period. Based on the daily and seasonal capture totals of Chinook, 2002 appears to have been an exceptionally productive year (compared to those sampled).

Growth of Chinook smolts in the Russian River is difficult to assess under the current sampling program. The sampling location for this study is located at RK 36.4, thus the fish have a significant amount of river to travel (and grow in) before reaching the ocean. Also, there is no way to determine the date of emergence or origin (mainstem or tributary). Thus, although Chinook smolts captured at the trap on a weekly basis are larger compared to those captured the week before, this could result because they are older fish (spawned and emerged from the gravel at an earlier date), or what habitat they were spawned in (Dry Creek vs. Mainstem), or because food resources and water quality conditions are improving later in the spring with an increase in temperature.

Chinook smolts captured in the traps ranged in length from 29 to 140 mm FL (Table 3-8). The average length of Chinook smolts captured during the approximate peak of smolts emigration (April 30 to May 6) ranged from 82 to 90 mm FL (excluding 2003 when high flows prevented sampling during this time period). Interestingly, Chinook smolts captured immediately following the high flow event in 2003 were similar in size to similarly aged smolts in other years. Thus the high flow event and associated turbidity did not appear to affect growth.

Table 3-6. Average fork length (mm) of Chinook salmon captured in the screw traps at the Mirabel Dam, 2000-2004.

Week	2000	2001	2002	2003	2004
March 1			38	39	
March 5			41	39	
March 12			51	43	
March 19			57	51	
March 26			60	57	
April 2	81		65	65	61
April 9	82		73	72	78
April 16	87	83	80	67	83
April 23	90	82	82	74	85
April 30	93	86	82	--	86
May 7	97	85	84	89	89
May 14	98	87	84	87	89
May 21	96	80	87	91	91
May 28	99	86	84	92	96
June 4	98	88	85	94	98
June 11	101		86	96	101
June 18	101		91	101	99
June 25	105		83	105	103

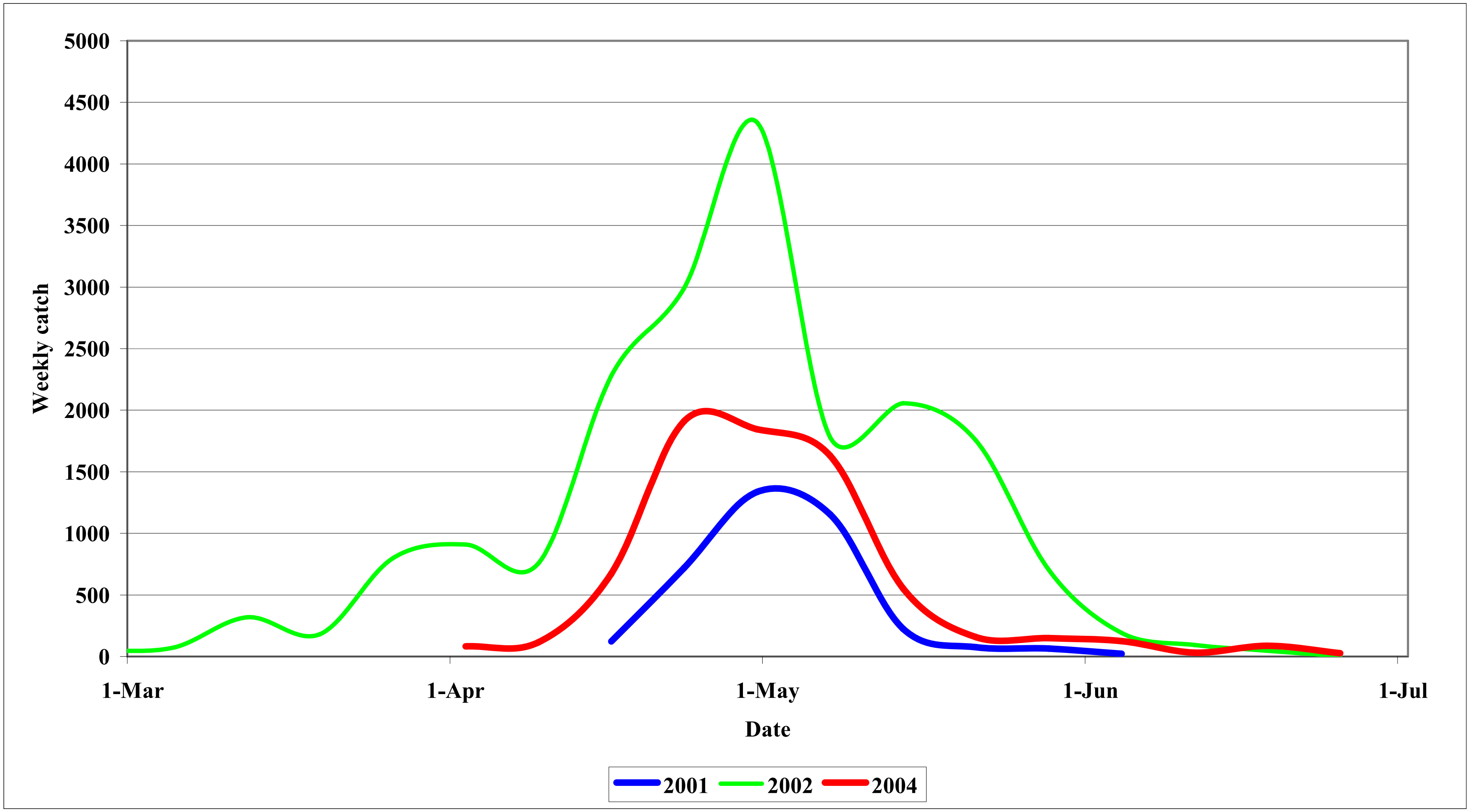

Figure 3-4. Chinook salmon smolt run timing based on the weekly estimated catch data from 2000-2002, and 2004 data.

Table 3-7. Weekly capture of Chinook smolts salmon in the Russian River near Mirabel, 2000 – 2004.

Week Starting	2000[1]	2001[2]	2002[3]	2003[4]	2004[5]
26-Feb			45	332	
5-Mar			74	841	
12-Mar			319	89	
19-Mar			181	169	
26-Mar			797	346	
2-Apr			908	377	82
9-Apr	189		757	176	115
16-Apr	118	122	2,279	17	672
23-Apr	226	720	2,992	60	1,911
30-Apr	166	1338	4,337	0	1,845
7-May	142	1154	1,780	50	1,631
14-May	136	226	2,056	508	552
21-May	134	76	1,755	690	158
28-May	95	64	704	1461	150
4-Jun	74	22	192	530	125
11-Jun	47		93	374	31
18-Jun	24		46	186	88
25-Jun	10		4	48	26
July 2				3	
Totals	**1,361**	**3,722**	**19,319**	**6,257**	**7,386**

[1]Notes for 2000 sampling season – Smolt sampling conducted from April 8th through June 29th (excluding April 18 and 19). Dam inflated on May 2. 8-foot trap operated from April 8th through 25th. One 5-foot trap operated from April 26th through May 2nd. Second 5-foot trap deployed on May 2nd (and fished in conjunction with the first trap) through the end of the study period. River was approximately 170 feet wide and uniform in depth and flow across the channel, with no defined thalweg.

[2]Notes for 2001 sampling season -- Smolt sampling conducted from April 20th through June 7th (excluding April 22 and May 28th and 29th). Dam inflated on April 21. Two 5-foot traps operated throughout the sampling period. Sand bar formed in the middle of the channel, concentrating the flow of water along both banks. Traps placed in defined thalweg along each bank, greatly improving trapping efficiencies over 2000 sampling season.

[3]Notes for 2002 sampling season -- Smolt sampling conducted from March 1 through June 27th (excluding April 16). Dam inflated on April 16. One 8-foot trap operated along the east bank and two 5-foot traps operated on the west bank throughout the sampling period. Sand bar and defined channels along banks remained during the 2002 sampling season.

[4]Notes for the 2003 sampling season -- Smolt sampling conducted from March 1 to July 3. Two five foot traps and one eight foot trap fished the entire season. High flows prevented sampling from March 15 through March 19, April 13 to April 21, April 24 to May 11. The traps were not fished on May 23 (Dam inflated), and on June 6 (crew attended a mandatory safety training class).

[5]Notes for the 2004 sampling season -- Smolt sampling conducted from April 1 to July 1, excluding April 8 when the dam was inflated. One 8-foot trap operated along the east bank and one 5-foot traps operated on the west bank throughout the sampling period.

Table 3-8. Actual and estimated numbers of Chinook captured during mark-recapture sampling (Note differences in days sampled)

Year	Number of Days sampled	Actual number caught	Estimated number caught (± 1 STD DEV)	Overall sampling efficiency
2001	29[1]	2,314	18,70 ± 5,022	11.4
2002	74[2]	18,448	168,229 ± 25,420	9.0
2003	25[3]	2,705	39,040 ± 15,348	8.4
2004	38[4]	6,758	90,724 ± 17,652	7.4

[1]Sampling conducted between May 3 – June 5
[2]Sampling conducted between March 26 and June 9.
[3]Sampling conducted between April 8 – April 12, May 16 – May 22, and May 24 – June 5.
[4] Sampling conducted between April 15 and May 24.

3.3.1.1 Temperatures and Chinook smolt emigration

Healthy appearing Chinook and steelhead smolts have been captured in the rotary screw traps at mean daily temperatures ranging up to 25.1˚C. Peak weekly counts were recorded when the weekly average temperature ranged between 16.4 and 19.4˚C in 2000 - 2002 and 2004. The daily average temperature during April and May (primary emigration period) typically range from approximately 14.5 to 21.5˚C, excluding the 2000 sampling season where the daily temperature ranged from 16.1 to 23.2˚C (Table 3-9). (significant amounts of both temperature and catch data were lost during several high flow events in 2003). The date that the weekly average temperature first exceeded 20.0˚C ranged from May 3 to May 30. Above this point, Chinook smolts may experience difficulties completing the smolting process (Marine and Cech, 2004).

Assessing the effect of temperature on Chinook smolts must be tempered by the fact that there are several temperature regimes within the Russian River. Temperature warms quickly to just above the confluence with Dry Creek, where the input of cold water at this junction effectively cools the water for several kilometers downstream. Still, Chinook smolts in the Russian River experience temperatures well above levels that considered to provide "optimal" conditions in other river systems without any apparent difficulties (based on size of smolts, appearance, and the fact that the adult run appears to be larger currently compared to historical runs).

Table 3-9. The weekly average and maximum daily temperatures during the peak of the Chinook smolt emigration period, Russian River at Mirabel, 2000-2004.

Year	Maximum Weekly Count	Week	Weekly average Temperature	Daily average temps.[1]	Date daily avg. temp. exceeded 20.0˚C
2000	204	April 23	16.4	16.1 – 23.2	May 20
2001	1,338	April 30	18.2	14.5 – 21.6	May 7
2002	4,337	April 30	16.5	14.6 – 21.8	May 30
2003[2]	N/A	N/A	N/A	N/A	N/A
2004	1,911	April 30	19.4	14.5 – 21.3	May 3[2]

[1]Average daily water temperature during the primary Chinook smolt emigration period (April 1 to May 31).
[2]High streamflow during a significant portion of the smolt emigration period disrupted the mark-recapture study during 2003.
[3]The average daily temperature exceeded 20.0˚C on three times prior to May 30.

3.3.2 Steelhead

Steelhead smolts were captured throughout the trapping season, but at lower numbers than Chinook smolts Wild steelhead smolts may be less likely to be captured in the rotary screw traps compared to Chinook smolts. However, the reduced numbers of steelhead smolts in the traps does not necessarily indicate that Chinook salmon population is larger than the steelhead population. Steelhead emigrate at a much larger size, and are stronger swimmers (based on size) and may be less likely to be captured, particularly by the 5-foot traps. Another factor in the lower numbers of steelhead (compared to Chinook salmon) is the difference in the two species life history strategy. Steelhead emigrate at an older age (usually age 2) compared to Chinook, which emigrate within two to four months of hatching. Salmonids experience a high mortality rate during their early life stages. Chinook smolts emigrate to the ocean in large numbers at a young age where they experience a high rate of mortality. Steelhead smolts experience a high rate of mortality during the first two years in freshwater, but the lower number of smolts produced have a much higher survival rate once they reach the ocean.

Between 53 and 250 steelhead smolts have been captured in any one year, depending on the length of time that the traps were fished (Table 3-10). Based on the sampling conducted, steelhead smolts emigrate period extends from at least March through June, but primarily from mid March through late May. During the 5-year study, wild steelhead smolts range in size between 129 and 259 mm, averaging 178 mm FL (Table 3-11).

Young-of-the-year steelhead have been captured in relatively large numbers in the screw traps in most years (Table 3-12). Capture of YOY steelhead has occurred as early as March 6, and as late as July 2. Peak numbers generally occur between April and mid June, with numbers decreasing in late June. The YOY steelhead captured in the trap exhibited considerable growth between March and June (Table 3-13). Young-of-the-year steelhead average 39 mm FL during the first week of April, increasing, on average, to 59 mm FL by the week of June 18.

Low numbers of juvenile steelhead have been observed rearing above and below the dam throughout the summer months, but the fate of the majority of the YOY steelhead observed is unknown. Little suitable spawning habitat is present in the river below at least Healdsburg except for Dry Creek. Therefore, the YOY steelhead observed in the river near Mirabel are likely produced in Dry Creek. What is not known is the fate of the YOY fish. Some fish manage to rear year around in the river, at least in the vicinity of the dam, while some fish may migrate to the estuary. It is also possible that some of the fish succumb to the relatively high water temperatures in the lower river or to predation by fish or birds.

3.3.2.1 Temperatures and steelhead smolt emigration

Based on five years of smolt trapping, steelhead smolts emigrate through the Mirabel Reach primarily from mid March through May. The date that water temperature monitoring has been initiated has ranged from March 1 to April 20 (Table 3-14). Water temperatures during peak emigration generally range between 15.0 and 18.7˚C.

Table 3-10. Weekly capture of wild steelhead smolts in the Russian River near Mirabel, 2000 – 2004.

Week Starting	2000[1]	2001[2]	2002[3]	2003[4]	2004[5]
26-Feb			1	4	
5-Mar			1	3	
12-Mar			38	5	
19-Mar			14	3	
26-Mar			24	43	
2-Apr	2		31	41	3
9-Apr	17		33	19	14
16-Apr	24	7	30	0	11
23-Apr	24	16	23	1	14
30-Apr	21	16	23	0	10
7-May	8	9	8	1	3
14-May	14	4	9	28	1
21-May	9	0	9	20	1
28-May	6	0	2	7	1
4-Jun	1	1	0	2	2
11-Jun	4		3	1	1
18-Jun	2		1	0	2
25-Jun	2		0	0	0
July 2				1	
Totals	**134**	**53**	**250**	**179**	**63**

Table 3-11. Minimum, average, and maximum fork lengths (mm) of wild steelhead smolts captured in the screw traps at the Mirabel Dam, 2000-2004.

Week	Minimum	Average	Maximum
2000	142	177	238
2001	139	179	233
2002	146	181	240
2003	139	175	259
2004	143	180	219

Table 3-12 Weekly capture of wild young-of-the-year steelhead in the Russian River near Mirabel, 2000 – 2004.

Week Starting	2000[1]	2001[2]	2002[3]	2003[4]	2004[5]
26-Feb			0	0	
5-Mar			0	5	
12-Mar			1	1	
19-Mar			6	12	
26-Mar			3	67	
2-Apr	0		55	170	16
9-Apr	3		51	132	119
16-Apr	20	1	447	4	54
23-Apr	33	17	81	20	108
30-Apr	224	4	657	0	42
7-May	30	13	755	22	192
14-May	49	23	976	74	322
21-May	80	34	1315	244	320
28-May	74	32	806	223	63
4-Jun	102	26	466	55	62
11-Jun	40		164	29	47
18-Jun	58		59	27	51
25-Jun	50		1	2	15
July 2				1	
Totals	**763**	**150**	**5,843**	**1,088**	**1,411**

Table 3-13 Average fork length (mm) of YOY steelhead captured in the screw traps at the Mirabel Dam, 2000-2004.

Week Starting	2000[1]	2001[2]	2002[3]	2003[4]	2004[5]
26-Feb				N/A	
5-Mar				28	
12-Mar			29	29	
19-Mar			34	28	
26-Mar			35	30	
2-Apr			38	33	39
9-Apr	44		43	40	41
16-Apr	47	29	41	36	48
23-Apr	46	42	47	39	43
30-Apr	42	65	49	N/A	48
7-May	44	53	52	54	50
14-May	53	53	59	60	49
21-May	57	67	66	62	48
28-May	70	66	66	63	52
4-Jun	63	69	66	60	51
11-Jun	71		69	72	51
18-Jun	82		81	71	59
25-Jun	84		125		N/A

Table 3-14. The weekly average and maximum daily temperatures during the peak of the steelhead smolt emigration period (March 15 through May 31), Russian River at Mirabel Inflatable Dam, 2000-2004.

Year	Maximum Weekly Count	Week	Weekly average Temperature	WAT[1]	Date daily avg. temp. exceeded 20.0˚C
2000	24	April 16 April 23	16.4[2]	16.1 - 23.2	May 20
2001	16 16	April 23 April 30	18.2 17.2	15.0 – 20.4	May 7
2002	38	March 12	11.6	11.9 – 18.7	May 30
2003	N/A	N/A	N/A	N/A	N/A
2004	14	April 9 April 23	16.3 18.5	16.3 18.7	May 3[3]

[1]The range of weekly average temperatures during the peak steelhead smolt emigration period (mid March through May).
[2]Temperature data loggers were installed on April 20, 2000.
[3]The average daily temperature exceeded 20.0˚C on three times prior to May 30.

3.4 SIGNIFICANT FINDINGS

A major component of this portion of the study was verifying that smolts were able to migrate downstream passed the dam. This study was successful at answering the question for Chinook smolts, but not steelhead smolts. Steelhead smolt emigration passed the dam was addressed in a companion study (Manning et al. 2003). Chinook smolt passage was determined using marked fish.

There are three routes for fish to move downstream of the dam; through the fish bypass, down the ladders, and passing directly over the dam. Manning et al. (2003) found that 80 percent of the steelhead smolts in their study passed over the dam. However, at full inflation, the dam forms a flat surface and water passing over the dam is typically a few inches deep. Observations at the dam indicated that steelhead smolts were reluctant to pass over the dam when fully inflated. Although several smolts were observed passing over the dam (many of which were subsequently captured in the screw traps), the dam had the potential to delay downstream movement of steelhead pass the dam. Based on the same observations, Chinook salmon passage did not appear to be delayed at the dam.

Manning *et al* (2003) reported that at least some hatchery steelhead smolts with surgically implanted radio tags did experience a delay, ranging from a few hours to a few days, in passing the dam. The radio tagged steelhead appeared to negotiate the slack water behind the dam with little difficulty, however, the smolts were delayed in negotiating the dam. Steelhead smolts apparently were inhibited by the nature of the shallow water sheeting over the dam. Steelhead smolts were observed beginning to pass over lip of the dam, before hitting a critical spot where they would swim against the current and move back upstream of the dam.

The Agency has the ability to manipulate the shape of the dam to a small degree. By carefully filling the dam with water and air, the dam operators were able to form a notch in the dam which concentrated the flow through a relatively narrow section of the dam (Figure 3-5). The flow through the notch produced a relatively deep, high velocity passage route over the dam. Radio tagged steelhead encountering the dam after the formation of the notch passed the dam at a significantly faster rate compared to the flat crest configuration (see Manning et al. 2003 for a detailed discussion of the Notch).

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Figure 3-5. Photo of Inflatable Dam illustrating notch used to improve steelhead smolt passage over dam.

As part of the mark-recapture study instituted to estimate Chinook smolts abundance, Chinook smolts were marked with an alternating upper and lower caudal clip on a weekly basis, then transported approximately 0.8 km upstream of the dam. On the day following a change in the clip used, Chinook smolts captured in the screw traps almost invariably possessed the new clip. Few Chinook smolts were recaptured bearing the previous week's clip, which would indicate that they had required more than 48 hours to pass the dam. Chinook smolts are two to four months old at the time of emigration, and are much smaller than steelhead smolts that emigrate as two-year-olds. The smaller sized Chinook smolts may be better at passing over the dam compared to the larger steelhead smolts. Alternatively, upon in countering the current flowing over the dam, Chinook smolts may be too weak to swim against the current and may be swept over the dam.

Chinook salmon smolts were captured in the traps between March 1 and July 3 (the earliest and latest dates that the traps were fished during the 5-year study). Peak emigration generally occurred from mid April through mid May. Emigrating smolts average between 80 and 90 mm FL during the peak emigration period.

Steelhead smolts were captured in much lower numbers compared to Chinook. The reason is likely a function of differences in life history traits and trap efficiencies. Steelhead emigrate to the ocean at (primarily) age 2, and have already experienced substantial mortality compared to Chinook which emigrate at the age of 2 to 4 months. In addition, the larger steelhead smolts are potentially better able to avoid capture in the traps because of their superior swimming ability. Steelhead smolts average approximately 180 mm FL in length during the emigration period. Steelhead smolts were captured in the trap from the first week in March through the last week in June during the 5-years studied. Peak emigration appears to occur from mid March through mid May.

4.0 WOHLER POOL FISH COMUNITY

The Inflatable Dam impounds approximately 5.1 km of river, creating a long pool, as opposed to a series of pools, runs and riffles that would exist without the dam in place. Since pools are the preferred habitat of adult predatory fish (e.g., pikeminnow and smallmouth bass – see section 1.8 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.* 2001, 2003, 2005). 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.

Although juvenile salmonids are susceptible to predation, river conditions early in the spring are not favorable for predation by bass and pikeminnow. Periodic high turbidity events hinder prey detection and capture by predators that are sight feeders (bass and pikeminnow). In addition, bass tend to be relatively inactive at water temperatures below approximately 15°C. However, the dam is inflated as streamflow declines in the spring, generally around mid April. The reduction in streamflow and the impounding of the river leads to clearer water conditions, and potentially an increase in temperature.

Young-of-the-year (YOY) Chinook salmon are present in the Wohler study area from approximately late February through at least June. Chinook salmon average approximately 35 to 40 mm FL in length during the first few weeks of life, then quickly grow to approximately 80 mm FL by mid April. Young-of-the-year steelhead are present from early to mid March throughout the remainder of the year. Young-of-the-year steelhead become relatively abundant in mid April, were they average approximately 40 mm FL. Steelhead smolts are present from at least early March through mid-June. Steelhead smolts are typically two years old at emigration, and range in length from approximately 150 to 250 mm FL (overall average in 2004 was 180 mm FL).

Some level of predation by the pikeminnow (native) and smallmouth bass (non-native) would likely occur with or without the dam. The question is: does the presence of the dam lead to increased predation over levels that would occur without the dam in place? Since it is not known what the predator populations would be in the Wohler Pool footprint without the dam in place, the focus of this study is to assess predator populations in the Wohler Pool under current conditions. This study examined both the overall number of each of the three potential predators, and the fraction of the population that is large enough to prey on the salmonids present in the river.

4.1 STUDY AREA

The study area was divided into five reaches (Figure 4-1). Reach #1 was located adjacent to Steelhead Beach Regional Park, which is located approximately 2.5 kilometers downstream of the Inflatable Dam. Reach #1 measured approximately 0.6 km in length. Reach #2 was located in the lower third of the Wohler Pool, and Reach #3 was located in the middle third of the Wohler Pool. Habitat in the Reaches 2 and 3 is significantly altered by the Inflatable Dam. Reach #4 occupies the upper 1,600 meters 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. Reach #5 is above the influence of the impoundment, and consists of natural pools, runs and riffles. Access along the Russian River just above and below the Inflatable Dam (outside the influence of the Dam) is limited. The upstream end of Reach #4 was marked by a swallow riffle in 2000 – 2002 and not passable by the electrofishing boat in those years, and thus was not sampled. These limitations prevented the expansion of the study into portions of the river that are not affected by the dam. The upstream end of Reach #5 was similarly truncated by a shallow riffle which restricted this reach to approximately 460 m.

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Figure 4-1 Boat electrofishing reaches, August 2003

4.2 METHODS

4.2.1 Sampling Site Selection

Each Reach was divided into sampling stations of equal length, each measuring 180 m. Depending on the length of the individual reaches, six or nine sampling stations were randomly selected. Prior to site selection, Reaches were further divided into three sub units consisting of the left bank, the mid channel, and the right bank of the river. Starting at the downstream end of a Reach, a starting point 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.

4.2.3 Boat Electrofishing

Fish were collected with a 16-foot electrofishing boat (Smith-Root, Inc. model SR16S). 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 railings. 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 lights 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). Sampling was conducted between 20:30 and 02:00. 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, thereby increasing 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 both a pump and an aerator that supplies 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 target species to determine the age structure of the fish community.

In addition, a second round of sampling was conducted at the four Reaches located above the dam. The second sampling effort focused solely on capturing large predatory fish, and included re-sampling portions of the river covered in the first round of sampling, as well as sampling habitat that provides habitat features favored by large piscivours.

4.3 RESULTS

4.3.1 Boat Electrofishing

Boat electrofishing surveys have been conducted in August between 2000 and 2004 (a preliminary survey was also conducted in 1999). Five Reaches were sampled in 1999, 2003 and 2004, and four Reaches were sampled in 2000-2002. Reach 1 (downstream of the Inflatable Dam) consisted of four shoreline-sampling units and two mid-channel sampling units. 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 (thalwag depth approximately 0.45 to 0.6 meters). 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. Reach 5 (above the influence of the dam) consisted of three shoreline sampling units (the upstream end of Reach is marked by a riffle that is too shallow for the electrofishing boat to navigate, which truncated this reach).

4.3.2.1 Community composition

During the 2004 sampling season, 1,920 fish representing 19 species and 8 families were collected (Table 4-1). In 2004, nine of the 19 species captured were native to the Russian River, and native species comprised 74.2 percent of the catch. Overall, species composition in the study area was dominated by four species: Sacramento suckers (38.3 percent), smallmouth bass (20.3), tule perch (17.3 percent), and hardhead (8.6 percent) (Table 4-2).

In Reach 1, Sacramento sucker (71.1 percent) were the most abundant species captured in 2004, followed by smallmouth bass (11.7 percent), and tule perch (4.5 percent). Species composition in Reach 1 differed appreciably in 2004 compared to other years sampled. Prior to 2004, sunfish (excluding smallmouth bass) comprised between 15.5 to 29.1 percent of the total fish community in Reach 1. In 2004, sunfish (excluding smallmouth bass) comprised 2.6 percent of the fish community in Reach 1. Over the five years sampled Sacramento suckers have been the dominant fish (36.2 percent of the catch), followed by smallmouth bass (20.4 percent) tule perch (13.1 percent) and bluegill (8.3 percent) (Appendix D). Predators greater than 200 mm FL comprised between 1.8 and 6.6 percent of the total catch in Reach 1 between 2000 and 2004.

In Reach 2, Sacramento sucker (29.4) and smallmouth bass (27.4 percent) were the most abundant species captured, followed by hardhead (17.3 percent) and tule perch (10.8 percent). Predatory fish greater than 200 mm FL comprised 3.7 percent of the fish captured in 2004. Over the five years sampled smallmouth bass (30.5 percent) were the dominant species captured, followed by suckers (24.3 percent), hardhead (19.6 percent), and tule perch (9.8) (Appendix D). Predators greater than 200 mm FL comprised between 0.8 and 3.7 percent of the total catch in Reach 2 between 2000 and 2004.

In Reach 3, tule perch (27.3), Sacramento sucker (26.8), and smallmouth bass (24.8 percent) were the most abundant species captured in 2004. Predatory fish greater than 200 mm FL comprised 4.3 percent of the fish captured. Over the four years sampled smallmouth bass (36.1 percent) was the dominant species captured, followed by suckers (23.4 percent), hardhead (12.3 percent), and tule perch (10.8) (Appendix D). Predators greater than 200 mm FL comprised between 1.0 and 4.7 percent of the total catch in Reach 3 between 2000 and 2004.

In Reach 4, Sacramento sucker (29.8 percent), tule perch (25.6 percent), and smallmouth bass (21.1), were the most abundant species. Predators greater than 200 mm FL comprised 2.1 percent of the fish captured in 2004. Over the four years sampled, Sacramento sucker (28.0 percent) and smallmouth bass (26.1 percent) were the dominant species captured, followed by tule perch (16.7 percent) hardhead (11.1 percent), and California roach (7.4 percent) (Appendix D). Predators greater than 200 mm FL comprised between 1.5 and 3.5 percent of the total catch in Reach 4 between 2000 and 2004.

In Reach 5, Sacramento sucker (48.1 percent) were the most abundance species, followed by smallmouth bass (13.5 percent), and tule perch (9.6 percent) (Appendix D). Predators greater than 200 mm FL comprised 1.9 percent of the fish in 2004 (3 total), and between 1.9 and 3.5 percent of the total catch in Reach 4 between 2000 and 2004.

Table 4-1. Total number of fish captured during boat electrofishing population sampling, Russian River, August 2004.

Species	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	TOTAL
Wild Steelhead	0	0	0	4	11	15
Hatchery Steelhead	0	0	0	0	0	0
Chinook	0	0	0	0	0	0
Pikeminnow	3	27	31	11	2	74
Hardhead	8	69	29	46	11	163
Roach	1	16	3	40	12	72
Hitch	3	5	9	3	0	20
Blackfish	0	5	1	0	1	7
Tule Perch	14	46	110	144	15	329
Sucker	219	117	150	168	75	729
Sculpin	0	0	0	1	2	3
Smallmouth bass	36	109	101	119	21	386
Largemouth bass	10	1	0	0	0	11
Bluegill	3	4	5	9	1	22
Green sunfish	4	2	2	9	1	18
Redear sunfish	0	3	2	11	0	16
Crappie	1	1	1	0	0	3
Shad	7	0	0	1	0	8
Carp	5	3	2	5	3	18
Bullhead	1	0	0	1	0	2
White Catfish	3	1	1	0	1	6
Stickleback	0	0	0	0	0	0
Striped bass	0	0	0	0	0	0
TOTALS	**318**	**409**	**447**	**572**	**156**	**1902**

Table 4-2. **Percentage composition of fish captured during boat electrofishing population sampling, Russian River, August 2004.**

Species	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5
Wild Steelhead	0.0	0.0	0.0	0.7	7.1
Hatchery Steelhead	0.0	0.0	0.0	0.0	0.0
Chinook	0.0	0.0	0.0	0.0	0.0
Pikeminnow	0.9	6.6	6.9	1.9	1.3
Hardhead	2.5	16.9	6.5	8.0	7.1
Roach	0.3	3.9	0.7	7.0	7.7
Hitch	0.9	1.2	2.0	0.5	0.0
Blackfish	0.0	1.2	0.2	0.0	0.6
Tule Perch	4.4	11.2	24.6	25.2	9.6
Sucker	68.9	28.6	33.6	29.4	48.1
Sculpin	0.0	0.0	0.0	0.2	1.3
Smallmouth bass	11.3	26.7	22.6	20.8	13.5
Largemouth bass	3.1	0.2	0.0	0.0	0.0
Bluegill	0.9	1.0	1.1	1.6	0.6
Green sunfish	1.3	0.5	0.4	1.6	0.6
Redear sunfish	0.0	0.7	0.4	1.9	0.0
Crappie	0.3	0.2	0.2	0.0	0.0
Shad	2.2	0.0	0.0	0.2	0.0
Carp	1.6	0.7	0.4	0.9	1.9
Bullhead	0.3	0.0	0.0	0.2	0.0
White catfish	0.9	0.2	0.2	0.0	0.6
Stickleback	0.0	0.0	0.0	0.0	0.0
Striped bass	0.0	0.0	0.0	0.0	0.0
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

4.3.1 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 and between years where the effort exerted to capture fish is not equal. The amount of effort spent at each site is dependent on several factors, including the size of the Reach, the number of fish present and the complexity of the habitat sampled. For this study, CPUE equals the average number of fish captured per one-minute of electrofishing. Stations were separated into shoreline and mid-channel habitats, since species abundance and composition differ between the two.

Overall, approximately 195 minutes of effort was expended sampling fish during the community composition phase of the study over a three night period (the timer malfunction during the Reach 2 survey event, thus the effort reported here is representative of Reaches 1, 3, 4 and 5). The CPUE varied widely between individual sampling stations within and between the Reaches. Catch-per-unit-effort ranged between 0.9 fish/minute to 7.7 fish/minute in mid channel stations, to 3.1 to 26.5 fish/minute at shoreline stations (Table 4-3 and 4-4). Sacramento sucker, smallmouth bass, and tule perch were the most abundant fish at all stations based on CPUE (Table 4-3). Wild steelhead were captured in Reaches 4 and 5, only.

Determining the abundance of predatory fish is the key component of the Wohler Pool fish community surveys. Thus, in addition to the fish populations surveys conducted during this phase of the study, an additional sampling effort was conducted solely targeting large predatory fish. For this study, any piscivorous species that exceeded 200 mm FL during the spring emigration period falls in the “active predator classification.” At this size any of the three predator species likely to be present are large enough

Table 4-3. Catch-Per-Unit-Effort by Reach, Inflatable Dam Study Area, Russian River, August 2004.

Shoreline stations					
Species	**Reach 1**	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**
Wild Steelhead	0.0	N/A[1]	0.0	0.1	0.6
Chinook	0.0		0.0	0.0	0.0
Pikeminnow	0.0		0.9	0.2	0.1
Hardhead	0.2		0.9	1.0	0.6
Roach	0.0		0.0	1.0	0.6
Blackfish	0.0		0.0	0.0	0.1
Hitch	0.1		0.2	0.0	0.0
Tule Perch	0.4		3.1	3.2	0.8
Sucker	5.2		1.8	2.7	3.8
Sculpin	0.0		0.1	0.0	0.1
Stickleback	0.0		0.0	0.0	0.0
Hatchery Steelhead	0.0		0.0	0.0	0.0
Smallmouth bass	1.0		2.8	2.8	1.1
Largemouth bass	0.3		0.0	0.0	0.0
Bluegill	0.1		0.2	0.2	0.1
Green sunfish	0.1		0.1	0.2	0.1
Redear sunfish	0.0		0.1	0.2	0.0
Crappie	0.0		0.0	0.0	0.0
Shad	0.2		0.0	0.0	0.0
Carp	0.2		0.0	0.1	0.2
Bullhead	0.0		0.1	0.0	0.0
White catfish	0.1		0.0	0.0	0.1
Striped bass	0.0		0.0	0.0	0.0
Totals	**7.9**		**10.3**	**12.0**	**8.0**

[1]Timer malfunctioned.

Table 4-4. Catch-Per-Unit-Effort by Reach, Mirabel Study Area, Russian River, August 2004.

Mid channel stations				
Species	**Reach 1**	**Reach 2**	**Reach 3**	**Reach 4**
Wild Steelhead	0.0	N/A[1]	0.0	0.0
Chinook	0.0		0.0	0.0
Pikeminnow	0.2		0.1	0.0
Hardhead	0.2		0.1	0.1
Roach	0.0		0.0	0.0
Blackfish	0.0		0.1	0.0
Hitch	0.0		0.1	0.0
Tule Perch	0.1		0.5	0.3
Sucker	4.5		2.6	1.5
Sculpin	0.0		0.0	0.0
Stickleback	0.0		0.0	0.0
Hatchery Steelhead	0.0		0.0	0.0
Smallmouth bass	0.5		0.4	0.2
Largemouth bass	0.1		0.0	0.0
Bluegill	0.0		0.0	0.0
Green sunfish	0.0		0.0	0.0
Redear sunfish	0.0		0.0	0.0
Crappie	0.0		0.0	0.0
Shad	0.0		0.0	0.0
Carp	0.0		0.0	0.0
Bullhead	0.1		0.0	0.0
White catfish	0.1		0.1	0.0
Striped bass	0.0		0.0	0.0
Totals	**5.7**		**3.8**	**2.3**

[1]Timer malfunctioned.

to feed on an 80 mm salmonid (approximates "average size" Chinook smolt), and has reached a stage in its development where fish are becoming an important component of its diet. On average, this occurs during the start of the third year of life (Age 2+) for the three dominant predatory fish in the Russian River. The predator sampling event occurs in August, approximately 4 months after the peak of the smolt emigration period. Although many of the fish in the August sample would have been less than 200 mm FL during the spring emigration period, using the data from August provides a conservative assessment of the number of predatory fish in the study area.

Data from both sampling efforts were combined to assess predator populations and steelhead use in the Wohler Pool. An additional 209 minutes of sampling were exerted in Reaches 2 through 5 in an effort to more adequately assess predator populations in the study reaches. In the predator analysis, mid channel habitats were excluded because the majority of predators greater than 200 mm FL were captured along shoreline habitat.

Smallmouth bass were the most prevalent predator in the study area. The capture rate (CPUE) for 200 mm FL and larger predators was highest in Reach 1 (0.48 predators/minute of sampling). Reach 1 was the only station where largemouth bass were a significant component of the predator population, and all (8 total) were between 200 and 230 mm FL. The predator CPUE in the above dam reaches ranged from 0.27 to 0.30 in Stations 2, 3, and 5. The CPUE in Station 4 was 0.16. The dominant predator (in terms of numbers) in the above dam reaches again was the smallmouth bass.

Smallmouth bass were more prevalent in stations 3 and 4 compared to stations 1 and 5 (above and below the pool) (Table 4-3). However, when only 200 mm FL smallmouth bass are compared (including those caught during the predator sampling event), Stations 1, 3, and 5 have similar CPUE, while the CPUE in station 2 and 4 are reduced (Table 4-5). The CPUE for pikeminnow was highest in Station 2, and similar in stations 1, 3 and 5. No pikeminnow over 200 mm FL were captured in Station 4 in 2004. Largemouth bass were most abundant in Station 1 and became progressively less abundant upstream of the dam.

Overall, Reaches 3 and 4 supported the largest predator populations, based on CPUE in four of the five years sampled (Table 4-5). Smallmouth bass were the most abundance predator greater than 200 mm FL overall in all Reaches and all years sampled with few exceptions. Overall, predator populations in the Wohler Reach appear to be low.

Table 4-5. CPUE of predators greater than 200 mm FL, by Reach, 2000-2004, all shoreline and predator sampling events combined.

Pikeminnow					
Species	**Reach 1**	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**
2000	0.00	--[1]	0.04	0.04	--[2]
2001	0.04	0.03	0.05	0.07	--[2]
2002	0.00	0.10	0.03	0.04	--[2]
2003	0.02	0.00	0.02	0.05	0.04
2004	0.10	0.12	0.08	0.00	0.05
Smallmouth bass					
Species	**Reach 1**	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**
2000	0.06	--[1]	0.14	0.19	--[2]
2001	0.17	0.02	0.40	0.29	--[2]
2002	0.11	0.14	0.32	0.12	--[2]
2003	0.15	0.15	0.18	0.23	0.05
2004	0.29	0.30	0.21	0.18	0.24
Largemouth bass					
Species	**Reach 1**	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**
2000	0.03	--[1]	0.01	0.00	--[2]
2001	0.11	0.00	0.00	0.00	--[2]
2002	0.05	0.00	0.00	0.00	--[2]
2003	0.00	0.06	0.00	0.00	0.00
2004	0.22	0.05	0.04	0.00	0.00

All species combined					
Species	**Reach 1**	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**
2000	0.09	--[1]	0.20	0.22	N/S
2001	0.32	0.23	0.46	0.36	N/S
2002	0.16	0.24	0.36	0.24	N/S
2003	0.17	0.21	0.20	0.28	0.10
2004	0.61	0.47[3]	0.33	0.18	0.29

[1] Timer failed in Reach 2 in 2000.
[2] Reach 5 only sampled in 2003 and 2004.
[3] Timer failed during the community sampling event. CPUE represents effort from predator sampling event, only.

4.3.3 Steelhead

Eighteen wild steelhead were captured during the August 2004 sampling events (regular and predator sampling). Wild steelhead were captured in Reaches 4 (7 total) and 5 (11 total) (Table 4-1). Wild steelhead ranged in length from 95 to 205 mm FL (Figure 4-2). Appendix E presents length-frequency histograms for all species captured in each Reach.

Between 1999 and 2004, a total of 89 wild steelhead were captured in the study area, although no steelhead have been captured downstream of the dam. The highest total number of steelhead captured in any one year was in 2000 (29 total), although sampling effort was greater in 2001-2004. At least three age classes of juvenile steelhead have been captured in the study area, although it is not known if individual fish rear for extended periods (more than a year) of time in the study area.

4.3.4 Adult Predator Populations

Three potential predators of salmonids were captured during the 2004 sampling season: Sacramento pikeminnow, smallmouth bass, and largemouth bass. In all, 24.8 percent of all fish captured during electrofishing sampling fell in the predator category. However, 73.7 percent (347) of the predators captured were young-of-the-year, and only 10.4 percent (36) of the predators were age 2+ or older (i.e., large enough to prey an 80 mm salmonid) (analysis only includes fish caught during regular electrofishing sampling events where an attempt was made to capture all fish regardless of size).

4.3.1.1 Pikeminnow

Pikeminnow comprised 3.9 (N=74) percent of the fish captured in 2004 (Tables 4-1 and 4-2) (excluding fish caught during the predator sampling event). Within individual reaches, pikeminnow comprised between 0.9 (Reach 1) and 6.9 (Reach 3) percent of the populations. Young-of-the-year accounted for 48 (64.9 percent) of the pikeminnow captured in 2004, while nine (12.2 percent) were aged as two-years-old or older (Figure 4-3). Pikeminnow were most abundant (based on CPUE) in Reach 3 (0.6 pikeminnow/minute of sampling along shoreline habitat).

In addition to the pikeminnow caught during the regular electrofishing sampling event, six additional pikeminnow age 2 or older were captured during the "predator" sampling event (19 pikeminnow age 2 or older for the 2004 sampling season). All 19 age 2 and older pikeminnow were likely large enough to consume the average size Chinook smolt captured during the emigration period, and 10 of the pikeminnow were likely large enough (≥410 mm FL) to eat an average size steelhead smolt.

Although pikeminnow attain a large size and are fairly long-lived, their abundance of pikeminnow greater than 200 mm FL appears to be low in the study area (Figure 4-3, Table 4-6). When all sampling events (1999 through 2004) were combined, the total number of pikeminnow greater than 200 mm FL was still relatively low (84) (Table 4-6).

In 2004, pikeminnow ranged in size from 50 to 700 mm FL (Figure 4-3). Overall all years sampled, pikeminnow averaged 67 mm FL (N=229) during August of their first year, 140 mm FL (N = 118) during August of their second year (age 1+), and 252 mm FL (N = 36) at age 2+ (Table 4-7). Based on the data collected to date, it appears that pikeminnow attain a size (>300 mm FL) to switch to a fish diet at the beginning of their fourth year of life (Age 3+). Pikeminnow aged as 4+ or older are large enough to prey on both Chinook salmon and steelhead smolts. Based on scale readings conducted for this study, pikeminnow four years of age and less could be confidently aged based on scale analysis. For pikeminnow age 5 and older, growth slows, and the annuli laid down at the margins of the scales could not be accurately differentiated. All pikeminnow aged as 5-years-old or more were combined. An example of this slow growth with advanced age was illustrated by the recapture of a pikeminnow tagged during August of 2001. This pikeminnow measured 615 mm in length and was aged as a 6-year-old fish. In 2003, this pikeminnow measured 655 mm in length, but was again aged as a 6-year-old fish. At least the last two annuli were laid so close together at the margin of the scales as to be undetectable.

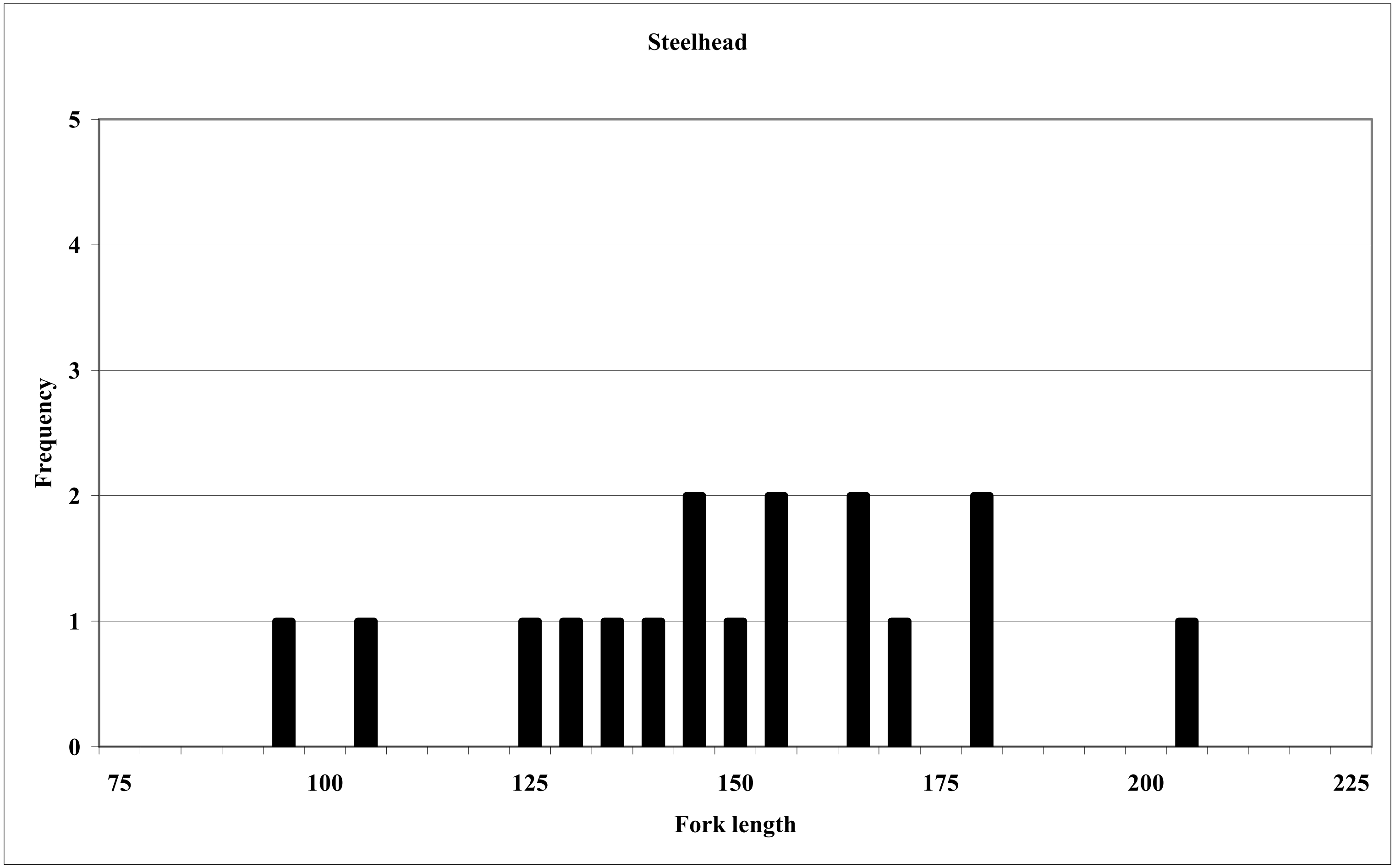

Figure 4-2. **Length-frequency histogram for wild steelhead captured during boat electrofishing, August 2004 (all stations combined).**

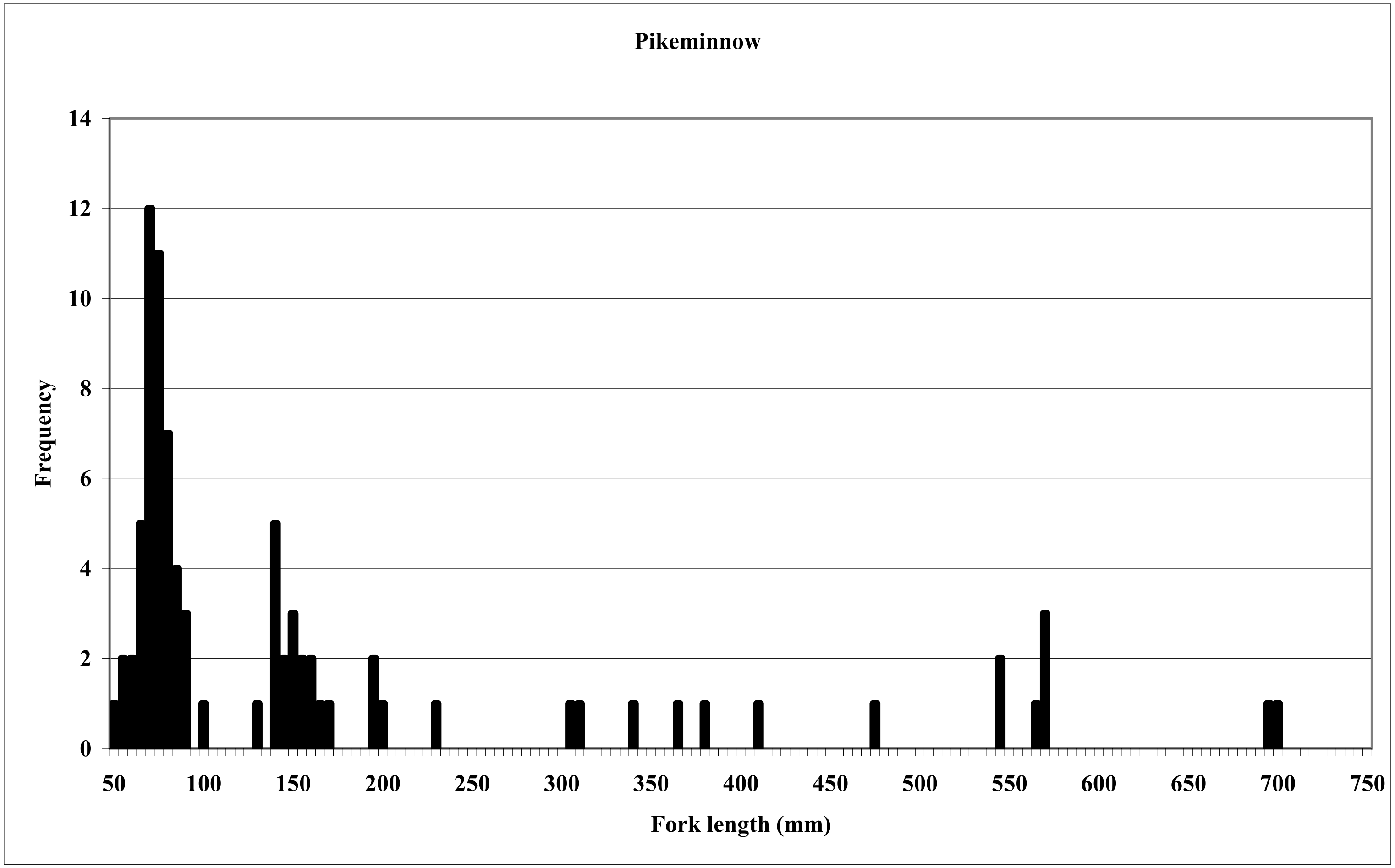

Figure 4-3. **Length-frequency histogram of all Sacramento pikeminnow captured during boat electrofishing surveys, 2004.**

Table 4-6. Average size and range by age class of Sacramento pikeminnow captured during boat electrofishing 1999-2004, Russian River.

Age 0+			
Segment	**Average**	**Range**	**N =**
1999	68	65 - 70	3
2000	64	35 - 85	70
2001	65	50 - 80	34
2002	65	40 - 95	53
2003	56	40 - 70	22
2004	74	50 - 100	48
Overall	**66**	**35 - 100**	**230**

Age 1+			
	Average	**Range**	N =
1999	128	95 - 155	7
2000	138	110 - 175	24
2001	157	140 - 195	14
2002	137	115 - 160	32
2003	144	110 - 190	22
2004	149	130 – 170	17
Overall	**142**	**95 - 195**	**116**

Age 2+			
	Average	**Range**	**N =**
1999	--	--	0
2000	244	240 – 270	5
2001	274	240 – 300	8
2002	265	265	1
2003	247	215 – 285	8
2004	239	195 – 310	6
Overall	**253**	**195 – 310**	**28**

Age 3+			
	Average	**Range**	**N =**
1999	385	385	1
2000	--	--	0
2001	349	320 - 380	6
2002	350	335 - 370	3
2003	330	330	1
2004	362	340 - 380	3
Overall	**354**	**320 - 385**	**13**

Table 4-7. Average size and range by age class of Sacramento pikeminnow captured during boat electrofishing 1999-2004 Russian River (Concluded).

Age 4+			
	Average	**Range**	**N =**
1999	--	--	0
2000	480	480	1
2001	455	455	1
2002	455	410 - 485	4
2003	443	430 - 455	2
2004	443	410 - 475	2
Overall	**453**	**350 - 475**	**10**

Age 5+ and older			
	Average	**Range**	**N =**
1999	528	528	1
2000	615	520 - 710	2
2001	567	530 - 615	3
2002	618	515 - 710	12
2003	657	535 - 725	8
2004	603	550 - 700	8
Overall	616	515 - 725	34

4.3.4.2 Smallmouth bass

Smallmouth bass comprised 20.3 percent (386) of the total catch during the August 2004 sampling event. Within individual reaches, smallmouth bass comprised between 11.3 (Reach 1) and 26.7 (Reach 2) percent of the fish captured. Approximately 77.2 percent of the smallmouth bass captured were aged as young-of-the-year, and 28 fish (7.3 percent) were aged as two-years-old or more (Figure 4-4). Smallmouth bass were most abundant (based on CPUE) in Reach 3 (1.96 smallmouth bass/minute of sampling in shoreline sampling sites), followed by Reache 4 (1.5 smallmouth bass/minute of sampling). Notable in Reaches 3 and 4 are at least three large bank stabilization projects utilizing boulders (rip-rap). Boulders provide cover for smallmouth bass, and relatively large numbers of small to medium sized smallmouth bass were captured along banks with rip rap extending into the river. Smallmouth bass were least abundant in Reach 1 and Reach 5 (0.82 and 1.08 smallmouth bass/minute of sampling, respectively). It is noteworthy that Reach 1 is the smallest unit, consisting of one long pool). Again, the timer failed in Station 2.

Smallmouth bass captured in August 2004 ranged in size from 55 to 460 mm FL (Figure 4-4). Over all year sampled, smallmouth bass averaged 81 mm FL (N = 3,034 in August of their first year, 178 mm FL (N = 555) during August of their second year (age 1+), and 262 mm FL (N = 162) at age 2+ (Table 4-8). No smallmouth bass large enough to prey on age 2+ or older steelhead were captured, however, the larger bass captured were likely big enough to prey on Age 1+ steelhead.

4.3.1.2 Largemouth bass

Largemouth bass comprised 0.6 percent (11 total) of the catch during the August 2004 sampling event. Ten of the largemouth bass were aged as 2+, and the remaining bass was aged as Age 4+ (Figure 4-5). Largemouth bass averaged 209 mm FL (N = 10, all sites combined) during August of their third year (age 2+) (Table 4-9). Largemouth bass, based on their morphology, are able to feed on larger fish at a smaller size compared to smallmouth bass, thus, it is conservatively assumed that Age 2+ are large enough to feed on emigrating Chinook smolts during the start of their third year (Age 2+)

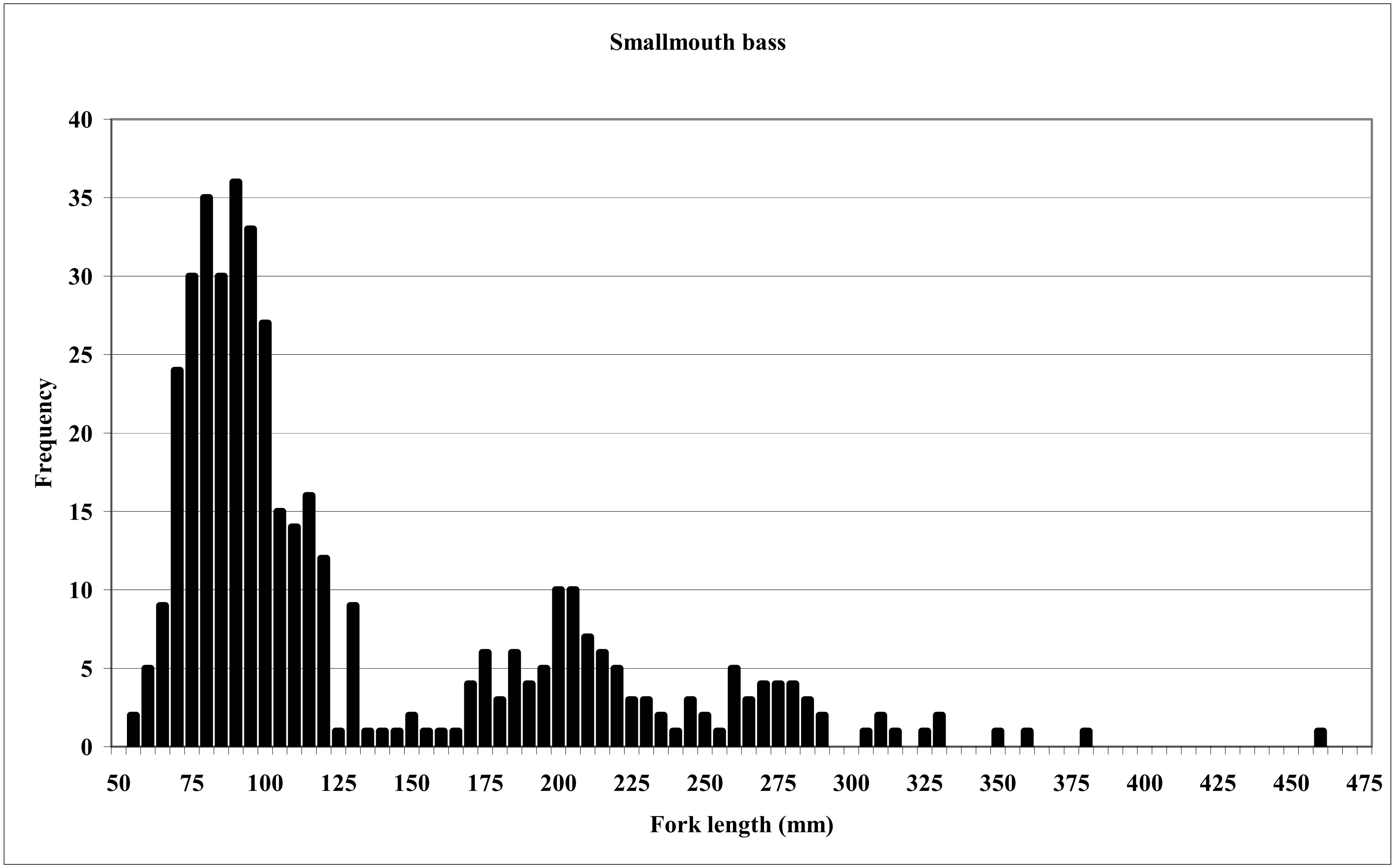

Figure 4-4. Length-frequency histogram for Smallmouth bass captured during boat electrofishing, August 2004.

Table 4-8. Average size and range by age class of all smallmouth bass captured during boat electrofishing during August surveys, 1999 - 2004, Russian River.

Age 0+			
Segment	**Average**	**Range**	**N =**
1999	85	55 - 120	208
2000	79	50 – 120	1,067
2001	79	50 – 135	583
2002	85	45 - 135	503
2003	74	45 - 115	375
2004	91	55 - 130	298
Overall	**81**	**45 – 135**	**3,034**
Age 1+			
	Average	**Range**	N =
1999	179	150 - 210	19
2000	175	130 – 210	134
2001	180	140 – 230	153
2002	183	150 - 230	76
2003	167	125 - 220	109
2004	190	135 - 235	64
Overall	**178**	**125 - 235**	**555**
Age 2+			
	Average	**Range**	**N =**
1999	264	240 - 295	11
2000	253	220 - 280	17
2001	264	235 - 295	46
2002	271	235 - 310	27
2003	253	228 - 285	41
2004	270	235 - 310	20
Overall	**262**	**228 - 310**	**162**
Age 3+			
	Average	**Range**	**N =**
1999	325	310 - 350	6
2000	307	300 – 320	3
2001	310	300 – 325	5
2002	333	325 - 340	2
2003	324	305 - 345	14
2004	340	330 - 380	2
Overall	**322**	**300 - 350**	**32**
Age 4+			
	Average	**Range**	**N =**
1999	379	375 - 380	2
2000	370	370	1
2001	373	360 - 390	6
2002	402	400 – 405	2
2003	388	355 - 430	9
2004	420	380 - 460	2
Overall	**386**	**355 - 405**	**22**

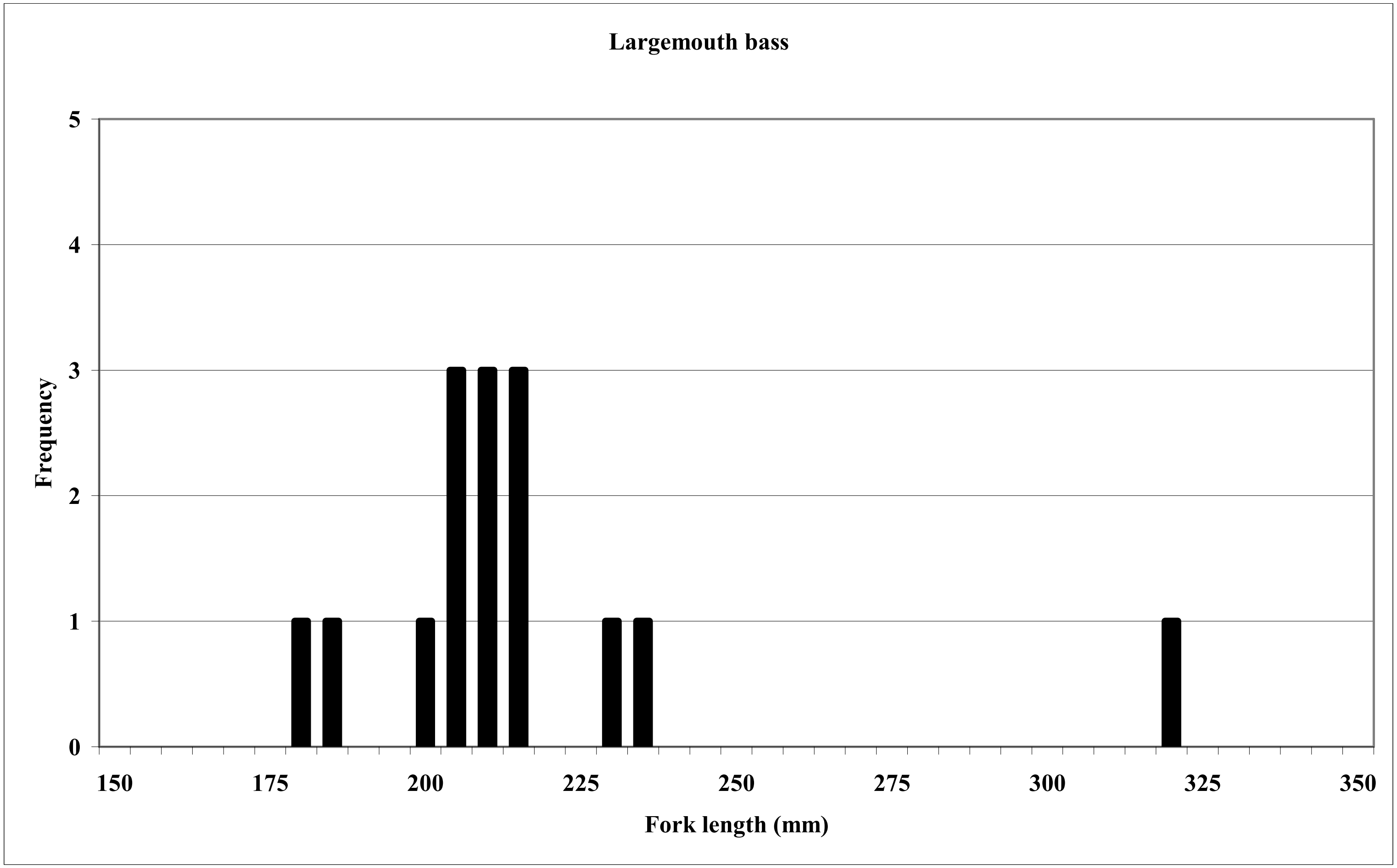

Figure 4-5. Length-frequency histogram for largemouth bass captured during boat electrofishing, August 2004.

Table 4-9. Average size and range by age class of largemouth bass captured during boat electrofishing, August 1999 - 2004, Russian River.

Age 0+			
Segment	**Average**	**Range**	**N =**
1999	--	--	0
2000	60	50 – 75	11
2001	56	40 – 65	9
2002	50	50	2
2003	81	75 - 85	5
2004			0
Total		**40 - 85**	**27**
Age 1+			
	Average	**Range**	**N =**
1999	--	--	0
2000	122	110 – 125	6
2001	132	120-150	3
2002	155	155	1
2003	117	105 – 136	3
2004	--	--	0
Total		**105 - 155**	**13**
Age 2+			
	Average	**Range**	**N =**
1999	--	--	0
2000	195	180 – 210	5
2001	195	175 – 220	4
2002	180	180 – 185	2
2003	168	153 - 195	7
2004	208	180 - 235	10
Total		**153 - 235**	**28**
Age 3+			
	Average	**Range**	**N =**
1999	--	--	0
2000	253	250 – 255	2
2001	--	--	0
2002	255	255	1
2003	--	--	0
2004		--	0
Total	**253**	**250 - 255**	**3**
Age 4+ and older			
	Average	**Range**	**N =**
1999	--	--	0
2000	430	430	1
2001	350	310 – 350	3
2002	460	460	1
2003	--	--	0
2004	320	320	1
Total		**320 - 460**	**6**

4.4 SIGNIFICANT FINDINGS

Three potential salmonid predators inhabit the study area, Sacramento pikeminnow, smallmouth bass, and largemouth bass. In addition, two striped bass have also been captured in the Wohler pool during six years of sampling). Although few adult pikeminnow were captured, they are capable of attaining a size large enough to feed on both Chinook salmon and steelhead smolts, and are a long-lived species, possibly up to 16 years (Scoppettone 1988). 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 an average size steelhead smolt and relatively few smallmouth bass large enough to feed on 80 mm FL Chinook smolts were captured. It is not known if the low number 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. Winter habitat conditions (i.e., when the dam is deflated) may a least partially explain the poor recruitment of smallmouth bass to older age classes (see below). Very few largemouth bass were captured. Abundance of largemouth bass was highest in Reach 1 in all years sampled. Smallmouth bass, pikeminnow, and possibly largemouth bass attain a size sufficient to prey on Chinook salmonids by the start of their third year of life (age 2+).

All five study Reaches provide suitable habitat conditions for the three predatory species of concern. Based on a review of habitat requirements for smallmouth and largemouth bass, Reach 1 and Reach 2 should provide the most suitable habitat in the study area when the dam is inflated. Stream gradient in the Russian River declines below the dam, and there is a higher frequency of pool type habitats compared to the above dam habitat (Chase *et al.* 2000). The greater depth and lower current velocity associated with pool habitats is preferred by centrarchids (which include smallmouth and largemouth bass). Not surprisingly, centrarchids dominate the fish population in Reach 1.

During six years of sampling, four species of fish, smallmouth bass, Sacramento sucker, hardhead, and tule perch have dominated the fish community above the Inflatable Dam (Reaches 2, 3, and 4). Smallmouth bass and Sacramento sucker dominated the catch, when all years and sites are combined (28.5 and 27.9 percent of the catch, respectively). Tule perch and hardhead ranked 3 (12.6 percent of the catch) and 4 (12.0 percent of the catch), respectively. Although, juvenile American shad were the 5th most abundant species captured overall, the majority were caught during the 2004 sampling event. The high numbers of juvenile shad were likely tied to the high flow conditions present in the river during the spring, which delayed the inflation of the dam and likely improved spawning conditions for shad. Pikeminnow were the 7th most abundant species captured during six years of sampling, accounting for 3.0 percent of the total catch. Largemouth bass comprised 0.5 percent of the fish captured during the study.

The fish community in Reach 1 differed from the above dam Reaches in most years 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 have been collected in relatively low numbers, primarily in Reaches above the dam ("Wohler Pool").

Reach 2 has the deepest water (excluding the small hole at the upstream end of Reach 3), the lowest current velocities, and abundant cover. However, 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 responds 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 ¼ to ½ of the lower Wohler Pool. This hypothesis is based on general observations made during the course of this study, and not on empirical data. However, the results of the electrofishing study support this conclusion.

All three predator species would inhabit the study reach with or without the dam in place, and populations of these species did not appear to be higher than those in upstream sections of the river based on snorkel surveys conducted by the Agency (Cook 2003). However, one potential impact that could not be directly assessed with the sampling techniques employed during this study was the potential for predators to occupy the reservoir just upstream of the dam, and prey on smolts as they negotiate passage by the dam.

5.0 Adult Upstream Migration

5.1 INTRODUCTION

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 that provide upstream passage, however, prior to this study the effectiveness of the ladders had not been tested. The dam is typically inflated during at least the first half of the adult Chinook salmon migration period, and may remain inflated into the beginning of the adult steelhead migration period during years with low rainfall in the fall and early winter.

The main objective of this study was to verify that anadromous fish are able to ascend the fish ladders around the inflatable dam. A secondary objective assessed the timing of migration and relative numbers of anadromous fish utilizing the fish ladders while the dam was inflated.

5.2 METHODS

5.2.1 Time-Lapse Video Photography

Passage of adult salmonids 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 (Figure 5-1). The exit boxes conform to the sides of the fish ladders and are designed such that the hydraulics of the ladders was not altered. A highly reflective background was attached to the upstream wall of the exit boxes to improve the lighting in the 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. Cameras were in operations almost continuously from August 1 until the dam was deflated in on December 7.

The recording speed (number of images recorded per second) for the time-lapse photography was held constant 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. Each time the tapes were changed, the camera lenses were 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 adult salmonid observed, the tape reviewer recorded the species (when possible), 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.” Fish identified as an adult Chinook salmon, steelhead, or salmonid were typically doubled checked by a senior biologist.

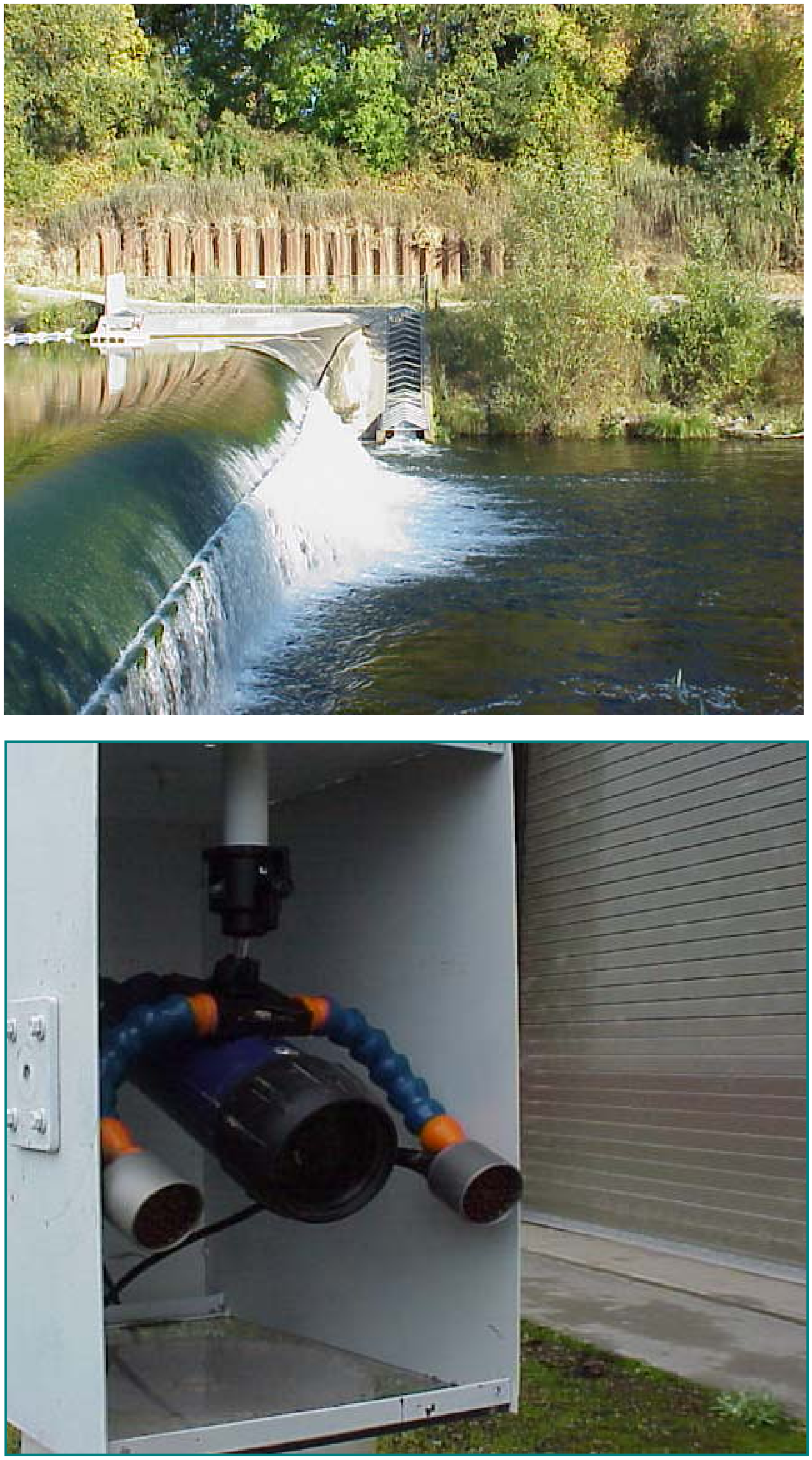

Figure 5-1. Photographs showing the eastside fish ladder and the video camera box.

5.2.2 Upstream Migrant Trapping

In 2003, a wire mesh trap measuring 4' x 6' was installed at the upstream end of the West Fish Ladder. Fish entering the trap were observed using a portable underwater camera connected to a six inch LCD screen that was monitored on site. The camera was mounted on the trap directly upstream of the fish ladder exit. When a fish was observed entering the trap, a panel was lowered that prevented the fish from moving back into the fish ladder. Captured adult salmonids were netted from the trap and transferred to a holding tank. The tank measured 4' x 4', and was supplied via a pump with fresh river water. Captured fish were placed in a sling where they were measured (nearest cm), weighed (Kg), scales removed for age analysis, and tissue samples collected for DNA analysis. The sling was suspended over the holding tank, and hung sufficiently low in the water that the fish remained submerged during data collection (except when weights were recorded). During weighing, the sling/fish were suspended from a digital scale by 80 lb test fishing line. Water was drained from the sling, and the weight recorded. Fish weighing was conducted next to the river, and fish were immediately released back into the river once the weights were recorded.

5.3 RESULTS

Video monitoring demonstrated that adult salmon (Chinook, chum, and pink) 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. The image quality of the videotapes was generally good to excellent, producing images of sufficient quality to identify and count the majority of the fish passing through the fish ladder (Figure 5-2).

5.3.1 Video Monitoring

Video cameras were deployed on August 1 and videotaping continued through the morning of December 8, 2004, when the dam was deflated. During this time-period, 258 videotapes were generated. Video monitoring was continuous throughout the study period with a few exceptions. Overall, the system provided reasonably clear images of fish moving through the video cameras.

Video monitoring (2000 - 2004) demonstrated that adult Chinook, chum, and pink salmon, steelhead, Pacific lamprey, and at least some American shad, 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 system. Turbidity was occasionally a problem, particularly during storm events, when turbidity levels 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 were a secondary objective. In addition, counts only represent numbers of fish migrating in the river during periods when the dam is inflated and the cameras are in operation. Species such a steelhead and Pacific lamprey migrate primarily after the dam has been deflated.

5.3.2 Fish Counts

At least thirteen species of fish have been identified passing in front of the video camera during the study period. Species observed included Chinook, chum, and pink salmon, steelhead, Pacific lamprey, American shad, Sacramento pikeminnow, hardhead, Sacramento sucker, smallmouth bass, common carp, channel catfish, and striped bass (one sub adult was observed moving downstream through the ladders in 2002). 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 only. These counts were broken out by species, with a general category defined as salmonid (fish could not

Figure 5-2. Video images of adult Chinook salmon passing through the exit box at the upper end of the west side fish ladder.

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 2004, 106 fish were identified as a salmonid, but could not be identified to species. Salmonids were partitioned into Chinook or steelhead in an attempt to better estimate the 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. In 2004, 102 of the 106 salmonids were classified as Chinook salmon, and the remaining four fish were classified as a steelhead.

5.3.2.2 Chinook

The final Chinook salmon count for 2004 was 4,686 (4,788 including "salmonids"). However, owing to a few technical difficulties, as well as poor water quality on a few days, this number is likely an underestimate of the true run size for this year for the following reasons:

- Turbidity occasionally obscured fish moving passed cameras.
- Chinook salmon were still being recorded in low numbers when the dam was deflated.

In 2004, flows were reduced during the first two months of the migration period. Average monthly streamflow measured at the Hacienda Bridge ranged between 109 (August) and 119 cfs (first two weeks of October). After October 17, the daily average flow increased to an average of 347 cfs over the last two weeks of October (Table 5-1). Flow in the Russian River was reduced (compared to the D1610 schedule) to conserve the coldwater storage in Lake Mendocino for release later in the fall during the primary Chinook salmon migration period. The Chinook run occurred approximately two week later in 2004 compared to 2003 (normal release schedule). The date that the 100th and 250th fish were counted at the dam occurred 16 and 14 days later in 2004 compared to 2003. However, the date that the 1,000th fish was counted at the dam was only 4 days later in 2004 compared to 2003 (Table 5-2). The run timing of Chinook can vary naturally, however, and it is not possible to determine how much of the delay is the result natural variation and how much was due to the reduction in streamflow between years.

The date that the first Chinook salmon was observed during video monitoring ranged from August 20 to September 4 during five years of video monitoring. Few fish were observed on a daily basis prior to late September in any year sampled (Table 5-2). Based on the five years of (mainly partial) data, the Chinook salmon run in the Russian River begins in earnest mid September, peaks October through mid November, and ends in late December (Figure 5-3). Interestingly, the daily maximum count of adult Chinook salmon has occurred within a twelve day period at the end of October through the first week of November (October 30, 2000, (138), November 1, 2001 (204), November 7, 2002 (2,213, partial count), October 31, 2003 (1,079), and October 26, 2004 (1,262)).

A direct comparison of population size cannot be made between years because the sampling periods are not equal. The fish ladders only operate when the dam is inflated. The date that the dam was deflated has ranged from November 13 to January 10. In addition, periods of high turbidity limit fish observations during all years sampled. Periods of high turbidity are associated with the higher flows that often coincide with periods of peak migration of Chinook salmon. Still, the counts in 2002, 2003, and 2004 are on the order of three to four times the number recorded in 2000, when essentially the entire adult Chinook salmon upstream migration period was surveyed.

The date that the weekly average water temperature decreased below 15.5˚C during the fall adult migration period ranged from October 13 to October 26 during the five year study (Table 2-6). This temperature threshold occurred after a significant number of adult Chinook salmon migrated passed the inflatable dam during 3 of the 5 years studied. In 2003, the warmest water year during the study, approximately 1,500 adult Chinook salmon were counted at the dam prior to the average daily temperature decreasing below 15.5°C.

Table 5-1. Average monthly flow (August through November) in 2000 (normal flow year), 2001 (dry year), and 2002 (dry spring), and 2003 (normal) and 2004 (dry spring).

Month	Average monthly flow (cfs) in 2000	Average monthly flow (cfs) in 2001	Average monthly flow (cfs) in 2002	Average monthly flow (cfs) in 2003	Average monthly flow (cfs) in 2004
	HB[1]	HB	HB	HB	HB
Aug	184	113	152	208	109
Sept	202	151	153	184	112
Oct	214	136	158	146	229[3]
Nov	286	1,350	296	319	354

[1]HB = Hacienda Bridge
[2]AW = Above Wohler P
[3]Oct 1—16, average flow – 119 cfs; from October 17 through 31, average flow = 347 cfs

Table 5-2. Weekly counts of Chinook salmon (includes "salmonids") observed migrating upstream through the Inflatable Dam fish passage facilities during video monitoring, 2000-2004 sampling seasons.

Date	2000[1]	2001[2]	2002[3]	2003[4]	2004[5]
1-Aug	0	0	0	--	0
8-Aug	0	0	0	--	0
15-Aug	0	0	1	--	0
22-Aug	1	0	8	--	0
29-Aug	0	3	7	2	1
5-Sep	9	1	18	7	1
12-Sep	38	7	19	20	3
19-Sep	23	12	65	23	8
26-Sep	50	17	1,223	181	16
3-Oct	31	240	113	146	42
10-Oct	115	51	628	515	51
17-Oct	81	10	272	232	585
24-Oct	466	300	153	532	2284
31-Oct	63	661	505	2969	183
7-Nov	24	81	2,337	1289	1164
14-Nov	182	--	20	47	217
21 Nov	200	--	37	95	57
28 Nov	111	--	14	45	59
5-Dec	19	--	54	--	15
12-Dec	14	--	--	--	--
19-Dec	17	--	--	--	--
26-Dec	1	--	--	--	--
2-Jan	0	--	--	--	--
9-Jan	0	--	--		--
Totals	**1,445**	**1,383**	**5,474**	**6,103**	**4,788**

[1]Dam deflated on January 10, 2001 (weekly totals include 188 "salmonids")
[2]Dam deflated on November 13, 2001 (weekly totals include 84 "salmonids")
[3]Dam was deflated on December 11, 2002 (weekly totals include 10 "salmonids")
[4]Dam was deflated on December 2, 2003 (weekly counts include 22 "salmonids)
[5]Dam was deflated on December 8, 2004 (weekly counts include 106 "salmonids)

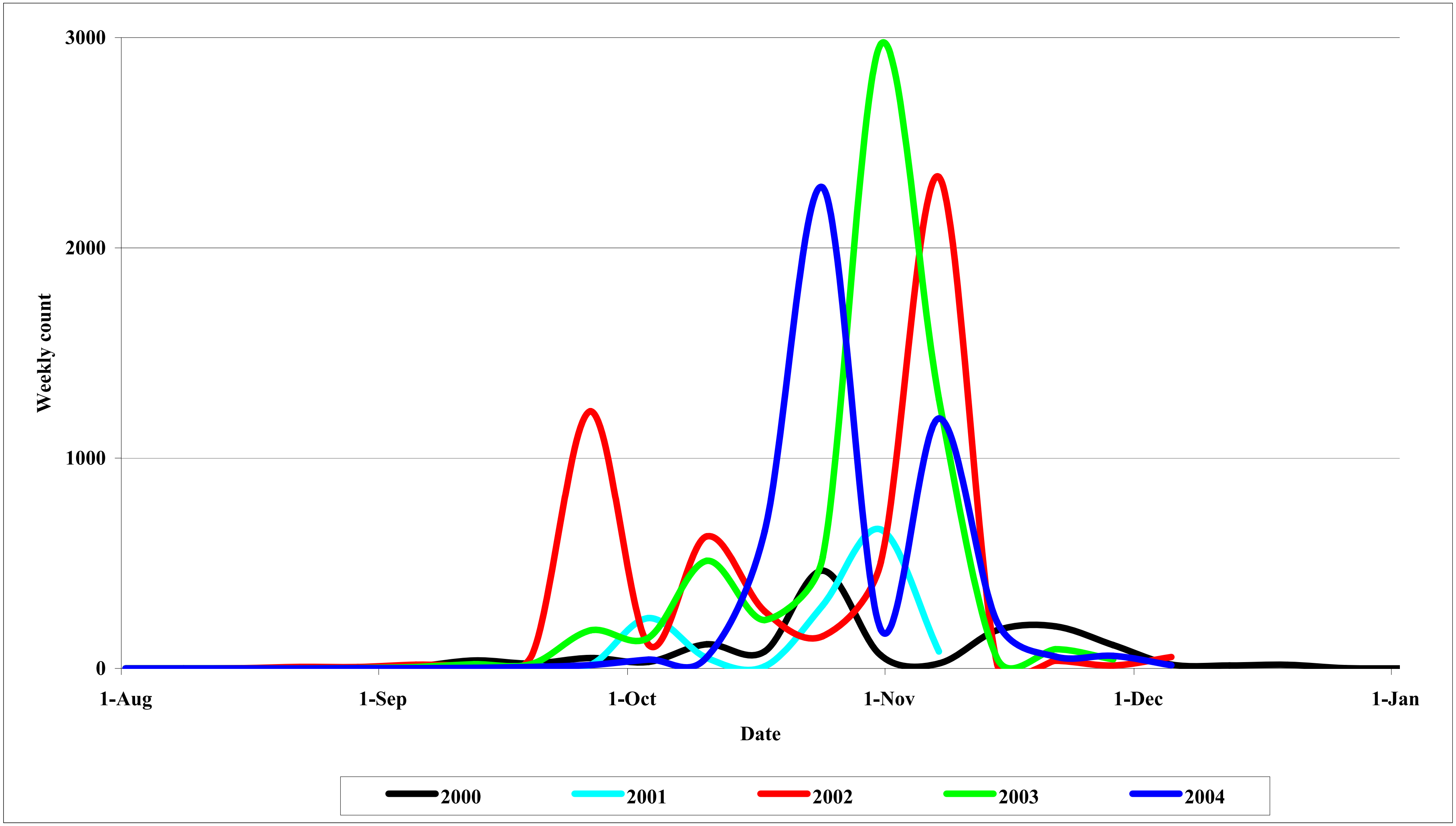

Figure 5-3. Run timing for adult Chinook salmon, Russian River at the Mirabel fish counting station, 2000 – 2004.

Streamflow released from Lake Mendocino was increased incrementally by a total of 50 cfs between October 7 through the 15th to provide improved migration and spawning conditions for Chinook salmon. In addition, the first significant rain event occurred between October 17 and 19, 2004. The combination of the increased releases and runoff coincided with the average daily water temperature falling below 15.5°C. The mean daily temperature at Station 6 was 18.1°C on October 7, the day that the first incremental increase (15 cfs) was made at Coyote Dam. On October 16, the day before the first rain event, the mean daily temperature at Station 6 was 15.9°C.

5.3.2.3 Chum and pink salmon

Pink salmon were identified in the video images in 2003, only. Male pink salmon have a distinctive humped back, which is a secondary sexual characteristic (thus the common name "humpy" is often applied to this species). Although the females have a body shape that is slightly different from Chinook salmon, female pink salmon could have been misclassified as Chinook during video review process. Pink salmon historically inhabited the Russian River; however, they have not been reported in the river since approximately 1955. It is not known if the pink salmon identified in the video monitoring are native to the Russian River or strays from other systems. Chum salmon were also observed in the video monitoring, and one was captured in an upstream migrant trap (see below). Chum salmon have been observed in 2000, 2002, 2003, and 2004 (3, 4, 3 and 2, respectively).

5.3.2.4 Size of adult salmonids

The upstream migrant trap was operated on nine nights in 2003, only. In all, 33 adult salmonids were captured, including 31 Chinook salmon, 1 chum salmon, and 1 hatchery steelhead. In addition, a small number of salmonids (likely Chinook based on video data) were able to pass through the wire mesh forming the cage. The Chinook salmon appeared to be comprised of two age classes. Scales samples taken from adult fish for aging were inconclusive. Chinook salmon are difficult to age from scales (Godfrey cited in Groot and Margolis 1998). The edges of the scales collected during this study were eroded, making confidently ageing fish difficult. Sacramento River Chinook salmon average approximately 55 cm FL at Age 2, and 70 cm FL at Age 3, and 90 cm at Age 4 (data cited in Moyle 2002). The smaller size group were likely composed of Age 2+ fish measuring between 44 and 68 cm, and weighing between 2.1 and 4.3 Kilograms (Kg), and the larger size group were composed of Age 3+ fish measuring between 75 and 92 cm, and weighing between 7.1 and 10.9 Kg (Figure 5-4). The two additional fish captured during upstream migrant trapping were a chum salmon measuring 63 cm and weighing 3.2 Kg, and a hatchery steelhead measuring 72 cm and weighing 4.6 Kg.

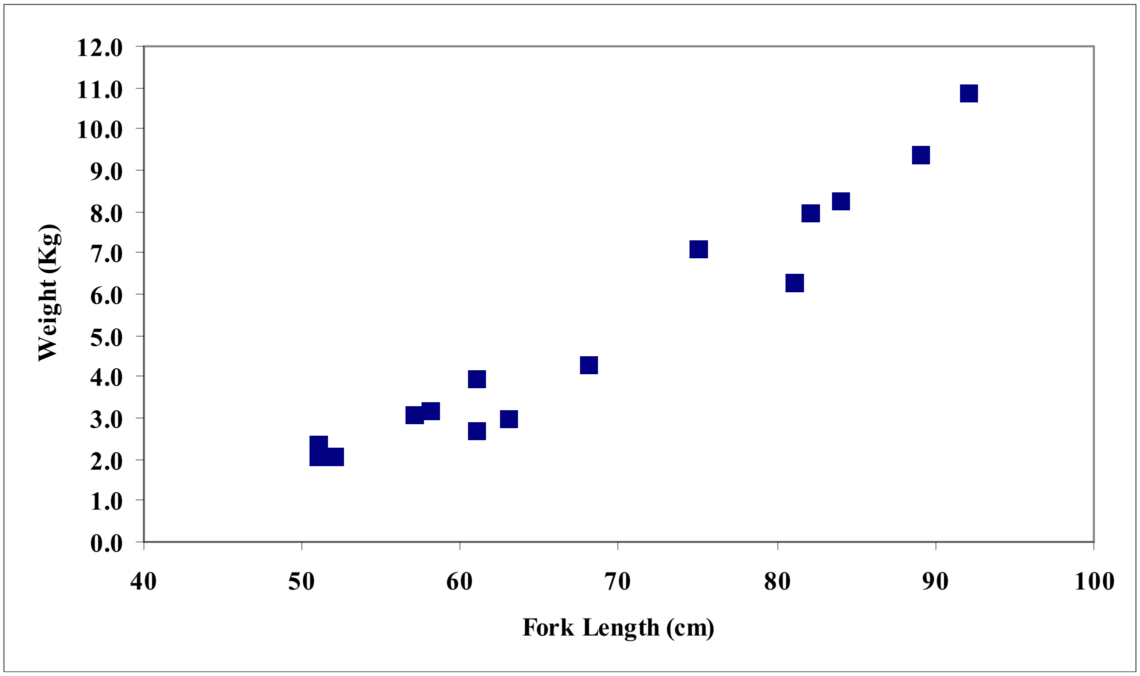

Figure 5-4. Length-weight regression for Chinook salmon captured in the upstream migrant trap at Mirabel, Russian River, Fall, 2003.

5.3.3 Steelhead

In 2004, 203 adult steelhead (88 wild and 115 hatchery) were counted during video monitoring (Table 5-3). Few adult steelhead were observed prior to the last week on November. Adult steelhead have been observed in large numbers only in 2000 (when the video monitoring continued into January. Adult steelhead apparently begin migrating through the Russian River in late November, with peak months likely being December through March (based on hatchery returns to Warm Springs Fish Hatchery).

5.3.3.1 Pacific lamprey

Twenty-three Pacific lamprey were observed passing through the fish ladders in 2004. In California, Pacific lamprey migrate upstream and spawn during the winter and spring (January through March (Trihey and Associates 1996, Chase 2001), March through late June (Moyle 2002), and the fall in the Trinity River, Moffett and Smith (1950, cited by Moyle 2002) and the Napa River (Wang 1986). Moyle (2002) concluded that there might be at least two distinct runs of Pacific lamprey in some rivers (similar to the multiple spawning runs of Chinook salmon observed in larger rivers). Pacific lamprey have been observed sporadically between October 1 and January 8 during the study (Table 5-4). In 2000, video monitoring was conducted from May 12 through January 10, 2001. 228 Pacific lamprey were observed in the fish ladders, primarily in May and June, with small numbers of Pacific lamprey observed migrating upstream through the fish ladders in late October and November (one was also observed in early January). Although

Table 5-3. Weekly counts of adult steelhead (includes wild, hatchery, steelhead of unknown origin and "salmonids") observed migrating upstream through the Inflatable Dam fish passage facilities during video monitoring, 2000-2004 sampling seasons.

Date	2000[1]	2001[2]	2002[3]	2003[4]	2004[5]
1-Aug	0	0	0	0	0
8-Aug	0	0	0	0	0
15-Aug	0	0	0	0	0
22-Aug	0	0	0	0	0
29-Aug	0	0	0	0	0
5-Sep	0	0	0	0	0
12-Sep	0	0	0	0	0
19-Sep	0	0	0	0	0
26-Sep	0	0	0	0	0
3-Oct	1	0	2	0	0
10-Oct	0	0	0	1	0
17-Oct	0	0	3	0	1
24-Oct	2	0	1	2	6
31-Oct	2	0	3	0	0
7-Nov	1	0	18	4	3
14-Nov	7	--	10	18	14
21 Nov	11	--	1	16	34
28 Nov	47	--	9	35	95
5-Dec	39	--	54	--	50
12-Dec	168	--	--	--	--
19-Dec	79	--	--	--	--
26-Dec	23	--	--	--	--
2-Jan	42	--	--	--	--
9-Jan	55	--	--	--	--
Totals	**477**	**0**	**101**	**76**	**203**

Table 5-4. Weekly counts of adult Pacific lamprey observed migrating through the fish ladders at Mirabel during video monitoring, Russian River, 1999-2004.

Date	2000	2001	2002	2003	2004
9-May	3		N/S	N/S	N/S
16-May	44	N/S	N/S	N/S	N/S
23-May	17	N/S	N/S	N/S	N/S
30-May	23	N/S	N/S	N/S	N/S
6-June	34	N/S	N/S	N/S	N/S
13-June	69	N/S	N/S	N/S	N/S
20-June	3	N/S	N/S	N/S	N/S
27-June	0	N/S	N/S	N/S	N/S
4-July	1	N/S	N/S	N/S	N/S
11-July	0	N/S	N/S	N/S	N/S
18-July	0	N/S	N/S	N/S	N/S
25-July	0	N/S	N/S	N/S	N/S
1-Aug	0	0	0	N/S	0
8-Aug	0	0	0	N/S	0
15-Aug	0	0	0	N/S	0
22-Aug	0	0	0	0	0
29-Aug	0	0	0	0	0
5-Sep	0	0	0	0	0
12-Sep	0	0	0	0	0
19-Sep	0	0	0	0	0
26-Sep	0	0	1	0	0
3-Oct	0	0	2	0	0
10-Oct	0	0	1	0	0
17-Oct	0	0	0	1	1
24-Oct	17	0	1	0	14
31-Oct	11	1	0	0	1
7-Nov	0	2	1	1	2
14-Nov	0	0	0	0	5
21 Nov	3	0	0	0	0
28 Nov	2	N/S	0	0	0
5-Dec	0	N/S	13	N/S	0
12-Dec	0	N/S	N/S	N/S	0
19-Dec	0	N/S	N/S	N/S	N/S
26-Dec	0	N/S	N/S	N/S	N/S
2-Jan	1	N/S	N/S	N/S	N/S
9-Jan	0	N/S	N/S	N/S	N/S
Totals	**228**	**3**	**19**	**2**	**23**

N/S[1] = Not Surveyed

the possibility exists for two distinct runs of lamprey in the Russian River based on the data collected (a fall run and a spring run), the data are inconclusive because of the lack of sampling during the late fall/winter period when the dam is deflated. The numbers of lamprey reported here are likely underestimates. Pacific lamprey can be difficult to observe on the videotapes, particularly during periods of low visibility (high turbidity).

5.4 SIGNIFICANT FINDINGS

Based on the results of video monitoring from 2000 through 2004, Chinook salmon and steelhead appear to be highly successful in finding and ascending the fish ladders around the Inflatable Dam. Relatively large numbers of adult fish of both species have been documented negotiating the ladders, and large numbers of fish milling at the base of the dam have not been observed. Direct observation (snorkel) surveys are limited by visibility, which tends to deteriorate in October and November when Chinook salmon and steelhead are most likely to be present in large numbers. However, if large numbers of salmonids had been present below the dam they would likely have been detected.

In 2004, approximately 4,788 adult Chinook salmon were counted ascending the fish ladders at the Mirabel Dam. During the five year study, the number of adult Chinook salmon counted at the Mirabel fish ladders has ranged from 1,383 to 6,081. These counts are likely underestimates based on the reasons described earlier in the report. This is in contrast to historical literature that suggests that Chinook salmon were never abundant in the Russian.

Based on the sampling effort to date, the Chinook salmon run pass the inflatable dam begins in September, peaks during October and November, and slowly diminishes through December. Chinook salmon tend to move in large pulses up the Russian River. In 2004, approximately 60 percent of the total run was counted during two pulses. The first occurred between October 25-28 when 2,006 (42 percent) of the adult Chinook salmon were counted, and again on November 11 and 12, when 855 (18 percent) of the fish were counted. In 2003, approximately 70 percent of the fish counted passed through the dam during a nine day stretch (October 31 through November 8). In 2002, 76.5 percent of the fish were counted over six days: October 1 and 2, (21.1 percent, primarily on the 2nd), October 15 and 16 (9.9 percent), and November 16 and 17 (45.6 percent). The daily total for November 17, 2002 (2,213 adult Chinook salmon) represents a partial count as visibility declined to the point where fish could not observed passing in front of the cameras.

Based on the paucity of historical records of Chinook salmon inhabiting the Russian River, the genetic origin of the Chinook salmon in the Russian River has been debated. There are at least three hypotheses to explain the presence of Chinook in the basin. First, they are remnants of a native run that was largely unnoticed during the past 100 years (possibly existing at very low population levels). Secondly, they may have resulted from the extensive stocking programs carried out over the last 100+ years. Finally, they may be strays from the Eel and/or the Sacramento rivers. Preliminary data from a genetics study conducted by the Bodega Marine Lab (BML 2002) concluded that the Russian River Chinook population is not closely related to Eel River or Central Valley (Sacramento-San Joaquin rivers) populations. Further, BML (2002) states that "Chinook in the Russian River do appear to belong to a diverse set of coastal Chinook populations." Based on the results of the BML, the leading hypothesis for the origin of the Russian River Chinook salmon is that they are a native run that has been largely unnoticed. The reason why these fish showed up in relatively large numbers during this time frame is unknown.

An important footnote to the abundance data presented above is that the length of time that the fish ladder was in operation varied each year. Thus, a direct comparison between the numbers of fish observed between years cannot be made. Still, it is interesting that the partial counts of Chinook salmon in 2002-2004 were 3.5 to 4.0 times the number counted in 2000, when virtually the entire run was surveyed.

Adult steelhead began their upstream migration in late October; however, the majority of their run occurs after the dam is deflated. Thus, little run information is available for this species. However, based on the data collected at the Warm Springs Fish Hatchery, at least the hatchery run peaks between December and March.

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APPENDIX A

COMMON WATER TEMPERATURES FOUND IN THE STUDY AREA IN CELSIUS AND FAHRENHEIT

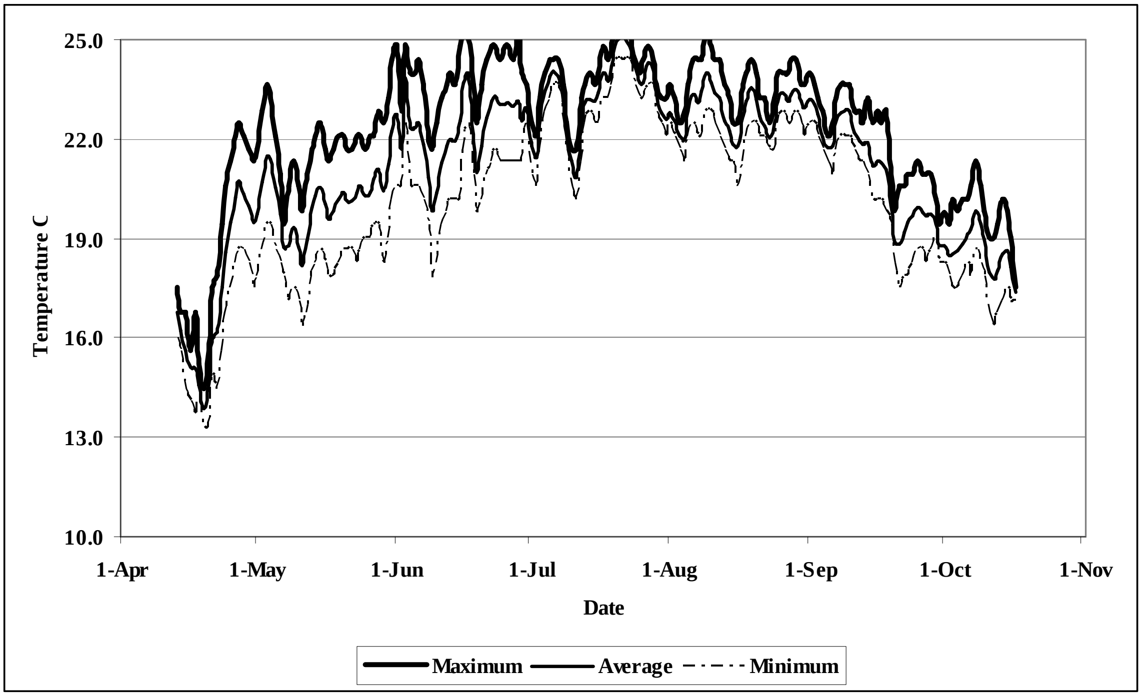
Appendix A. Common water temperatures found in the study area in ºCelsius and ºFahrenheit.

ºC[1]	ºF
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

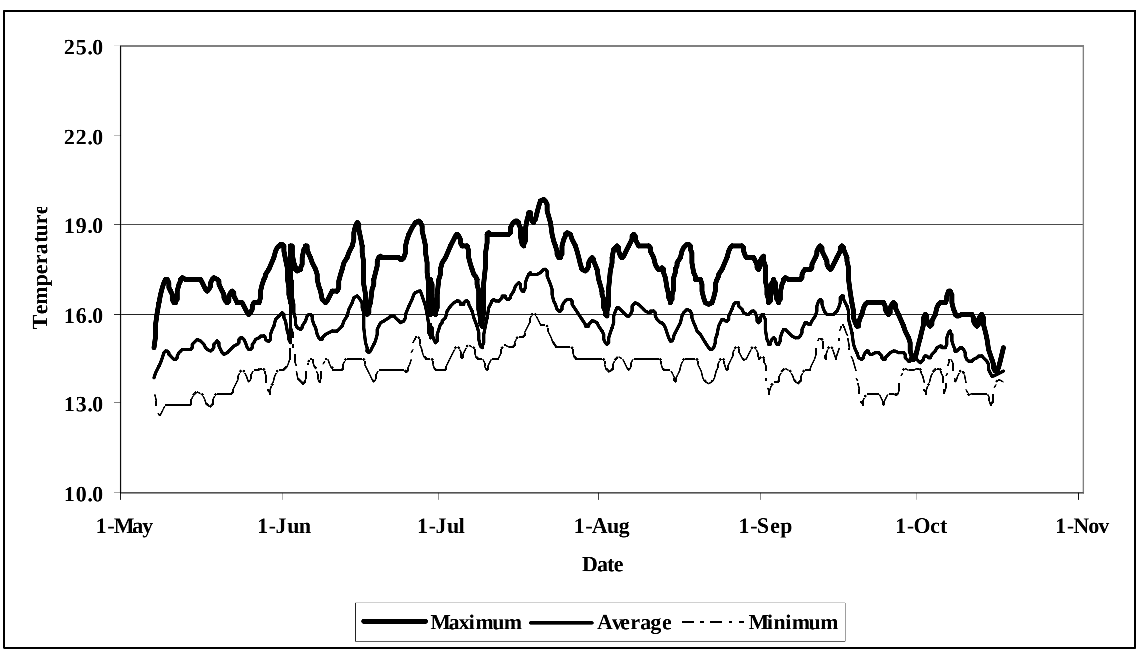
[1]The formula to convert ºC to ºF is:
(ºC X 1.8) + 32

APPENDIX B

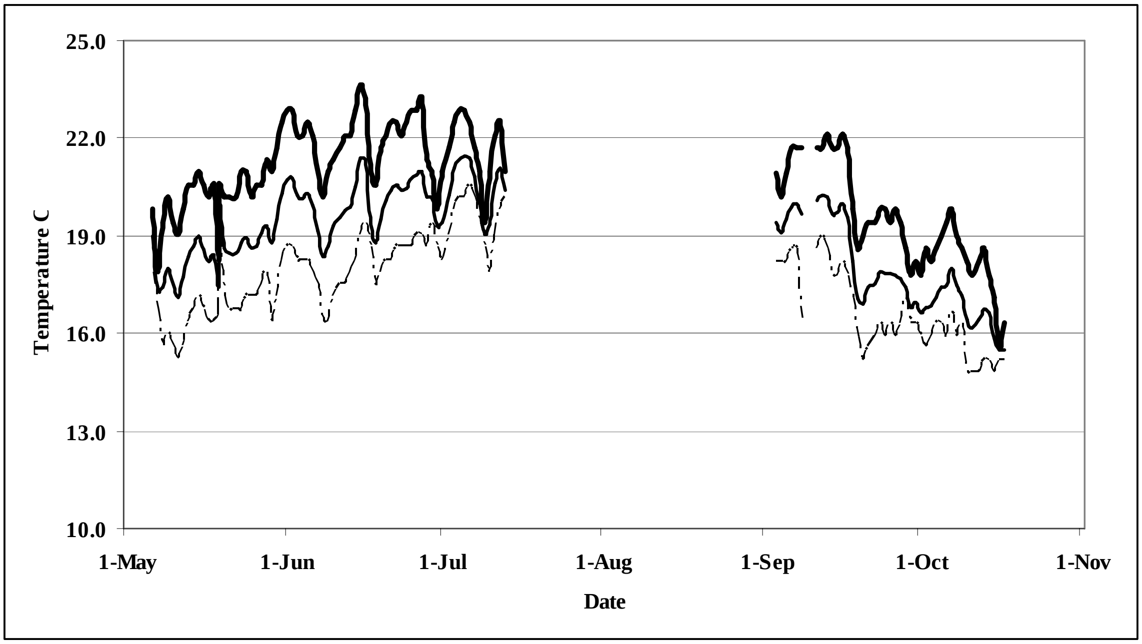
GRAPHS OF DAILY MAXIMUM, AVERAGE, AND MINIMUM WATER TEMPERATURES RECORDED NEAR THE RIVER'S SURFACE AND THE DEEPEST POINT AT EACH SAMPLING STATION WITHIN THE MIRABEL STUDYAREA, 2004 SAMPLING SEASON



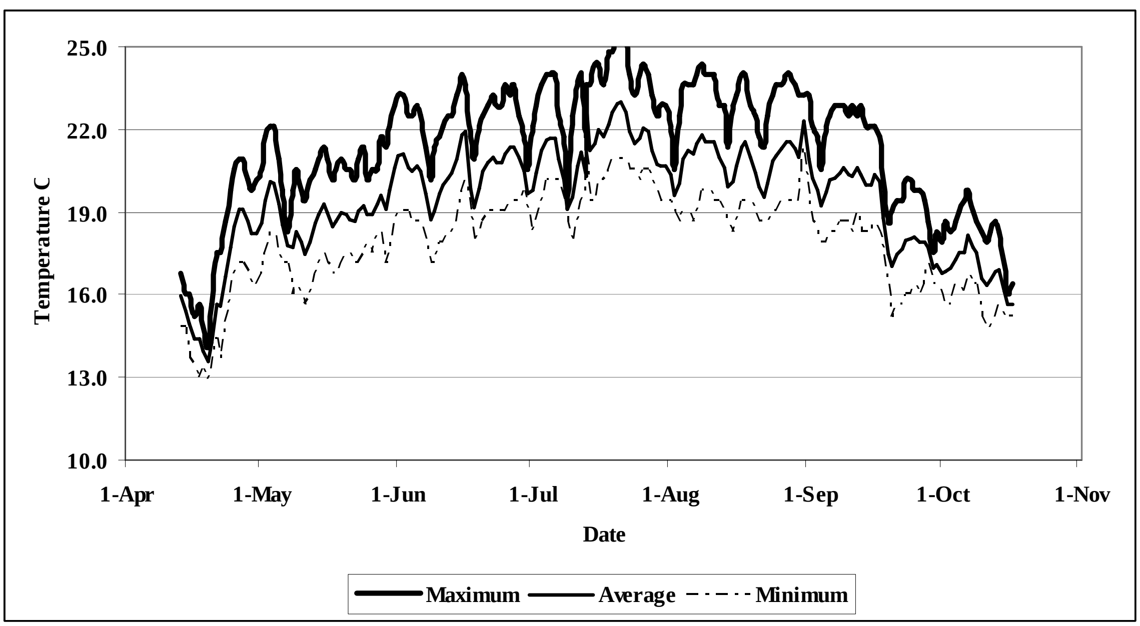
Appendix B. **Maximum, average, and minimum water temperatures at Station 0, April 13 through October 17, 2004.**



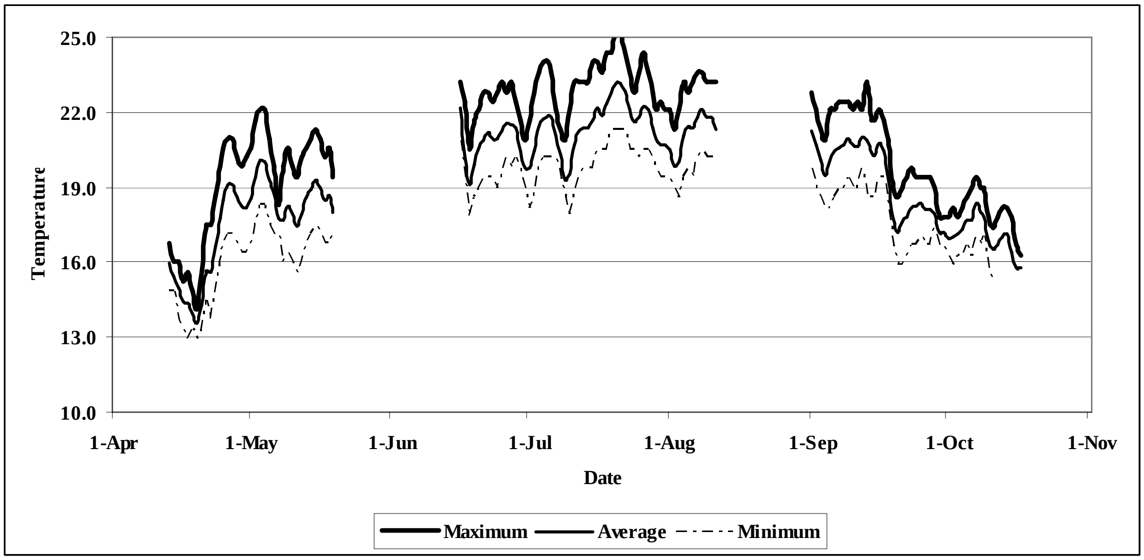
Appendix B. **Maximum, average, and minimum water temperatures in Lower Dry Creek, April 13 through October 17, 2004.**



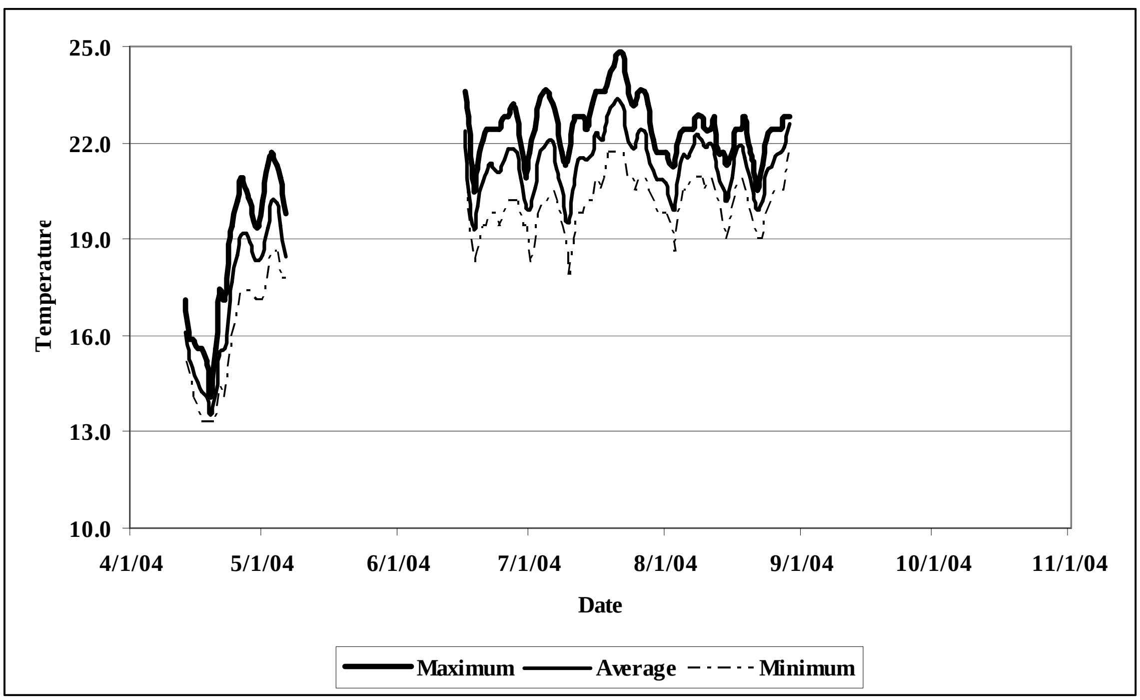
Appendix B. Maximum, average, and minimum water temperatures at Station 1, April 13 through October 17, 2004.



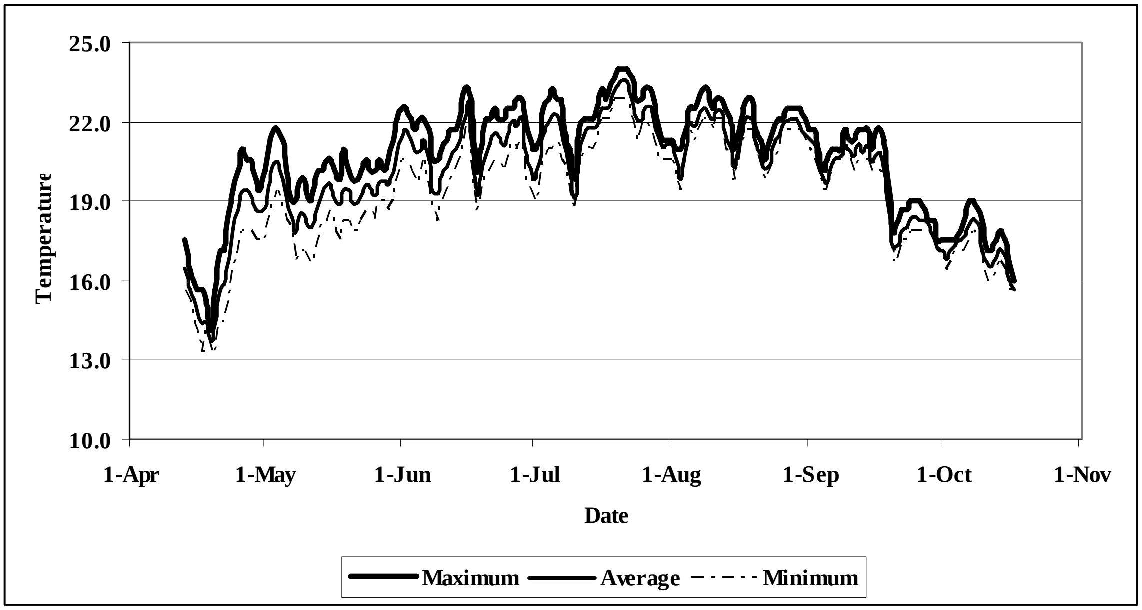
Appendix B. Maximum, average, and minimum water temperatures at Station 2, April 13 through October 17, 2004.



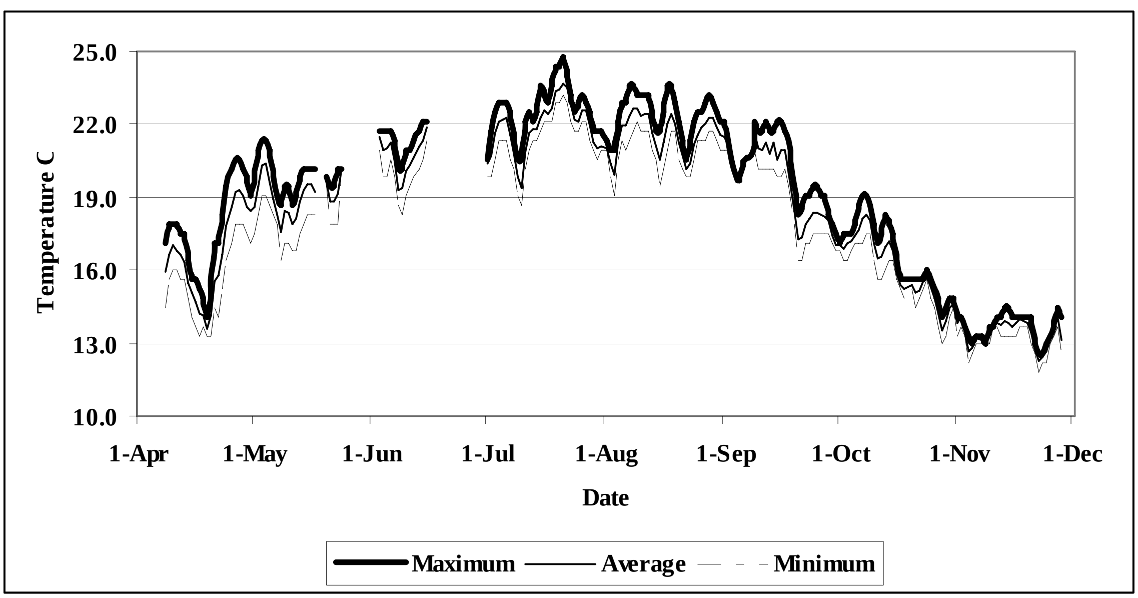
Appendix B. Maximum, average, and minimum water temperatures at Station 3, April 13 through October 17, 2004.



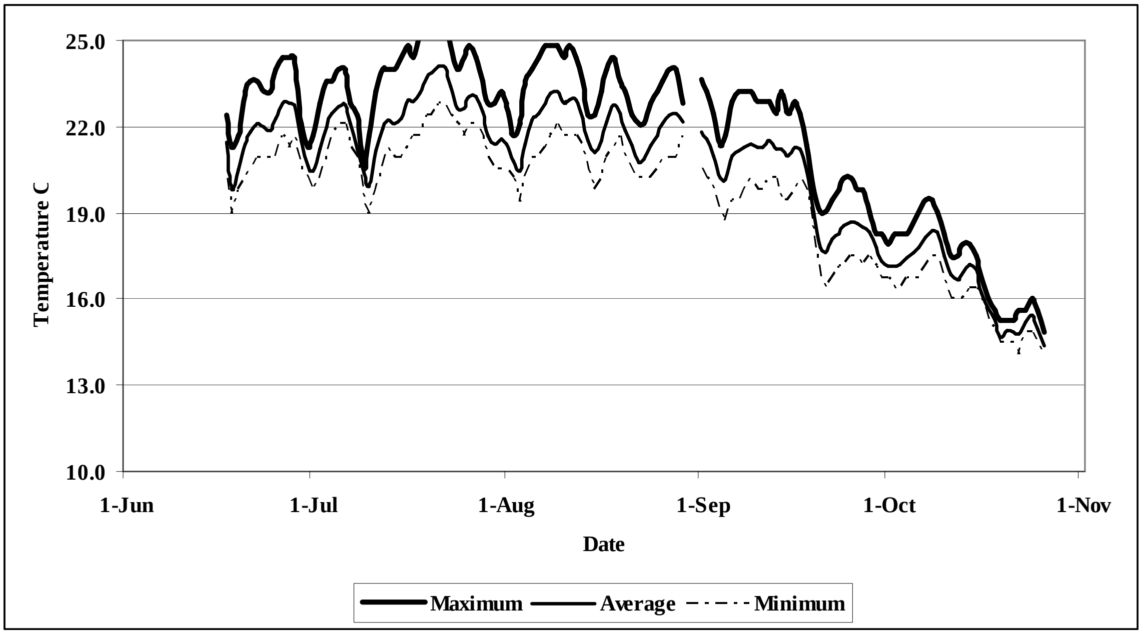
Appendix B. Maximum, average, and minimum water temperatures at Station 4, April 13 through October 17, 2004.



Appendix B. **Maximum, average, and minimum water temperatures at Station 5, April 13 through October 17, 2004.**



Appendix B. **Maximum, average, and minimum water temperatures at Station 6, April 13 through October 17, 2004.**



Appendix B. **Maximum, average, and minimum water temperatures at Station 7, April 13 through October 17, 2004.**

APPENDIX C

DAILY CATCH IN ROTARY SCREW TRAPS, MIRABEL STUDY AREA, RUSSIAN RIVER, APRIL 1 THROUGH JULY 1, 2004

Appendix C. Daily catch in rotary screw traps, Mirabel Study Area, Russian River, 2004.

Date	Chinook	Hatchery steelhead	Wild steelhead	Wild parr	YOY steelhead	Coho	Adult lamprey	Eyed lamprey
1-Apr	19	1	1	0	2	0	0	0
2-Apr	17	1	0	0	4	0	0	0
3-Apr	11	2	1	0	0	0	0	0
4-Apr	4	0	1	0	2	0	1	0
5-Apr	10	1	0	0	0	0	0	0
6-Apr	12	0	0	0	4	0	1	0
7-Apr	9	0	0	0	4	0	0	0
8-Apr	**Dam inflated, traps pulled for the day**							
9-Apr	5	0	1	0	48	0	1	0
10-Apr	17	0	3	0	34	0	1	0
11-Apr	20	1	4	0	12	0	4	0
12-Apr	20	0	0	0	14	0	1	0
13-Apr	11	0	1	0	7	0	2	0
14-Apr	6	5	0	0	2	0	3	0
15-Apr	36	48	5	0	2	0	1	0
16-Apr	24	32	1	0	5	0	2	0
17-Apr	11	25	2	0	4	0	0	0
18-Apr	43	35	1	0	5	0	0	0
19-Apr	60	36	1	0	7	0	1	0
20-Apr	99	64	5	0	6	0	1	0
21-Apr	140	41	0	1	13	0	0	0
22-Apr	295	36	1	0	14	0	0	0
23-Apr	241	32	3	1	36	0	0	0
24-Apr	188	27	3	0	20	1	0	0
25-Apr	314	19	2	1	16	0	0	0
26-Apr	344	5	2	0	11	2	1	0
27-Apr	265	6	2	0	10	0	1	0
28-Apr	351	4	1	0	8	0	0	0
29-Apr	208	2	1	0	7	0	0	0
30-Apr	230	2	1	0	7	0	0	0
1-May	263	0	0	0	13	0	0	1
2-May	260	0	1	0	4	0	0	0
3-May	386	0	3	0	8	0	0	0
4-May	398	2	5	0	6	0	0	0
5-May	181	0	0	0	1	0	0	0
6-May	127	0	0	0	3	0	0	0
7-May	97	0	0	0	9	0	0	0
8-May	129	1	0	0	18	0	0	0
9-May	263	0	1	0	32	0	0	0
10-May	290	0	0	0	28	0	0	0
11-May	265	0	2	0	40	0	0	0

Appendix C. Daily catch in rotary screw traps, Mirabel Study Area, Russian River, 2004 (continued).

Date	Chinook	Hatchery steelhead	Wild steelhead	Wild parr	YOY steelhead	Coho	Adult lamprey	Eyed lamprey
12-May	205	0	0	0	30	0	0	0
13-May	382	3	0	0	35	0	0	0
14-May	235	1	0	0	63	0	0	0
15-May	100	0	1	0	58	0	0	0
16-May	77	0	0	0	73	0	0	0
17-May	45	0	0	0	28	0	0	0
18-May	32	1	0	0	22	0	0	0
19-May	36	0	0	0	22	0	0	0
20-May	27	0	0	0	56	0	0	0
21-May	21	0	0	0	58	0	0	0
22-May	48	0	0	0	96	0	0	0
23-May	16	0	0	0	63	0	0	0
24-May	26	0	0	0	33	1	0	0
25-May	13	0	0	0	34	0	0	0
26-May	23	0	0	0	20	0	0	0
27-May	11	0	1	0	16	0	0	0
28-May	9	0	0	0	5	0	0	0
29-May	22	0	1	0	7	0	0	0
30-May	18	0	0	0	17	0	0	0
31-May	25	0	0	0	16	0	0	0
1-Jun	19	0	0	0	5	0	0	0
2-Jun	31	0	0	1	13	0	0	0
3-Jun	26	0	0	0	0	0	0	0
4-Jun	5	0	0	0	4	0	0	0
5-Jun	1	0	0	0	0	0	0	0
6-Jun	27	0	0	0	4	0	0	0
7-Jun	30	0	0	0	18	0	0	0
8-Jun	21	0	0	0	9	0	0	0
9-Jun	26	0	0	0	18	0	0	0
10-Jun	15	0	2	0	9	0	0	0
11-Jun	11	1	0	0	13	0	0	0
12-Jun	3	0	0	0	9	0	0	0
13-Jun	6	0	0	0	4	0	0	0
14-Jun	5	0	1	0	4	0	0	0
15-Jun	1	0	0	0	2	0	0	0
16-Jun	2	0	0	0	5	0	0	0
17-Jun	3	0	0	0	10	0	0	0
18-Jun	19	0	0	3	2	0	0	0
19-Jun	15	0	1	0	7	0	0	0
20-Jun	13	0	0	0	7	0	0	0
21-Jun	12	0	0	0	10	0	0	0

Appendix C. Daily catch in rotary screw traps, Mirabel Study Area, Russian River, 2004 (continued).

Date	Chinook	Hatchery steelhead	Wild steelhead	Wild parr	YOY steelhead	Coho	Adult lamprey	Eyed lamprey
22-Jun	9	0	0	3	7	0	0	0
23-Jun	15	0	1	2	10	0	0	0
24-Jun	5	0	0	0	8	0	0	0
25-Jun	0	0	0	1	5	0	0	0
26-Jun	2	0	0	1	0	0	0	0
27-Jun	7	0	0	0	6	0	0	0
28-Jun	14	0	0	0	2	0	0	0
29-Jun	1	0	0	1	0	0	0	0
30-Jun	0	0	0	2	0	0	0	0
1-Jul	2	0	0	2	2	0	0	0
TOTALS	**7,386**	**434**	**63**	**19**	**1,411**	**4**	**21**	**1**

Appendix C. Daily catch in rotary screw traps, Mirabel Study Area, Russian River, 2004 (continued).

Date	Ammocoetes	Western brook lamprey	White catfish	Channel catfish	Bullhead	Largemouth bass	Smallmouth bass	Green sunfish
1-Apr	10	0	0	0	0	0	0	1
2-Apr	20	0	1	0	0	0	0	0
3-Apr	16	0	0	0	0	0	0	1
4-Apr	5	0	0	0	0	0	0	0
5-Apr	7	0	0	0	0	0	0	0
6-Apr	11	0	2	0	0	0	0	0
7-Apr	11	0	0	0	0	0	0	0
8-Apr								
9-Apr	6	0	0	0	0	0	0	0
10-Apr	0	0	0	0	0	0	0	0
11-Apr	5	0	2	0	0	0	0	0
12-Apr	4	0	0	0	0	0	0	3
13-Apr	1	0	0	0	0	0	0	0
14-Apr	3	0	0	0	0	0	0	3
15-Apr	2	0	0	0	0	0	0	0
16-Apr	1	0	0	0	0	0	0	0
17-Apr	0	0	0	0	0	0	0	0
18-Apr	0	0	0	0	0	0	0	0
19-Apr	0	0	0	0	0	0	0	0
20-Apr	2	0	1	0	0	0	0	0
21-Apr	1	0	0	0	0	0	0	0
22-Apr	8	0	0	0	0	0	0	0
23-Apr	5	0	0	0	0	0	0	1
24-Apr	2	0	0	0	0	0	0	0
25-Apr	0	0	0	0	0	0	1	2
26-Apr	0	0	1	0	0	0	0	1
27-Apr	4	0	1	0	1	0	0	1
28-Apr	7	0	0	0	2	0	0	2
29-Apr	2	0	0	0	2	0	0	0
30-Apr	1	0	0	0	1	0	0	1
1-May	2	0	0	0	0	0	0	1
2-May	0	0	0	0	0	0	0	0
3-May	0	0	0	0	0	0	0	0
4-May	1	0	0	0	0	0	0	3
5-May	0	0	1	0	0	0	0	0
6-May	1	0	1	0	0	0	0	0
7-May	4	0	0	0	0	0	0	0
8-May	1	0	0	0	1	0	0	1
9-May	5	0	0	0	0	0	0	0
10-May	1	0	0	0	0	0	0	0
11-May	3	0	1	0	0	1	0	0

Appendix C. Daily catch in rotary screw traps, Mirabel Study Area, Russian River, 2004 (continued).

Date	Ammocoetes	Western brook lamprey	White catfish	Channel catfish	Bullhead	Largemouth bass	Smallmouth bass	Green sunfish
12-May	0	0	0	1	0	2	0	0
13-May	2	0	0	0	0	0	0	0
14-May	0	0	0	0	0	0	1	0
15-May	1	0	0	0	1	0	0	0
16-May	1	0	0	0	0	0	4	0
17-May	0	0	0	0	0	0	0	0
18-May	0	0	0	0	1	0	0	0
19-May	0	0	0	2	0	2	0	0
20-May	0	0	2	0	0	3	0	1
21-May	2	0	0	0	0	25	4	1
22-May	1	0	0	0	0	0	44	0
23-May	0	0	0	0	0	0	20	0
24-May	1	0	0	0	0	0	24	0
25-May	0	0	0	0	0	0	40	0
26-May	0	0	0	0	0	0	11	0
27-May	0	0	0	0	0	0	27	1
28-May	0	0	0	0	0	0	12	0
29-May	2	0	0	0	0	0	18	0
30-May	0	0	0	1	0	0	33	0
31-May	0	0	0	0	0	0	21	0
1-Jun	0	0	0	0	0	1	29	0
2-Jun	0	0	0	0	1	0	79	1
3-Jun	0	0	0	0	0	0	37	2
4-Jun	1	0	0	0	0	0	16	0
5-Jun	0	0	0	0	0	1	8	0
6-Jun	0	0	1	0	0	0	36	0
7-Jun	2	0	0	0	0	0	25	0
8-Jun	2	0	0	0	0	0	15	1
9-Jun	3	0	0	0	0	0	18	0
10-Jun	0	0	0	0	0	0	8	0
11-Jun	0	0	1	0	0	0	12	0
12-Jun	1	0	0	0	0	0	19	0
13-Jun	1	0	0	0	0	0	21	0
14-Jun	1	0	0	0	0	0	9	1
15-Jun	1	0	0	0	0	0	2	0
16-Jun	2	0	0	0	0	0	17	1
17-Jun	0	0	0	0	0	0	14	0
18-Jun	1	0	0	0	0	0	21	2
19-Jun	3	0	0	1	0	0	22	0
20-Jun	0	0	0	0	0	0	15	0
21-Jun	1	0	0	0	0	0	20	0

Appendix C. Daily catch in rotary screw traps, Mirabel Study Area, Russian River, 2004 (continued).

Date	Ammocoetes	Western brook lamprey	White catfish	Channel catfish	Bullhead	Largemouth bass	Smallmouth bass	Green sunfish
22-Jun	1	0	0	0	0	0	18	0
23-Jun	1	0	0	0	0	0	14	1
24-Jun	1	0	0	1	0	0	6	0
25-Jun	1	0	0	0	0	0	16	0
26-Jun	3	0	1	0	0	0	5	0
27-Jun	1	0	0	0	0	0	14	1
28-Jun	1	0	0	0	0	0	12	0
29-Jun	0	0	0	0	0	0	9	1
30-Jun	0	0	0	0	0	0	10	0
1-Jul	0	0	0	0	0	0	4	1
TOTALS	**190**	**0**	**16**	**6**	**10**	**35**	**811**	**36**

Appendix C. Daily catch in rotary screw traps, Mirabel Study Area, Russian River, 2004 (continued).

Date	Bluegill	Crappie	Pikeminnow	Hardhead	Sculpin	Tule perch	Stickleback	Sacramento sucker
1-Apr	0	0	11	12	1	0	0	1
2-Apr	1	0	8	3	0	0	0	0
3-Apr	2	0	10	7	1	0	0	3
4-Apr	0	0	4	8	0	0	0	0
5-Apr	0	0	3	42	0	0	1	1
6-Apr	0	0	1	42	1	0	0	0
7-Apr	1	0	0	24	1	0	1	0
8-Apr	Dam inflated, traps pulled for the day							
9-Apr	0	0	0	7	3	0	1	3
10-Apr	0	2	0	0	2	0	2	5
11-Apr	1	0	0	13	3	0	2	2
12-Apr	1	0	0	10	0	2	3	2
13-Apr	0	0	1	1	2	1	0	0
14-Apr	1	0	0	3	0	1	0	0
15-Apr	0	0	0	0	4	0	1	0
16-Apr	0	0	0	0	3	0	1	0
17-Apr	0	0	0	1	5	0	0	1
18-Apr	0	0	0	1	2	1	0	1
19-Apr	0	0	0	0	3	0	1	0
20-Apr	1	0	0	0	5	0	0	1
21-Apr	0	2	1	4	5	0	1	3
22-Apr	1	0	1	23	14	0	19	5
23-Apr	3	0	1	21	36	2	116	3
24-Apr	2	1	1	10	25	1	170	3
25-Apr	1	2	0	13	17	0	137	2
26-Apr	2	5	1	5	9	0	68	0
27-Apr	7	3	1	11	10	1	29	1
28-Apr	3	0	0	3	25	1	60	2
29-Apr	3	3	0	0	27	0	8	0
30-Apr	1	2	0	2	30	0	22	0
1-May	4	0	1	1	32	0	14	0
2-May	3	2	0	1	12	0	1	1
3-May	4	7	0	0	14	0	2	2
4-May	3	4	0	1	16	0	4	0
5-May	2	1	0	1	19	0	4	0
6-May	1	3	0	0	11	0	1	3
7-May	0	1	0	1	12	0	2	0
8-May	0	0	0	0	4	0	0	0
9-May	1	0	0	1	4	1	1	0
10-May	1	2	1	2	4	0	0	1
11-May	0	2	0	0	10	1	0	2

Appendix C. Daily catch in rotary screw traps, Mirabel Study Area, Russian River, 2004 (continued).

Date	Bluegill	Crappie	Pikeminnow	Hardhead	Sculpin	Tule perch	Stickleback	Sacramento sucker
12-May	0	0	1	1	5	0	0	0
13-May	1	2	0	9	2	0	0	2
14-May	0	2	0	10	2	1	0	0
15-May	2	0	0	0	8	0	6	0
16-May	0	0	0	2	3	1	1	0
17-May	0	0	0	10	11	1	1	1
18-May	0	1	1	2	7	0	0	1
19-May	1	0	1	7	1	0	0	0
20-May	1	1	0	0	1	0	2	0
21-May	2	2	0	1	3	1	1	0
22-May	4	0	0	0	7	1	2	2
23-May	2	0	2	6	4	0	1	1
24-May	2	2	3	5	5	1	2	0
25-May	5	4	0	7	3	1	1	0
26-May	1	1	0	1	2	1	1	0
27-May	1	0	0	2	1	0	0	0
28-May	2	4	0	3	0	0	0	0
29-May	2	3	0	0	5	0	0	0
30-May	0	2	1	1	0	0	0	1
31-May	2	0	1	0	0	0	0	0
1-Jun	3	0	0	0	0	0	2	0
2-Jun	0	1	0	0	2	0	5	0
3-Jun	0	0	0	0	0	0	2	0
4-Jun	0	1	2	0	2	0	0	0
5-Jun	0	0	0	0	4	0	0	0
6-Jun	1	1	0	7	1	0	0	1
7-Jun	1	0	0	0	7	1	2	0
8-Jun	0	0	0	0	3	1	1	0
9-Jun	0	2	0	0	4	0	0	0
10-Jun	2	0	0	0	2	0	0	0
11-Jun	2	0	0	0	0	0	0	0
12-Jun	2	0	0	0	1	0	1	0
13-Jun	2	1	0	0	1	0	0	0
14-Jun	1	0	0	0	1	0	0	0
15-Jun	0	0	0	0	1	0	0	0
16-Jun	0	1	0	0	4	0	0	1
17-Jun	0	0	0	0	3	0	1	0
18-Jun	1	0	0	2	7	0	0	0
19-Jun	2	1	0	0	2	1	0	2
20-Jun	1	0	0	0	4	0	0	0
21-Jun	3	0	1	3	6	1	0	0

Appendix C. Daily catch in rotary screw traps, Mirabel Study Area, Russian River, 2004 (continued).

Date	Bluegill	Crappie	Pikeminnow	Hardhead	Sculpin	Tule perch	Stickleback	Sacramento sucker
22-Jun	0	0	1	1	1	0	0	0
23-Jun	3	3	0	1	2	1	0	0
24-Jun	0	0	1	1	2	0	0	0
25-Jun	1	0	0	0	6	2	0	0
26-Jun	2	0	1	0	1	0	0	0
27-Jun	2	0	0	0	2	1	0	0
28-Jun	1	0	1	0	3	1	0	0
29-Jun	0	0	0	0	1	1	0	0
30-Jun	1	0	4	0	0	0	0	0
1-Jul	0	0	0	0	0	1	0	0
TOTALS	**109**	**77**	**67**	**356**	**515**	**31**	**704**	**60**

Appendix C. Daily catch in rotary screw traps, Mirabel Study Area, Russian River, 2004 (continued).

Date	Golden shiner	Hitch	Carp	Sacramento blackfish	California roach	Fathead minnow	Mosquito fish	American Shad
1-Apr	0	0	0	0	0	0	0	0
2-Apr	0	0	0	0	0	1	0	0
3-Apr	0	0	0	0	0	2	0	0
4-Apr	0	0	0	0	0	0	0	0
5-Apr	0	0	0	0	0	1	0	0
6-Apr	0	0	0	0	0	0	0	0
7-Apr	0	0	0	0	0	0	0	0
8-Apr								
9-Apr	0	0	0	0	0	0	0	0
10-Apr	0	0	0	4	9	0	0	0
11-Apr	0	0	0	0	1	1	0	1
12-Apr	0	0	0	0	0	0	0	0
13-Apr	0	0	0	0	0	1	0	1
14-Apr	0	0	0	0	0	0	0	0
15-Apr	0	0	0	0	0	0	0	0
16-Apr	0	0	0	0	0	0	0	0
17-Apr	0	0	0	0	0	0	0	0
18-Apr	0	0	0	1	0	0	0	0
19-Apr	0	0	0	0	1	0	0	0
20-Apr	0	0	0	0	0	0	0	0
21-Apr	0	0	0	1	2	0	0	0
22-Apr	0	0	0	4	2	0	0	0
23-Apr	1	0	0	0	0	0	0	0
24-Apr	1	0	0	12	2	0	0	0
25-Apr	0	0	0	4	2	0	0	0
26-Apr	0	0	0	1	0	0	0	0
27-Apr	2	0	0	2	0	1	0	0
28-Apr	1	0	0	0	2	0	0	0
29-Apr	0	0	0	0	0	0	0	0
30-Apr	0	0	0	1	0	0	0	0
1-May	0	0	0	0	0	0	0	0
2-May	0	0	0	1	0	0	0	0
3-May	0	0	0	2	0	0	0	0
4-May	0	0	0	7	0	0	0	0
5-May	0	0	0	2	0	0	0	0
6-May	0	0	0	1	0	0	0	0
7-May	0	0	0	0	0	0	0	0
8-May	0	0	0	1	0	0	0	0
9-May	0	0	0	0	0	0	0	0
10-May	0	0	0	1	0	0	0	2
11-May	0	0	0	3	0	0	0	1
12-May	0	0	0	0	0	0	0	1

Appendix C. Daily catch in rotary screw traps, Mirabel Study Area, Russian River, 2004 (continued).

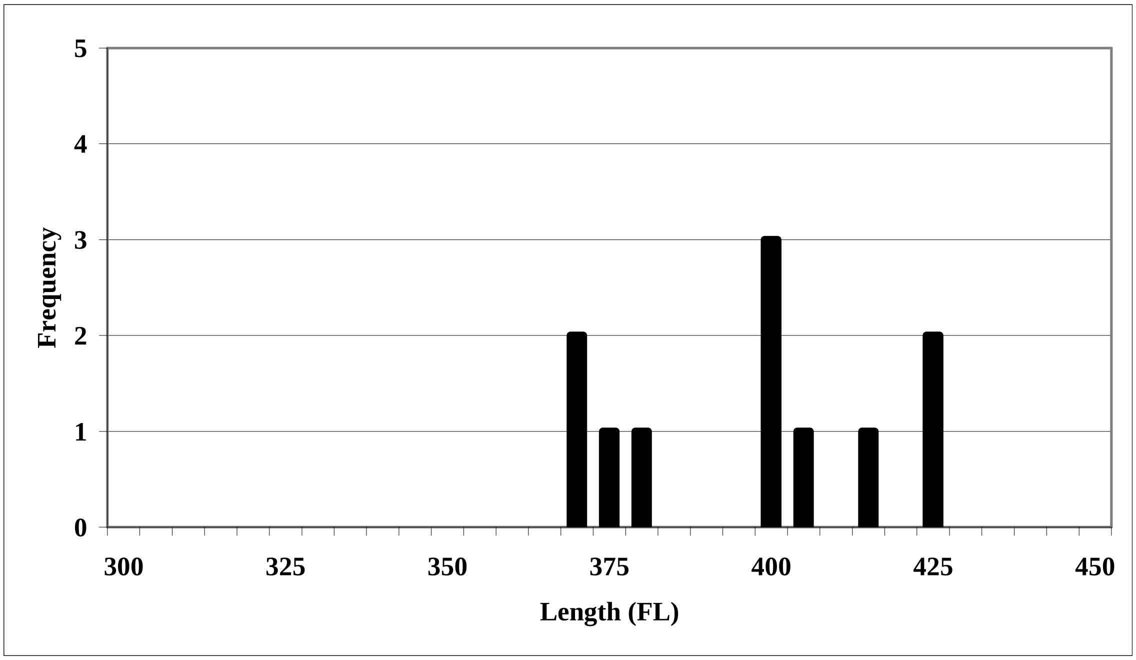
Date	Golden shiner	Hitch	Carp	Sacramento blackfish	California roach	Fathead minnow	Mosquito fish	American Shad
13-May	0	0	0	0	0	0	0	3
14-May	0	0	0	1	0	0	0	2
15-May	0	0	0	1	1	0	0	0
16-May	0	0	0	0	2	0	0	3
17-May	0	0	0	1	1	0	0	0
18-May	0	0	0	0	0	0	0	0
19-May	0	0	0	0	0	0	0	2
20-May	0	0	0	1	1	0	0	1
21-May	0	1	1	0	0	0	0	0
22-May	0	2	2	0	0	0	0	0
23-May	0	0	0	0	0	0	0	0
24-May	0	0	0	0	0	0	0	0
25-May	1	0	0	0	1	0	0	0
26-May	1	1	1	0	0	0	0	1
27-May	0	0	2	1	0	0	0	0
28-May	0	0	0	0	0	0	0	0
29-May	0	0	0	0	0	0	0	0
30-May	1	0	0	0	0	0	0	1
31-May	0	0	0	0	0	0	0	0
1-Jun	0	0	1	0	0	0	0	1
2-Jun	0	0	0	1	0	0	0	0
3-Jun	0	0	0	0	0	0	0	0
4-Jun	0	0	0	0	0	0	0	0
5-Jun	0	0	0	0	0	0	0	0
6-Jun	0	0	0	1	0	0	0	0
7-Jun	0	0	0	0	1	0	0	0
8-Jun	0	0	0	0	1	0	0	0
9-Jun	0	0	1	0	1	0	0	0
10-Jun	0	0	1	0	0	0	0	0
11-Jun	0	0	1	0	0	0	0	0
12-Jun	0	0	0	0	0	0	0	0
13-Jun	0	0	1	0	0	0	0	2
14-Jun	0	0	0	1	0	0	0	0
15-Jun	0	0	0	0	0	0	0	0
16-Jun	1	0	0	0	0	0	0	0
17-Jun	0	0	0	0	0	0	0	0
18-Jun	0	0	1	0	0	0	0	0
19-Jun	0	0	2	0	0	0	0	0
20-Jun	0	0	1	0	0	0	0	0
21-Jun	0	0	0	0	0	0	0	0
22-Jun	0	0	0	0	0	0	0	0
23-Jun	0	0	0	0	0	1	0	0

Appendix C. Daily catch in rotary screw traps, Mirabel Study Area, Russian River, 2004 (concluded).

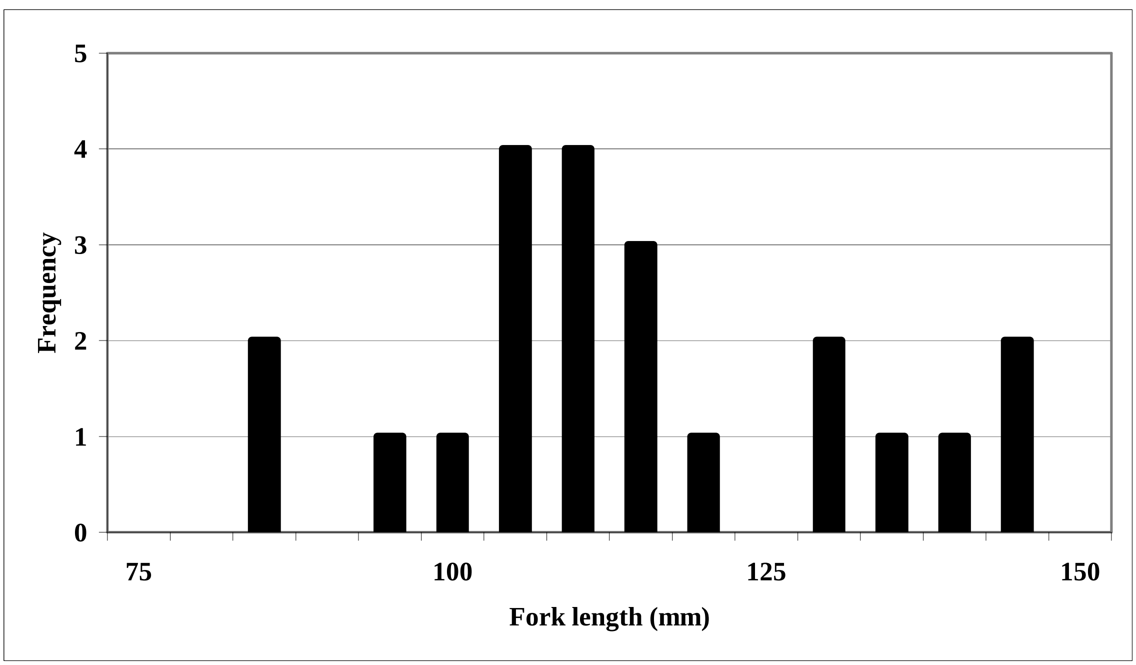
Date	Golden shiner	Hitch	Carp	Sacramento blackfish	California roach	Fathead minnow	Mosquito fish	American Shad
24-Jun	0	0	1	0	0	0	0	0
25-Jun	0	0	1	0	0	0	0	0
26-Jun	0	0	0	0	2	0	0	0
27-Jun	0	0	1	0	0	0	0	0
28-Jun	0	0	1	0	3	0	0	3
29-Jun	0	0	0	0	0	0	0	0
30-Jun	0	0	0	0	0	0	0	1
1-Jul	0	0	0	0	1	0	0	0
TOTALS	**9**	**4**	**19**	**56**	**36**	**8**	**0**	**26**

APPENDIX D

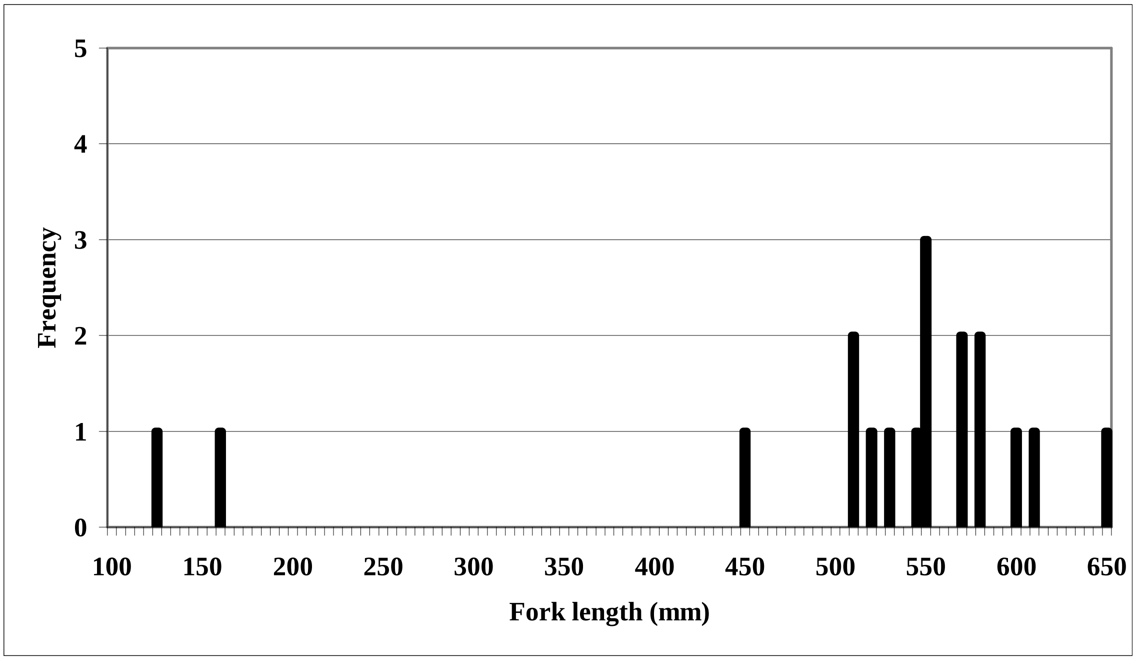
LENGTH-FREQUENCY HISTOGRAMS FOR EACH SPECIES BY REACH COLLECTED DURING BOAT ELECTROFISHING SAMPLING, AUGUST 2004, MIRABEL STUDY AREA



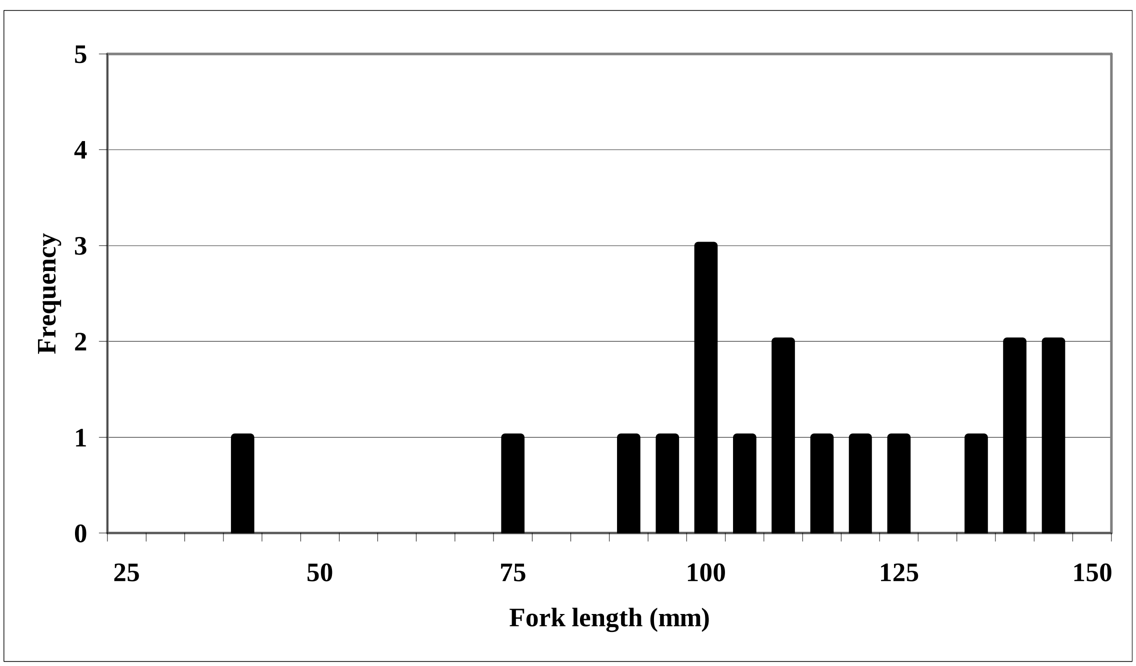
Appendix D. Blackfish length-frequency histogram, all reaches combined, August 2004.



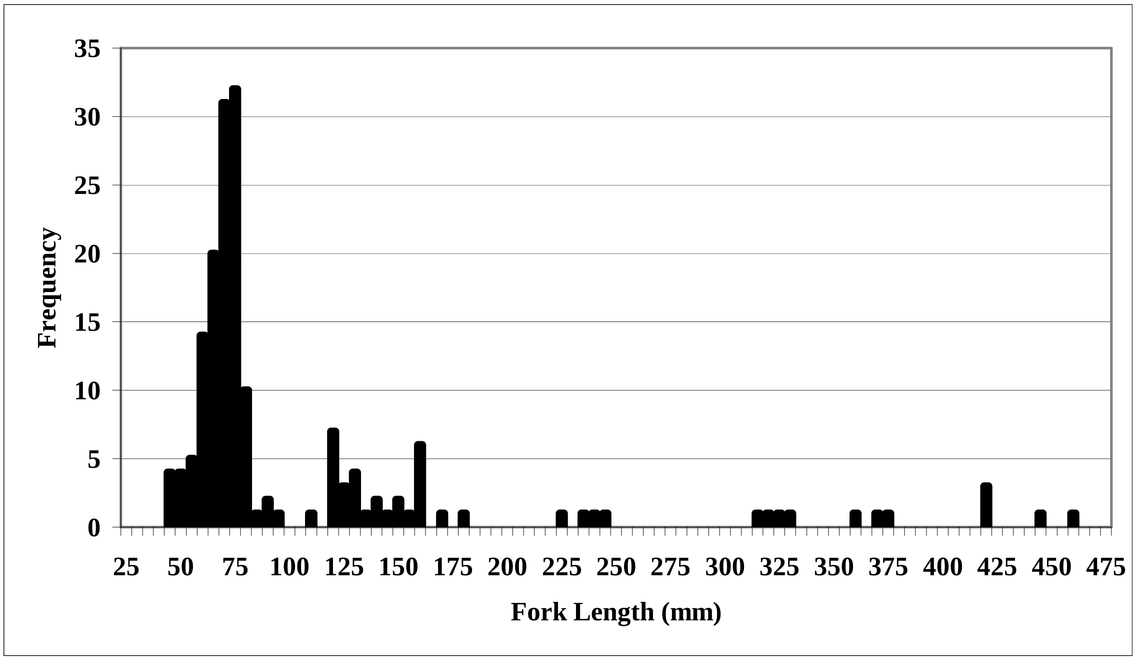
Appendix D. Bluegill length-frequency histogram, all reaches combined, August 2004.



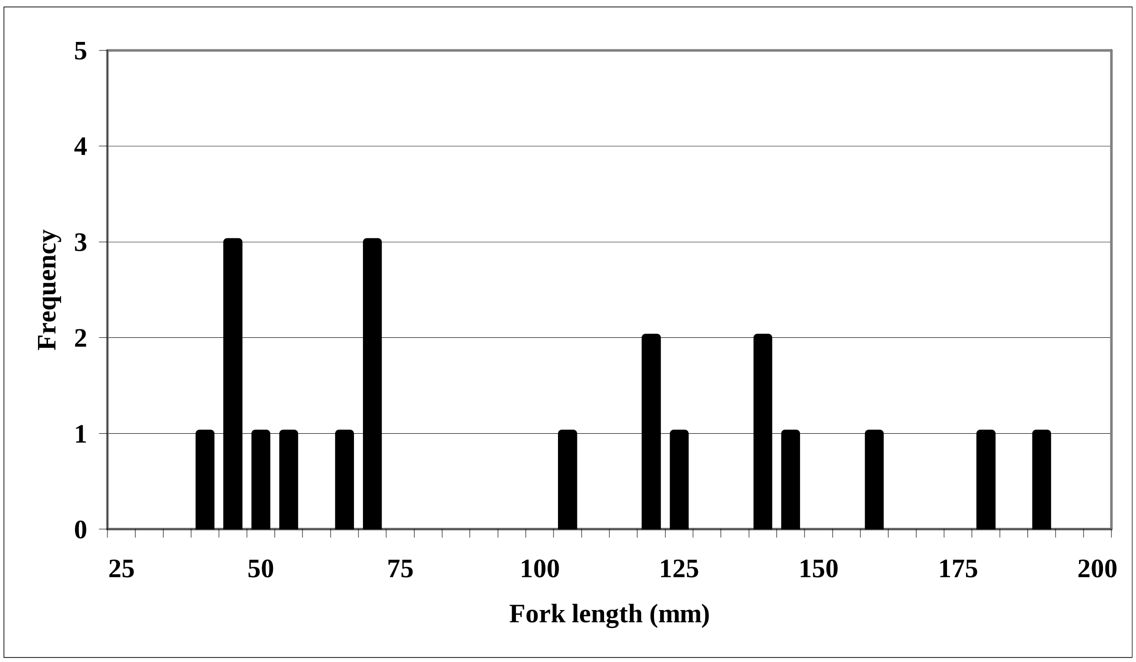
Appendix D. Carp length-frequency histogram, all reaches combined, August 2004.



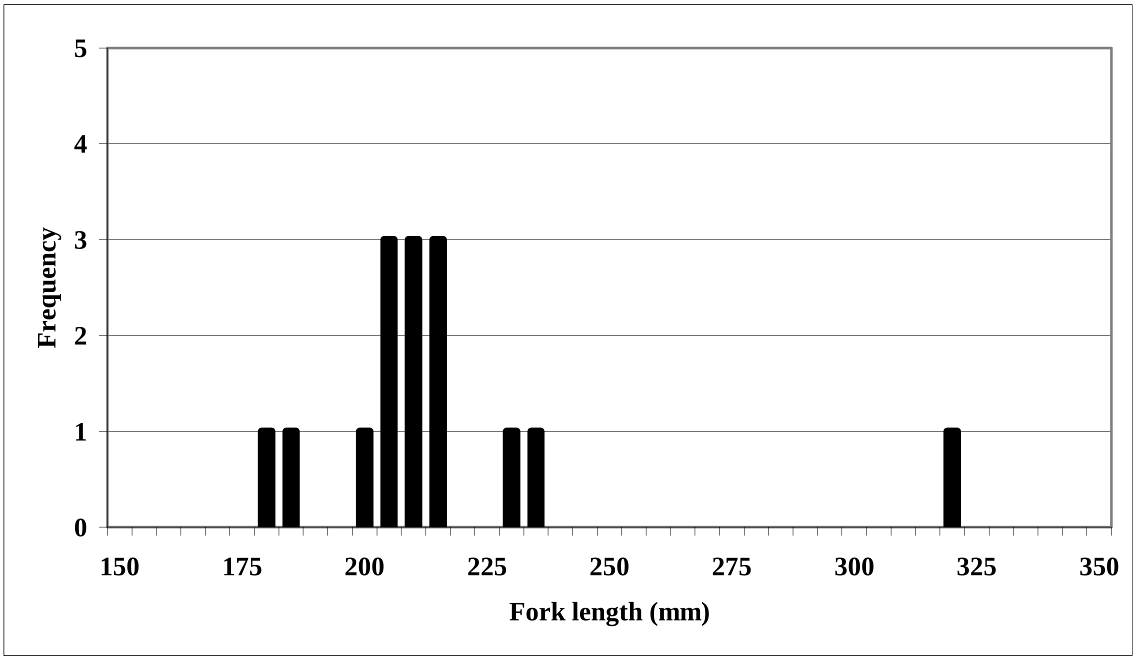
Appendix D. Carp length-frequency histogram, all reaches combined, August 2004.



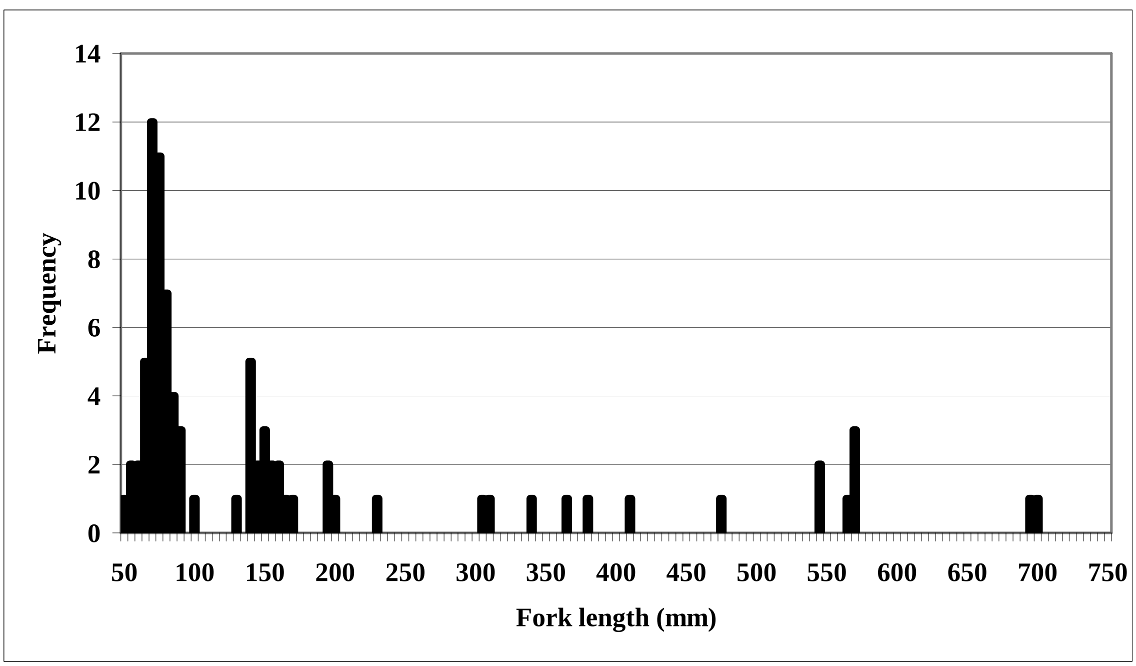
Appendix D. **Hardhead length-frequency histogram, all reaches combined, August 2004.**



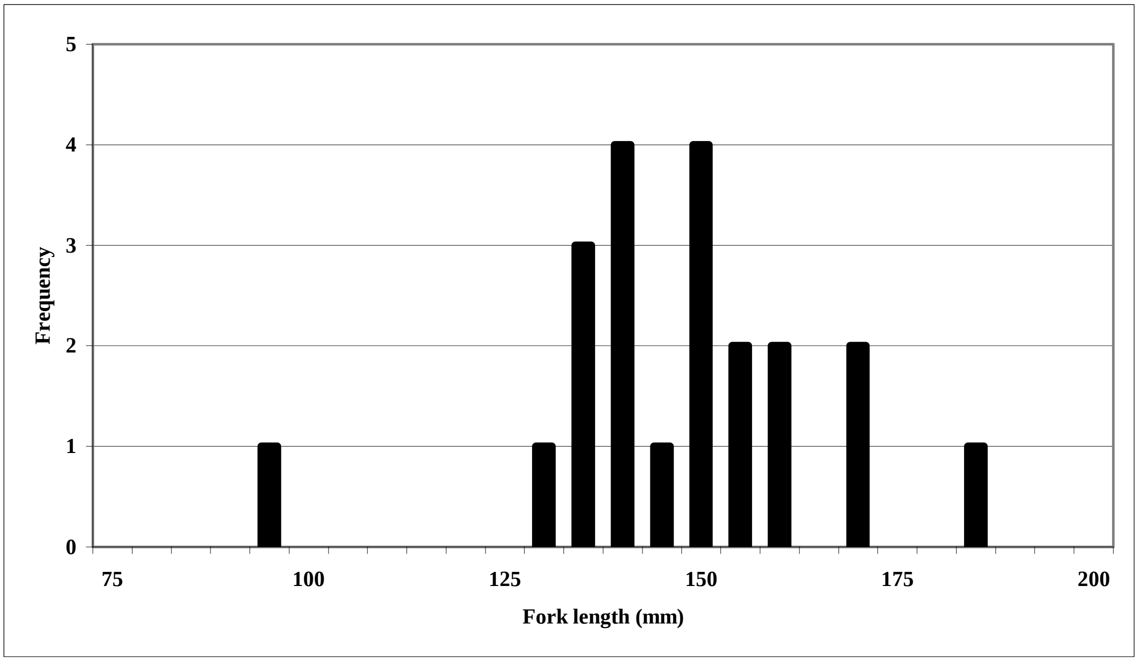
Appendix D. **Hitch length-frequency histogram, all reaches combined, August 2004.**



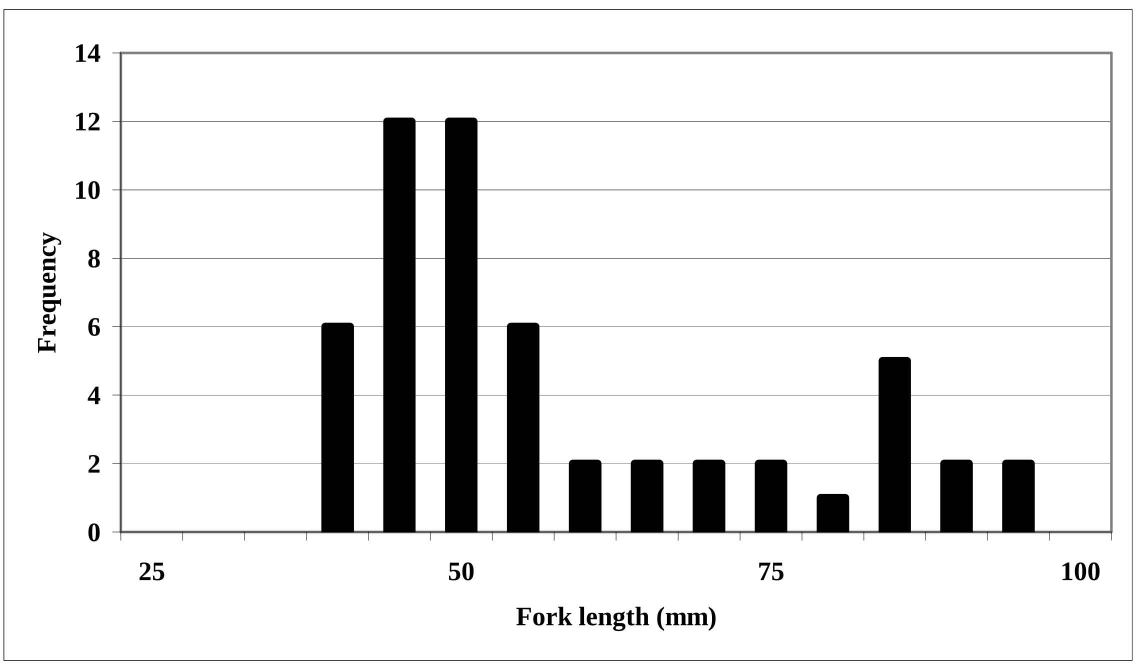
Appendix D. **Largemouth bass length-frequency histogram, all reaches combined, August 2004.**



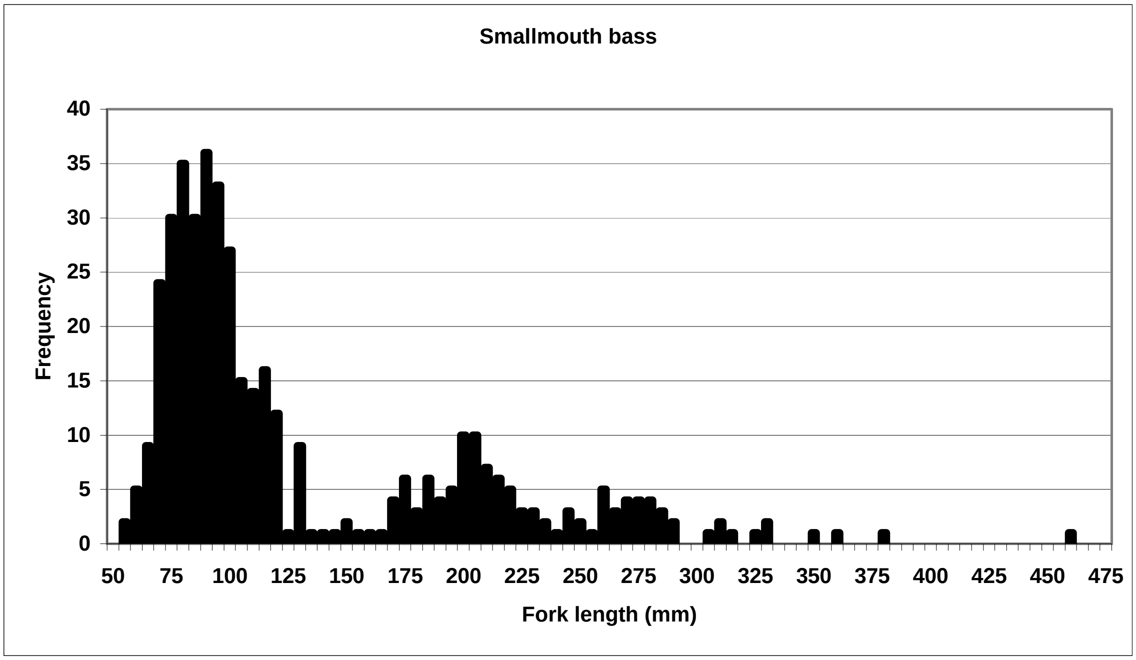
Appendix D. **Pikeminnow length-frequency histogram, all reaches combined, August 2004.**



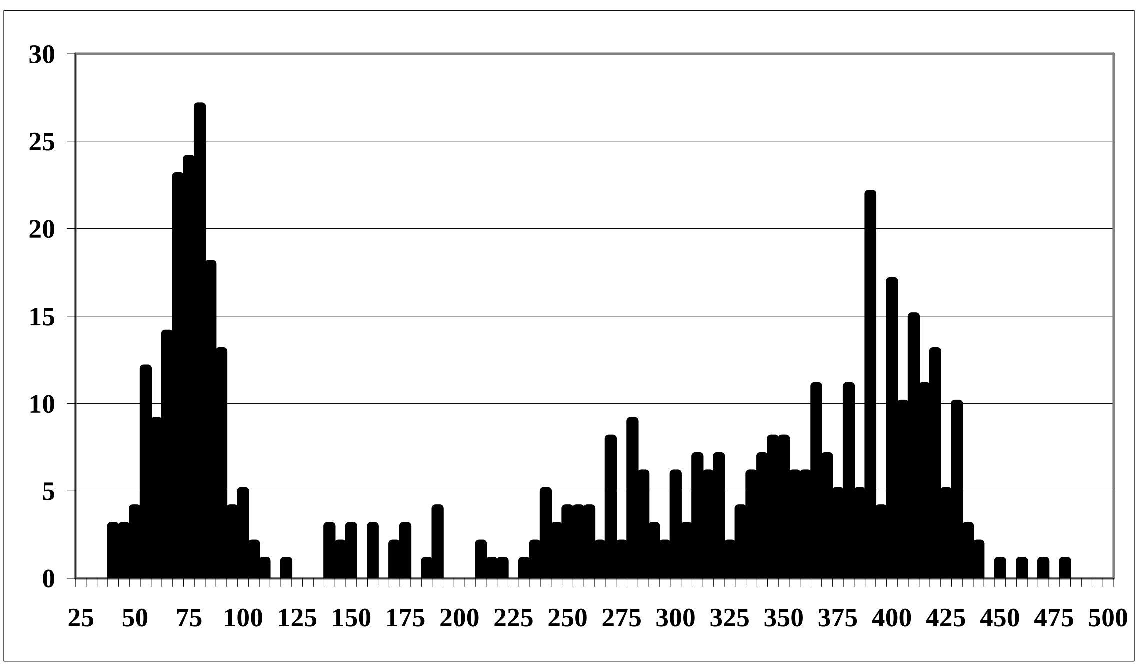
Appendix D. **Redear length-frequency histogram, all reaches combined, August 2004.**



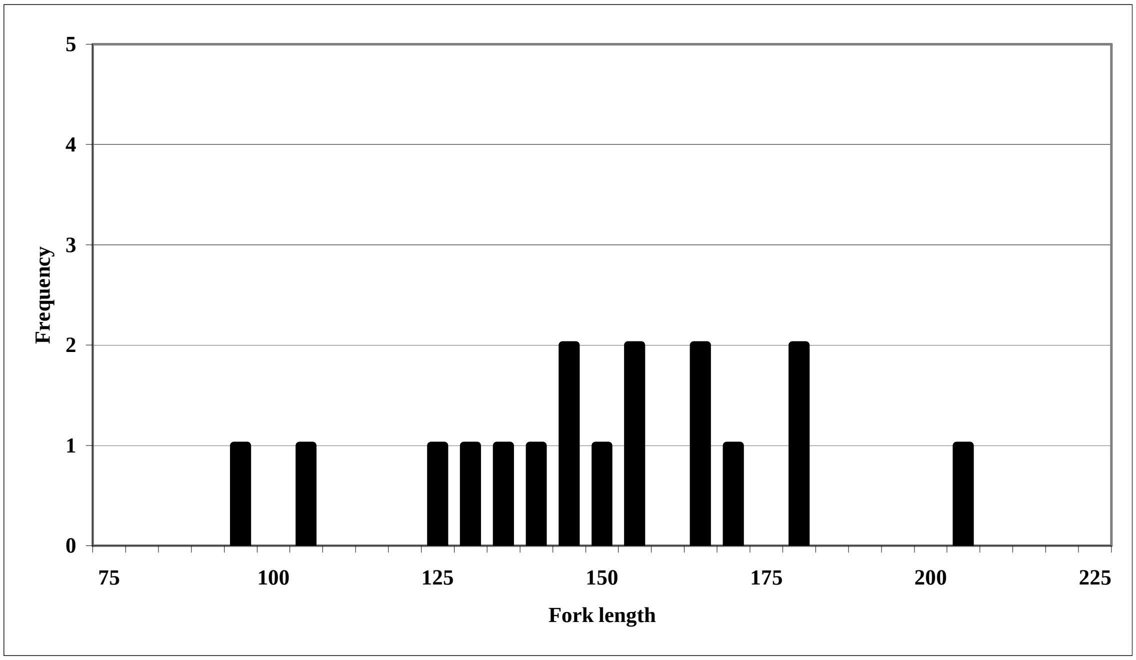
Appendix D. **Roach length-frequency histogram, all reaches combined, August 2004.**



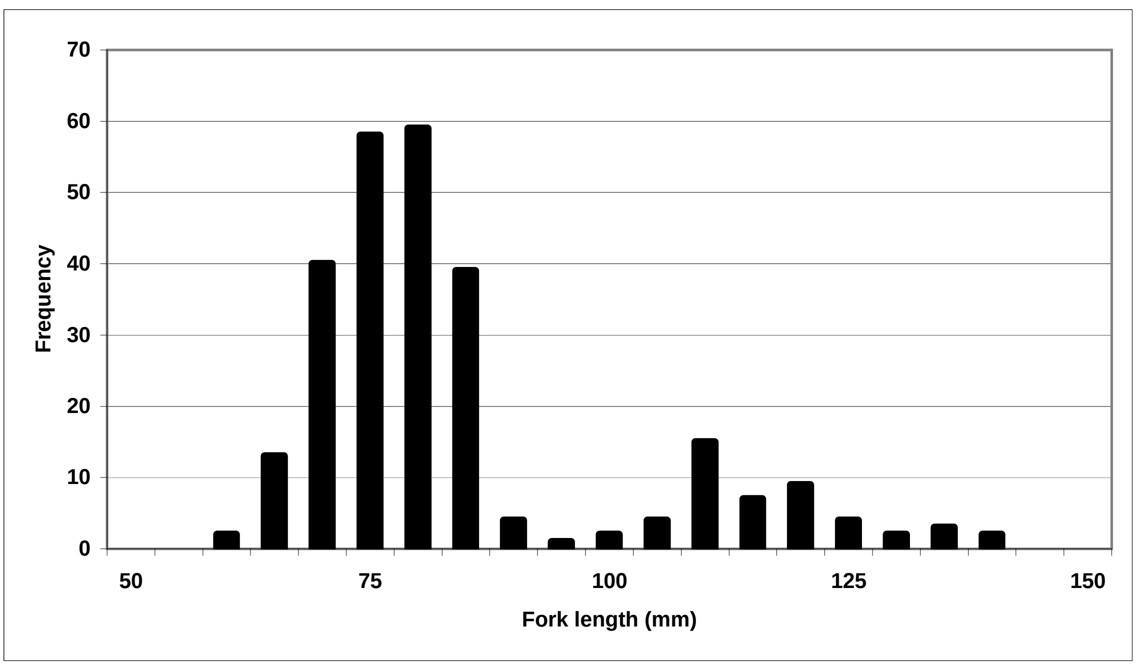
Appendix D. Smallmouth bass length-frequency histogram, all reaches combined, August 2004.



Appendix D. Smallmouth bass length-frequency histogram, all reaches combined, August 2004.



Appendix D. Wild steelhead length-frequency histogram, all reaches combined, August 2004.



Appendix D. Tule perch length-frequency histogram, all reaches combined, August 2004.

Appendix D. Lengths of fish species with few individuals captured during August 2003 surveys.

Species	Fork lengths (mm)
Black Bullhead	180, 220
Black crappie	150, 210
Sculpin	75, 80, 105
American shad	55, 60, 70, 75, 75, 85, 85, 110
White catfish	40, 110, 115, 130, 215, 260, 270, 270