SONOMA COUNTY WATER AGENCY'S
MIRABEL RUBBER DAM/WOHLER POOL
FISH SAMPLING PROGRAM:
YEAR 4 RESULTS
2003

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EXECUTIVE SUMMARY

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

Three species of fish (Chinook salmon, coho salmon, and steelhead) listed as threatened under the federal Endangered Species Act (ESA) inhabit the Russian River drainage. In December 1997, the U.S. Army Corps of Engineers, 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 third year of study.

WATER TEMPERATURE

The monthly average temperature of water flowing through the Wohler Pool was estimated to increase by 0.16ºC (July) and 0.12ºC (August) above what would have been expected without the dam in place in 2003.

The estimated net effect of the dam was to raise the monthly average water temperature in the Wohler Pool from 22.0 to 22.2°C in July, and from 21.3 to 21.4°C in August.

Based on a review of literature, water temperatures in the study area were sub optimal for at least the last month 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. However, healthy appearing Chinook salmon and steelhead smolts were captured during periods when maximum daily surface temperatures ranged to 23.2ºC (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 2003 sampling seasons.

SMOLT EMIGRATION

Chinook salmon were captured in relatively low numbers starting on March 1 in 2002 and 2003 (indicating that Chinook begin to emerge from the gravel by late February). High flow events in 2003 disrupted sampling in 2003. However, based on all years sampled, Chinook smolt are present in the Mirabel Dam site by late February, with peak abundance occurring during the last two weeks in April and first two week in May. Chinook emigration slowly declines through May and early June, and is essentially completed by early July. The size of the Chinook smolt run was estimated over a five-week period in 2001 and over an 11-week period in 2002, and sporadically in 2003 (when flows permitted). In 2001, 20,245 Chinook smolts were estimated to have emigrated past the dam between May 3 and June 4. During 2002, an estimated 94,172 Chinook smolts passed the dam during the same period. Between March 26 and June 4, 2002, an estimated 215,875 Chinook smolts were estimated to have emigrated past the traps. In 2003, Chinook emigration was estimated on 25 days (April 9 – 12, May 17 – 22, and May 25 – June 5, and June 8 – 10). During these times, an estimated 37,749 (± 6,088) Chinook smolts emigrated passed the traps.

Steelhead smolts were captured throughout the trapping season, but at lower numbers than Chinook smolts. Steelhead emigrate at a much larger size, and are stronger swimmers (based on size) and may be less likely to be captured, particularly by the 5-foot traps. Another factor in the lower numbers of steelhead (compared to Chinook salmon) is the difference in the two species life history strategy. Steelhead emigrate at an older age (usually age 2) compared to Chinook, which emigrate within two to four months of hatching. Salmonids experience a high mortality rate during their early life stages. Although fewer steelhead smolts survive to migrate to the ocean, they are larger than Chinook smolts and have a much higher rate of survival in the ocean.

For the season, 181 wild steelhead smolts were captured in the rotary screw trap. In past years, steelhead smolts were captured primarily in mid March through April, with the run extending through June. Wild steelhead smolts in the Russian River emigrate primarily as 2-year-old fish.

The capture of Chinook and wild and hatchery steelhead smolts after dam 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 of the delay could not be determined by the current study. A companion study, Manning *et al.* (2000, 2003, in press), 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 clip on a weekly basis, then transported approximately 0.8 km upstream of the dam. On the day following a change in the clip used, Chinook smolts captured in the screw traps almost invariably possessed the new clip. Few

Chinook smolts were recaptured bearing the previous week's clip, which would indicate that they had required more than 48 hours too 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

During five years of sampling, four species of fish, smallmouth bass, Sacramento sucker, hardhead, and tule perch have dominated the fish community (in terms of numbers captured during August electrofishing surveys) above the Inflatable Dam (Reaches 2, 3, and 4). In 2003, juvenile American shad were also captured in fairly large numbers. This event is likely tied to the high flow conditions present in the river during the spring, which delayed the inflation of the dam and likely improved spawning conditions for shad. American shad are broadcast spawners, releasing their semi-buoyant eggs into the water column, and depend on their being sufficient flow to keep the eggs suspended in the water column until they hatch, usually 6 to 8 days after spawning at 17˚C. The increase in juvenile shad likely reflects springtime flow conditions in 2003, and not a change in the overall fish composition in the study area.

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

Three potential salmonid predators inhabit the study area, Sacramento pikeminnow, smallmouth bass, and largemouth bass (in addition, a fourth species, striped bass, has also been captured in the Wohler pool, although only two individuals have been captured during four years of sampling). 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, and are a long-lived species (possibly up to 16 years (Scoppettone 1988). Smallmouth bass are the most abundant species inhabiting the study area. The majority of smallmouth bass captured were young-of-the-year, however. No smallmouth bass large enough to prey on an average size steelhead smolt and very few smallmouth bass large enough to feed on 80 mm FL Chinook smolts were captured. It is not known if the low number of older smallmouth bass is due a high rate of mortality among YOY bass, or a high rate of dispersal by YOY bass to areas outside of the study area. Winter habitat conditions (i.e., when the dam is deflated) may at least partially explain the poor recruitment of smallmouth bass to older age classes (see below). Very few largemouth bass were captured. Abundance of largemouth bass was highest in Reach #1 in all years sampled. Smallmouth bass, pikeminnow, and possibly largemouth bass attain a size sufficient to prey on Chinook salmonids by the start of their third year of life (age 2+).

VIDEO MONITORING

Based on the results of video monitoring from 1999 through 2003, Chinook salmon and steelhead appear to be highly successful in finding and ascending the fish ladders around the Inflatable Dam. Relatively large numbers of adult fish of both species have been documented negotiating the ladders, and large numbers of fish milling at the base of the dam have not been observed. However, a satisfactory method of assessing low numbers of fish holding 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.

In 2003, approximately 6,100 adult Chinook salmon were counted ascending the fish ladders at the Mirabel Dam. The 2003 adult Chinook salmon run was approximate 4.0 times the size the size of the 2000 run, when virtually the entire migration period was surveyed. This is in contrast to historical literature that suggests that Chinook salmon 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 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 have not appeared to be successful. The Chinook run began in early September during the five years sampled (1999-2003), and relatively large numbers of salmon have not been observed prior to October in any year. High stream flows brought on by the onset of winter rains have precluded sampling during the tail end of the upstream Chinook migration period in every year except 2000. In 2000, the run peaked in late November and ended in late December (Chase *et al*. 2001). . During August of each of the first three years sampled, one Chinook salmon has been observed in the fish ladders, and nine were counted in 2002.

In 2003, approximately 70 percent of the fish counted passed through the dam during a nine day stretch (October 31 through November 8). In 2002, 76.5 percent of the fish were counted over six days: October 1 and 2, (21.1 percent, primarily on the 2^{nd}), October 15 and 16 (9.9 percent), and November 16 and 17 (45.6 percent). The 2,213 Chinook salmon counted on November 17, extending into the early morning of November 18, 2002 was greater than any annual total count from the previous three years sampling (and this was a partial count owing to high turbidity/low visibility conditions occurring early on the morning of the 18^{th}).

Based on the paucity of historical records of Chinook salmon inhabiting the Russian River, the genetic origin of the Chinook salmon in the Russian River has been debated. Preliminary data from a genetics study conducted by the Bodega Marine Lab (BML 2002) concluded that the Russian River Chinook population is not closely related to Eel River or Central Valley (Sacramento-San Joaquin Rivers) populations. Further, BML (2002) states that "Chinook in the Russian River do appear to belong to a diverse set of coastal Chinook populations."

An important footnote to the abundance data presented above is that the length of time that the fish ladder was in operation varied each year. Thus, a direct comparison between the numbers of fish observed between years cannot be made. Still, it is interesting that the numbers of Chinook salmon counted in 2002 and 2003 were 3.5 to 4.0 times the number counted in 2000, when virtually the entire run was surveyed.

Adult steelhead began their upstream migration in late October, however, the majority of their run occurs after the dam is deflated. Thus, little run information is available for this species.

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1.0 INTRODUCTION

The Sonoma County Water Agency (Agency) diverts water from the Russian River to meet residential, municipal, and agricultural demands. Water diverted primarily results from releases from upstream storage reservoirs. Water is stored in Lake Sonoma and Lake Mendocino, and releases are made to meet downstream demands and minimum instream flow requirements. The Agency'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 (Inflatable Dam) raises the water level and submerges the intakes to three diversion pumps (Figure 1-2). The water is pumped through a dike into a system of canals that supply water to five infiltration ponds. Water is also diverted through two screened control gates that feed two additional infiltration ponds at the Wohler facility. The backwater created by the Inflatable Dam also raises the upstream water level and submerges a larger streambed area along the river. This increased depth and enlargement of the submerged area significantly increases infiltration to the aquifer.

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

The Russian River provides habitat for several special status fish species, including three that are protected under the Federal Endangered Species Act (ESA). On October 31, 1996, the National Marine Fisheries Service (NMFS 1996 (now called NOAA (National Oceanic and Atmospheric Administration) Fisheries) 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 September 16, 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 NOAA Fisheries to "insure that any action authorized, funded, or carried out by such an agency is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat.…" In the present case, the endangered species are anadromous salmonids, which are managed by the NOAA Fisheries. The U.S. Army Corps of Engineers, as the federal sponsor, and the Agency, as the local sponsor, entered into a Memorandum of Understanding (MOU) with the NOAA Fisheries to begin the consultation process in December 1997. The MOU covers the Agency's flood control and water supply projects throughout the Russian River Basin. 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.

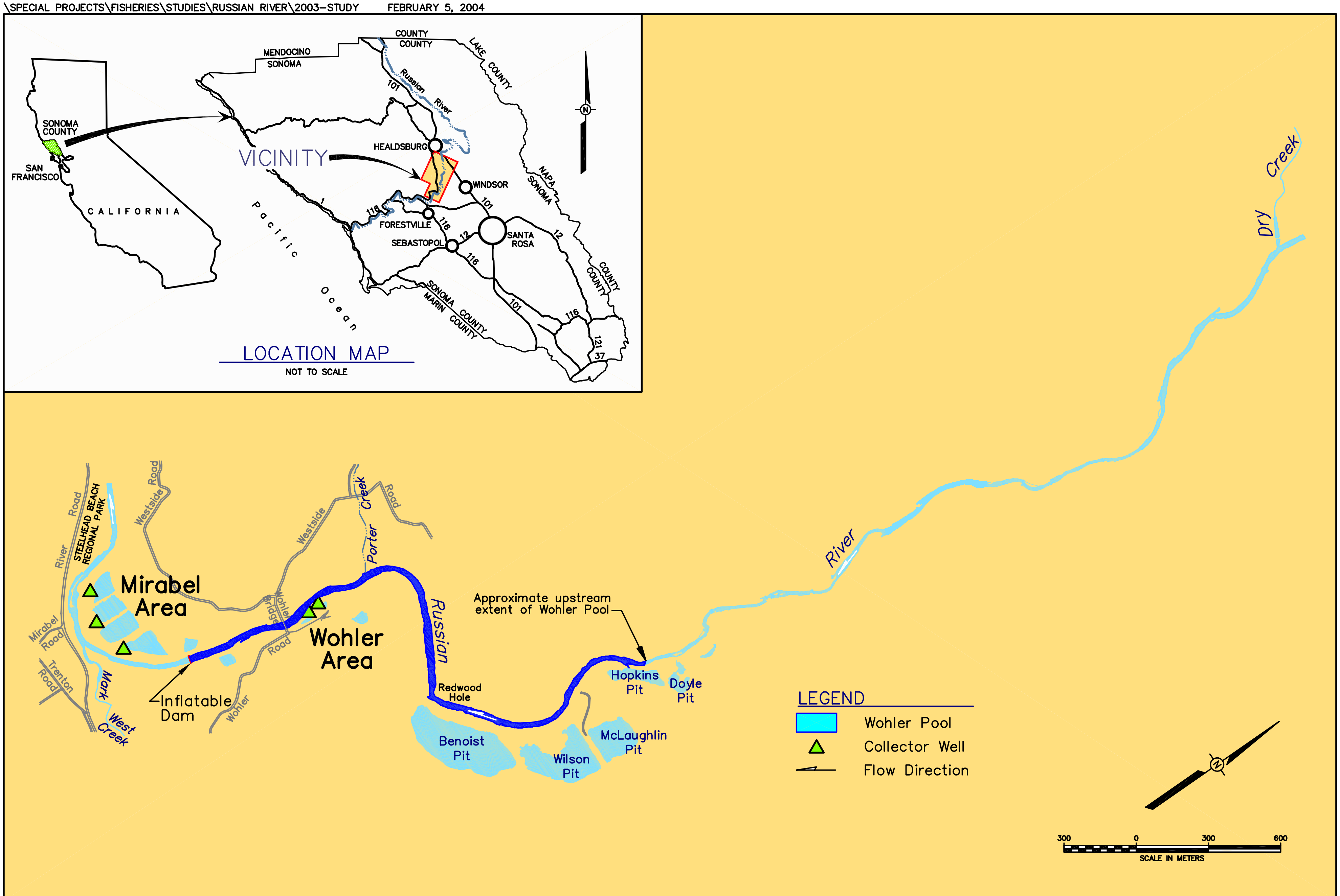


Figure 1-1 Map of Study Area

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

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

- The impoundment slows the flow of water through the basin, and may result in an increase in water temperatures within the impoundment and downstream of the dam. An increase in temperature may degrade conditions if juvenile steelhead rear in the lower river.
- The Inflatable Dam impounds approximately 5.1 km of river, essentially creating a long pool. The impoundment decreases current velocities which smolts use during their downstream migration to the ocean. The loss of this tactile cue may result in smolts becoming disoriented while passing through the impoundment, which 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 *et al.* 2001, 2003, and in Press) 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 initiated a five-year study to assess the potential impacts associated with its diversion facilities at Wohler and Mirabel, and to develop mitigation measures as appropriate.

Prior to initiating this 5-year study, the Agency conducted a study entitled "Sonoma County Water Agency's Mirabel Inflatable Dam/Wohler Pool Reconnaissance Fish Sampling Program" (Chase *et al.* 1999). That program assessed the appropriateness of a variety of sampling methodologies to assess fish and aquatic habitat conditions in the Wohler Pool. The results of that study (Chase *et al.* 2000a) form the basis for the development of the study plan used for this project (Chase *et al* 2000b). This report documents the results of the third 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 12.7 RK upstream of the dam (Figure 1-1).

The Steelhead Beach Sampling location is a relatively large (approximate 620 meter long) natural pool located downstream of the dam. 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. Two water temperature monitoring stations were located 6.4 and 7.1 RK above the upstream extent of the pool.

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) Below Dam sampling station: Located at RK 36.3 (60 m downstream of the Inflatable Dam.
   - Rotary Screw trap
   - Continuous water temperature monitoring station

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: 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 47.9
   - Continuous water temperature monitoring station

7) Above Dry Creek Confluence: RK 49.1
   - Continuous water temperature monitoring station

1.2 HISTORICAL LOWER RUSSIAN RIVER FISH SURVEYS

The fish community in the study area (Steelhead Beach and the Wohler Pool) has been surveyed by various sampling techniques over the past 5 years. In addition, the lower Russian River fish community has been previously surveyed on several occasions between 1954 and 1993 (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, 31 species, including 16 native species, have been collected or observed during fish sampling programs conducted between 1999 and 2003 (Table 1-1). Five additional species of fish have also been reported in the Russian River. Coho salmon (*Oncorhynchus kisutch*) and coastrange sculpin (*Cottus aleuticus*) inhabit streams located primarily downstream from the Inflatable Dam, and at least historically, inhabited a small number of streams above the dam. Coho salmon have also been reported in the Dry Creek and Mark West Creek Basins in recent years, however, they have not been observed during this study. River 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 do not spawn or rear their young in the river.

Overall, native species comprised approximately 60 percent of the total catch during the past five years of fish sampling in the study reach. The fish community in the Study Reach was dominated (numerically) by smallmouth bass (30.7 percent), Sacramento sucker (25.5 percent), hardhead (13.8 percent), and tule perch (11.8 percent), all years and all stations, combined.

Table 1-1. Common and scientific names of species captured in the Russian River during 1999 through 2003 sampling efforts, including their status (native or introduced), life history strategy (anadromous or resident), and their regulatory status.

Common Name	Scientific Name	Status	Resident - Anadromous	Regulatory status
American shad	*Alosa sapidissima*	Introduced	Anadromous	--
Sacramento sucker	*Catostomus occidentalis*	Native	Resident	--
California roach	*Lavinia symmetricus*	Native	Resident	CSC[1]
Hardhead	*Mylopharodon conocephalus*	Native	Resident	CSC
California blackfish	*Orthodon microlepidotus*	Uncertain[2]	Resident	--
Hitch	*Lavinia exilicauda*	Native	Resident	--
Pikeminnow	*Ptychocheilus grandis*	Native	Resident	--
Fathead minnow	*Pimephales promelas*	Introduced	Resident	--
Golden shiner	*Notemigonus crysoleucas*	Introduced	Resident	--
Common carp	*Cyprinus carpio*	Introduced	Resident	--
Threespine stickleback	*Gasterosteus aculeatus*	Native	Resident	--
Bluegill	*Lepomis macrochirus*	Introduced	Resident	--
Green sunfish	*Lepomis cyanellus*	Introduced	Resident	--
Redear sunfish	*Lepomis microlophus*	Introduced	Resident	--
Black crappie	*Pomoxis 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	--
White catfish	*Ameiurus catus*	Introduced	Resident	--
Bullhead	*Ameiurus melas*	Introduced	Resident	--
Mosquitofish	*Gambusia affinis*	Introduced	Resident	--
Pacific lamprey	*Lampetra tridentata*	Native	Anadromous	--
Western brook lamprey	*Lampetra richardsoni*	Native	Resident	--
Chinook salmon	*Oncorhynchus tshawytscha*	Native	Anadromous	FT[3]
Chum salmon	*Oncorhynchus keta*	Native/Stray	Anadromous	--
Pink salmon	*Oncorhynchus gorbuscha*	Native/Stray	Anadromous	
Steelhead	*Oncorhynchus mykiss*	Native	Anadromous	FT
Striped bass	*Morone saxitalis*	Introduced	Anadromous	--

[1]California species of special concern

[2] Status of this species is uncertain. Although they are native to the Sacramento River, their status in the Russian River is not clear (Hopkirk 1973).

[3] Listed as Threatened under the Federal Endangered Species Act

During historical surveys, native resident fish (Sacramento sucker and Sacramento pikeminnow), introduced sunfish (e.g., smallmouth bass and green sunfish), and juvenile American shad dominated the catch. Russian River tule perch were collected in low numbers during all surveys. It is important to note that beach seines are biased towards capturing smaller individuals, and are limited to sampling relatively shallow habitats that have smooth, unobstructed substrates, with moderately sloped contours. Beach seines are generally not effective at capturing species that are found in heavy cover (e.g., adult smallmouth bass), or fast swimming species (e.g. adult pikeminnow).

Young-of-the-year and age-1 or older steelhead were collected infrequently during the summer rearing period. Summertime water temperatures are believed to limit steelhead in the lower river. During a 1954 study, four juvenile steelhead were captured at one site (water temperature 24.4° C), ranging in length from 10.7 to 18.3 cm (CDFG 1954). All steelhead were infected with external parasites. No juvenile steelhead were observed or captured during a 1984 CDFG study (Cox 1984). However, in one study (CDFG 1955) 153 steelhead (mainly young-of-the-year) were captured in the lower Russian River at 30 sampling stations (generally one beach seine haul per site). No coho and only two Chinook salmon have 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 in the river (this report) and in the estuary (MSC 1997).

Based on five 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 two adult striped bass have been captured, and four juvenile striped bass have been observed, in the study area during the first five years of this study.

Fish communities in the Russian River Basin form analogous aggregations to those described by Moyle and Nichols (1973), Moyle (2002). Fish populations change in response to habitat conditions. Two important factors affecting the distribution of fish are water temperature and stream gradient. The borders between fish zones are not distinct, but gradually shift from one zone to another in response to changes in habitat. The five freshwater zones described by Moyle and Nichols (1973) and Moyle (1976) are; the Rainbow Trout Zone (RTZ), the California Roach Zone (CRZ), the Squawfish (Pikeminnow) - Sucker - Hardhead Zone (SSHZ), the Deep-bodied Fish Zone (DFZ), and the Estuarine Fish Zone (EZ).

The Rainbow Trout Zone (RTZ) is found in headwater streams with relatively high gradients, cold (seldom greater than 21°C) well-oxygenated water. Fish communities are dominated by rainbow trout, although sculpin are often found in the lower portions of the zone. Examples of the RTZ include the upper reach of Mark West and Santa Rosa creeks. The CRZ is typified by warm, intermittent streams. California roach are the dominant species in the middle section of Mark West Creek and below Highway 12 on Santa Rosa Creek. The Pikeminnow - Sucker - Hardhead Zone is found in the mainstem Russian River near Mirabel.

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 bass 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.

1.4 LIFE HISTORY REQUIREMENTS FOR TARGET SPECIES

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

Water temperature within the study reach warrants special consideration. 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 other metabolic activities 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).

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

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

1.4.1 Chinook Salmon

Adult Chinook salmon migrate upstream through the study area to their spawning habitat, located primarily in mainstem Russian River upstream of the city of Healdsburg (Cook 2003), and in larger 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 (one to four months of age). Chinook salmon in the Russian River emigrate through the Wohler Pool at about 90 millimeters (mm) fork length (FL) (range 32 to 140 mm). Factors that stimulate downstream migration are not well known (Healey 1991), however, streamflow likely plays a role. The primary concerns for Chinook smolts are water temperature, passage around the Inflatable Dam, and exposure to predation.

The upper lethal water temperature for Chinook salmon has been 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).

Figure 1-3. Russian River Chinook salmon smolt.

Fall Chinook salmon reportedly migrate at temperatures ranging from 10.6 to 19.4°C, with an optimal temperature of 12.2°C (Bell 1991). Upstream migration by adult Chinook salmon in the San Joaquin River was halted when temperatures exceeded 21.1°C, but resumed when temperatures declined below 18.3°C (Hallock 1970, cited by ENTRIX (in DW Kelly and Associates and 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 ENTRIX (in DW Kelly and Associates and 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 five years of investigations. Coho salmon spawn primarily in tributaries located downstream of the study area. However, historically, coho salmon were known to inhabit a small number of tributaries upstream of the Mirabel/Wohler area. Coho migrate upstream during the fall (November and December), and juvenile emigration occurs during the spring (March through May). Coho salmon spawn and rear in tributaries, thus the only life stages potentially affected by the dam are emigrating smolts and upstream migrating adults. Coho salmon, 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) 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. Adult steelhead migrate through the study area during the winter (December through March), when the dam is generally not inflated. Steelhead smolts, however, emigrate during the Spring (March through early June) and may be negatively impacted by the dam. In addition, low numbers of steelhead may rear in the Study Area throughout the summer. Low numbers of juvenile wild and hatchery steelhead have been observed in the study area during all five years of sampling. Steelhead smolts emigrate through the Wohler Pool at an average size of approximately 175 mm FL (range 83 to 259 mm). Young-of-the-year steelhead have been captured below the dam, measuring between 29 mm and approximately 130 mm FL, depending on the time of year.

Figure 1-4 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. Wurtsbaugh and Davis (1977) reported that for fish fed to satiation, an increase in temperature led to an increase in the maximum consumption rates. The high feeding rates decreased the negative effects of increased water temperatures, up to 22.5°C for rainbow trout. Above 22.5°C, feeding rates decreased, possibly due to temperature related stress.

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 to. Site-specific temperature tolerance data are not available for salmonids in the Russian River Basin. A series of threshold temperatures were developed based on the available literature and recommendations of the NCRWQCB (Klamt 2000). The terms used to discuss the results of this study are similar, and can be confusing at first glance. Table 2-2 presents the terminology and their definitions used in this report, while Table 2-3 presents the criteria and supporting citations. The temperature regimes described do not necessarily represent absolute thresholds where impacts will occur to Chinook and coho salmon and steelhead inhabiting the Russian River. The thresholds do provide a framework to assess the overall suitability of the thermal regimes within the study area to support salmonids. Temperature thresholds used are divided into two classes; long term (chronic) affects, and short term (acute) affects. Salmonids can survive short-term exposure to relatively high temperatures without appreciable mortalities occurring. However, long-term exposure to moderately high temperatures can result in adverse affects (e.g., reduction in growth). At a sufficiently high temperature, mortality can occur over the short term. For example, Sullivan *et al.* (2000) estimated a 10 percent mortality rate for yearling rainbow trout exposed to a temperature of 26.5°C for six hours, and that the same rate of mortality would be expected to occur during a one-hour exposure to a temperature of 28.3°C. Water temperatures were evaluated primarily using a 7-day running average temperature and daily maximum temperatures.

Table 1-2. 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 supporting citations used to assess thermal regimes in Mirabel reach of the Russian River.

Temp	7-day running averages and MWAT thresholds	Source
14.5	Coho found in all Mattole River tributaries with MWATs below this threshold	Welsh *et al.* 2001
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	Hallock 1970 CDWR 1988
23.0	Chronic stress, survival jeopardized at temperatures above threshold for steelhead	Roelofs *et al.* 1993
Temp	**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 Sullivan *et al.* 2000
22.0	Salmonids utilization of cool water refuge begins to increase, feeding decreases	Nielsen *et al.* 1994 Sullivan *et al.* 2000
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 the top piscivore in the Russian River. Site-specific information on pikeminnow in the Russian River is limited, and most of what is known about their biology and life history comes from studies conducted in other river systems, primarily in the Sacramento and San Joaquin. In addition, a considerable amount of work has been conducted on the closely related northern pikeminnow (*P. oregonensis*) predation on salmonid smolts in the Columbia River Basin.

Historical observations of pikeminnow in the Russian River are generally limited to Taft and Murphy (1950), and a few CDFG reports, primarily during the late 1950s/early 1960s chemical treatment (rotenone) projects. Pikeminnow occupy pools throughout the Russian River and the lower reaches of the larger tributaries. Pikeminnow are native to the Russian River, and would be found in the area with or without the dam. Large pikeminnow are apparently widespread above the Wohler Pool, and were observed in most large pools sampled during a snorkel survey in 2002 (Cook 2003).

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

Figure 1-5. 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 sculpin. Juvenile salmonids were found in 2 percent of the 1,127 pikeminnow stomachs examined.

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

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

Zimmerman (1999) developed a linear regression for the size of salmonids that could be consumed by northern pikeminnow between 250 and 550 mm FL (the northern pikeminnow is closely related and similar in morphology to the Sacramento pikeminnow) (Table 1-4). Based on this regression, northern pikeminnow ranging in size from 250 and 550 mm FL can consume salmonids ranging in length from 116 to 227 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.

Growth rate is an important factor to consider when assessing the potential for a predator to impact a prey species. Until the predator becomes large enough to feed on the prey species, they are not a threat. Lengths of pikeminnow captured in August (average between 1999 - 2002) in the Russian River are as follows (Table 1-5):

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

Table 1-5. Average fork lengths and numbers of Sacramento pikeminnow, by age class, captured in the Russian River during August electrofishing surveys (1999 – 2003 sampling seasons combined).

	Age 0+	Age 1+	Age 2+	Age 3+	Age 4+	Age 5+ up
Number	181	98	22	12	5	28
Average	65	141	257	352	439	603
Range	35 - 95	105 - 200	195 - 300	320 - 385	410 - 455	515 - 710

It should be noted that aging large cyprinids (e.g., pikeminnow) by scale analysis is unreliable (Scoppetone (1988, Moyle 2002). Growth of older fish slows considerably, and the annuli are laid too close together to accurately age fish by this method. This point was highlighted by the capture of a pikeminnow tagged in 2001. This individual measured 615 mm FL in August of 2001, and 655 mm FL in August of 2003. The fish was aged as 5 years old in 2001, but would have only been aged as a 5 or 6 year old fish based on scale analysis in 2003. Clearly, the age of this fish would have been underestimated. Pikeminnow are a long lived species, with fish as old as 16 years old being aged from otoliths (a much more reliable, but lethal, technique to age older fish) (Scoppetone 1988).

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

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 mid to late June in 2000 and 2002.

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

Optimal water temperatures for growth range from 26 to 29°C, and preferred temperatures range from 21 to 27°C (data cited by Edwards *et al.* 1983, Carlander 1977). Growth reportedly does not occur at temperatures below 10 to 14°C. Smallmouth bass prefer DO levels in excess of 6.0 ppm. Edwards and Gebhart (1983) cite data showing that adult smallmouth bass seek cover when temperatures drop to 15 to 20°C, and become inactive at approximately 10°C.

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

Smallmouth bass will consume a wide variety of food items, including fish, crayfish, insects, and amphibians (Moyle 2002). Smallmouth bass have been documented to feed on salmonids, primarily under-yearling Chinook salmon smolts (same life stage found in the Russian River). Underyearling Chinook salmon comprised 59 percent of the diet of smallmouth bass in one Columbia River study (Tabor *et al.* 1993). However, in another study, also on the Columbia River, underyearling Chinook accounted for only 4 percent of smallmouth bass prey items (Poe *et al.* 1991). Zimmerman (1999) reported that subyearling Chinook salmon accounted for 12.4 to 25.8 percent of the diet of smallmouth bass collected in three sections of the Columbia River during a seven-year study (smallmouth bass were collected during the spring and summer smolt emigration period).

Zimmerman (1999) developed a linear regression for the size of salmonids that could be consumed by smallmouth bass between 200 and 400 mm FL (Table 1-6). 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.

Little data are available on the abundance and distribution of largemouth bass in the Russian River. They are apparently confined to the lower sections of the river, but are not generally considered abundant. Largemouth bass were captured in low numbers in this study.

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

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).

Figure 1-7 Largemouth bass captured in the Russian River

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 summer period, water temperature tends to increase naturally as a river flows from its headwaters to the ocean. The rate of increase varies depending on climatic conditions, river morphology, and habitat quality. Impoundments such as Wohler Pool may degrade water quality, primarily by increasing the rate at which water temperature increases. Impoundments slow the flow of water through the basin. The longer that water resides in the pool, the greater the opportunity for warming through solar radiation. The primary objective of this study is to determine to what degree, if any, the impoundment increases the rate at which water warms compared to free flowing riverine conditions.

A secondary objective of this study is to provide a general description of the spring through fall thermal regime within the study area, and compare this to the temperature requirements of the target species (Chinook salmon, coho salmon, steelhead). 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).

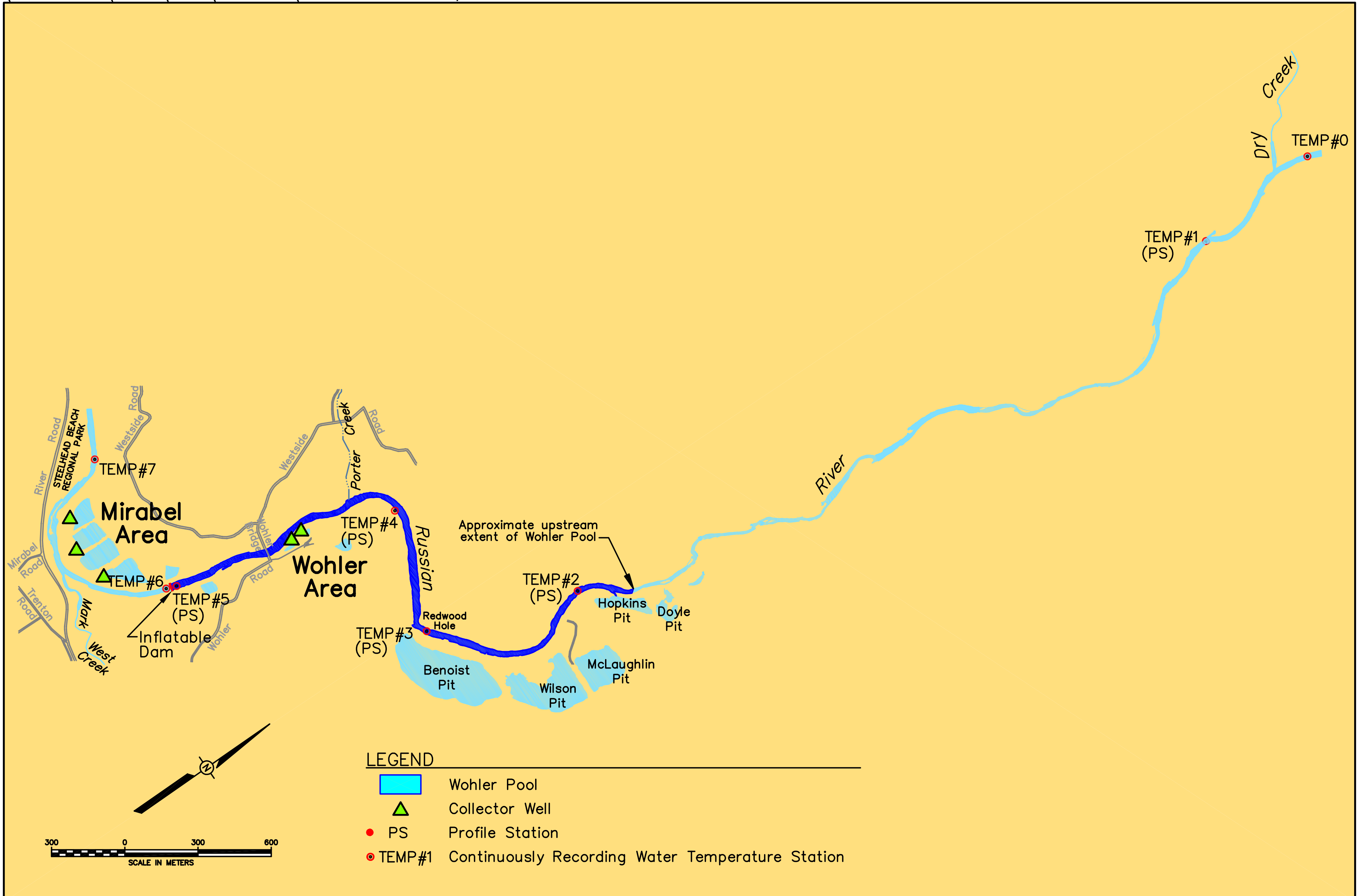
The final objective of this study is to determine the potential for the Wohler Pool to become thermally stratified during the summer. The density of water decreases as the temperature increases (thus, warm water "floats" on top of cold water). Thermal stratification develops when a strong density gradient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

2.2 METHODS

Eight continuously recording water temperature-monitoring stations were selected within the study area in 2003 (Figure 2-1). In previous years, seven water temperature stations were monitored. The additional station in 2003 was designated at "Station 0" to maintain continuity of the numbering system between years. Water temperature data were collected using Hobo 8K data loggers (Onset Computers, Inc.). At stations 1, 3 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 Stations 0, 2, and 6, one data logger was deployed at a depth of approximately 1 meter (these were relatively shallow stations with moving water, therefore the temperatures at these stations was uniform top to bottom). Data loggers were programmed to record temperature on an hourly basis, 24 hours a day.

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 ± 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 ºC to ºF is presented in Appendix A.



SONOMA COUNTY WATER AGENCY

Figure 2-1 Continuous water temperature and water quality profile stations - 2003

2.3 RESULTS

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

2.3.1 Streamflow

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

- 125 cfs during normal water supply conditions
- 85 cfs during dry water supply conditions, 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 three years of this study. The 2003 water year qualified as a normal year under the conditions set by Decision 1610. Streamflows measured below the inflatable dam during June through August of 2003 were generally higher compared to the flows released during the same time frame in 2000 and 2002.

In addition to flow, channel morphology is also different above and below the Inflatable Dam. Above the Wohler Pool is approximately 70 percent run, compared to habitat below the dam that is approximately 70 percent pool (Chase *et al.* 2000b). The difference in streamflow and channel morphology undoubtedly affects residence time of the water flowing through these reaches. The differences in streamflow and channel morphology affect the rate at which water temperature changes above and below the dam, thus, the above and below reaches are not 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), 2001 (dry year), and 2002 (dry spring), and 2003 (normal).

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

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

2.3.2 Continuous Temperature Recording

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

Table 2-2. Dates of operation for data loggers at seven continuous temperature recording Stations, 2002.

Station	Date deployed	End date	Periods of non operation
0	March 5	October 13	None
1 (bottom)	March 6	October 13	April 11 through June 3[1]; June 13 through June 18[2]
1 (surface)	June 12	October 13	None
2	March 5	October 13	April 11 to May 15[1]; May 30 to June 11[1]
3 (bottom)	May 30	September 18	September 19 on[2]
3 (surface)	May 30	October 13	None
4 (bottom)	May 30	August 28	June 12 to June 18[2]; August 29 on[2]
4 (surface)	May 30	October 13	None
5 (bottom)	May 30	October 13	None
6	February 21	November 10	March 22-26; April 11 – May 13[1]; June 8 – June 16[2]
7 (bottom)	March 5	October 13	May 26 to June 4

[1]Data loggers lost during high flow event.
[2]Data logger failed

2.3.3 Rate and Magnitude of Change in Water Temperature between Stations

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

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

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

The rate of change in the average monthly water temperature was similar (0.04°C/km) in July and August, 2003, over the 6.5 km distance between Stations #1 and #2 (Table 2-2). The rate of change in water temperature resulted in an overall increase in Magnitude of the average monthly temperature of water flowing between the two stations of 0.29°C for July and August, respectively (Table 2-2). The rate of change in the daily average water temperature ranged from 0.00 to 0.08°C/km for July and August (Table 2-3), equating to an overall change in the magnitude of the temperature of 0.0 to 0.51°C over the 6.5 km distance.

Table 2-3 The minimum and maximum daily and the average monthly rate of change in temperatures (°C/km) and the magnitude of change in temperatures (°C) between Stations #1 and #2, July and August, 2003, Russian River.

Date	Minimum daily change		Average Monthly change		Daily maximum change	
	(°C/km)	(°C)	(°C/km)	(°C)	(°C/km)	(°C)
July	0.00	0.00	0.04	0.29	0.08	0.51
August	0.00	0.00	0.04	0.29	0.07	0.43

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

The rate of change in the average monthly water temperature was 0.08 and 0.07°C/km, respectively, in July and August, 2003, over the 6.5 km distance between Stations #1 and #2 (Table 2-3). The rate of change in water temperature resulted in an overall increase in Magnitude of the average monthly temperature of water flowing between the two stations of 0.39°C during July and 0.35°C August (Table 2-3). The rate of change in the daily average water temperature ranged from 0.00 to 0.13°C/km for July and August (Table 2-2), equating to an overall change in the magnitude of the temperature of 0.0 to 0.67°C over the 6.5 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 in July and August were increased from 0.2°C, compared to what would have been expected without the dam (Table 2-5, Figure 2-2, Appendix C). The estimated net effect of the dam was to raise the monthly average water temperature in the Wohler Pool from 22.0 to 22.2°C in July, and from 21.3 to 21.4°C in August.

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 #2 and #6, July and August 2003, Russian River.

Date	Minimum daily change		Average Monthly change		Daily maximum change	
	(°C/km)	(°C)	(°C/km)	(°C)	(°C/km)	(°C)
July	0.01	0.05	0.08	0.39	0.13	0.64
August	0.00	0.00	0.07	0.35	0.13	0.67

Table 2-5. Actual and estimated average monthly magnitude of change in the water temperatures in the Wohler Pool reach using the temperature data developed for the above impoundment rate of increase, July through August, 2003.

Month	Actual monthly increase in surface temperatures (°C)	Estimated increase using Above Reach Rates (°C)	Difference between actual and estimated temperatures (°C)
July	0.39	0.23	0.16
August	0.35	0.23	0.12

2.3.5 Seasonal Water Temperatures within the Study Area.

Chinook salmon and steelhead, and possibly coho salmon, 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 17.8ºC and the MWMT is below 21.1ºC for migrating adults and 20.5ºC for Chinook and steelhead smolts. Rearing conditions for juvenile steelhead should be suitable when the MWAT is less than 17.8ºC and the MWMT should be below 20.5ºC to provide suitable growth conditions for juvenile steelhead (a reduction in the growth rate of greater than 10 percent has been reported for temperatures above 20.5ºC (Sullivan *et al.* 2002). Temperature above 26.0ºC can result in direct mortality in a matter of hours.

In general, water temperatures were sub optimal during at least a portion of the time for all life stages at all stations (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 upstream sites (Stations #1 and #2). 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 the first few weeks of the upstream migration period, but quickly improved during October when the majority of the fish began entering the river. Steelhead migration begins in late November/December, after temperatures have declined to acceptable levels.

2.3.5.1 Seasonal water temperatures during the smolt emigration period.

Water temperatures during the steelhead and Chinook salmon emigration period are generally below the criteria thresholds throughout the majority of the spring emigration period (April and May). Weekly average (≤17.8ºC) and weekly maximum (≤20.5ºC) temperatures were suitable for Chinook salmon and steelhead smolts until May 16 and May 19, respectively in 2003 (Table 2-6). These temperature criteria were exceeded within a day of each other at all stations (above and below the project area). The weekly average temperature exceeded 21.1ºC (the point that emigration has been halted in other river systems) on June 14, although, the emigration period is essentially over by this date. During the past three years, the date that the temperature first exceeded the 17.8ºC MWAT has ranged from late April to mid-May, the 20.5ºC MWMT from early to mid-May, and the 21.1ºC criteria from mid May to late June (Table 2-3).

Table 2-6. Dates that water temperatures first exceeded selected water temperature criteria, 2000- 2003.

Year	≥17.8 (MWAT)	≥20.5 (MWMT)	≥21.1 (MWAT)
2000	May 14	May 15	May 18
2001	April 21	May 7	May 16
2002	May 5	May 25	May 29
2003	May 16	May 19	June 22

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 mid May through approximately mid October at all temperature monitoring stations. The 7 day average water temperature recorded at the four Wohler Pool stations were generally ≥20.5ºC from approximately mid June through mid September, with a maximum daily temperature (bottom) ranging between 22.9 and 25.2ºC within the impoundment, June through September (Table 2-7). The weekly maximum temperature exceeded 22.0ºC (the temperature at which salmonids begin seeking cool water refuge) 86 times at Station #0, 36 times at Station #1, 82 times at Station #2, and 97 times at Station #5, respectively, during June through September, 2003 (Table 2-6). Hourly temperatures peaked at 25.6ºC Stations 0, and exceeded 25.0ºC for a total of 64 hours total in 2003, primarily from July 15th through the 22nd. At Station 2, water temperature exceeded 25.0ºC for one hour on July 21. Temperatures in this range are approaching lethal levels.

2.3.5.3 Water temperature conditions during the fall adult migration period.

Water temperatures were sub optimal during the first three to four weeks during the adult upstream migration period (September). Average weekly temperatures exceeded 17.8ºC at Station #6 through October 10 (Table 2-6). Water temperatures rapidly decreased after this date, and the 7 day average temperature declined below 17.8ºC October 5 at Station 2, and October 11 at Station 6. Water temperatures improved rapidly starting the second week of October, with weekly average temperatures falling below 15.0ºC on October 25 (Figure 2-8).

Table 2-7. **Maximum daily average, daily maximum, maximum weekly average, and maximum weekly maximum temperatures, by month, at 8 water temperature monitoring stations, Wohler Pool, 2003.**

Maximum Daily Average Temperature (by month) (°C)								
Month	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
March 5	16.2	15.5	15.8	N/A	N/A	N/A	15.9	16.0
April	15.6	DLF	DLF	N/S	N/S	DLF	DLF	15.8
May	21.0	DLF	DLF	N/S	N/S	23.0	20.6	20.5
June	24.4	22.3	22.6	22.3	22.9	23.3	23.0	23.5
July	25.1	22.4	22.9	22.8	23.1	22.2	23.2	23.9
August	23.5	21.4	21.7	21.8	22.0	23.3	22.3	22.7
September	22.1	21.0	21.2	21.3	N/A	N/A	22.6	21.9
October 13	N/S	N/S	N/S	N/S	N/S	N/S	20.5	N/S

Daily Maximum Temperature (by month) (°C)								
Month	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
March 5	17.1	16.8	16.8	N/S	N/S	N/S	17.1	16.8
April	17.1	DLF	DLF	N/S	N/S	N/S	N/A	17.5
May	22.5	DLF	DLF	N/S	N/S	N/S	22.1	21.3
June	25.2	23.2	24.4	23.2	24.8	24.4	24.0	24.4
July	25.6	23.6	25.6	25.2	25.2	24.4	24.0	24.8
August	24.0	22.5	24.0	24.0	23.6	23.2	22.9	23.6
September	23.6	22.5	22.9	22.9	DLF	23.6	23.2	23.6
October	N/S	N/S	N/S	N/S	N/S	N/S	21.0	N/S

Maximum Weekly Average Temperature (by month) (°C)								
Month	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
March 5	15.1	14.7	14.9	N/S	N/S	N/S	15.1	15.2
April	14.6	DLF	DLF	N/S	N/S	N/S	N/S	14.7
May	20.9	DLF	DLF	N/S	N/S	N/S	20.6	20.0
June	23.2	21.4	21.6	21.5	21.9	22.1	22.2	22.8
July	24.9	22.2	22.6	22.7	22.9	23.1	23.0	23.7
August	22.9	20.9	21.2	21.3	21.5	22.3	21.6	22.2
September	21.3	20.5	20.3	20.4	DLF	22.4	22.0	21.2
October	N/S	N/S	N/S	N/S	N/S	N/S	19.9	N/S

Maximum Weekly Maximum Temperature (by month) (°C)								
Month	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
March 5	16.2	15.9	16.0	N/S	N/S	N/S	16.1	16.2
April	15.8	DLF	DLF	N/S	N/S	N/S	DLF	15.9
May	22.5	DLF	DLF	N/S	N/S	N/S	21.9	21.0
June	24.5	22.6	23.2	23.0	23.5	23.5	23.3	24.0
July	25.3	23.3	24.7	24.8	24.8	24.2	23.9	24.5
August	23.4	22.1	23.4	23.4	23.1	23.1	22.3	23.2
September	22.5	22.3	22.1	22.1	DLF	23.0	22.5	22.5
October	N/S	N/S	N/S	N/S	N/S	N/S	20.5	N/S

1 NS = Not sampled

2 DLF = Data logger failed

Table 2-8. **Number of times that the weekly average bottom temperature exceeded 17.8ºC, by month[1] at Stations 0 through 7, March through September, 2003.**

Stations	June	July	Aug	Sept	Oct
0	30	31	31	30	N/S[3]
1	DLF[2]	31	31	30	N/S
2	DLF	31	31	28	N/S
3	30	31	31	18	N/S
4[4]	DLF	31	28	N/S	N/S
5	30	31	31	30	N/S
6	21	31	31	20	10
7	26	31	31	30	N/S

Table 2-9. **Number of times that the weekly average bottom temperature exceeded 20.0ºC, by month[1] at Stations 0 through 7, March through September, 2003.**

Station s	June	July	Aug	Sept	Oct
0	30	31	31	30	N/S
1	DLF	31	31	12	N/S
2	DLF	31	31	7	N/S
3	20	31	31	7	N/S
4	DLF	31	28	N/S	N/S
5	22	31	31	26	N/S
6	16	31	31	25	0
7	20	31	31	22	N/S

Table 2-10. **Number of times that the weekly maximum weekly bottom temperature exceeded 22.0ºC, by month[1], at Stations 0 through 7, March through September, 2003.**

Station s	June	July	Aug	Sept	Oct
0	23	31	26	6	N/A
1	DLF	22	3	2	N/A
2	DLF	31	31	1	N/A
3	19	31	31	1	N/A
4	DLF	31	28	N/S	N/A
5	19	31	28	19	N/A
6	10	31	18	5	0
7	16	31	31	5	N/A

Table 2-11. **Number of times that the daily maximum bottom temperature exceeded 24.0ºC, by month[1], at Stations 0 through 7, March through September, 2003.**

Station s	June	July	Aug	Sept	Oct
0	7	13	0	0	N/S
1	DLF	0	0	0	N/S
2	DLF	9	0	0	N/S
3	0	13	0	0	N/S
4	DLF	11	0	N/S	N/S
5	2	3	0	0	N/S
6	0	0	0	0	0
7	2	11	0	0	N/S

[1]Includes the first week of the following

[2]NS = No sampled
[3]DLF = Data logger failed for a significant portion of the month
[4]Data logger failed after the 28th of August

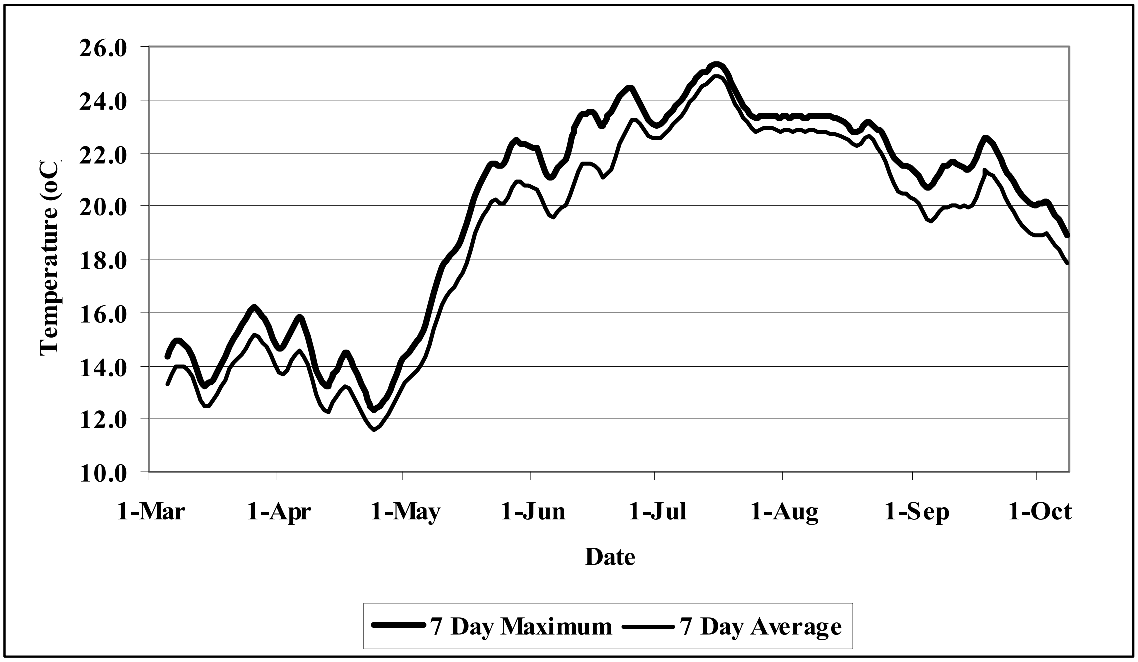


Figure 2-2 Weekly maximum and weekly average water temperatures recorded at a depth of 1.0 meters, Station #0, Russian River Above Dry Creek, 2003.

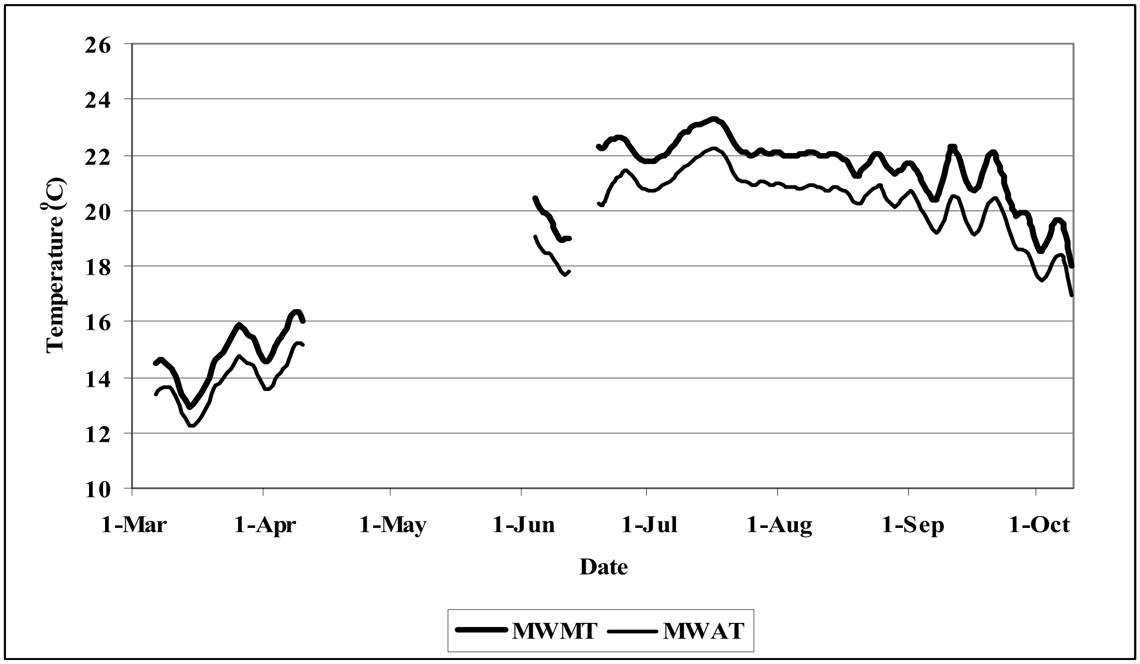


Figure 2-3 **Weekly maximum and weekly average water temperatures recorded at a depth of 1.0 meters, Station #1, Russian River 1 km downstream of Dry Creek, 2003.**

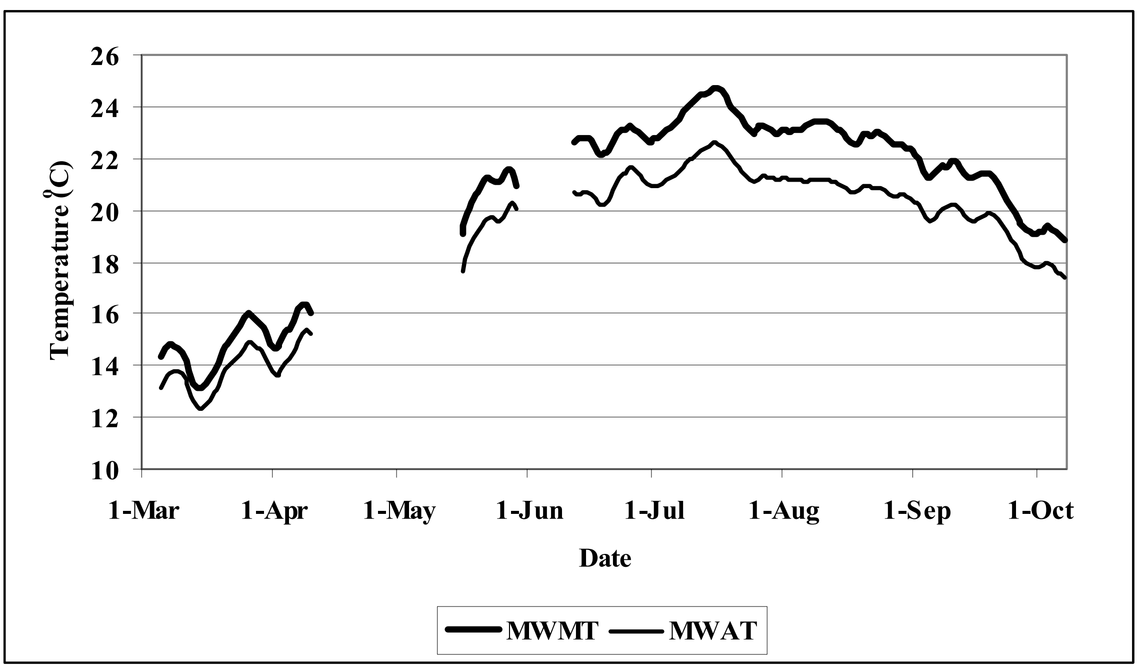


Figure 2-4 **Weekly maximum and weekly average water temperatures recorded at a depth of 1.0 meters, Station #2, Russian River at the upstream end of the Wohler Pool, 2003.**

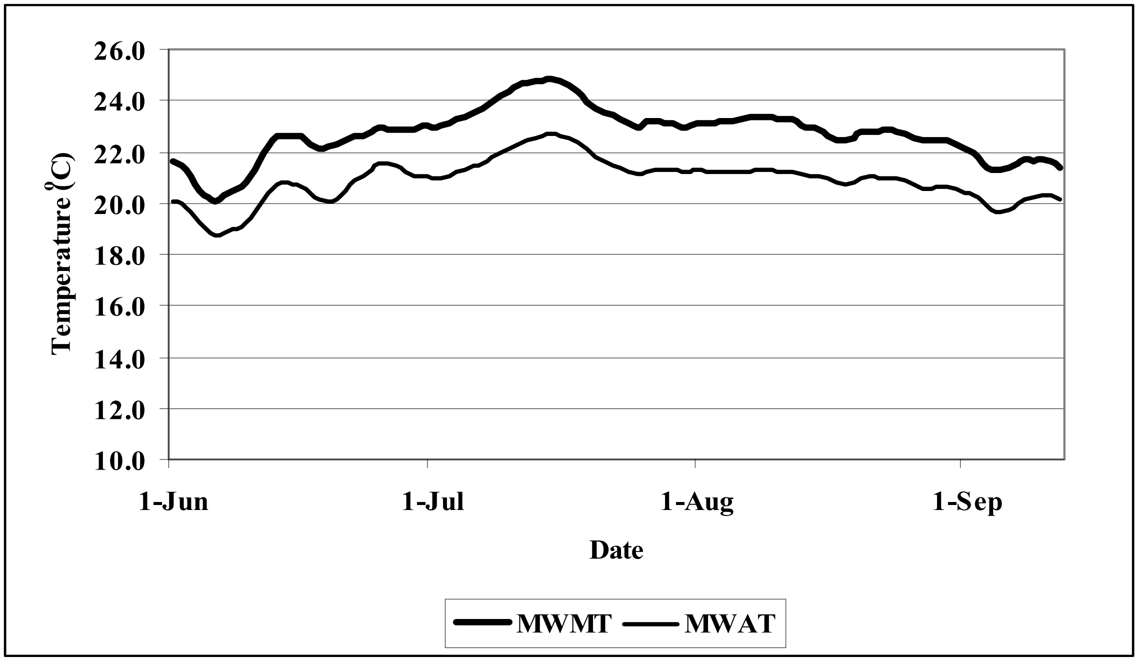


Figure 2-5 Weekly maximum and weekly average water temperatures recorded at a depth 4.0 meters, Station #3, Mirabel Russian River, upper 1/3 of the Wohler Pool 2003.

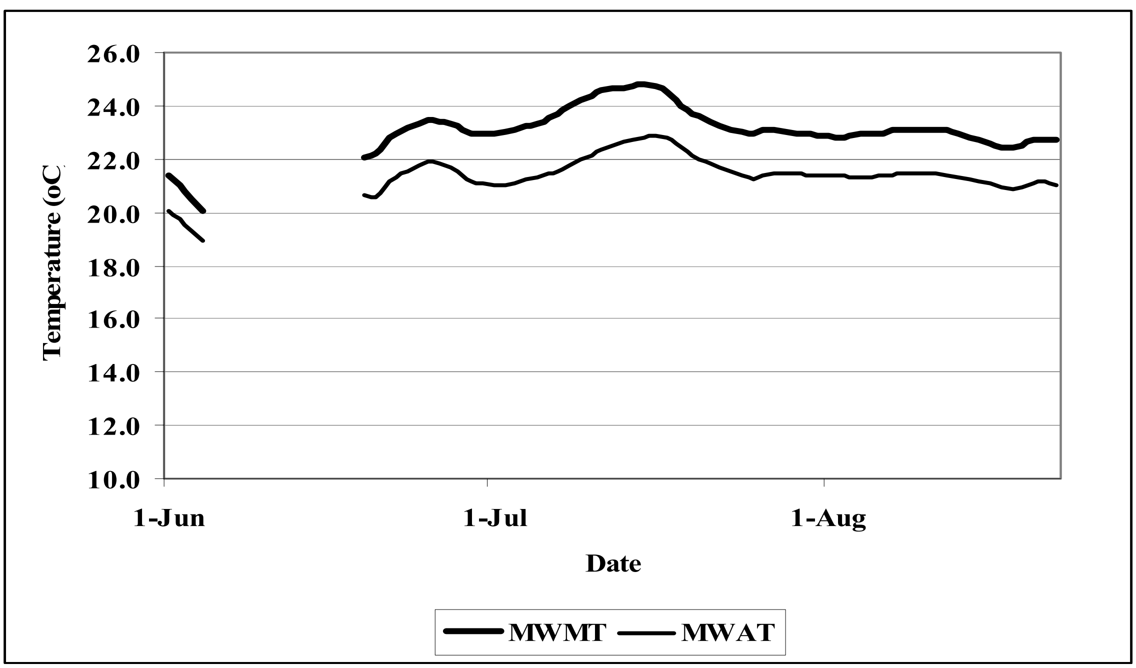


Figure 2-6 Weekly maximum and weekly average water temperatures recorded at a depth of 3.0 meters, Station #4, Russian River, lower 1/3 of the Wohler Pool, 2003.

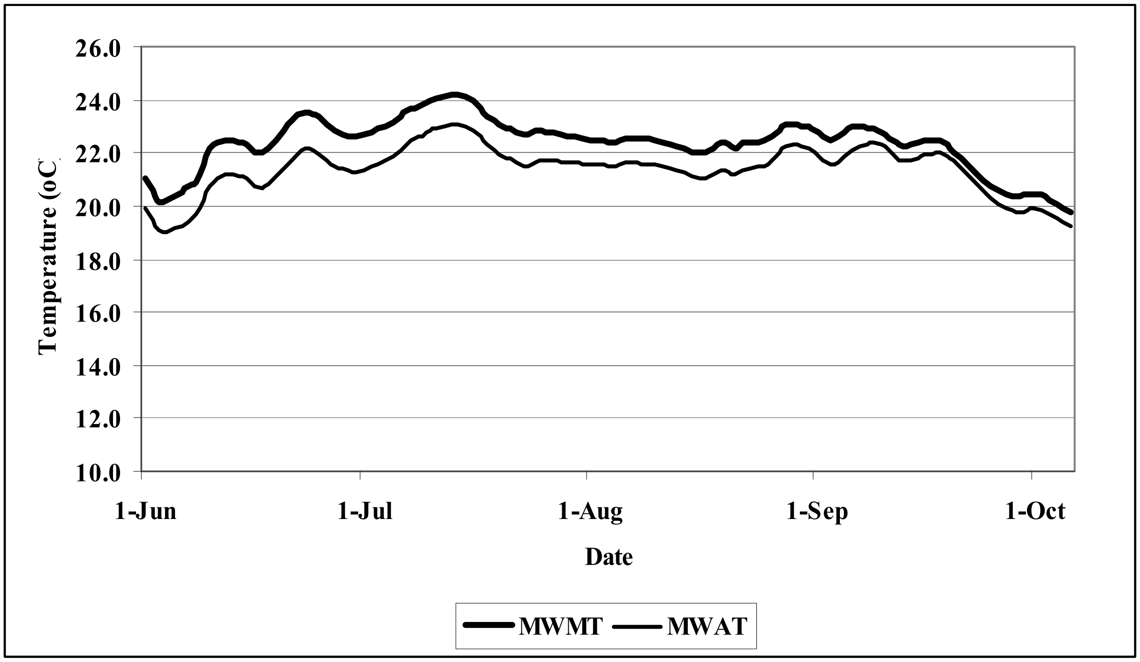


Figure 2-7. **Weekly maximum and weekly average water temperatures recorded at a depth of 3.0 meters, Station #5, Russian River at the Mirabel Inflatable Dam, 2003.**

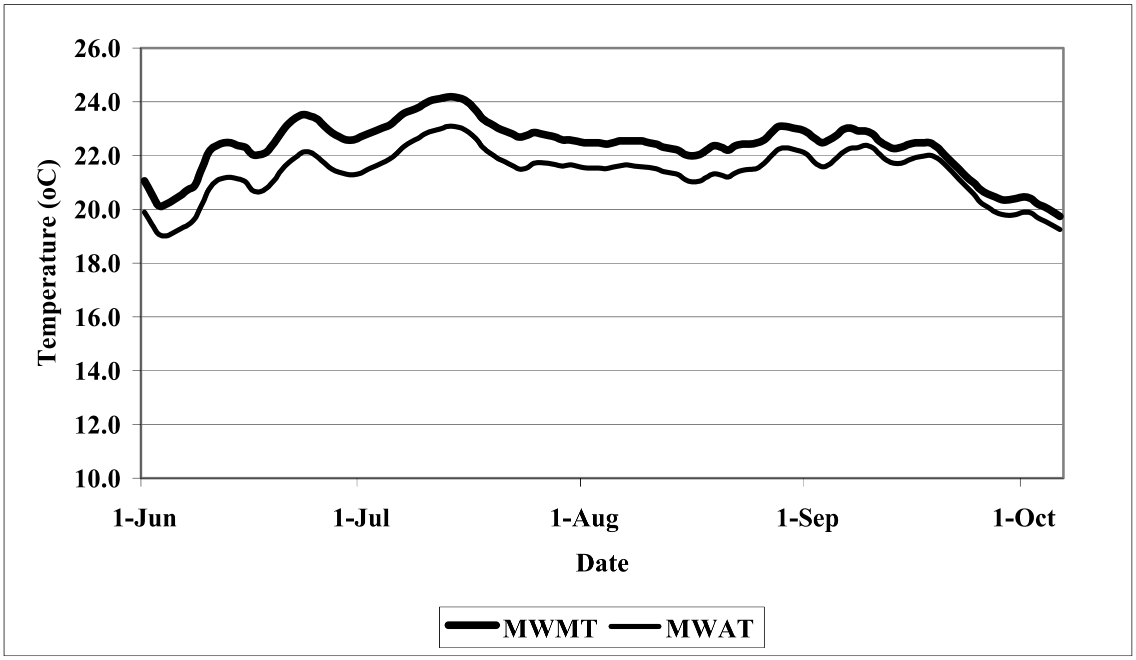


Figure 2-8. Weekly maximum and weekly average water temperatures recorded at a depth of 2.0 meters, Station #6, Russian River at Mirabel Dam fish ladder outlet, 2003.

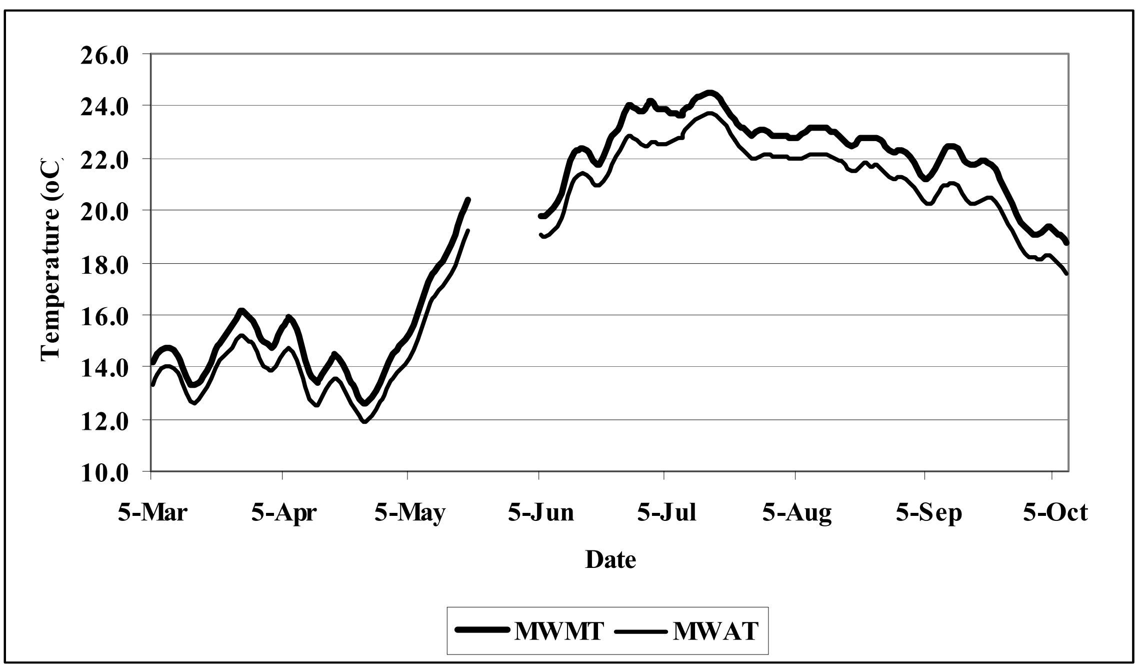


Figure 2-9. Weekly maximum and weekly average water temperatures recorded at a depth of 2.0 meters, Station #7, Russian River at Steelhead Beach County Park, 2003.

2.4 WATER TEMPERATURE PROFILES

Water profiles were collected on five occasions between July 17 and October 14, 2003 (Table 2-11). Dissolved oxygen profiles were collected during the last 4 sampling. The Wohler Pool did not become thermally stratified during the 2003 sampling season, with the possible exception of Station 5. Most of the difference in water temperature was observed in the upper 0.5 meters of the water column. The largest difference in temperature between the one-meter readings and the bottom (3.0 meter reading) was 1.0 to 1.4 °C during the July and August profiles.

Daytime dissolved oxygen (DO) levels were 8.0 ppm or higher (Table 2-11). Conductivity ranged from 203 to 261 μmhos (Table 2-11).

2.5 WATER TEMPERATURES AND FISH OBSERVATIONS

The above discussion of seasonal water temperatures provides an overview of the thermal conditions present during part of three different life history phases for Chinook salmon and steelhead. These observations, combined with the corresponding water temperatures, provide site-specific data relevant to the Russian River. However, to persist through time, a species must be able to survive, grow, and reproduce. Observations of fish at any particular time (and temperature regime) do not mean that they are meeting all of the above criteria. Observations of fish must be tempered by the fact that the present day thermal regimes in the river likely do not represent natural (historical) conditions and that although salmonids may be surviving under the present thermal regime, conditions may be 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.

2.6 SIGNIFICANT FINDINGS

The monthly average temperature of water flowing through the Wohler Pool was estimated to increase by 0.16ºC (July) and 0.12ºC (August) above what would have been expected without the dam in place in 2003. The estimated net effect of the dam was to raise the monthly average water temperature in the Wohler Pool from 22.0 to 22.2°C in July, and from 21.3 to 21.4°C in August.

Compared to proposed water temperature standards for the Russian River, water temperatures in the study area were sub optimal for at least the last month 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 23.2ºC (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 2003 sampling seasons.

Table 2-12. Water quality profiles data, Wohler Pool - Russian River, 2003.

Station #1					
Temperature					
Depth	**July 17**	**Aug 12**	**Aug 28**	**Sept 18**	**Oct 14**
0.1	21.5	20.7	20.8	17.8	16.3
0.5	21.5	20.7	20.8	17.8	16.2
1.0	21.5	20.7	20.8	17.8	16.3
2.0	21.5	20.7	20.8	17.8	16.4
2.5					
3.0					
Dissolved Oxygen					
0.1	N/A	9.4	11.0	10.0	10.7
0.5	N/A	9.6	11.0	10.0	10.8
1.0	N/A	9.6	11.0	10.0	10.7
2.0	N/A	9.5	10.0	10.0	10.6
Conductivity					
1.0	226	223	225	217	227

Station #2					
Temperature					
Depth	**July 17**	**Aug 12**	**Aug 28**	**Sept 18**	**Oct 14**
0.1	22.0	22.0	21.4	18.2	16.4
0.5	22.0	22.0	21.4	18.2	16.4
1.0	22.0	22.0	21.4	18.3	16.4
2.0	22.1	22.0	21.4	18.3	16.5
Dissolved Oxygen					
0.1	N/A	9.9	11.0	9.3	10.2
0.5	N/A	9.9	11.1	9.4	10.1
1.0	N/A	9.8	11.0	9.4	10.1
2.0	N/A	9.2	10.6	9.4	9.9
Conductivity					
1.0	232	231	225	226	230

Table 2-12. Water quality profiles data, Wohler Pool - Russian River, 2003 (concluded).

Station #3					
Temperature					
Depth	**July 17**	**Aug 12**	**Aug 28**	**Sept 18**	**Oct 14**
0.1	22.2	21.8	21.4	18.8	16.7
0.5	22.2	21.8	21.4	18.8	16.7
1.0	22.2	21.8	21.4	18.8	16.7
2.0	22.2	21.8	21.4	18.8	16.8
3.0	22.2	21.8	21.5	18.8	16.7
3.5	22.2	21.8	N/A	18.9	16.8
Dissolved Oxygen					
0.1	N/A	9.4	10.9	9.0	9.0
0.5	N/A	9.3	10.8	9.0	9.5
1.0	N/A	9.4	11.0	9.0	9.4
2.0	N/A	9.3	10.0	9.1	9.5
3.0	N/A	9.2	10.0	9.1	9.6
3.5	N/A	8.8	N/A	9.0	9.5
Conductivity					
1.0	233	233	226	226	226

Station #5					
Temperature					
Depth	**July 17**	**Aug 12**	**Aug 28**	**Sept 18**	**Oct 14**
0.1	26.3	23.4	22.3	21.4	20.1
0.5	22.9	21.9	21.6	20.6	17.8
1.0	22.3	21.3	20.8	19.4	17.0
2.0	22.1	20.9	20.3	19.1	17.0
3.0	22.2	20.9	20.3	19.2	17.2
Dissolved Oxygen					
0.1	N/A	8.1	8.5	8.3	8.0
0.5	N/A	8.3	8.8	8.3	9.0
1.0	N/A	8.2	9.1	8.0	9.2
3.0	N/A	8.0	8.8	8.4	9.3
2.5	N/A	8.3	8.8	8.4	9.3
Conductivity					
1.0	235	227	229	225	225

3.0 SMOLT EMIGRATION

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

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

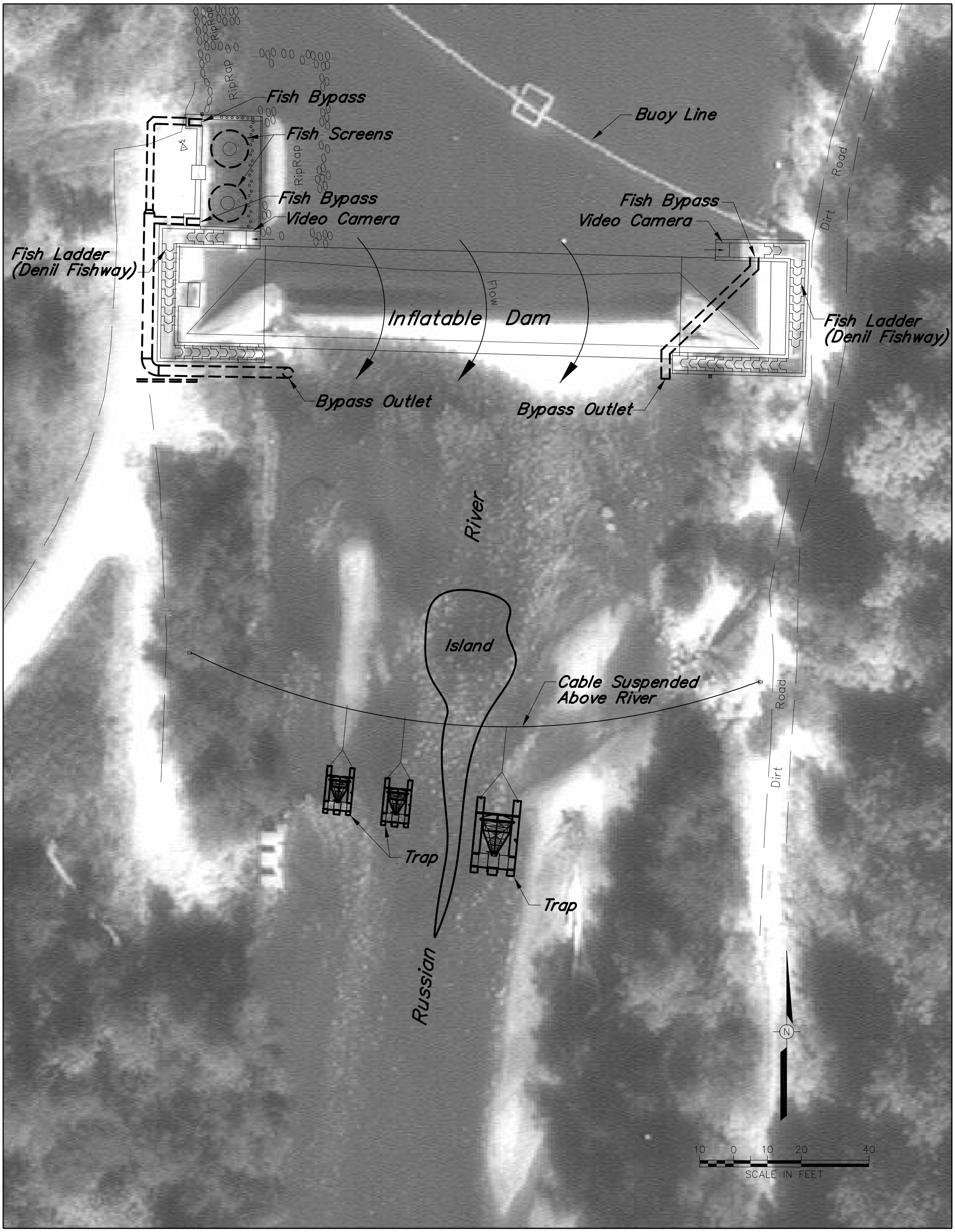
3.1 METHODS

3.1.1 Rotary Screw Trap

Rotary screw fish traps consist of a cone of perforated stainless steel panels which houses an internal Archimedes screw assemblage. Water striking the angled surface of the internal screw rotates the cone and screw assembly. As the assembly rotates, fish are trapped within the chambers formed by the screw and moved rearward into the live box at the back of the trap. The live box is constructed such that areas of very low water velocity are provided as resting areas for fish held in the box. Debris such as leaves and small twigs entering the live box are impinged on a rotating debris screen located at the back of the live box. As the screen rotates, debris is carried out of the box, maintaining a relatively clean environment for the fish held in the live box. The cone is mounted between two pontoons and is lowered and raised with a bipod and windlass located at the front of the cone. Rotary screw traps are lowered into the water column until half of the cone is submerged (an 8-foot diameter trap requires a minimum depth greater than 4.0-feet to operate).

The rotary screw trap site is located approximately 60 m downstream of the Inflatable Dam (Figure 3-1). Rotary screw traps are designed to capture downstream migrating juvenile fish (Figure 3-2). The screw traps are generally fished in the main channel where the water velocities are highest and the water column is the deepest (thalweg) since emigrating smolts are likely to be concentrated in these areas. Maintaining the trap in the desired location within the channel required a series of cables secured to the shoreline.

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



DATE OF PHOTOGRAPHY: SEPT 30, 1999

\SPECIAL PROJECTS\FISHERIES\STUDIES\RUSSIAN RIVER\2003-TRAP FEBRUARY 18, 2004

SONOMA COUNTY WATER AGENCY

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

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

The main line consisted of a 170-foot long, 0.75-inch steel cable. The cable was pulled across the river, stretched tight, and secured to the piles with heavy equipment. The bridle consisted of a 20-foot length of 0.75-inch steel cable 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 and low flying aircraft (e.g., helicopters) that an obstruction was placed across the river.

3.1.2 Operation of the Rotary Screw Fish Trap

Three rotary screw traps (two 5-feet in diameter and one 8-feet in diameter) were operated throughout the 2003 sampling season. The rotary screw traps were installed in the river on the afternoon of February 28 and fished through the morning of July 3, excluding periods of high flow. In 2003, late spring storms increased streamflow in the Russian River above levels that could be sampled safely from April 13 through May 11, excluding April 22 and 23. No data were collected during this time period. Fish captured by the screw traps were netted out of the live well and placed in an insulated ice chest (approximately 3.0’ X 2.0’) supplied with freshwater. Aerators were operated to maintain DO levels in the ice chest. Prior to data collection, fish were transferred to a five-gallon bucket containing water and Alka-seltzer, which was used as an anesthetic. Fish captured were identified to species, measured to the nearest mm (FL), scales were collected from wild steelhead smolts, and tissue samples (an approximately 1 mm^2 section clipped from the caudal fin) were taken from a sub sample of Chinook and steelhead smolts. After data collection, fish were placed in a bucket containing fresh river water. Dissolved oxygen levels in the recovery buckets were also augmented with aerators to insure that the DO level remained near saturation. Once equilibrium was regained, the fish were released into the river downstream of the screw traps. In accordance with the Agency’s Section 10 Permit, once water temperatures exceeded 21.1˚C, fish were not handled, but were netted from the live well, identified and enumerated, and released without being measured.

3.1.3 Mark-Recapture Study

A mark-recapture study was initiated in an attempted to estimate the number of juvenile Chinook salmon emigrated past the dam. The study was conducted from April 8 through April 12, and then again from May 16 through June 11. Chinook salmon captured in the trap were sub sampled, and up to 50 fish daily (depending on the number of fish captured) were marked with a caudal clip (identical to the clip used to collected tissue samples). Only Chinook salmon >60 mm FL were included in the marking process. Marked fish were held in container of water equipped with aerators, and transported and released approximately 0.8 km above the dam. The proportion of marked to unmarked fish captured in the traps was then used to calculate a weekly estimate of the number of Chinook smolts emigrating past the dam (Bjorkstedt 2000).

3.2 RESULTS

3.2.1 Rotary Screw Trapping Results

The capture of fish in the screw traps was influenced by the time of year, streamflow, and potentially whether the dam was inflated or deflated. Trapping in 2003 was disrupted be a series of spring storms that increased streamflow above the point that the traps could be operated safely and efficiently. The screw traps were operated from the afternoon of February 28 through the morning of July 3, excluding the periods from March 15 through the March 19, April 13 through April 21; April 24 through May 11, May 23, and June 6. The river configuration remained almost unchanged between 2001, 2002, and 2003 trapping seasons (an island formed in the river between the dam and the trapping location between the 2000 and 2001 trapping seasons. The split channels concentrate streamflow in to two relatively small channels (compared to conditions in 1999 and 2000), creating excellent conditions for fishing the screw traps). As a result, the trapping efficiencies in 2001, 2002 and 2003 were superior to those experienced during the 1999 and 2000 trapping seasons.

During the 2003 trapping season, 14,229 fish (excluding larval cyprinids and larval Sacramento suckers) including 25 species were captured (Appendix D provides daily catch data for all species). Chinook smolts were the most abundant species collected, followed by ammocoetes (immature lamprey), young-of-the-year steelhead, and threespine stickleback.

3.2.2 Salmonids

3.2.2.1 Chinook salmon

Chinook smolts were captured throughout the trapping season (March 1 – July 3, 2003). During the first few weeks of the trapping season, Chinook captured in the traps were generally less than 50 mm FL, and several were noted as still in the process of "buttoning up" (the suture where the yolk sack extends from the abdomen was still in the process of closing). Chinook were captured through the end of the trapping season in 2003 (July 3). The high flows experienced during the mid-April through mid May period coincided with the peak Chinook smolt emigration period (based on previous years sampling results). Therefore, the 2003 season cannot be assessed in terms of the abundance of emigrating Chinook smolts. For the season, 6,255 Chinook smolts were captured in the traps (Table 3-1).

The mark-recapture study was compromised by frequent rain and high flow events in 2003. The mark-recapture study was conducted from April 8 through April 12, from May 16 through May 22, and from May 24 through June 11, excluding June 7. During the study period, 1,072 Chinook smolts were marked with a caudal clip and released approximately 0.8 km upstream of the traps: 180 marked smolts were subsequently recaptured. Weekly capture efficiencies were developed for the 11-week period. Weekly capture efficiencies ranged from 11.1 percent to 2.7 percent during the study (Table 3-2). For the mark-recapture study period (all catch data combined), the capture efficiency was 8.4 percent. Estimates of the number of smolts emigration past the trap during the periods sampled was 37,749 (± 6,088) (Table 3-2). However, unlike 2002, the majority of the smolt emigration period was missed due to the high flow conditions persistent throughout the 2003 sampling period.

A comparison of water temperatures and smolt emigration could not be made because of the length of time that the traps were inoperable due to the frequent high flow events in 2003.

The average size of Chinook smolts captured in the screw trap increased from 39 mm FL during the first week of March to 105 mm FL during the last week of June (Table 3-3). Individual Chinook smolts ranged in length from 32 to 130 mm FL throughout the 2003 sampling period. For the first time during the study, two yearling Chinook smolts were captured in 2003. Determination of yearling status was based on the size of the fish compared to other fish captured during that time period. In addition, two Chinook smolts were captured during boat electrofishing in August 2002.

Table 3-1. Weekly salmonid catch in the rotary screw trap, 2003 sampling season.

Week	Chinook	Wild steelhead smolts	Steelhead parr	Young-of-the-year steelhead	Hatchery steelhead
26-Feb	332	4	1	0	287
5-Mar	839	3	0	5	158
12-Mar[1]	89	5	2	1	66
19-Mar[1]	170	3	1	12	82
26-Mar	345	43	0	67	212
2-Apr	389	41	0	170	84
9-Apr[1]	176	19	0	132	21
16-Apr[1]	17	0	0	4	0
23-Apr[1]	60	1	0	20	0
30-Apr[1]	0	0	0	0	0
7-May[1]	50	1	0	22	0
14-May	509	28	0	74	1
21-May	690	20	2	244	1
28-May	1,441	7	0	223	2
4-Jun[2]	499	2	0	55	0
11-Jun	374	1	0	29	3
18-Jun	186	0	1	27	1
25-Jun	48	0	0	2	0
July 2[3]	3	1	0	1	1
Total	**6,255**	**181**	**7**	**1,091**	**919**

[1]Trap not operated due to high flows from March 15 through the March 19, April 13 through April 21; April 24 through May 11, May 23, and June 6.
[2]Trap not operated on June 6, due to field crew attending mandatory safety training class.
[3]Trapping ended July 3.

Table 3-2. Results of the Chinook smolt mark-recapture study, spring 2002.

Week of	Smolts marked	Smolts recaptured	Weekly efficiency	Actual catch	Seasonal estimate
26-Mar	N/S	N/S[1]			
2-Apr	N/S	N/S[1]			
9-Apr	119	13	10.9	176	
16-Apr	N/S	N/S[2]			
23-Apr	N/S	N/S[2]			
30-Apr	N/S	N/S[2]			
7-May	N/S	N/S[2]			
14-May	221	14	2.7	312	
21-May	221	14	6.3	406	
28-May	324	36	11.1	1,441	
4-Jun	222	22	9.9	370	
Seasonal Total	**1,072**	**90**	**8.4**	**2,705**	**37,749 ± 6,088**

N/S[1] Not sampled, fish to small to mark
N/S[2] High flow event, traps not in operation

Table 3-3. Weekly minimum, average, and maximum lengths of Chinook salmon smolts captured in the rotary screw trap, 2003 sampling season.

Week of	Number	Minimum length	Average length	Maximum length
March 1-March 4	308	34	39	52
March 5 - March 11	578	32	39	87
March 12 - March 18[1]	76	35	43	115
March 19 - March 25[1]	146	34	51	69
March 26 - April 1	281	35	57	85
April 2 - April 8	282	37	65	90
April 9 - April 15[1]	173	39	72	103
April 16 - April 22[1]	17	43	67	88
April 23 - April 29[1]	52	58	74	99
April 30 - May 6[1]	0	--	--	--
May 7 - May 13[1]	16	78	89	99
May 14 - May 20	483	62	88	109
May 21 - May 27[1]	429	73	91	111
May 28 - June 3	838	62	92	120
June 4 – June 10[2]	419	41	94	122
June 11 - June 17	339	52	96	117
June 18 - June 24	112	76	101	120
June 25 – July 3[3]	14	93	105	130

[1]Trap not operated due to high flows from March 15 through the March 19, April 13 through April 21; April 24 through May 11, May 23, and June 6.
[2]Trap not operated on June 6, field crew attending mandatory safety training class.
[3]Trapping ended July 3.

3.2.2.2 Juvenile steelhead:

Steelhead smolts were captured throughout the trapping season, but at lower numbers than Chinook smolts. Wild steelhead smolts in the Russian River emigrate primarily as 2-year-old fish (Chase *et al.* 2003). Steelhead captured in 2003 were classified into age classes based on length at age data collected during the first three years of this study. In 2003, 1,279 wild steelhead were captured; including 1,091 YOY, 7 Age 1+ parr, and 181 Age 2+ smolts. The average size of Age 0+ steelhead increased from 28 mm FL in early March to 71 mm FL in late June (Table 3-5). Age 1+ fish ranged in length from 85 to 136 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 135 to 224 mm FL, and the Age 3+ smolt was 259 mm FL (Figure 3-4, Table 3-6).

Table 3-4. Weekly catch and size range (mm) of young-of-the-year steelhead captured in the screw trap, 2003

Week of	N	Minimum	Average	Maximum
26-Feb	0	--	--	--
5-Mar	5	27	28	29
12-Mar[1]	1	29	29	29
19-Mar[1]	15	25	28	40
26-Mar	61	25	30	45
2-Apr	125	25	33	55
9-Apr[1]	109	27	40	66
April 16[1]	4	30	36	46
April 23[1]	17	25	39	55
April 30[1]	0	--	--	--
May 7[1]	10	36	54	65
May 14	64	27	60	81
May 21[1]	173	24	62	105
May 28	165	31	63	96
June 4[2]	39	41	60	104
11-Jun	22	48	72	106
18-Jun	19	37	71	120
25-Jun[3]	5[4]	--	--	--

[1]Trap not operated due to high flows from March 15 through the March 19, April 13 through April 21; April 24 through May 11, May 23, and June 6.
[2]Trap not operated on June 6, field crew attending mandatory safety training class.
[3]Trapping ended July 3.
[4]NOAA Fisheries permit does not allow fish to be handled (measured) at temperatures above 21˚C. This threshold was exceeded daily after June 25.

Table 3-5. Weekly average, minimum and maximum lengths of steelhead smolts captured in the screw trap, 2003

Week of	N	Minimum	Average	Maximum
26-Feb	4	167	189.8	206
5-Mar	3	167	185.7	206
12-Mar	5	160	204.8	259
19-Mar	3	175	179.3	185
26-Mar	39	136	178.9	222
2-Apr	40	129	174.3	224
9-Apr[1]	18	143	166.5	215
April 16[1]	0			
April 23[2]	1	151	151.0	151
April 30[2]	0	N/A		
May 7[2]	0			
May 14	26	139	165.6	192
May 21	16		170.8	
May 28	6		167.5	
June 4	2	158	161.0	164
11-Jun	1	195	195.0	195
18-Jun	0	--	--	--
25-Jun[3]	2	N/A	N/A	N/A

[1]Traps not operated April 13 through the 22
[2]Traps not operated from April 24 through May 11
[3]NOAA Fisheries permit does not allow fish to be handled (measured) at temperatures above 21˚C. This threshold was exceeded daily after June 25.

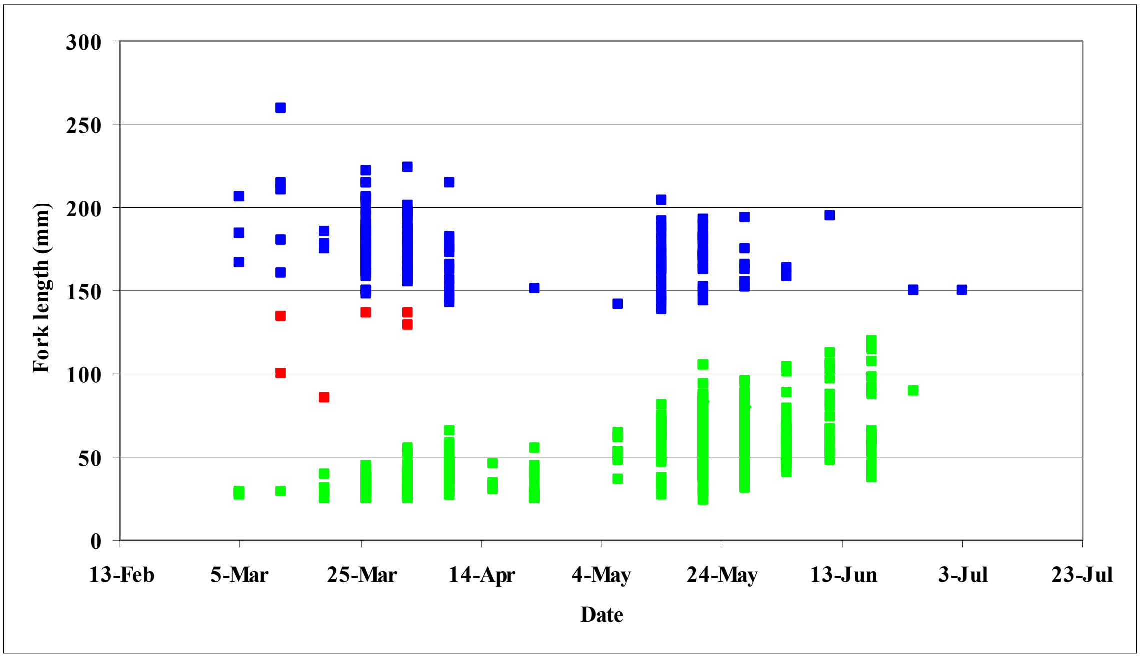


Figure 3-3. Scatter plot of steelhead lengths, grouped by week of capture. Green squares = young of the year fish, red squares = parr, and blue squares = smolts.

3.3 SIGNIFICANT FINDINGS

Rotary screw traps were operated primarily during the second half of the spring emigration period during the first three years of this study (1999-2001). In 2002 and 2003, the traps were deployed on March 1, and in the case of 2002, operated throughout the majority of the emigration period (though June 27). Since several operational factors vary between years (time of year that the traps are operated, size and number of traps deployed, and the efficiency of the traps), 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.

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

The size of the Chinook smolt run was estimated over a five-week period in 2001 and over an 11-week period in 2002, and sporadically in 2003 (when flows permitted). In 2001, 20,245 Chinook smolts were estimated to have emigrated past the dam between May 3 and June 4. During 2002, an estimated 94,172 Chinook smolts were passed the dam during the same period. Between March 26 and June 4, 2002, an estimated 215,875 Chinook smolts were estimated to have emigrated past the traps. In 2003, Chinook emigration was estimated on 25 days (April 9 – 12, May 17 – 22, and May 25 – June 5, and June 8 – 10). During these times, an estimated 37,749 (± 6,088) Chinook smolts emigrated past the traps.

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 be less likely to be captured, particularly by the 5-foot traps. Steelhead smolts were captured throughout the trapping season, but at lower numbers than Chinook smolts. Another factor in the lower numbers of steelhead (compared to Chinook salmon) is the difference in the two species life history strategy. Steelhead emigrate at an older age (usually age 2) compared to Chinook, which emigrate within two to four months of hatching. Salmonids experience a high mortality rate during their early life stages. Steelhead smolts have already pastsed through this stage, and have a much higher rate of survival in the ocean compared to Chinook salmon smolts.

For the season, 181 wild steelhead smolts were captured in the rotary screw trap. In past years, steelhead smolts were captured primarily in mid March through April, with the run extending through June. Wild steelhead smolts in the Russian River emigrate primarily as 2-year-old fish.

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, 2003, in press), 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 clip on a weekly basis, then transported approximately 0.8 km upstream of the dam. On the day following a change in the clip used, Chinook smolts captured in the screw traps almost invariably possessed the new clip. Few Chinook smolts were recaptured bearing the previous week's clip, which would indicate that they had required more than 48 hours to pass the dam. Chinook smolts are two to four months old at the time of emigration, and are much smaller than steelhead smolts that emigrate as two-year-olds. The smaller sized Chinook smolts may be better at passing over the dam compared to the larger steelhead smolts.

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.

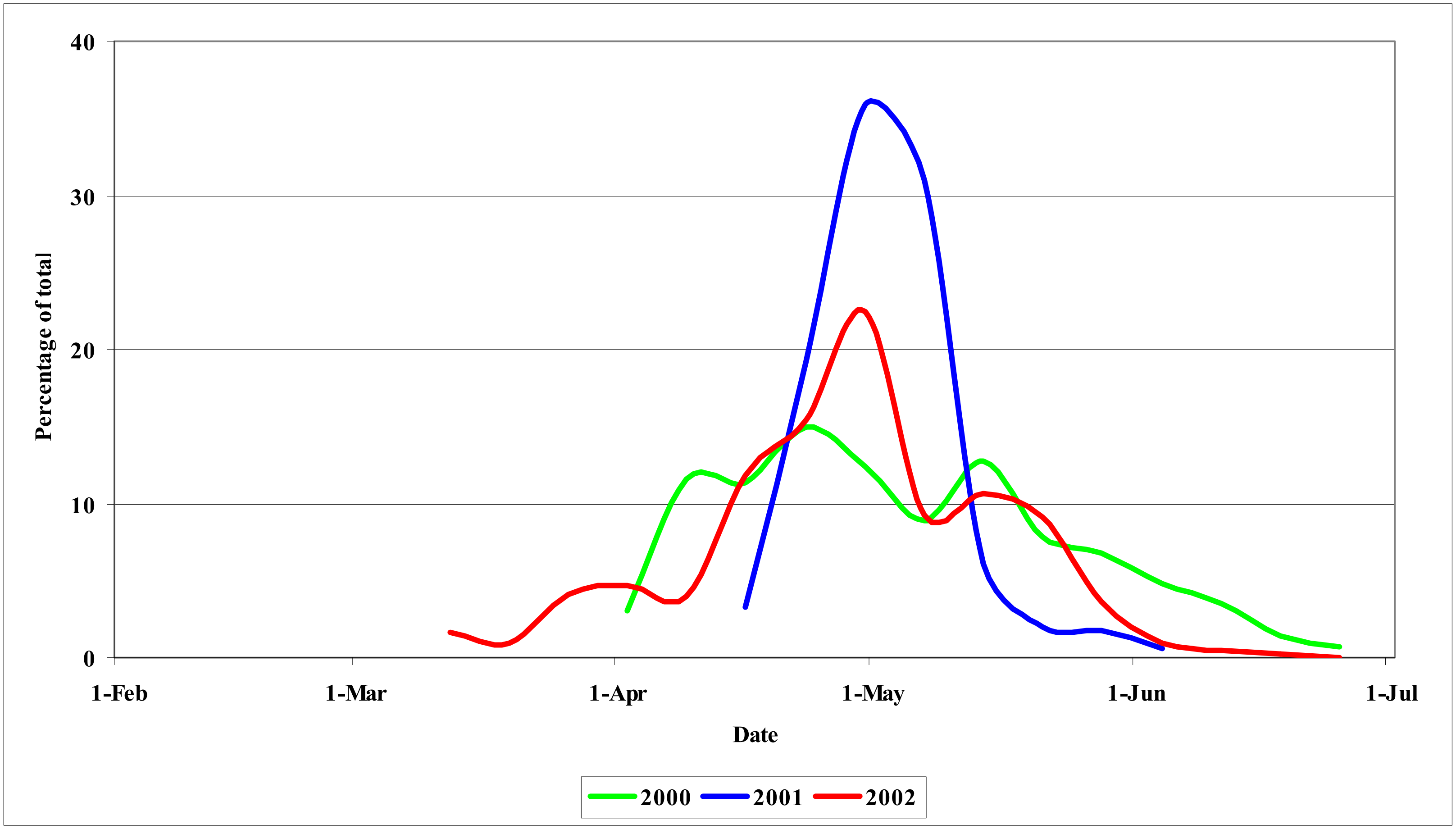


Figure 3-4. Chinook salmon smolt run timing based on the weekly estimated catch data from 2002.

4.0 WOHLER POOL FISH COMUNITY

The Inflatable Dam impounds approximately 5.1 km of river, creating a long pool, as opposed to a series of pools, runs and riffles that would exist without the dam in place. Since pools are the preferred habitat of adult predatory fish (e.g., pikeminnow and smallmouth bass – see section 1.4 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, 2003, in press). In addition, the pool formed behind the dam may create suitable habitat for spawning and rearing of predator fish. If conditions created by the impoundment are favorable, this may lead to an increase in survival of predatory fish that may disperse to other sections of the river.

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

Young-of-the-year (YOY) Chinook salmon are present in the Wohler study area from approximately late February through at least June. Chinook salmon average approximately 35 to 40 mm FL in length during the first few weeks of life, then quickly grow to approximately 80 mm FL by mid April. YOY-of-the-year steelhead are present from early to mid March throughout the remainder of the year. Young-of-the-year steelhead become relatively abundant in mid April, were they average approximately 40 mm FL. Steelhead smolts are present from at least early March through mid-June. Steelhead smolts are typically two years old at emigration, and range in length from approximately 150 to 250 mm FL (overall average in 2003 was 175 mm FL).

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

4.1 STUDY AREA

The study area was divided into five reaches. 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). Reach #5 is located above the influence of the Wohler Pool. 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 occupies the upper 1,600 meters of the Wohler Pool, and is minimally affected by the dam, with the influence of the dam declining to virtually zero at the upstream end. Reach # 5 is above the influence of the impoundment, and consist of natural pools, runs and riffles. 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. The shallow riffle at the upstream end of Reach #4 was not passable in the electrofishing boat except in 1999 and 2003, and other 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.

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Figure 4-1 Boat electrofishing reaches, August 2003

4.2 METHODS

4.2.1 Sampling Site Selection

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

4.2.3 Boat Electrofishing

Fish were collected with a 16-foot electrofishing boat (Smith-Root, Inc. model SR16S). The electrofishing boat uses an onboard generator that sends an electric current through two anodes mounted to the front of the boat. A series of cathodes mounted on the front of the boat complete the current. The strength of the current is controlled by the boat operator, and is maintained at the minimum level required to effectively capture fish. The front of the boat is designed as a flat platform enclosed on the front and sides with safety 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 lights mounted on the front and rear of the boat allow for safe operation during nighttime sampling efforts. Electrofishing was conducted in early August to minimize the potential of encountering adult salmonids. Sampling was conducted during hours of darkness. Smallmouth bass have been shown to be more vulnerable to capture during electrofishing surveys conducted at night (Paragamian 1989). Sampling was conducted between 20:30 and 02:00. 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 both a pump and an aerator that supplies fresh, oxygenated water, to the holding tank. Captured fish were identified to species and measured to the nearest 0.5 cm FL. Scale samples were collected from representative target species to determine the age structure of the fish community.

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

4.3 RESULTS

4.3.2 Boat Electrofishing

Boat electrofishing surveys have been conducted in August between 2000 and 2003 (a preliminary survey was also conducted in 1999). Five Reaches were sampled in 2003 and 1999, and four Reaches were sampled in 2000-2002. Reach 1 (downstream of the Inflatable Dam) consisted of four shoreline-sampling units and two mid-channel sampling units. Reaches 2 and 4 consisted of nine sampling units each (six shoreline and three mid-channel units) and Reach 3 consisted of four shoreline-sampling units and two mid-channel sampling units. Water surface elevation (thus depth) is directly influenced by the dam in Reaches 2 and 3. Reach 4 is located above a relatively shallow glide (thalwag depth approximately 0.45 to 0.6 meters). The influence of the Inflatable Dam on depth is approximately 20 cm at the lower end of Reach 4, and zero at the upper end of Reach 4. Reach 5 (above the influence of the dam) consisted of 3 shoreline sampling units (the upstream end of Reach is marked by a riffle that is too shallow for the electrofishing boat to navigate, which truncated this reach).

4.3.2.1 Community composition

During the 2003 sampling season, 2,564 fish representing 18 species and 8 families were collected (Table 4-1, Appendix E). In addition, juvenile Pacific lamprey were observed in most reaches, but were too small to be captured with the dip nets used for this study. In 2003, eight of the 18 species captured were native to the Russian River, and native species comprised 55.3 percent of the catch. Overall, species composition in the study area was dominated by four species: Sacramento suckers (20.7 percent), smallmouth bass (20.3), tule perch (18.3 percent), and YOY American shad (16.8 percent) (Table 4-2).

Species composition in 2003 differed from other years in that young-of-the-year American shad were present in relatively large numbers in several of the Reaches (from 3 to 10 times greater than the next highest yearly total at Stations 1 through 4). Young-of-the year American shad abundance reflects the number of adults that migrated upstream of the dam prior to its inflation. The spring of 2003 was relatively wet, and likely contributed to above average spawning conditions for shad. The increase in YOY shad abundance lowered the percentage composition of the other species, but does not necessarily reflect an actual change in the fish community compared to past years sampled.

In Reach 1, tule perch (26.6 percent) were the most abundant species captured in 2003, followed by Sacramento sucker (23.3 percent), smallmouth bass (17.0 percent), bluegill (9.7 percent) and green sunfish (4.5 percent). Centrarchids (bass and sunfish), excluding smallmouth bass, continued to comprise a higher percentage (18.5 percent) of the fish community at Reach 1 compared to the upstream reaches (approximately 5.0 percent of the catch in each of the three upstream reaches). Predatory fish greater than 200 mm FL comprised 2.2 percent of the fish captured in 2003. Over the four years sampled Sacramento suckers have been the dominant fish (29.8 percent of the catch, 2000-2003 combined), followed by smallmouth bass (22.0 percent) tule perch (14.6 percent) and bluegill (9.6 percent). Predators greater than 200 mm FL comprised between 1.8 and 3.2 percent of the total catch in Reach 1 between 2000 and 2003.

In Reach 2, YOY America shad (23.1 percent) and smallmouth bass (21.1 percent) were the most abundant species captured, followed by Sacramento sucker (19.1 percent), hardhead (18.4 percent) and tule perch (11.4 percent). Predatory fish greater than 200 mm FL comprised 3.8 percent of the fish captured in 2003. Over the four years sampled smallmouth bass (31.3 percent) were the dominant species captured, followed by suckers (23.1 percent), hardhead (20.2 percent), and tule perch (9.5). Predators greater than 200 mm FL comprised between 0.8 and 4.4 percent of the total catch in Reach 2 between 2000 and 2003.

In Reach 3, smallmouth bass (28.2 percent) was the most abundant species captured in 2003, followed by YOY American shad (20.6 percent), tule perch (18.6 percent), Sacramento sucker (14.2 percent), and hardhead (6.3 percent). Predatory fish greater than 200 mm FL comprised 3.8 percent of the fish captured. Over the four years sampled smallmouth bass (36.1 percent) was the dominant species captured, followed by suckers (23.4 percent), hardhead (12.3 percent), and tule perch (10.8). Predators greater than 200 mm FL comprised between 1.0 and 4.7 percent of the total catch in Reach 3 between 2000 and 2003.

In Reach 4, Sacramento sucker (22.2 percent), smallmouth bass (20.6), and tule perch (20.1 percent) were co-dominant. Predators greater than 200 mm FL comprised between 3.5 percent of the fish captured in 2003. Over the four years sampled, Sacramento sucker (27.6 percent) and smallmouth bass (27.3 percent) were the dominant species captured, followed by tule perch (14.5 percent) hardhead (11.8 percent), and California roach (7.5 percent). Predators greater than 200 mm FL comprised between 1.5 and 3.5 percent of the total catch in Reach 4 between 2000 and 2003.

In Reach 5, Sacramento sucker (31.7 percent) were the most abundance species, followed by juvenile American shad (22.2 percent), roach (16.7 percent) and tule perch (13.1 percent). A total of six predators (three smallmouth bass and three pikeminnow) were captured in Reach 5.

4.3.1 Catch-per-unit-effort

Catch-per-unit-effort (CPUE) is a measure of a species relative abundance. It is also a way of comparing sampling sites where the effort exerted to capture fish is not equal. The amount of effort spent at each site is dependent on several factors, including the size of the Reach, the number of fish present and the complexity of the habitat sampled. For this study, CPUE equals the average number of fish captured 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 0.5 fish/minute at Station 2.2 to 18.07 fish/minute at Station 4-2 (Table 4-3 and 4-4 presents CPUE data by Reach, Appendix G provides a breakdown of the CPUE by stations within each Reach). Catch-per-unit-effort in shoreline habitats within the Wohler Pool ranged from 6.42 (Reach 1) to 12.6 fish/minute (Reach 4). The CPUE at Reach 1 was intermediate to the above dam reaches (9.58 fish/minute). CPUE at the mid channel stations decreased with distance upstream (Table 4-4).

Determining the abundance of predatory fish is the key component of the Wohler Pool fish community surveys. Thus, in addition to the fish populations surveys conducted during this phase of the study, an additional sampling effort was conducted solely targeting large predatory fish. For this study, any piscivorous species that exceeded 200 mm FL during the spring emigration period falls in the "active predator classification." At this size any of the three predator species likely to be present are large enough to feed on an 80 mm salmonid (approximates and "average size Chinook smolt), and has reached a stage in its development where fish are becoming and important component of its diet. On average, this occurs during the start of the third year of life (Age 2+) for the three dominant predatory fish in the Russian River. Age 2+ fish less than 200 mm FL were included in the active predator class.

Data from both sampling efforts were combined to assess predator populations in the Wohler Pool. An additional 184 minutes of sampling were exerted in Reaches 2 through 5 in an effort to more adequately assess the predator populations in the study area. The capture rate (CPUE) for Age 2+ and older predators was higher in Reaches 3 and 4 (Wohler Pool stations), ranging from 0.29 fish/minute of sampling, respectively, compared to 0.13 and 0.11 fish/minute at Stations 1 and 5, respectively (Table 4-5). The CPUE for Pikeminnow was highest in Reaches 4 and 5 (0.06 and 0.05 fish/minute, respectively). The CPUE for smallmouth bass was highest in Reaches 3 and 4 (0.26 and 0.23 fish/minute, respectively). No Largemouth bass Age 2 or older were captured in 2003.

Table 4-1. Total number of fish captured during boat electrofishing population sampling, Russian River, August 2003.

Species	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	TOTAL
Wild Steelhead	0	1	0	4	2	7
Hatchery Steelhead	0	0	0	0	0	0
Chinook	0	0	0	0	0	0
Pikeminnow	5	15	14	11	5	50
Hardhead	16	106	37	18	9	186
Roach	0	0	26	82	37	145
Hitch	5	2	0	5	0	12
Blackfish	9	0	0	5	0	14
Tule Perch	118	66	109	148	29	470
Sucker	103	110	83	164	70	530
Sculpin	1	0	1	1	0	3
Smallmouth bass	75	122	165	152	6	520
Largemouth bass	8	5	0	2	0	15
Bluegill	43	10	9	10	6	78
Green sunfish	20	3	12	19	7	61
Redear sunfish	8	1	3	0	0	12
Crappie	0	1	0	0	0	1
Shad	15	133	121	112	49	430
Carp	15	1	4	4	1	25
Bullhead	0	0	0	0	0	0
Channel Catfish	1	1	2	1	0	5
Stickleback	0	0	0	0	0	0
Striped bass	0	0	0	0	0	0
TOTALS	442	577	586	738	221	2564

Table 4-2. **Percentage composition of fish captured during boat electrofishing population sampling, Russian River, August 2002.**

Species	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5
Wild Steelhead	0.0	0.2	0.0	0.5	0.9
Hatchery Steelhead	0.0	0.0	0.0	0.0	0.0
Chinook	0.0	0.0	0.0	0.0	0.0
Pikeminnow	1.1	2.6	2.4	1.5	2.3
Hardhead	3.6	18.4	6.3	2.4	4.1
Roach	0.0	0.0	4.4	11.1	16.7
Hitch	1.1	0.3	0.0	0.7	0.0
Blackfish	2.0	0.0	0.0	0.7	0.0
Tule Perch	26.7	11.4	18.6	20.1	13.1
Sucker	23.3	19.1	14.2	22.2	31.7
Sculpin	0.2	0.0	0.2	0.1	0.0
Smallmouth bass	17.0	21.1	28.2	20.6	2.7
Largemouth bass	1.8	0.9	0.0	0.3	0.0
Bluegill	9.7	1.7	1.5	1.4	2.7
Green sunfish	4.5	0.5	2.0	2.6	3.2
Redear sunfish	1.8	0.2	0.5	0.0	0.0
Crappie	0.0	0.2	0.0	0.0	0.0
Shad	3.4	23.1	20.6	15.2	22.2
Carp	3.4	0.2	0.7	0.5	0.5
Bullhead	0.0	0.0	0.0	0.0	0.0
White	0.2	0.2	0.3	0.1	0.0
Stickleback	0.0	0.0	0.0	0.0	0.0
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 4-3. Catch-Per-Unit-Effort by Reach, Inflatable Dam Study Area, Russian River, August 2002.

Shoreline stations					
Species	**Reach 1**	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**
Wild Steelhead	0.00	0.00	0.00	0.08	0.1
Chinook	0.00	0.00	0.00	0.00	0.0
Pikeminnow	0.06	0.24	0.34	0.20	0.1
Hardhead	0.21	1.78	0.89	0.37	0.2
Roach	0.00	0.00	0.58	1.67	1.0
Blackfish	0.19	0.00	0.00	0.06	0.0
Hitch	0.00	0.00	0.00	0.10	0.0
Tule Perch	1.65	0.74	2.38	2.63	0.8
Sucker	1.33	1.01	0.96	2.24	1.9
Sculpin	0.00	0.00	0.02	0.02	0.0
Stickleback	0.00	0.00	0.00	0.00	0.0
Hatchery Steelhead	0.00	0.00	0.00	0.00	0.0
Smallmouth bass	0.93	1.97	3.82	3.07	0.2
Largemouth bass	0.17	0.09	0.00	0.04	0.0
Bluegill	0.89	0.18	0.22	0.20	0.2
Green sunfish	0.36	0.05	0.29	0.39	0.2
Redear sunfish	0.15	0.02	0.07	0.00	0.0
Crappie	0.00	0.02	0.00	0.00	0.0
Shad	0.13	0.42	1.56	1.43	1.3
Carp	0.32	0.02	0.10	0.08	0.0
Bullhead	0.00	0.00	0.00	0.00	0.0
White catfish	0.02	0.02	0.02	0.02	0.0
Striped bass	0.00	0.00	0.00	0.00	0.0
Totals	**6.42**	**6.56**	**11.25**	**12.60**	**6.02**

Table 4-4. Catch-Per-Unit-Effort by Reach, Mirabel Study Area, Russian River, August 2002.

Mid channel stations				
Species	**Reach 1**	**Reach 2**	**Reach 3**	**Reach 4**
Wild Steelhead	0.00	0.02	0.00	0.00
Chinook	0.00	0.00	0.00	0.00
Pikeminnow	0.12	0.04	0.00	0.03
Hardhead	0.37	0.16	0.00	0.00
Roach	0.00	0.00	0.06	0.00
Blackfish	0.00	0.00	0.00	0.05
Hitch	0.31	0.04	0.00	0.00
Tule Perch	2.46	0.50	0.32	0.50
Sucker	2.46	1.07	1.37	1.42
Sculpin	0.06	0.00	0.00	0.00
Stickleback	0.00	0.00	0.00	0.00
Hatchery Steelhead	0.00	0.00	0.00	0.00
Smallmouth bass	1.90	0.26	0.19	0.03
Largemouth bass	0.00	0.00	0.00	0.00
Bluegill	0.06	0.00	0.00	0.00
Green sunfish	0.18	0.00	0.00	0.00
Redear sunfish	0.06	0.00	0.00	0.00
Crappie	0.00	0.00	0.00	0.00
Shad	0.55	2.19	1.79	1.10
Carp	0.00	0.00	0.00	0.00
Bullhead	0.00	0.00	0.00	0.00
White catfish	0.00	0.00	0.03	0.00
Striped bass	0.00	0.00	0.00	0.00
Totals	**8.54**	**4.27**	**3.77**	**3.13**

Table 4-5. CPUE of Age 2 and older predators, by Reach, 2003.

Species	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5
Pikeminnow	0.01	0.05	0.03	0.06	0.05
Smallmouth bass	0.05	0.13	0.23	0.22	0.06
Largemouth bass	0.00	0.00	0.00	0.00	0.00
Total	**0.11**	**0.18**	**0.26**	**0.28**	**0.11**

4.3.3 Steelhead

Seven wild steelhead were captured during the August 2003 sampling event. Wild steelhead were captured in Reaches 2 (1 total), 4 (4 total) and 5 (2 total) (Table 4-1). Wild steelhead ranged in length from 130 to 154 mm FL (Figure 4-2). Appendix H presents length-frequency histograms for all species captured in each Reach). The seven steelhead were aged one-year-old fish.

4.3.4 Adult Predator Populations

Three potential predators of salmonids were captured during the 2003 sampling season: Sacramento pikeminnow, smallmouth bass, and largemouth bass. In all, 15.8 percent (20.5 percent if YOY shad are removed) of all fish captured during electrofishing sampling fell in the predatory category. However, 69.1 percent (404) of the predators captured were young-of-the-year, and only 7.4 percent (43) of the predators were age 2+ or older (i.e., large enough to prey an 80 mm salmonid) (analysis only includes fish caught during regular electrofishing sampling events where an attempt was made to capture all fish regardless of size).

4.3.1.1 Pikeminnow

Pikeminnow comprised 2.0 (N=50) percent of the fish captured in 2003 (Tables 4-1 and 4-2) (excluding fish caught during the predator sampling event). Within individual reaches, pikeminnow comprised between 1.1 (Reach 1) and 2.6 (Reach 2) percent of the populations. Young-of-the-year accounted for 22 (44.0 percent) of the pikeminnow captured in 2003, while six (12.0 percent) were aged as two-years-old or more (Figure 4-3). Pikeminnow were most abundant (based on CPUE) in Reach 3 (0.34 pikeminnow/minute of sampling along shoreline habitat), followed by Reaches 2 and 4 (0.24 and 0.20 pikeminnow/minute.

In addition to the pikeminnow caught during the regular electrofishing sampling event, 10 additional pikeminnow age 2 or older were captured during the “predator” sampling event (19 pikeminnow age 2 or older for the 2003 sampling season). All 19 age 2 and older pikeminnow were likely large enough to consume the average size Chinook smolt captured during the emigration period, and 10 of the pikeminnow were likely large enough (≥425 mm FL) to eat an average size steelhead smolt

Although pikeminnow attain a large size and are fairly longed lived, the abundance of pikeminnow greater than 200 mm FL appears to be low in the study area (Table 4-7). Combining all sampling events (1999 through 2003), the accumulative effort resulted in a relatively low number of pikeminnow captured in the study area. In total, 69 pikeminnow greater than 200 mm FL have been captured during five years of sampling (Table 4-6).

In 2003, pikeminnow ranged in size from 40 to 726 mm FL (Appendix G). Pikeminnow averaged 141 mm FL (N = 98, all sites and years combined) during August of their second year (age 1+), and 257 mm FL (N = 22) at age 2+ (Table 4-7). Based on the data collected to date, it appears that pikeminnow attain a size (>300 mm FL) to switch to a fish diet at the beginning of their fourth year of life (Age 3+) (Table 4-8). Pikeminnow aged as 4+ or older are large enough to prey on both Chinook salmon and steelhead smolts. Based on scale readings conducted for this study, pikeminnow four years of age and less could be confidently aged based on scale analysis. For pikeminnow age 5 and older, growth slows, and the annuli laid down at the margins of the scales could not be confidently differentiated. All pikeminnow aged as 5-years-old or more were combined. An example of this slow growth with advanced age was illustrated by the recapture of a pikeminnow tagged during August of 2001. This pikeminnow measured 615 mm in length and was aged as a 6-year-old fish. In 2003, this pikeminnow measured 655 mm in length, but was again aged as a 6-year-old fish. At least the last two annuli were laid so close together at the margin of the scales as to be undetectable.

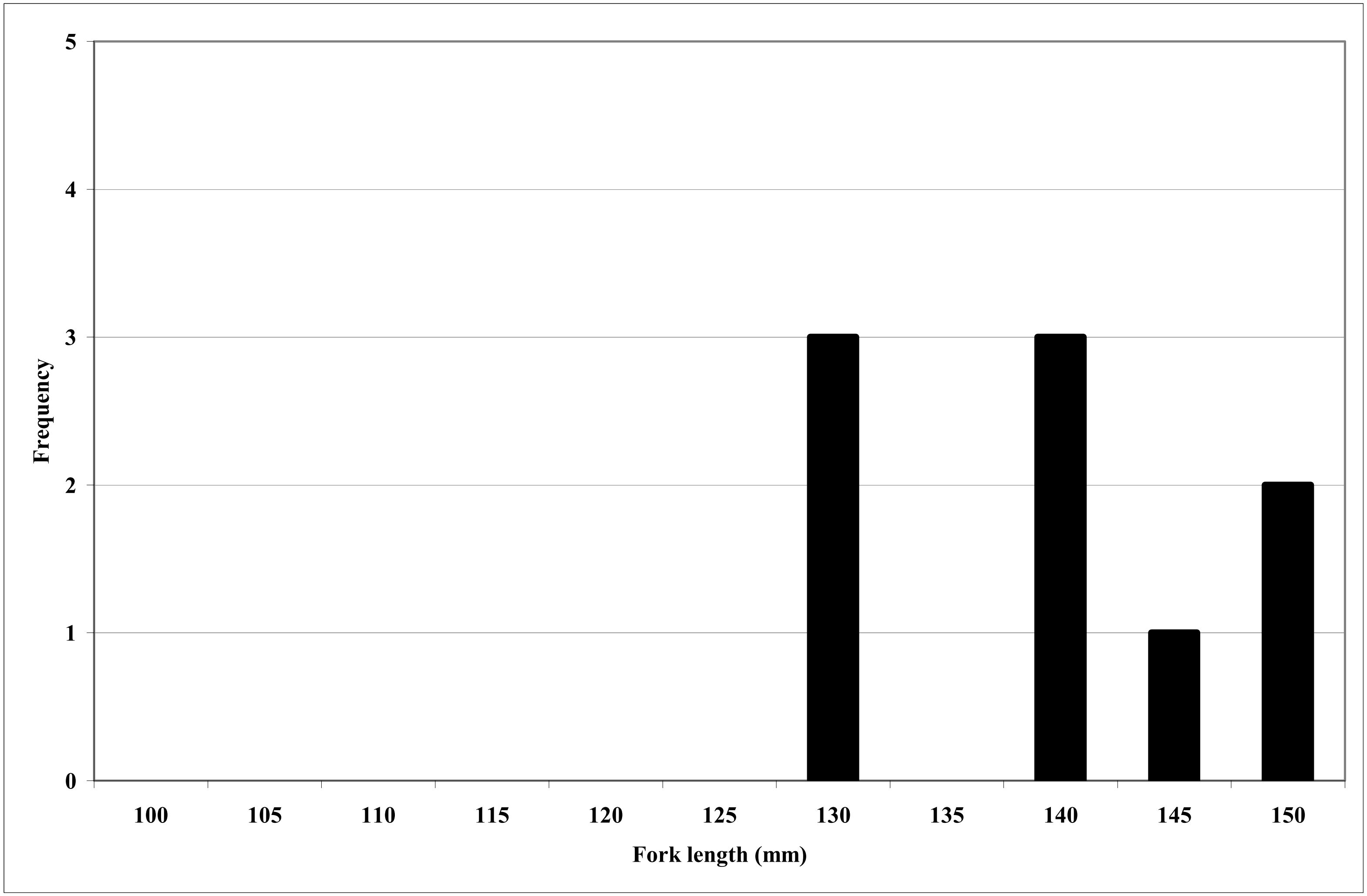

Figure 4-2. Length-frequency histogram for wild steelhead captured during boat electrofishing, August 2003 (all stations combined).

Table 4-6. Total number of pikeminnow and total number of pikeminnow greater than 200 mm FL captured by boat electrofishing, 1999 – 2003, combined.

		Total number of Pikeminnow greater than				
Segment	**Total number of pikeminnow**	**200+**	**300+**	**400+**	**500+**	**Total 200+**
Reach 1[2,3,4,8]	18	1	2	1	0	4
Reach 2[1,3,4,5,6,7.8.9]	111	5	3	4	11	23
Reach 3[1,2,3,4,5,6,78.9]	99	7	2	1	5	15
Reach 4[1,2,3,4,5,6,78.9]	123	8	5	2	8	23
Reach 5[1,8,9]	3	0	0	0	4	4

[1]Station sampled in August 1999.
[2]Station sampled in Spring 2000
[3]Station sampled in August 2000
[4]Station sampled during August 2001
[5]Station sampled during “predator” sampling event, August 2001
[6]Station sampled August 2002
[7]Station sampled during “predator” sampling event, August 2002
[8]Station sampled August 2003

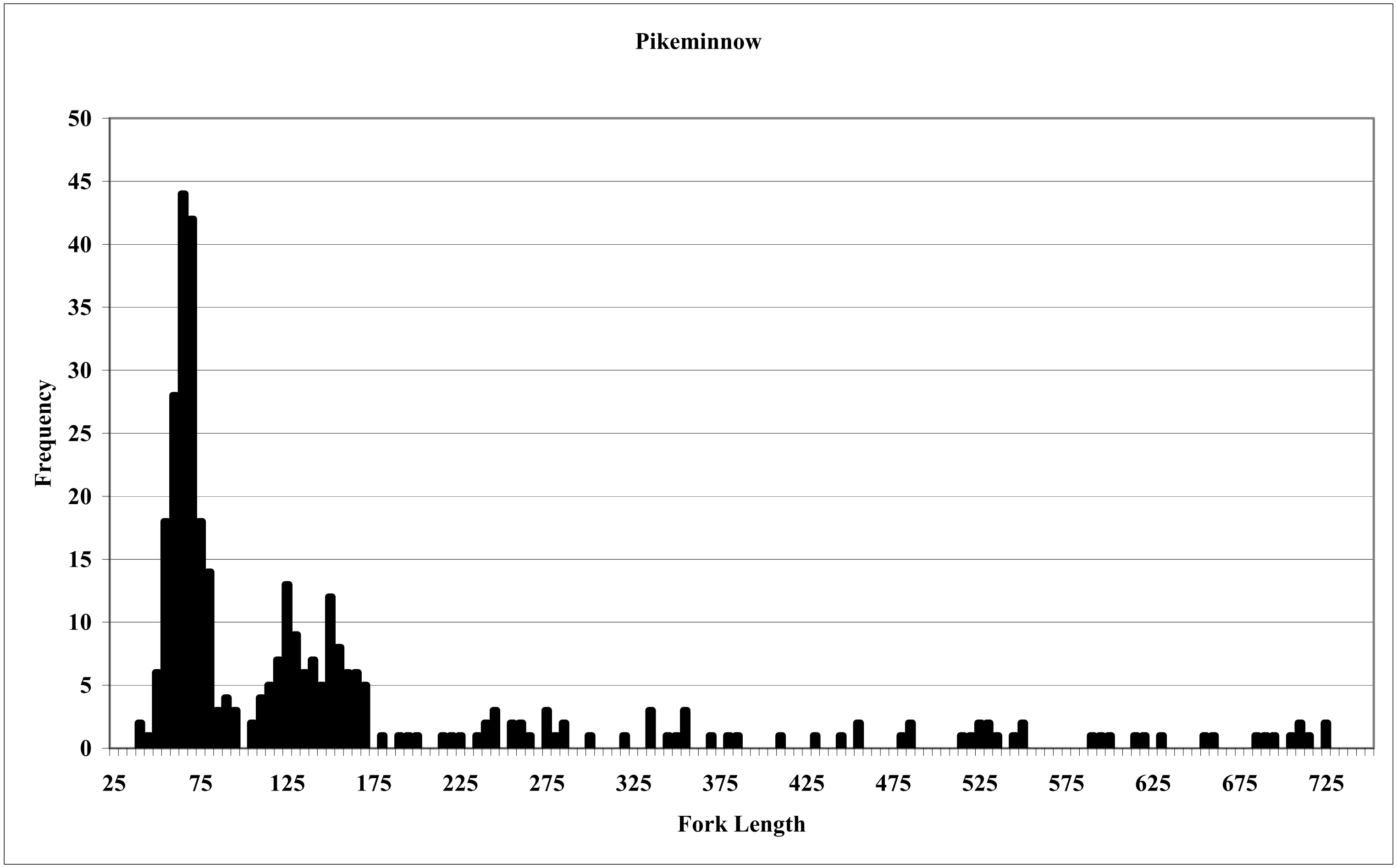

Figure 4-3. Length-frequency histogram of all Sacramento pikeminnow captured during boat electrofishing surveys, 1999 through 2003.

Table 4-7. Average size and range by age class of Sacramento pikeminnow captured during boat electrofishing 1999-2003, Russian River.

Age Class	N =	Average FL (mm)	Range
Age 0+	181	65	35 - 95
Age 1+	98	141	105 - 200
Age 2+	22	257	215 - 300
Age 3+	12	352	320 - 385
Age 4+	5	439	410 - 455
Age 5+ and older	28	603	480 - 726

4.3.4.2 Smallmouth bass

Smallmouth bass comprised 20.3 percent (520) of the total catch during the August 2003 sampling event. Within individual reaches, smallmouth bass comprised between 28.2 (Reach 3) and 2.7 (Reach 5) percent of the fish captured. Approximately 72 percent of the smallmouth bass captured were aged as young-of-the-year, and 40 fish (8 percent) were aged as two-years-old or more (Figure 4-4). Smallmouth bass were most abundant (based on CPUE) in Reach 3 (3.82 smallmouth bass/minute of sampling in shoreline sampling sites), followed by Reaches 4 (3.07 smallmouth bass/minute of sampling). Notable in Reaches 3 and 4 are at least three large bank stabilization projects utilizing boulders (rip-rap). Boulders provide cover for smallmouth bass, and relatively large numbers of small to medium sized smallmouth bass were captured along banks with rip rap extending into the river. Smallmouth bass were least abundant in Reach 1 and Reach 5 (0.93 and 0.16 smallmouth bass/minute of sampling, respectively). It is noteworthy that Reach 1 is the smallest unit, consisting of one long pool).

Overall, very few adult smallmouth bass were captured during the study (40 total). Adult smallmouth bass (Age 2+ and older) were more abundant upstream of the dam (Table 4-9). At Reach 1, six adult smallmouth bass were captured, compared to 15, 20, and 21 in Reaches 2, 3, and 4, respectively (including the predator sampling event).

Smallmouth bass captured in August 2003 ranged in size from 45 to 430 mm FL (Figure 4-4). Smallmouth bass averaged 167 mm FL (N = 109, all site combined) during August of their second year (age 1+), and 253 mm FL (N = 41, all sites combined) at age 2+ (Table 4-9). No smallmouth bass large enough to prey on age 2+ or older steelhead were captured, however, the larger bass captured were likely big enough to prey on Age 1+ steelhead.

4.3.1.2 Largemouth bass

Largemouth bass comprised 0.6 percent (15 total) of the catch during the August 2003 sampling event. Seven of the seven largemouth bass were aged as 0+, and the remaining eight were aged as Age 1+ (Figure 4-5).

Largemouth bass captured in August 2003 ranged in length from 75 to 195 mm FL (Figure 4-5). Largemouth bass averaged 117 mm FL (N = 3, all sites combined) during August of their second year (age 1+), and 168 mm FL (N=7, 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 conservatively assumed that Age 2+ are large enough to feed on emigrating Chinook smolts during the start of their third year (Age 2+).

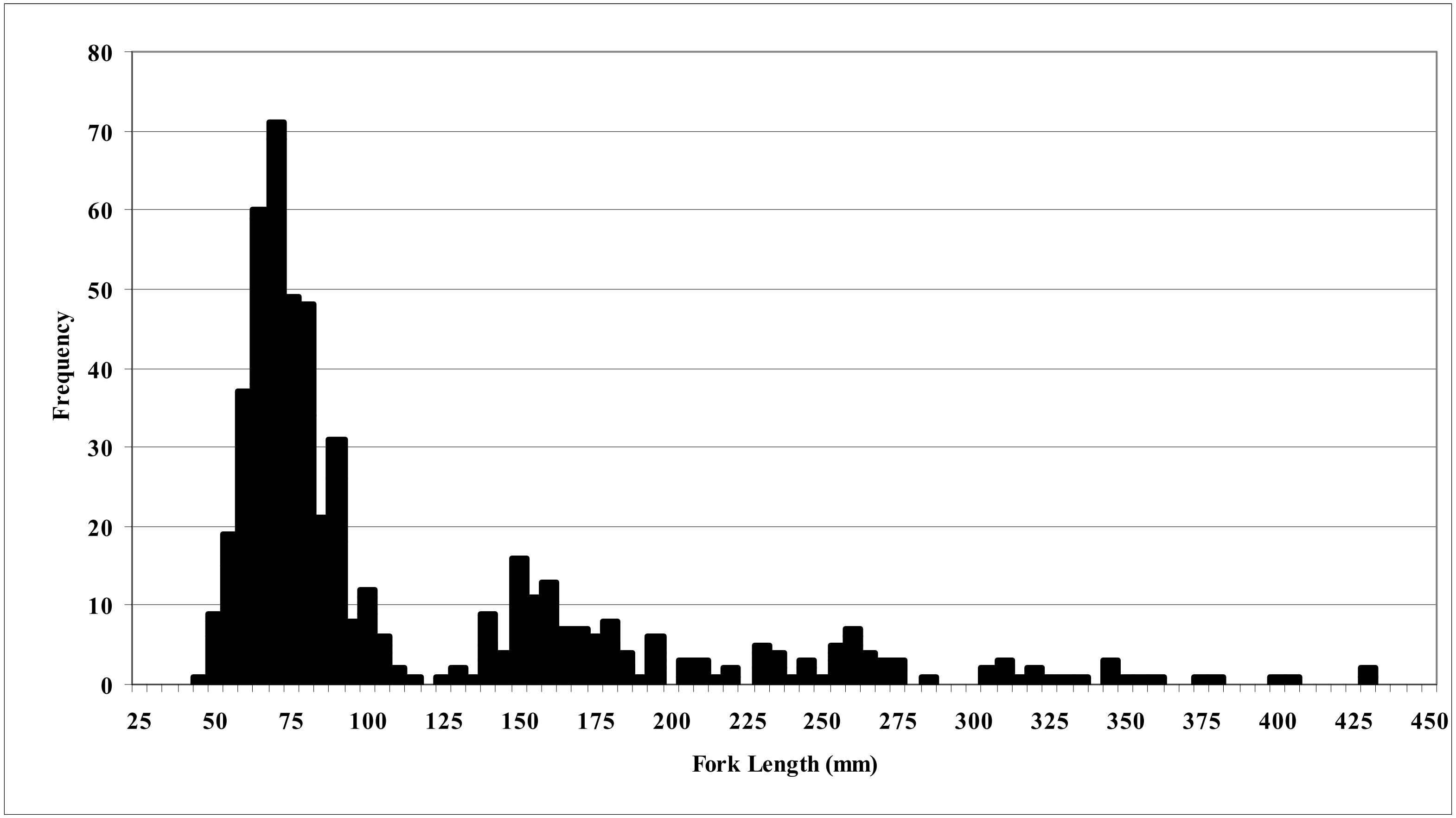

Figure 4-4. Length-frequency histogram for Smallmouth bass captured during boat electrofishing, August 2003.

Table 4-8. Average size and range by age class of all smallmouth bass captured during boat electrofishing during August surveys, 1999 - 2003, Russian River.

Age 0+			
Segment	**Average**	**Range**	**N =**
1999	85	55 - 120	208
2000	79	50 – 120	1,067
2001	79	50 – 135	583
2002	85	45 - 135	503
2003	74	45 - 115	375
Overall	**80**	**45 – 135**	**2,736**

Age 1+			
	Average	**Range**	N =
1999	179	150 - 210	19
2000	175	130 – 210	134
2001	180	140 – 230	153
2002	183	150 - 230	76
2003	167	125 - 220	109
Overall	**176**	**125 - 230**	**491**

Age 2+			
	Average	**Range**	**N =**
1999	264	240 - 295	11
2000	253	220 - 280	17
2001	264	235 - 295	46
2002	271	235 - 310	27
2003	253	228 - 285	41
Overall	**261**	**228 - 310**	**142**

Age 3+			
	Average	**Range**	**N =**
1999	325	310 - 350	6
2000	307	300 – 320	3
2001	310	300 – 325	5
2002	333	325 - 340	2
2003	324	305 - 345	14
Overall	**321**	**300 - 350**	**30**

Age 4+			
	Average	**Range**	**N =**
1999	379	375 - 380	2
2000	370	370	1
2001	373	360 - 390	6
2002	402	400 – 405	2
2003	388	355 - 430	9
Overall	**383**	**355 - 405**	**20**

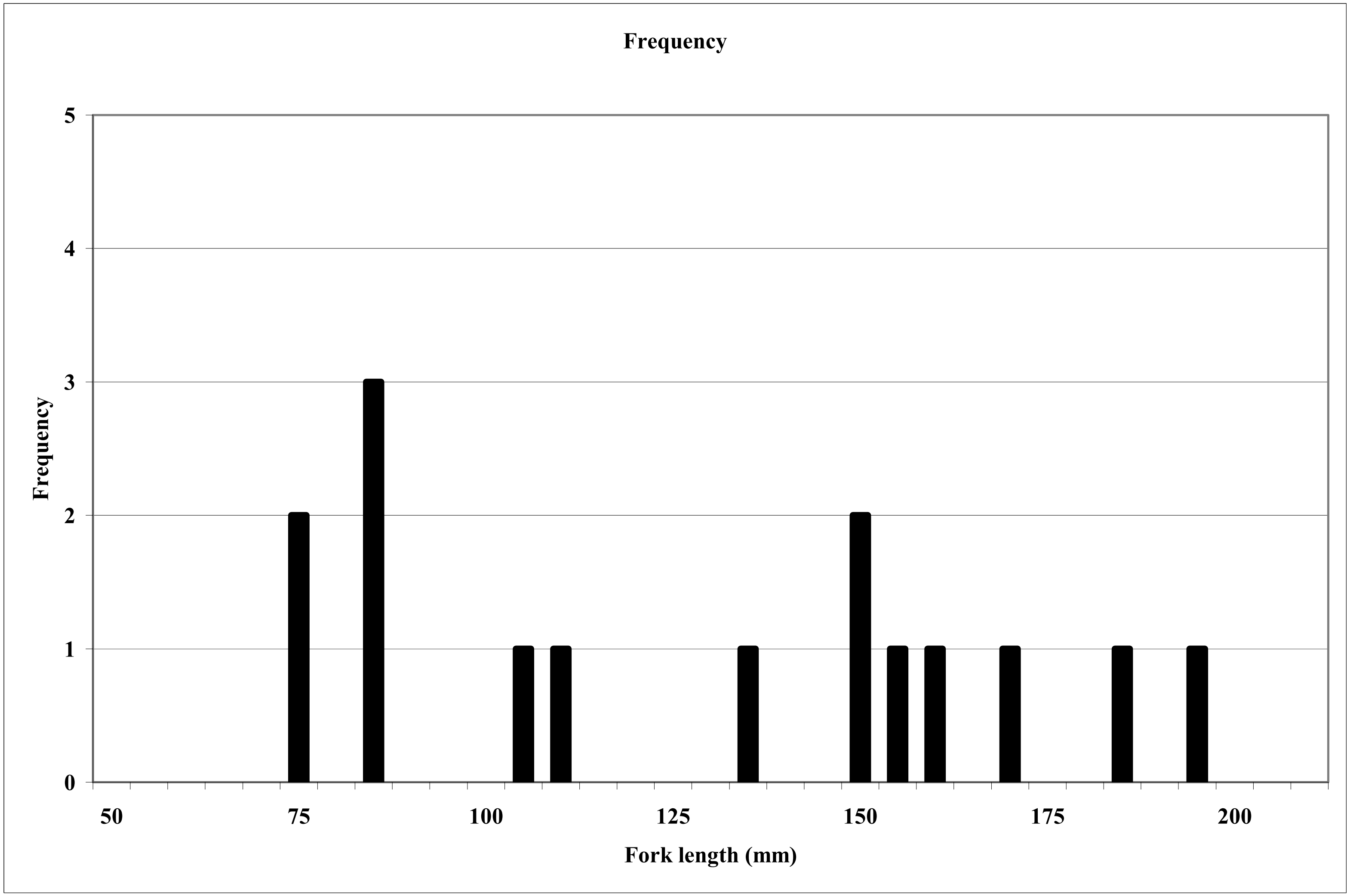

Figure 4-5. **Length-frequency histogram for largemouth bass captured during boat electrofishing, August 2003.**

Table 4-9. Average size and range by age class of largemouth bass captured during boat electrofishing, August 1999 - 2003, Russian River.

Age 0+			
Segment	**Average**	**Range**	**N =**
1999			
2000	60	50 – 75	11
2001	56	40 – 65	9
2002	50	50	2
2003	81	75 - 85	5

Age 1+			
	Average	**Range**	**N =**
1999	--	--	0
2000	122	110 – 125	6
2001	132	120-150	3
2002	155	155	1
2003	117	105 – 136	3

Age 2+			
	Average	**Range**	**N =**
1999	--	--	0
2000	195	180 – 210	5
2001	195	175 – 220	4
2002	180	180 – 185	2
2003	168	153 - 195	7

Age 3+			
	Average	**Range**	**N =**
1999	--	--	0
2000	253	250 – 255	2
2001	--	--	0
2002	255	255	1
2003	--	--	0

Age 4+ and older			
	Average	**Range**	**N =**
1999	--	--	0
2000	430	430	1
2001	350	310 – 350	3
2002	460	460	1
2003	--	--	0

4.4 SIGNIFICANT FINDINGS

During five years of sampling, four species of fish, smallmouth bass, Sacramento sucker, hardhead, and tule perch have dominated the fish community above the Inflatable Dam (Reaches 2, 3, and 4). In 2003, juvenile American shad were also captured in fairly large numbers. This event is likely tied to the high flow conditions present in the river during the spring, which delayed the inflation of the dam and likely improved spawning conditions for shad. The inflation of the dam was delayed by the high flows which may have allowed a greater than normal number of shad to spawn above the dam. In addition, American shad are broadcast spawners, releasing their semi-buoyant eggs into the water column. Higher streamflows in the spring may have improved embryonic development by maintaining sufficient flow to keep the eggs suspended in the water column until they hatched, (approximately 6 to 8 days after spawning at 17˚C). The increase in juvenile shad likely reflects springtime streamflow conditions in 2003, and not a change in the overall fish composition in the study area.

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 have been collected in relatively low numbers, primarily in Reaches above the dam ("Wohler Pool").

Three potential salmonid predators inhabit the study area, Sacramento pikeminnow, smallmouth bass, and largemouth bass (in addition, a fourth species, striped bass, has also been captured in the Wohler pool, although only two individuals have been captured during four years of sampling). 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, and are a longed lived species (possibly up to 16 years (Scoppettone 1988). Smallmouth bass are the most abundant species inhabiting the study area. The majority of smallmouth bass captured were young-of-the-year, however. No smallmouth bass large enough to prey on an average size steelhead smolt and very few smallmouth bass large enough to feed on an 80 mm FL Chinook smolts were captured. It is not known if the low number of older smallmouth bass is due a high rate of mortality among YOY bass, or a high rate of dispersal by YOY bass to areas outside of the study area. Winter habitat conditions (i.e., when the dam is deflated) may a least partially explain the poor recruitment of smallmouth bass to older age classes (see below). Very few largemouth bass were captured. Abundance of largemouth bass was highest in Reach 1 in all years sampled. Smallmouth bass, pikeminnow, and possibly largemouth bass attain a size sufficient to prey on Chinook salmonids by the start of their third year of life (age 2+).

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

Reach 2 has the deepest water (excluding the small hole at the upstream end of Reach 3), the lowest current velocities, and abundant cover. However, based on the electrofishing results presented below, smallmouth and largemouth bass abundances were lowest in the lower half of Reach 2 compared to the rest of the Study Reach. A potential explanation for this is the observed lack of habitat during the late winter/early spring period when streamflows are decreasing, but prior to dam inflation (streamflow between approximately 800 and 1,500 cfs). During high flow events, fish move into heavy cover to avoid high velocities. As flow drops after the cessation of winter rains, low velocity habitat (relatively deep water with heavy cover) is still available in Reaches 1, 3, and 4. Reach 1 is a main channel pool under normal summer base flows, and as high winter flows subside, habitat returns to this condition (thus low velocity refuge remains available to fish throughout the winter to summer transition period). Reach 4 is also primarily pool habitat that is only slightly influenced by the dam, and habitat response in a manner similar to Reach 1 as winter flows decrease. Habitat at Reach 3 without the dam would be classified primarily as a run/glide habitat, however. The thalweg (deepest section of the channel) remains against the right hand bank throughout most of the Reach. As streamflow decreases from winter to summer flows, moderate depths and cover (mainly overhanging vegetation and large woody debris) provide velocity relief for fish. Habitat in lower half of Reach 2, however, becomes a series of relatively shallow riffle and glide habitats with moderately high current velocities. The thalweg shifts to the middle of the channel through this section of the river, eliminating the potential benefits provide by overhanging vegetation and woody debris associated with the riparian corridor. Refuge from the relatively high velocity currents is lacking during the winter to summer transition period in the lower ¼ to ½ of the lower Wohler Pool. This hypothesis based on general observations made during the course of this study, and not on empirical data. However, the results of the electrofishing study support this conclusion.

5.0 Adult Upstream Migration

5.1 INTRODUCTION

The Inflatable Dam is approximately 11-feet high when fully inflated, and may form a barrier to upstream migrating fish. The dam is equipped with two denil-type fish ladders that provide upstream passage, however, prior to this study the effectiveness of the ladders had not been tested. The dam is typically inflated during at least the first half of the adult Chinook salmon migration period, and may remain inflated into the beginning of the adult steelhead migration period during years with low rainfall in the fall and early winter.

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

5.2 METHODS

5.2.1 Time-Lapse Video Photography

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

A square metal extension (exit box), measuring 4'x4'x7', was mounted to the upstream end of the each fish ladder (Figure 5-1). The exit boxes conform to the sides of the fish ladders and are designed such that the hydraulics of the ladders was not altered. A highly reflective background was attached to the upstream wall of the exit boxes to improve the lighting in the boxes. The cameras were mounted in custom manufactured boxes extending off the downstream side of the exit boxes. The boxes were constructed of 3/16" steel. A clear acrylic window was inserted between the exit boxes and the camera boxes. Cameras were in operations almost continuously from September 3 until the dam was deflated in on December 2.

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

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

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

5.2.2 Upstream Migrant Trapping

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

5.3 RESULTS

Video monitoring demonstrated that adult salmon (Chinook, chum, and pink) and steelhead were able to detect and ascend the fish ladders around the Inflatable Dam. Video monitoring provided conclusive evidence that salmonids plus a variety of other species were able to negotiate the ladders (Figure 3-1). The image quality of the videotapes was generally good to excellent, producing images of sufficient quality to identify and count fish passing through the fish ladder.

5.3.1 Video Monitoring

Video cameras were deployed on August 1, however, a system failure occurred on August 3rd and sampling was precluded until September 3rd. Overall, the system provided reasonably clear images of fish moving through the video cameras (Figure 4-2). Videotaping continued through the morning of December 2, 2003, when the dam was deflated. During this time-period, 188 videotapes were generated. Video monitoring was continuous throughout the study period with a few exceptions. The Westside camera was out (VCR failed) from September 19 through September 22, and on a few occasions, turbidity limited visibility.

Video monitoring (1999 - 2003) demonstrated that adult Chinook, chum, and pink salmon, steelhead, Pacific lamprey, and at least some American shad, are able to locate and ascend the Mirabel fish passage facilities. The total number of adult anadromous fish passing through the fish ladder can only be estimated from the data collected, however, owing to a few problems inherent in the system. Turbidity was occasionally a problem, particularly during storm events, when turbidity levels increased to the point where the back wall of the exit boxes could not be observed, thus fish could have passed undetected. This is particularly troublesome because this limitation can only be minimally addressed by increasing the lighting in the exit boxes, and because salmon and steelhead tend to migrate during freshets which are associated with higher turbidity levels. However, the study objective was to determine if salmonids find and ascend the fish passage facilities, only. Data on the numbers of salmonids and the timing of upstream migration past the dam were a secondary objective. In addition, counts only represent numbers of fish migrating in the river during periods when the dam is inflated and the cameras are in operation (September 3rd to December 2nd in 2003).

5.3.2 Fish Counts

At least thirteen species of fish have been identified passing in front of the video camera. Species observed included Chinook, chum, and pink salmon, steelhead, Pacific lamprey, American shad, Sacramento pikeminnow, hardhead, Sacramento sucker, smallmouth bass, common carp, channel catfish, and striped bass (one juvenile was observed moving downstream through the ladders in 2002). Most of the non-anadromous species were noted as "milling about" in the exit boxes, as opposed to migrating upstream or downstream through the fish ladders. Detailed counts were made of anadromous fish only. These counts were broken out by species, with a general category defined as salmonid (fish could not 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 2003, 23 fish were 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. Salmonids were partitioned by taking the percentage of Chinook salmon to steelhead identified in the ladder each day, and multiplying the number of salmonids by these percentages. In 2003, 22 of the 23 salmonids were classified as Chinook salmon, and the remaining fish was classified as a steelhead.

5.3.2.2 Chinook

The final Chinook salmon count for 2003 was 6,083 (6,105 including "salmonids"). However, owing to a few technical difficulties, as well as poor water quality on a few days, this number is likely an underestimate of the true run size for this year for the following reasons:

- Cameras did not become operational until September 3, although few salmon are observed in the fish ladder prior to this date based on observations from previous years.
- The Westside camera was out of service for 4 days during the 2003 sampling season. During this time, 9 Chinook salmon were counted migrating past the Eastside camera (the percentage of fish passing each camera was approximately 50-50).
- Chinook salmon were still being recorded in low, but consistent numbers when the dam was deflated (average of approximately 12 fish per day over the final week of video monitoring). In addition, a substantial number of fish were observed swimming over the dam when it was being deflated, some of which were clearly Chinook salmon.

Chinook salmon were first observed during video monitoring on September 4 (second day of sampling). Few fish were observed on a daily basis prior to September 30 (Table 5-1). Unlike past years when the Chinook run was punctuated by a series of pulses, most of the Chinook run occurred over a single nine day period in 2003. Between October 31 and November 8, 4,202 (69 percent of the total observed) adult Chinook salmon were counted passing through the fish ladders. Based on the four years of (mainly partial) data, the Chinook salmon run in the Russian River begins in earnest mid September, peaks October through mid November, and ends in late December. Interestingly, the daily maximum count of adult Chinook salmon has occurred within an eight day period at the end of October through the first week of November (October 30, 2000, (138), November 1, 2001 (204), November 7, 2002 (2,213, partially count), and October 31, 2003 (1,079)).

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

The weekly average temperature during late August and September ranged from 19.8 to 22.0°C. On October 13, when the first significant number of adult Chinook salmon passed through the fish ladders (368 fish), the weekly average temperature was 16.9°C, although it ranged as high as 19.0°C four days prior to this date. Water temperatures declined rapidly in the mainstem Russian River during the last week of October. The daily average water temperature decreased from 16.1 to 12.7°C between October 28 and October 31.

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

Table 5-1. Weekly counts of Chinook salmon (includes "salmonids") observed migrating upstream through the Inflatable Dam fish passage facilities during video monitoring, 2000-2003 sampling seasons.

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

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

5.3.2.3 Chum and pink salmon

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

5.3.2.4 Size of adult salmonids

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

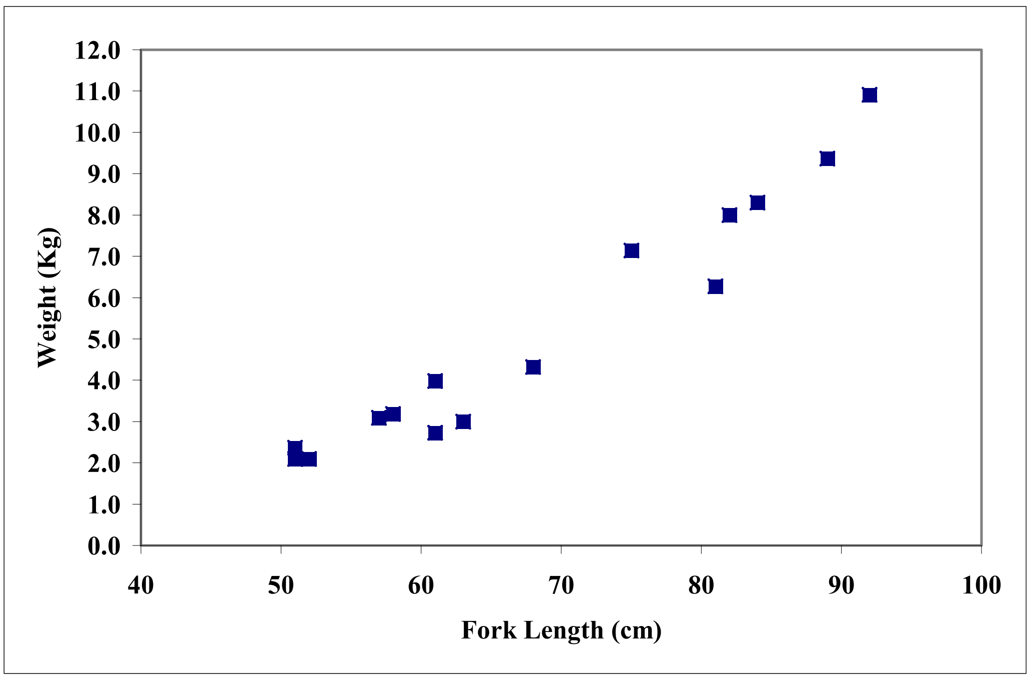

Figure 5-3. Length-weight regression for Chinook salmon captured in the upstream migrant trap at Mirabel, Russian River, Fall, 2003.

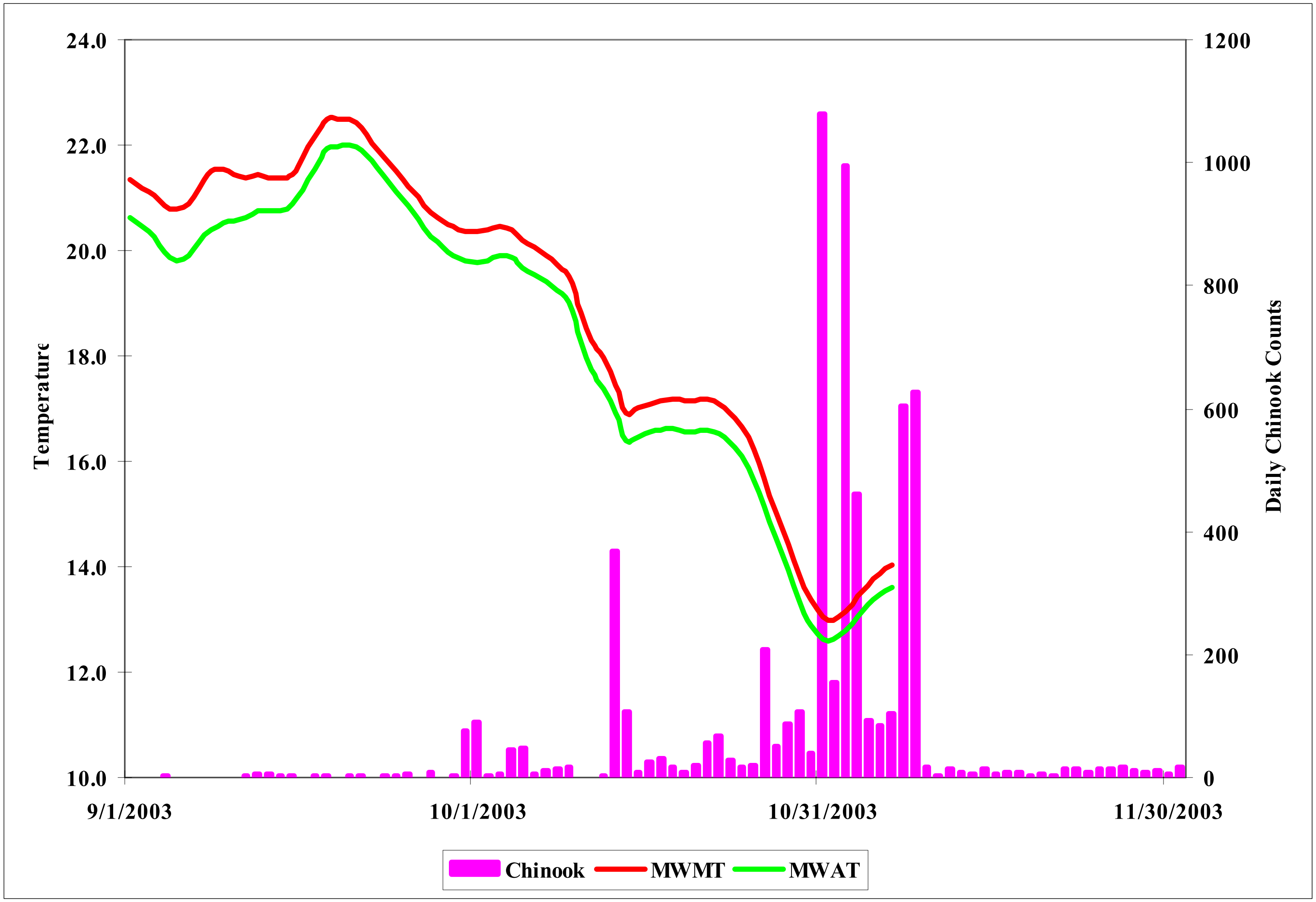

Figure 5-4. Daily Chinook salmon counts plotted against the weekly average temperature (WAT) and the weekly maximum temperature (WMT) recorded in the Russian River, September 1 through December 2, 2003 (water temperature probe lost after October 15).

5.3.3 Steelhead

In 2003, 76 adult steelhead (8 wild, 50 hatchery, and 18 of unknown origin) were counted during video monitoring. Adult steelhead have been observed in large numbers only in 2000 (when the video monitoring continued into January. Adult steelhead apparently begin migrating through the Russian River in late November, with peak months likely being December through March.

5.3.3.1 Pacific lamprey

Two Pacific lamprey were observed passing through the fish ladders in 2003. In California, Pacific lamprey migrate upstream and spawn during the winter and spring (January through March (Trihey and Associates 1996, Chase 2001), March through late June (Moyle 2002), and the fall in the Trinity River, Moffett and Smith (1950, cited by Moyle 2002) and the Napa River (Wang 1986). Moyle (2002) concluded that there might be at least two distinct runs of Pacific lamprey in some rivers (similar to the multiple spawning runs of Chinook salmon observed in larger rivers). Pacific lamprey were observed sporadically between October 1 and December 10 in 2002 (Table 5-2). In 2000, video surveillance was conducted from May 12 through January 10, 2001. 228 Pacific lamprey were observed in the fish ladders, primarily in May and June, with small numbers of Pacific lamprey observed migrating upstream through the fish ladders in late October and November (one was also observed in early January). Although the possibility exists for two distinct runs of lamprey in the Russian River based on the data collected (a fall run and a spring run), the data are inconclusive because of the lack of sampling during the late fall/winter period when the dam is deflated. The numbers of lamprey reported here are likely underestimates. Pacific lamprey can be difficult to observe on the videotapes, particularly during periods of low visibility (high turbidity).

Table 5-2. Daily counts of adult Pacific lamprey observed migrating through the fish ladders at Mirabel during video monitoring, Russian River, 1999-2003.

Date	1999	2000	2001	2002	2003
9-May	0	3		N/S	N/S
16-May	0	44	N/S	N/S	N/S
23-May	4	17	N/S	N/S	N/S
30-May	0	23	N/S	N/S	N/S
6-June	0	34	N/S	N/S	N/S
13-June	0	69	N/S	N/S	N/S
20-June	0	3	N/S	N/S	N/S
27-June	0	0	N/S	N/S	N/S
4-July	0	1	N/S	N/S	N/S
11-July	0	0	N/S	N/S	N/S
18-July	0	0	N/S	N/S	N/S
25-July	0	0	N/S	N/S	N/S
1-Aug	0	0	0	0	N/S
8-Aug	0	0	0	0	N/S
15-Aug	0	0	0	0	N/S
22-Aug	0	0	0	0	0
29-Aug	0	0	0	0	0
5-Sep	0	0	0	0	0
12-Sep	0	0	0	0	0
19-Sep	0	0	0	0	0
26-Sep	0	0	0	1	0
3-Oct	0	0	0	2	0
10-Oct	1	0	0	1	0
17-Oct	0	0	0	0	1
24-Oct	23	17	0	1	0
31-Oct	13	11	1	0	0
7-Nov	9	0	2	1	1
14-Nov	0	0	0	0	0
21 Nov	N/S[1]	3	0	0	0
28 Nov	N/S	2	N/S	0	0
5-Dec	N/S	0	N/S	13	N/S
12-Dec	N/S	0	N/S	N/S	N/S
19-Dec	N/S	0	N/S	N/S	N/S
26-Dec	N/S	0	N/S	N/S	N/S
2-Jan	N/S	1	N/S	N/S	N/S
9-Jan	N/S	0	N/S	N/S	N/S
Totals	**50**	**228**	**3**	**19**	**2**

N/S[1] = Not Surveyed

5.4 SIGNIFICANT FINDINGS

Based on the results of video monitoring from 1999 through 2003, Chinook salmon and steelhead appear to be highly successful in finding and ascending the fish ladders around the Inflatable Dam. Relatively large numbers of adult fish of both species have been documented negotiating the ladders, and large numbers of fish milling at the base of the dam have not been observed. However, a satisfactory method of assessing fish holding 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.

In 2003, approximately 6,100 adult Chinook salmon were counted ascending the fish ladders at the Mirabel Dam. The 2003 run represents an approximate 4.0 times increase over the number of Chinook salmon counted passing the dam in 2000, when virtually the entire run was surveyed. This is in contrast to historical literature that suggests that Chinook salmon 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 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 have not appeared to be successful. The Chinook run essentially began in early September during the four years sampled (1999-2002). 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 of the first three years sampled, one Chinook salmon has been observed in the fish ladders, and nine were counted in 2002. Relatively large numbers of salmon have not been observed prior to October in any year.

In 2003, approximately 70 percent of the fish counted passed through the dam during a nine day stretch (October 31 through November 8). In 2002, 76.5 percent of the fish were counted over six days: October 1 and 2, (21.1 percent, primarily on the 2^{nd}), October 15 and 16 (9.9 percent), and November 16 and 17 (45.6 percent). The 2,213 Chinook salmon counted on November 17 was greater than any annual total count from the previous three years sampling.

Based on the paucity of historical records of Chinook salmon inhabiting the Russian River, the genetic origin of the Chinook salmon in the Russian River has been debated. There are at least three hypotheses to explain the presence of Chinook in the basin. First, they are remnants of a native run that was largely unnoticed during the past 100 years (possibly existing at very low population levels). Secondly, they may have resulted from the extensive stocking programs carried out over the last 100+ years. Finally, they may be strays from the Eel and/or the Sacramento rivers. Preliminary data from a genetics study conducted by the Bodega Marine Lab (BML 2002) concluded that the Russian River Chinook population is not closely related to Eel River or Central Valley (Sacramento-San Joaquin rivers) populations. Further, BML (2002) states that "Chinook in the Russian River do appear to belong to a diverse set of coastal Chinook populations." Based on the results of the BML, the leading hypothesis for the origin of the Russian River Chinook salmon is that they are a native run that has been largely unnoticed. The reason why these fish showed up in relatively large numbers in 2002 and 2003 is unknown.

An important footnote to the abundance data presented above is that the length of time that the fish ladder was in operation varied each year. Thus, a direct comparison between the numbers of fish observed between years cannot be made. Still, it is interesting that the numbers of Chinook salmon counted in 2002 and 2003 were 3.5 to 4.0 times the number counted in 2000, when virtually the entire run was surveyed.

Adult steelhead began their upstream migration in late October, however, the majority of their run occurs after the dam is deflated. Thus, little run information is available for this species.

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