American River Snorkel Survey 2004
Data Report

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Introduction

Under a grant from the U.S. Fish and Wildlife Service, the Fishery Foundation of California conducted a snorkel survey of the Lower American River (LAR) from February to September, 2004. The survey assesses the biological results and effectiveness of actions under the Central Valley Project Improvement Act {Section 3406(b)(16)}. In particular, this survey monitored juvenile fish populations and summer-time adult steelhead populations within the LAR as part of a comprehensive assessment program to monitor fish and wildlife resources of the Central Valley. The juvenile fish survey was conducted from February to June and the steelhead survey was conducted from July to September. The survey period was confined to February through September due to the low numbers of salmonids observed outside of this time frame. The survey objectives included (1) determine how juvenile Chinook salmon (*O. tshawytscha*) and steelhead (O. mykiss) use the LAR from December through June; and (2) determine how juvenile salmonids use various river habitats.

Jackson (1992) conducted snorkel surveys of the LAR from 1989 to 1991. He focused on 15 macrohabitat polygons. His objective was to determine microhabitat preferences of juvenile salmon. He concluded that microhabitat use of each macrohabitat polygon was unique because of the different morphology and habitat availability of each polygon. He also found much greater numbers of young salmon in years with higher flows 105 m^3/s (3600 cfs) versus low flows 9.9 m^3/s (340 cfs). Based on this and other studies (Water Forum 2001, Jones and Stokes 2002) there appears to be a general consensus that flow and water temperature are the limiting factors for salmon and steelhead smolt production in the LAR.

These recent findings also suggest that lower flows provide insufficient habitat for rearing young salmon and steelhead in the LAR. However, uncertainty remains as to what flows are optimal for rearing and migration of salmonids, as well as other aspects of the biology of salmon and steelhead in the LAR (Williams 2000). The 2004 snorkel survey is yet another step toward addressing these questions.

The snorkeling procedure employed in the 2004 survey is similar to the procedure used in the 2003 survey. As in 2003, the 2004 sampling locations were composed of an array of two-dimensional units or polygons representing habitats found throughout the river. If salmonid use can be related to habitat conditions in the polygons and habitat conditions can be related to flow, then streamflow can be related to the value of habitat in the LAR. If habitat use can be translated into habitat value, then habitat use patterns may help in defining habitat restoration needs and alternatives. Williams (1999) related that defining habitat for such purposes has not been satisfactorily resolved, especially in large rivers such as the LAR.

As in 2003, the 2004 snorkel survey offers the potential of obtaining relative temporal and spatial densities and distributions of various life stages of juvenile salmonids in the LAR.

Lower American River Study Area insert 2003 map

Location

The 2004 snorkel survey was conducted at 9 locations in the LAR between Watt Avenue and Nimbus Dam at river mile 23(Figure 1)(Appendix B). These locations represent a variety of habitat conditions in various reaches of the LAR.

Figure 1. Year 2004 sampling locations the Lower American River.

We divided the LAR into reaches per Snider et al. (1992), who divided the river based on geomorphology and hydraulic criteria. Subreaches for the upper river (Snider et al.'s Reach 3) were broken out by bar complex simply because the parkway facilities are commonly referred to in this format.

Fish Community

The LAR between Nimbus Dam and the mouth at the Sacramento River is an important spawning and rearing habitat for fall-run Chinook salmon, steelhead trout, American shad *(Alosa sapidissima)*, and many native fish species including Sacramento splittail(*Pogonichthys macrolepidotus),* Sacramento pikeminnow(*Ptychocheilus grandis*), Sacramento sucker(*Catostomus occidentalis)*, tule perch(*Hysterocarpus traski)*, and Pacific lamprey *(Lampetra tridentata)*. In addition the LAR is seasonally important habitat for adult striped bass*(Morone saxatilis)* and American Shad that migrate upstream into the LAR from the Sacramento River and Bay-Delta estuary. The steelhead trout and Sacramento splittail have been federally listed as threatened.

Many of these fish species use the aquatic habitats of the LAR for spawning, rearing, and feeding. Gravel riffles and runs provide spawning habitat for many species including salmon and steelhead, which lay their eggs in gravel spawning beds in higher gradient areas of the river from fall through spring. Shallow low gradient areas of the lower river are spawning habitat for splittail and rearing habitat for many of the other locally important fish species.

The steelhead population of the Central Valley ecological unit includes steelhead from the LAR. Steelhead trout are most abundant in the river in winter and spring. Adult steelhead may be found in the river during any month of the year but primarily migrate into the river to spawn in the winter and spring. The native steelhead were a spring-run, which migrated into the river in spring and then remained over summer and fall to spawn the next winter or spring. Young steelhead hatch in late winter and spring, and rear in the river until the following winter and spring before migrating downstream to the ocean as smolts. Some may remain in the river a year or more before migrating to the ocean.

Adult fall-run Chinook salmon begin migrating into the LAR in summer, gradually peaking in abundance in October and November where spawning occurs in gravel beds of the upper 10 miles of the LAR. The run supports an extensive recreational fishery from late spring through the fall.

Natural production of salmon offspring is supplemented by smolts produced at the Nimbus hatchery, which are transported by truck and released into San Francisco Bay. In addition, the Nimbus hatchery is also responsible for the release of over 400,000 steelhead smolts into San Francisco Bay.

Methods

Survey Design

Snorkel surveys were conducted twice per month from February through September 2004. Surveys were conducted at 9 sampling locations (Figure 1) approximately every two miles over the lower 23 miles of the LAR. Surveys were conducted over a period of two to four days. Nighttime surveys were conducted on occasion to evaluate the difference in numbers of juvenile salmonids observed between daytime and nighttime and whether nightime surveys were more beneficial.

Sampling locations were chosen to be representative of habitat in the various reaches of the river and to represent the broad array of physical habitat in the LAR. Sampling locations were chosen systematically to represent the longitudinal distribution of fish in the river through the survey period. More sampling locations were chosen in the upper river because this area is known to be the primary spawning and rearing habitat with a greater gradient and diversity of habitat. Choice of sampling locations was influenced to some degree by accessibility, especially in the lower river where access was limited.

At each of the sampling locations the available habitat area was visually surveyed and representative habitat units designated as sampling units, or polygons. The polygons were laid out as two-dimensional features and called polygons (because of their varying sizes and shapes). Polygons varied in size from 30 to 150 feet in length and 6 to 10 feet in width. Polygon dimensions differed as a function of homogeneity of the habitat within the polygon. For example mainstem run polygons were generally 100-150 feet in length because habitat varied little in large runs and pools of the main river channel. Shoreline and side channels polygons were smaller, varying in size from 30 to 100 feet in length, because variability in habitat was greater. In designating polygons we followed the general approach of Thomas and Bovee (1993) and Kocik and Ferreri (1988). According to these researchers polygons (they use the term cells) are discrete functional habitat units having a consistent range of microhabitat variables (depth, velocity, substrate, and cover). The functional habitat unit concept allows a flexible approach to evaluating habitat and determining seasonal habitat use patterns at a scale that can be readily visualized and is understandable. For example, shallow shoreline riffle margins with uniform cover were one common type of polygon; while mainstem runs with consistent depth and substrate were another. Other common types were backwater and riffle/pool margins with and without cover, and deep pool margins or clay banks with and without cover. In most cases polygons had unique qualities with obvious differences from other polygons among and within sampling locations, but polygons could be categorized into one general type or another (e.g., shoreline, sidechannel, riffle, and with or without cover).

The number of units chosen varied directly with the diversity of habitat at the sampling location. For example, sampling locations with islands and side channels were allocated more polygons. Despite some sampling locations having nearly 20 units, most units within a sampling location had some unique habitat features or conditions that differentiated them from other units.

Polygons were chosen from the available array of riffles, pools, runs/glides, and backwaters following mesohabitat classification systems in the standard literature (Bisson et al. 1981). At each sampling location, sampling polygons were designated from as many mesohabitat types as possible. Given the high variability in habitat available among and within possible river sampling locations, the final survey array has some degree of randomness despite being discretely chosen. No map of habitat at the polygon level was available for the river from which to choose sampling locations or polygons in a random or systematic fashion.

Not all polygons were sampled in each survey for various reasons. In some cases under high flows it was not possible to sample all polygons. Some polygons could no longer be sampled in low flow periods. In some cases other polygons were added or substituted. Generally, for each sampling period, surveys were conducted at most of the designated sampling polygons at each sampling location.

Sampling locations were generally accessed by vehicle or boat, and then polygons were reached by foot, boat, or swimming. During high flow periods, some polygons could only be accessed by small boat because of the danger of swimming across the river.

Sampling Technique

Snorkeling was conducted similar to other snorkel surveys (Edmundson et al 1968; Hankin and Reeves 1988, Jackson 1992). One snorkeler generally sampled each polygon. At times a second snorkeler followed the data collector for the purposes of observing, training, or quality assurance checking. For near shore polygons, the diver proceeded upstream against the current. In eddies, the diver proceeded against the current. In faster water the diver often had to pull along the shoreline using rocks and brush to hold or gain position. Deeper and center stream polygons were sampled by the diver proceeding downstream with the current. Swimming with the current in deeper water brought about less avoidance than appeared to be the case when swimming downstream in shallow water. It also appeared to be effective (at least in terms of approaching large wary fish) because of the general high rate of speed when moving over the deeper waters of the main channel of the river.

Fish were identified, counted, and sized as the diver proceeded up or down the sampling polygon. Typically, fish were observed while swimming upstream along shore either six feet from shore (velocity permitting) or directly along shore allowing upstream and offshore viewing. Care was taken to observe and count fish just once by passing fish and allowing them to escape downstream of the diver. Some counts were made as fish escaped past the diver, but generally divers were able to observe fish under normal behavioral conditions before fish were passed or escaped downstream past the diver. Generally, fish escaped when approached by passing inshore or offshore past the divers and going downstream. Some fish, especially large fish, escaped by heading offshore to deeper water. Some, especially schooling fish like tule perch and Chinook salmon escaped upstream, and for these the divers had to ensure they were not counted twice. In shallow waters along shorelines, it was nearly impossible to make accurate counts if divers approached from upstream, because of sediment disturbance and higher speed involved, as well as the orientation of the fish in the current toward the approaching diver. For these same reasons, sampling polygons were sampled sequentially from downstream to upstream polygons.

Data Collection

Divers recorded their observations on PVC slates attached to their forearms. Numbers of fish were recorded by species and size group as the diver proceeded through the polygon (Table 1). Individual concentrations of fish were recorded along with habitat conditions associated with the concentration. Habitat conditions of the polygon were recorded including depth, velocity, substrate, and cover. All sampling locations were surveyed twice each month.

Table 1. Fish length codes and sizes for spring 2004 juvenile salmonid sampling on the Lower American River.

Length Code	Size (mm)
1	20-40
2	40-60
3	60-80
4	80-100
5	100-200
6	200-300
7	300-400
8	400-600
9	>600

Fish were identified to species following keys in Moyle (2002). Larvae and early juvenile suckers and minnows (principally pikeminnow) were not counted our included because of their extreme abundance and widespread distribution beginning in spring. Only when they reached approximately 20-40 mm in early summer and could they be identified to species and thus included in the survey data.

Temperature was recorded with thermometers at each polygon. Selected temperatures were recorded within polygons if divers thought temperature gradients were affecting fish distribution. Generally, temperature varied little among all the sampling locations sampled because of the relatively high flows especially in late spring and summer. Temperature variability within sampling locations was noticeable on warm afternoons at some sampling locations with backwaters exposed to the sun.

Flow data were obtained from the California Data Exchange Center (http://cdec.water.ca.gov/riv_flows.html). Additional temperature data was obtained from the United States Geological Survey (http://waterdata.usgs.gov/nwis/qw).

Data Processing

Data were transferred from slates to standard field “write-in-the-rain” data sheets. From data sheets, data were transferred directly to Microsoft Excel spreadsheets. All tables and charts were created in Microsoft Excel.

Results

River Flows and Stage Heights

River flows were relatively high from mid to late February ranging from 3,000-7,000 cfs, but declined through March to 3,000-4,000 cfs (Figure 2). Streamflow increased to 7,800 cfs in early April and then dropped sharply to around 2,500 cfs in early May. Flows ranged from 1,800 cfs to 2,500 cfs through June.

The February pulse coupled with high water releases in the Sacramento River caused the stage height in the LAR, measured at the H Street Bridge near CSUS, to rise by over seven feet (Figure 3). The effect of this higher stage was to inundate the lower river flood plain from Watt Avenue to the mouth. A second high flow event occurred in early April when almost 8000 cfs flowed through the American. The gauge station measured a two-feet rise at the H Street Bridge stage level during this pulse. Again, the flood plain along the lowest reaches of the American River from Howe Avenue to the mouth was inundated.

Flows during the summer adult steelhead surveys ranged from around 1,200 to 3,500 cfs (Figure 4) with flows decreasing sharply in late July and continuing to decline through the end of September. Stage height at the H Street Bridge shows a similar pattern (Figure 5).

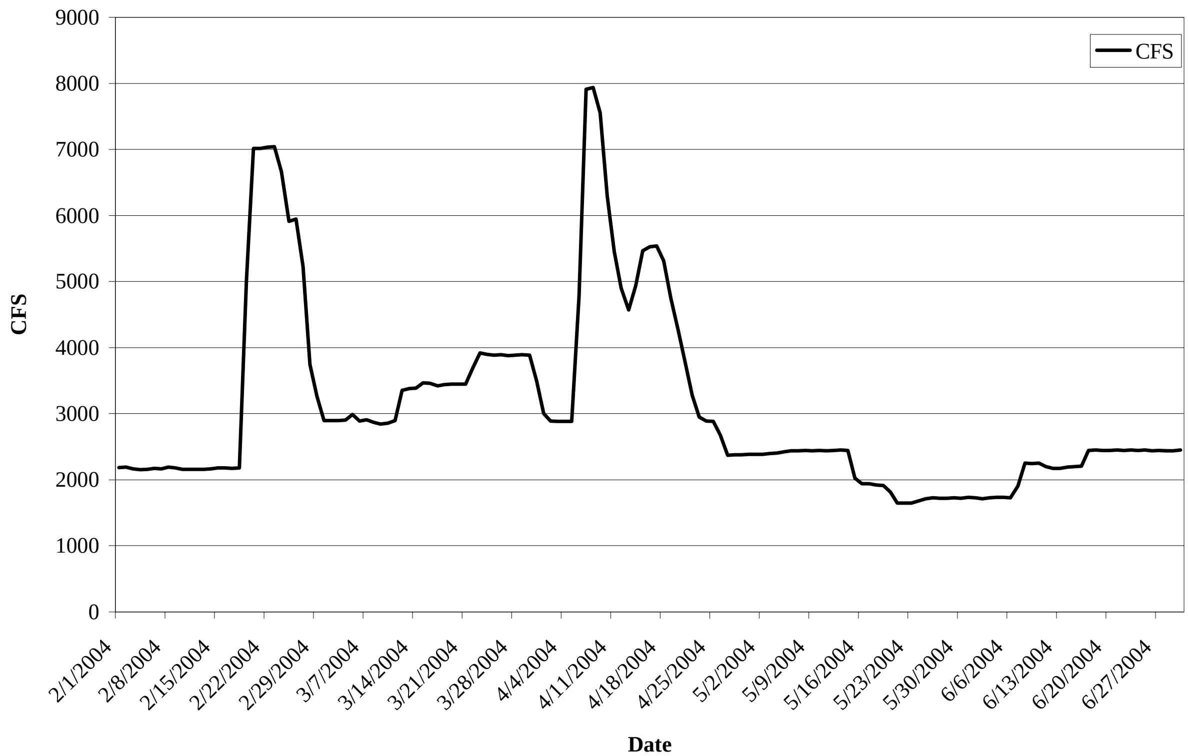

Figure 2. Mean daily instream flow on the Lower American River measured at the Fair Oaks Gauging Station, February 1- June 30, 2004. Source**:** USGS station 11446500.

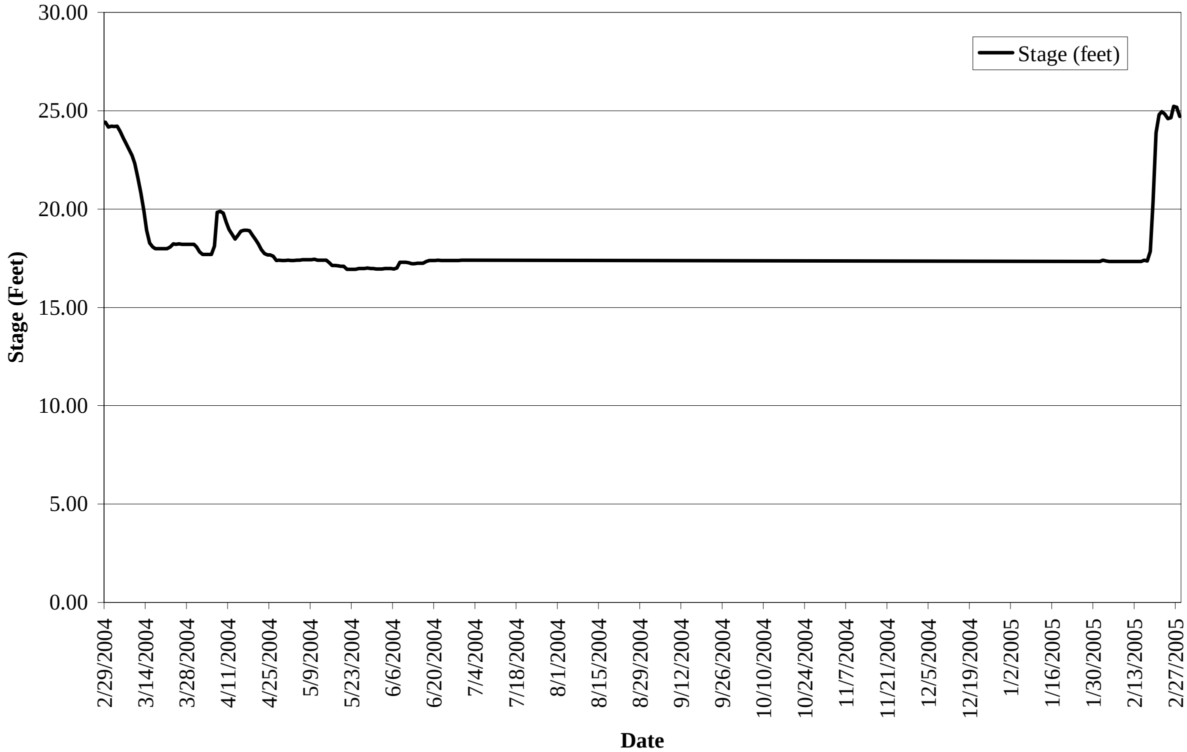

Figure 3. Mean Daily River Stage (Feet) on the Lower American River measured at the H Street Bridge Station, February 1- June 30, 2004. Source: CA Department of Water Resources station HST.

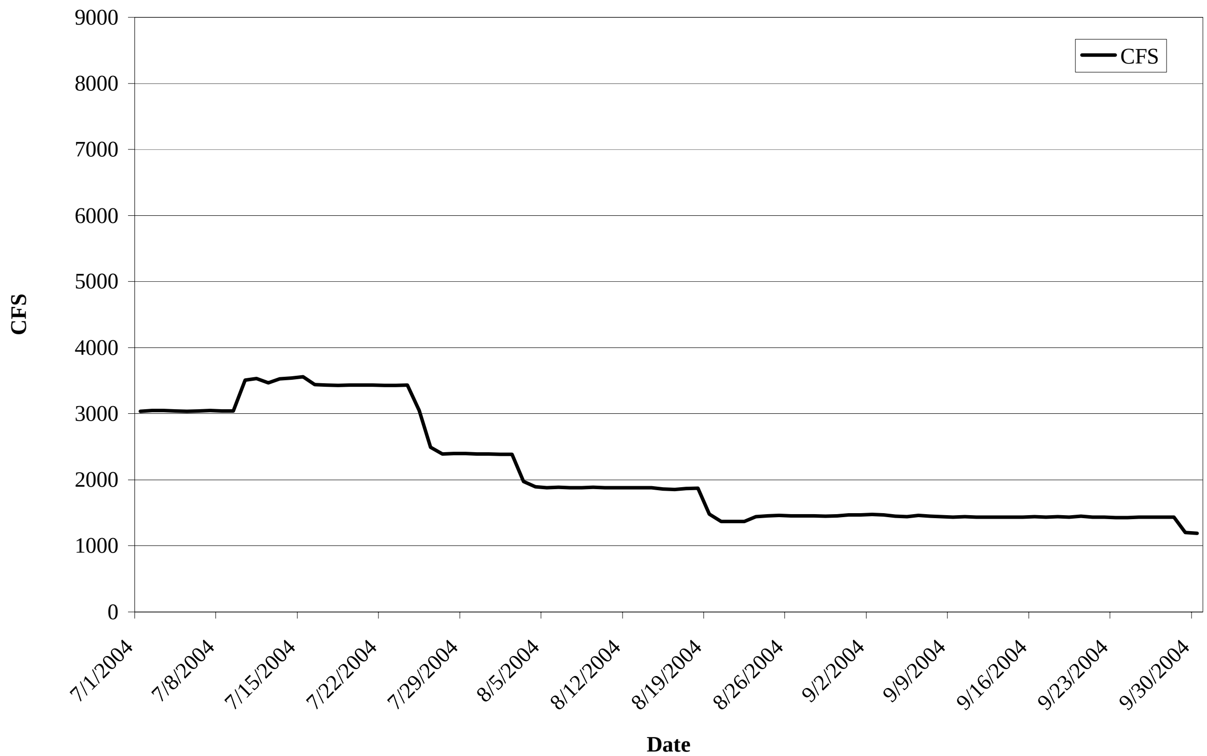

Figure 4. Mean instream flow on the Lower American River measured at the Fair Oaks Gauging Station, July 1- September 30, 2004. Source: USGS station 11446500.

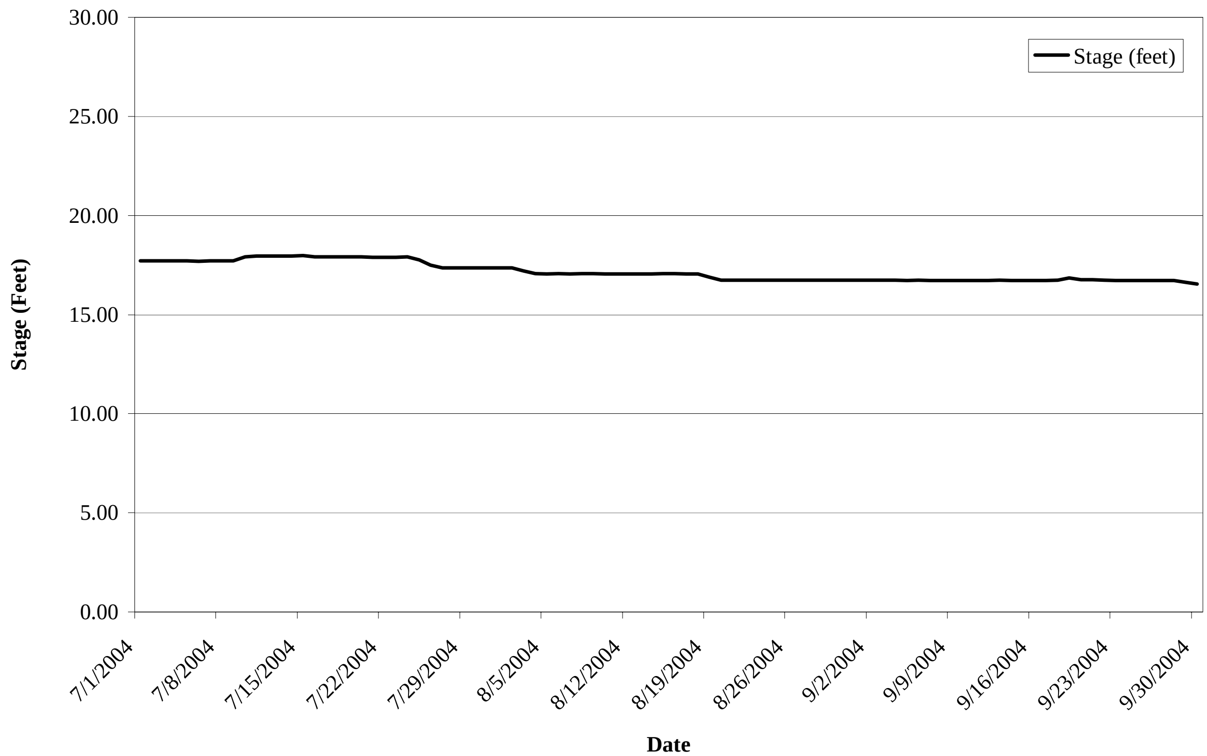

Figure 5. Mean Daily River Stage (Feet) on the Lower American River measured at the H Street Bridge Station, July 1- September 30, 2004. Source: CA Department of Water Resources station HST.

Water Temperatures

Divers recorded temperature at each sampling polygon during each survey. During low flow periods the recorded temperatures varied as much as 5 °C between the swift flowing center transects and the warmer, shallower backwater pools. When river flows were at their highest the longitudinal river temperatures across all sampling locations varied as little as 1 °C.

The flows in the LAR are controlled by the Bureau of Reclamation for water storage, flood control and recreation. In the upper reach the temperature of the water released from Nimbus Dam remains suitable for trout and salmon for most of the sampling period (Figure 6). Moving downstream into the lower reach where the river begins to flatten out and meander, the temperature rises in the slow currents. Maximum daily water temperature was 10-12°C in February and March (Figure 7). In early April maximum water temperature rose to the 14-16°C range. By summer, water temperature ranged from 16 - 20°C at the USGS Watt Avenue gauge. Elevated temperatures limit the time that salmon and steelhead utilize the lowest reaches of the American River for rearing and may help explain the rapid decline in salmonid densities in May through June.

During high flow events the flood plain located in the lower reach of the American River are inundated with water and provide valuable habitat for salmonids. High flows are vital in keeping the temperature of the LAR in a suitable range for salmonids especially in the lower reach where the low channel gradient allows the water temperature to rise above the critical level preferred by salmon and steelhead.

Figures 8 and 9 show water temperatures from July 1 to September 30, 2004, when summer steelhead surveys were conducted. Maximum temperatures were between 19-22.5°C at the Watt Avenue station and between 17-20°C upstream at the Fair Oaks station throughout this period. Figure 10 shows water temperatures recorded at survey sampling locations over the entire survey period February to September.

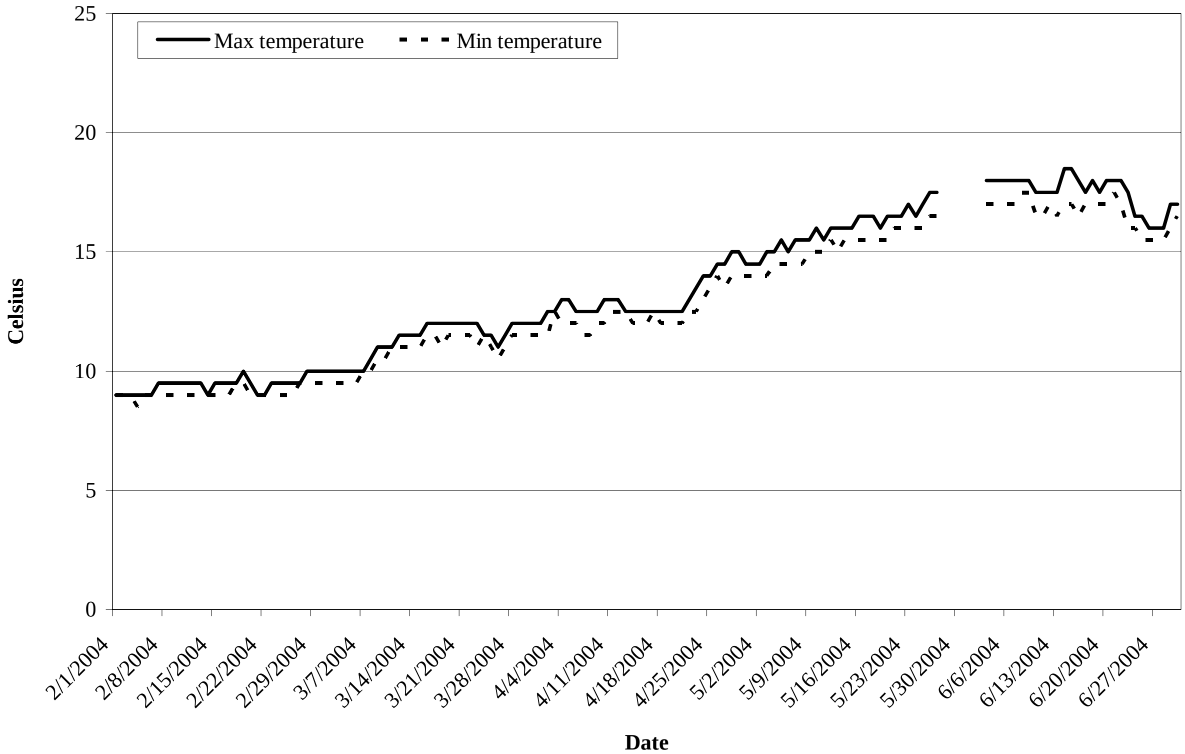

Figure 6. Maximum and minimum daily temperatures at the American River Fair Oaks station from February 1 to June 30, 2004. Source: USGS station 11446500.

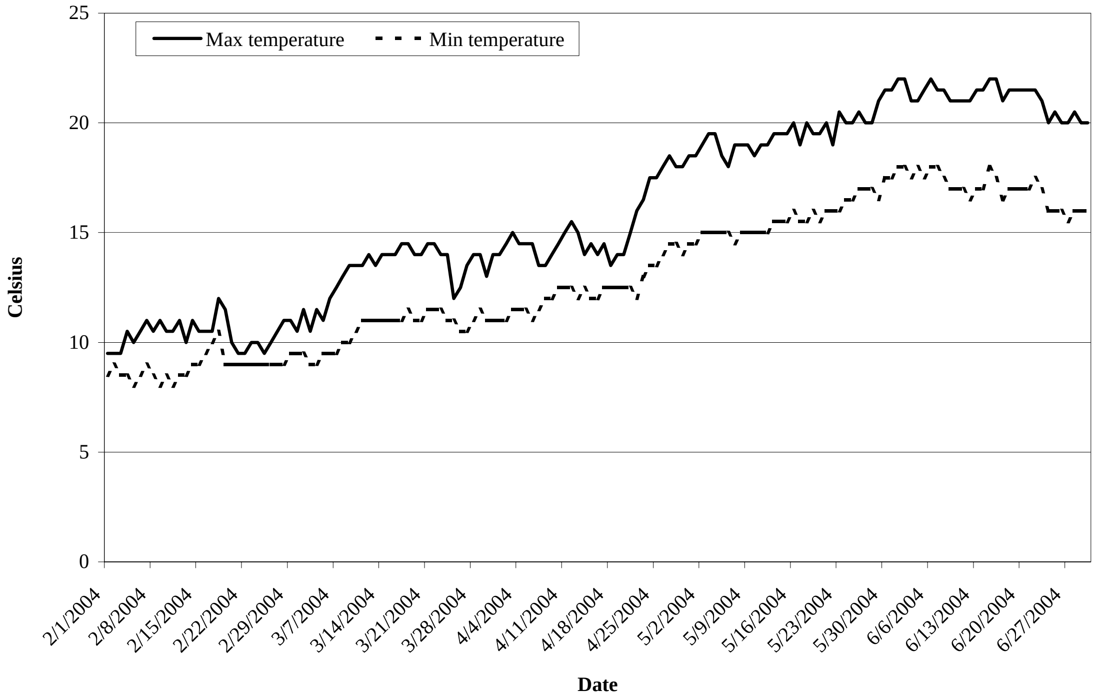

Figure 7. Maximum and minimum daily temperatures at the American River Watt Ave station from February 1 to June 30, 2004. Source**:** USGS station 11446980.

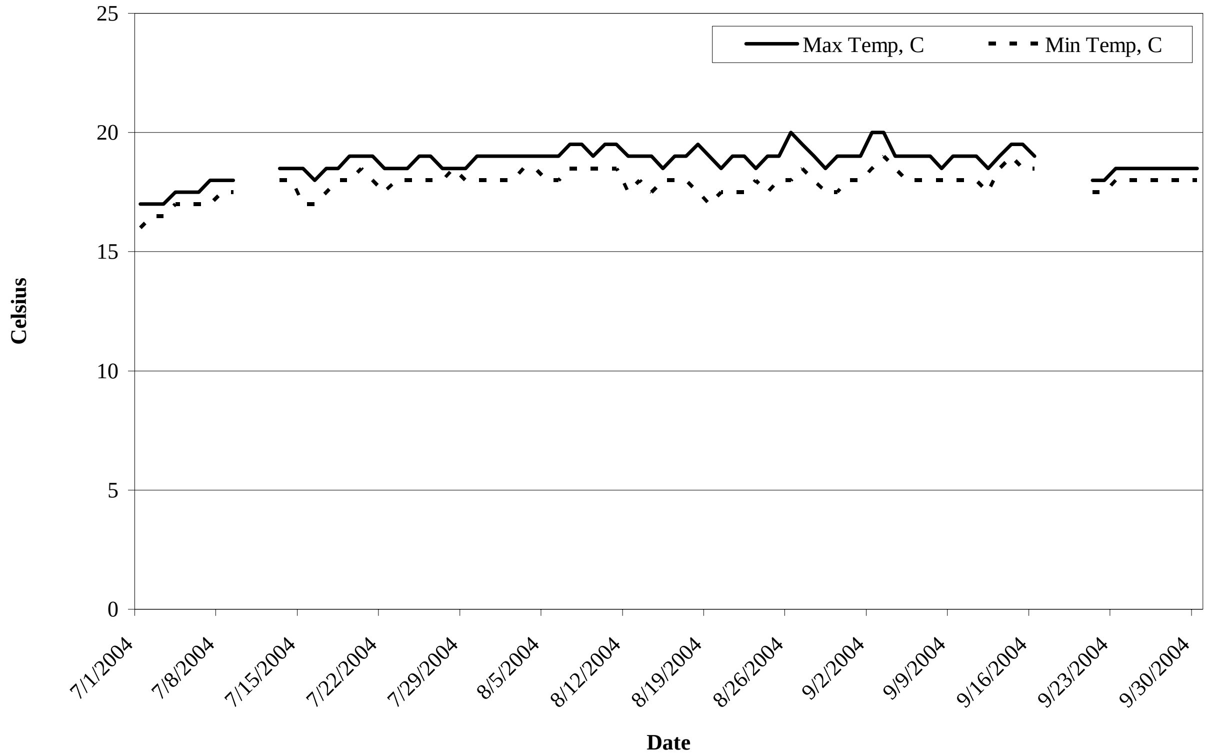

Figure 8. Maximum and minimum daily temperatures at the American River Fair Oaks station from July 1 – September 30, 2004. Source: USGS station 11446500.

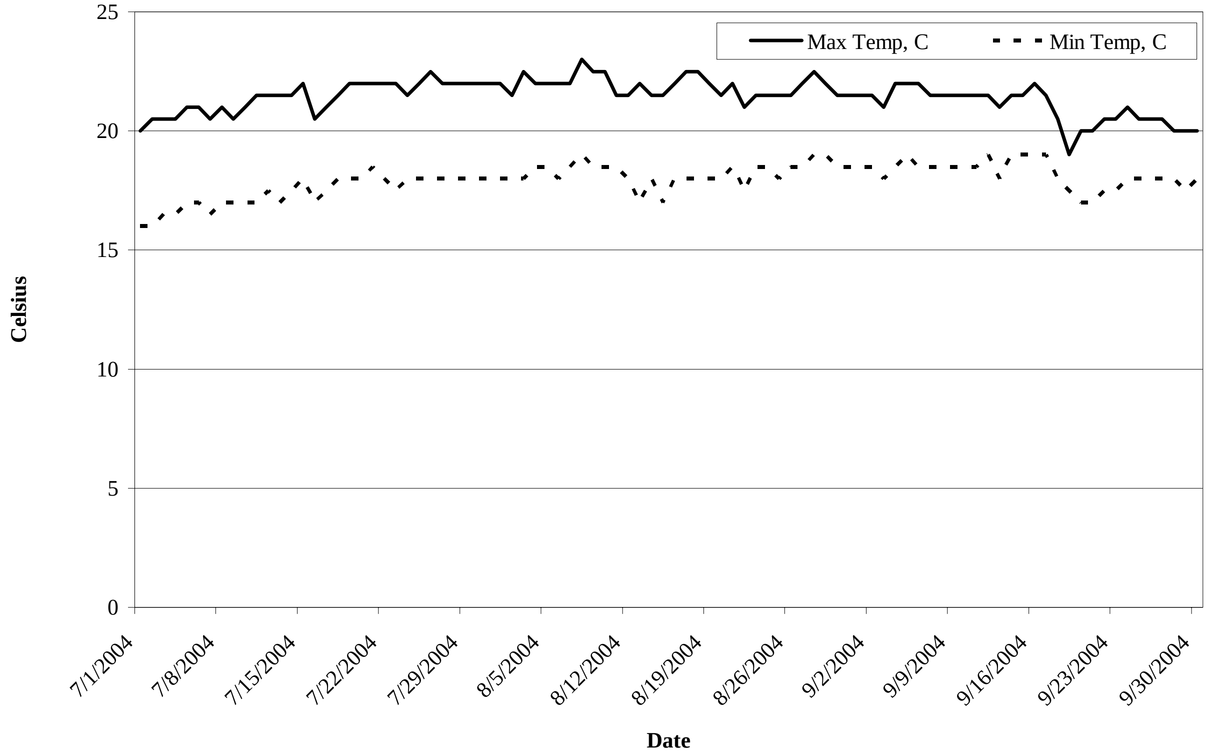

Figure 9. Maximum and minimum daily temperatures at the American River Watt Ave station from July 1 to September 30, 2004. Source: USGS station 11446980.

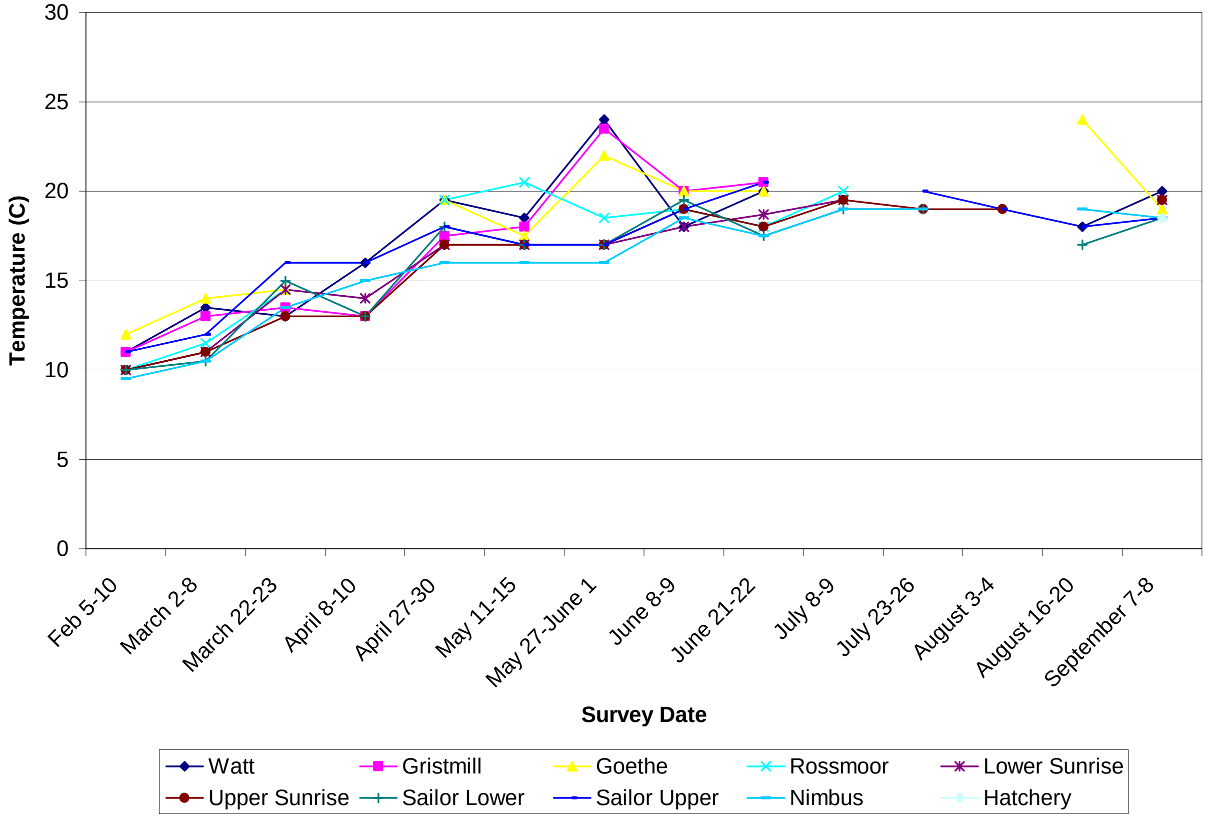

Figure 10. Maximum water temperatures measured at 10 sampling locations on Lower American River during the survey period February 1 – September 30, 2004.

Species and Life Stages

During the snorkel surveys divers observed Chinook salmon and steelhead trout as adults, yearlings, and young of the year.

Chinook Salmon

Chinook young were observed in all surveys from February 5 through June 22. They were also observed in minor numbers in all surveys from July 8 through September 8. Observed densities of juvenile salmon, averaged for all of the sample locations, peaked during the early April survey (1,329/100ft^2) (Figure 11). Most of the young salmon observed were fry (20-40 mm) or fingerlings (40-60 mm). Number of fry observed peaked in early April. However, the number of fingerlings observed peaked earlier in late March (Figure 12). After the initial sharp decline in observed densities in late April, densities continued to decline through June. Lower Sailor had the highest densities of Chinook salmon ranging from 0 to 21 per square foot during the entire survey period. Nimbus Basin had the lowest observed densities (0 to 1.83/ft^2) throughout the survey period.

Two nighttime surveys were conducted on April 8 at Gristmill and Upper Sunrise sampling locations for comparison to daytime surveys. Average density of Chinook juveniles was slightly higher in the nighttime surveys. Gristmill daytime average density was 0.40 Chinook per square foot and nighttime average density was 0.60. Upper Sunrise daytime average density was 1.43 Chinook per square foot and nighttime average density was 2.10.

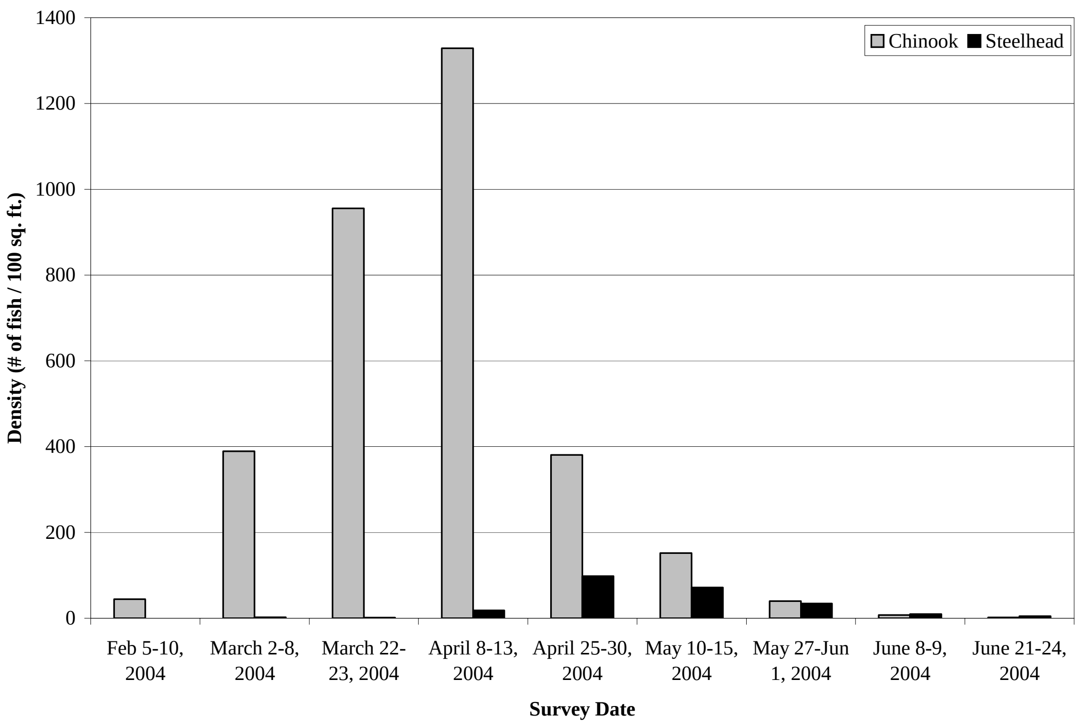

Figure 11. Density of juvenile Chinook salmon and steelhead in Lower American River (Total number of fish observed in all sampling locations/total area surveyed), Feb. 5 – June 22, 2004.

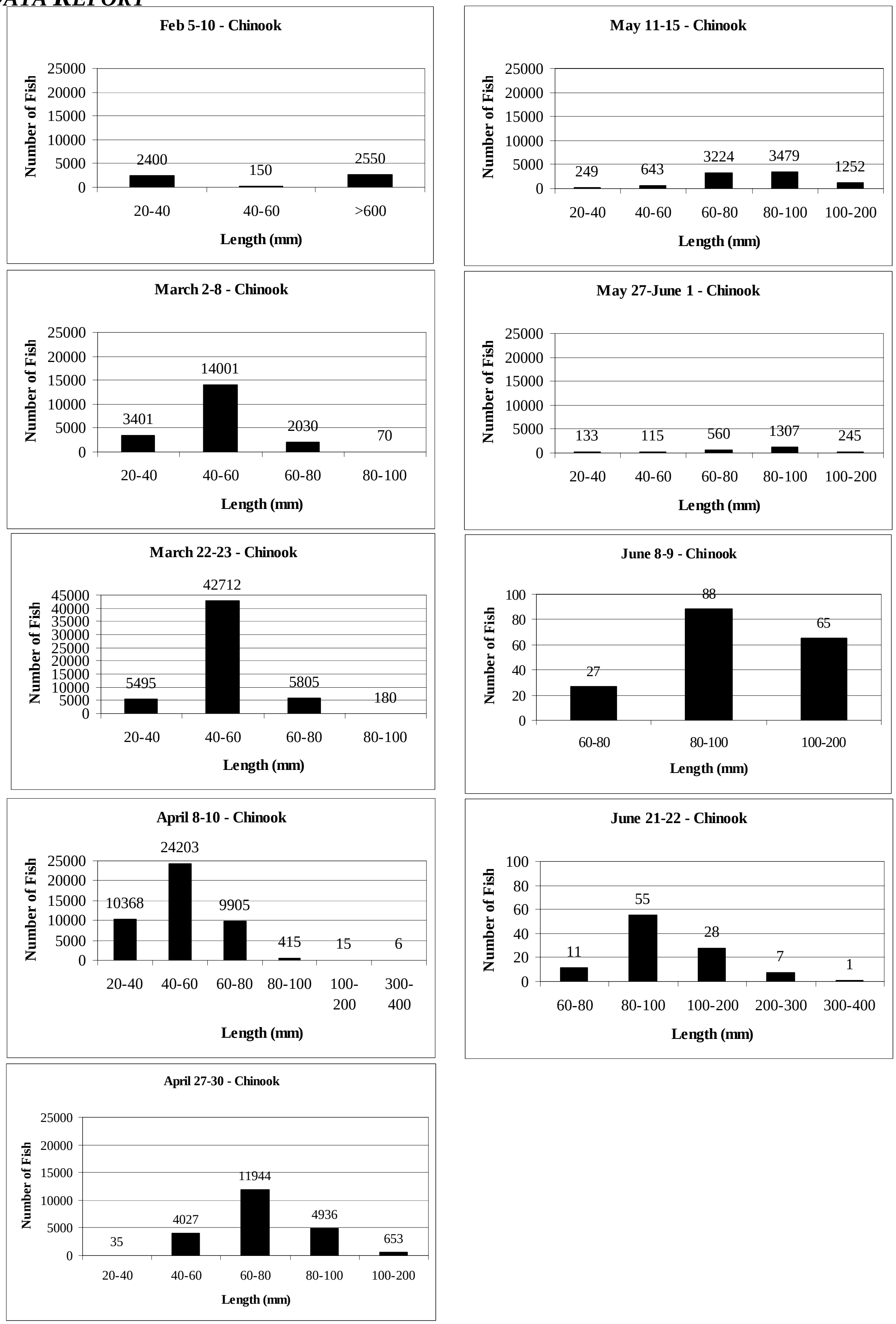

Figure 12. Length frequency of Chinook salmon in the Lower American River by survey period. The number of fish represents the total number of juvenile Chinook observed for all sample locations

Steelhead

Fry steelhead began to appear in early March at the Goethe and Rossmore sampling locations. By early April they were found at all sampling locations except Upper Sailor. Density of steelhead peaked in late April. In early May the density and numbers of steelhead fry observed began to decline although they were still observed at all sampling locations. Fry were still emerging through early June (Figure 13). Numbers of young steelhead increased from early May through early June. Observed densities of young steelhead peaked in the late April survey (98/100ft^2).(Figure 11). Densities were calculated by summing the total observations at each sampling location and dividing by the total area surveyed. By early June, overall steelhead density began a steady decline through the remainder of the survey period. Temperatures in the lower river reached sub-optimal levels (> 20ºC) for trout by early June.

The peak density of steelhead was at Upper Sunrise with 1.25 per square foot. Upper Sailor had the lowest densities of steelhead ranging from 0 to 0.03 per square foot. In early June steelhead remained most abundant at Upper Sunrise, Rossmore and Goethe. Smaller numbers were found further upstream at Lower Sunrise, Upper Sailor Lower Sailor and Nimbus. By late June densities continued to decline except at Nimbus.

Juvenile steelhead were commonly observed in polygons with shallow riffle habitat which is better at excluding predators that prefer pools such as striped bass.

Summer steelhead surveys documented a single steelhead greater than 600 mm in August at the Nimbus Hatchery (dive survey). Steelhead in the 200-300 mm and 400-600 mm size ranges were observed from late July through September at Watt, Goethe, Upper Sunrise, Upper Sailor , Lower Sailor, Nimbus and the Hatchery. Figure 14 shows the length distribution of steelhead from July to September.

The data sheets for abundance of Chinook salmon and steelhead juveniles are presented in Appendix A.

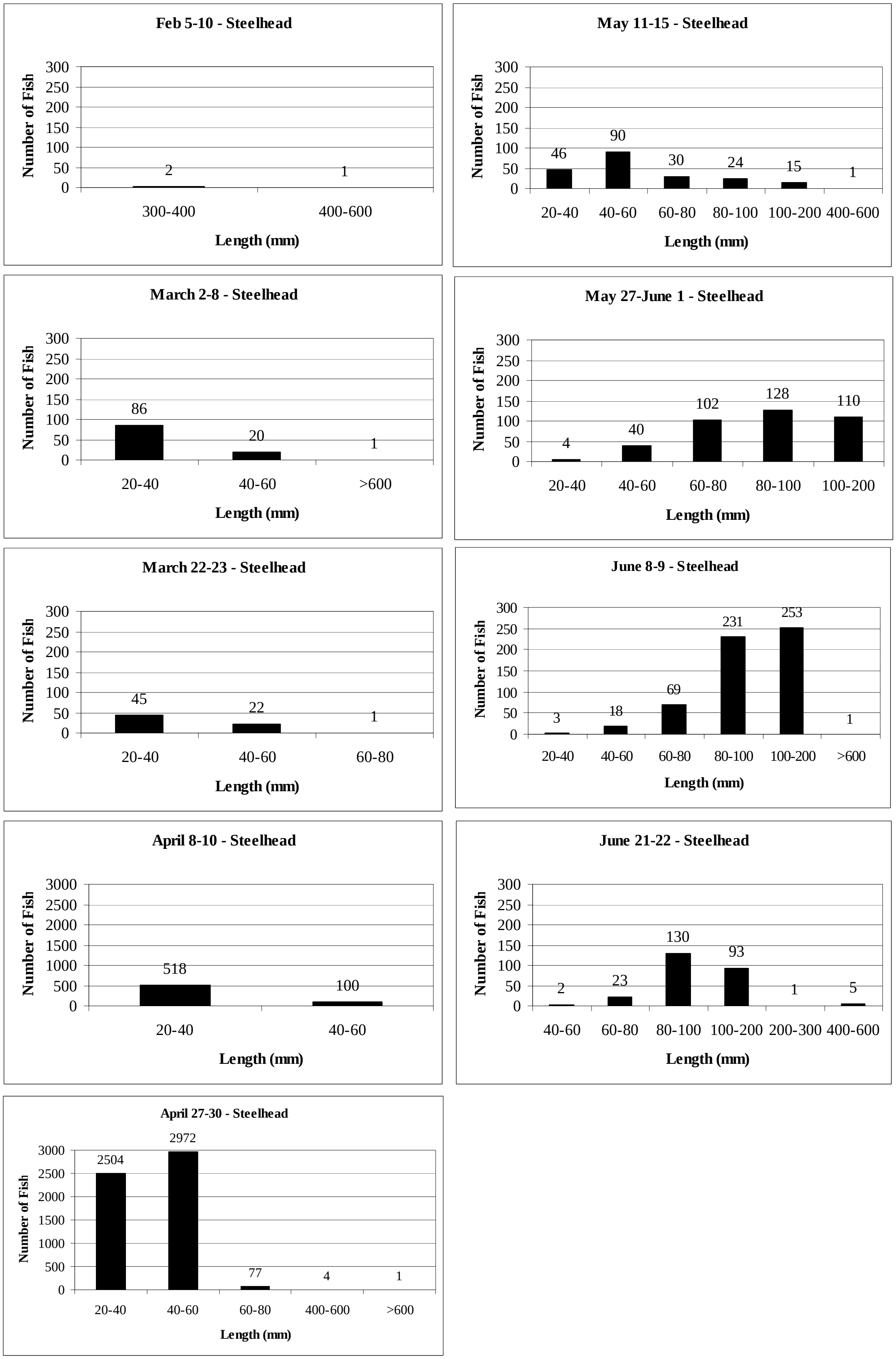

Figure 13. Length frequency of total steelhead observed by survey date in the Lower American River, February 5 – June 22, 2004. The number of fish represents the total number of steelhead observed for all sample locations.

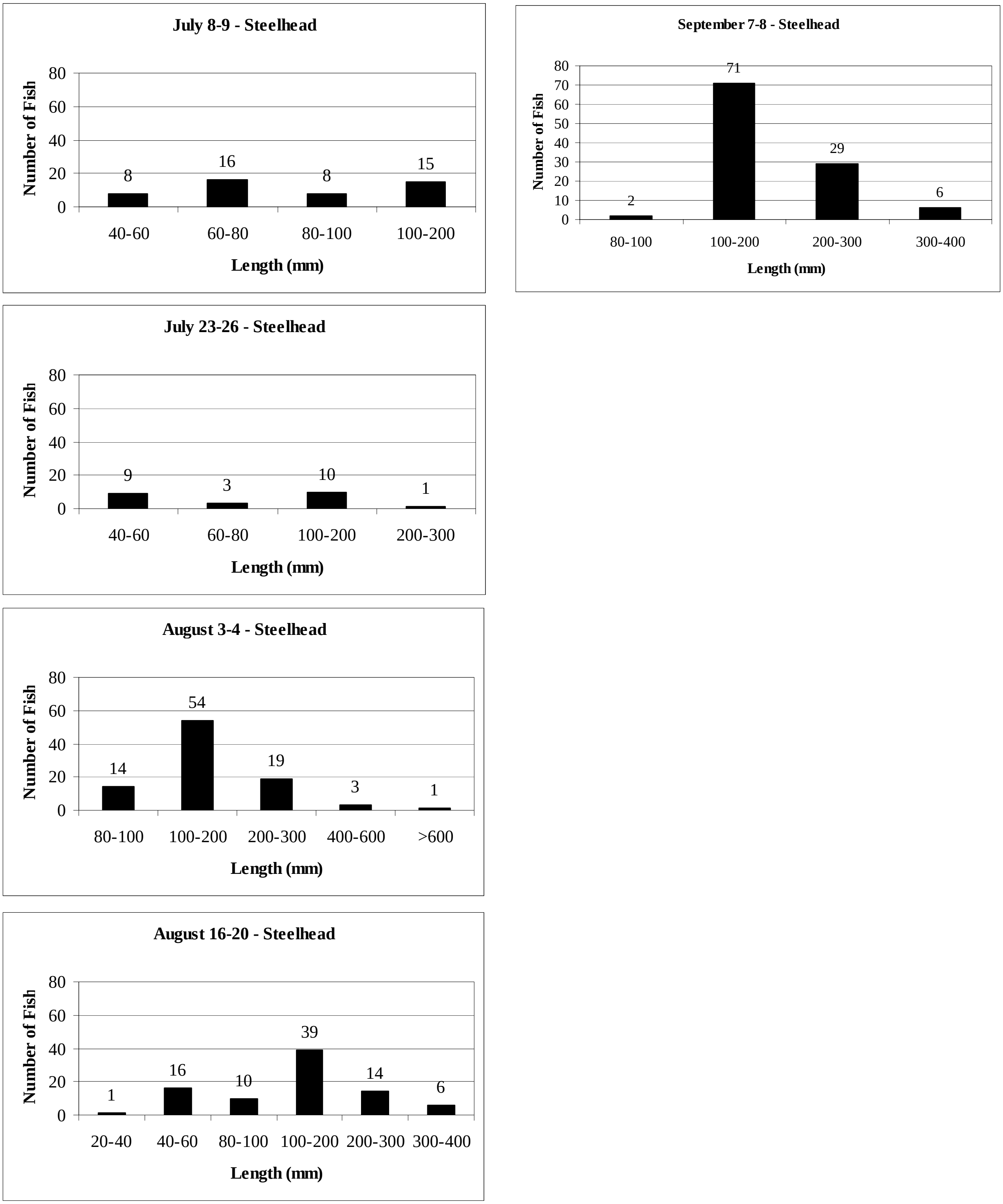

Figure 14. Length frequency of total steelhead observed by survey date in the Lower American River, July 8 – September 22, 2004. The number of fish represents the total number of steelhead observed for all sample

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Appendix A: Data Sheets for Salmonids, blacked out areas not surveyed.

	Feb 5-10, 2004			March 2-8, 2004			March 22-23, 2004		
	Survey 1			Survey 2			Survey 3		
Station	Square Feet	Chinook	Steelhead	Square Feet	Chinook	Steelhead	Square Feet	Chinook	Steelhead
Watt 1	1200	0	0	800	815	0	900	0	0
Watt 2	600	0	0	480	375	0	[redacted]	[redacted]	[redacted]
Watt 3	450	0	0	600	0	0	600	275	0
Watt 4	600	0	0	600	5	0	[redacted]	[redacted]	[redacted]
Watt 5	600	0	0	600	110	0	[redacted]	[redacted]	[redacted]
Watt 6	600	0	0	600	2120	0	[redacted]	[redacted]	[redacted]
Watt 7	600	0	0	[redacted]	[redacted]	[redacted]	600	0	0
Watt 8	500	127	0	[redacted]	[redacted]	[redacted]	600	555	0
Watt 9	1000	210	0	[redacted]	[redacted]	[redacted]	600	430	0
Watt 10	120	0	0	[redacted]	[redacted]	[redacted]	600	650	0
Watt 11	240	1	0	[redacted]	[redacted]	[redacted]	300	215	0
Watt 12	600	0	0	[redacted]	[redacted]	[redacted]	600	280	0
Watt 13	600	0	0	[redacted]	[redacted]	[redacted]	600	233	0
Watt 14	720	0	0	[redacted]	[redacted]	[redacted]	600	36	0
Watt 15	720	0	0	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Watt 16	720	0	0	[redacted]	[redacted]	[redacted]	900	0	0
Watt 17	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
TOTAL	9870	338	0	3680	3425	0	6900	2674	0
Gristmill 1	600	45	0	480	35	0	600	900	0
Gristmill 2	480	0	0	600	95	0	600	1000	0
Gristmill 3	1800	0	0	600	1200	0	600	3600	0
Gristmill 4	600	0	0	600	43	0	600	90	0
Gristmill 5	450	0	0	600	140	0	600	160	0
Gristmill 6	600	0	0	600	905	0	600	95	0
Gristmill 7	600	0	0	600	425	0	600	690	0
Gristmill 8	600	0	0	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Gristmill Trans A	[redacted]	[redacted]	[redacted]	800	0	0	800	0	0
TOTAL	5730	45	0	4200	2843	0	5000	6535	0
Goethe 1	600	5	0	480	366	0	600	360	0
Goethe 2	600	13	0	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Goethe 2a	900	0	0	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Goethe 3	600	251	0	[redacted]	[redacted]	[redacted]	600	840	0
Goethe 4	600	95	0	600	590	0	600	340	0
Goethe 4A	600	0	0	900	0	0	900	0	0
Goethe 5	1200	0	0	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Goethe 6	1200	10	0	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Goethe 7	450	150	0	600	620	0	600	180	0
Goethe 8	600	120	0	600	530	30	600	1375	0
Goethe 8A	600	0	0	600	350	70	[redacted]	[redacted]	[redacted]
Goethe 9	600	35	0	600	525		600	1985	0
TOTAL	8550	679	0	4380	2981	100	4500	5080	0
Rossmore 1	600	0	0	600	0	0	600	0	0
Rossmore 2	600	32	0	600	280	5	600	1250	0
Rossmore 3	450	10	0	600	55	1	600	1040	0
Rossmore 3A	600	660	0	[redacted]	[redacted]	[redacted]	600	1050	0
Rossmore 4	400	0	0	600	3	0	600	300	0
Rossmore 5	1800	0	0	1800	0	1	1200	0	0
Rossmore 6	450	0	0	450	12	0	600	1500	0
Rossmore 7	600	0	0	600	0	0	420	0	0
Rossmore 8	480	0	0	480	310	0	600	2300	0
Rossmore A	600	0	0	600	573	0	420	1900	0
TOTAL	6580	702	0	6330	1233	7	6240	9340	0
Lower Sunrise 1	600	0	0	600	300	0	600	1100	0
Lower Sunrise 2	600	1	0	600	0	0	600	460	0
Lower Sunrise 3	500	0	0	500	0	0	600	1700	0
Lower Sunrise 4	200	0	0	500	470	0	600	100	0
Lower Sunrise 5	600	0	0	600	0	0	600	700	0
Lower Sunrise 6	600	0	0	600	0	0	600	700	0
Lower Sunrise 7	600	5	0	600	0	0	600	550	0
Lower Sunrise 8	1600	0	0	1600	0	0	1600	0	0
Lower Sunrise 7A	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
TOTAL	5300	6	0	5600	770	0	5800	5310	0

	Feb 5-10, 2004				March 2-8, 2004			March 22-23, 2004		
	Survey 1			Survey 2			Survey 3		
Station	Square Feet	Chinook	Steelhead	Square Feet	Chinook	Steelhead	Square Feet	Chinook	Steelhead
Upper Sunrise 1	600	25	0	600	425	0	600	1700	0
Upper Sunrise 2	600	0	0	600	225	0	600	925	0
Upper Sunrise 3	600	0	0	600	630	0	600	325	0
Upper Sunrise 4	600	1	0	600	18	0	600	450	0
Upper Sunrise 4A				480	200	0	600	520	0
Upper Sunrise 5	600	6	1	600	320	0	600	900	0
Upper Sunrise 6	600	0	0	600	15	0	600	0	0
Upper Sunrise 7	600	0	0	600	0	0			
Upper Sunrise 8	600	5	1	600	235	0	600	1220	0
Upper Sunrise 9	600	55	0	600	660	0	600	3670	0
Upper Sunrise 10	600	150	0	480	206	0	480	1900	0
Upper Sunrise 11							600	0	0
Upper Sunrise 12	600	0	1				600	0	0
TOTAL	6000	242	3	6360	2934	0	7080	11610	0
Sailor lower 1	600	0	0	450	2500	0	450	1944	0
Sailor lower 2	600	7	0	450	400	0	450	1800	0
Sailor lower 3	600	1	0	600	100	0	600	160	0
Sailor lower 4	600	0	0	600	200	0	600	950	0
Sailor lower 5	600	0	0	900	0	0	900	0	0
Sailor lower 6	600	0	0						
Sailor lower 6A									
Sailor lower 7	600	0	0	420	1	0	420	0	0
Sailor lower 8	600	0	0	600	0	0	600	275	5
Sailor lower 9	600	0	0	600	0	0	600	180	0
Sailor lower 10	600	0	0	600	0	0	600	275	0
Sailor lower 11	600	0	0	600	25	0	600	600	0
Sailor lower 12	600	15	0	600	0	0	600	500	0
Sailor lower T1	600	0	0	900	0	0	900	0	0
Sailor lower T2									
TOTAL	7800	23	0	7320	3226	0	7320	6684	5
Sailor upper 1				600	0	0	600	270	0
Sailor upper 2				600	0	0	600	0	0
Sailor upper 3	480	7	0	480	570	0	480	2376	0
Sailor upper 4	600	0	0	600	0	0	600	700	40
Sailor upper 5	600	0	0	600	140	0	600	1050	0
Sailor upper 6				600	0	0	600	3	0
Sailor upper 6a				600	0	0	600	990	0
Sailor upper 7	300	0	0	300	60	0	600	100	0
Sailor upper 8	360	1	0	600	335	0	600	0	23
Sailor upper 9	1500	0	0	900	0	0	900	0	0
Sailor upper 9a	900	0	0	600	0	0	600	0	0
Sailor upper 10									
Sailor upper T A				900	0	0	900	0	0
X-Sect.	900	0	0						
TOTAL	4740	8	0	7380	1105	0	7080	5489	63
Nimbus 1	600	0	0	450	30	0	450	40	0
Nimbus 2	600	0	0	480	350	0	480	300	0
Nimbus 3	600	260	0	600	230	0	600	240	0
Nimbus 4	600	240	0	600	300	0	600	125	0
Nimbus 5	600	0	0	600	0	0	600	110	0
Nimbus 5a	600	0	0	300	0	0	300	95	0
Nimbus 5b				300	0	0	300	115	0
Nimbus 6				900	0	0	900	0	0
Nimbus 7							600	300	0
Nimbus 7a	600	0	0	600	40	0			
Nimbus 7b	600	0	0	600	35	0			
Nimbus 8				600	0	0	600	45	0
Nimbus 9	600	2	0	900	0	0	900	0	0
X Trans.									
TOTAL	5400	502	0	6930	985	0	6330	1370	0

	April 8-13, 2004			April 25-30, 2004			May 10-15, 2004		
	Survey 4			Survey 5			Survey 6		
Station	Square Feet	Chinook	Steelhead	Square Feet	Chinook	Steelhead	Square Feet	Chinook	Steelhead
Watt 1	800	0	0	800	3	0	900	0	0
Watt 2									
Watt 3				600	3	1	600	0	0
Watt 4									
Watt 5	600	250	0	600	41	0	480	50	41
Watt 6									
Watt 7	600	0	0	600	14	2	600	30	0
Watt 8	600	455	25	600	325	0	600	0	25
Watt 9	600	1365	25	600	425	0	600	30	0
Watt 10	600	1175	0	600	23	0	600	61	3
Watt 11	600	152	0	600	120	0	300	0	0
Watt 12	600	540	0	600	45	0	600	6	5
Watt 13	600	0	0	600	18	0	600	15	0
Watt 14	600	5	0	600	0	0	600	1	6
Watt 15									
Watt 16	600	0	0	600	0	1	600	3	0
Watt 17									
TOTAL	6800	3942	50	7400	1017	4	7080	196	80
Gristmill 1				480	26	5	600	50	20
Gristmill 2				600	45	0	600	0	0
Gristmill 3	600	560	0	600	0	0	600	0	0
Gristmill 4	600	40	25	600	40	161	600	0	25
Gristmill 5	600	115	0	600	7	12	600	3	
Gristmill 6				600	0	0	900	0	0
Gristmill 7				450	190	125			
Gristmill 8				600		31	600	27	24
Gristmill Trans A									
TOTAL	1800	715	25	4530	308	334	4500	80	69
Goethe 1	480	1440	0	480	40	0	600	29	3
Goethe 2									
Goethe 2a									
Goethe 3	600	935	7	600	240	8	600	30	20
Goethe 4	600	153	12	600	125	0	600	76	48
Goethe 4A	900	0	0	900	40	0	900	0	0
Goethe 5									
Goethe 6									
Goethe 7				600	145	30	600	241	25
Goethe 8	600	2160	0	600	812	0	600	525	14
Goethe 8A	600	55	65	600	80	0	600	0	0
Goethe 9	600	750	55	600	1428	0	600	490	0
TOTAL	4380	5493	139	4980	2910	38	5100	1391	110
Rossmore 1				600	0	0	600	0	0
Rossmore 2				600	1220	180	600	15	208
Rossmore 3				600	800	272	600	110	262
Rossmore 3A				450	540	250	480	80	215
Rossmore 4	800	120	30	800	0	40	600	7	25
Rossmore 5	900	0	0	900	320	0	1200	375	2
Rossmore 6	450	800	0	450	250	45	600	45	25
Rossmore 7	600	150	0	600	30	40	420		25
Rossmore 8	480	1300	0	480	210	32	600	19	0
Rossmore A	600	1080	35	600	0	70	600	50	8
TOTAL	5630	3450	65	6080	3370	929	6300	701	770
Lower Sunrise 1	600	640	30	600	45	0	600	0	171
Lower Sunrise 2	600	3	0	600	850	0	600	500	0
Lower Sunrise 3	600	245	40	600	25	85	600		2
Lower Sunrise 4	600	260	0	600	15	25	600	45	0
Lower Sunrise 5	600	1900	0	600	525	0	600	220	0
Lower Sunrise 6	600	430	1	600	0	55	600		20
Lower Sunrise 7	600	230	0	600	20	40	600	20	215
Lower Sunrise 8	1600	0	0	1600	0	0	1600	0	0
Lower Sunrise 7A	600	770	10						
TOTAL	6400	4478	81	5800	1480	205	5800	785	408

	April 8-13, 2004			April 25-30, 2004			May 10-15, 2004		
	Survey 4			Survey 5			Survey 6		
Station	Square Feet	Chinook	Steelhead	Square Feet	Chinook	Steelhead	Square Feet	Chinook	Steelhead
Upper Sunrise 1	600	2390	22	600	395	90	600	142	274
Upper Sunrise 2	600	550	125	600	240	325	600	307	216
Upper Sunrise 3	600	400	30	600	34	387	600	1	147
Upper Sunrise 4	600	40	5	600	0	360	600	46	180
Upper Sunrise 4A				480	275	10	640	111	120
Upper Sunrise 5	600	1900	0	600	405	40	800	15	17
Upper Sunrise 6	600	1010	0	600	100	120	600	32	69
Upper Sunrise 7	600	250	0	600	80	0	600	0	36
Upper Sunrise 8				600	270	200	600	810	560
Upper Sunrise 9				600	290	670	600	20	240
Upper Sunrise 10				600	1960	750	480	1100	58
Upper Sunrise 11	900	0	0	600	40	0	1200	400	0
Upper Sunrise 12	900	6	0	600	0	0	900	0	0
TOTAL	6000	6546	182	7680	4089	2952	8820	2984	1917
Sailor lower 1	450	9500	50	450	1500	300	450	370	0
Sailor lower 2	450	760	0	600		180	450	0	0
Sailor lower 3				600		150	600	50	0
Sailor lower 4	600	12	0	600		57	600	85	12
Sailor lower 5	900	0	0	600	70	2	900	0	0
Sailor lower 6	600	140	0						
Sailor lower 6A									
Sailor lower 7				600	108	0	420	0	0
Sailor lower 8	600	800	0	600	1	0	600	0	0
Sailor lower 9	600	240	2	600	80	1	600	0	0
Sailor lower 10	600	8	0	600	0	0	600	0	0
Sailor lower 11				600	465	50	600	500	365
Sailor lower 12				600	495	80	600	50	50
Sailor lower T1	900	0	0	900	0		600	0	0
Sailor lower T2									
TOTAL	5700	11460	52	7350	2719	820	7020	1055	427
Sailor upper 1	600	950	0	600	575	30	600	47	0
Sailor upper 2				600	180	0	600	1	0
Sailor upper 3				600	2500	120	480	780	0
Sailor upper 4	600	1075	0	600	350	0	600	0	0
Sailor upper 5	600	835	0	600	12	0	600	0	0
Sailor upper 6	600	640	0	600	270	50	600	0	0
Sailor upper 6a	600	550	0	600	210	0	600	140	0
Sailor upper 7	600	1000	0				600	60	0
Sailor upper 8	360	380	0				360	22	10
Sailor upper 9	1500	0	0	1500	0	0	900	0	0
Sailor upper 9a	600	0	0				600	0	0
Sailor upper 10	600	660	0						
Sailor upper T A				900	0	0	900	0	0
X-Sect.									
TOTAL	6660	6090	0	6600	4097	200	7440	1050	10
Nimbus 1	450	350	0	450	30	0	450	0	0
Nimbus 2	480	540	0	480	16	0	480	0	0
Nimbus 3	600	215	0	600	275	0	600	0	0
Nimbus 4	600	110	0	600	75	0	600	6	0
Nimbus 5	600	0	0	600	40	0	600	0	0
Nimbus 5a	450	800	0	450	550	0	300	549	75
Nimbus 5b	450	115	23	450	85	0	300	10	190
Nimbus 6	900	0	0	900	0	0	900	0	0
Nimbus 7	450	608	1	450	26	80	600	0	60
Nimbus 7a	240	0	0				600	0	0
Nimbus 7b	300	0	0						
Nimbus 8				600	508	0	600	40	61
Nimbus 9				900	0	0	900	0	1
X Trans.	600	0	0						
TOTAL	6120	2738	24	6480	1605	80	6930	605	387

	May 27-Jun 1, 2004			June 8-9, 2004			June 21-24, 2004		
	Survey 7			Survey 8			Survey 9		
Station	Square Feet	Chinook	Steelhead	Square Feet	Chinook	Steelhead	Square Feet	Chinook	Steelhead
Watt 1	900	0	0	900	0	0	900	0	0
Watt 2									
Watt 3	600	0	0	600	0	0	600	0	0
Watt 4									
Watt 5				480	0	3	480	0	0
Watt 6									
Watt 7	600	0	0	600	0	1	600	0	0
Watt 8	600	9	20	600	0	3	600	0	1
Watt 9	600	1	5	600	16	0	600	0	3
Watt 10	600	0	0	600	0	0	600	0	0
Watt 11	300	0	0	300	0	0	600	0	0
Watt 12	600	0	0	600	0	0	600	0	0
Watt 13	600	17	0	600	1	1	600	0	0
Watt 14				600	0	0	600	0	0
Watt 15									
Watt 16	900	0	0	900	0	0			
Watt 17				600	0	0			
TOTAL	6300	27	25	7980	17	8	6780	0	4
Gristmill 1	600	0	0	600	0	2			
Gristmill 2	600	27	29	600	0	0			
Gristmill 3	600	0	1	600	0	0	600	0	0
Gristmill 4	600	0	5	600	2	6	600	0	0
Gristmill 5	600	0	6	600	0	0	450	0	0
Gristmill 6	900	0	1	900	0	0	900	0	0
Gristmill 7	600	0	9	600	0	1	600	0	0
Gristmill 8	600	0	50	600	0	3	600	0	0
Gristmill Trans A				800	0	0			
TOTAL	5100	27	101	5900	2	12	3750	0	0
Goethe 1	600	47	27	600	20	31	600	0	11
Goethe 2									
Goethe 2a									
Goethe 3	600	2	8	600	0	1	600	0	1
Goethe 4	600	0	26	600	8	5	600	0	3
Goethe 4A	900	0	40	900	0	11	900	0	4
Goethe 5									
Goethe 6									
Goethe 7	600	10	25	600	0	21	600	0	22
Goethe 8	600	80	0	600	0	2	600	0	0
Goethe 8A							600	0	0
Goethe 9	600	30	0	600	24	0	600	0	0
TOTAL	4500	169	126	4500	52	71	5100	0	41
Rossmore 1	600	0	8	600	0	3	600	0	3
Rossmore 2	600	0	0	600	25	14	600	0	0
Rossmore 3	600	23	41	600	0	37	600	0	11
Rossmore 3A	480	6	54	480	0	40	600	0	11
Rossmore 4	600	0	5	600	0	5	600	0	1
Rossmore 5	1200	0	0	1200	20	0	600	0	0
Rossmore 6	600	85	0	600	24	5	450	0	3
Rossmore 7	420	110	195	420	1	14	600	0	13
Rossmore 8	600	60	0	600	0	3			
Rossmore A	420	0	20	420	2	0	600	0	3
TOTAL	6120	284	323	6120	72	121	5250	0	45
Lower Sunrise 1	600	2	15	600	0	0	600	0	0
Lower Sunrise 2	600	60	0	600	0	0	600	0	0
Lower Sunrise 3	600	16	0	600	0	1	500	0	0
Lower Sunrise 4	600	50	0	600	0	0	2000	0	0
Lower Sunrise 5	600	175	35	600	30	6	600	24	0
Lower Sunrise 6	600	17	1	600	6	6	600	0	0
Lower Sunrise 7	600	35	0	600	0	0	600	0	0
Lower Sunrise 8	1600	0	0	1600	0	0	1600	0	0
Lower Sunrise 7A									
TOTAL	5800	355	51	5800	36	13	7100	24	0

	May 27-Jun 1, 2004			June 8-9, 2004			June 21-24, 2004		
	Survey 7			Survey 8			Survey 9		
Station	Square Feet	Chinook	Steelhead	Square Feet	Chinook	Steelhead	Square Feet	Chinook	Steelhead
Upper Sunrise 1	600	155	70	600	0	0	600	0	0
Upper Sunrise 2	600	113	165	600	7	55	600	0	7
Upper Sunrise 3	600	0	153	600	5	19	600	0	1
Upper Sunrise 4	600	0	50	600	0	1	600	0	0
Upper Sunrise 4A	600	54	106	640	0	0	640	0	2
Upper Sunrise 5	600	60	40	800	0	2	600	0	0
Upper Sunrise 6	600	5	27	600	25	5	600	0	0
Upper Sunrise 7	600	16	1						
Upper Sunrise 8	600	15	123	600	0	82	600	21	3
Upper Sunrise 9	600	30	158	600	10	36	600	0	0
Upper Sunrise 10	600	5	179	480	21	42	480	10	0
Upper Sunrise 11	1200	0	0	1200	2	0	600	0	0
Upper Sunrise 12	900	10	0	900	0	9	600	0	1
TOTAL	8700	463	1072	8220	70	251	7120	31	14
Sailor lower 1	600	0	0	450	0	0	450	0	0
Sailor lower 2	450	50	0	450	0	0	450	0	0
Sailor lower 3	600	30	0	600	0	0	600	0	0
Sailor lower 4	600	0	0	600	0	0	600	0	0
Sailor lower 5	900	60	0	900	10	1	900	0	0
Sailor lower 6									
Sailor lower 6A									
Sailor lower 7	600	50	0	420	14	21	420	0	0
Sailor lower 8	600	0	0	600	0	0	600	0	0
Sailor lower 9	600	0	0	600	0	0	600	0	0
Sailor lower 10	600	0	0	600	0	0	600	0	0
Sailor lower 11	600	24	46	600	0	1	600	0	4
Sailor lower 12	600	95	36	600	23	5	600	0	0
Sailor lower T1	900	0	0	600	0	0	900	0	0
Sailor lower T2									
TOTAL	7650	309	82	7020	47	28	7320	0	4
Sailor upper 1	600	0	0	600	0	1	600	0	0
Sailor upper 2	600	0	0	600	2	0	600	0	0
Sailor upper 3	480	200	23	480	55	52	480	1	13
Sailor upper 4	600	225	20	600	0	0	600	0	0
Sailor upper 5	600	0	6	600	0	0			
Sailor upper 6	600	10	0	600	0	0	600	0	1
Sailor upper 6a	600	0	0	600	0	0	600	0	0
Sailor upper 7	600	80	0	600	0	0	600	0	0
Sailor upper 8	360	36	70	360	20	2	360	0	0
Sailor upper 9	1500	0	0	900	0	0	900	0	0
Sailor upper 9a	600	0	0	600	47	0	900	0	1
Sailor upper 10									
Sailor upper T A	900	0	0	900	0	0	900	0	0
X-Sect.									
TOTAL	8040	551	119	7440	124	55	7140	1	15
Nimbus 1	450	0	0	450	0	0	450	0	0
Nimbus 2	480	1	1	480	0	0	480	0	1
Nimbus 3	600	0	2	600	0	0	600	0	0
Nimbus 4	600	0	0	600	0	0	600	0	0
Nimbus 5	600	0	23	600	0	0	600	10	0
Nimbus 5a	300	7	0	300	0	0	300	0	10
Nimbus 5b	300	0	0	300	0	2			
Nimbus 6	900	0	0	900	0	0			
Nimbus 7	600	0	0				600	30	85
Nimbus 7a	600	147	92	600	0	13	600	6	35
Nimbus 7b									
Nimbus 8	600	20	0						
Nimbus 9	900	0	0						
X Trans.									
TOTAL	6930	175	118	4830	0	15	4230	46	131

Appendix B: Aerial Photos of Sampling Locations and Polygons

Watt

Plate A4-1. Polygons at Watt site.

Gristmill

Plate A5-1. Polygons at Gristmill site.

Goethe

Plate A6-1. Polygons at Goethe site. Note side channel at right was watered and fully connected all of the 2003 sampling season.

Rossmore

Plate A7-1. Polygons at Rossmore site. Note salmon redds (lighter blotches) adjacent to and downstream of gravel pad placements at boat launch site.

Lower Sunrise

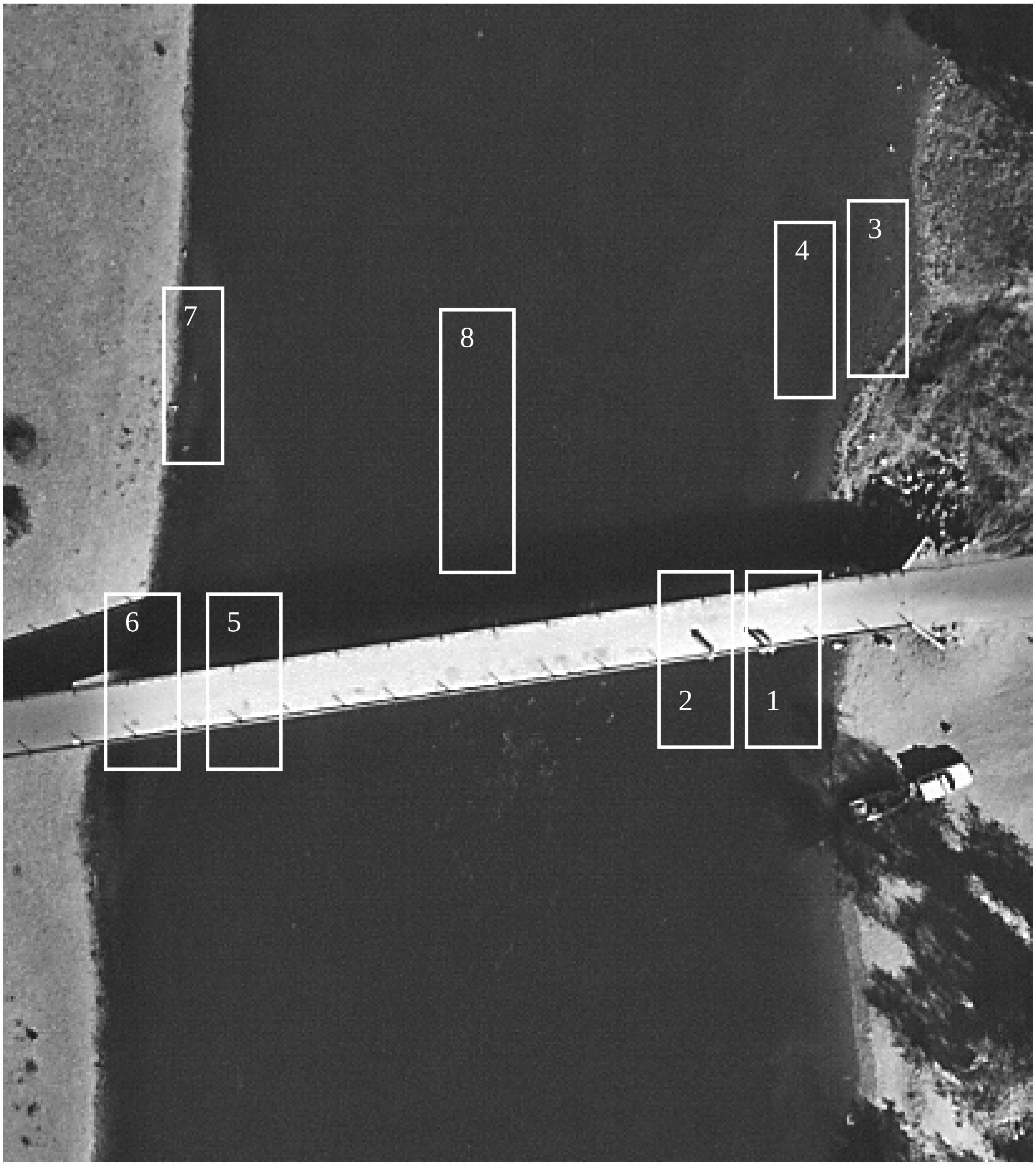

Plate A8-1. Polygons at Lower Sunrise Site.

Upper Sunrise

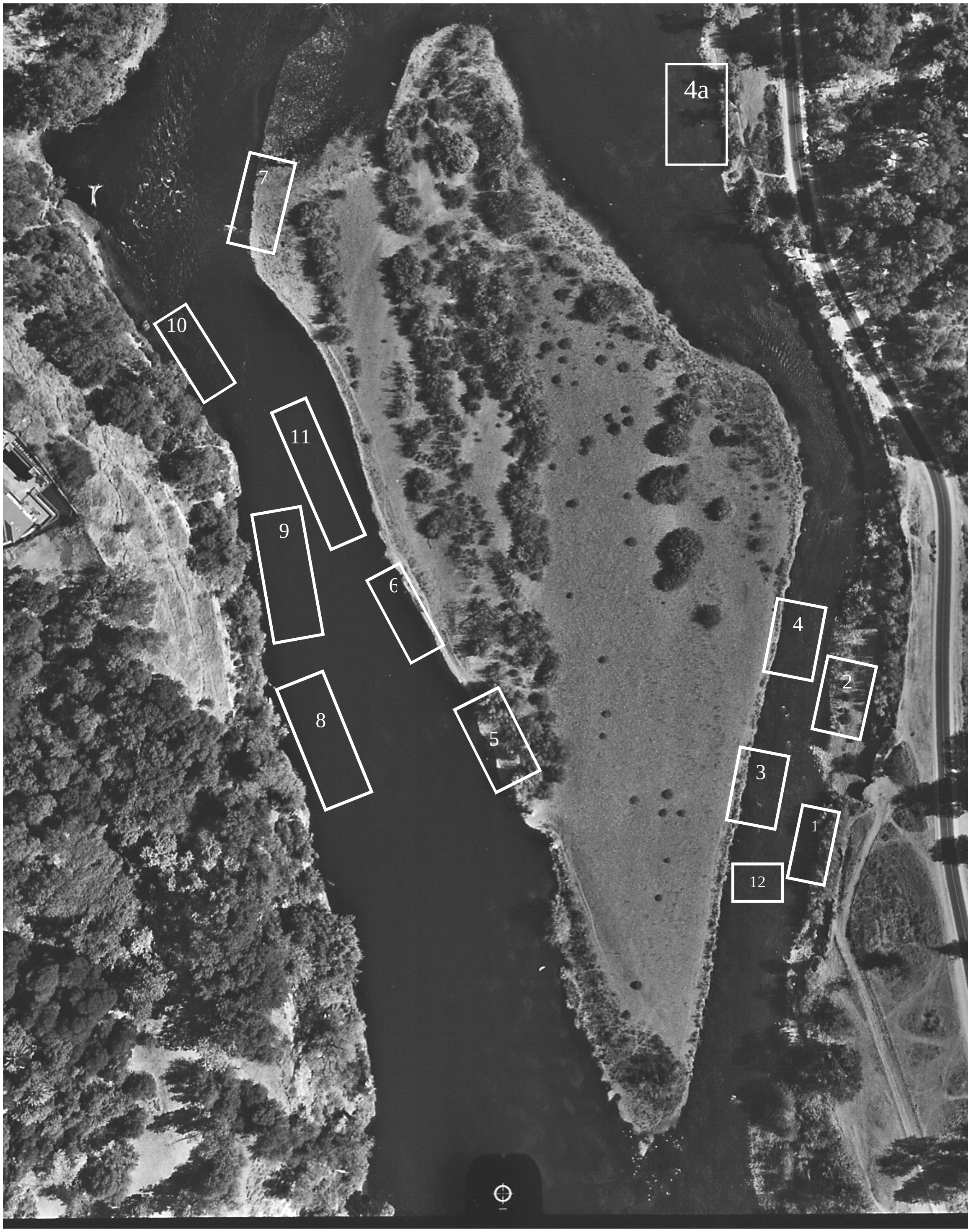

Plate A9-1. Polygons at Upper Sunrise Site.

Lower Sailor Bar

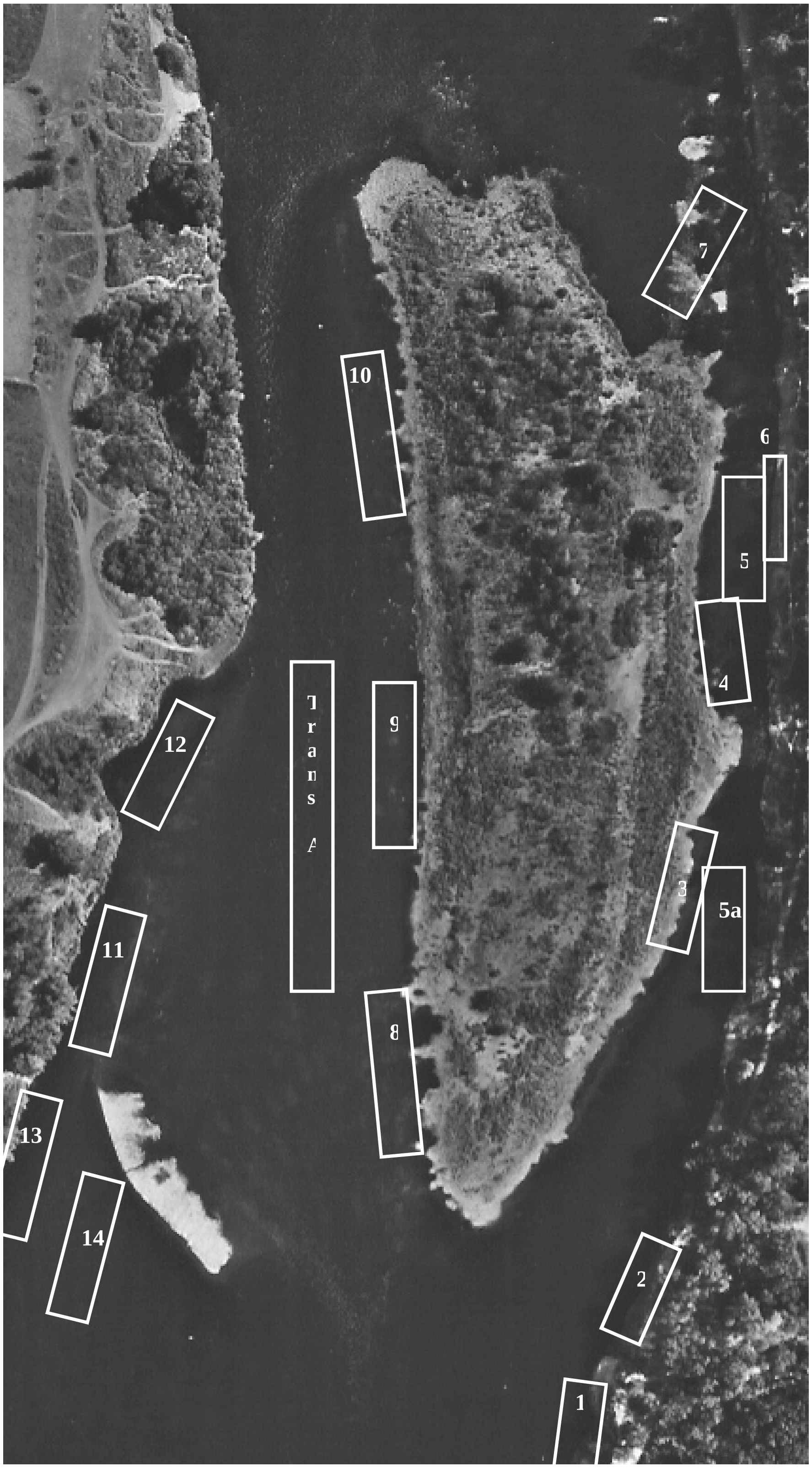

Plate A10-1. Polygons at lower Sailor Bar Site.

Upper Sailor Bar

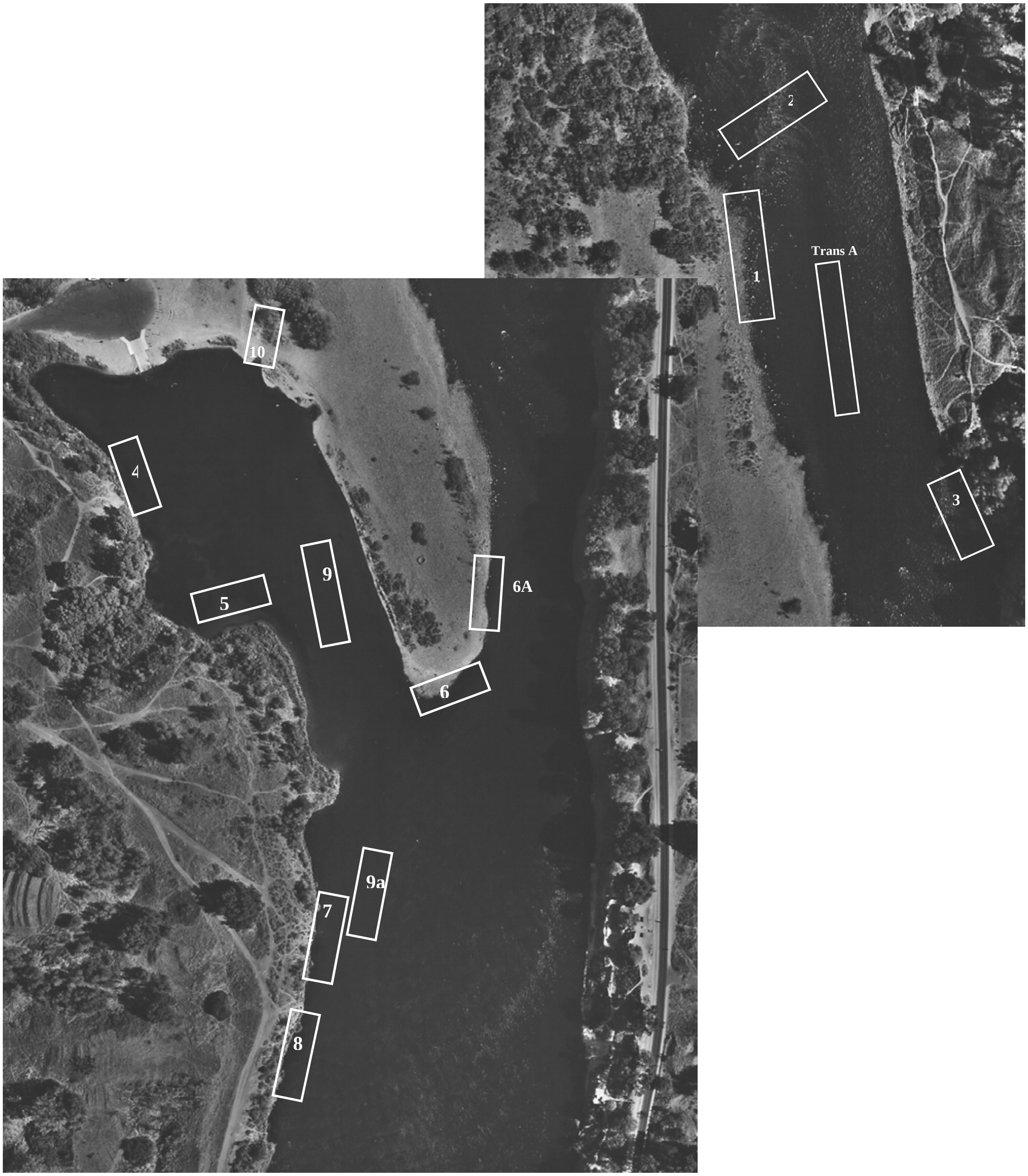

Plate A11-1. Upper Sailor Bar polygons.

Nimbus Basin

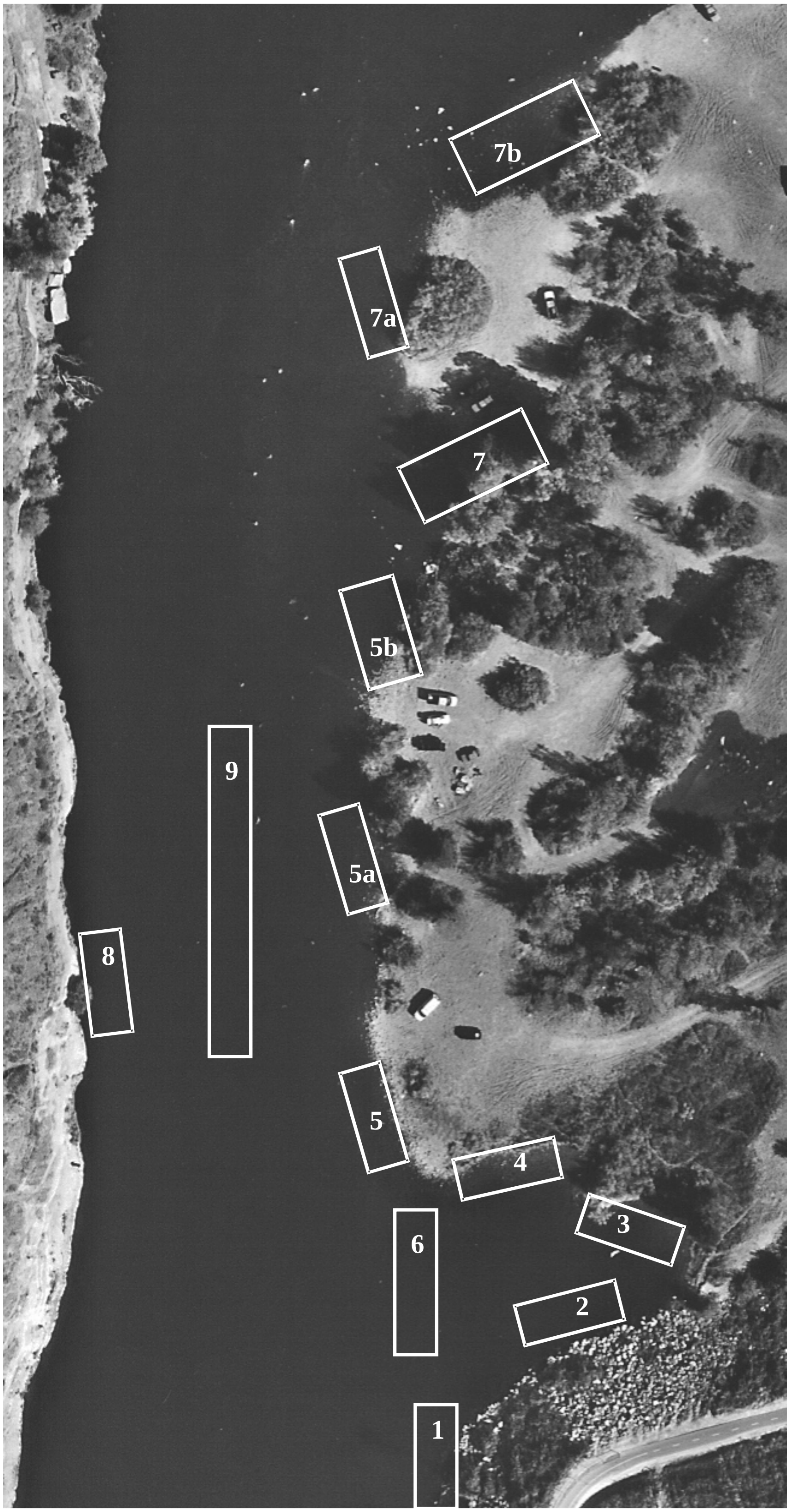

Plate A12-1. Polygons in Nimbus Basin.