Snorkel Survey of the Lower American River 2006
Data Report-Draft

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Introduction

The Fishery Foundation of California conducted a snorkel survey of the Lower American River (LAR) from June through August 2006 under a grant from the U.S. Fish and Wildlife Service. The purpose of the survey was to monitor fish populations and assess the biological results and effectiveness of actions taken under the Central Valley Project Improvement Act (Section 3406(b)(16)). In particular, juvenile Chinook (*Onchorhynchus tshawytscha*) populations and summer-time steelhead (*Onchorhynchus mykiss*) populations were monitored within the LAR as part of a comprehensive assessment program to monitor fish and wildlife resources of the Central Valley. The surveys objectives include: (1) determine how juvenile Chinook salmon and steelhead use the LAR and (2) determine how juvenile salmonids use various river habitats.

Jackson (1992) conducted snorkel surveys of the LAR from 1989 to 1991. His objective was to determine microhabitat preferences of juvenile salmon using 15 different macrohabitat units. He concluded that microhabitat use of each macrohabitat unit was unique because of the different morphology and habitat availability of each unit. 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, there appears to be a general consensus that flows and water temperature are the limiting factors for salmon and steelhead smolt production in the LAR (Snider and Titus 2000, Water Forum 2001, Jones and Stokes 2002).

These recent findings also suggest that lower flows provide insufficient habitat for rearing young Chinook salmon and steelhead trout 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 2006 snorkel survey is yet another step toward addressing these questions.

Since 2003, the Fishery Foundation of California has surveyed sites that are composed of two-dimensional units or polygons representing habitats found throughout the LAR. If salmonid use can be related to habitat conditions in the units and habitat conditions can be related to flow, then flow 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.

The 2006 snorkel survey, in combination with the 2003, 2004, and 2005 snorkel surveys, offers the potential of obtaining population estimates of juvenile salmonids of the LAR.

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 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 the 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. The steelhead population of the LAR has declined from a combination of factors including dam construction (Nimbus and Folsom Dams), low flows, high water temperatures during summer rearing, predation by fish, over-harvesting by anglers, complication involving hatchery production (e.g. competition, genetics, disease), water diversions, and poor spawning and degraded rearing habitat conditions (Williams 2000, Water Forum 2001).

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.

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 approximately 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, Nimbus Hatchery is also responsible for the release of over 400,000 steelhead smolts in the San Francisco Bay.

Lower American River Study Area

Location

The 2006 snorkel survey was conducted at 7 locations in the LAR between Watt Avenue and Nimbus Dam at river mile 23 (Figure 1). Sailor Bar and Sunrise were each divided into two independent locations bringing the total sample locations to nine. These locations were designated to represent habitat conditions in the LAR.

Figure 1. Year 2006 survey sites on the Lower American River.

The LAR sample locations were chosen based on geomorphology and hydraulic criteria per Snider et al. (1992). Subreaches for the upper river (Snider et al.'s Reach 3) were selected by bar complex simply because the parkway facilities are commonly referred to in this format.

Methods

Survey Design

Snorkel surveys were conducted from June through August 2006. Surveys were historically conducted from February through August, however, this year's survey did not begin until June due to high water flows and turbid water conditions caused by rain. Surveys were conducted at nine sampling locations located approximately every two miles over the lower 23 miles of the LAR. Surveys were conducted on a bi-monthly basis over the period of one to two days per survey.

Sample 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. They were chosen systematically to represent the longitudinal distribution of fish in the river through the survey period. More sample 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 sample locations was influenced to some degree by accessibility, especially in the lower river where access was limited.

At each of the sample locations the available habitat area was visually surveyed and representative habitat units designated as sampling units or polygons. The units 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. 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 channel 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). Accordingly, 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 understood. 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 sites, but polygons could be categorized into one general type or another (e.g., shoreline, side-channel, riffle, and with or without cover).

The number of units chosen varied directly with the diversity of habitat at the sample location. For example, sample locations with islands and side channels were allocated more sampling units. Despite some sample locations having multiple units, most units within a sampling location had some unique habitat feature or condition 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 sample location, sampling polygons were designated from as many mesohabitat types as possible. Given the high variability in habitat available among within each sampling location, the final survey array had 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 location or polygons in a random or systematic fashion.

Not all polygons were sampled in each survey for various reasons. In some cases it was not possible to sample all polygons under high flows because of the danger of swimming across the river. Some polygons could no longer be sampled in low flow periods as they were lacked adequate depth or were no longer present. Generally, for each sampling period, surveys were conducted at most of the designated sampling polygons at each

sampling location. Sampling locations were accessed by vehicle and polygons were reached by foot and by swimming.

Sampling Technique

Snorkeling was conducted similar to other snorkel surveys (Edmundson et al 1968; Hankin and Reeves 1988, Jackson 1992). Generally, one diver sampled a polygon. However, a second snorkeler followed the data collector at times for observation and training purposes. The diver proceeded upstream, against the current for near shore polygons and against the current in eddies. Thus allowing the diver to take more accurate counts by approaching fish from behind and avoid causing sediment disturbance and the high speed involved in floating downstream. Near shore polygons were also sampled sequentially from downstream to upstream units for the same reasons aforementioned. In faster water the diver often had to pull along the shoreline using rocks and brush to hold or gain position. Center stream polygons were sampled as the diver floated downstream with the current. Flowing with the current in deeper water appeared to bring about less avoidance than 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 through a polygon. When proceeding upstream, the diver would typically observe fish six feet from shore (water velocity permitting) or directly from the shore to allow upstream and offshore viewing. Generally, divers were able to count fish under normal behavioral conditions before the diver passed by fish or fish escaped downstream or upstream. Care was taken to observe and count fish only once. Most fish that tried to escape the presence of the diver did so by swimming downstream of the diver or by moving offshore into deeper water. Some fish would escape by swimming upstream of the diver. In this case the diver would take mental note and subtract those individuals from the total number of fish counted further upstream.

Data Collection

Divers recorded observations on dive slates attached to their forearms. Number of fish, species, and sizes (Table 1) were recorded as the diver proceeded through a polygon. Habitat conditions of the polygon including depth, velocity, substrate and cover were also recorded on the slates. Depth was recorded in number of feet from water surface to river bottom within the polygon. Velocity was recorded as major and minor type. Cover was recorded as three categories: type of cover, size of cover, and quantity and quality of cover. Quantity and quality of cover was defined as the degree of dependence of the fish on the cover in combination with the extent of overhead cover. Overhead cover consisted of cover within 18 inches above the water surface. All sampling locations were surveyed at least once per month.

Fish were identified to species according to keys in Moyle (2002). Larvae and early juvenile suckers and minnows (principally pikeminnow) were occasionally counted but not always due to their extreme abundance and widespread distribution. These fish were

included in the survey data when they reached approximately 20-40mm in early summer and could be identified to species.

Table 1. Length Codes for Sizes of Fish for 2006 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

Flow data was obtained from the California Data Exchange Center (http://cdec.water.ca.gov/riv_flows.html). Temperature was recorded with thermometers at each sampling location by exposing the thermometer tip to water in polygons. Additional temperature data was obtained from the United States Geological Survey (http://waterdata.usgs.gov/nwis/dv?cb).

Data Processing

Data was transferred from dive slates to standard field data sheets. Date, location, transparency (visibility in feet), and time were also recorded on data sheets. All data was later transferred from data sheets to Microsoft Excel spreadsheets. All tables and charts were created in Microsoft Excel.

Results

River Flows

The flows in the LAR are controlled by the Bureau of Reclamation for water storage, flood control and recreation. River flows were high in early February reaching a maximum of 16,000cfs but declined sharply in mid-month to a minimum of 3,970cfs. By March flows began to increase reaching a peak flow during the survey period of 35,300cfs in April. Flows dropped sharply in late April and again in late May. A slight increase in flows occurred in early June but the following trend was a general decrease in the rivers flow throughout the rest of the month. The flow rate stabilized between approximately between 3,940cfs and 3,330cfs by the end of the survey period (Figure 2).

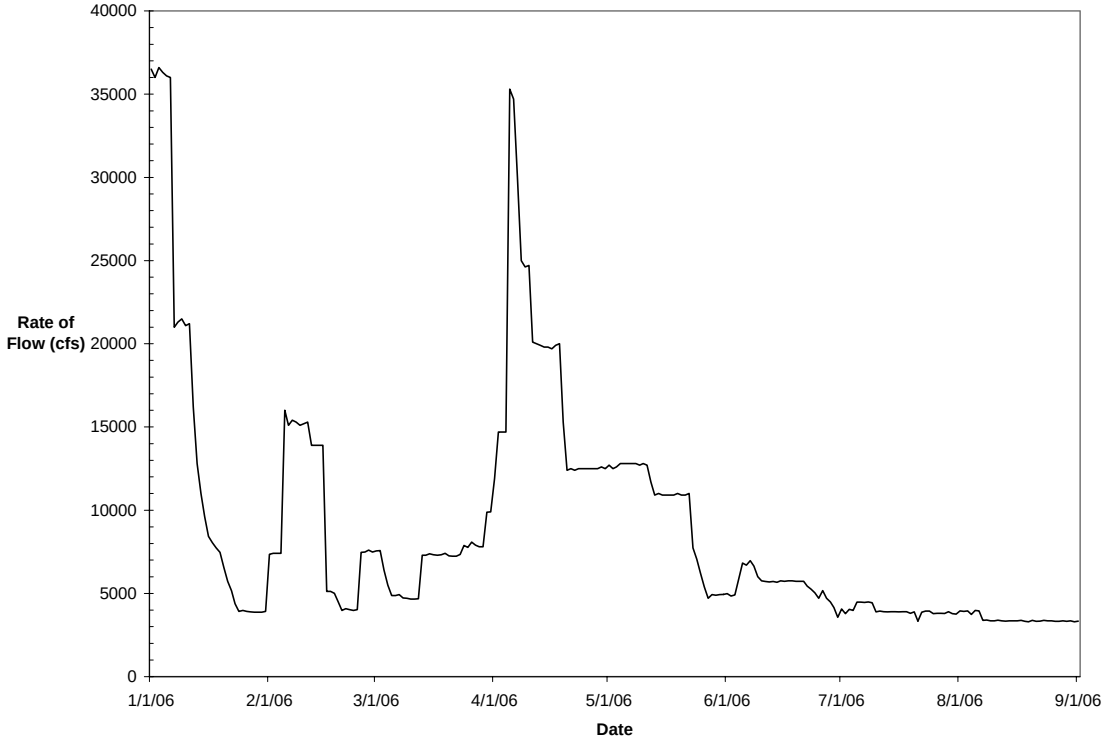

Figure 2. Lower American River Streamflow for 2006 (CDEC, Fair Oaks Gauge).

Water Temperatures

Water temperature varied within sampling locations and even within polygons. However, the variations between sampling locations and polygons generally did not exceed more than 1°C of difference. The overall water temperature of the LAR increased over the season (Figure 3) and was warmer at more downstream sampling locations. Some temperatures in the margins of shallow riffles and in backwaters were warmer by approximately 0.5-1 degree though limited heating of the main body of water occurred near these polygons.

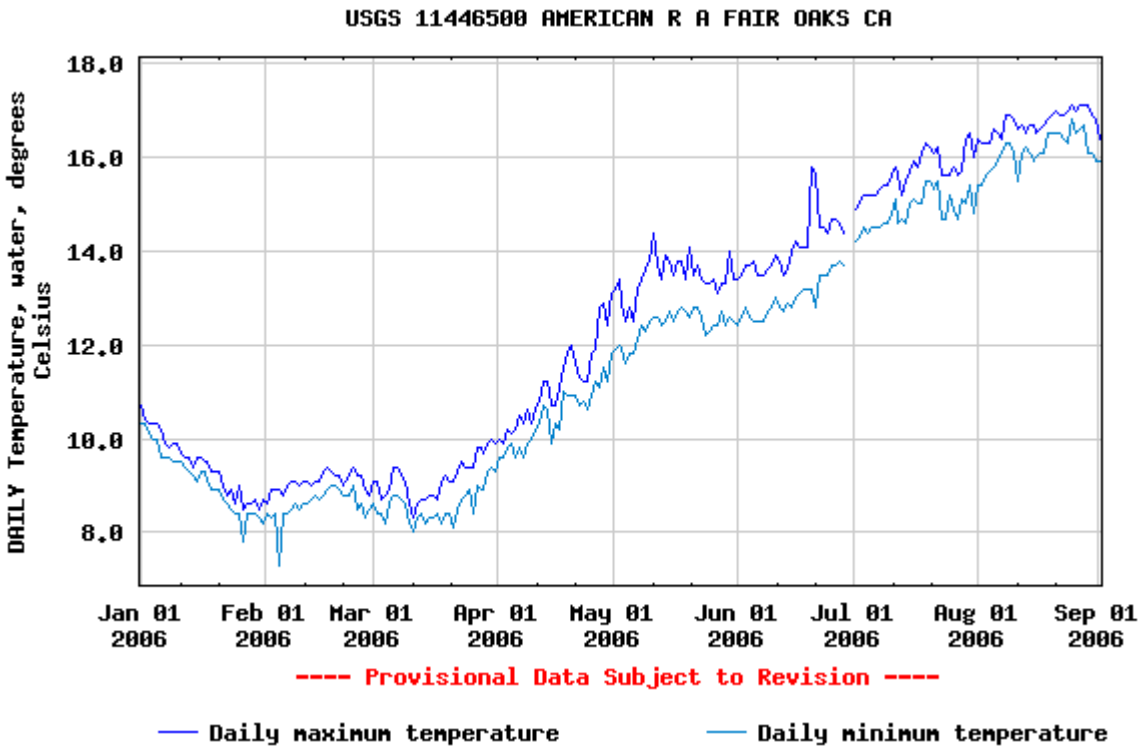

Figure 3. Lower American River Temperatures for 2006 (CDEC).

Species and Life Stages

Divers observed Chinook salmon and steelhead trout as adults, yearlings, and young. A total of 5,208 individuals were observed throughout the entire survey period.

Chinook

Juvenile Chinook were observed in June and July. Juvenile Chinook <40mm were not observed during the 2006 survey because sampling in that year started later than sampling in previous years (Figure 4). By early August, no Chinook were observed in any of the sampling location (Figure 5). The total number of Chinook increased from early to mid June then steadily dropped to zero through mid July (Figure 5). There was a general growth trend in the sizes of the fish throughout the survey. Size 40-200mm fish were observed throughout the month of June and into early July. By the end of July fish size 60-200mm were observed (Figure 6).

Chinook in the 0-100mm size ranges were generally 20mm larger than steelhead.

A total of 3,194 Chinook were observed during the survey (Figure 5). Chinook were observed at all sampling location except for Gristmill. Most of the individuals were observed in the upper and middle sampling locations of the Lower American River. An overall peak count of 1,551 individuals occurred at Lower Sunrise (Figure 7). The polygons in which chinook were observed within these sampling locations consisted

mainly of both instream and overhead cover of small to medium sized vegetation with 25-75% cover.

Densities of Chinook ranged from 0.02 to 24.72 fish per square foot. Fish densities were greatest in June, peaking mid-month, and dropped through the remainder of the survey period.

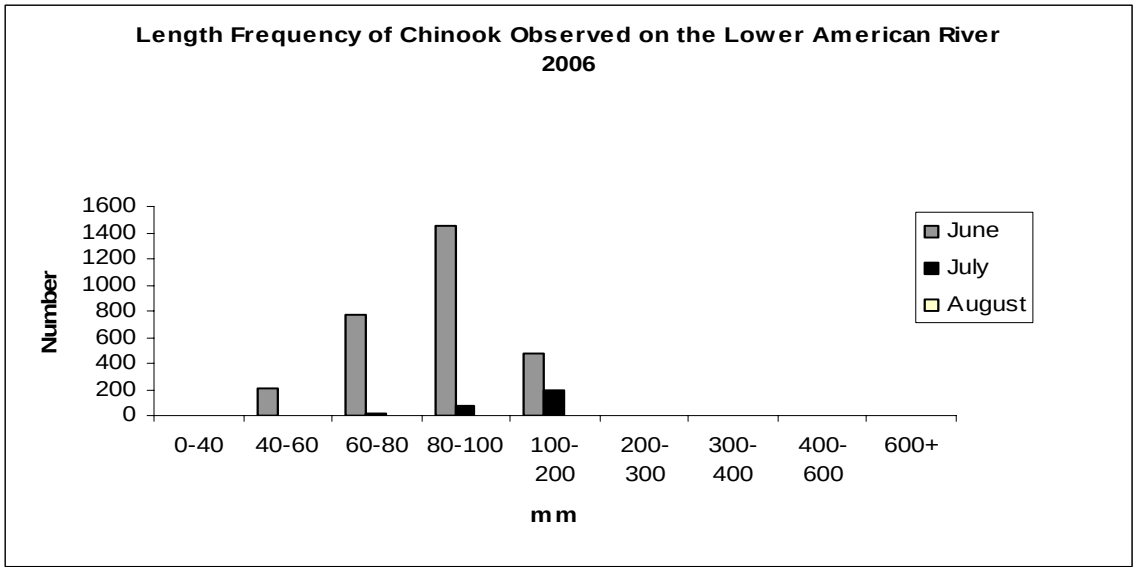

Figure 4. Length frequency of (*Onchorhynchus tshawytscha)* Observed by month on Lower American River 2006. Monthly numbers represent an aggregate count for all sampling locations.

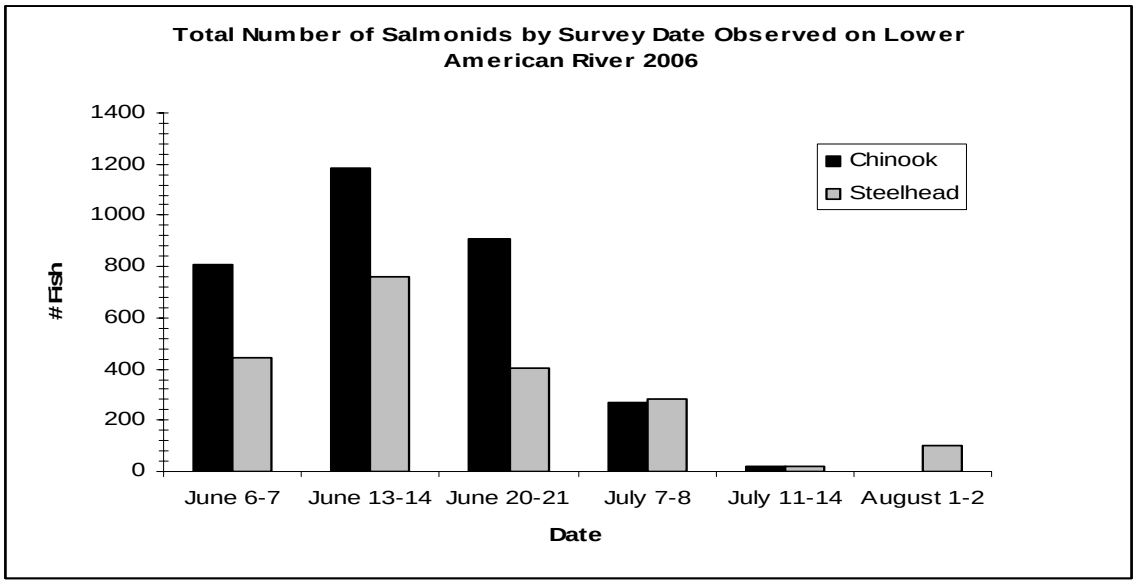

Figure 5. Total Number of Salmonids Observed in the 9 sampling locations along the Lower American River 2006.

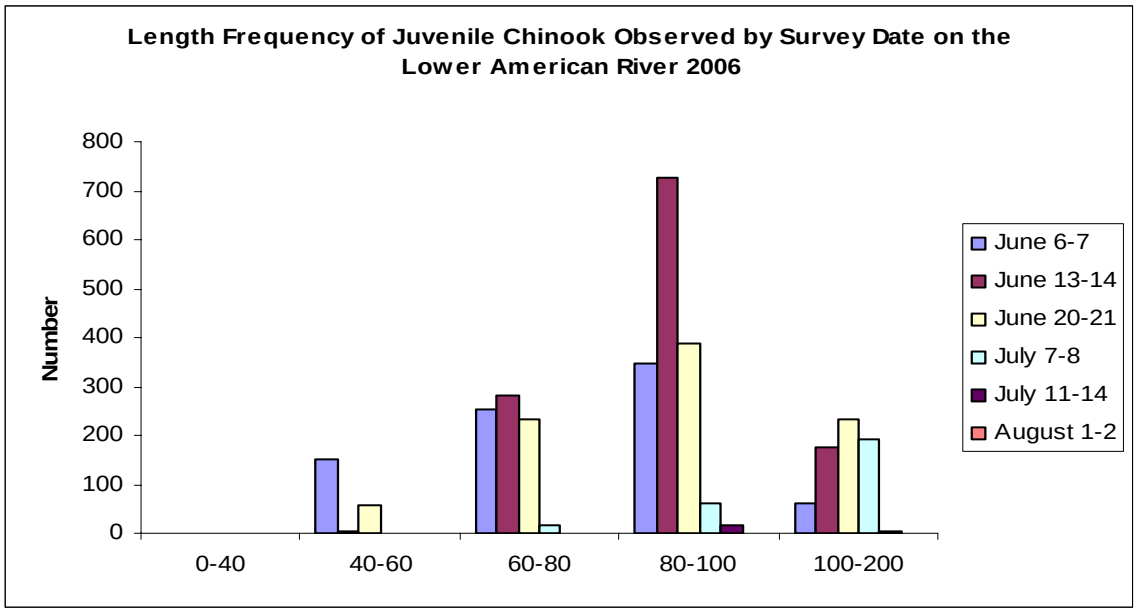

Figure 6. Length Frequency of juvenile Chinook observed by survey date on Lower American River 2006.

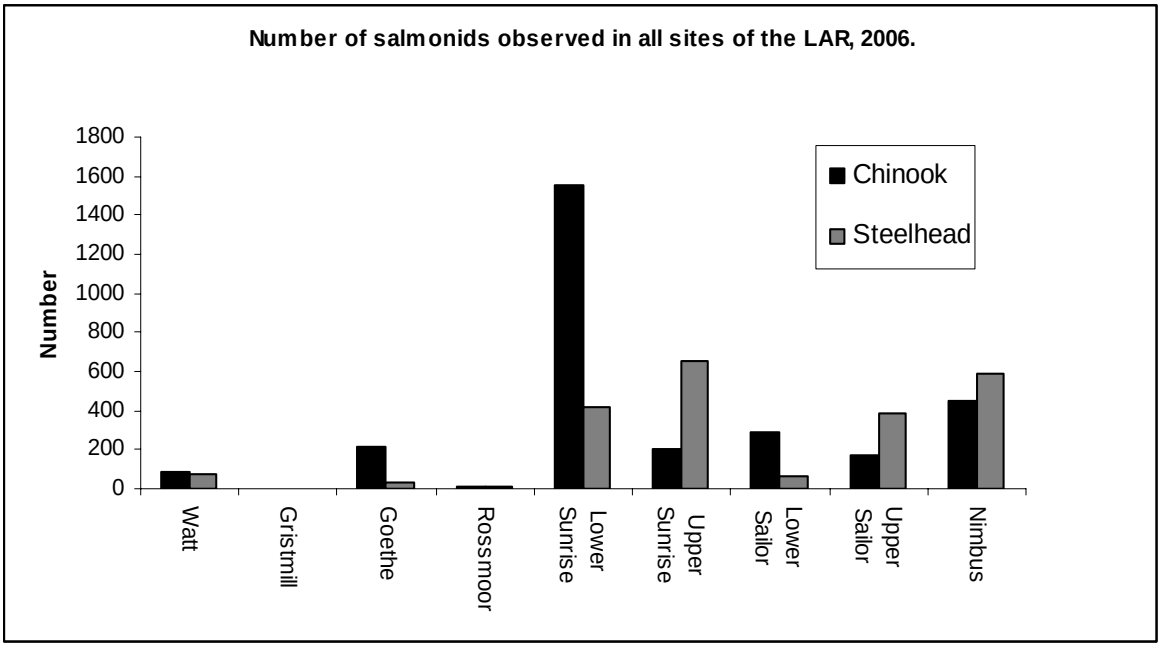

Figure 7. Total Number of Salmonids Observed per Sampling location on Lower American River 2006.

Steelhead

Steelhead were observed in June, July, and August (Figure 5). Fry were observed throughout June and July but only young steelhead 60-100mm were observed in August. The total number of fish dropped over the survey period but there was a general trend of an increase in sizes of fish. Smaller fish tended to be more prevalent throughout early

and mid July in comparison to Chinook. A few large trout (300-600+mm) were observed (Figure 8).

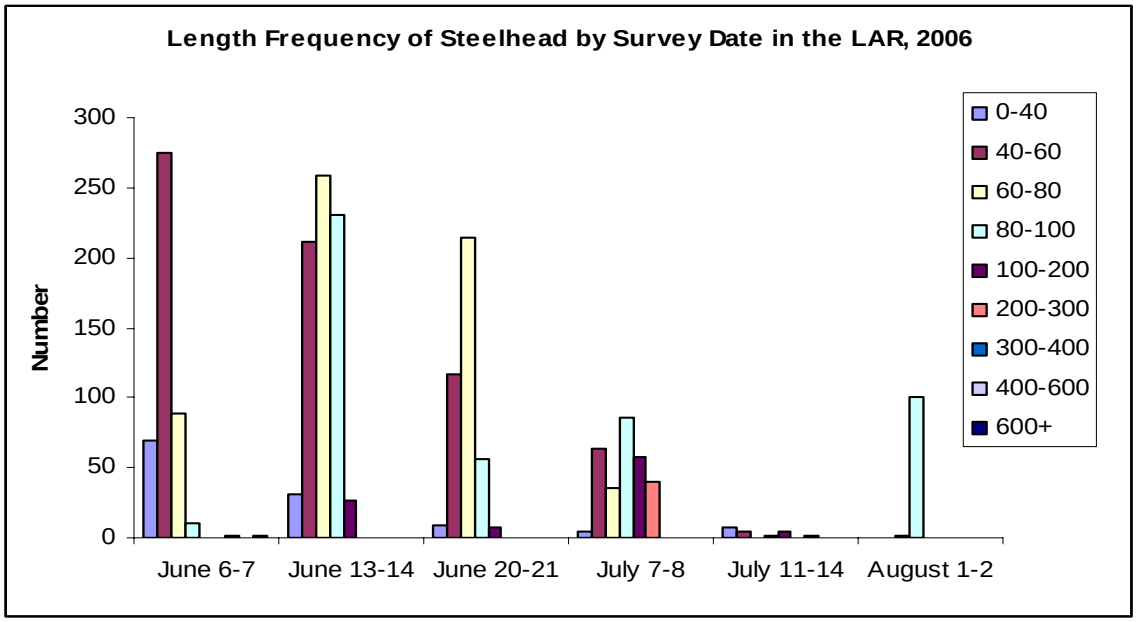

Figure 8. Length Frequency of juvenile Steelhead observed by survey date on Lower American River 2006.

The total number of steelhead observed during the survey was 2,014 individuals (Figure 5). Steelhead were observed at all sampling location except for Gristmill. Most of the steelhead observed occurred in the upper sampling locations of the Lower American River including Nimbus, Upper Sailor, Upper Sunrise and Lower Sunrise (Figure 7). Steelhead were observed in a range of polygon cover types within these sampling locations. Some fish were observed in polygons with no cover but most cover types included both instream and overhead cover, small to medium sized vegetation with 0-75% cover.

Steelhead densities ranged from 0.60 to 15.85 fish per square foot. Though steelhead densities were lower than chinook their numbers followed the same trend. Densities were greatest in June, peaking mid-month, and dropped through the remainder of the survey period.

Acknowledgements

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Appendix A: Data Tables for 2006 Survey.

(Shaded cells represent un sampled polygons)

	Area Sampled	June 6-7, 2006		Area Sampled	June 13-14, 2006		Area Sampled	June 20-21, 2006	
Sampling Location	Area sq.ft	Chinook	Steelhead	Area sq.ft	Chinook	Steelhead	Area sq.ft	Chinook	Steelhead
Watt 1	600	8	2	600	1	0	600	0	0
Watt 2	600			600			600	1	0
Watt 2A	450			450			450	0	0
Watt 3	600			600			600	0	0
Watt 4	900			900			900		
Watt 5	600			600			600		
Watt 6	600			600			600		
Watt 7	600	0	0	600	55	65	600	0	2
Watt 8	600	10	0	600	0	0	600	0	0
Watt 9	600	3	0	600	0	0	600	0	0
Watt 10	600	0	0	600	0	0	600	2	0
Watt 10A	600	0	2	600	0	0	600	0	0
Watt 11	600			600	0	0	600		
Watt 12	900	0	0	900	8	0	900		
Sum	4500	21	4	5100	64	65	5250	3	2
Gristmill 1	600			600			600		
Gristmill 2	600			600			600		
Gristmill 3	600			600	0	0	600		
Gristmill 4	600			600	0	0	600		
Gristmill 5	600			600	0	0	600		
Gristmill 6	600			600	0	0	600		
Gristmill 7	450			450	0	0	450		
Gristmill 8	600			600	0	0	600		
Gristmill Trans A	800			800			800		
Sum	0	0	0	3450	0	0	0	0	0

Goethe 1	600	0	0	600	25	20	600	15	0
Goethe 2	600	0	0	600	125	0	600	35	0
Goethe 2A	600	0	0	600	0	0	600	0	0
Goethe 3	600	0	0	600	0	0	600	1	1
Goethe 4	600	0	0	600	0	0	600	0	0
Goethe 5	600	0	1	600	0	1	600	1	0
Goethe 5A	900	0	0	900	0	0	900	0	0
Goethe 6	480	0	0	480	0	0	480	0	0
Sum	4980	0	1	4980	150	21	4980	52	1
Rossmore 1	600			600			600		
Rossmore 2	600			600			600		
Rossmore 3	600			600			600		
Rossmore 3A	450			450			450		
Rossmore 4	800			800	0	0	800		
Rossmore 5	900			900			900		
Rossmore 6	450			450	0	0	450		
Rossmore 7	480			480	15	0	480		
Rossmore 8	480			480	0	0	480		
Rossmore A	600			600	0	0	600		
Sum	0	0	0	2810	15	0	0	0	0
Lower Sunrise 1	600	50	0	600	0	11	600	0	38
Lower Sunrise 2	600	240	0	600	400	1	600	280	0
Lower Sunrise 3	600	20	60	600	0	45	600	0	65
Lower Sunrise 4	600	20	0	600	0	0	600	0	0
Lower Sunrise 5	600	0	0	600	0	1	600	0	0
Lower Sunrise 6	600	0	0	600	375	20	600	0	0
Lower Sunrise 7	600	0	1	600	0	0	600	0	1
Lower Sunrise 8	1600	0	0	1600	1	0	1600	5	0

Sum	5800	330	61	5800	776	78	5800	285	104
Upper Sunrise 1	600	120	15	600	0	225	600	0	78
Upper Sunrise 2	600	0	51	600	0	31	600		
Upper Sunrise 3	600	0	0	600	0	1	600	0	0
Upper Sunrise 4	600	0	7	600	0	0	600	0	1
Upper Sunrise 4A	640	0	0	640			640	0	122
Upper Sunrise 5	600	0	2	600	0	3	600	12	0
Upper Sunrise 6	600	50	45	600	0	20	600	15	0
Upper Sunrise 7	600	0	0	600	0	0	600	0	0
Upper Sunrise 8	600			600			600	0	0
Upper Sunrise 9	600			600			600	0	0
Upper Sunrise 10	480			480			480	2	0
Upper Sunrise 11	900	0	0	900	0	0	900	0	0
Upper Sunrise 12	900	0	3	900			900	0	0
Sum	6640	170	123	5100	0	280	7720	29	201
Sailor lower 1	450	40	0	450	80	0	450	80	0
Sailor lower 2	450	0	1	450	0	0	450	2	0
Sailor lower 3	600	0	15	600	0	0	600	0	0
Sailor lower 4	600	0	0	600	0	0	600	0	0
Sailor lower 5	900	0	0	900	0	0	900	0	1
Sailor lower 6	600	0	0	600	0	0	600	0	0
Sailor lower 7	450	0	0	450	0	0	450	0	0
Sailor lower 8	600	0	10	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			600	0	0	600		
Sailor lower 12	600			600			600		
Sailor lower Tr A	900	0	0	900			900	0	0
Sum	6750	40	26	6450	80	0	6750	82	1

Sailor upper 1	600	0	0	600	0	0	600	0	1
Sailor upper 2	600	0	0	600	0	0	600	0	0
Sailor upper 3	600			600	0	0	600	140	21
Sailor upper 4	600	15	105	600	0	0	600	1	0
Sailor upper 4AA	600	0	0	600	0	0	600		
Sailor upper 5	600	0	0	600	0	0	600	0	0
Sailor upper 6	600	0	35	600	0	30	600	0	0
Sailor upper 6A	600	0	60	600	0	13	600	0	0
Sailor upper 7	600	0	0	600	0	0	600	0	0
Sailor upper 8	600	0	0	600	0	0	600	0	0
Sailor upper 9	900	0	0	900	0	0	900	0	0
Sailor upper 9A	600	0	0	600	0	0	600	0	0
Sailor upper 10	600	0	0	600			600	0	0
Sailor upper T A	900	0	0	900			900	0	0
Sum	8400	15	200	7500	0	43	8400	141	22
Nimbus 1	600	0	0	600	0	0	600	0	2
Nimbus 2	600	0	0	600	0	0	600	0	0
Nimbus 3	600	0	10	600	0	5	600	0	50
Nimbus 4	600	5	7	600	40	15	600	160	0
Nimbus 5	600	0	0	600	0	0	600	75	0
Nimbus 5a	450	0	11	450	0	120	450	0	6
Nimbus 5b	450	190	1	450	0	100	450	0	1
Nimbus 6	900	0	0	900	0	0	900	0	0
Nimbus 7	450	0	0	450	0	24	450	0	14
Nimbus 7a	600	40	0	600	60	9	600	79	0
Nimbus 8	600			600			600		
Nimbus 9	900	0	1	900	0	0	900	0	0
Sum	6750	235	30	6750	100	273	6750	314	73
Sum Total	43820	811	445	47940	1185	760	45650	906	404

	Area Sampled	July 7-8, 2006		Area Sampled	July 11-14, 2006		Area Sampled	August 1-2, 2006	
Survey Site	Area sq.ft	Chinook	Steelhead	Area sq.ft	Chinook	Steelhead	Area sq.ft	Chinook	Steelhead
Watt 1	600	0	0	600	0	0	600	0	0
Watt 2	600			600	0	0	600		
Watt 2A	450			450	0	0	450		
Watt 3	600			600	0	2	600		
Watt 4	900			900	0	0	900		
Watt 5	600			600	3	0	600		
Watt 6	600			600	0	0	600		
Watt 7	600	0	1	600	0	0	600	0	0
Watt 8	600	0	0	600	0	0	600	0	0
Watt 9	600	0	0	600	0	0	600	0	0
Watt 10	600	0	0	600	0	0	600	0	0
Watt 10A	600	0	0	600	0	0	600	0	0
Watt 11	600			600	0	0	600	0	0
Watt 12	900	0	0	900	0	0	900	0	0
Sum	4500	0	1	8850	3	2	5100	0	0
Gristmill 1	600			600			600		
Gristmill 2	600			600			600		
Gristmill 3	600	0	0	600	0	0	600		
Gristmill 4	600	0	0	600	0	0	600		
Gristmill 5	600	0	0	600	0	0	600		
Gristmill 6	600	0	0	600	0	0	600		
Gristmill 7	450	0	0	450	0	0	450		
Gristmill 8	600	0	0	600	0	0	600		
Gristmill Trans A	800			800			800		

Sum	3450	0	0	3450	0	0	0	0	0
Goethe 1	600	0	0	600	2	0	600	0	0
Goethe 2	600	0	0	600	13	2	600	0	0
Goethe 2A	600	0	0	600	1	0	600	0	0
Goethe 3	600	0	0	600	0	0	600	0	0
Goethe 4	600	0	0	600	0	0	600	0	0
Goethe 5	600	0	0	600	0	2	600	0	0
Goethe 5A	900	0	0	900	0	2	900	0	0
Goethe 6	480	0	0	480	0	0	480	0	0
Sum	4980	0	0	4980	16	6	4980	0	0
Rossmore 1	600	0	0	600	0	0	600	0	0
Rossmore 2	600	0	1	600	0	0	600		
Rossmore 3	600	0	0	600	0	0	600		
Rossmore 3A	450	0	3	450	0	0	450		
Rossmore 4	800	0	0	800	0	0	800	0	0
Rossmore 5	900	0	0	900	0	0	900	0	0
Rossmore 6	450	0	0	450	0	0	450	0	0
Rossmore 7	480	0	0	480	0	0	480	0	0
Rossmore 8	480	0	4	480	0	4	480	0	0
Rossmore A	600	0	0	600	0	0	600	0	0
Sum	5960	0	8	5960	0	4	4310	0	0
Lower Sunrise 1	600	0	2	600			600	0	1
Lower Sunrise 2	600	140	80	600			600	0	0
Lower Sunrise 3	600	0	3	600			600	0	0
Lower Sunrise 4	600	0	54	600			600	0	0
Lower Sunrise 5	600	20	35	600			600	0	0
Lower Sunrise 6	600	0	0	600			600	0	0
Lower Sunrise 7	600	0	0	600			600	0	0

Lower Sunrise 8	1600	0	0	1600			1600	0	0
Sum	5800	160	174	0	0	0	5800	0	1
Upper Sunrise 1	600	0	2	600			600	0	0
Upper Sunrise 2	600	1	7	600			600	0	0
Upper Sunrise 3	600	0	1	600			600	0	0
Upper Sunrise 4	600	0	0	600			600	0	0
Upper Sunrise 4A	640	0	4	640			640	0	0
Upper Sunrise 5	600	5	30	600			600	0	0
Upper Sunrise 6	600	0	0	600			600	0	0
Upper Sunrise 7	600	0	0	600			600	0	0
Upper Sunrise 8	600	0	0	600			600	0	0
Upper Sunrise 9	600	0	1	600			600	0	0
Upper Sunrise 10	480	0	0	480			480	1	0
Upper Sunrise 11	900	0	0	900			900	0	0
Upper Sunrise 12	900			900			900	0	0
Sum	7420	6	45	0	0	0	8320	1	0
Sailor lower 1	450	75	25	450			450	0	0
Sailor lower 2	450	0	0	450			450	0	0
Sailor lower 3	600	0	0	600			600	0	0
Sailor lower 4	600	0	0	600			600	0	0
Sailor lower 5	900	0	0	900			900	0	0
Sailor lower 6	600			600			600		
Sailor lower 7	450	0	0	450			450	0	0
Sailor lower 8	600	0	2	600			600	0	0
Sailor lower 9	600			600			600	0	0
Sailor lower 10	600	0	0	600			600	0	0
Sailor lower 11	600	0	0	600			600		
Sailor lower 12	600	10	10	600			600		
Sailor lower Tr A	900	0	0	900			900	0	0
Sum	6750	85	37	0	0	0	6150	0	0

Sailor upper 1	600	0	0	600			600	0	1
Sailor upper 2	600	0	0	600			600	0	0
Sailor upper 3	600	2	15	600			600	0	0
Sailor upper 4	600	0	0	600			600	0	0
Sailor upper 4AA	600	0	0	600			600	0	0
Sailor upper 5	600	0	0	600			600	0	0
Sailor upper 6	600	0	0	600			600	0	0
Sailor upper 6A	600	0	0	600			600	0	0
Sailor upper 7	600	0	0	600			600	0	0
Sailor upper 8	600	0	0	600			600	0	0
Sailor upper 9	900	0	0	900			900	0	0
Sailor upper 9A	600	15	0	600			600	0	100
Sailor upper 10	600	0	0	600			600	0	0
Sailor upper T A	900	0	0	900			900	0	0
Sum	9000	17	15	0	0	0	9000	0	101
Nimbus 1	600	0	0	600	0	0	600	0	0
Nimbus 2	600	0	1	600	0	0	600	0	0
Nimbus 3	600	0	0	600	0	0	600	0	0
Nimbus 4	600	0	3	600	0	6	600	0	0
Nimbus 5	600	0	0	600			600	0	0
Nimbus 5a	450	0	0	450	0	0	450	0	0
Nimbus 5b	450	0	0	450	0	0	450	0	0
Nimbus 6	900	0	0	900	0	0	900	0	0
Nimbus 7	450	0	0	450	0	0	450	0	0
Nimbus 7a	600	0	0	600	2	0	600	0	0
Nimbus 8	600	0	1	600	2	0	600		
Nimbus 9	900	0	0	900	0	0	900	0	0
Sum	7350	0	5	6750	4	6	6750	0	0
Sum Total	55210	268	285	29990	23	18	50410	1	102

Appendix B: Sampling Locations and Polygons.

Watt

Plate A4-1. Sampling units at Watt site.

Gristmill

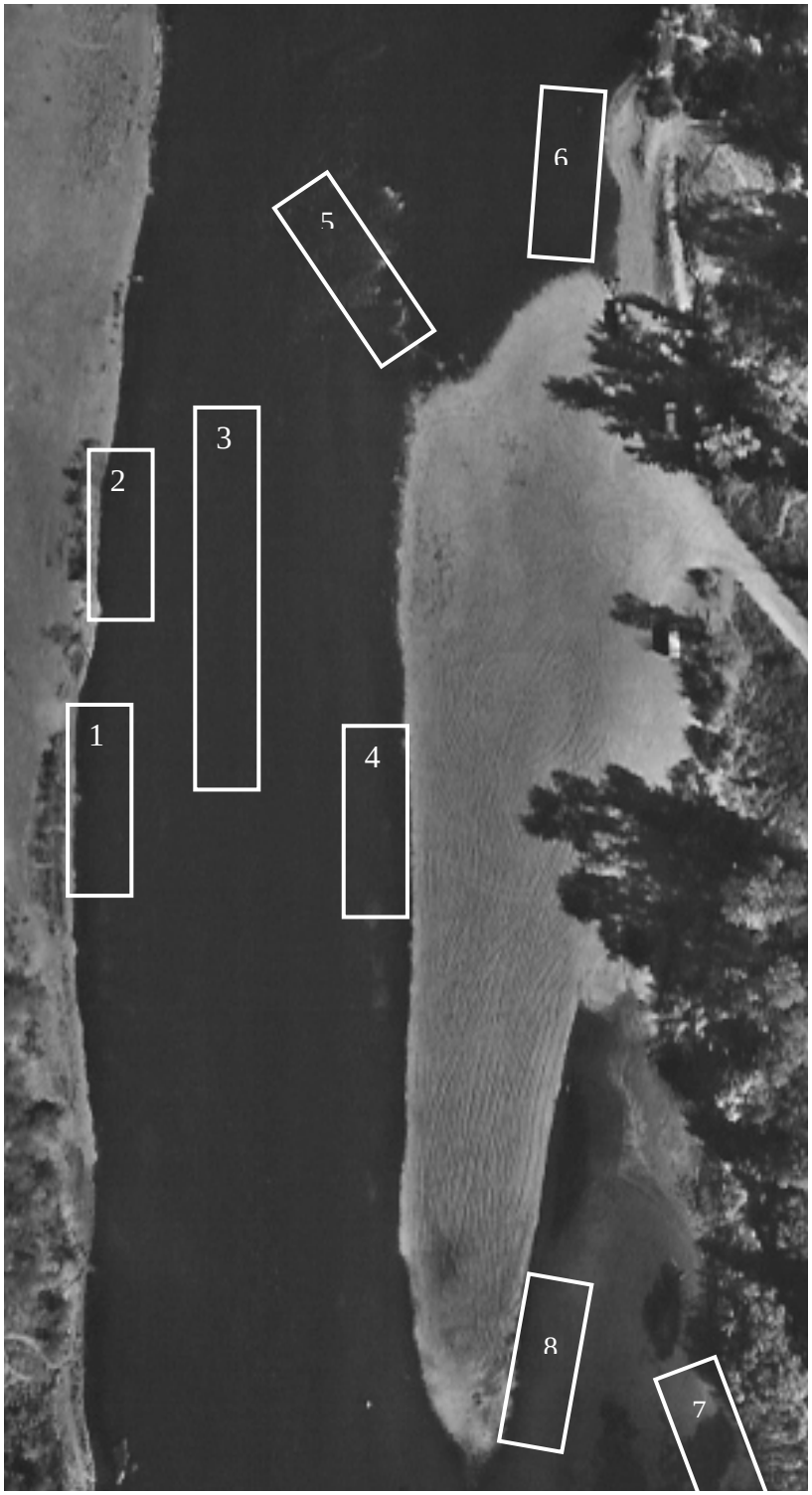

Plate A5-1. Sampling units at Gristmill site.

Goethe

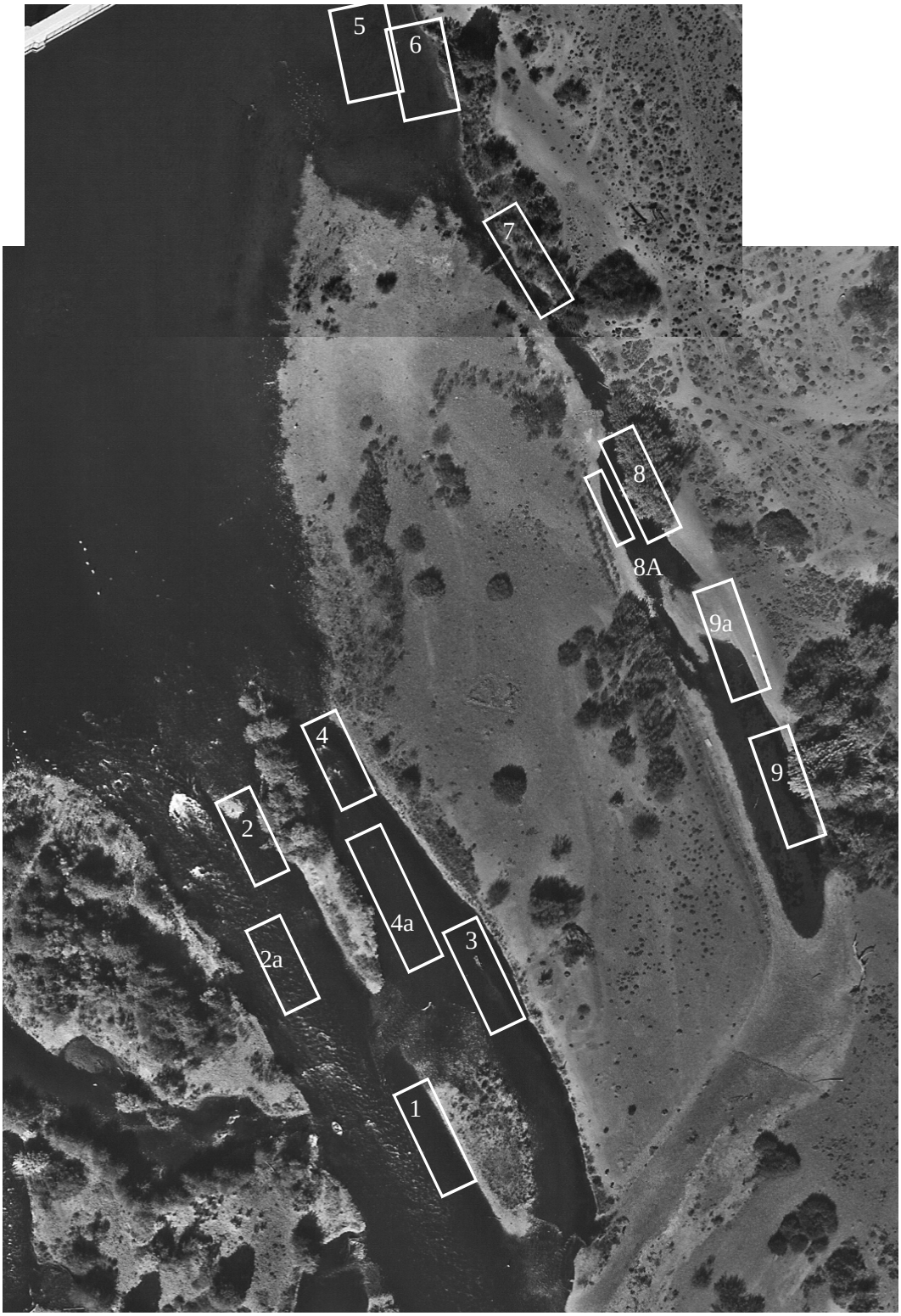

Plate A6-1. Sampling units at Goethe site. Note side channel at right was watered and fully connected all of the 2003 sampling season.

Rossmore

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

Lower Sunrise

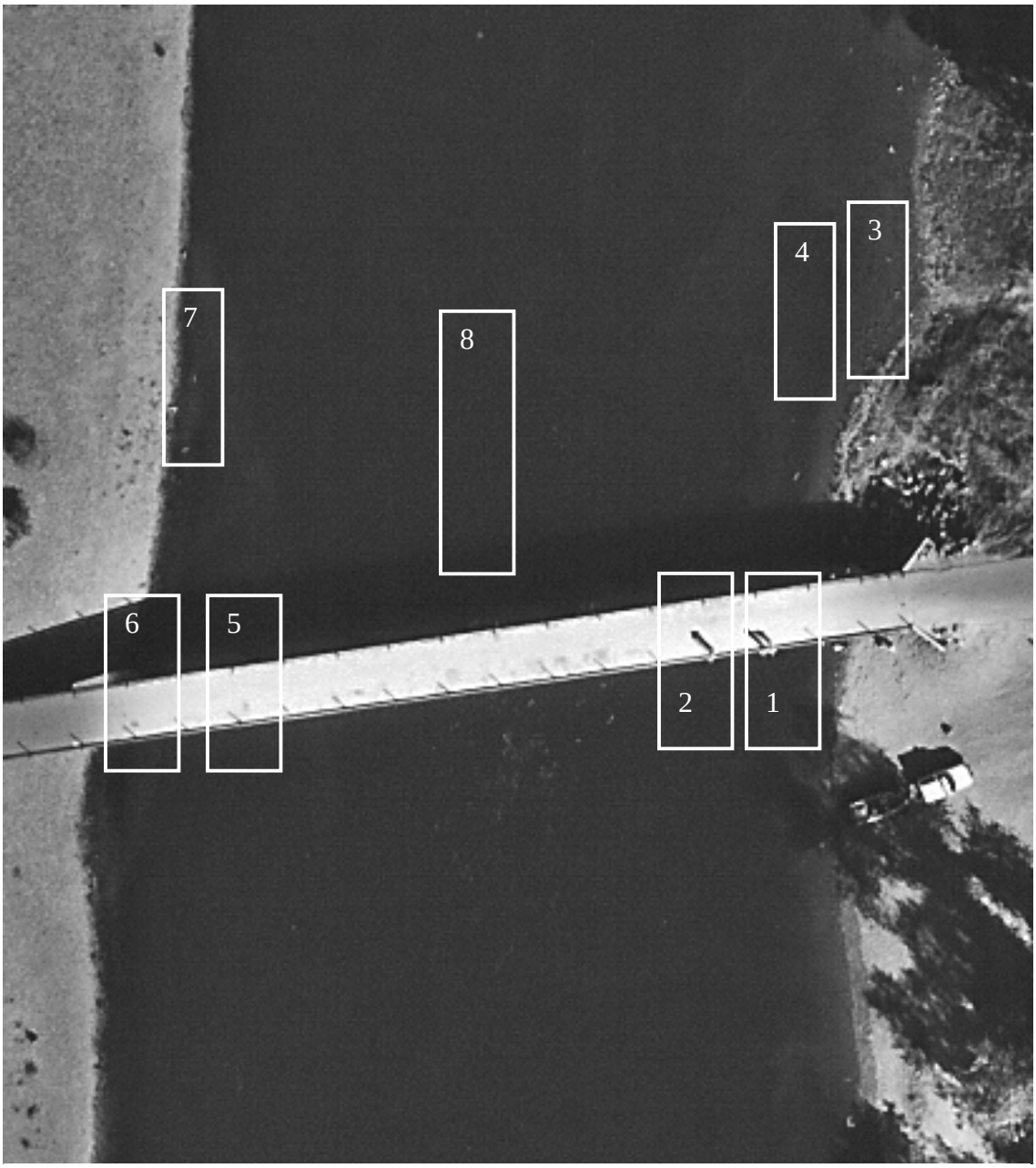

Plate A8-1. Sampling units at Lower Sunrise Site.

Upper Sunrise

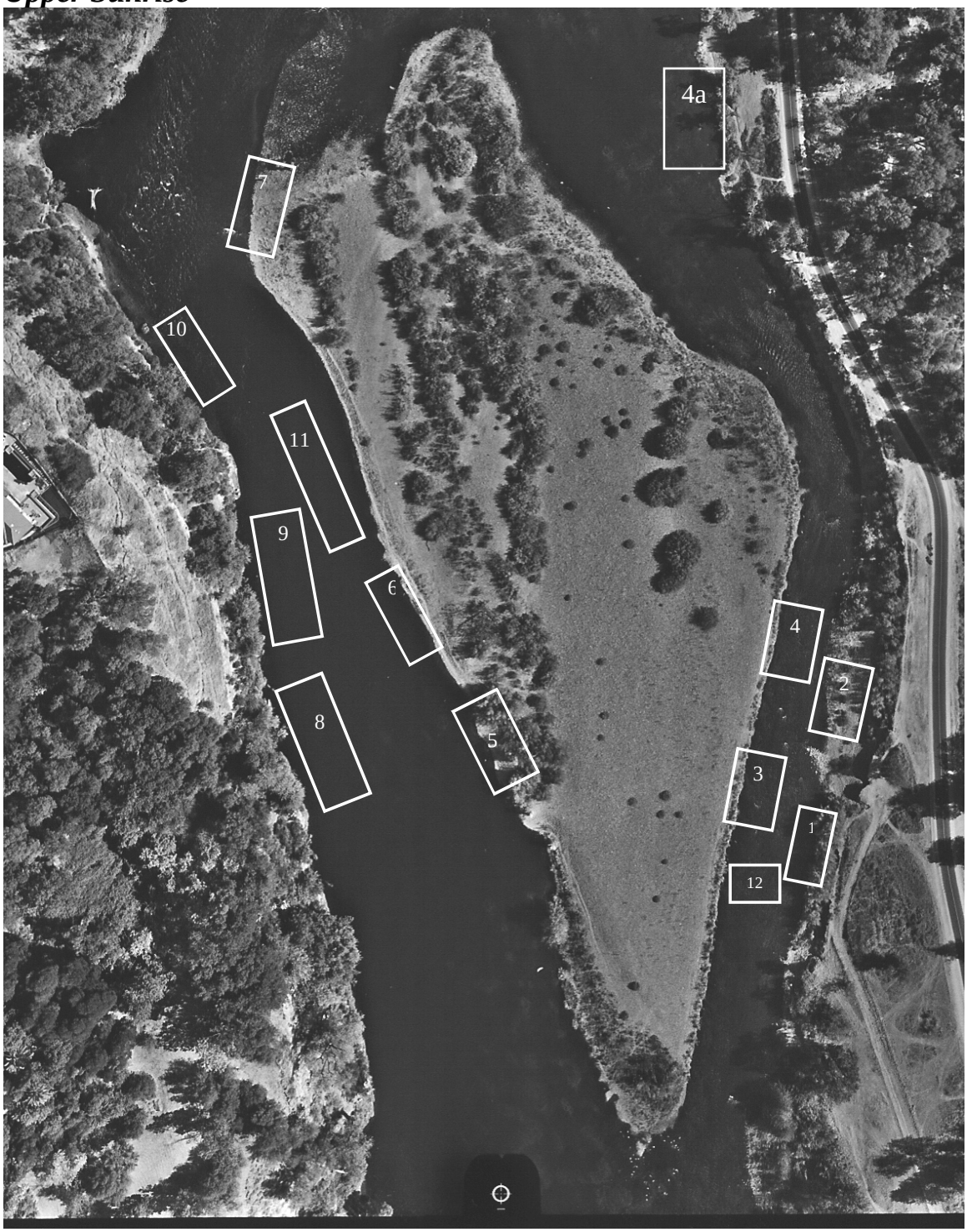

Plate A9-1. Sampling units at Upper Sunrise Site.

Lower Sailor Bar

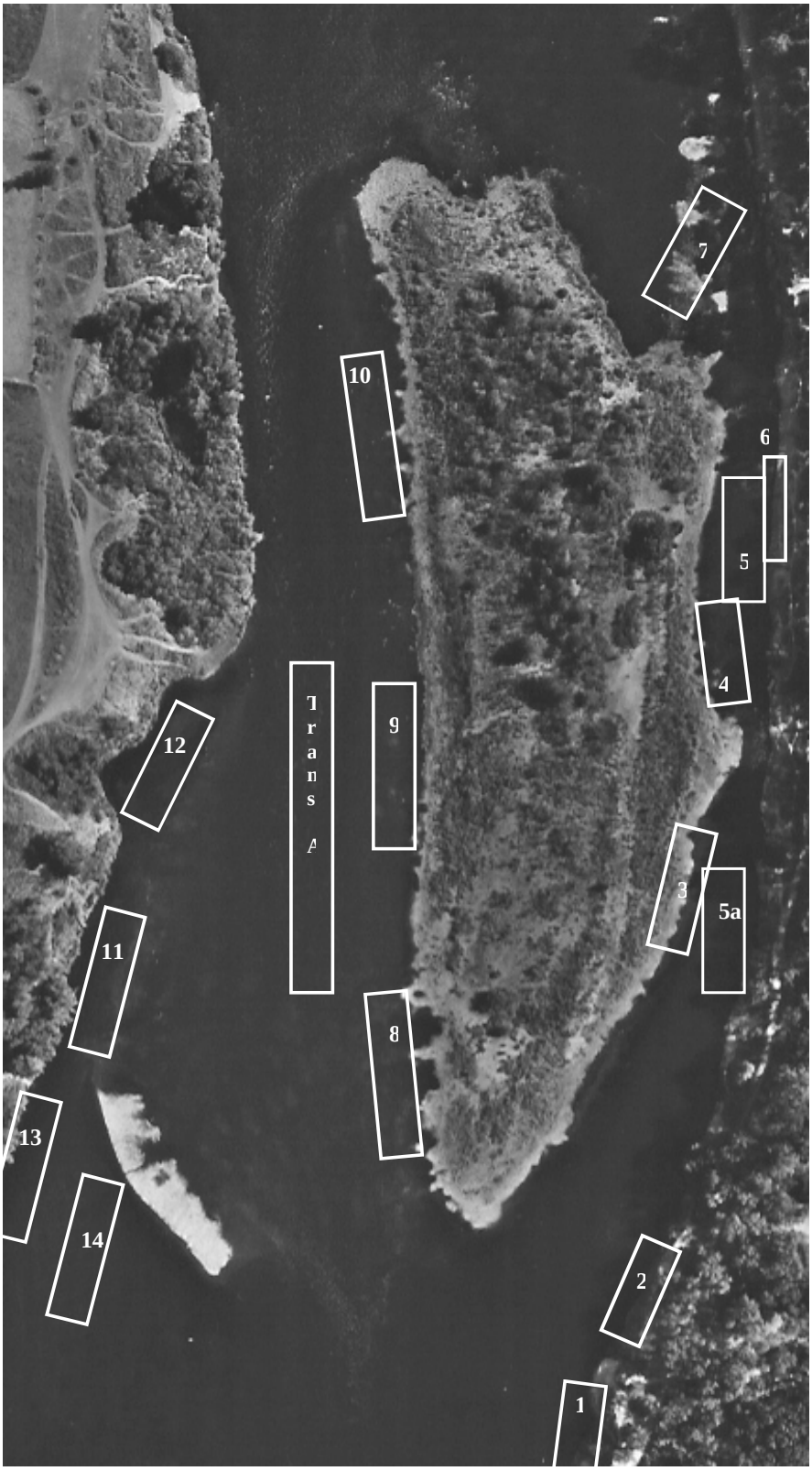

Plate A10-1. Sampling units at lower Sailor Bar Site.

Upper Sailor Bar

Plate A11-1. Upper Sailor Bar sampling units.

Nimbus Basin

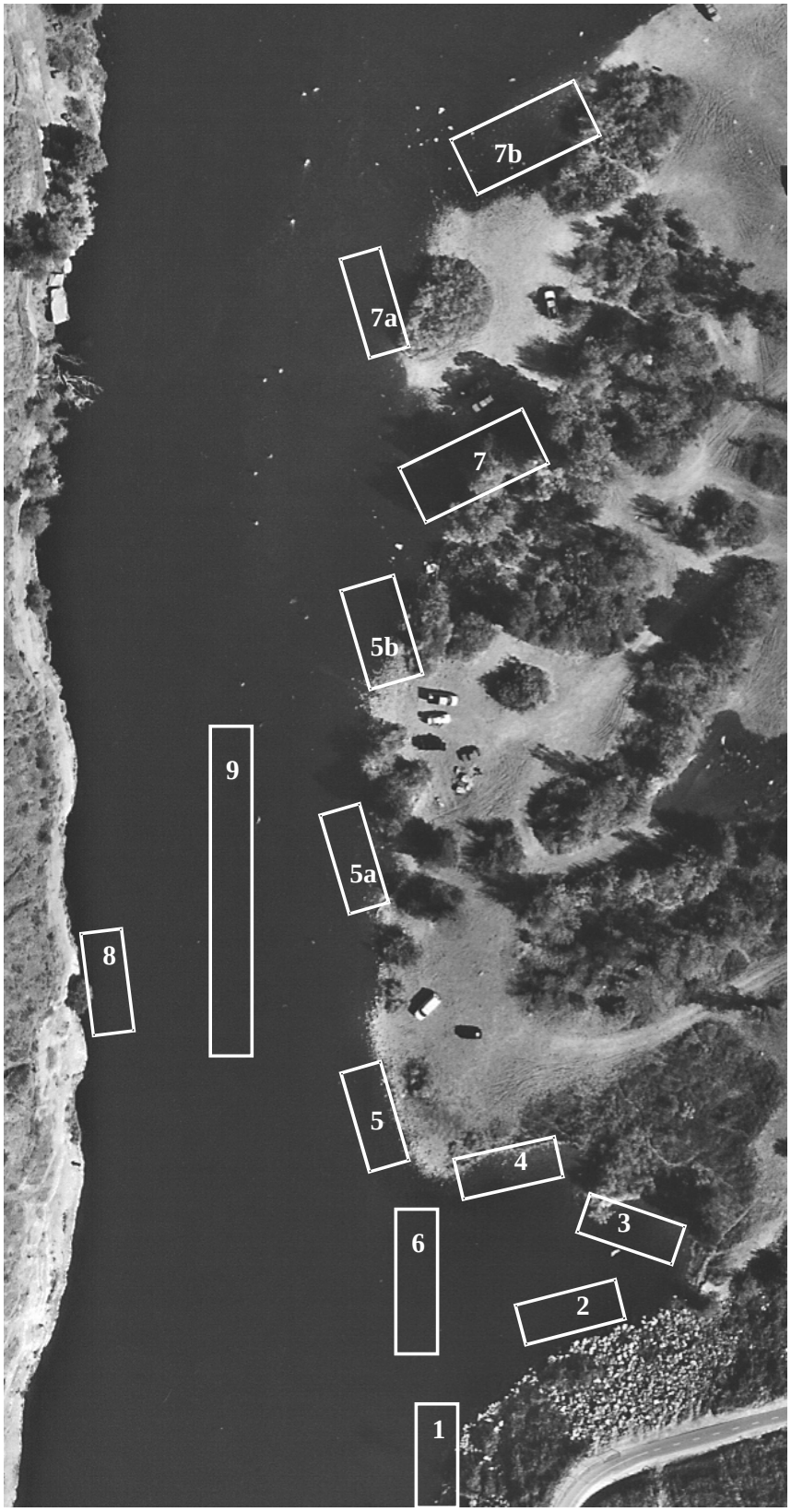

Plate A12-1. Sampling units in Nimbus Basin.