SONOMA COUNTY WATER AGENCY'S MIRABEL RUBBER DAM/WOHLER POOL FISH SAMPLING PROGRAM: YEAR 2 RESULTS 2001

SONOMA COUNTY WATER AGENCY

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

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

The three listed species are anadromous, meaning they spawn and rear in freshwater, then migrate to the ocean where they grow and mature. They then migrate back to their natal freshwater habitat where they spawn and complete their life cycle. Chinook salmon, coho salmon, and steelhead use the lower mainstem Russian River (including the study area) primarily as a migration corridor. Adults pass through the Mirabel Reach during their migration to upstream spawning and rearing habitat Juveniles (smolts) 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 have been conducted to assess the actual effects of the dam's operations on salmonid populations In light of these uncertainties, the Agency is conducting a five-year study to assess the potential impacts associated with the facilities, and to develop mitigation measures as appropriate. This report documents the results of the second year of study.

WATER TEMPERATURE

The Wohler Pool and the resulting impoundment appear to have a small influence on the rate at which water warms. Compared to the rate at which water warms over the 6 5 km reach immediately above the Wohler Pool, the water flowing through the Wohler Pool was estimated to increase (in magnitude) from 0 1 (September) to 0 6°C (June) above what would have been expected without the dam in place The increase in the rate at which water warms within the Wohler Pool due to the presence of the impoundment had the effect of raising the average monthly surface water temperature from 20.6 to 21.2 in June, from 20.5 to 21.0 in July, from 20.3 to 20.6 in August, and from 18.6 to 18.7 in September.

Compared to proposed water temperatures standards for the Russian River, water temperatures in the study area were sub optimal for at least the last half of the smolt emigration period, the entire juvenile steelhead rearing period, and the beginning of the adult upstream migration period. The sub optimal 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 25.2°C. In addition, juvenile steelhead were captured and observed in the Wohler Pool throughout the summer months. Water temperatures were sub optimal during the first few weeks of the adult migration period, but steadily improved as the migration season progressed.

SMOLT EMIGRATION

The rotary screw trap was operated between April 20 and June 7, 2001. During the trapping season, 3,722 chinook smolts were captured. A mark-recapture study was conducted between May 3 and June 5. During this time, an estimated 18,104 chinook smolts emigrated past the Inflatable Dam. Chinook smolts were captured in significant numbers of the first day of sampling in both 2000 (April 8) and 2001 (April 20). Downstream migrant traps were operated through June 29, 2000. Small numbers of smolts were captured through June 28, although few fish were captured during the last two weeks of June (an average of approximately 2.5 fish/day captured in traps). Based on the numbers of smolts captured, emigration peaks during the last two weeks of April and the first two weeks of May. The numbers of Chinook smolts captured in the screw traps declined rapidly after May 20 in both 2000 and 2001.

Steelhead smolts were captured throughout the trapping season, but at lower numbers than Chinook smolts. For the season, 53 wild steelhead smolts were captured in the rotary screw trap (Table 3-1). Steelhead smolts were captured primarily in late April and early May. Wild steelhead smolts in the Russian River emigrate primarily as 2-year-old fish.

Previous studies suggest that the dam may delay passage around the dam of least some hatchery steelhead smolts. The magnitude could not be determined by the current study. A companion study, Manning *et al.* (2000 and 2001), was instituted to define the potential impacts of the dam on steelhead smolts. Chinook smolt emigration through the study area did not appear to be delayed by the dam. As part of the mark-recaptured study instituted to estimate Chinook smolts abundance, Chinook smolts were marked with an alternating upper and lower caudal (tail) clip on a weekly basis, then transported approximately 2,500 feet 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 weeks 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 maybe better at passing over the dam compared to the larger steelhead smolts.

This study provides valuable insight into the run timing of Chinook and wild steelhead smolts. This information defines the period when salmonid smolts are most likely to encounter the dam, and will be used to manage the Inflatable Dam to minimize impacts to listed species.

WOHLER POOL FISH COMMUNITY

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

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

ADULT UPSTREAM MIGRATION

Based on the results of video monitoring from 1999 through 2001, Chinook salmon and steelhead appear to have little problem finding and ascending the fish ladders around the Inflatable Dam. Relatively large numbers of adult fish of both species have been documented successfully negotiating the ladders, and large numbers of fish milling at the base of the dam have not been observed. However, a satisfactory method of assessing fish populations at the base of the dam has not been identified. Direct observation (snorkel) surveys were limited by visibility, which tends to deteriorate in November when Chinook salmon and steelhead are most likely to be present in large numbers.

For the second year in a row, over 1,300 adult Chinook salmon were observed migrating through the fish ladders. This is in contrast to historical literature that suggests that Chinook were never abundant in the Russian. In 2001, approximately 1,380 adult Chinook salmon were observed migrating upstream through the fish ladders. The Chinook run essentially began in early September in 1999, 2000, and 2001. The entire spawning run has been surveyed in its entirety in 2000, only (Chase *et al.* 2001). In 2000, the run peaked in late November and ended in late December. During August of each year sampled, one Chinook salmon has been observed in the fish ladders, and large numbers of salmon have not been observed prior to October in any year. Steelhead began their upstream migration in late October, however, the majority of their run occurs after the dam is deflated. No steelhead were observed in the ladders during the fall survey period.

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1.0 INTRODUCTION

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

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

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

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 NMFS 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 NMFS. The U.S. Army Corps of Engineers, as the federal sponsor, and the Agency, as the local sponsor, entered into a Memorandum of Understanding (MOU) with the NMFS 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. The Agency is preparing 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 will be incorporated into the Agency's Biological Assessment.

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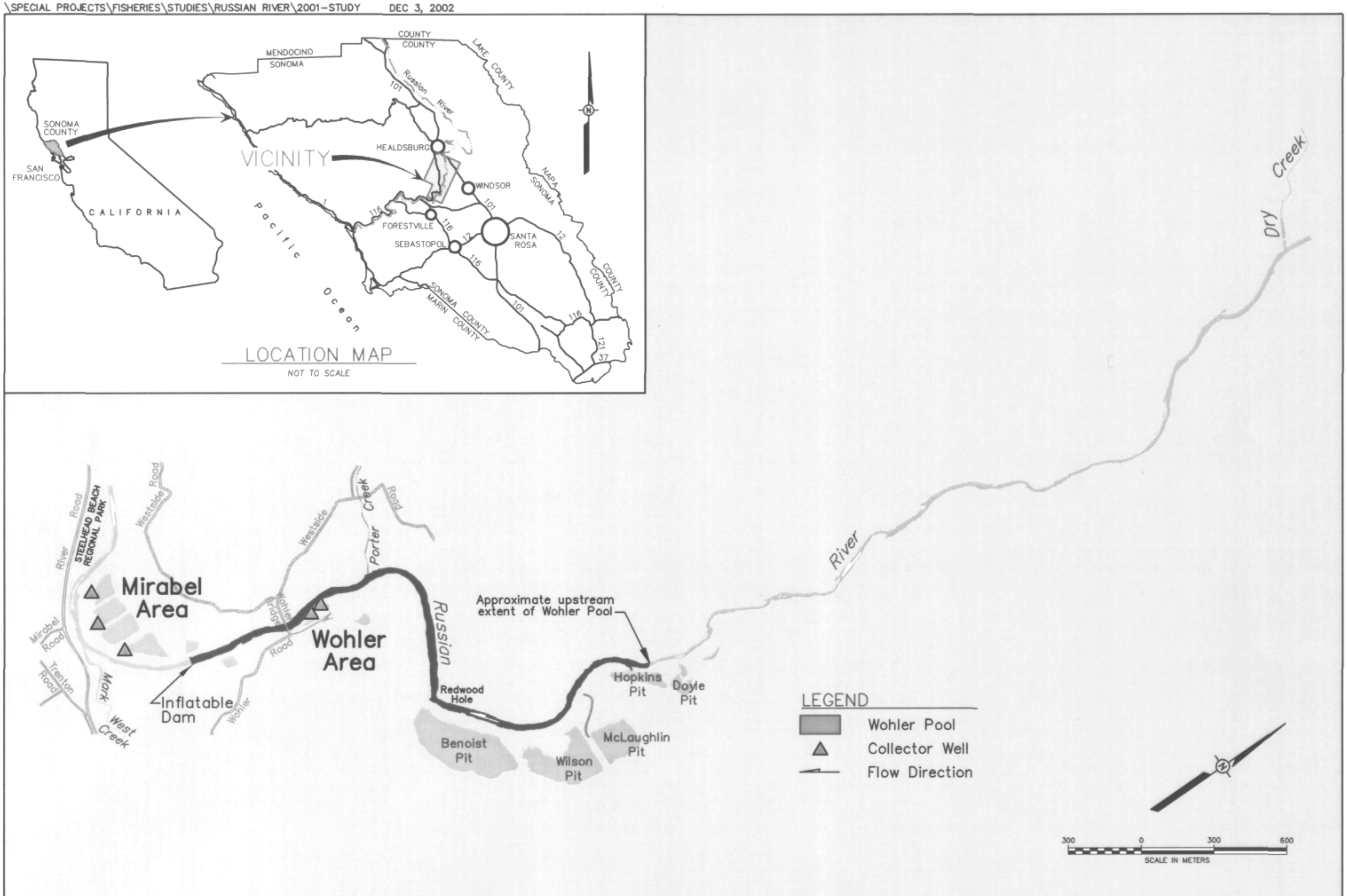

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Figure 1–1 Map of Study Area

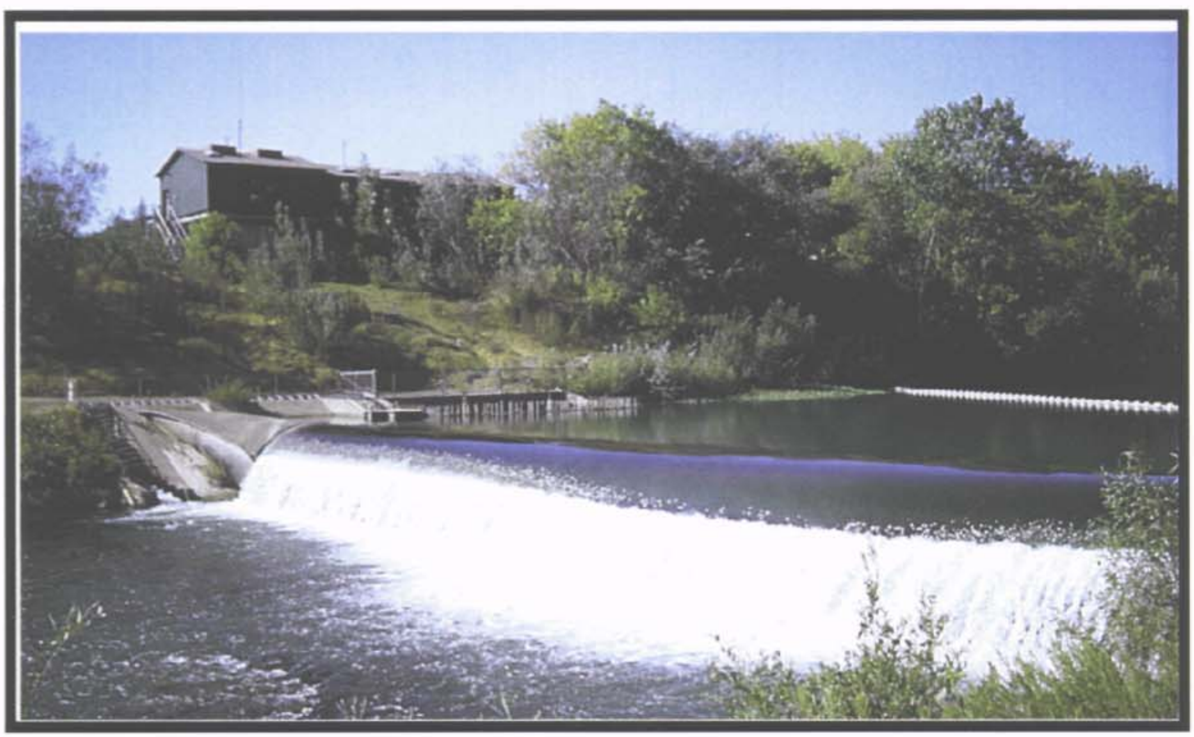


Figure 1-2. The Mirabel Rubber Dam (lower picture) and a portion of Wohler Pool (upper picture).

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

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

- The impoundment created by the dam affects approximately 5.1 km of river, essentially creating a long pool. The impoundment decreases current velocities which smolts use during their downstream migration to the ocean. The loss of this tactile cue may result in smolts becoming disoriented while passing through the impoundment, and this may result in a delay in outmigration. Although there are three avenues for juvenile fish to pass by the dam (going over the dam and through the fish ladders and fish bypass facilities), fish that become disoriented may have difficulty finding these passage routes. This potential impact is only partially addressed in this study. A companion study (Manning *el al.* 2000, Manning *el al.* in prep.) covers this topic in detail.

- 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.

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

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

Prior to initiating this 5-year study, the Agency conducted a study entitled "Sonoma County Water Agency's Mirabel Inflatable Dam/Wohler Pool Reconnaissance Fish Sampling Program" (Chase *et al*. 1999). That program assessed the appropriateness of a variety of sampling methodologies to assess fish and aquatic habitat conditions in the Wohler Pool. The results of that study (Chase *el al.* 2000a) form the basis for the development of the study plan used for this project (Chase *el al.* 2000b). This report documents the results of the second year of 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 12.0 RK upstream of the dam (Figure 1-1). During the initial year of this 5-year study (2000), each sampling location was plotted on a base map using GPS coordinates.

Steelhead Beach Sampling location is a relatively large (approximate 620 meter long) natural pool located downstream of the dam. This is the only sampling habitat that is totally outside of the dam's influence. Wohler Pool is a 5.1 km long impoundment formed by the dam. The water surface elevation (depth) and current velocity in the lower 3.0 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.

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

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

2) Downstream (rotary screw trap) sampling station: Located at RK 36.4 (60 m downstream of the Inflatable Dam.

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

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

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

6) Below Dry Creek Confluence: RK 47.8
   - Continuous water temperature monitoring station

1.2 HISTORICAL LOWER RUSSIAN RIVER FISH SURVEYS

The lower Russian River fish community has been surveyed on several occasions between 1954 and the present (e.g., CDFG 1954, 1955, 1957, 1984, Hopkirk and Northen 1980, Nielsen and Light 1993). These surveys have generally been conducted during the summer (July through August) period. Sampling techniques were generally limited to beach seining.

To date, 27 species, including 14 native species, have been collected or observed during video monitoring in the lower Russian River during the 1999 through 2001 sampling seasons (Table 1-1). Six additional species of fish have also been reported in the Russian River. Coho salmon inhabit streams below the Inflatable Dam, and at least historically, inhabited a small number of streams upstream of the dam. Coho salmon have also been reported in the Dry Creek Basin, however, they have not been observed during this study. River lamprey and western Brook lamprey are occasionally observed/captured in the river as well. White and green sturgeon *(Acipenser transmontanus* and *A. medirostris),* occasionally entered the Russian River, at least historically, although these species apparently did not spawn or rear their young in the river, and a third species, pink salmon *(0. gorbuscha)* is believed to be extirpated from the river. During historical surveys, native resident fish (Sacramento sucker and Sacramento pikeminnow), introduced sunfish (e.g., smallmouth bass and green sunfish), and juvenile American shad dominated the catch. Russian River tule perch were collected in low numbers during all surveys. It is important to note that beach seines are biased towards capturing smaller individuals, and are limited to sampling relatively shallow habitats that have smooth, unobstructed substrates, with moderately sloped contours. Beach seines are generally not effective at capturing species that are found in heavy cover (e.g., adult smallmouth bass), or fast swimming species (e.g. adult pikeminnow).

Table 1-1. Common and scientific names of species captured in the Russian River during 1999 through 2001 sampling efforts, including their status (native or introduced), life history strategy (anadromous or resident), and their regulatory status.

Common Name	Scientific Name	Status	Observed in current study	Regulatory status[1]
American shad	*Alosa sapidissima*	Introduced	Anadromous	—
Sacramento sucker	*Catostomus occidentalis*	Native	Resident	—
California roach	*Lavinia symmetricus*	Native	Resident	CSC[1]
Hardhead	*Mylopharodon conocephalus*	Native	Resident	CSC
California blackfish	*Orthodon microlepidotus*	Uncertain[3]	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	—
White crappie	*Pomoxis annularis*	Introduced	Resident	—
Smallmouth bass	*Micropterus dolomuieu*	Introduced	Resident	—
Largemouth bass	*Micropterus salmoides*	Introduced	Resident	—
Prickly sculpin	*Cottus asper*	Native	Resident	—
Riffle sculpin	*Cottus gulosus*	Native	Resident	—
Tule perch	*Hysterocarpus traski*	Native	Resident	CSC
Channel catfish	*Ictalurus punctatus*	Introduced	Resident	—
Bullhead	*Ameiurus spp.*	Introduced	Resident	—
Mosquitofish	*Gambusia affinis*	Introduced	Resident	—
Pacific lamprey	*Lampetra tridentata*	Native	Anadromous	—
Chinook salmon	*Oncorhynchus tshawytscha*	Native	Anadromous	FT
Chum salmon	*Oncorhynchus keta*	Native/Stray	Anadromous	
Steelhead	*Oncorhynchus mykiss*	Native	Anadromous	FT
Striped bass	*Morone saxitalis*	Introduced	Anadromous	—

[1] California species of special concern
[2] Listed as Threatened under the Federal endangered Species Act
[3] 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).

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

Based on three 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 potential predator, striped bass, also inhabits portions of the lower Russian River. However, only one stripped has been captured in the study area during three years of sampling.

1.3 TARGET SPECIES

Six fish species of concern inhabit the study area: the three federally protected salmonids (Chinook salmon, coho salmon, and Steelhead), and three potential predators (the native Sacramento pikeminnow, and the introduced smallmouth and largemouth bass). Assessing the potential influences of the dam on these species requires an understanding of their life history requirements. The following section provides a brief discussion of the life histories of each of the six species of concern. The life history discussions are limited to the life stages of each species likely to be present in the study area during periods of the year when the dam is inflated.

The discussions are limited to the specific life history requirements likely to be affected by the inflation of the Inflatable Dam. Discussion of salmonids was limited to the water temperature requirements (effects of flow on emigration is covered in Manning *et al.* 2001). The impoundment has the potential to provide spawning and rearing habitat for potential predators, therefore, a more detail discussion of life history requirements are presented for these species

1.4 LIFE HISTORY REQUIREMENTS FOR TARGET SPECIES

1.4.1 Chinook Salmon

Two life stages of Chinook salmon are potentially affected by the Inflatable Dam; adults returning from the ocean, and smolts migrating to the ocean. Adult Chinook salmon migrate upstream through the study area to their spawning habitat, located primarily in mainstem Russian River from Alexander Valley upstream, and in selected tributaries such as Dry Creek. Upstream migration occurs from the last week in August through December (primarily October and November). The primary concern for upstream migrating adults is passage around the Inflatable Dam and water temperature conditions in the river at the start of the upstream migration period. Juvenile Chinook salmon (Figure 1-3) in the Russian River emigrate as fingerlings from approximately late-February through June. Chinook salmon in the Russian River emigrate through the Wohler Pool at about 90 millimeters (mm) fork length (FL) (range 43 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.

Figure 1-3. Russian River Chinook salmon smolt.

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

The upper lethal water temperature for Chinook salmon has been reported to be 25.0°C (Brett 1952 and Bell 1986), and 23.0°C (± 1.1°C) (Baker *et al.* 1995). The preferred temperature range for Chinook salmon has been reported to range from 12.0 to 14.0°C (Brett 1952) and 7.2 to 14.4°C (Bell 1986). Excellent growth rates for juvenile Chinook salmon have been reported to occur at temperatures ranging between 15.0 and 18.9°C (Brett *et al.* 1972, cited by Raleigh *et al.* 1986). Water temperatures above 21.1°C have been reported to stop downstream migration of Chinook salmon smolts (CDWR 1988 cited by RWQCB 2000).

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 DW Kelly and Associates and ENTRIX (1992). The temperature of the water that the adults are exposed to prior to spawning can result in a reduction in survival of the subsequent embryos (Hinze 1959, cited by DW Kelly and Associates and ENTRIX (1992)). Eggs from salmon held for a prolonged time period at 15.6 to 16.7°C had a lower survival rate to hatching (70 percent) compared to eggs from salmon held at 12.8 to 15.0°C (80 percent survival).

1.4.2 Coho Salmon

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

The upper lethal temperature for coho fry has been reported to range from 22.9 to 25.0°C, depending on the temperature that the fish were acclimated to (5.0 to 23.0°C, respectively) (Brett 1952, DeHart cited by Konecki *et al.* 1995), 25.6°C (Bell 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).

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). The Environmental Protection Agency (EPA 1977, cited by RWQCB 2000) 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). 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. Moyle *et al.* (1989) concluded that maximum water temperatures should not exceed 21.9 to 25.0°C for an extended period.

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).

1.4.3 Steelhead

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

Figure 1-4 Russian River Steelhead smolt

The upper lethal water temperature for Steelhead has been reported to be 23.9°C (Bell 1986). However, 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). Steelhead streams should have summer water temperatures between 10.0 and 15.0°C, with maximum water temperatures below 20.0°C (Barnhart 1986). Nielsen *et al.* (1994) reported an increase in agonistic behavior and a decrease in foraging as stream temperatures increased above 22°C. Steelhead were not observed to move into thermally stratified pools at temperatures below 22°C. 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 Maximum Weekly Average Temperature (MWAT) has not been calculated for steelhead.

1.4.4 Summary of Critical Water Temperature Levels

The above review of water temperature requirements for steelhead and coho salmon 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 too. 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 available literature and recommendations of the NCRWQCB (Table 1 -2). The temperatures regimes described do not necessarily represent absolute thresholds where impacts will occur to steelhead and Chinook and coho salmon 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.

The terms used to discuss the results of this study are similar, and can be confusing at first glance. Table 2-1 presents the terminology and their definitions used in this report.

Table 1-2. 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 1-3. Threshold temperature criteria and rational (with citations) used to assess thermal regimes in Mirabel reach of the Russian River.

Temp	Rational for 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
16.7	MWAT of Mattole River tributaries supporting coho salmon.	Welsh *et al.* 2001
17.8	Temperature regimes below this threshold should adequately protect salmonid rearing and outmigration life history phases.	NCRWQCB 2000
20.0	Temperatures above this threshold result in chronic effects to steelhead; upper range at which coho growth occurs	Roelofs *et al.* 1993; Bell 1973
21.1	Chinook smolt emigration and adult salmonid upstream migration inhibited	Halleck 1970 CDWR 1988
23.0	Chronic stress, survival jeopardized at temperatures above threshold for steelhead	Roelofs *et al.* 1993
Temp	Rational for MWMT and maximum daily temperature 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 temperature for steelhead streams. Approximates the recommended MWMT (20.5°C) to protect steelhead growth.	Barnhart 1986
22.0	Salmonids utilization of cool water refuge begins to increase, feeding decreases	Nielsen *et al.* 1994 Sullivan *et al.* 2000
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

1.4.5 Sacramento Pikeminnow

The Sacramento pikeminnow (Figure 1-5) 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 undoubtedly the top piscivore in the Russian River. Site-specific information on pikeminnow in the Russian River is limited, and most of what is known about their biology and life history comes from studies conducted in other river systems, primarily in the Sacramento and San Joaquin. In addition, a considerable amount of work has been conducted on 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 limited to Taft and Murphy (1950), and 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 Study Area, and would be found in the area with or without the dam.
Pikeminnow prefer warm water streams with abundant pools (Taft and Murphy 1950, Moyle and Nichols 1973). Adult pikeminnow occupy deep pools with abundant cover, during the day they tend to be sedentary (Smith 1982, Brown 1990). Juveniles (70 to 120 mm 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 1-5 Pikeminnow (with streamer tag) captured in the Wohler Pool, Russian River

Pikeminnow prefer warm water compared to 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 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 are known to eat 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). However, salmonids seldom constitute a significant proportion of pikeminnow diet in free flowing sections of rivers (Buchanan *et al.* 1981).

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 sculpins. Juvenile salmonids were found in 2 percent of the 1,127 pikeminnow stomachs examined.

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

Zimmerman (1999) developed a linear regression for the size of salmonids that could be consumed by northern pikeminnow between 250 and 550 mm FL (the northern pikeminnow is closely related and similar in morphology to the Sacramento pikeminnow) (Table 1-4). Based on this regression, northern pikeminnow ranging in size from 250 and 550 mm FL can consume salmonids ranging in length from 116 to 220 mm FL. The largest pikeminnow captured in this study was 710 mm FL, thus it could consume larger prey items than those studied by Zimmerman.

Table 1-4. 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

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).

Growth rate is an important factor to consider when assessing the potential for a predator to impact a prey species. Until the predator becomes large enough to feed on the prey species, they are not a threat. Although Dettman (1976), reported that pikeminnow in the Russian River grew very slowly, data collected in this study seems to refute that suggestion. Pikeminnow captured in the Russian River during this study were similar in size to fish captured in the Sacramento River (Table 1-5). Brown (1990) calculated the growth rate of pikeminnow from nine populations in the Sacramento River basin. Back-calculated lengths for the nine Sacramento River and tributary pikeminnow populations and the lengths of pikeminnow captured in August 2000 in the Russian River are as follows:

Table 1-5. Back-calculated lengths of Sacramento pikeminnow inhabiting the Sacramento River[1] and selected tributaries, and lengths of Sacramento pikeminnow captured in the Russian River in August 2000.

	Age l+	Age 2+	Age 3+	Age 4+	Age 5+	Age 6+	Age 7+	Age 8+
Tributaries[2]	52-69	104-144	168-205	241-260	262-322	304-380	377-406	403-433
Sacramento River[2]	85-128	168-221	239-288	297-341	346-379	385-409	419-440	445-470
Russian River[3]	64	144	264	354	468		—	—

[1] From Brown 1990.
[2] Lengths back-calculated.
[3] Fork lengths average over the 1999 - 2001 study period. Length data collected in August (i.e., the Russian River fish are approximately 4 months younger than the fish in the Sacramento study).

The lengths of the pikeminnow captured in the Russian River are not back-calculated to the time of annulus formation (e.g., the end of the previous growing season). Thus, the Russian River fish are approximately four months younger than the corresponding age class used for the Sacramento fish (e.g., the Russian pikeminnow in the Age 1+ category are 8 months old, and the pikeminnow in the Age 2+ category are 1 year, 8 months old, etc.).

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. In larger river, groups of pikeminnow have been observed (in what looks like) spawning in pool tailouts. 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).

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

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

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

Pikeminnow were seldom abundant where centrarchids were common (Moyle and Nichols 1973). Pikeminnow 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).

1.4.6 Smallmouth Bass

Smallmouth (Figure 1-4) 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

Figure 1-6. Smallmouth bass captured in the Russian River.

stocked outside of their native range. Smallmouth bass appear to be widespread throughout the mainstem Russian River, with peak abundances reportedly occurring in the Alexander Valley. Smallmouth bass are widespread and abundant in the Study Area.

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

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

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

Zimmerman (1999) developed a linear regression for the size of salmonids that could be consumed by smallmouth bass between 200 and 400 mm FL (Table 1-5). Based on this regression, a 200 mm smallmouth bass can consume a 100 mm salmonid, and a 383 mm FL smallmouth bass (largest smallmouth bass captured in this study) can consume a 134 mm salmonid.

Smallmouth bass are spring spawners, and spawning is generally initiated after water temperature increases to 12.8 to 15.5°C (range 4.4 to 21.1°C) (Emig 1966). Preferred spawning substrate is gravel, but silt and sand can be utilized. Nests are generally built at depths between 0.3 to 0.9 m (Edwards *et al.* 1983). Spawning generally occurs in quiet backwater areas of streams.

Table 1-6. The theoretical maximum sized salmonid that can be consumed by smallmouth bass between 200 and 400 mm FL (based on Zimmerman 1999).

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

1.4.7 Largemouth Bass

Largemouth (Figure 1-5) 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.

Figure 1-7 Largemouth bass captured in the Russian River

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 the present study (2000), but were not captured during a similar study conducted in 1999 (Chase *et al.* 2000b).

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

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

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

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

2.0 WATER TEMPERATURE MONITORING

2.1 INTRODUCTION

During the typically warm summer period, water temperature tends to increase naturally as a river flows from its headwaters to the ocean. The rate of increase varies depending on climatic conditions, river morphology, and habitat quality. 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 the residence time, the greater the opportunity for water to be warmed 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). Salmonid life stages potentially affected by an increase in water temperature associated with the Wohler Pool are: the spring emigration period, steelhead rearing (summer), and fall upstream migration period (there is essentially no salmonid spawning habitat within the footprint of the Wohler Pool).

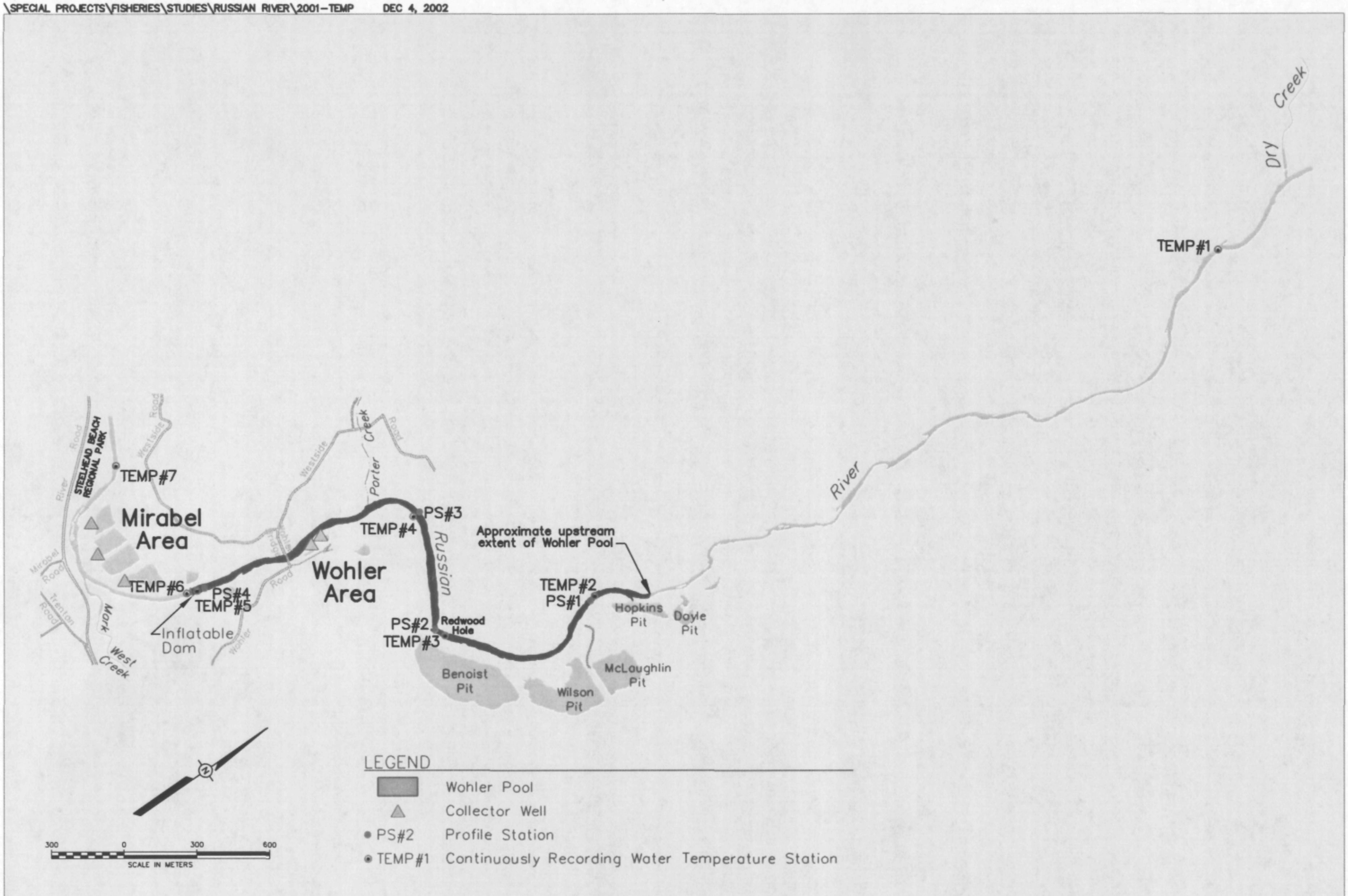
The final objective of this study is to determine the potential for the Wohler Pool to become thermally stratified during the summer. The density of water decreases as the temperature increases (thus, warm water "floats" on top of cold water). When thermal stratification develops, a strong density gradient forms between the warmer surface water and the cooler water below. The density gradient prevents mixing between the two layers of water, and the bottom layer of water can remain several degrees cooler throughout the summer. The cooler layer of water, if present, could provide suitable temperatures for salmonids rearing in the mainstem river.

2.2 METHODS

Seven continuously recording water temperature monitoring stations were selected within the study area (Figure 2-1). Water temperature data were collected using Hobo 8K data loggers (Onset Computers, Inc.). At stations 1 through 5 and 7, 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 Station 6 (below the dam), one data logger was placed at the outlet of the west fish ladder. Data loggers were programmed to record temperature on an hourly basis, 24 hours a day. The temperature monitors were deployed at stations 2-5 on April 26, and on May 23 at Stations 1, 6 and 7. Water temperatures were recorded at stations 1-5 and 7 though November 4, and through November 14 at Station 6.

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

Water quality profile (water temperature, dissolved oxygen, and conductivity) monitoring was conducted at four stations ranging from the Inflatable Dam (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 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 °C to °F is presented in Appendix A.



SONOMA COUNTY WATER AGENCY

Figure 2–1 Continuous water temperature and water quality profile stations – 2001

2.3 RESULTS

Temperature criteria used for assessing 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

Streamflow 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, and
- 35 cfs during critical water supply conditions

Although streamflows above and below the Inflatable Dam are typically greater than the minimum allowable flow, the flow above and below the dam differs by the amount diverted by the Agency and other diverters. Low flow discharges measured above and below the Inflatable Dam have varied significantly during the first two years of this study. The 2001 water year qualified as a dry year under the conditions set by Decision 1610. Consequently, streamflows in the Russian River were lower in 2001 compared to 2000 (Table 2-1). Streamflows measured below the inflatable dam during June through August were approximately half of the flows released during the same time frame in 2000 (≈110 cfs compared to 184 to 267 cfs). In addition, physical habitat 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 habitat type 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 directly 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) and 2001 (Dry year).

Month	Average monthly flow (cfs) in 2000		Average monthly flow (cfs) in 2001	
	Hacienda	Above Wohler	Hacienda	Above Wohler
June	267	347	114	246
July	196	287	111	196
August	184	301	113	219
September	202	290	151	274

2.3.2 Continuous Temperature Recording

Water temperatures were recorded continuously at seven locations within the study area (see Appendices B and C for tables and graphs of daily minimum, average, and maximum temperatures recorded at each station). Water temperatures at Station #1 represent temperatures 6.5 RK above the influence of the impoundment. Station #2 is located at the upstream end of the impoundment and represents the temperature of the river as it first encounters the 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 numbers 3, 4 and 5 are located in approximately the upper 2/3rds, 1/2 and lower 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 less than the streamflow between 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.

Individual data loggers failed for a two-week period at Station #2 (surface - July 5 to July 24)) and at Station #4 (bottom - August 28 to September 12). Water temperatures recorded with the surface and bottom data loggers were generally within 0.2°C of each other at these stations throughout the sampling season. Since the surface and bottom water temperatures were almost identical at the two stations, water temperature data collected with the remaining functioning data logger were used in place of the lost data. The data loggers at Station #7 (bottom) either malfunctioned or were tampered with between May 28 and June 9 (bottom), and May 28 and 29 (surface). The temperature recorded at this station closely mimicked temperatures recorded at the Air Temperature Monitoring Station located at Mirabel. Data collected during this time period was excluded from the analysis.

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 rate of change in water temperature and the overall magnitude of the change 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 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 daily surface water temperatures ranged from -0.02 to 0.21°C/km between June 1 and September 30, 2001, over the 6.5 km between Stations #1 and #2 (Table 2-2). The rate of change in water temperature resulted in an overall increase in daily average temperature of water flowing between the two stations of -0.1 and 1.4°C during this time-span (Table 2-2). The rate of change in the monthly average water temperature ranged from 0.06 to 0.10°C/km, June through September (Table 2-2), equating to an overall change in the magnitude of the temperature of 0.4 to 0.7°C over the 6.5 km distance.

Table 2-2. The minimum and maximum daily and the average monthly rate of change in temperatures and the magnitude of change in temperatures (°C) between Stations #1 and #2, June through September 2001, Russian River (temperatures recorded at depths of 0.5 and approximately 3.0 meters).

Surface (0.5 meters)			
Date	Minimum daily rate of change (°C/km)	Average monthly rate of change (°C/km)	Daily maximum rate of change (°C/km)
June	0.01	0.09	0.21
July	0.07	0.10	0.18
August	0.06	0.10	0.14
September	-0.02	0.06	0.14
	Minimum daily change in magnitude (°C)	Average monthly change in magnitude (°C)	Maximum daily change in magnitude (°C)
June	0.1	0.6	1.4
July	0.5	0.7	1.2
August	0.4	0.7	0.9
September	-0.1	0.4	1.0

Bottom (3.0 meters)			
Date	Minimum daily rate of change (°C/km)	Average monthly rate of change (°C/km)	Daily maximum rate of change (°C/km)
June	0.00	0.07	0.18
July	-0.02	0.10	0.19
August	0.06	0.11	0.23
September	-0.02	0.06	0.11
	Minimum daily change in magnitude (°C)	Average monthly change in magnitude (°C)	Maximum daily change in magnitude (°C)
June	0.0	0.5	0.5
July	-0.1	0.7	1.2
August	0.4	0.7	1.5
September	-0.1	0.4	0.7

The rate of change in the daily average bottom water temperatures ranged from -0.02 to 0.23°C/km between June 1 and September 30, 2001 (Table 2-2). The rate of change in water temperature resulted in an overall increase in daily average temperature of water flowing between the two stations of -0.1 and 1.5°C during this time-span (Table 2-2). The rate of change in the monthly average water temperature ranged from 0.06 to 0.11°C/km, June through September (Table 2-2), equating to an overall change in the magnitude of the average monthly temperature of 0.4 to 0.7°C over the 6.5 km distance.

2.3.3.2 Rate and magnitude of change in water temperature between Stations #2 and #5 (Wohler Pool)

The rate of change in the daily average surface water temperatures ranged from -0.12 to 0.42°C/km between June 1 and September 30, 2001, over the 5.1 km between Stations #2 and #5 (Table 2-3). The rate of change in water temperature resulted in an overall increase in daily average temperature of water flowing through the Wohler Pool of -0.6 and 2.3°C during this time-span (Table 2-3). The rate of change in the monthly average water temperature ranged from 0.07 to 0.20°C/km, June through September (Table 2-3), equating to an overall change in the average monthly water temperature of 0.4 to 1.1° over the 5.1 km distance.

The rate of change in the daily average bottom water temperatures ranged from -0.18 to 0.42°C/km between June 1 and September 30, 2001 (Table 2-3). The rate of change in water temperature resulted in an overall increase in magnitude of the daily average temperature of water flowing between Stations #2 and #5 of -1.0 and 2.3°C during this time-span (Table 2-3). The rate of change in the monthly average water temperature ranged from 0.04 to 0.16°C/km, June through September (Table 2-3), equating to an overall change in the magnitude of the average monthly water temperature of 0.2 to 0.9°C over the 5.1 km distance.

2.3.3.3 Rate of change in weekly average water temperature between stations #6 and #7

The rate of change in the daily average surface water temperature ranged from -0.9 to 0.54°C/km between June 1 and September 30, 2001, over the 2.3 km between Stations #6 and #7 (Table 2-4). The rate of change in water temperature resulted in an overall increase in magnitude of the daily average temperature of water flowing between stations #6 and #7 of -0.2 and 1.3°C during this time-span (Table 2-4). The rate of change in the monthly average water temperature ranged from 0.10 to 0.30°C/km, June through September (Table 2-4), equating to an overall change in the magnitude of the temperature of 0.2 to 0.7°C over the 2.3 km distance.

The rate of change in the daily average bottom water temperatures ranged from -0.19 to 0.44°C/km between June 1 and September 30, 2001, over the 2.3 km between Stations #6 and #7 (Table 2-4). The rate of change in water temperature resulted in an overall increase in magnitude of the daily average temperature of water flowing between stations #6 and #7 of -0.4 and 1.0°C during this time-span (Table 2-4). The rate of change in the monthly average water temperature ranged from 0.18 to 0.21°C/km, June through September (Table 2-4), equating to an overall change in the magnitude of the temperature of 0.4 to 0.5°C over the 2.3 km distance.

2.3.4 Overall Influence of the Inflatable Dam on Water Temperature.

The crux of this section 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 surface water temperatures developed for the Above Pool Reach indicates that the average monthly water temperatures between June and September were increased from 0.1°C to 0.6°C, compared to what would have been expected without the dam (Table 2-5, Figure 2-2, Appendix C). The increase in the rate at which water warms within the Wohler Pool due to the presence of the impoundment had the effect of raising the average monthly surface water temperature from 20.6 to 21.2 in June, from 20.5 to 21.0 in July, from 20.3 to 20.6 in August, and from 18.6 to 18.7 in September.

Using the monthly average rate of change in bottom water temperatures developed for the Above Pool Reach indicates that the average monthly water temperatures between June and September were increased

Table 2-3. The minimum and maximum daily and the average monthly rate of change in temperatures and the magnitude of change in temperatures (°C) between Stations #2 and #5, June through September 2001, Russian River (temperatures recorded at a depth of 0.5 and approximately 3.0 meters).

Surface (0.5 meters)			
Date	Minimum daily rate of change (°C/km)	Average monthly rate of change (°C/km)	Daily maximum rate of change (°C/km)
June	-0.12	0.20	0.42
July	0.06	0.20	0.41
August	0.04	0.16	0.27
September	-0.08	0.07	0.19
	Minimum daily change in magnitude (°C)	Average monthly change in magnitude (°C)	Maximum daily change in magnitude (°C)
June	-0.6	1.1	2.3
July	0.3	1.1	2.2
August	0.2	0.9	1.5
September	-0.4	0.4	1.1

Bottom (3.0 meters)			
Date	Minimum daily rate of change (°C/km)	Average monthly rate of change (°C/km)	Daily maximum rate of change (°C/km)
June	-0.18	0.16	0.42
July	0.05	0.12	0.28
August	-0.04	0.10	0.24
September	-0.10	0.04	0.17
	Minimum daily change in magnitude (°C)	Average monthly change in magnitude (°C)	Maximum daily change in magnitude (°C)
June	-1.0	0.9	2.3
July	0.3	0.7	1.5
August	-0.2	0.5	1.3
September	-0.6	0.2	0.9

Table 2-4. The minimum and maximum daily and the average monthly rate of change in temperatures and the magnitude of change in temperatures (°C) between Stations #6 and #7, June through September 2001, Russian River (temperatures recorded at a depth of 0.5 meters).

Surface (0.5 meters)			
Date	Minimum daily rate of change (°C/km)	Average monthly rate of change (°C/km)	Daily maximum rate of change (°C/km)
June	0.09	0.29	0.53
July	0.19	0.30	0.54
August	0.12	0.24	0.35
September	-0.09	0.10	0.22
	Minimum daily change in magnitude (°C)	Average monthly change in magnitude (°C)	Maximum daily change in magnitude (°C)
June	0.2	0.7	1.2
July	0.4	0.7	1.3
August	0.3	0.6	0.8
September	-0.2	0.2	0.5

Bottom (3.0 meters)			
Date	Minimum daily rate of change (°C/km)	Average monthly rate of change (°C/km)	Daily maximum rate of change (°C/km)
June	-0.19	0.18	0.42
July	-0.12	0.18	0.35
August	0.04	0.21	0.44
September	-0.04	0.21	0.40
	Minimum daily change in magnitude (°C)	Average monthly change in magnitude (°C)	Maximum daily change in magnitude (°C)
June	-0.4	0.4	1.0
July	-0.3	0.4	0.8
August	0.1	0.5	1.0
September	-0.1	0.5	0.9

Table 2-5. Actual and estimated average monthly magnitude of change in the surface and bottom water temperatures in the Wohler Pool reach using the temperature data developed for the above impoundment rate of increase, June through September, 2001.

Surface			
Month	Actual monthly increase in surface temperatures (°C)	Estimated increase using Above Reach Rates (°C)	Difference between actual and estimated temperatures (°C)
June	1.1	0.5	0.6
July	1.1	0.6	0.5
August	0.9	0.6	0.3
September	0.4	0.3	0.1

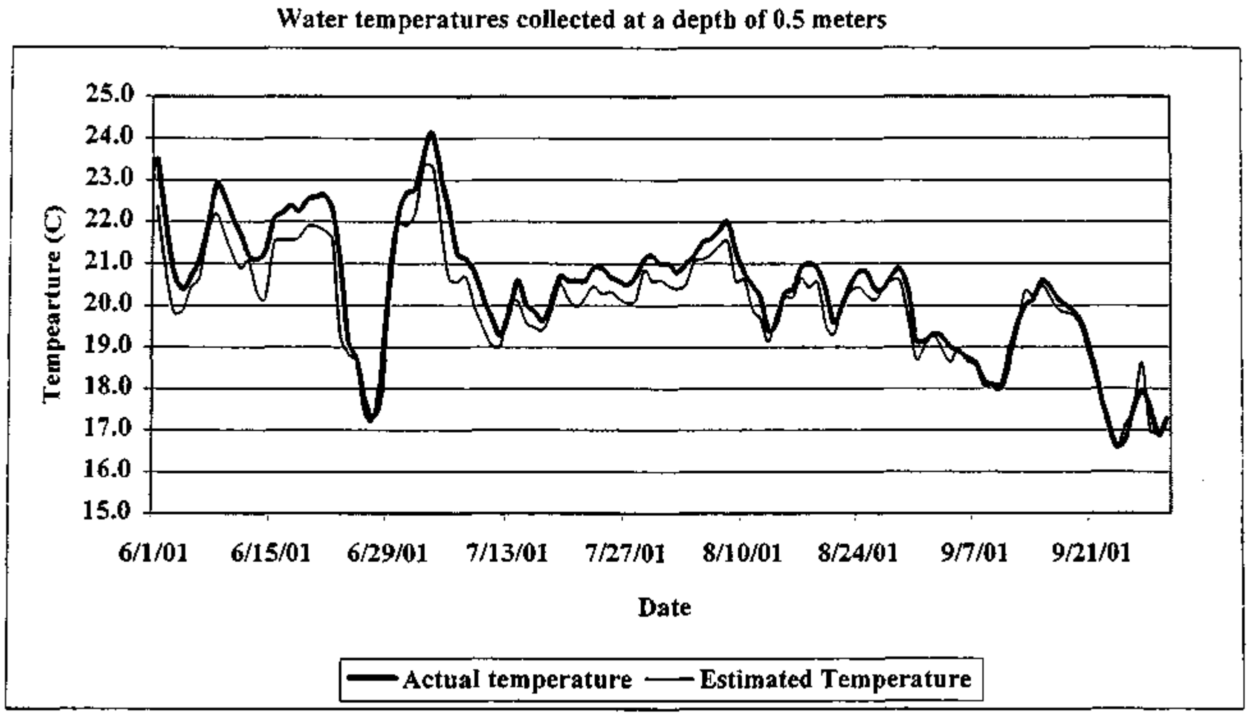
Bottom			
Month	Actual monthly increase in surface temperatures (°C)	Estimated increase using Above Reach Rates (°C)	Difference between actual and estimated temperatures (°C)
June	0.9	0.5	0.4
July	0.7	0.1	0.6
August	0.5	-0.1	0.6
September	0.2	-0.1	0.3

between 0.3°C and 0.6°C over what would have been expected without the dam (Table 2-5, Figure 2-2 Appendix D). The increase in rate at which water warms within the Wohler Pool due to the presence of the impoundment had the effect of raising the average monthly bottom water temperature from 20.5 to 20.9 in June, from 19.9 to 20.5 in July, from 19.7 to 20.3 in August, and from 18.2 to 18.5 in September.

2.3.5 Seasonal Water Temperatures within the Study Area.

The three listed salmonids migrate through the study area as juveniles and adults, and juvenile steelhead rear within the study area in low numbers. Thermal conditions providing adequate protection for juvenile and adult migrating steelhead and Chinook salmon should be suitable when the MWAT is below 17.8°C and the MWMT is below 21.1°C for migrating adults and 20.0°C for smolts. Rearing conditions for juvenile steelhead should be suitable when the MWAT is less than 17.8°C and the MWMT should be below 20.0°C to provide optimal growth conditions for juvenile steelhead (a reduction in the growth rate of greater than 10 percent has been reported for temperatures above 20.5°C). Temperature above 26.0°C can result in direct mortality in a matter of hours.

In general, water temperatures were sub optimal for all life stages during the sampling period (Figures 2-3 - 2-9). The suitability of water temperatures during the spring juvenile emigration period generally declined as the season progressed. The sub optimal 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 (Stations #1 and #2) upstream sites. Conditions were generally poor for rearing steelhead during July and August, before improving during the last two weeks in September. Conditions for upstream migrating adults (primarily Chinook salmon) were sub optimal during



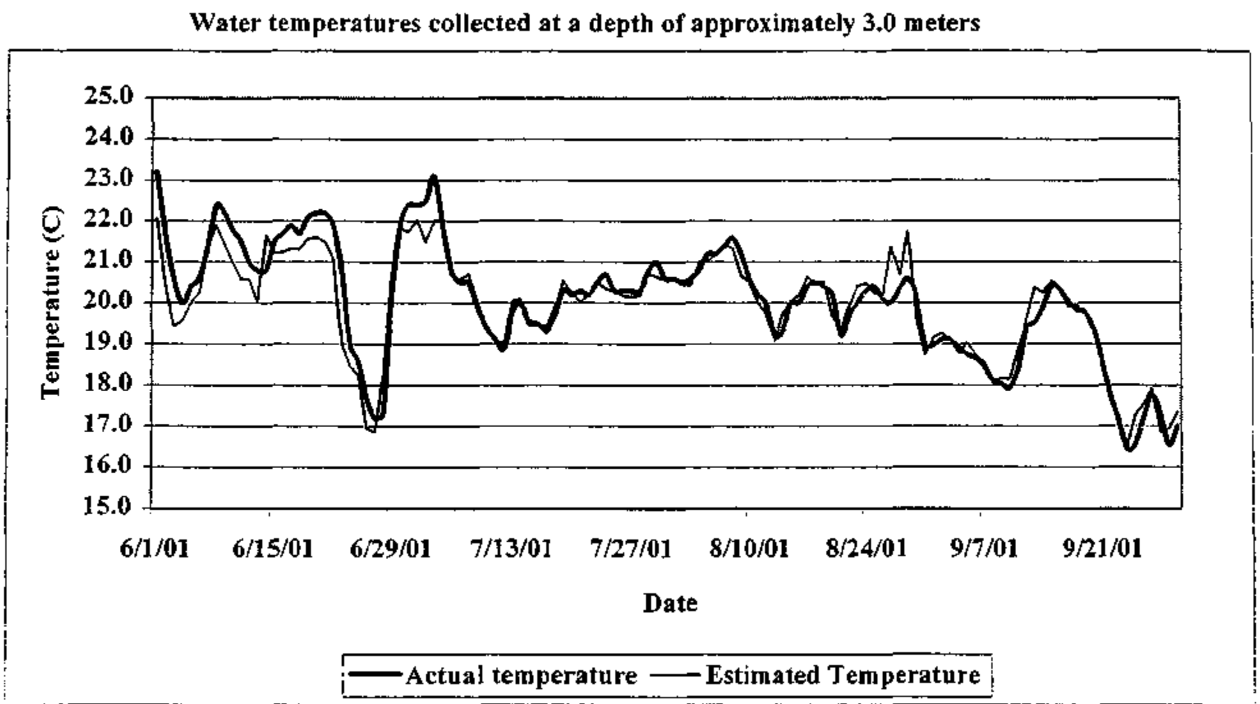


Figure 2-2. Actual water temperatures collected at Station #5 and estimated water temperatures using the monthly average rate of change in surface and bottom water temperatures developed for the Above Pool Reach at Station #5.

the first few weeks of the upstream migration period, but quickly improved during October when the majority of the fish began entering the river.

2.3.5.1 Seasonal water temperatures during the late spring smolt emigration period.

Water temperatures were sub optimal for smolt emigration throughout the study area during parts of May and June (Table 2-6). The 7-day average temperature was ≥17.8°C at Station #2 beginning April 26, and the average daily temperatures exceeded 21.1°C by mid May at Station #5 (Inflatable Dam) (Figures 2-3 through 2-9). The suitability of the water temperature regimes generally decreased with distance downstream during the last weeks of the emigration period. For example, At Station # 1 (above the pool), the weekly average temperature (7-day moving average) exceeded 17.8°C almost continuously, and exceeded 20.0°C 15 times, during June (Tables 2-7 through 2-10 present the number of times that selected temperature criteria were exceeded for surface temperatures, only. Appendix E presents the number and percentage of days that the water temperature criteria were exceeded for all criteria discussed in Table 1-3, by month, for both surface and bottom measurements). At Station #1, the weekly average temperature exceeded 20.0°C 27 times, and the maximum daily temperature exceeded 24.0°C 17 times during June (Table 2-10). The weekly average temperature also exceeded 21.1°C 24 times (reported temperature at which emigration ceases). Although the temperatures were often well above established criteria for emigrating smolts, healthy appearing Chinook salmon and steelhead smolts were captured during periods when maximum daily surface temperatures ranged to 25.2°C (see Section 3.0 for a detailed discussion of smolt emigration through the study area, including a comparison of water temperatures and smolts captured in the rotary screw traps).

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

Water temperatures were sub optimal for rearing juvenile steelhead from June through approximately mid September. Maximum daily water temperatures within the Wohler Pool ranged between 21.3 and 26.7°C during the June through September period within the study area (Table 2-6), and the weekly average temperature ranged between 20.2 and 23.7°C. At Station #1, the weekly average temperature exceeded 17.8°C almost continuously between June 1 and mid September, and exceeded 20.0°C on 19 occasions (15 times during June) (Tables 2-7 and 2-8). The weekly maximum temperature exceeded 22.0°C (the temperature at which salmonids begin seeking cool water refuge) on 60 percent of the days in June, and 16.1 percent of the days in July and August, respectively Table 2-9). Rearing conditions (based on water temperature) generally declined with distance downstream. At the upstream end of the Wohler Pool (Station #2), the weekly average temperature exceeded 17.8°C everyday, and 20.0°C 56 times between May 1 and approximately mid September. The weekly maximum temperature exceeded 22.0°C 47 times during this time-period. Maximum daily temperatures approached potentially lethal levels (>26.0°C) 7 times at Station #7 in 2001. This is the only station where temperature exceeded this criterion. Temperatures within the Wohler Pool were intermediate to Stations #1 and #7, but generally exceeded most published temperature criteria for salmonids.

2.3.5.3 Seasonal water temperatures during the fall adult upstream migration period.

Water temperatures were sub optimal during the first three to four weeks during the adult upstream migration period (September). Average daily temperatures ranged up to 20.4°C at Station #7, and weekly average temperatures ranged between 17.7 and 20.1°C (Table 2-6). After September 21, water temperatures were generally suitable for upstream migration. Water temperatures remained suitable for all upstream stations during October (Tables 2-7 through 2-10).

Table 2-6. Maximum daily average, daily maximum, maximum weekly average, and maximum weekly maximum temperatures, by month, at 7 water temperature monitoring stations, Wohler Pool, 2001.

Maximum Daily Average Temperature (°C)							
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**
May	22.2	22.7	22.6	22.9	23.1	22.7	N/A
June	21.2	21.8	22.0	22.6	23.5	23.2	23.7
July	21.7	22.6	22.8	23.2	24.1	24.0	24.8
August	20.2	20.9	20.8	21.4	22.0	21.9	22.5
September	20.4	20.4	20.4	20.5	20.6	20.6	20.4
October	17.5	18.0	18.0	18.2	18.4	18.5	18.6

Daily Maximum Temperature (by month) (°C)							
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**
May	24.8	25.2	24.8	24.4	25.2	24.0	N/A
June	23.6	24.0	24.0	24.4	24.4	24.0	26.3
July	24.4	24.8	24.4	24.4	25.6	25.2	26.7
August	21.2	22.9	22.5	22.5	23.2	22.9	24.8
September	22.1	22.1	21.7	21.3	21.3	21.3	22.1
October	19.0	19.8	19.4	19.0	19.1	19.0	20.2

Maximum Weekly Average Temperature (°C)							
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**
May	20.3	20.8	20.9	21.3	21.8	21.5	N/A
June	20.8	21.6	21.7	22.1	23.0	22.9	23.7
July	20.4	21.3	21.4	22.0	22.8	22.8	23.7
August	18.9	20.5	20.4	20.9	21.5	21.4	22.0
September	20.0	20.0	19.9	20.1	20.2	20.2	20.1
October	17.0	17.3	17.3	17.4	17.6	17.6	17.7

Maximum Weekly Maximum Temperature (°C)							
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**
May	22.6	23.0	22.8	22.8	23.0	22.4	N/A
June	23.4	23.8	23.6	23.5	24.4	24.1	26.0
July	22.9	23.4	23.1	23.2	24.1	23.9	25.8
August	21.1	22.2	21.9	22.0	22.9	22.3	24.0
September	21.4	21.4	21.0	20.8	21.0	20.7	21.6
October	18.2	18.6	18.4	18.4	18.1	18.1	19.0

Table 2-7. Number of times that the weekly average surface temperature exceeded 17.8°C, by month[1] at Stations #1 through #7, May through October, 2001.

Stations	May	June	July	August	September	October
1	N/A	30	31	31	18	0
2	31	30	31	31	18	0
3	31	30	31	31	18	0
4	31	30	31	31	18	0
5	31	30	31	31	19	0
6	N/A	30	31	31	21	0
7	N/A	30	31	31	26	0

Table 2-8. Number of times that the weekly average surface temperature exceeded 20.0°C, by month[1] at Stations #1 through #7, May through October 2001.

Stations	May	June	July	August	September	October
1	N/A	15	2	0	2	0
2	18	22	8	6	2	0
3	20	22	7	6	0	0
4	26	23	19	16	2	0
5	26	25	28	27	3	0
6	N/A	25	28	27	3	0
7	N/A	27	31	29	3	0

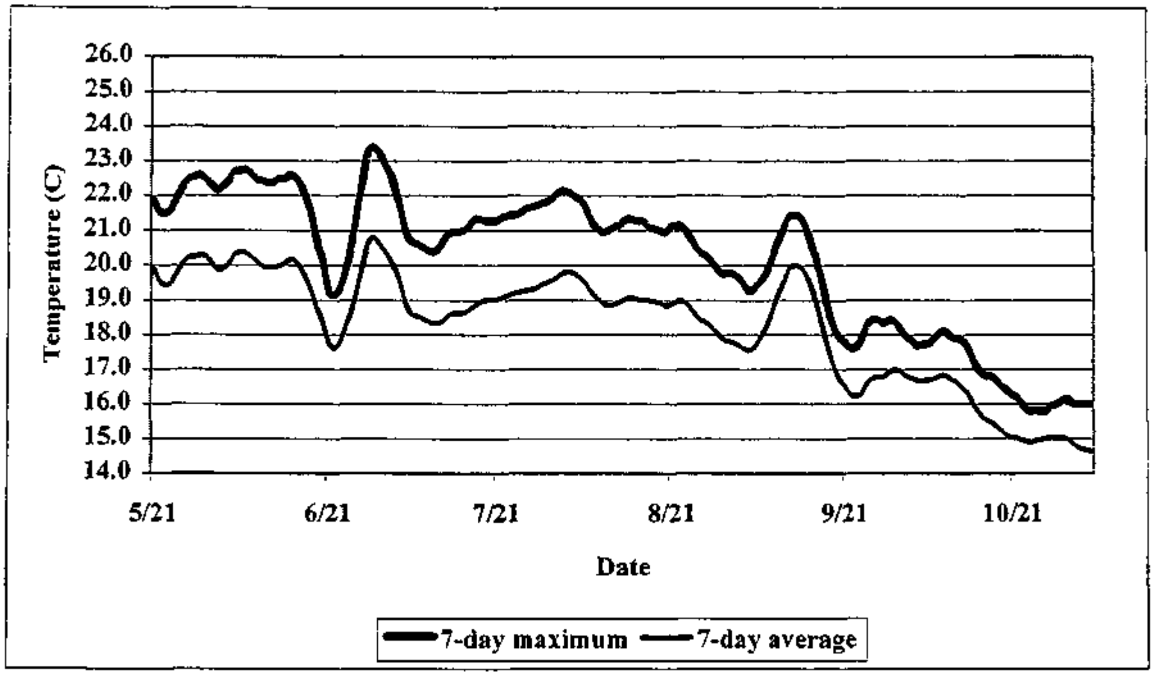
Table 2-9. Number of times that the weekly maximum weekly surface temperature exceeded 22.0°C, by month[1], at Stations #1 through #7, May through October, 2001.

Stations	May	June	July	August	September	October
1	N/A	18	5	5	1	0
2	16	22	5	4	0	0
3	15	22	3	0	0	0
4	15	22	4	1	0	0
5	15	23	11	7	0	0
6	N/A	23	5	5	0	0
7	N/A	25	31	28	0	0

Table 2-10. Number of times that the daily maximum surface temperature exceeded 24.0°C, by month[1], at Stations #1 through #7, May through October, 2001.

Stations	May	June	July	August	September	October
1	N/A	0	0	0	0	0
2	2	2	3	0	0	0
3	1	1	2	0	0	0
4	1	1	2	0	0	0
5	1	7	5	0	0	0
6	N/A	1	4	0	0	0
7	N/A	17	8	4	0	0

[1] Includes the first 1 to 6 days of the following month, depending on the date (e.g. the 7-day average temperature for June 29th would extent through July 5th).



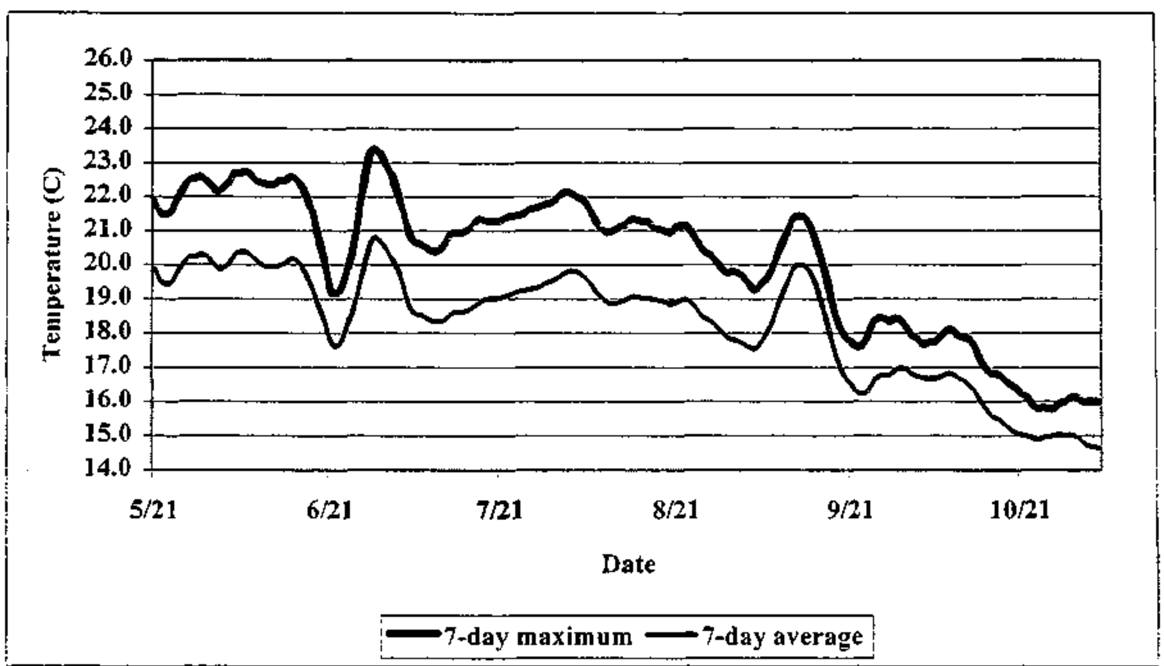
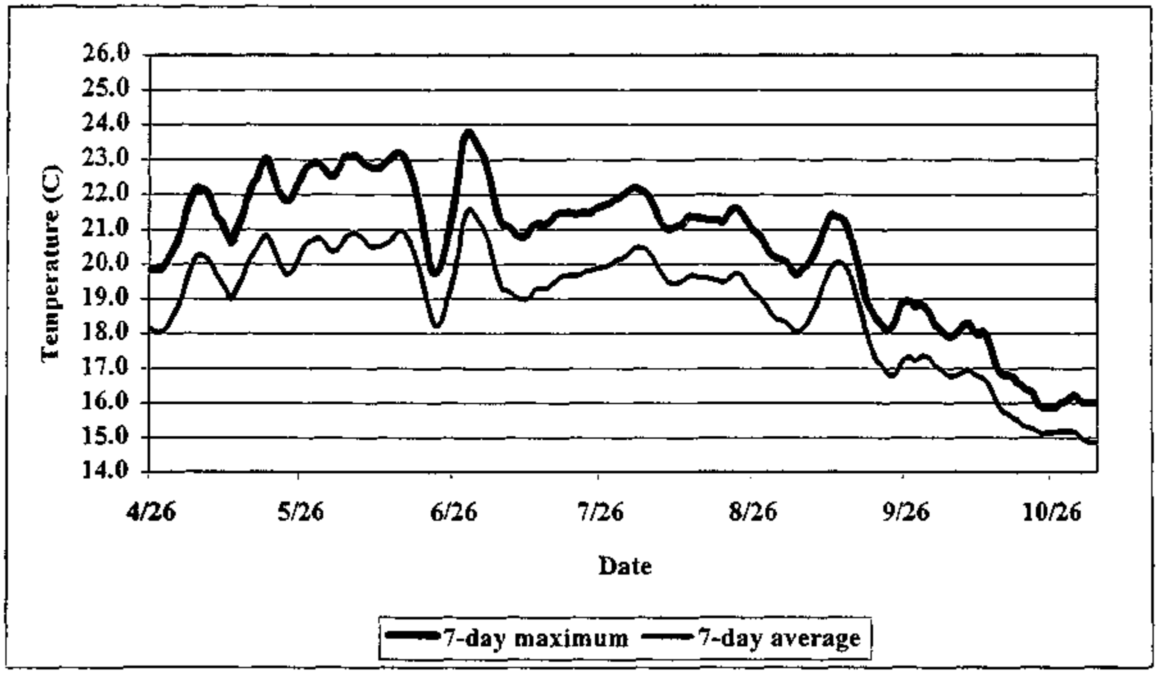


Figure 2-3. **7-day maximum and the 7-day average water temperatures recorded at a depth of 0.5 meters (top figure) and 2.0 meters (bottom figure), Station #1, Mirabel Study Area, Russian River, May 21 through November 4 2001.**



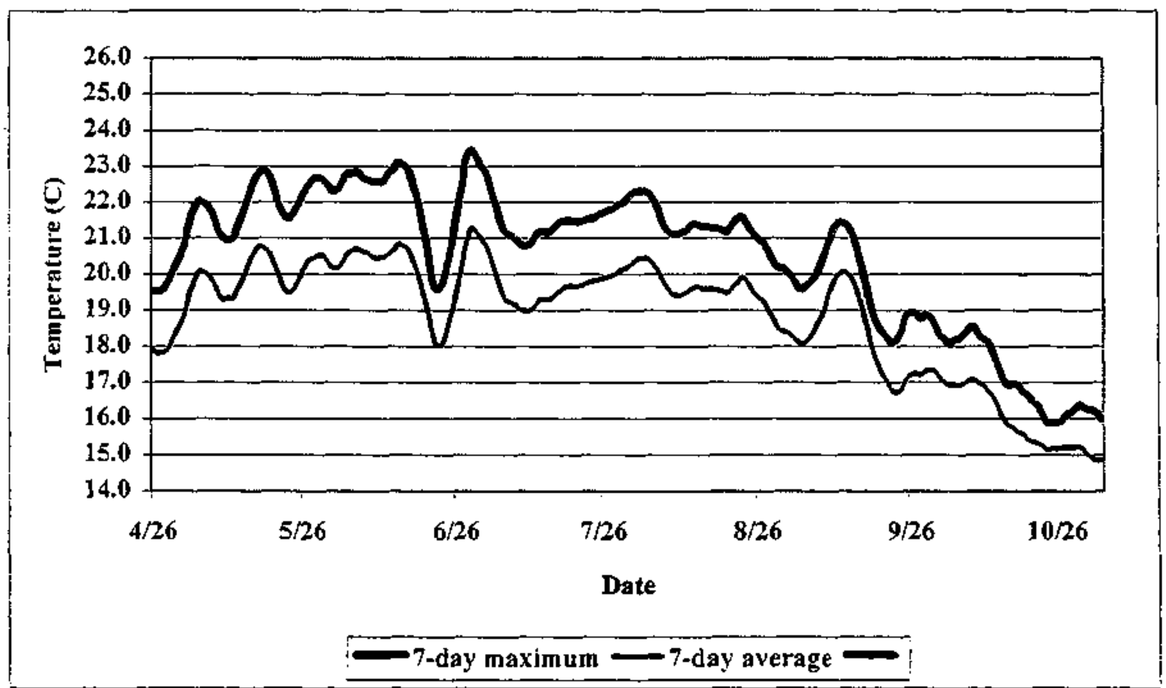
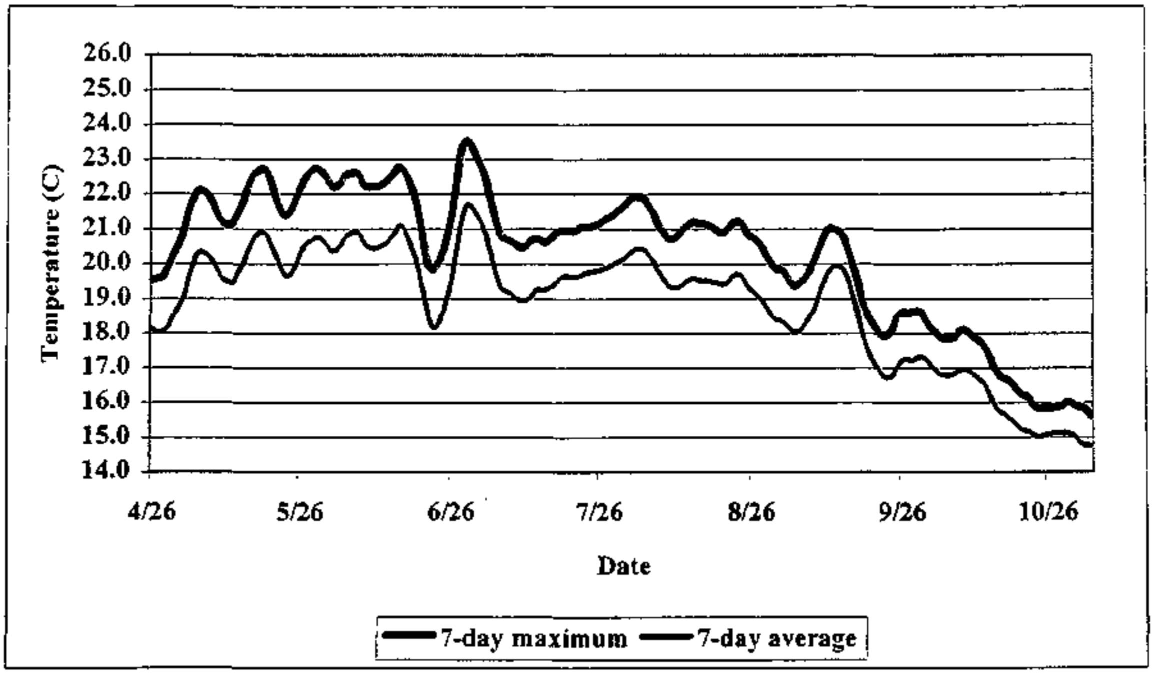


Figure 2-4. **7-day maximum and 7-day average water temperatures recorded at a depth of 0.5 meters (top figure) and 3.0 meters (bottom figure), Station #2, Mirabel Study Area, Russian River, April 26 through November 4, 2001.**



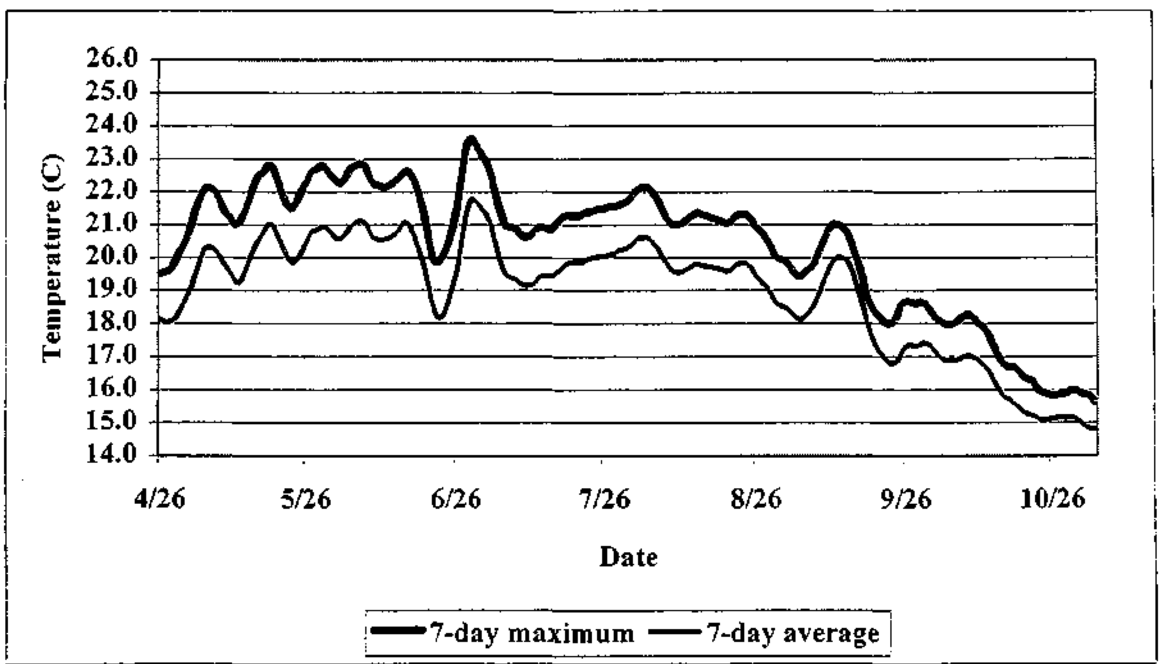
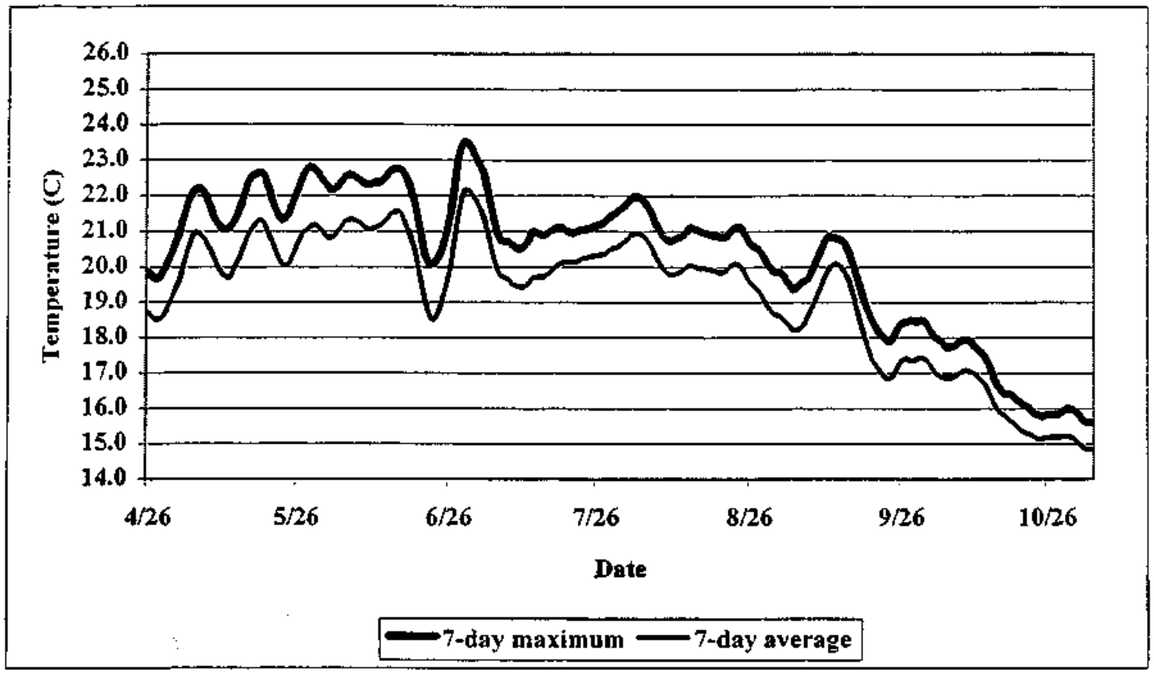


Figure 2-5. 7-day maximum and 7-day average water temperatures recorded at a depth of 0.5 meters (top figure) and 4.0 meters (bottom figure), Station #3, Mirabel Study Area, Russian River, April 26 through November 4 2001.



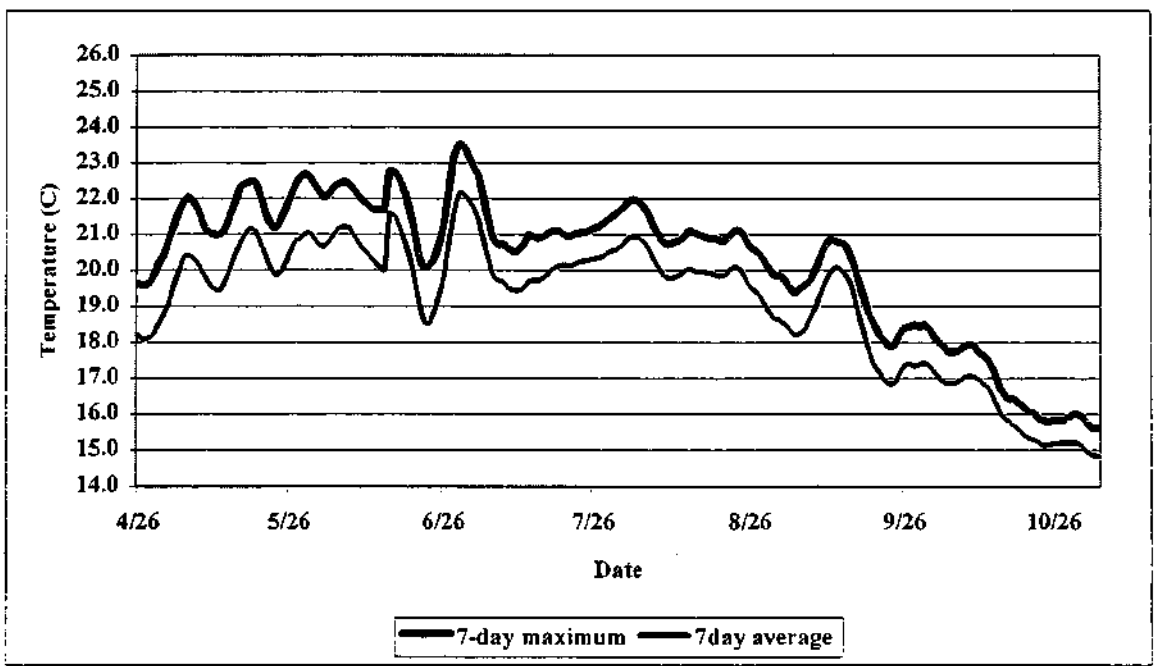
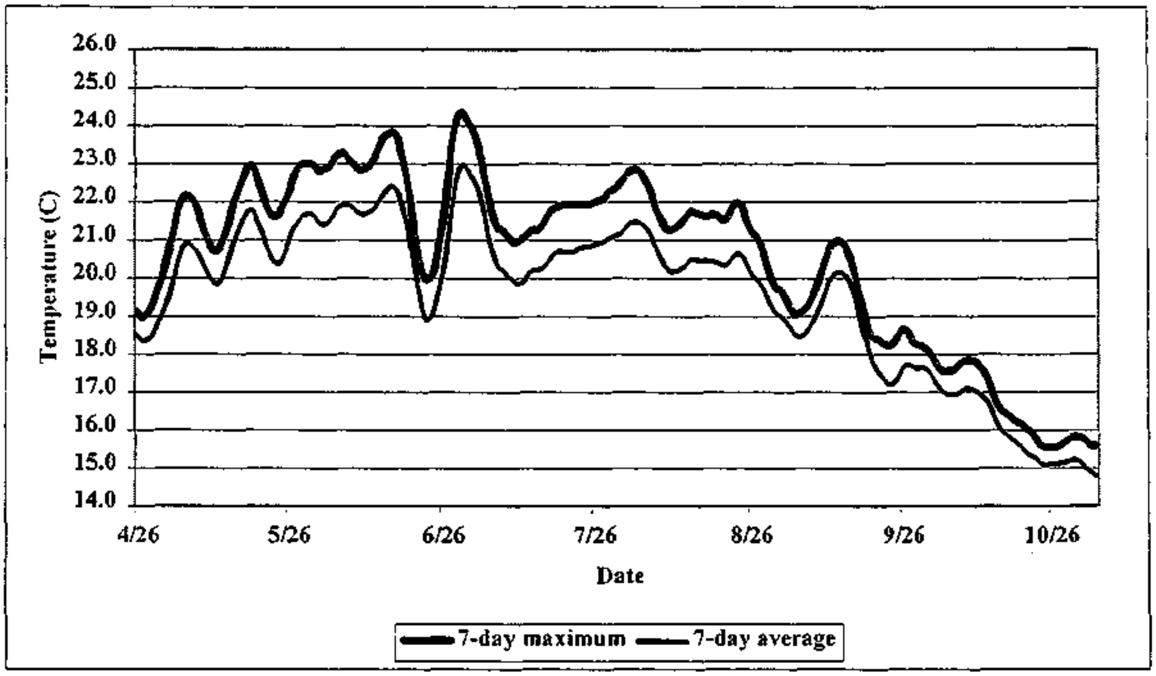


Figure 2-6 7-day maximum and 7-day average water temperatures recorded at a depth of 0.5 meters (top figure) and 3.0 meters (bottom figure), Station #4, Mirabel Study Area, Russian River, April 26 through November 4 2001.



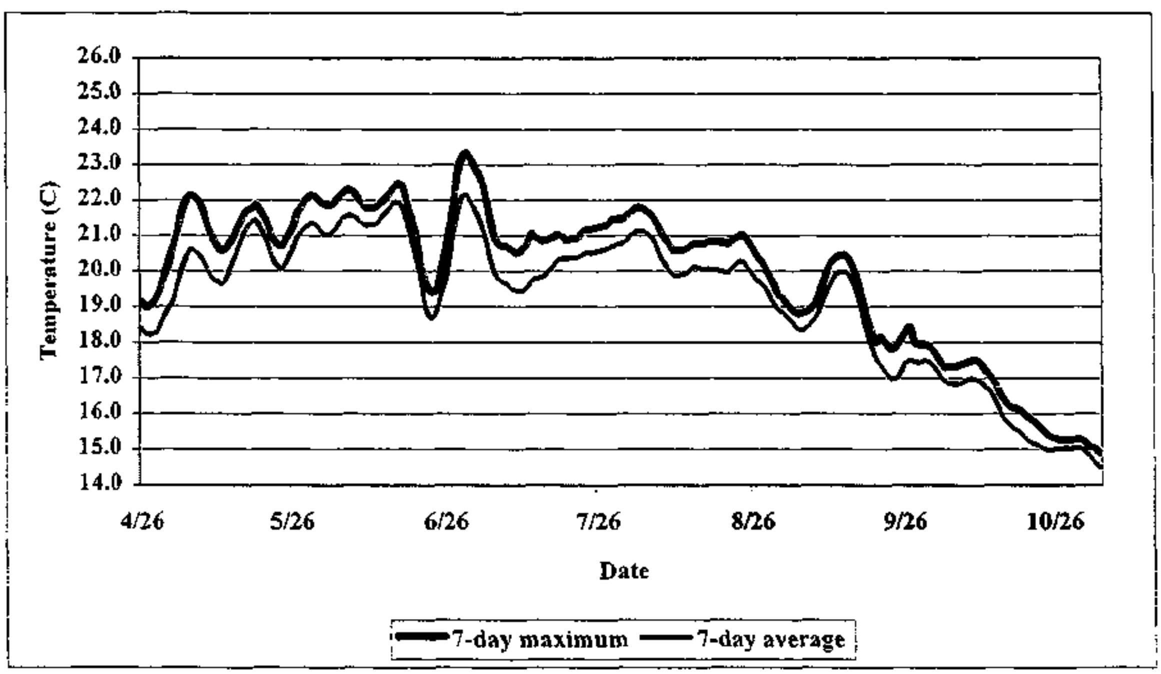


Figure 2-7 7-day maximum and 7-day average water temperatures recorded at a depth of 0.5 meters (top figure) and 3.0 meters (bottom figure), Station #5, Mirabel Study Area, Russian River, April 26 through November 4 2001.

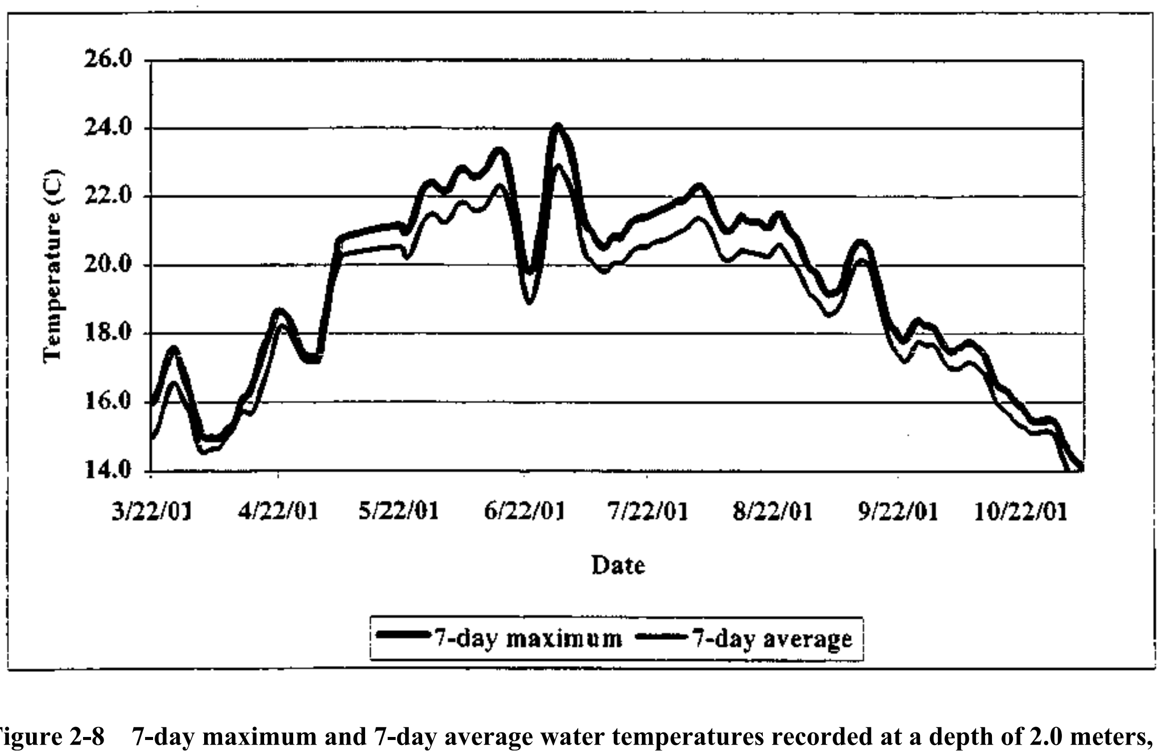
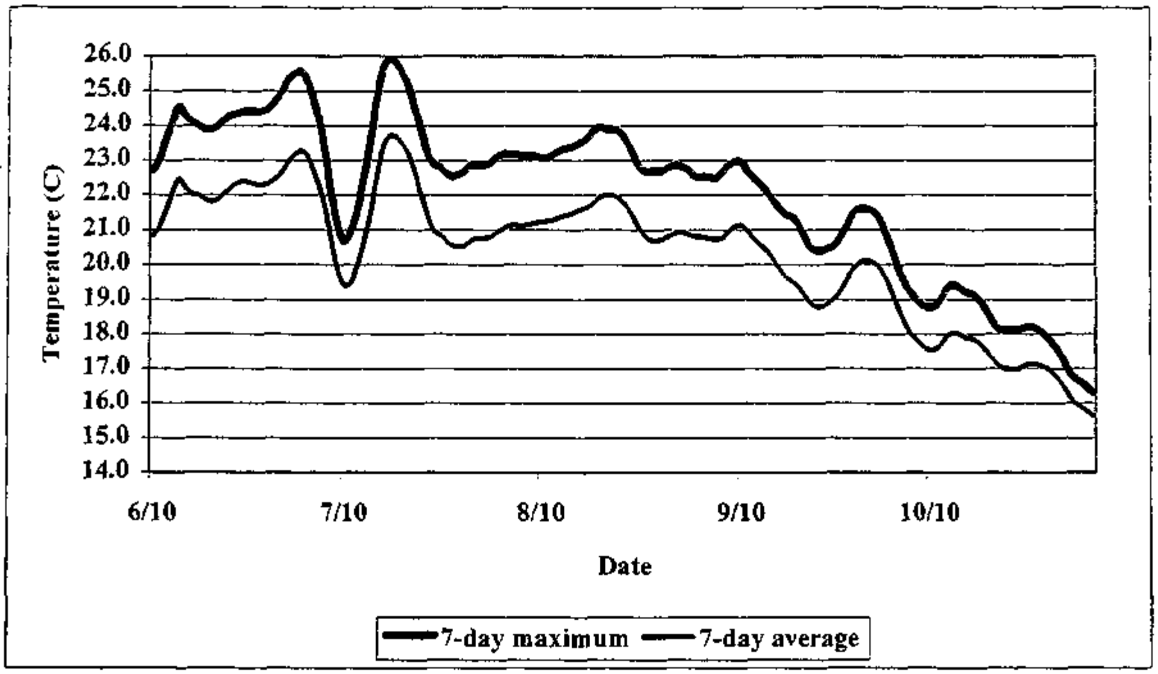


Figure 2-8 7-day maximum and 7-day average water temperatures recorded at a depth of 2.0 meters, Station #6, Mirabel Study Area, Russian River, March 22 through November 4, 2001.



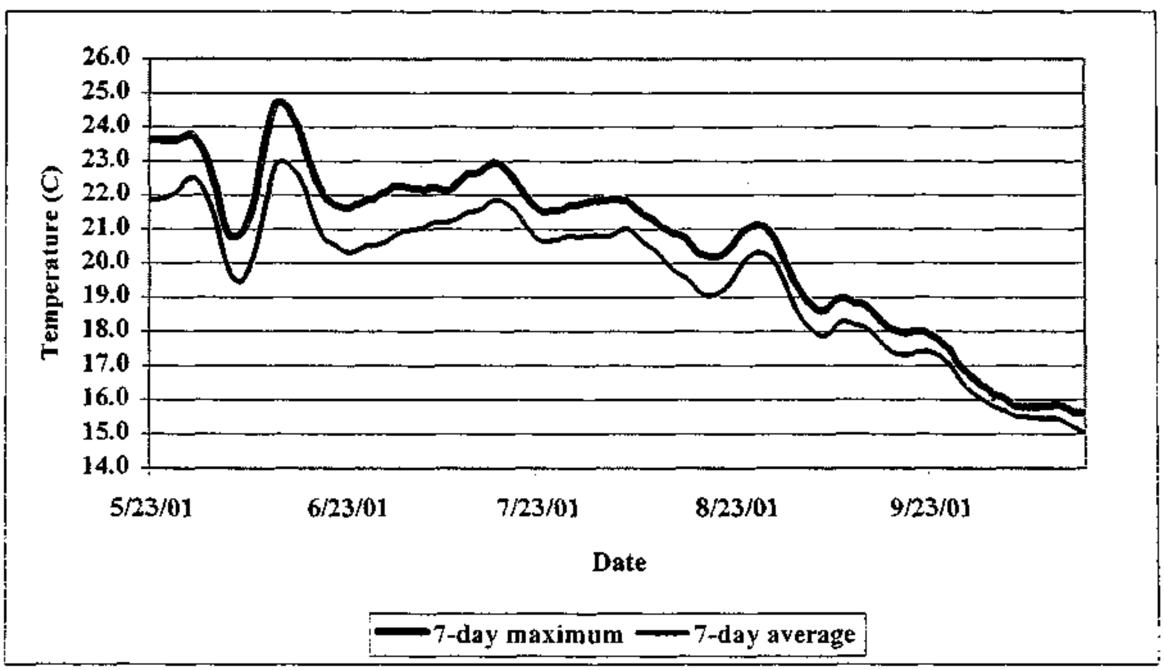


Figure 2-9 7-day maximum and 7-day average water temperatures recorded at a depth of 0.5 meters (top figure) and 2.0 meters, (bottom figure), Station #7, Mirabel Study Area, Russian River, May 24 through November 4, 2001.

2.3.6 Water Temperature Profiles

Water and dissolved oxygen profiles were collected on 10 occasions between May 17 and November 5, 2001 (Table 2-11). The Wohler Pool did not become thermally stratified during the 2001 sampling season. The largest difference between the surface (0.1 m) and bottom (3.0 m) water temperatures recorded occurred at the Station #5 on June 14 (3.0°C). Bottom and surface temperatures were within 0.7°C at Stations #2 through #4. The greatest change in water temperature generally occurred within the upper 0.5 meters of the water column. Water temperatures recorded at a depth of 0.5 meters were within 1.3°C of the bottom depth at all stations. At the three upstream profiling stations, the maximum change in temperature between a depth of 0.5 m and the deepest spot for each profile was 0.7°C at Station #4, and 0.3°C at stations #3 and #2.

Daytime dissolved oxygen (DO) levels ranged from 6.4 to 13.2 ppm (Table 2-11). Except for a two-week period in July, DO levels were within acceptable levels for rearing steelhead juveniles. Conductivity ranged from 203 to 274 µmhos (Table 2-11).

2.4 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 sub optimal, and may negatively affect the long-term survival of these 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.

2.5 SIGNIFICANT FINDINGS

The Wohler Pool and the resulting impoundment appear to have a small influence on the rate at which water warms. Compared to the rate at which water warms over the 6.5 km reach immediately above the Wohler Pool, the water flowing through the Wohler Pool was estimated to increase (in magnitude) from 0.1 (September) to 0.6°C (June) above what would have been expected without the dam in place. The increase in the rate at which water warms within the Wohler Pool due to the presence of the impoundment had the effect of raising the average monthly surface water temperature from 20.6 to 21.2 in June, from 20.5 to 21.0 in July, from 20.3 to 20.6 in August, and from 18.6 to 18.7 in September

Compared to proposed water temperatures standards for the Russian River, water temperatures in the study area were sub optimal for at least the last half of the smolt emigration period, the entire juvenile steelhead rearing period, and the beginning of the adult upstream migration period. The sub optimal 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 25.2°C (see Section 3.0 for a detailed discussion of smolt emigration through the study area, including a comparison of water temperatures and smolts captured in the rotary screw traps). In addition, juvenile steelhead were captured and observed in the Wohler Pool throughout the summer months. Water temperatures were sub optimal 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 2001 sampling seasons.

Table 2-11. Water quality profiles data, Wohler Pool - Russian River, May 17 through November 5, 2001.

Station #2										
Temperature										
Depth	**May 17**	**June 14**	**July 3**	**July 19**	**Aug 21**	**Sept 13**	**Sept 27**	**Oct 11**	**Oct 25**	**Nov 5**
0.1	19.4	21.5	21.5	19.4	21.7	21.3	18.7	17.5	16.6	15.2
0.5			21.4	19.6	21.7	21.1	18.7	17.4	16.6	15.2
1.0		21.3	21.3	19.6	21.7	21.0	18.6	17.4	16.6	15.1
2.0			21.1		21.7	21.0	18.6	17.4	16.6	15.2
2.5	195	21.5				20.9	18.5		16.6	15.2
Dissolved Oxygen										
0.1	8.9	9.0	7.5	10.9	13.2	12.3	12.7	10.7	12.4	12.5
0.5			7.5	11.7	13.2	11.9	12.6	10.6	12.1	12.1
1.0		8.8	7.5	11.8	12.9	12.0	12.0	11.0	12.2	12.4
2.0			7.4	11.9	13.0	11.6	11.7	11.1	12.3	12.2
2.5	8.9	9.0			13.2	12.3	12.1		11.9	12.3
Conductivity										
1.0	270	240	228	218	204	237	209	221	227	236

Station #3										
Temperature										
Depth	**May 17**	**June 17**	**July 3**	**July 19**	**Aug 21**	**Sept 13**	**Sept 27**	**Oct 11**	**Oct 25**	**Nov 5**
0.1	19.9	21.1	21.9	20.2	21.2	20.2	18.3	16.9	15.9	15.4
0.5			21.7	20.0	21.3	20.2	18.3	16.9	15.9	15.1
1.0		21.0	21.6	19.9	21.3	20.2	18.3	16.9	15.9	15.1
2.0		20.8	21.6	19.8	21.4	20.3	18.2	16.9	15.9	14.9
3.0		20.9	21.5	19.7	21.4	20.3	18.2	16.9	16.0	14.9
4.0		20.9	21.5	19.7	21.4	20.3	18.2	17.0	16.0	14.9
5.0	19.7	20.9	21.5			20.3				14.9
Dissolved Oxygen										
0.1	9.0	8.5	6.6	11.2	11.7	10.4	11.3	9.5	10.9	12.4
1.0			6.7	11.0	11.7	10.3	11.0	8.8	10.8	12.1
2.0		8.5	6.7	11.2	11.5	10.0	10.5	8.9	10.8	11.8
3.0		8.5	6.6	11.3	12.0	10.6	10.7	9.8	10.9	11.7
3.5		8.6	6.5	11.3		10.4	10.3	9.4	10.6	11.4
4.0		8.5	6.5	11.4		10.6	10.3	9.2	10.8	11.5
4.5	8.6	8.4	6.5			10.5				11.7
Conductivity										
1.0	270	240	235	217	203	235	211	222	229	237

Table 2-11. Water quality profiles data, Wohler Pool - Russian River, May 17 through November 2000 (concluded).

Station #4										
Temperature										
Depth	**May 17**	**June 14**	**July 3**	**July 19**	**Aug 21**	**Sept 13**	**Sept 27**	**Oct 11**	**Oct 25**	**Nov 5**
0.1	20.7	21.1	22.4	20.4	20.7	20.4	18.7	17.4	15.5	15.3
0.5		21.1	22.2	20.3	20.7	20.3	18.4	17.2	15.5	15.1
1.0	20.2	20.8	22.1	20.2	20.7	20.3	18.2	17.2	15.6	14.9
2.0		20.4	22.0	20.2	20.7	20.2	18.1	17.1	15.5	14.9
3.0	20.1	20.4	22.0	20.1	20.8	20.2	18.0	17.1	15.6	14.8
3.4				20.1		20.4			15.6	
Dissolved Oxygen										
0.1	8.7	8.4	6.7	10.4	10.2	9.6	8.6	8.0	10.0	11.3
0.5			6.6	10.6	9.8	9.6	9.0	8.8	9.6	11.2
1.0	8.2	7.9	6.6	10.8	10.4	9.0	8.9	8.9	9.8	11.1
2.0	8.0	7.6	6.5	10.5	10.2	9.4	8.7	8.2	9.8	10.9
3.0		7.7	6.4	10.1	10.2	9.0	8.7	8.1	9.6	10.9
3.4				11.0		9.7			10.1	
Conductivity										
1.0	270	242	232	217	203	239	212	222	230	238

Station #5										
Temperature										
Depth	**May 17**	**June 14**	**July 3**	**July 19**	**Aug 21**	**Sept 13**	**Sept 27**	**Oct 11**	**Oct 25**	**Nov 5**
0.1	22.3	23.9	22.9	22.2	22.1	21.2	20.2	17.5	17.6	17.7
0.5	22.0	21.6	22.8	22.1	22.1	20.8	19.0	17.5	16.4	15.8
1.0	20.2	21.1	22.7	21.0	22.2	20.3	18.7	17.4	15.9	15.4
2.0	20.2	21.0	22.7	20.7	21.5	20.0	18.4	17.3	15.8	15.2
3.0	20.2	20.9	22.7	20.8	21.3	20.0	18.4	17.3	15.8	15.1
Dissolved Oxygen										
0.1	7.7	7.1	8.1	11.8	10.3	10.2	9.9	9.2	10.0	10.4
0.5	8.5		7.9	10.4	10.0	10.5	9.7	9.0	10.0	10.8
1.0	7.7	7.6	7.7	11.0	9.2	10.2	9.5	9.5	10.3	11.1
2.0	7.8	7.0	8.0	10.8	9.2	10.3	9.6	9.8	10.5	11.3
3.0	7.8	7.6	8.3	10.7	9.3	10.3	8.5	10.3	10.1	11.9
Conductivity										
1.0	274	243	231	217	203	239	212	222	228	235

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 salmonid 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. The disoriented smolts may be delayed or unable to find their way downstream of the dam. Smolts have a seasonal "window of opportunity" to complete the physiological process (smoltification) necessary to survive in the marine environment. A substantial delay in migration may result in smolts revert to a "resident form," thus spending an additional year in freshwater. Depending on summertime conditions, this may greatly increase mortality of smolts failing to successfully migrate to the ocean. 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 provided information on species composition, timing of emigration (past a particular point on the river), allowed for the collection of size and age data, plus allowed for the collection of tissue for DNA sequencing. Tissue samples collected during the study are provided to the NMFS for analysis, and results of their study will be published by the Service. A mark-recapture study was also initiated during the last five weeks of smolt sampling to estimate the magnitude of the number of Chinook salmon smolts emigrating past the dam. Radio-telemetry provided information on the rate of emigration of hatchery steelhead smolts with surgically implanted radio transmitters through the pool and past the dam, as well as providing some insight into the fate of those that did not pass the dam. The results of the radio-telemetry study are presented in a companion study (Manning *et al* 2000, Manning *et al.* in prep.).

3.1 METHODS

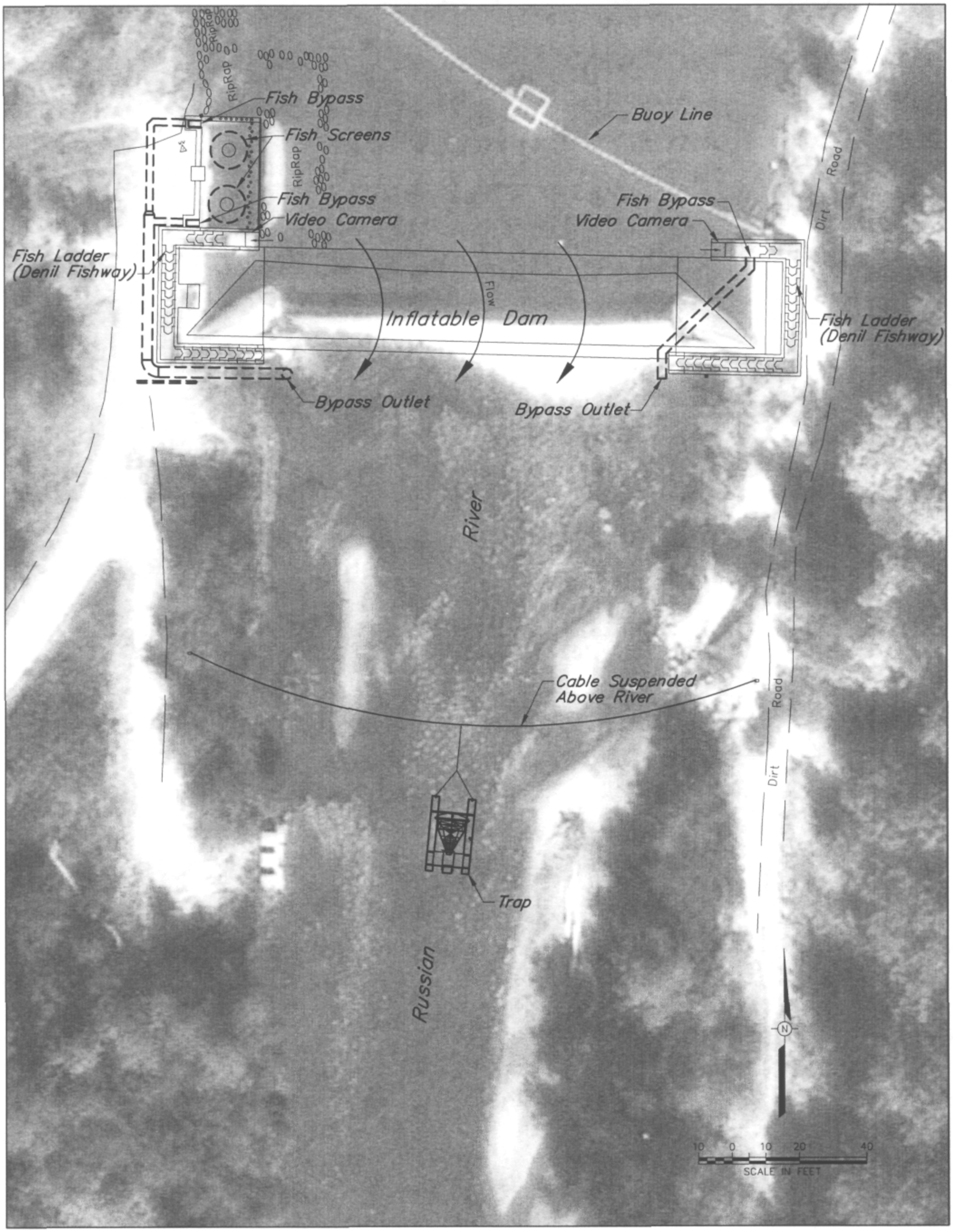
3.1.1 Rotary Screw Trap

The rotary screw trap site was 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.

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

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



DATE OF PHOTOGRAPHY: SEPT 30, 1999

SONOMA COUNTY WATER AGENCY

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

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

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

3.1.2 Operation of the Rotary Screw Fish Trap

Two rotary screw traps (5 feet in diameter) were used during the 2001 sampling season. The rotary screw fish trap is a cone consisting of perforated stainless steel panels which houses an internal Archimedes screw. Water striking the angled surface of the internal screw rotates the cone and screw assembly. As the assembly rotates, fish are trapped within the chambers formed by the screw and moved rearward into the live box at the back of the trap. The live box is constructed such that areas of very low water velocity are provided as resting areas for fish held in the box. Debris such as leaves and small twigs entering the live box are impinged on a rotating debris screen located at the back of the live box. As the screen rotates, debris is carried out of the box, maintaining a relatively clean environment for the fish held in the live box. The cone is mounted between two pontoons and is lowered and raised with a bipod and windlass located at the front of the cone. Rotary screw traps are lowered into the water column until half of the cone is submerged (a 5-foot diameter trap requires a minimum depth greater than 2.5-feet to operate).

The rotary screw traps were installed in the river on the afternoon of April 19 and fished through the morning of June 7. Fish captured by the screw traps were netted out of the live well and placed in a plastic box (approximately 3.0 feet by 2.0 feet) containing freshwater. Prior to data collection, fish were placed in 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 augmented with one or two small aerators to insure that the DO levels remained saturated. Once equilibrium was regained, the fish were released into the river downstream of the screw traps.

3.1.3 Mark-Recapture Study

Beginning May 3, Chinook salmon captured in the trap were subsampled, and up to 25 fish (depending on the number of fish captured) were marked with a caudal clip (identical to the clip used to collected tissue samples). Marked fish were held in a container of water equipped with aerators, and transported and released approximately 2,500 feet above the dam. The proportion of marked to unmarked fish captured in the traps were 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 is inflated or deflated. Streamflow generally declined throughout the study, with few exceptions. The screw traps were operated from April 19 through June 7, excluding three days. The traps were not operated on April 22 and May 28-29 due to insufficient flow in the river to operate the traps. The river configuration was altered significantly between the 2000 and 2001 trapping seasons. An island formed in the river between the dam and the trapping location. The split channels concentrated streamflow in relatively small channels (compared to conditions in 2000), creating excellent conditions for fishing the screw traps. As a result, the trapping efficiencies in 2001 were undoubtedly superior to those experienced during the 1999 and 2000 trapping season.

During the 2001 trapping season, 4,519 fish (excluding larval fish, mainly Sacramento sucker, pikeminnow, and hardhead) including twenty-one species were captured (Table 3-1). Chinook smolts were the most abundant species collected, followed by young-of-the-year steelhead, sculpin, ammocoetes (immature lamprey), and white crappie.

3.2.2 Salmonids

3.2.2.1 Chinook salmon

Chinook smolts were captured throughout the trapping season (April 20 - June 7, 2001). Although trapping began after the start of the Chinook salmon emigration season, based on the daily catch rates, it appeared that Chinook smolt emigration peaked between late April and mid-May (Table 3-1). After mid-May, the daily Chinook smolt catch quickly declined from a peak daily catch of 333 on May 8 to ≤ 17 per day starting May 22. For the season, 3,722 smolts were captured in the traps (Appendix F provides daily catch data for all species).

A mark-recapture study was initiated on May 3, continuing through June 5. During the study period, 525 Chinook smolts were marked with a caudal clip and released approximately 0.8 km upstream of the traps: 60 smolts were subsequently recaptured. Weekly capture efficiencies were developed for the five-week period. Capture efficiencies ranged from 20.0 percent during the first week of the mark-recapture study to 2.7 percent during the last week of the study (Table 3-2). For the mark-recapture study period (all catch data combined), the capture efficiency was 11.4 percent. Estimates of smolts migrating past the traps were developed using both the weekly and combined capture efficiencies during the five-week sampling period (Table 3-2). Estimates of smolt emigration past the trap ranged from 18,511 using the weekly capture efficiencies, to 20,341 using the seasonal capture efficiency. During the five-week mark-recapture study, 2,314 Chinook smolts were actually caught. The estimates presented do not represent a seasonal estimate of smolt abundance since the first part of the emigration period was not sampled.

Water temperatures were recorded at Station 2 (upstream end of Wohler Pool) from April 26 through the end of smolt sampling. Data from this station reflects the thermal environment in the river influencing smolts prior to entering the Wohler Pool. Based on a literature review conducted by the NCRWQCB, Chinook salmon exhibit positive growth at temperatures between 4.4 and 18.9°C, are prevented from emigrating at 21.1°C, and have a daily maximum temperature of approximately 23.3°C. The 7-day average water temperatures ranged from 18.0 to 20.9°C, and 7-day maximum temperatures ranged up to 23.1°C between April 26 and June 7, 2001 (Figure 2-4). During the peak Chinook smolt emigration period (last week in April and the first two weeks of May), the weekly average temperature ranged from 18.0 to 20.3°C, and the weekly maximum temperature ranged from 20.6 to 23.2°C. The daily Chinook smolt catch declined beginning the week of May 12. At the same time, the daily average water temperature also declined slightly. This suggests that the rapid decline in the number of Chinook smolts captured in the trap was likely related a natural decrease in the number of smolts remaining in the river as the emigration run declined, and was not related to water temperature.

Table 3-1. Weekly catch in the rotary screw trap catch, 2001 sampling season.

	Week of								
Species	**4-16[1]**	**4-23**	**4-30**	**5-7**	**5-14**	**5-21**	**5-28**	**6-4[2]**	**Totals**
Chinook salmon smolts	122	720	1,338	1,154	226	76	64	22	3,722
Wild steelhead smolts	7	16	16	9	4	0	0	1	53
Hatchery steelhead smolts	3	1	2	0	0	1	1	0	8
Young-of-the-year steelhead	1	17	4	13	23	34	32	26	150
Adult steelhead	0	0	1	0	0	1	0	0	2
Adult lamprey	0	4	1	0	0	0	0	0	5
Ammocoete	107	21	2	1	1	3	0	1	136
Pikeminnow	0	2	0	0	0	0	0	0	2
Hardhead[3]	0	2	4	1	1	2	0	1	11
Sculpin	0	41	18	18	25	17	12	7	138
Tule perch	0	0	0	1	2	5	1	3	12
Threespine stickleback	0	8	4	12	8	1	0	0	33
Sacramento sucker	0	4	0	0	1	4	2	3	14
California roach	0	5	3	1	3	3	10	1	26
Hitch	0	0	0	1	0	0	0	0	1
Golden shiner	0	1	0	0	0	0	0	0	1
Carp	0	0	0	0	0	1	3	3	7
Fathead minnow	0	1	0	0	1	1	0	0	3
Smallmouth bass	0	0	0	0	0	1	7	17	25
Largemouth bass	0	0	0	0	0	0	5	0	5
Green sunfish	0	2	3	3	0	1	0	1	10
Bluegill	0	3	5	5	0	1	1	0	15
White crappie	0	6	62	22	14	15	10	2	131
Channel catfish	0	1	0	1	0	1	0	0	5
Bullhead sp.	0	2	0	1	1	0	0	0	4
TOTAL	240	857	1,464	1,243	309	170	148	88	4,519

[1] Trap fished for 4 days during the first week of sampling
[2] Trap fished for 4 days during the last week of sampling
[3] Several hundred larval pikeminnow and hardhead were captured in the traps, but not enumerated
[4] Several thousand larval suckers were captured in the traps, but not enumerated

Table 3-2. Results of the 2001 mark-recapture study.

Week of	Chinook smolts marked	Chinook smolts recaptured	Weekly trap efficiency	Weekly estimate	Seasonal estimate	Actual catch
Apr 30[1]	75	15	20.0	4,115	7,200	823
May 7	174	23	13.2	8,730	10,096	1,154
May 14	169	18	10.7	2,122	1,977	226
May 21	70	3	4.3	1,657	621	71
May 28[2]	37	1	2.7	1,887	446	51
Seasonal Total	525	60	11.4	18,511	20,341	2,314

[1] Three days only sampled during this weekly period
[2] Traps were not operated on May 28 and 29. Time-period covered for this week was May 30 through June 5.

The average size of Chinook smolts captured in the screw trap remained relatively constant throughout the trapping season (Table 3-3). Chinook smolts captured at Mirabel averaged 83 mm in length during the first week of trapping, and 88 mm in length during the last week of trapping. Individual Chinook smolts ranged in length from 43 to 109 mm FL throughout the 2001 sampling period.

Wild Steelhead Smolts: Steelhead smolts were captured throughout the trapping season, but at lower numbers than Chinook smolts. For the season, 53 wild steelhead smolts were captured in the rotary screw trap (Table 3-1). Steelhead smolts were captured primarily in late April and early May.

Wild steelhead smolts in the Russian River emigrate primarily as 2-year-old fish. Scale samples were collected from 48 wild steelhead captured in the screw trap. Of these, eight were aged as Age 0+, one was aged as Age 1+, and 29 were aged as Age 2+ (10 scale samples were unreadable due to re-absorption of scale tissue). Ages were assigned to all steelhead captured in the screw trap using both fish of known age (scales), and based on length frequency histograms. Since fish were captured over a three-month period, fish were grouped based on date of capture (one-week intervals). The steelhead captured were produced in several different streams in the upper basin; each stream with potentially different rearing conditions. Thus, steelhead from one stream may be considerably larger than steelhead of the same age rearing in a different stream. Only three steelhead were aged as one-year-old (Figure 3-4). Age 1+ fish ranged in length from 112 to 145 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 may not have been ocean bound emigrants. Age 2+ smolts ranged in length from 145 to 223 mm FL (Figure 3-4, Table 3-5).

Wild Steelhead Young-of-the-Year (YOY): A total of 150 YOY steelhead were captured during the 2001 trapping season. It is not known if the YOY took up residence in the mainstem river, moved into tributary streams, emigrated to the estuary/ocean, or perished. A few YOY steelhead were captured in the Wohler Pool during August electrofishing surveys. These fish were generally larger than similar aged steelhead captured in Mark West and Santa Rosa creeks during fall surveys conducted by the Agency. In the Russian River Basin, water temperature in the lower reaches of most tributaries is generally above the range that salmonids can survive, and the flow is very low to non-existent. As a result, steelhead are unable to move between tributaries and the mainstem by early summer. Therefore, steelhead captured in the mainstem during the summer were either hatched in the mainstem, or migrated to the mainstem during the winter/spring period when streamflow and water temperatures were suitable. The relatively large size suggests that at least some of the fish surviving to the summer demonstrate excellent growth rates. However, survival rates are unknown, but appear to be low. Age 0+ steelhead ranged in length from 24 to 93 mm FL during the study (Table 3-4). The average length of YOY steelhead increased from 42 mm during the third week in April (excluding the one YOY steelhead captured during the week of April 16), to 69.0 mm during the first week in June.

Table 3-3. Weekly minimum, average, and maximum lengths of Chinook salmon smolts captured in the rotary screw trap, 2001 sampling season.

Week of	Number	Minimum length	Average length	Maximum length
Apr 16	122	52	83	97
Apr 23	670	43	82	109
Apr 30	1327	50	86	108
May 7	772	48	85	108
May 14	239	59	87	108
May 21	76	66	80	102
May 28	65	65	86	102
Jun 4	21	74	88	107

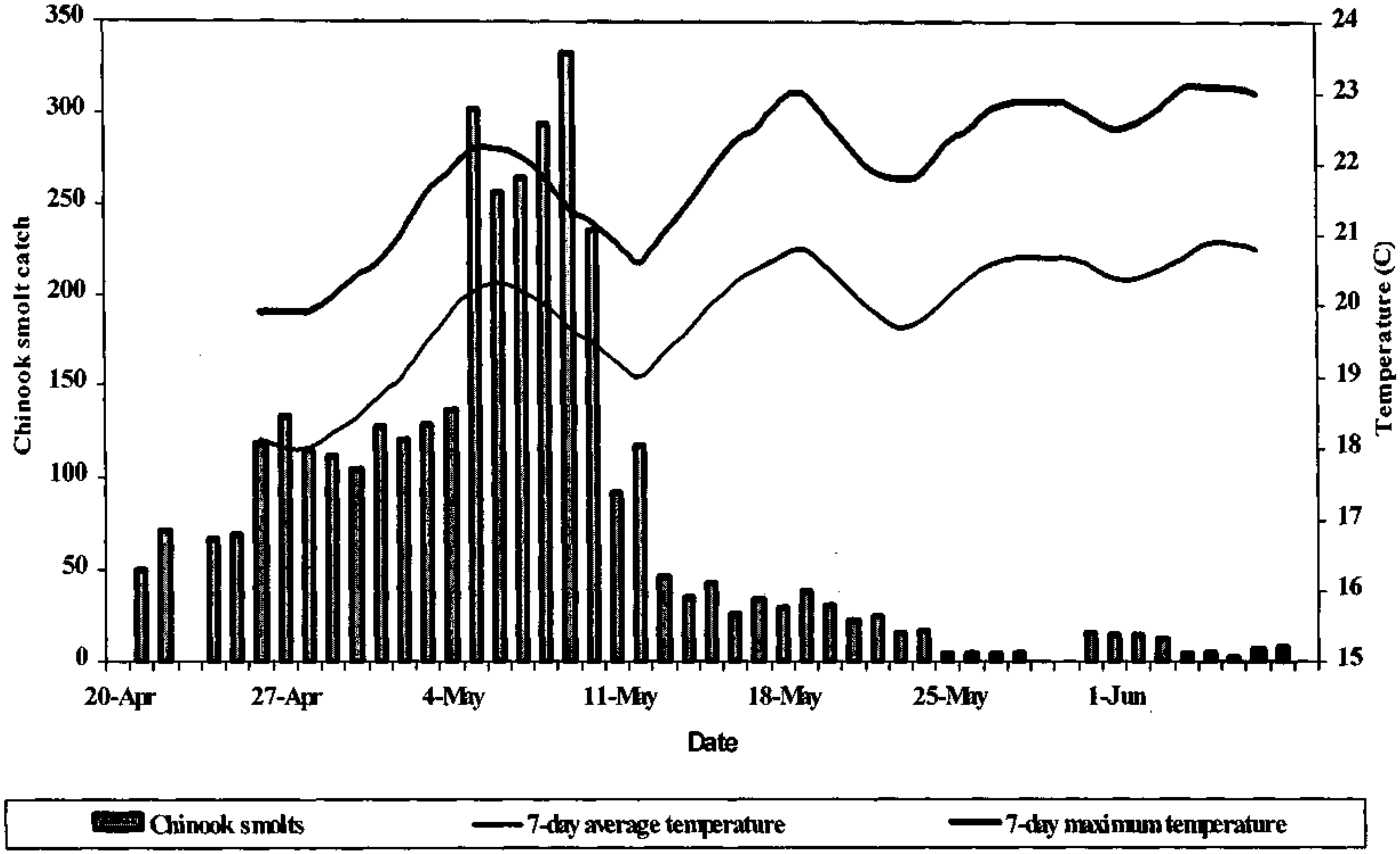


Figure 3-3. **Daily Chinook smolt catch and the corresponding 7-day average temperatures and the 7-day average maximum temperatures (temperatures recorded at Station #2, upstream of the influence of the Inflatable Dam).**

Table 3-4. Weekly catch and size range (mm) of young-of-the-year steelhead captured in the screw trap, 2001

Week of	N	Minimum	Average	Maximum
April 16	1	29	29	29
April 23	16	27	42	65
April 30	5	50	65	88
May 7	13	34	53	73
May 14	23	25	53	75
May 21	35	52	67	90
May 28	32	24	66	92
June 4	25	37	69	93

Table 3-5. Weekly average, minimum and maximum lengths of steelhead smolts captured in the screw trap, 2001

Week of	N =	Minimum length (mm)	Average length (mm)	Maximum length (mm)
April 16	7	139[1]	169	196
April 23	16	144[1]	176	223
April 30	15	160	188	210
May 7	9	160	180	194
May 14	4	162	177	188
May 21	0	—	—	—
May 28	0	—	—	—
June 4	1	145	145	145

[1] Aged as a one-year-old fish

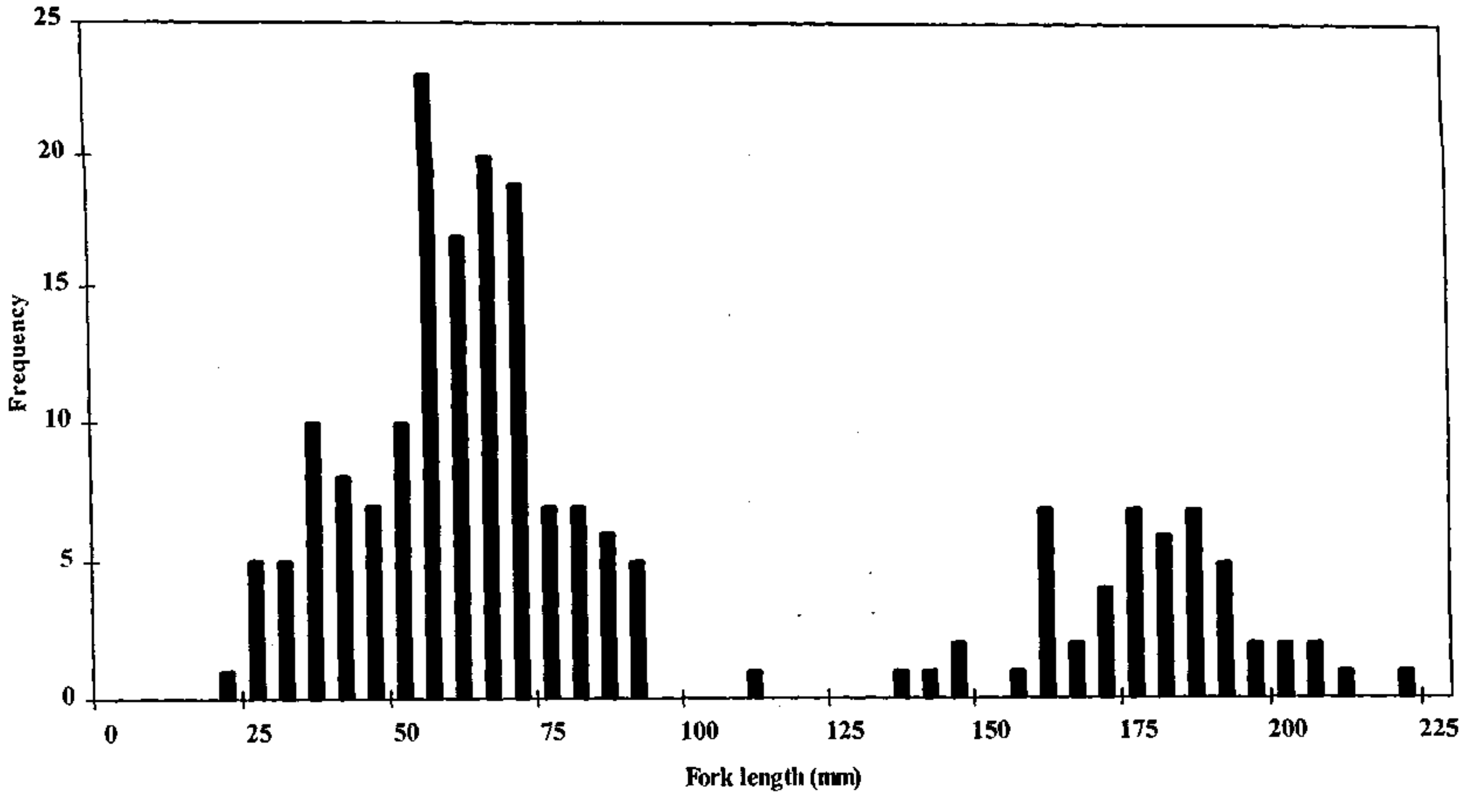


Figure 3-4. Length-frequency histogram for steelhead captured in the rotary fish screw trap, Russian River, 2000.

3.3 SIGNIFICANT FINDINGS

Rotary screw traps have been operated during the spring emigration period for parts of three seasons (1999-2001). The length of time that the traps have been operated has varied greatly between years. In 1999, the traps were fished sporadically for 19 days (fished for three to 10 days at a time between April 22 and May 29) in conjunction with a hatchery steelhead mark-recapture study. In 2000, the traps were operated from April 8 through June 29 (excluding two days when runoff from a storm prevented safe operation of the traps). In 2001, the traps were deployment from April 19 through June 7.

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), it is not possible to make direct comparisons between sampling seasons. Still, a few preliminary conclusions can be drawn from the data collected to date.

The beginning of the Chinook salmon downstream migration period has not been documented. Chinook smolts were captured in significant numbers of the first day of sampling in both 2000 (April 8) and 2001 (April 20). Downstream migrant traps were operated through June 29, 2000. Small numbers of smolts were captured through June 28, although few fish were captured during the last two weeks of June (an average of approximately 2.5 fish/day captured in traps). Based on the numbers of smolts captured, emigration peaks during the last two weeks of April and the first two weeks of May. The numbers of Chinook smolts captured in the screw traps declined rapidly after May 20 in both 2000 and 2001.

Wild steelhead smolts are less likely to be captured in the rotary screw traps compared to Chinook smolts. Steelhead emigrate at a much larger size, and are stronger swimmers (based on size) and may avoid the traps, particularly the 5-foot traps. Steelhead smolts were captured throughout the trapping season, but at lower numbers than Chinook smolts. For the season, 53 wild steelhead smolts were captured in the rotary screw trap (Table 3-1). Steelhead smolts were captured primarily in late April and early May. Wild steelhead smolts in the Russian River emigrate primarily as 2-year-old fish.

The average length of Chinook smolts as they emigrate past the dam is approximately 87 mm (range 43 -140, all years combined) (Table 3-6). In 1999 and 2001, the average length varied little during the period sampled. In 2000, the average length of smolts increased 24 mm between the first week in April and the last week in June. The weekly average length of Chinook smolts in 2000 was greater than those in corresponding weeks in 1999 and 2001.

Average weekly water temperatures during the last six weeks of the smolt emigration period ranged from 18.1 to 20.7°C, with maximum daily temperatures up to 25.2°C. Average weekly water temperatures remained below 21.1°C during the smolt emigration period. All smolts captured appeared to be healthy and vigorous despite average weekly temperatures above the levels that prevented growth in other river systems.

The capture of Chinook and wild and hatchery steelhead smolts after inflation indicates that the dam is not a complete barrier to migration. Previous studies suggest that the dam may delay passage around the dam of at least some hatchery steelhead smolts. The magnitude could not be determined by the current study. A companion study, Manning *et al.* (2000 and 2001), was instituted to define the potential impacts of the dam on steelhead smolts. Chinook smolt emigration through the study area did not appear to be delayed by the 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 (tail) clip on a weekly basis, then transported approximately 2,500 feet 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 weeks 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 maybe better at passing over the dam compared to the larger steelhead smolts.

This study provides valuable insight into the run timing of Chinook and wild steelhead smolts. This information defines the period when salmonid smolts are most likely to encounter the dam, and will be used to manage the Inflatable dam to minimize impacts to listed species.

Table 3-6. Average weekly lengths of Chinook smolts captured in the rotary screw trap below the Mirabel Dam, Russian River, 1999 - 20001.

Week of	1999	2000	2001
2-April	—	81	—
9-April	—	82	—
16-April	—	87	83
23-April	83	90	82
30-April	88	93	86
7-May	91	97	85
14-May	—	98	87
21-May	86	96	80
28-May	—	99	86
4-June	—	98	—
11-June	—	101	—
18-June	—	101	—
25-June	—	105	—

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

4.1 STUDY AREA

The study area was divided into four reaches. Reach #1 is located adjacent to Steelhead Beach Regional Park, and is located downstream of the Inflatable Dam. Reach 2 is located in the lower third of the Wohler Pool, Reach #3 is located in the middle third of the Wohler Pool, and the Reach 4 is located in the upper third of the Wohler Pool (Figure 4-1). The lower end of the Steelhead Beach reach is located approximately 2.5 kilometers downstream of the dam, and measures approximately 0.6 km in length. Reach #4 is at the upstream end of the Wohler Pool, and is minimally affected by the dam, with the influence of the dam declining to virtually zero at the upstream end. Habitat in the Reaches 2 and 3 is significantly altered by the Inflatable Dam. Access along the Russian River just above and below the Inflatable Dam (outside the influence of the Dam) is limited. A shallow riffle at the upstream end of this reach was not passable in the electrofishing boat, and sites suitable for launching the electrofishing boat at other locations have not been identified at this point. These limitations prevented the expansion of the study into portions of the river that are not affected by the dam.

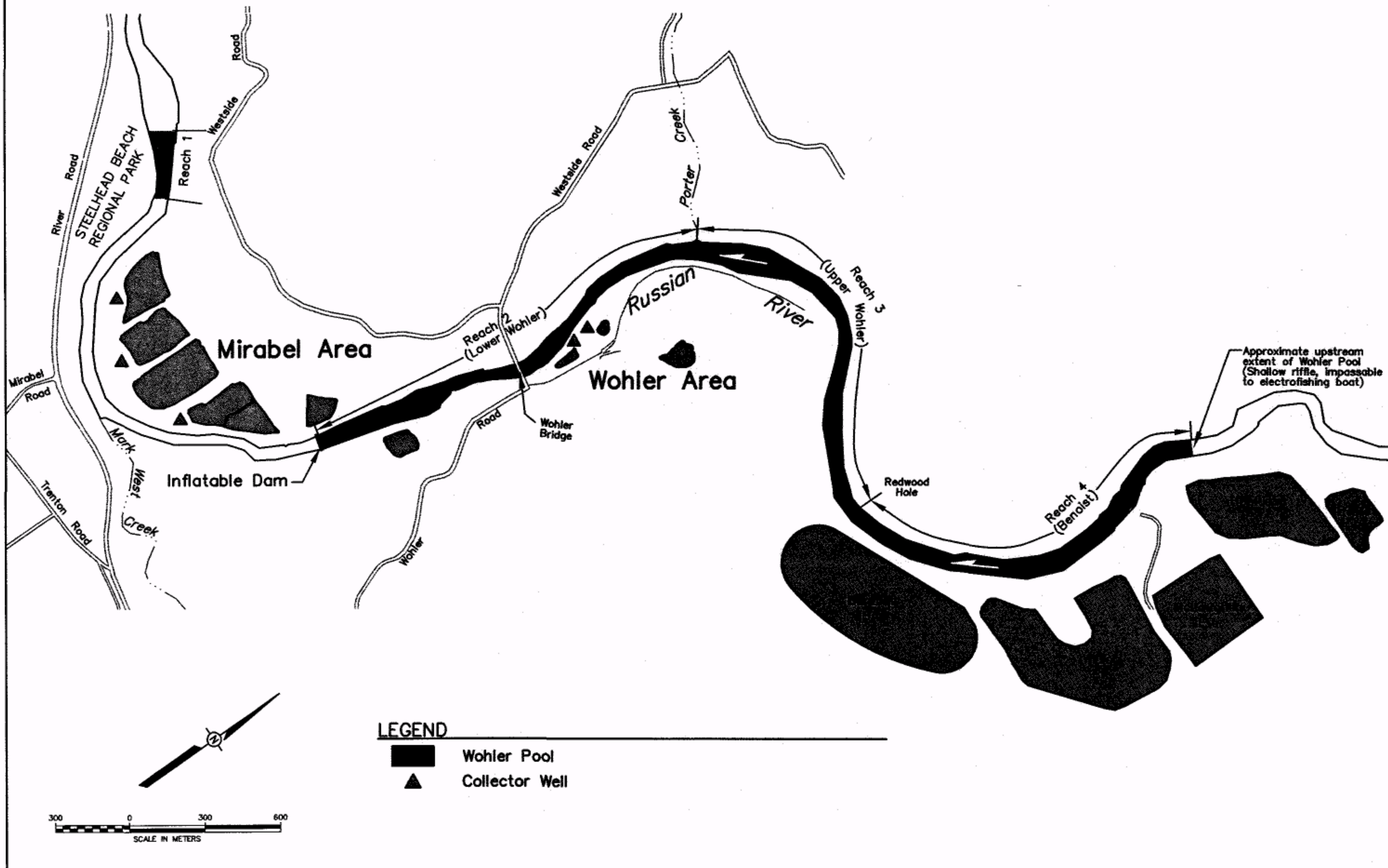
4.2 METHODS

4.2.1 Sampling Site Selection

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

4.2.3 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 railing. The platform is large enough to allow two crewmembers to net fish stunned during electrofishing. Fish are collected using nets that measure 17" x 17", mounted on eight-foot long fiberglass handles. The motor is mounted on a transom jack which allows the engine to be raised or lowered depending on water depth. The transom jack combined with the shallow draft of the boat allows for the safe operation in water less than two feet deep. A series of floodlights mounted on the front and rear of the boat allow for safe operation during nighttime sampling efforts.



SONOMA COUNTY WATER AGENCY

Figure 4–1 Boat electrofishing reaches, August 2001

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

During electrofishing, an attempt was made to net all fish stunned. However, special emphasis was placed on capturing target species (adult piscivorous fish) and juvenile salmonids. Fish captured were held in a live well. The live well was equipped with a recirculating pump and an aerator that supplied fresh, oxygenated water to the holding tank. Captured fish were identified to species and measured to the nearest 0.5 cm FL. Scale samples were collected from representative fish to determine the age structure of the fish community. Smallmouth bass and pikeminnow greater than 200 mm FL were tagged with either a streamer tag (smallmouth bass) or a T-bar tag (pikeminnow) (Floytag Inc.). The location and length of each tagged fish was recorded. A second electrofishing survey was conducted the week following the original sampling event in an attempt to recapture as many tagged fish as possible. During the secondary (predator fishing) sampling event, only predators greater than 200 mm were targeted for capture. The ratio of tagged to untagged fish captured during the two surveys was used to estimate the number of smallmouth bass and pikeminnow exceeding 200 mm FL inhabiting the study area.

4.3 RESULTS

4.3.2 Boat Electrofishing

Boat electrofishing surveys were conducted in August 2001. Four Reaches were sampled. Reach 1 was located downstream of the Inflatable Dam and consisted of four shoreline sampling units and two mid-channel sampling units. Reaches 2, 3 and 4 were located upstream of the Inflatable Dam and are contiguous. Reaches 2 and 4 consisted of nine sampling units each (six shoreline and three mid-channel units) and Reach 3 consisted of four shoreline sampling units and two mid-channel sampling units. Water surface elevation (thus depth) is directly influenced by the dam in Reaches 2 and 3. Reach 4 is located above a relatively shallow glide (maximum depth 1.5 to 2.0 feet). The influence of the Inflatable Dam on depth is approximately 20 cm at the lower end of Reach 4, and zero at the upper end of Reach 4.

4.3.2.1 Community composition

During the 2001 sampling season, 2,319 fish representing 20 species and 9 families were collected (Table 4-1, Appendix G). In addition, one species was observed but not captured, and another species was captured in 1999, but not in 2000 or 2001. Juvenile Pacific lamprey were observed in most reaches in all years, but are too small to be captured with the dip nets used for this study. In 1999, one adult striped bass was captured in Reach 3. Eight of the twenty species are native to the Russian River. Native species comprised 58.2 percent of the catch. Overall, species composition in the study area was dominated by three species: Sacramento suckers (35.5 percent), smallmouth bass (34.1) and hardhead (11.1 percent) (Table 4-2).

In terms of abundance, species native to the Russian River account for four of the top five species in Reaches 2 through 4. Reaches 2 and 3 were identical in terms of order of rank of the six most abundance species (smallmouth bass, Sacramento sucker, hardhead, tule perch, pikeminnow and carp). Species composition in Reach 4 differs somewhat in that Sacramento suckers were the dominant species, followed by smallmouth bass, hardhead, tule perch, California roach and green sunfish (pikeminnow ranked 7th). Although Sacramento suckers were the most abundant species in Reach 1, the overall population was dominated by non-native fish. In terms of abundance, suckers were followed by smallmouth bass, bluegill,

Table 4-1. Total number of fish captured during boat electrofishing sampling, Russian River, August 2001.

Species	Reach 1	Reach 2	Reach 3	Reach 4	TOTAL
Wild Steelhead	0	3	0	5	8
Hatchery Steelhead	0	1	0	0	1
Pikeminnow	7	15	21	13	56
Hardhead	1	94	44	118	257
Roach	1	0	0	47	48
Hitch	0	1	0	0	1
Blackfish	12	2	0	0	14
Tule Perch	29	16	35	70	150
Sucker	166	164	114	378	822
Sculpin	0	0	2	5	7
Smallmouth bass	128	188	232	243	791
Largemouth bass	19	0	0	0	19
Bluegill	33	3	2	2	40
Green sunfish	13	3	1	15	32
Redear sunfish	1	0	0	0	1
Crappie	3	0	0	0	3
Shad	3	5	0	1	9
Carp	27	9	8	7	51
Bullhead	1	0	1	0	2
Channel Catfish	0	0	5	1	6
Stickleback	0	0	0	1	1
TOTALS	444	504	465	906	2319

Table 4-2. Percentage composition of fish captured during boat electrofishing sampling, Russian River, August 2001.

Species	Reach 1	Reach 2	Reach 3	Reach 4	TOTAL
Wild Steelhead	0.0	0.6	0.0	0.6	0.3
Hatchery Steelhead	0.0	0.2	0.0	0.0	<0.1
Pikeminnow	1.6	3.0	4.5	1.4	2.4
Hardhead	0.2	18.7	9.5	13.0	11.1
Roach	0.2	0.0	0.0	5.2	2.1
Hitch	0.0	0.2	0.0	0.0	0.0
Blackfish	2.7	0.4	0.0	0.0	0.6
Tule Perch	6.5	3.2	7.5	7.7	6.5
Sucker	37.4	32.5	24.5	41.7	35.5
Sculpin	0.0	0.0	0.4	0.6	0.3
Smallmouth bass	28.8	37.3	49.9	26.8	34.1
Largemouth bass	4.3	0.0	0.0	0.0	0.8
Bluegill	7.4	0.6	0.4	0.2	1.7
Green sunfish	2.9	0.6	0.2	1.7	1.4
Redear sunfish	0.2	0.0	0.0	0.0	0.0
Crappie	0.7	0.0	0.0	0.0	0.1
Shad	0.7	1.0	0.0	0.1	0.4
Carp	6.1	1.8	1.7	0.8	2.2
Bullhead	0.2	0.0	0.2	0.0	0.1
Channel Catfish	0.0	0.0	1.1	0.1	0.3
Stickleback	0.0	0.0	0.0	0.1	<0.1
TOTAL	100.0	100.0	100.0	100.0	100.0

tule perch, carp and largemouth bass. The major difference between Reach 1 and the three upstream reaches was the abundance of centrarchids (bass and sunfish). Even excluding smallmouth bass, non-native fish comprised 25.2 percent of the species composition in Reach 1. Non-native species (excluding smallmouth bass decreased from 4.6 (Reach 2) to 2.9 (Reach 4) percent of the fish present in the three upstream reaches.

4.3.1.1 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 where the effort exerted to capture fish is not equal (i.e., more effort is spent capturing fish at one station compared to another). The amount of effort spent at each site is dependent on several factors, including the number of fish present and the complexity of the habitat sampled. For this study, CPUE equals the average number of fish captured for every one-minute that the electrofishing unit was in operation at each site. Stations were separated into shoreline and mid-channel habitats, since species abundance and composition differ between the two.

The CPUE varied widely between individual shoreline sampling stations within and between the Reaches. Catch-per-unit-effort ranged from 2.15 fish/minute at Station 2-2 to 10.21 fish/minute at Station 3-6 (Table 4-3 and 4-4 presents CPUE data by Reach, Appendix G provides a breakdown of the CPUE by stations within each Reach). CPUE increased with distance above the dam in Reaches 2, 3, and 4, from 6.0 to 12.5 fish/minute. The CPUE at Reach #1 was intermediate to the above dam reaches (7.5 fish/minute). CPUE at the mid channel stations followed a similar pattern of increasing catch with distance above the dam, although the CPUE for mid channel stations in Reach 1 was higher than the CPUE in the mid channel Reaches above the dam.

The capture rate (CPUE) for Age 2+ and older (≥240 mm FL) predatory fish was similar between Reaches, ranging from 0.19 to 0.24 fish/minute of sampling (Table 4-5). For individual species, CPUE ranged from 0.03 to 0.07 for pikeminnow and from 0.13 to 0.19 for smallmouth bass. Largemouth bass were only captured in Reach 1.

4.3.3 Steelhead

Eight wild and one hatchery steelhead were captured during the August 2001 sampling event. Wild steelhead were captured in Reaches 2 (3 total) and 4 (5 total) (Table 4-1). The hatchery steelhead was captured in Reach 2. Wild steelhead ranged in length from 105 to 225 mm FL (Figure 4-2). Appendix H presents length-frequency histograms for all species captured in each Reach). Four-year classes of steelhead were captured in 2001 (Figure 4-2). One age 0+ steelhead (105 mm FL) was captured (Figure 4-2). Age 1+, 2+ and 3+ steelhead averaged 144 (N= 5), 210 (N = 1), and 225 (N=l) mm FL, respectively.

Table 4-3. Catch-Per-Unit-Effort by Reach, Inflatable Dam Study Area, Russian River, August 2000.

	Shoreline stations			
Species	**Reach 1**	**Reach 2**	**Reach 3**	**Reach 4**
Wild Steelhead	0.00	0.04	0.00	0.00
Hatchery Steelhead	0.00	0.00	0.00	0.00
Pikeminnow	0.13	0.10	0.34	0.19
Hardhead	0.02	1.15	0.83	1.90
Roach	0.02	0.00	0.00	0.76
Blackfish	0.13	0.03	0.00	0.00
Hitch	0.00	0.00	0.00	0.00
Tule Perch	0.43	0.23	0.66	0.87
Sucker	2.24	1.62	0.95	4.47
Sculpin	0.00	0.00	0.04	0.03
Smallmouth bass	2.47	2.56	4.49	3.88
Largemouth bass	0.39	0.00	0.00	0.00
Bluegill	0.71	0.04	0.04	0.03
Green sunfish	0.28	0.04	0.02	0.24
Redear sunfish	0.02	0.00	0.00	0.00
Crappie	0.04	0.00	0.00	0.00
Shad	0.02	0.00	0.00	0.00
Carp	0.58	0.13	0.14	0.11
Bullhead	0.02	0.00	0.00	0.00
Channel Catfish	0.00	0.00	0.10	0.02
Stickleback	0.00	0.00	0.00	0.02
	7.51	5.96	7.61	12.50

Table 4-4 Catch-Per-Unit-Effort by Reach, Mirabel Study Area, Russian River, August 2000 (Concluded).

	Mid-channel stations			
Species	**Reach 1**	**Reach 2**	**Reach 3**	**Reach 4**
Wild Steelhead	0.0	0.0	0.0	0.1
Hatchery Steelhead	0.0	0.0	0.0	0.0
Pikeminnow	0.0	0.1	0.1	0.0
Hardhead	0.0	0.2	0.1	0.0
Roach	0.0	0.0	0.0	0.0
Blackfish	0.2	0.0	0.0	0.0
Hitch	0.0	0.0	0.0	0.0
Tule Perch	0.3	0.0	0.1	0.4
Sacramento sucker	2.3	0.8	2.0	2.7
Sculpin	0.0	0.0	0.0	0.1
Smallmouth bass	0.5	0.1	0.1	0.1
Largemouth bass	0.0	0.0	0.0	0.0
Bluegill	0.0	0.0	0.0	0.0
Green sunfish	0.0	0.0	0.0	0.0
Redear sunfish	0.0	0.0	0.0	0.0
Crappie	0.0	0.0	0.0	0.0
Shad	0.1	0.1	0.0	0.0
Carp	0.0	0.0	0.0	0.0
Bullhead	0.0	0.0	0.0	0.0
Channel Catfish	0.0	0.0	0.0	0.0
Stickleback	0.0	0.0	0.0	0.0
Total	3.6	1.3	2.5	3.5

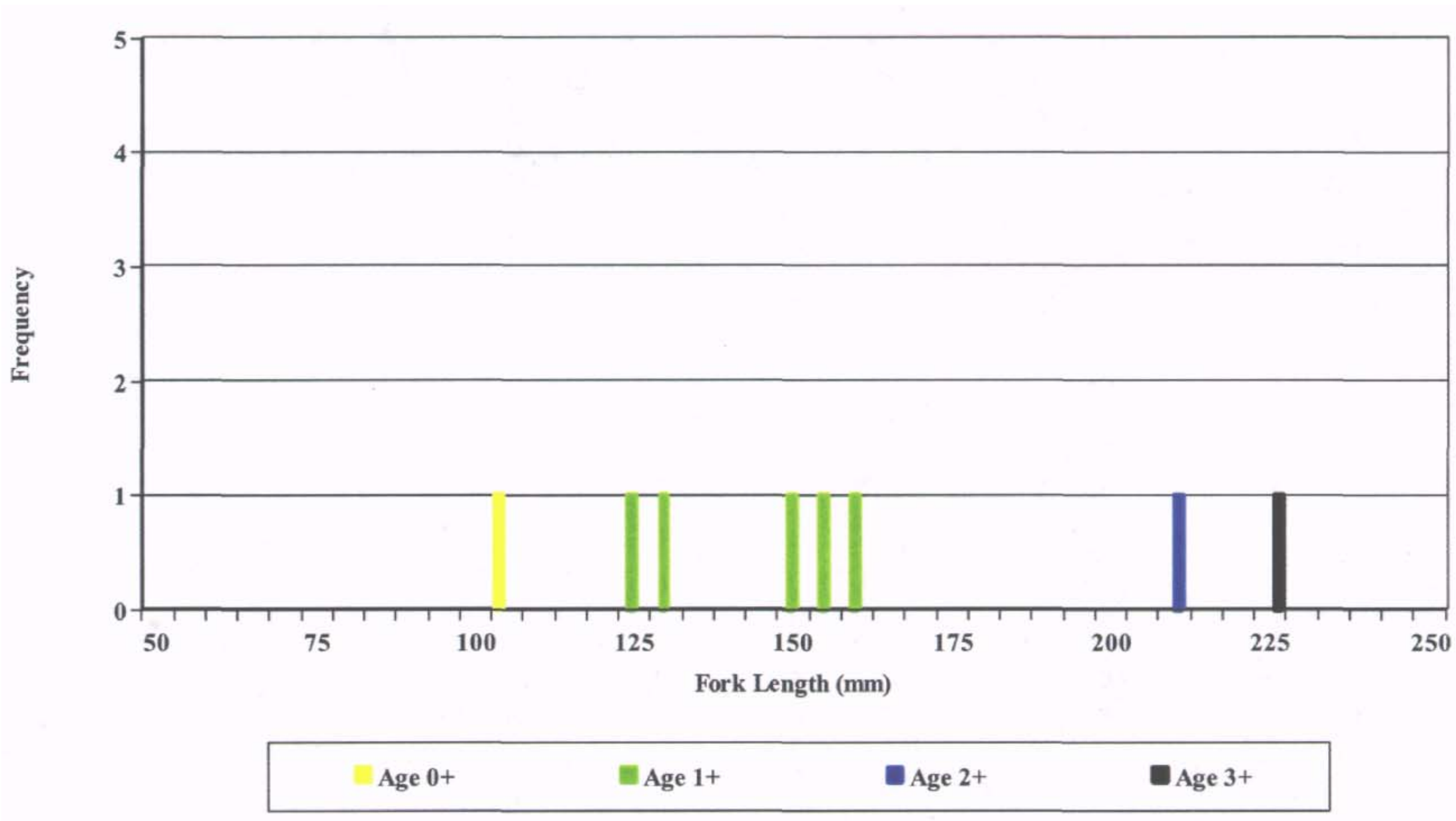


Figure 4-2. Length-frequency histogram for Steelhead captured during boat electrofishing, August 2001 (all stations combined).

Table 4-5. CPUE for Age 2 and older predators by Reach.

Species	Reach 1	Reach 2	Reach 3	Reach 4
Pikeminnow	0.04	0.03	0.05	0.07
Smallmouth bass	0.13	0.15	0.19	0.16
Largemouth bass	0.04	0.00	0.00	0.00
Total	0.20	0.19	0.24	0.22

4.3.4 Adult Predator Populations

Three potential predators of salmonids were captured during the study: Sacramento pikeminnow, smallmouth bass, and largemouth bass. In all, 37.7 percent (875) of all fish captured during electrofishing sampling fell in the predatory category. However, 77.0 percent (674) of the predators captured were young-of-the-year, and only 6.3 percent (55) of the predators were age *2*+ or older (i.e., large enough to prey on juvenile salmonids).

4.3.4.1 Pikeminnow

Pikeminnow comprised 2.4 (N=56) percent of the fish captured in 2001 (Tables 4-1 and 4-2) (excluding fish caught during the predator sampling event). Within individual reaches, pikeminnow comprised between 1.4 (Reach #4) and 4.5 (Reach #3) percent of the populations. Thirty-four (60.7 percent) of the 56 pikeminnow captured were aged as young-of-the-year, while nine fish (16.1 percent) were age as two-years-old or more (Figure 4-3). Young-of-the-year pikeminnow were relatively evenly distributed in the three above dam Reaches. Young-of-the-year were least abundant in Reach #1.

In addition to the pikeminnow caught during the regular electrofishing sampling event, 10 additional pikeminnow greater than 200 mm FL were captured during the "predator" sampling event. Pikeminnow large enough to prey on Chinook smolts were found primarily in the three upstream Reaches. Twelve of the 19 fish were greater than 300 mm FL (the size where fish become important in their diet) in August, (although the smaller members of this group may have been too small to be a serious predator of Chinook smolts during the spring salmonid emigration period). Four pikeminnow ranged in length between 455 and 615 mm FL during August 2001, and are capable of consuming emigrating Chinook and small steelhead smolts. Pikeminnow greater than 300 mm FL were primarily captured above the Inflatable Dam (11 of 12 fish).

Based on the 1999 and 2000 electrofishing surveys, abundance of pikeminnow greater than 200 mm FL in the study area appears to be low (Table 4-7). In 1999, electrofishing was conducted in approximately the same locations as in 2000 (Chase *et al.* 2000b). During this survey, 13 pikeminnow were captured, three of which were large enough to prey on salmonid smolts. In spring of 2000, a spot electrofishing survey was conducted in an attempt to captured radio tagged steelhead smolts that remained in the Wohler Pool for an extended period of time (Maiming *et al.* 2000). During the spring survey, two large pikeminnow were captured. For the four sampling events combined (1999 through 2001), the accumulative effort resulted in a relatively low number of pikeminnow captured in the study area. In total, 29 pikeminnow greater than 200 mm FL were captured during the four surveys, combined (Table 4-6). Pikeminnow were tagged in 2001, only. Therefore, it is possible that some of the pikeminnow were captured more than once. No tagged pikeminnow were recaptured during the second phase of the sampling program. Therefore, it was not possible to estimate the population of pikeminnow longer than 200 mm FL inhabiting the study area.

Table 4-6. Total number of pikeminnow and total number of pikeminnow greater than 200 mm FL captured by boat electrofishing, 1999 - 2001, combined.

Segment	Total number of pikeminnow	Total number of Pikeminnows greater than			
		200	300	400	500
Reach 1[2,3]	12	1	1	0	0
Reach 2[1,3,4]	60	2	2	1	1
Reach 3[1,2,3,4]	56	5	2	0	3
Reach 4[1,2,3,4]	59	4	3	1	3

[1] Station sampled in August 1999.
[2] Station sampled in Spring 2000.
[3] Station sampled in August 2001.
[4] Station sampled during "predator" sampling event

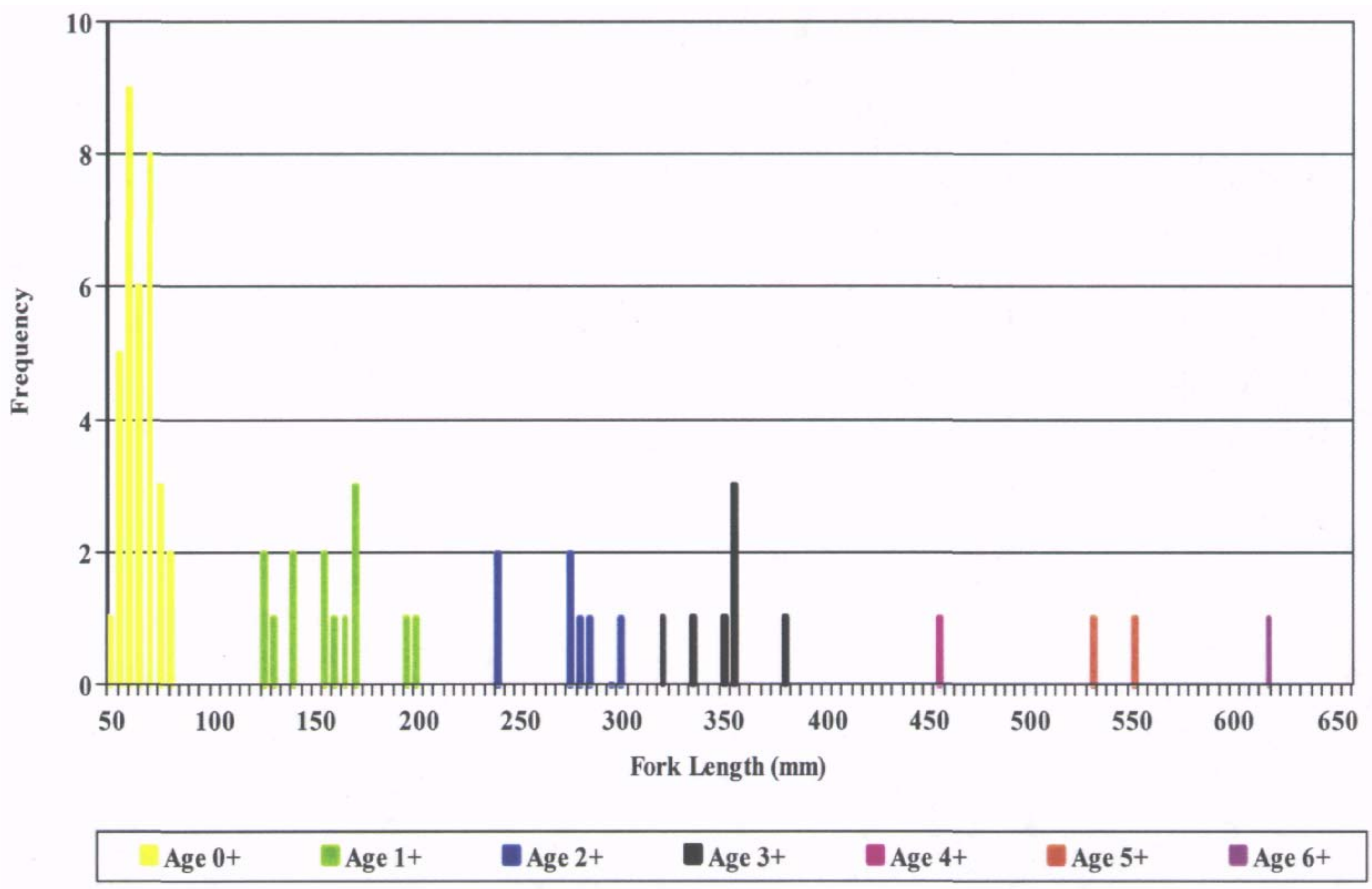


Figure 4-3. Length-frequency histogram for Sacramento pikeminnow captured during boat electrofishing, August 2001 (all stations combined).

Table 4-7. Average size and range by age class of Sacramento pikeminnow captured during boat electrofishing by Reach, August 2000, Russian River (includes fish caught during the predator survey).

Age 0+			
Segment	**Average**	**Range**	**N =**
Reach 1	61	55 - 70	4
Reach 2	66	55 - 82	9
Reach 3	62	50 - 70	13
Reach 4	70	65 - 80	8
Overall	65	50 - 80	34

Age 1+			
	Average	**Range**	**N =**
Reach 1	160	160	1
Reach 2	168	140 - 195	3
Reach 3	154	125 - 200	7
Reach 4	152	130 - 170	3
Overall	157	140 - 200	14

Age 2+			
	Average	**Range**	**N =**
Reach 1	240	240	1
Reach 2	—	—	0
Reach 3	275	275	1
Reach 4	276	240 - 300	5
Overall	271	240 - 300	7

Age 3+			
	Average	**Range**	**N =**
Reach 1	320	320	1
Reach 2	345	335 - 355	2
Reach 3	368	355 - 380	2
Reach 4	353	350 - 355	2
Overall	350	320 - 380	7

Age 4+			
	Average	**Range**	**N =**
Reach 1	—	—	0
Reach 2	415	415	1
Reach 3	—	—	0
Reach 4	—	—	0
Overall	415	415	1

Age 5+ and older			
	Average	**Range**	**N =**
Reach 1	—	—	0
Reach 2	615	615	1
Reach 3	540	530 - 550	2
Reach 4	—	—	0
Overall	565	530 - 615	3

Pikeminnow ranged in size from 50 to 615 mm FL (Figure 4-3). Pikeminnow averaged 157 mm FL (N = 14, all sites combined) during August of their second year (age 1+), and 271 mm FL (N = 14, all sites combined) at age 2+ (Table 4-7). Based on the data collected to date, it appears that pikeminnow attain a size sufficient to prey on Chinook salmon at the beginning of their third year of life (Age 2+) (Table 4-8). Pikeminnow aged as 4+ or older are large enough to prey on both Chinook salmon and steelhead.

Table 4-8 Average size of pikeminnow (captured in August) by age class, 1999 through 2001.

Year	Age 0+	Age 1+	Age 2+	Age 3+	Age 4+	Age 5+ and older
1999	70	128	—	385	—	528
2000	64	138	244	—	498	710
2001	65	157	271	350	455	565
Mean	64	144	264	354	468	568

Pikeminnow can migrate long distances during their spawning migration (Harvey and Nakamoto 1999). Pikeminnow were observed moving upstream through the fish ladder in 2000 into the Wohler Pool (see section 5.0), possibly migrating to or from their spawning grounds. In addition, large pikeminnow were observed near the dam during early spring when smolts were present in the pool. Although additional sampling may be warranted during the spring salmonid emigration period to determine pikeminnow populations in the Study Area, the presence of adult and juvenile salmonids would likely result in a take of these species (primarily steelhead).

4.3.4.2 Smallmouth bass

Smallmouth bass comprised 34.1 percent (791) of the total catch during the August 2001 sampling event. Within individual reaches, smallmouth bass comprised between 26.8 (Reach 4) and 49.9 (Reach 3) percent of the fish captured. Approximately 80 percent of the smallmouth bass captured were aged as young-of-the-year, and 30 fish (3.8 percent) were aged as two-years-old or more (Figure 4-4). Smallmouth bass were most abundant (based on CPUE) in Reach 3 (4.49 smallmouth bass/minute of sampling in shoreline sampling sites), followed by Reaches 4 (3.88 smallmouth bass/minute of sampling). Smallmouth bass were least abundant in Reach 1 (2.47 smallmouth bass/minute of sampling).

Overall, very few adult smallmouth bass were captured during the study (30 total). Adult smallmouth bass (Age 2+ and older) were more abundant upstream of the dam (Table 4-9). At Reach 1, three adult smallmouth bass were captured, compared to 20, 17, and 16 in Reaches 2, 3, and 4, respectively.

Smallmouth bass captured in August 2001 ranged in size from 50 to 390 mm FL (Figure 4-4). Smallmouth bass averaged 181 mm FL (N = 151, all site combined) during August of their second year (age 1+), and 268 mm FL (N = 46, all sites combined) at age 2+ (Table 4-9). Smallmouth bass likely attain a size sufficient to prey on Chinook salmon at the beginning of their third year of life (Age 2 +). No smallmouth bass large enough to prey on age 1+ or older steelhead were captured.

4.3.4.3 Largemouth bass

Largemouth bass comprised 1.1 percent (26) of the catch during the August 2001 sampling event, all in Reach 1. Eleven of the 19 largemouth bass were aged as 0+, and seven were aged as Age 2+ or older (Figure 4-5).

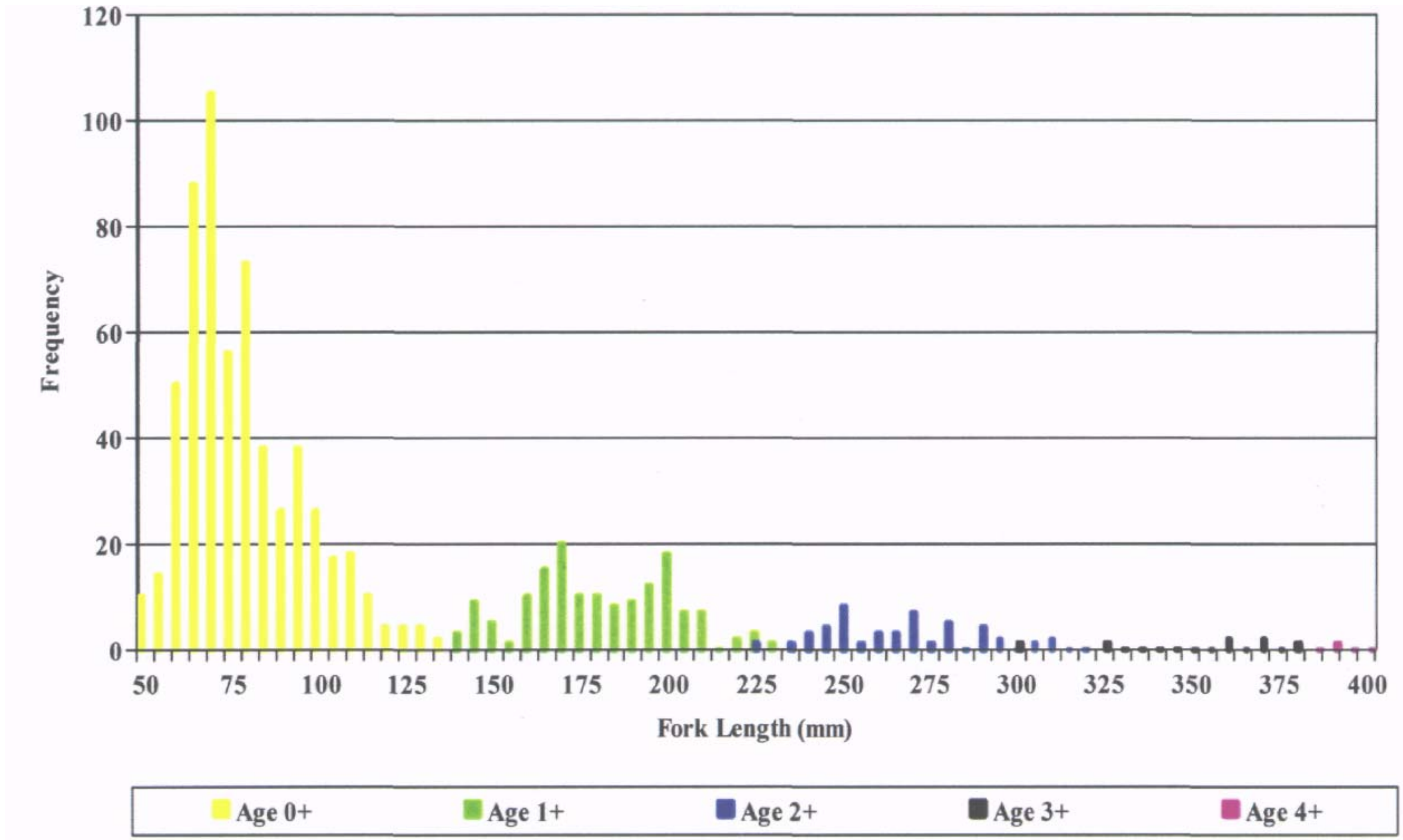


Figure 4-4. **Length-frequency histogram for smallmouth bass captured during boat electrofishing, August 2001 (all stations combined).**

Table 4-9. Average size and range by age ing, class of smallmouth bas s captured during boat electrofish August 2001, Russia n River (includes fish caught during the predator survey).

Age 0+			
Segment	**Average**	**Range**	**N =**
Reach 1	75	50 - 125	111
Reach 2	84	50 - 130	172
Reach 3	75	50 - 135	159
Reach 4	79	50 - 130	141
Overall	79	50 - 135	583

Age 1+			
	Average	**Range**	**N =**
Reach 1	180	145 - 225	16
Reach 2	188	165 - 210	13
Reach 3	183	145 - 235	68
Reach 4	177	140 - 225	57
Overall	181	140 - 230	151

Age 2+			
	Average	**Range**	**N =**
Reach 1	268	245 - 290	2
Reach 2	276	245 - 310	16
Reach 3	265	240 - 290	16
Reach 4	263	240 - 295	15
Overall	268	245 - 295	46

Age 3+			
	Average	**Range**	**N =**
Reach 1	360	360	1
Reach 2	360	325 - 380	3
Reach 3	370	370	1
Reach 4	360	360	1
Overall	362	325 - 380	6

Age 4+			
	Average	**Range**	**N =**
Reach 1	—	—	0
Reach 2	390	390	1
Reach 3	—	—	0
Reach 4	—	—	0
Overall	390	390	1

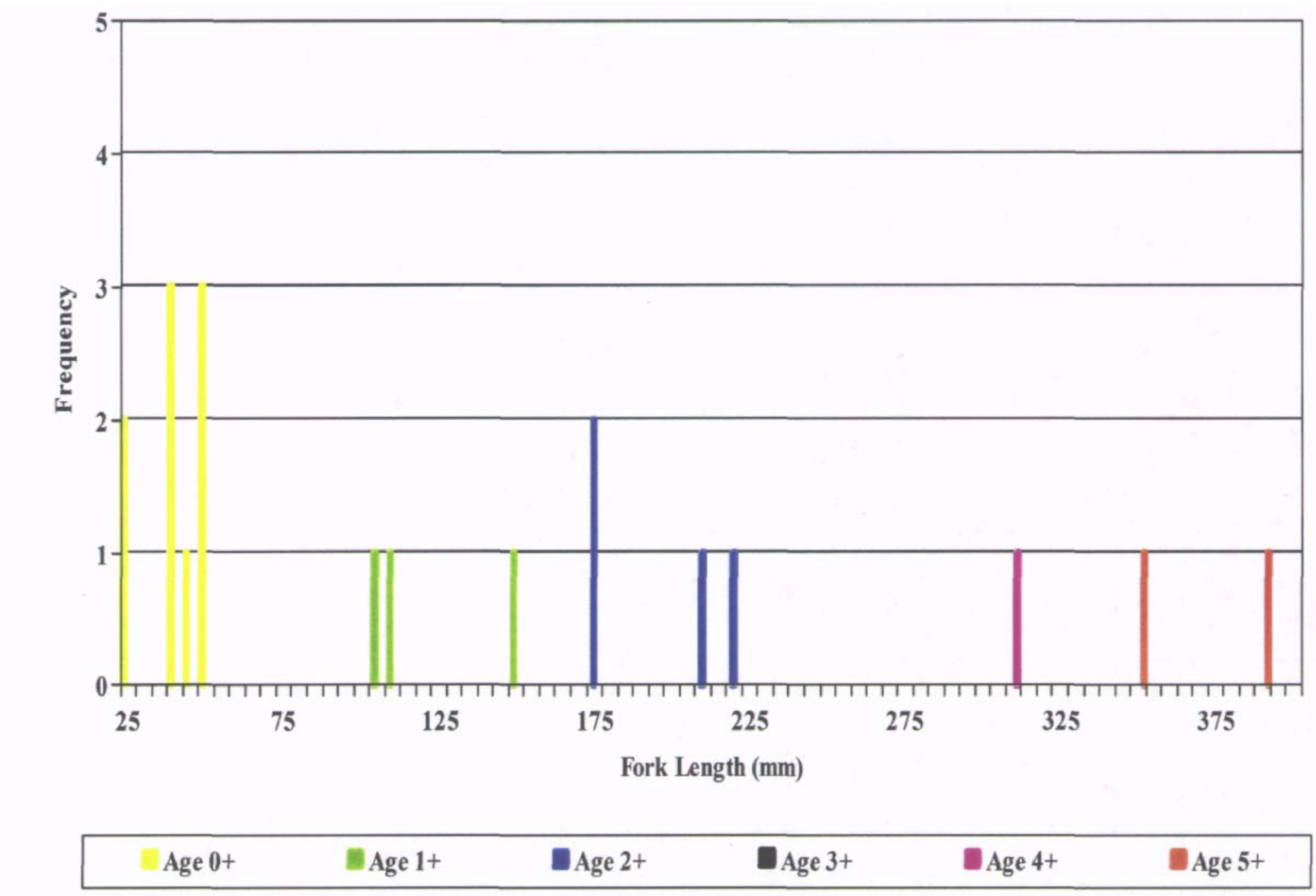


Figure 4-5. Length-frequency histogram for largemouth bass captured during boat electrofishing, August 2001 (all stations combined).

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

Age 0+			
Segment	**Average**	**Range**	**N =**
Reach 1	56	25 - 50	9
Reach 2	—	—	0
Reach 3	—	—	0
Reach 4	—	—	0
Overall	56	25 - 50	9

Age 1+			
	Average	**Range**	**N =**
Reach 1	132	120 - 150	3
Reach 2	—	—	0
Reach 3	—	—	0
Reach 4	—	—	0
Overall	132	120 - 150	3

Age 2+			
	Average	**Range**	**N =**
Reach 1	195	175 - 220	4
Reach 2	—	—	0
Reach 3	—	—	0
Reach 4	—	—	0
Overall	195	175 - 220	4

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

Age 4+ and older			
	Average	**Range**	**N =**
Reach 1	350	310 - 350	3
Reach 2	—	—	0
Reach 3	—	—	0
Reach 4	—	—	0
Overall	350	310 - 350	3

Largemouth bass appear to grow slower than smallmouth bass, possible because of their thermal requirements (see Section 1.4.7). Largemouth bass captured in August 2001 ranged in length from 25 to 390 mm FL (Figure 4-5). Largemouth bass averaged 122 mm FL (N = 6, all sites combined) during August of their second year (age 1+), and 195 mm FL (N=5, all sites combined) during August of their third year (Age 2 +). Largemouth bass, based on their morphology, are able to feed on larger fish at a smaller size compared to smallmouth bass, thus, it is assumed that Age 2+ are large enough to feed on at least the smaller sized emigrating Chinook smolts during the start of their third year (Age 2+).

4.4 SIGNIFICANT FINDINGS

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

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

5.0 ADULT UPSTREAM MIGRATION

5.1 INTRODUCTION

The Inflatable Dam is approximately 11-feet high when folly inflated, and may form a barrier to upstream migrating fish. The dam is equipped with two denil type fish ladders to provide for upstream passage, however, prior to this study, the effectiveness of the ladders had not been tested. The 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 were smooth-sided, conformed to the sides of the fish ladders, and were designed such that the hydraulics of the ladders were not altered. To facilitate fish identification, a highly reflective background was attached to the back wall of the exit boxes. The cameras were mounted in custom manufactured boxes extending off the downstream side of the exit boxes. The boxes were constructed of 3/16" steel. A clear acrylic window was inserted between the exit boxes and the camera boxes. The cameras were in operation continuously while the dam was inflated.

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

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

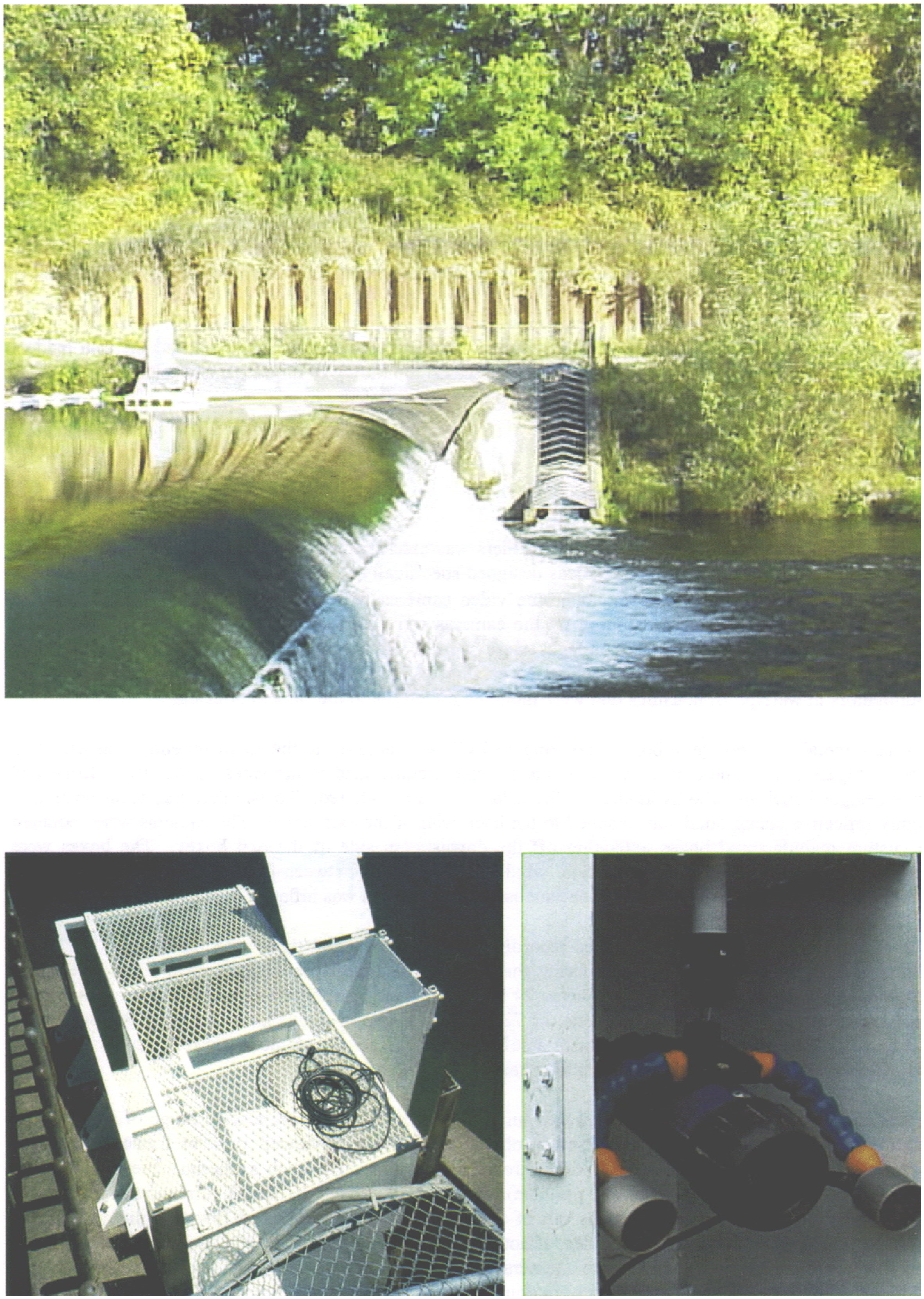


Figure 5-1. Eastside fish ladder (top photo), camera box and fish exit box (bottom left photo, and underwater camera (bottom right photo).

5.3 RESULTS

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

5.3.1 Video Monitoring

Video monitoring was conducted from August 7 through the morning of November 13, 2001. During this time-period, 194 videotapes were generated. Video monitoring was continuous throughout the study period with a few exceptions. On a few occasions, the end of a tape was reached prior to the tapes being changed, and the lights failed for approximately one week on the East side camera. In addition, turbidity occasionally limited visibility.

Video monitoring demonstrated that adult Chinook salmon, steelhead, Pacific lamprey, American shad, and pikeminnow are able to locate and ascend the Mirabel fish passage facilities. The total number of adult anadromous fish passing through the fish ladder can only be estimated from the data collected, however, owing to a few problems inherent in the system. Turbidity was occasionally a problem, particularly during storm events, when turbidity levels occasionally increased to the point where the back wall of the exit boxes could not be observed, thus fish could have passed undetected. This is particularly troublesome because this limitation can only be minimally addressed by increasing the lighting in the exit boxes, and because salmon and steelhead tend to migrate during freshets which are associated with higher turbidity levels. However, the study objective was to determine if salmonids find and ascend the fish passage facilities, only. Data on the numbers of salmonids and the timing of upstream migration past the dam are 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 were operated (August to mid November in 2001).

5.3.2 Fish Counts

At least eleven species of fish were identified entering the fish ladders in 2001. Species observed included Chinook salmon, steelhead, Pacific lamprey, American shad, Sacramento pikeminnow, hardhead, Sacramento sucker, smallmouth bass, common carp, and channel catfish. Most of the non-anadromous species were noted as "milling about" in the exit boxes, as opposed to migrating upstream or downstream through the fish ladders. Detailed counts were made of anadromous fish and large Cyprinids (potential predators) only. These counts were broken out by species, with a general category defined as salmonid (fish could not be identified to species, but had identifiable characteristics (e.g., general body shape, adipose fin, etc.) of the family Salmonidae.

5.3.2.1 Salmonids

In 2001, 84 fish could be identified as a salmonid, but could not be identified to species. Salmonids were partitioned into Chinook or steelhead in an attempt to estimate the true number of each of these species observed in the fish ladders. Unlike in 2000 when both adult Chinook salmon and steelhead were observed migrating through he fish ladders, in 2001, no adult steelhead were observed in the video tapes. Early fall rains resulted in the dam being lowered in mid November, prior to the onset of the adult steelhead upstream migration period. All 84 salmonids were thus classified as Chinook salmon.

5.3.2.2 Chinook

In 2001, 1,299 (1,383 when combined with the "salmonid" category) Chinook salmon were identified in the videos (Table 5-2). This number represents a minimum count for Chinook salmon. The lights failed on the east camera for approximately one week during the Chinook run, and on some days, turbidity levels reduced visibility to the point to the point where the back walls of the exit boxes could not be observed on

Table 5-1. Weekly counts of Chinook salmon observed migrating upstream through the Inflatable Dam fish passage facilities during video monitoring, 2001 sampling season.

Date	Chinook
6-Aug	0
13-Aug	0
20-Aug	0
27-Aug	1
3-Sep	2
10-Sep	6
17-Sep	10
24-Sep	7
1-Oct	116
8-Oct	186
15-Oct	4
22-Oct	85
29-Oct	807
5-Nov	58
12-Nov	17[1]
Totals	1,299

[1] Sampling ended on the morning of November 13

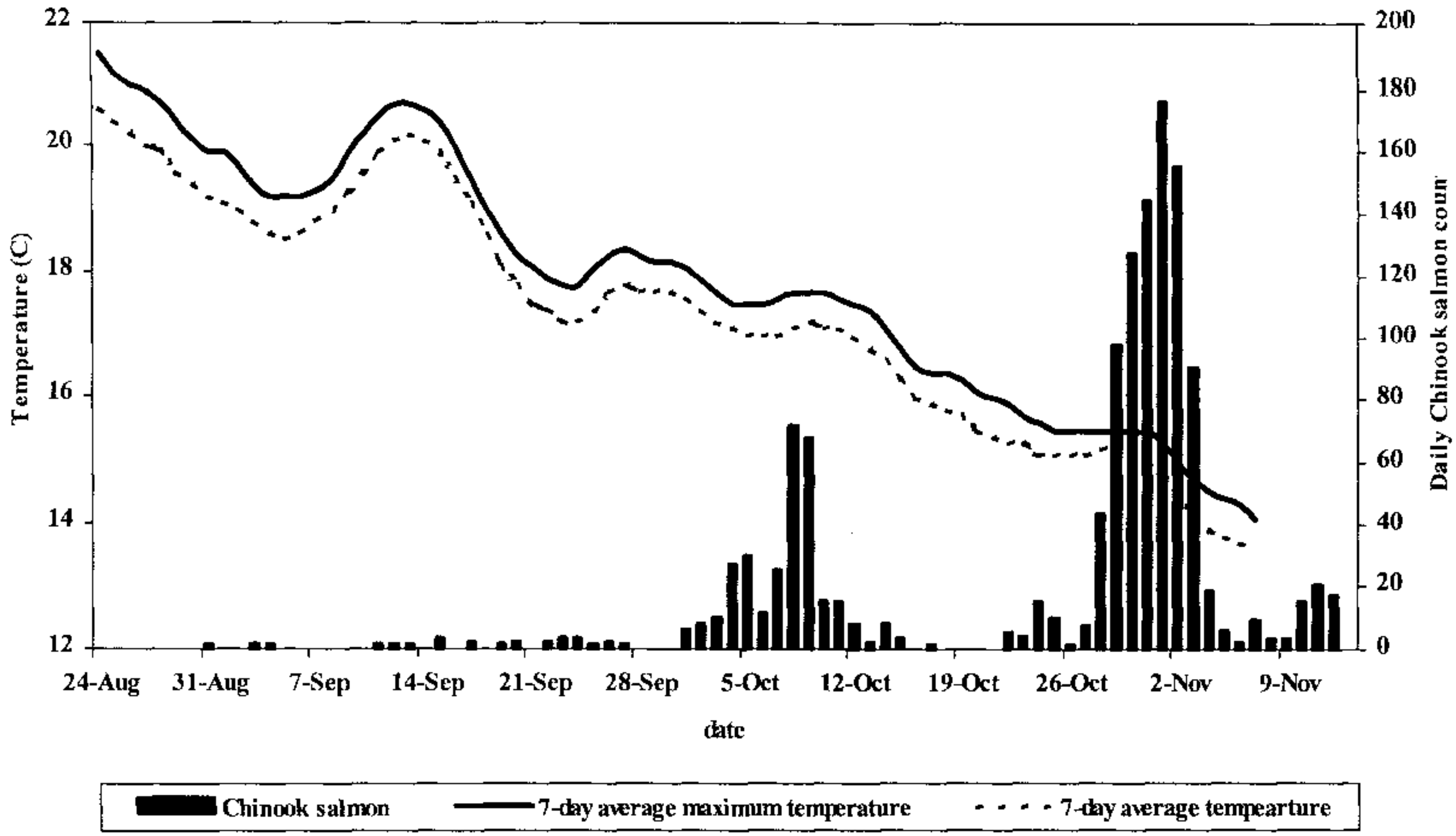


Figure 5-2. **Daily Chinook salmon counts plotted against the mean weekly average temperature and the mean weekly maximum temperature recorded in the Russian River, August 7 through November 12, 2001.**

the videotapes (as a result, some salmon may have migrated through the boxes undetected). In addition, the adult Chinook salmon migration period extended through December in 2000. During the 2000 run, approximately 38 percent of the run was recorded passing the dam after the mid November date when the dam was deflated in 2001.

Chinook salmon were first observed during video monitoring on August 31, although only 26 Chinook salmon were observed prior to October 1. The majority of the Chinook salmon observed occurred during two pulses, the first occurring between October 1 and the 15th, and the second between October 28 and November 4 (Figure 5-2).

Chinook salmon were observed in the fish ladders at streamflows ranging from 99 to 1,199 cfs (Figure 5-2). Streamflows in this range apparently provide adequate conditions for adult Chinook salmon to migrate through the lower Russian River. It should be noted that no adult Chinook salmon were observed during video monitoring on the few days when streamflow was less than 99 cfs.

Average daily water temperatures ranged from 20.6 to 13.1°C during the 2001 upstream migration period (Figure 5-3). The weekly average temperature during the first part of the run (September) ranged from 17.2 to 20.2°C. Beginning October 1, the weekly average temperature was 17.6°C, and generally declined as the run progressed. The weekly average water temperature was 14.7°C during the peak of the Chinook migration period (October 28 through November 4).

5.3.2.3 Steelhead

No adult steelhead were observed in the video tapes during the 2001 sampling period. Steelhead migration appears to begin in earnest in late November (based on 2000 video monitoring data), and the lack of steelhead observed in the ladders is likely a function of the dam being deflated in mid November, prior to the onset of the steelhead migration.

5.3.2.4 Juvenile steelhead

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

5.3.2.5 Pacific lamprey

In northern California rivers, Pacific lamprey migrate upstream to spawn between April and July (Moyle 1976, Wang 1986), although in the Trinity River, Moffett and Smith (1950, cited by Moyle 1976) reported lamprey migrating upstream in August and September. In 2001, 3 Pacific lamprey were observed migrating through the fish ladders in October and November. In 2000, 228 Pacific lamprey were observed in the fish ladders, primarily in May and June, and small number of Pacific lamprey were also observed migrating upstream through the fish ladders in October and November.

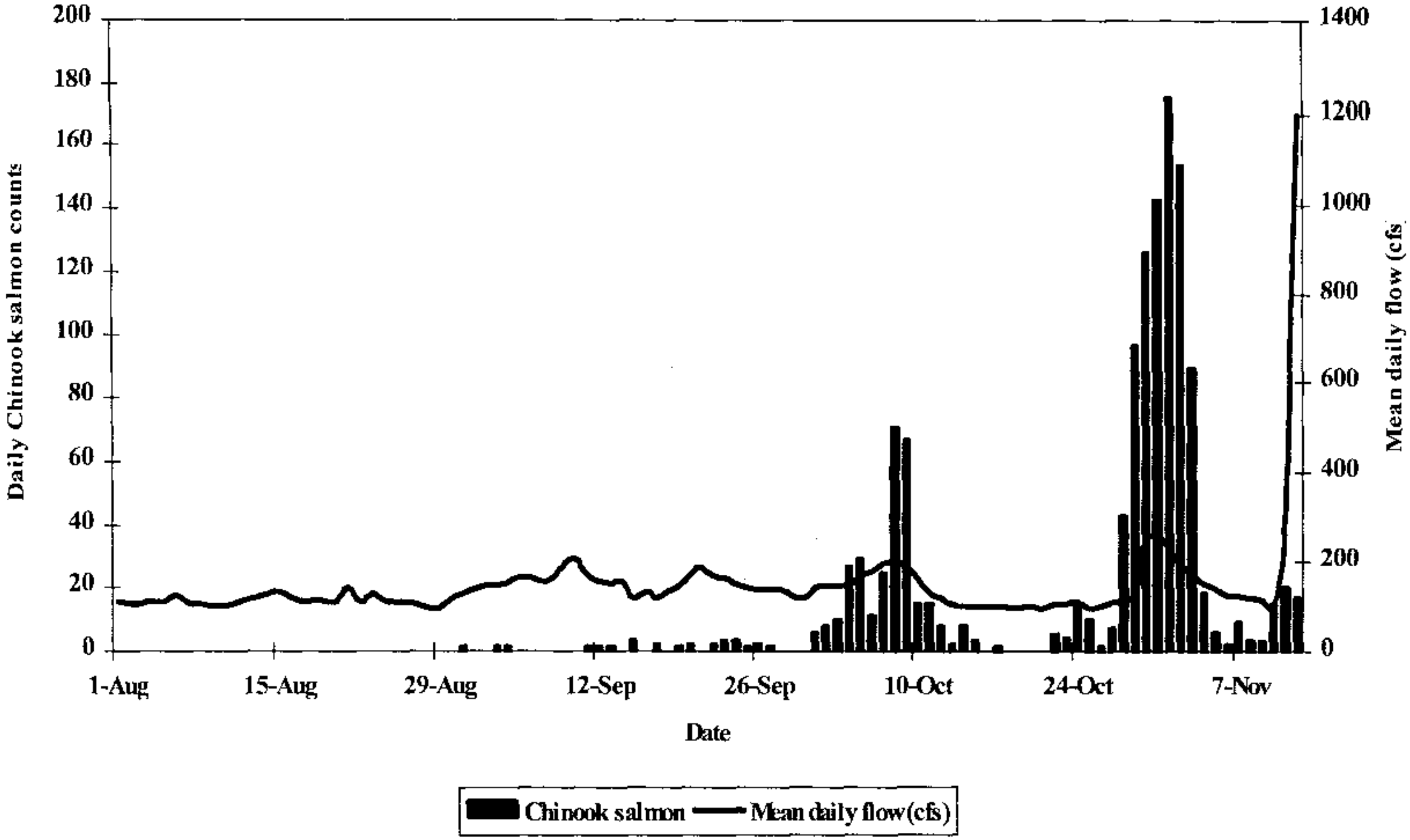


Figure 5-3. **Daily Chinook salmon counts plotted against the average daily streamflow recorded at Hacienda Bridge, Russian River, 2001.**

5.4 SIGNIFICANT FINDINGS

Based on the results of video monitoring from 1999 through 2001, Chinook salmon and steelhead appear to have little problem finding and ascending the fish ladders around the Inflatable Dam. Relatively large numbers of adult fish of both species have been documented successfully negotiating the ladders, and large numbers of fish milling at the base of the dam have not been observed. However, a satisfactory method of assessing fish populations at the base of the dam has not been identified. Direct observation (snorkel) surveys were limited by visibility, which tends to deteriorate in November when Chinook salmon and steelhead are most likely to be present in large numbers.

For the second year in a row, over 1,300 adult Chinook salmon were observed migrating through the fish ladders. This is in contrast to historical literature that suggests that Chinook were never abundant in the Russian. Steiner (1996) reviewed the historical literature pertaining to salmonids in the Russian River and cited several sources that suggested that Chinook salmon were rare in the Russian River. For example, Shapovalov (1946, 1947, and 1955) reported that there were few, if any, Chinook salmon in the Russian River. Although a few sources did suggest that Chinook salmon inhabit the Russian, Steiner concluded that: "... there are very few chinook presently in the Russian River basin." Moyle (2002), states that the Chinook salmon in the Russian River "disappeared" from the river due to the advent of agriculture and water projects in the river, and that attempts to reestablish Chinook salmon through stocking has not appeared to be successful. In 2001, approximately 1,380 adult Chinook salmon were observed migrating upstream through the fish ladders. The Chinook run essentially began in early September in 1999, 2000, and 2001. The entire spawning run has been surveyed in its entirety in 2000, only (Chase *et al.* 2001). In 2000, the run peaked in late November and ended in late December. During August of each year sampled, one Chinook salmon has been observed in the fish ladders, and large numbers of salmon have not been observed prior to October in any year. Steelhead began their upstream migration in late October, however, the majority of their run occurs after the dam is deflated. No steelhead were observed in the ladders during the 2001 fall survey period.

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