Salmonid Monitoring of Habitat Restoration Sites in the Upper Sacramento River in 2017-2018

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2017-2018 PROJECT SUMMARY

This season marks the third year of juvenile habitat restoration monitoring as part of the Upper Sacramento River Anadromous Fish Habitat Restoration Project, which operates under the Central Valley Project Improvement Act (CVPIA) (B13) habitat restoration project. From July 2017 through June of 2018 staff from the Pacific States Marine Fisheries Commission (PSMFC) Chico State University (CSUC), and California Department of Fish and Wildlife (CDFW) cooperatively conducted field surveys to monitor salmonid use of spawning and rearing habitat restoration sites along the Upper Sacramento River Basin (USRB) from Keswick Dam (river mile 301) to the Red Bluff Diversion Dam (river mile 243) . Three strategies for restoration have been implemented to increase juvenile and adult habitat to date. Adult spawning restoration sites primarily consist of gravel placement to promote spawning by Chinook salmon (*Oncorhynchus tshawytscha*) and Steelhead/Rainbow trout (*Oncorhynchus mykiss*). Juvenile rearing restoration sites are primarily side channel construction or rehabilitation, designed to provide increased juvenile rearing habitat. Habitat structure placement has also been implemented to increase edge habitat and deep water habitat for juvenile salmonids during fluctuating flow releases from Keswick Dam.

During the 2017-2018 field season, two side channel restoration sites, and one habitat structure placement project were constructed. Lake California side channel is a 1,500 meter long channel located upstream of the Jelly's Ferry bridge adjacent to the community of Lake California at river mile 269. Before restoration was completed the channel was essentially cut off at low river flows resulting in isolated pools and a backwater channel. Construction to open the mouth of the channel was completed in December, 2017. An estimated 3,000 square meters of habitat are now available to salmonids at the lowest flows. Kapusta side channel is a 290 meter long side channel located about one mile downstream of the mouth of Clear Creek at river mile 288. The side channel was officially connected with the main-stem Sacramento River on April 25, 2018. Pre-construction, Kapusta was a stagnant backwater choked with non-native aquatic vegetation. Opening it up to the mainstem created an estimated 400 square meters of juvenile rearing habitat. The Kutras Lake restoration project was a collaboration between multiple agencies including Trout Unlimited and CDFW to place large habitat structures within a historic dredge site, which supplied rock for the construction of Shasta Dam known today as Kutras Lake. Placement of 17 habitat structures comprised of manzanita, live oak, and valley oak limbs cabled to heavy-duty sandbags, created an estimated 1,000 cubic meters of rearing habitat. These habitat structures were placed near the edges of the lake on April 5th and 6th, 2018.

During the 2017-18 monitoring season (June 2017 to July 2018) a total of 13,147 salmonids were observed in the control side channels during snorkel surveys. Of these, 1,476 were classified as late-fall-run Chinook salmon (late-fall), 813 winter-run Chinook salmon (winter-run), 6,708 fall-run Chinook salmon (fall-run), and 4,102 Steelhead/Rainbow trout. Additionally, 33,374 salmonids were observed during post-project surveys of restored side channels. Of these 2,989 were classified as late-fall, 1,919 as winter-run and 20,782 as fall run. An additional 7,658 Steelhead/Rainbow trout were observed within restored sites. Baseline data was collected on restoration sites identified by cooperating CVPIA planning agencies. Baseline data was collected during high flows when these unimproved sites were available to juvenile salmonids. A total of 2,369 salmonids were observed in project sites pre-construction. This field season marks the first time in this projects' history in which a full year of post-project data has been collected on a restored site. North Cypress was a dry river bank that only became inundated during flood events on the USRB, prior to restoration (completed January 2, 2017). Multi-year snorkel data is presented in the results section of this report.

Habitat mapping was also added this season as part of the overall monitoring plan. This mapping effort is a multi-faceted GIS based analysis of the suitable habitat available for juvenile salmonid rearing within the USRB. Three types of habitat criteria are currently being mapped at three separate flow regimes. Cover, and depth and velocity polygons have been created to show the amount of aquatic habitat that meet suitability criteria established by Goodman, Som, Alvarez, & Martin (2015). Macrohabitat data has also been collected on each side channel as well as fish-habitat relations data (microhabitat use). These are ongoing aspects of the monitoring effort and will be presented in their entirety in subsequent monitoring reports.

Future monitoring efforts to evaluate the effectiveness of new habitat restoration sites currently in planning will be conducted by the monitoring team throughout the coming years and be reported.

INTRODUCTION

Problem Statement

The Central Valley Chinook Salmon and Steelhead Recovery Plan identifies the current stressors to threatened and endangered anadromous salmonid stocks in the Central Valley (NMFS, 2014). The juvenile rearing and outmigration life stage of winter and spring runs of Chinook salmon and Steelhead/Rainbow trout utilizing the upper Sacramento River (Keswick Dam downstream to Red Bluff Diversion Dam) are confronted by several stressors that are ranked as high to very high including: loss of floodplain habitat; loss of natural morphologic function; loss of riparian habitat and instream cover; and competition and predation (NMFS, 2014). The upper Sacramento River is where initial juvenile rearing occurs for anadromous salmonid stocks that spawn in the Sacramento River, whereas the middle and lower Sacramento River reaches primarily serve as a migration corridor (NMFS, 2014).

Although less than 20% of the upper Sacramento River has been leveed for flood protection of population centers or agriculture, natural geologic formations and controlled flow regimes have resulted in channelization and disconnection from historical floodplains (NMFS, 2014). Most historic side channel features are either not connected to main stem river flows or are connected at higher flows and disconnect at lower flows, effectively stranding fish as river flows recede.

Scientific Basis for Side Channel Restoration

The approach for the Upper Sacramento River Anadromous Fish Habitat Restoration Project derives from the hypothesis that, if you reconnect side channels for the range of flows that salmonid juveniles encounter, the physical and biological characteristics of the habitat will support a greater abundance of salmonid juveniles that are larger and in better condition to out migrate. The conceptual model underlying this hypothesis, and which forms the basis for the monitoring plan approach is provided below (Figure 1). An in-depth discussion of this conceptual model is available in the *Upper Sacramento River Anadromous Fish Habitat Restoration Project Monitoring Plan and Protocols* (Tussing & Banet 2017)

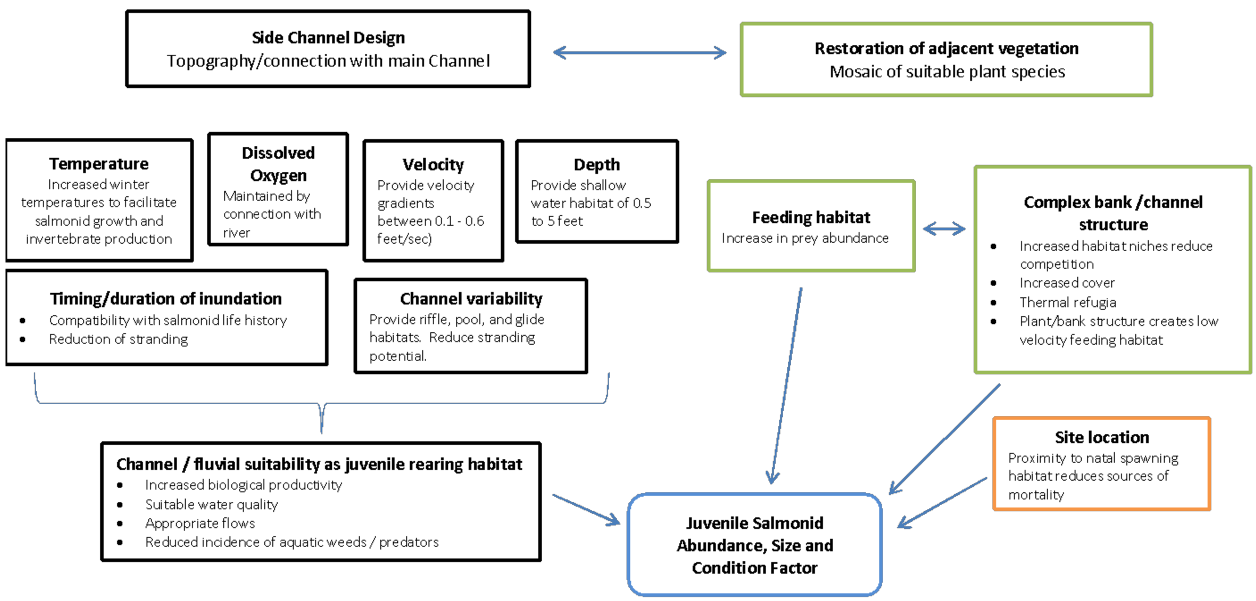

Figure 1. Conceptual model of design-related elements and their influence on biotic and abiotic juvenile salmonid habitat elements

Restoration Goals and Objectives

The primary management goals of the Project are to:

1. Increase the availability, quality and quantity of spawning and rearing habitat for Sacramento River Basin Chinook salmon and steelhead trout
2. Restore, maintain or enhance natural system processes whenever possible

3. Determine project effectiveness, including cost, project longevity and maintenance requirements, with an efficient and scientifically-robust monitoring program
4. Demonstrate a positive, detectable salmonid population response to habitat enhancement activities
5. Contribute to the long-term health of the river ecosystem (water quality, invertebrate and fish assemblages, riparian and floodplain habitat function, etc)
6. Incorporate information learned to improve future projects (adaptive management)
7. Contribute to scientific understanding of aquatic ecology
8. Work collaboratively with partners to identify and implement projects that are cost effective and benefit aquatic resources, emphasizing anadromous salmonids, in the short and long term.

The primary objectives of the restoration project are to provide:

1. An increase in the areal extent of spawning habitat meeting suitability criteria and the use of spawning habitat.
2. An increase in the areal extent of rearing habitat meeting juvenile salmonid rearing habitat suitability criteria.
3. Increase in salmonid juvenile abundance/density at restoration sites after implementation, as compared to before implementation.
4. Improvement in the average condition factor of salmonids using the side channels.
5. An increase in available prey abundance, including both drift and benthic macroinvertebrates.
6. Improved size and average condition of salmonids using the side channels, as compared to those that have not been documented using the side channels.
7. Increased extent and quality of riparian habitat at Sand Slough.

METHODS

Site Selection

Control site selection

Three functioning side channels and two mainstem sites were selected along the upper Sacramento River as control sites to be paired with project sites for comparison as they are completed. The side channel controls provide juvenile rearing habitat year-round during the lowest flow releases (i.e. 3,250 cfs) expected from Keswick Dam during water conservation periods (NMFS, 2014). They were selected based on size, and proximity to the proposed B13 restoration (impact) side channels. The two main-stem control sites were selected based on proximity to proposed project sites and presence of suitable habitat (depth, velocity and cover). The five sites are as follows: Wyndham control side channel, Clear Creek control side channel, and Bourbon Island control side channel, Mainstem North, and Mainstem South. These sites are included in Figure 2 along with pre and post-project sites. A breakdown of which project site they will be paired with for future analysis is presented in Table 3.

Project site selection/prioritization

Project sites have been identified and prioritized for construction through the CVPIA habitat restoration process. Restoration sites are sites that were either previously connected to the river and have since been cut off to fish due to increased channelization, or sites that are only available to juvenile fish during certain times of year (i.e. during high releases from Keswick dam). Sites are then prioritized for construction based on a multitude of factors which may include but are not limited to: stranding potential at lower Keswick releases, feasibility of construction, land-owner cooperation, site longevity and maintenance requirements, and overall perceived benefit to juvenile salmonids, with emphasis on benefits to listed species. Figure 2 shows locations of project sites that are currently in various stages of planning or construction that have been monitored for juvenile salmonid rearing to date, as well as locations of monitored completed project sites and control sites.

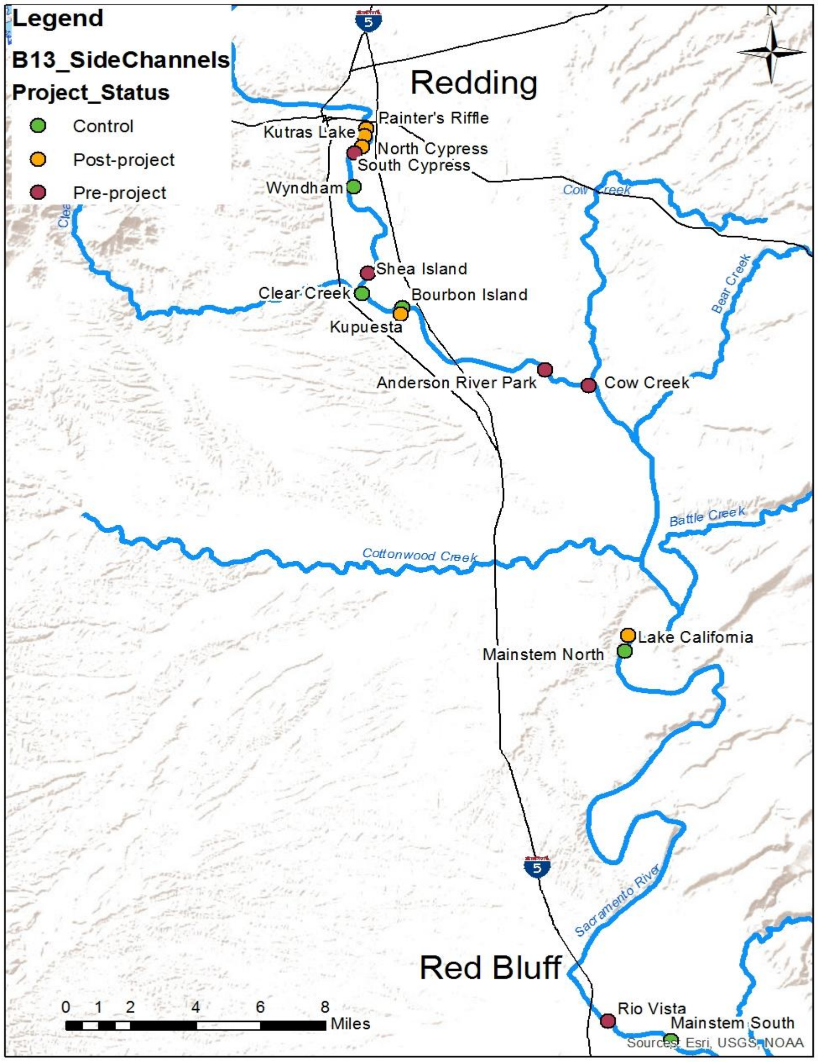

Figure 2. Map of control, pre-project (pre-construction) and post-project side channels that have been surveyed thus far as part of the habitat restoration monitoring project.

Fish Abundance Index and Associated Physical Variables

Snorkel surveys were generally conducted at each site every two weeks between 9AM and 3PM. Data collected from each site was classified following the designations in Table 1. The order in which control, impact, and baseline sites were surveyed were randomized whenever possible, in order to reduce the likelihood that data is confounded with time of day. We recorded several physical variables each time a site was surveyed (Table 2). Visibility, weather, and water temperature were recorded on site, and flow was calculated in the office using data from nearby gauging stations. Surveys were conducted at both control and project sites each month whenever possible, but due to logistic constraints (e.g low water prior to restoration, safety concerns, etc.) there are some discrepancies.

TABLE 1. DATA CLASSIFICATION

CONTROL	*Control data is collected from previously existing side channels and areas of the main stem of the Sacramento River. This data is used as a point of comparison, in order to help determine if the restoration is achieving the desired results.*
BASELINE	*Baseline data is collected from a site that is slated for restoration, before the restoration begins. This data can be compared with control data that is collected concurrently, and to impact data that is collected after restoration occurs. Note that collection of baseline data is dependent on the condition of the site prior to restoration; limited accessibility or lack of water means that not all restoration sites have baseline data.*
IMPACT	*Impact data is collected from a site that has been restored. This data can be compared to baseline data (when available) and nearby control sites in order to monitor the effects of side channel restoration.*

Each swimmer calibrated his or her vision prior to commencing a snorkel survey in order to account for the visual distortion that occurs in water. To do this, the swimmer submerged their face and mask in the water, and another crew member held a calibration tool equipped with a model fish of known lengths in front of the swimmer for a short period of time. This process was repeated until the swimmer was comfortable with the calibration.

Flows and conditions at some sites were not amenable to snorkeling upstream. Because of this, all surveys were conducted downstream to maintain consistency. Swimmers formed a line perpendicular to flow prior to the start of the survey and recorded the start time of the survey. At most sites, two snorkelers were used to survey edge habitat along each bank of a side channel. For mainstem sites, one snorkeler surveyed the edge of the main river bank. Swimmers maintained their line in order to reduce the likelihood of double counting fish. Juvenile salmonids were identified, classified by size, and counted as they passed by the snorkeler. Other fish species were noted and counted as well, in order to gather information on species richness and the presence of predators. After the survey was completed, an end time was recorded. During data entry, size observations were used to classify

TABLE 2. PHYSICAL VARIABLES	
VISIBILITY	*Visibility is measured using a secchi disk. A member of the crew submerges his or her face into the water and extends the pole upstream along the plane of their eye level until the disc can no longer be seen. The distance from the disc to the swimmer's eye is recorded in feet.*
WEATHER	*Weather is measured on a numeric scale as follows: 1- Clear, 2 - Partly Cloudy, 3 - Cloudy, 4 - Rain, 5 - Snow, 6 - Fog. For this report, monthly weather scores are reported both as mean and mode numeric values.*
WATER TEMPERATURE	*Water temperature is measured in Fahrenheit during each survey.*
CALCULATED FLOW	*Flow is determined using data from nearby gauging stations. Lake California, Mainstem North, Mainstem South, and Rio Vista use data from the Bend Bridge (BND) gauging station in Red Bluff, CA. All other sites use data from the Keswick (KWK) gauging station in Keswick, CA.*

Our eventual goal is to analyze the differences in the numbers and density of juvenile salmonids between control, baseline, and impact sites using temporal time series analysis. However, given that many of our restored sites are in their infancy, we do not yet have enough data or statistical power to justify conducting these tests. Instead, we have created a series of graphs that provide a visual representation of the data thus far. Each restoration site (baseline or impact) is presented alongside a control site that is geographically close. These pairings are presented in Table 3, below.

Kutras Lake habitat snorkel index

Kutras "lake" index snorkel surveys are conducted as part of the overall suite of snorkel surveys, every two weeks. Because there is no measurable flow within the lake, snorkels are conducted in a clockwise direction around the lake. Previous to construction, snorkel surveys were conducted on thirteen pre-designated habitat placement sites within Kutras Lake every two weeks. All surveys were conducted by snorkeling the edge habitat starting with the far Northeast bank, proceeding in a clockwise direction and ending with the northwest corner of the lake near the Aqua Golf driving range. Nine Control sites that consist of only pre-existing edge habitat have been established near the seventeen habitat structures for comparison. All juvenile fish observed are classified by species. Chinook salmon observed are classified by run, based on the length to date chart (Appendix A). Adult predator fish are also recorded and identified to species.
All sites (control and impact) have been marked using GPS and given identification numbers.

TABLE 3. SITE PAIRINGS

CONTROL	BASELINE / IMPACT	Notes
Clear Creek	Shea Island	Baseline data only for Shea Island
Wyndham	North Cypress	Impact data only for North Cypress. Restoration completed January 2017.
Wyndham	Painter's Riffle	Impact data only for Painter's Riffle. Restoration completed December 2014.
Mainstem North	Lake California	Baseline and impact data available for Lake California. Restoration completed 12/19/2017.
Mainstem South	Rio Vista	Baseline data only for Rio Vista.
Bourbon Island	Cow Creek Island	Baseline data only for Cow Creek Island
Bourbon Island	Kapusta	Impact data only for Kapusta. Restoration completed April 2018.

Juvenile Habitat Mapping and Suitability

Juvenile habitat mapping was implemented on a schedule that allowed us to map a range of flows. Targets were as follows: winter flows (3,250-4,500 cfs), fall flows (4,500-7,000 cfs) and summer flows (10,000+ cfs). When possible, all three habitat mapping protocols were implemented on the same day in order to maintain consistency between the flows at which date were collected.

<u>Habitat Types</u>

At each site, cross sections for discharge measurement were established following the Standard Operating Procedure for Discharge Measurements in Wadeable Streams in California (CDFW, 2013). Cross sections were benchmarked for future use. Habitat typing and mapping followed methods from the California Stream Habitat Restoration Manual (CDFW, 2010). Surveys began at the downstream end of side channels, and proceeded upstream to the side channel inlet. Habitats were classified to level III using the habitat types hierarchy provided in CDFW (2010) (Figure 3, below).

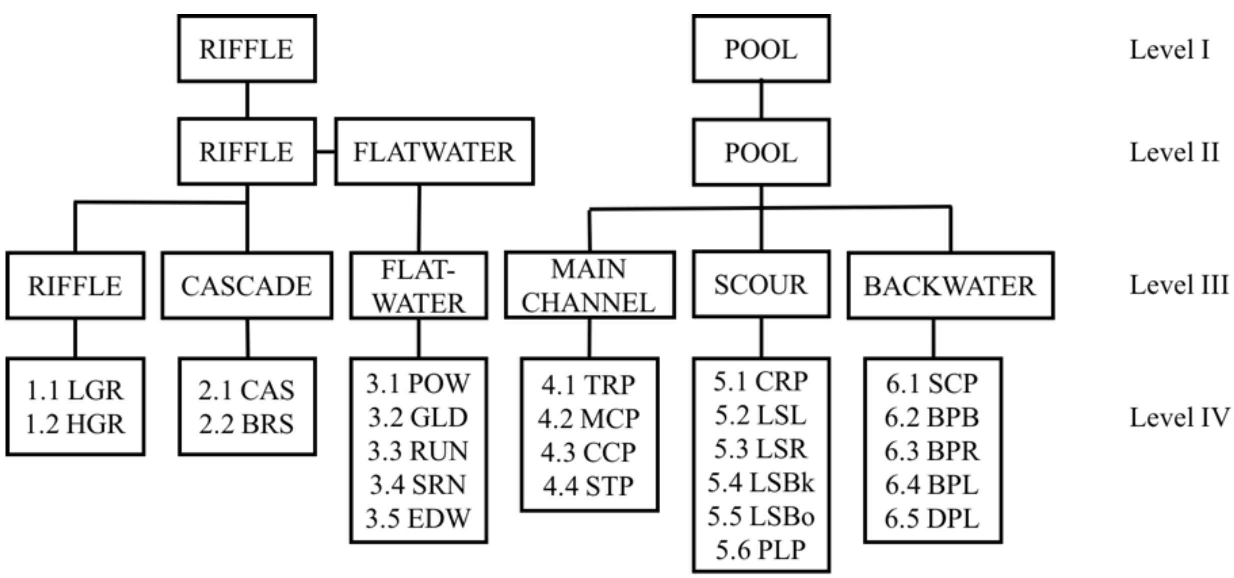

Figure 3. Habitat hierarchy from California Stream Habitat Restoration Manual (CDFW 2010).

The wetted perimeter and breaks between habitat types were mapped for the entire length of the channel using a Trimble GPS. The maximum depth was recorded for each habitat type (habitat unit), and average depth was calculated using data taken by a stadia rod across several transects. Dominant and codominant substrate within he wetted area was identified following classification of CDFW (2010), shown in Table 4. Tree canopy cover was measured as percent stream area covered with a spherical densiometer.

Table 4. Substrate Size Classification	
Particle Size	**Diameter (Inches)**
Boulder	>10
Cobble	2.5-10
Gravel	0.8-2.5
Sand	<0.8
Silt/Clay	N/A
Bedrock	N/A

Depth, Velocity, and Cover

Juvenile habitat mapping efforts followed the juvenile habitat suitability criteria of Goodman et al. (2015) apply to age-0 presmolt (>50mm) Chinook salmon. These criteria include depth, velocity and distance to cover (Table 5). Cover types mapped followed the primary cover types previously identified during the study of Flow-Habitat Relationships for Chinook Salmon Rearing in the Sacramento River between Keswick Dam and Battle Creek (USFWS, 2005; Table 6).

Table 5. Juvenile Chinook Salmon Habitat Suitability Criteria (Goodman et al., 2015)		
Parameter	**Upper Range (m)**	**Upper Range (ft)**
Depth	1	3.3
Velocity (/s)	0.24	0.8
Distance to Cover	0.6	2.0

Table 6. Juvenile Salmonid Habitat Cover Types (Holmes et al., 2014; USFWS, 2005)

Cover Type	Cover Code	Definition
No cover	0.1	
Cobble	1	3”-12” particle size, < 50% embedded
Boulder	2	>12” particle size
Fine wood vegetation	3	<1” Diameter
Branches, small woody debris	4	< 12” Diameter
Log, large woody debris	5	> 12” Diameter
Overhead cover	7	> 2’ above substrate, < 1.5’ off water surface
Undercut banks	8	
Aquatic vegetation	9	In-water vegetative cover
Rip rap	10	

To map depth and velocity, the field crew used a Trimble GPS. Data was collected when the accuracy of the Trimble unit allowed mapping to occur at a scale of one meter or less. Using juvenile depth and velocity suitability criteria identified in Table 5 above, the crew outlined areas of suitable habitat by measuring depth and velocity using hand-held flow meters on top-setting rods. This allowed identification of discrete polygons throughout the side channel that simultaneously met both depth and velocity criteria (i.e. depth and velocity were not mapped independently). We excluded small habitat areas (< 2m x 2m) from perimeter mapping in order to reduce geo-spatial error.

The Trimble GPS was also used to map cover. Using juvenile cover suitability criteria identified above (Table 5, distance to cover), the crew outlined the perimeter of in-water escape cover, and geo-referenced locations of this outline using the Trimble GPS. The in-water escape cover was mapped separately for each of the cover types without overlapping polygons. In some cases where cover types overlapped, and separate mapping of types was not feasible (e.g. minimum size criteria), the polygon was classified by the dominant cover type. The mapping of unembedded cobble as a cover type is the one exception to the general rule, and was mapped independently and often overlapped with other cover types. Similar to the depth and velocity mapping, we excluded small areas of cover less than 2m x 2m to reduce geo-spatial error from perimeter mapping.

Microhabitat Use

We used stratified random sampling to select habitats for inclusion in data collection for microhabitat use, in order to ensure the full range of available habitat types were captured, and that a commensurate amount of surface area was sampled for each habitat type. Surveys focused on both suitable and unsuitable habitat (as defined in Table 5) in order to establish the difference between fish use of preferred vs. available habitat.

For selected habitat units, snorkelers worked in an upstream direction and at a slow pace to observe the point locations of undisturbed fish. The location of fish observed was marked with a weighted tag on the stream bottom. The species, run, size, and number of the juveniles were recorded on tags for any observed salmonid juveniles less than 201mm in fork length. Estimates of fish size and selection of the appropriate size class bin was aided by the use of a dive cuff with photographs of salmonids at bin lengths. Size class bins included <41mm, 41-50mm, 51-60mm, and then by 20mm bin widths up to a maximum of 200mm. After the habitat unit was surveyed, flagged locations were revisited, and data was collected on fish attributes, GPS point location, habitat type, depth (total water column), distance to bank, distance to cover, cover type, mean water column velocity, and substrate. Each weighted flag and size class observed was considered a single observation regardless of the numbers of fish observed in each size class.

RESULTS

Fish Abundance Index and Associated Physical Variables

During the 2017-18 monitoring season (June 2017 to July 2018) a total of 13,147 salmonids were observed in the control side channels during snorkel surveys. Of these, 1,476 were classified as late-fall-run Chinook salmon (late-fall), 813 winter-run Chinook salmon (winter-run),6,708 fall-run Chinook salmon (fall-run), and 4,102 Steelhead/Rainbow trout. Additionally, 33,374 salmonids were observed during post-project surveys of restored side channels. Of these 2,989 were classified as late-fall, 1,919 as winter-run and 20,782 as fall run. An additional 7,658 trout were observed within restored sites. Baseline data was collected on restoration sites identified by cooperating CVPIA planning agencies. Baseline data was collected during high flows when these unimproved sites were available to juvenile salmonids. A total of 2,369 salmonids were observed in project sites pre-construction. This field season marks the first time in this projects' history in which a full year of post-project data has been collected on a restored site. North Cypress was a dry river bank that only became inundated during flood events on the USRB, prior to restoration (completed January 2, 2017). The graphs presented on the following pages show data from the 2017-18 monitoring season, along with monitoring data from earlier years of the project.

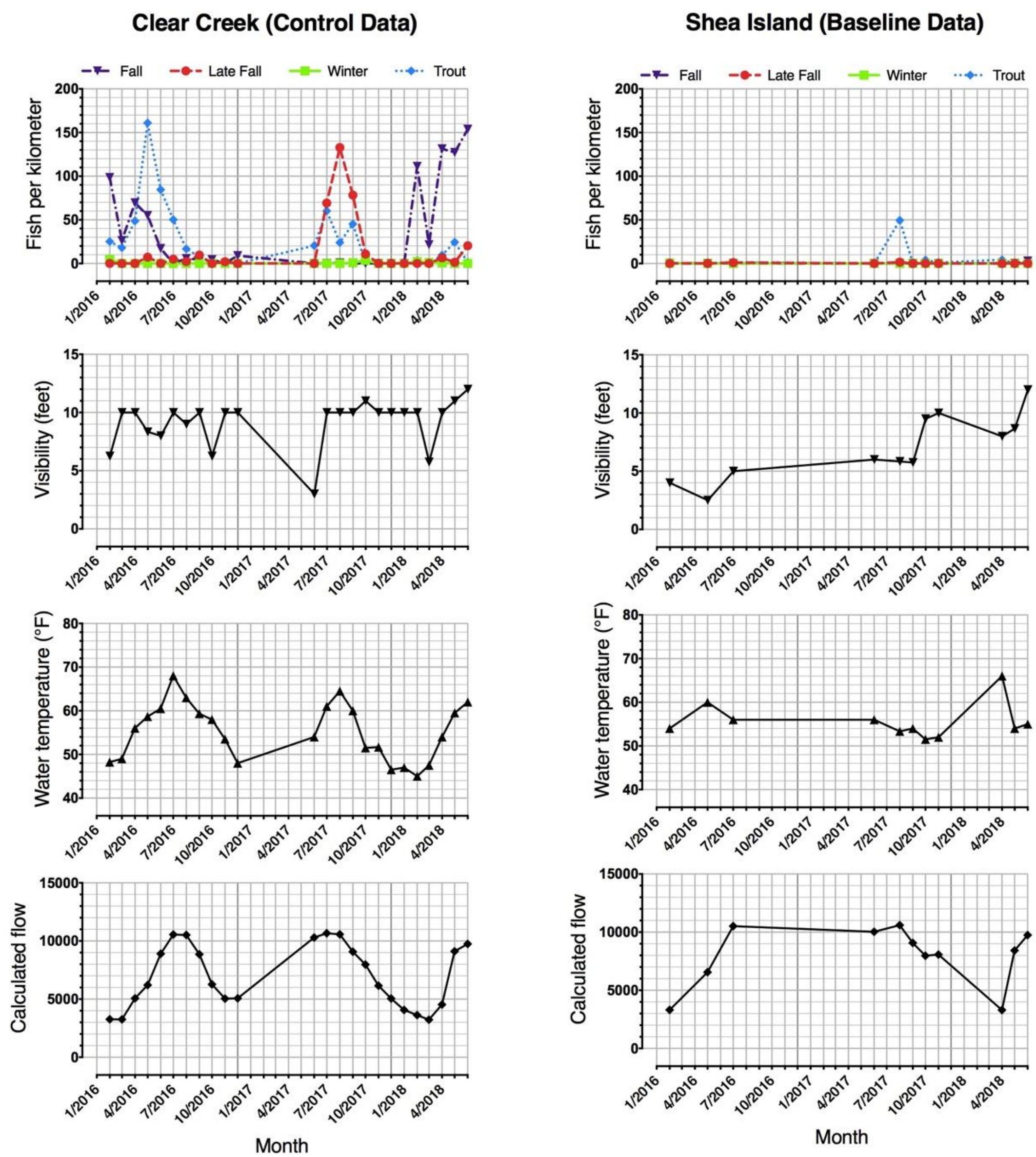

Figure 4. Comparison of Clear Creek control data and Shea Island baseline data. For fish per kilometer, visibility, water temperature, and calculated flow, data points represent the mean of all survey days during a given month. Fish per kilometer is an index value, and was calculated by dividing the number of fish counted by snorkelers surveying along each bank by the length of the survey area. See Table 2 for a description of physical variables.

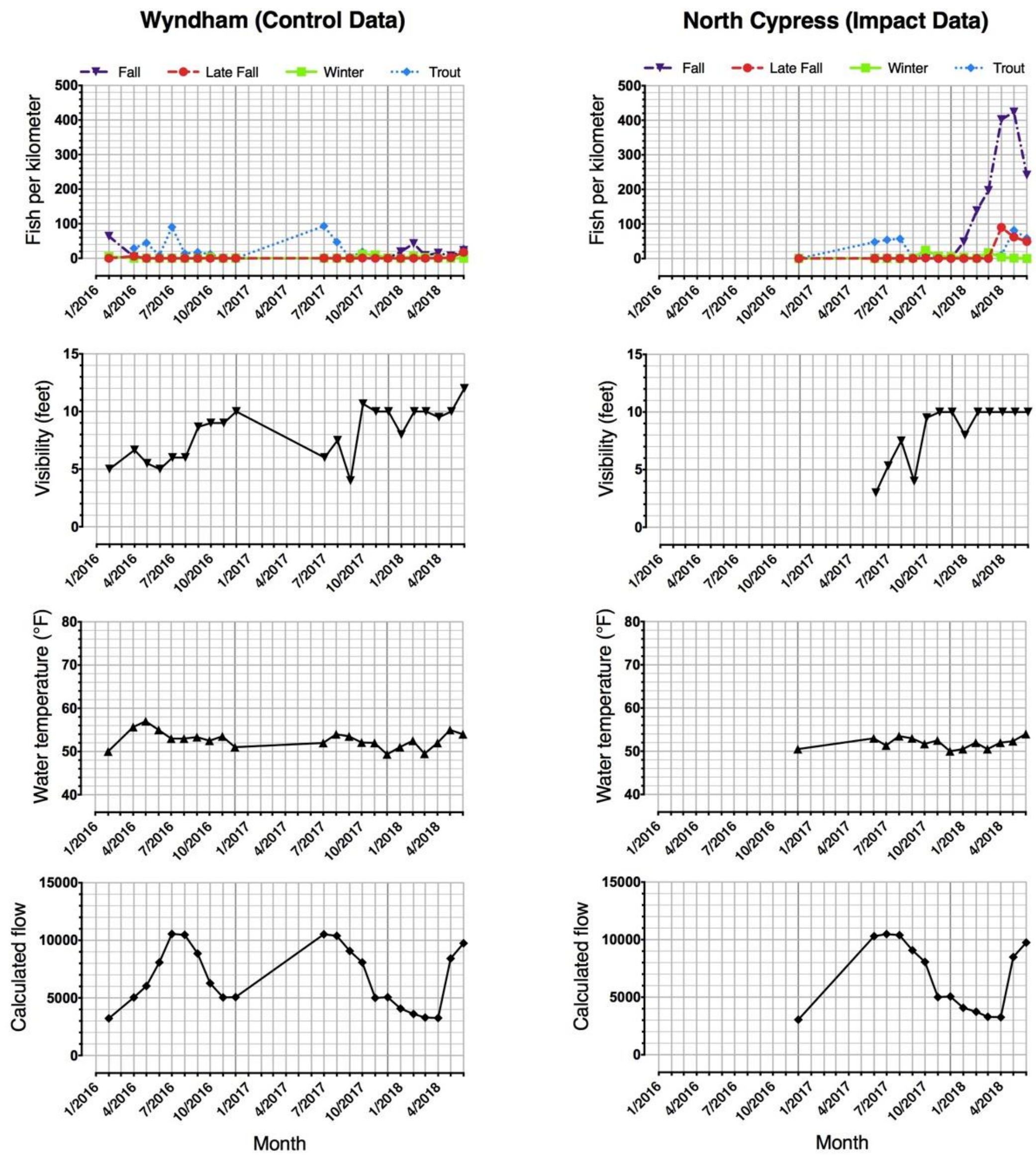

Figure 5. Comparison of Wyndham control data and North Cypress impact data. For fish per kilometer, visibility, water temperature, and calculated flow, data points represent the mean of all survey days during a given month. Fish per kilometer is an index value, and was calculated by dividing the number of fish counted by snorkelers surveying along each bank by the length of the survey area. See Table 2 for a description of physical variables.

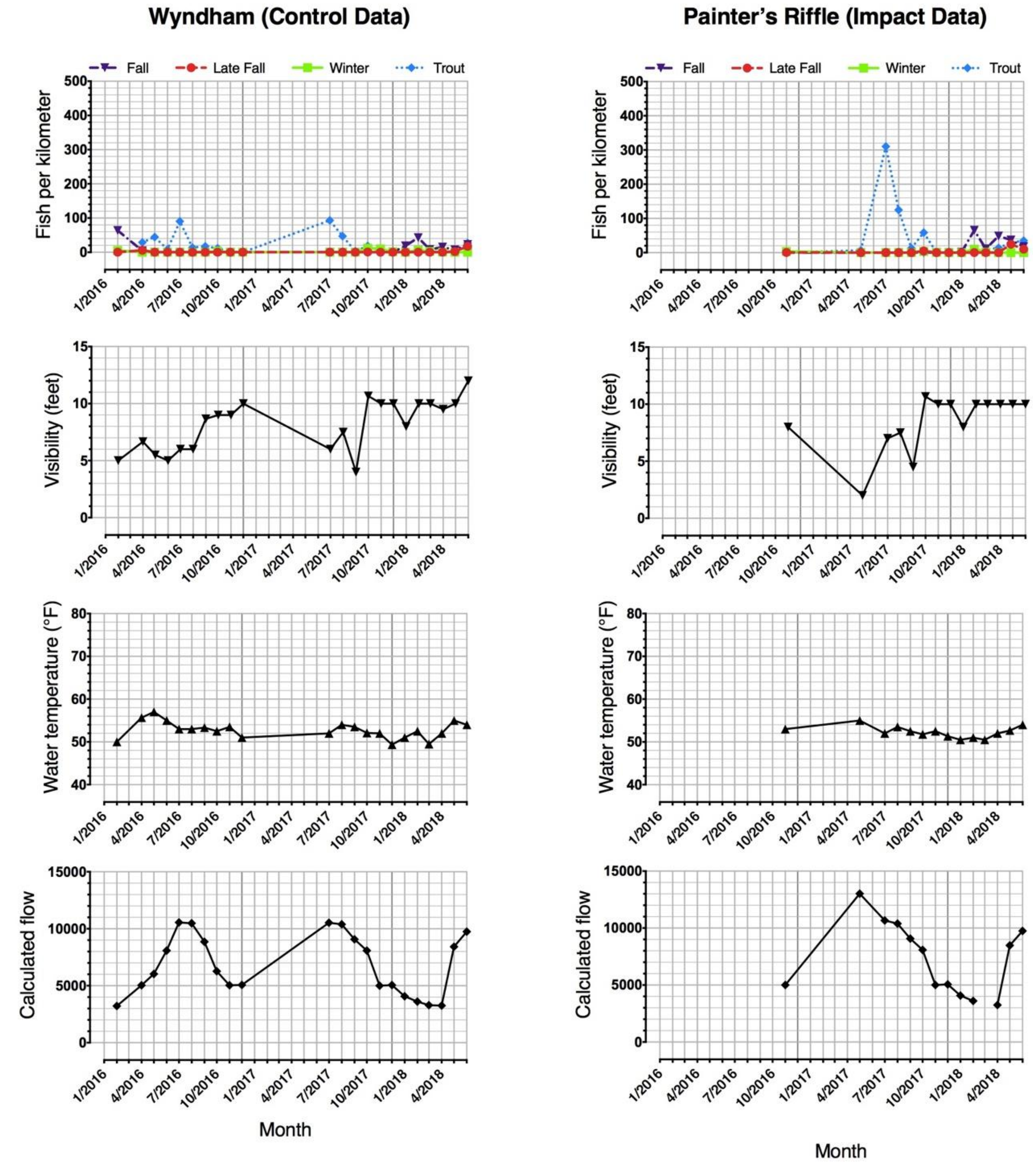

Figure 6. Comparison of Wyndham Creek control data and Painter's Riffle impact data. For fish per kilometer, visibility, water temperature, and calculated flow, data points represent the mean of all survey days during a given month. Fish per kilometer is an index value, and was calculated by dividing the number of fish counted by snorkelers surveying along each bank by the length of the survey area. See Table 2 for a description of physical variables.

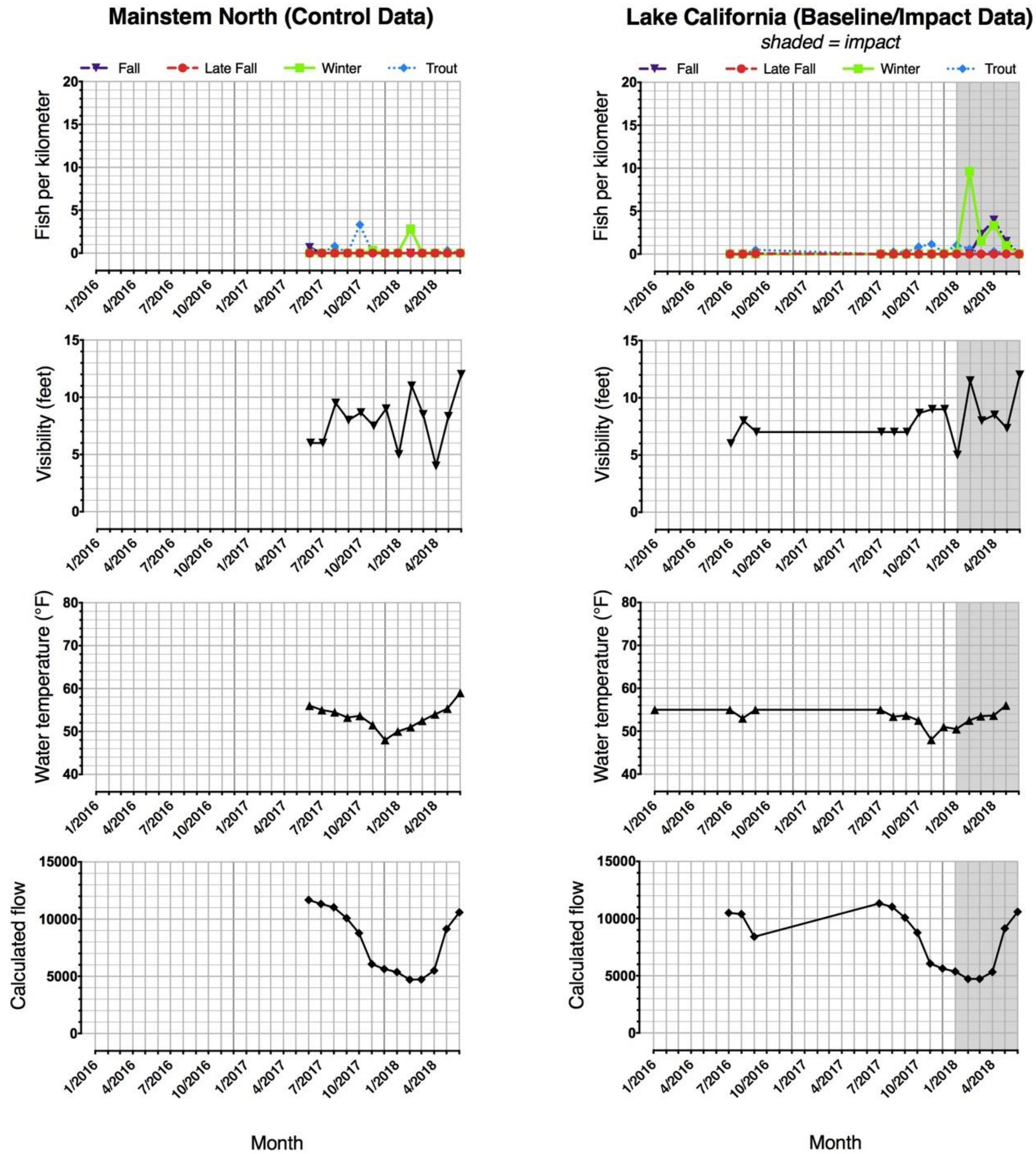

Figure 7. Comparison of Mainstem North control data and Lake California baseline and impact data. For fish per kilometer, visibility, water temperature, and calculated flow, data points represent the mean of all survey days during a given month. Fish per kilometer is an index value, and was calculated by dividing the number of fish counted by snorkelers surveying along each bank by the length of the survey area. See Table 2 for a description of physical variables.

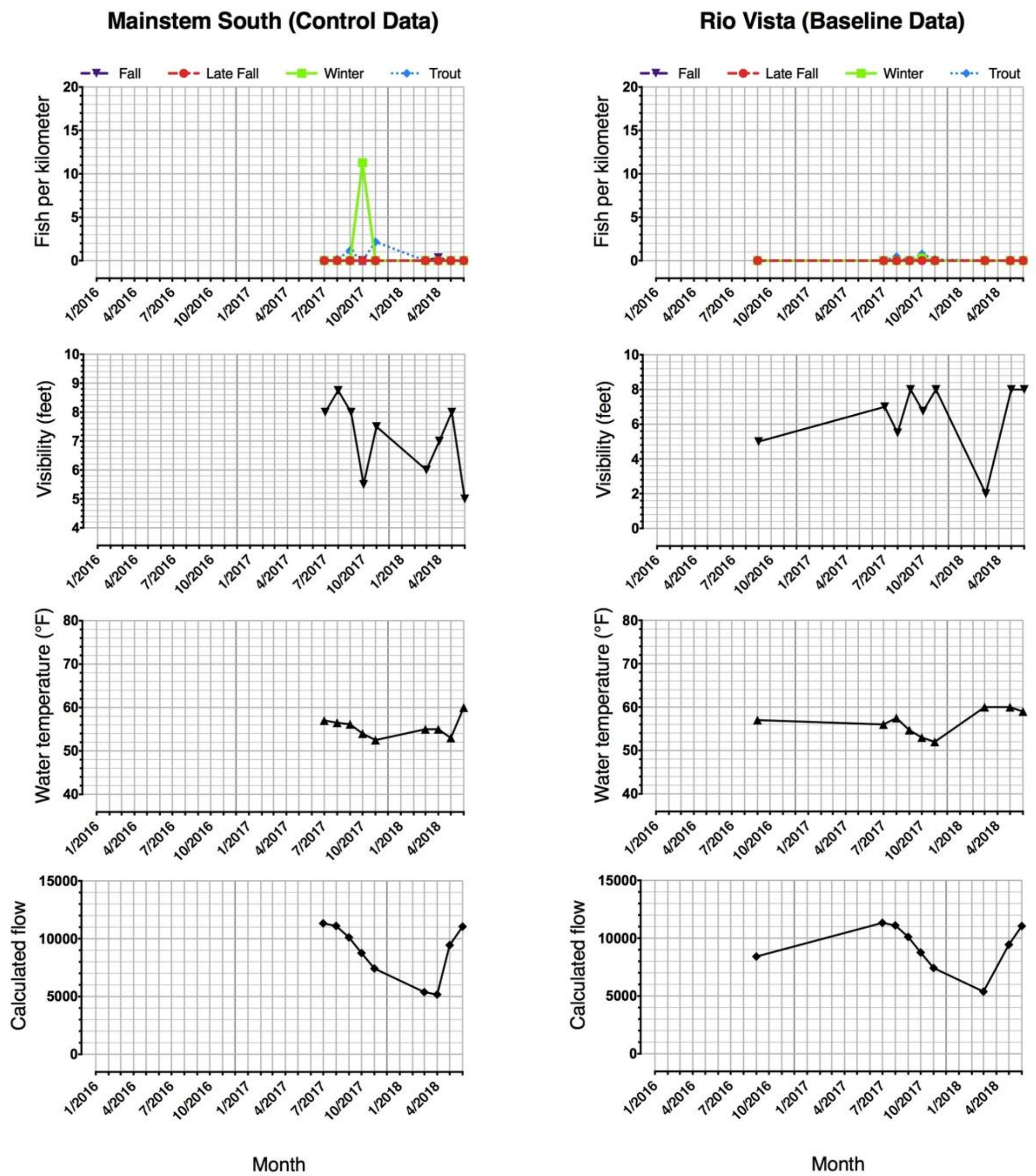

Figure 8. Comparison of Mainstem South control data and Rio Vista baseline data. For fish per kilometer, visibility, water temperature, and calculated flow, data points represent the mean of all survey days during a given month. Fish per kilometer is an index value, and was calculated by dividing the number of fish counted by snorkelers surveying along each bank by the length of the survey area. See Table 2 for a description of physical variables.

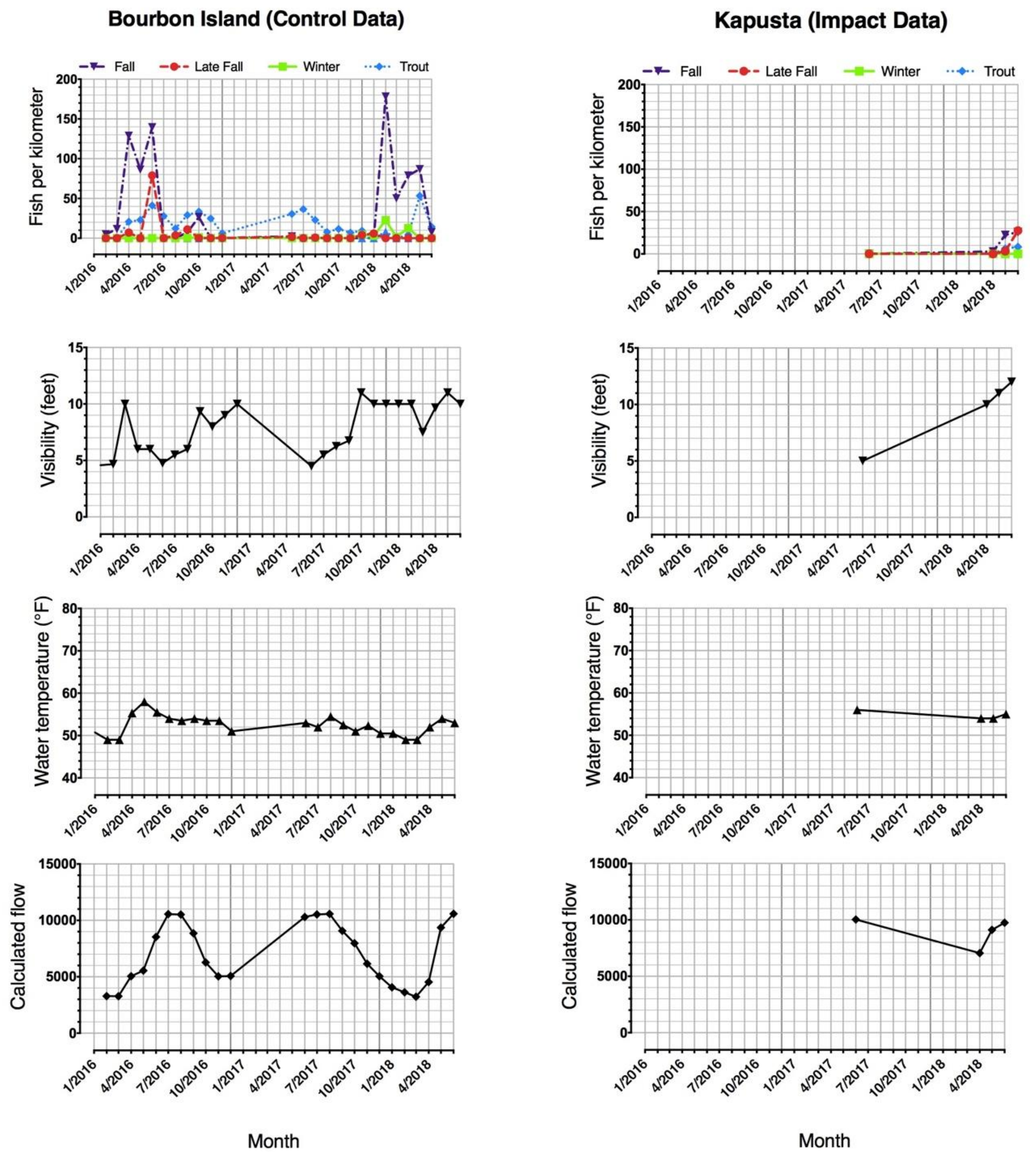

Figure 9. Comparison of Bourbon Island control data and Kapusta impact data. For fish per kilometer, visibility, water temperature, and calculated flow, data points represent the mean of all survey days during a given month. Fish per kilometer is an index value, and was calculated by dividing the number of fish counted by snorkelers surveying along each bank by the length of the survey area. See Table 2 for a description of physical variables.

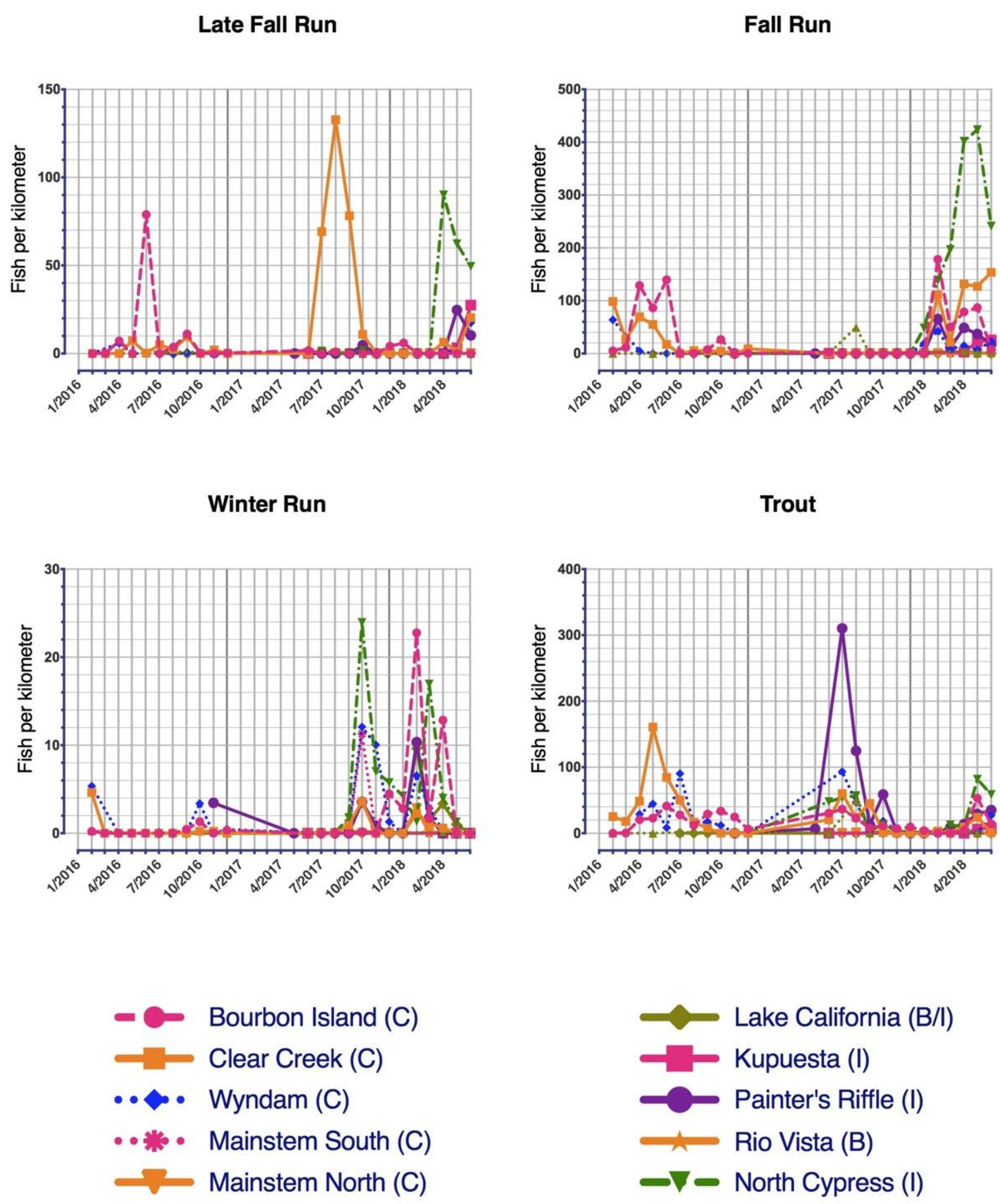

Figure 10. Observations of juveniles from each of the observed Chinook salmon runs and of Steelhead/Rainbow trout. Control, impact, or baseline is indicated in parentheses next to the site names in the legend. Note that the scale on the x-axis differs for each graph. Fish per kilometer is an index value, and was calculated by dividing the number of fish counted by snorkelers surveying along each bank by the length of the survey area.

Kutras Lake Habitat Structure Snorkel Surveys

Snorkel index surveys of the rearing structures sites began on March 9, 2018 to provide pre-project data. Three pre-project surveys were completed prior to structure placement within the lake. Thirteen proposed placement sites were snorkeled for relative salmonid abundance. On April 5th and 6th, 2018 seventeen rearing habitat structures were sunk along the edges of Kutras "lake." Post-project snorkel index surveys began on April 16, 2018. Since the project's completion nine snorkel surveys have been completed. To reduce bias, due to structure size, and timing, all data has been processed to show average salmonids per snorkel per habitat type. During the pre-project surveys 20.1 salmonids per snorkel per site were observed. During post project surveys thus far, 16.2 salmonids per snorkel per site have been observed near the new habitat structures (impact sites). Additionally, 3.1 salmonids per snorkel per site have been observed within the established control sites.

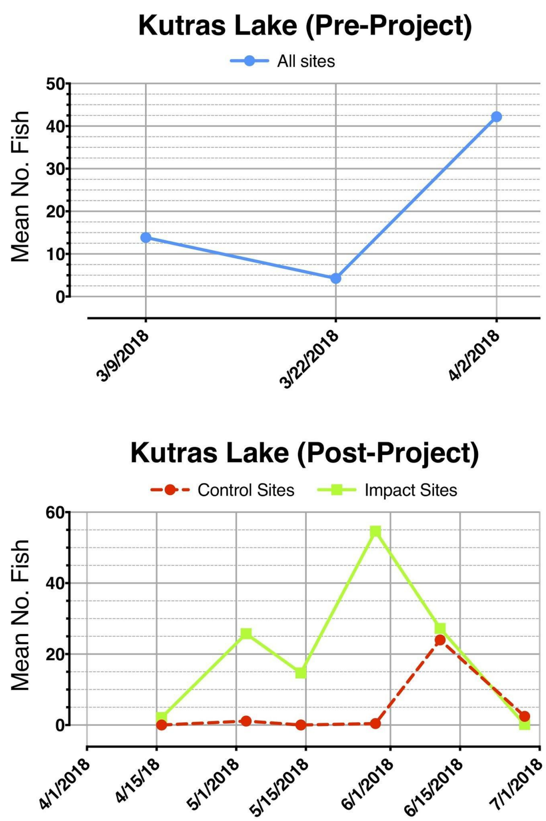

Figure 11. Mean number of salmonids at Kutras Lake before and after project implementation

Juvenile Habitat Mapping

During the 2017-18 field season all juvenile rearing side channels were mapped for depth and velocity, cover, and macrohabitat at least once. The two target flow regimes that crews were able to capture polygons for were the high flow (10,000 cfs+) and low flow (3,250-4,500 cfs) regimes. Keswick flows were not held at the intermediate flow (4,500-7,000 cfs) regime long enough during the field season for crews to collect habitat mapping data for every side channel. GIS data is currently being analyzed for accuracy by PSMFC personnel as well as the Chico State GIC lab. Below we show examples from two side channels, North Cypress and Painter's Riffle. Data for all three flow regimes will be presented in subsequent habitat restoration monitoring reports.

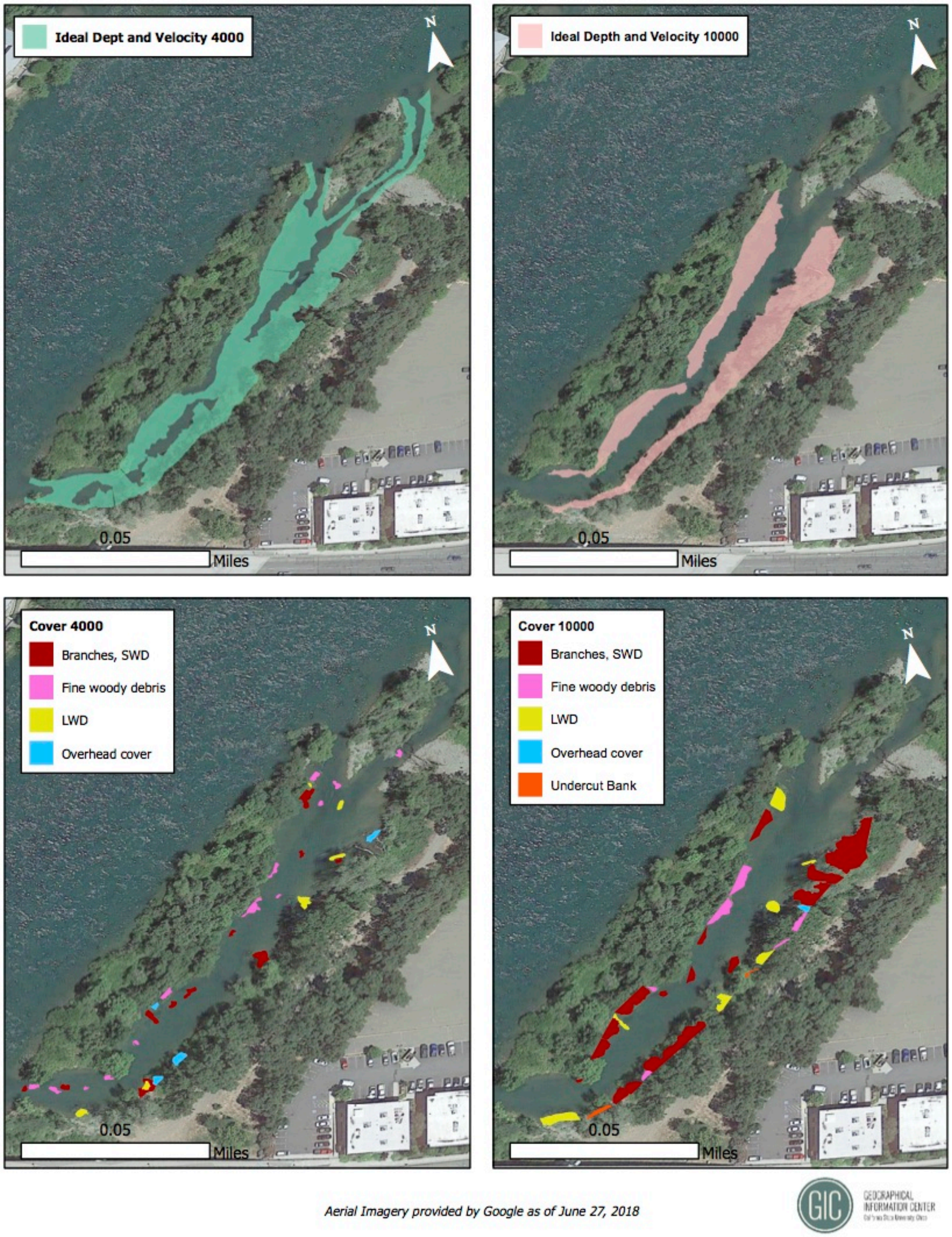

Figure 12. Examples of completed habitat mapping on North Cypress Impact side channel. In this example polygons for cover and ideal depth and velocity are represented for two of the flow regimes. Images on the left of the page represent depth and velocity, and cover polygons for flows of 3,250-4,500 cfs. Images on the right represent depth and velocity, and cover polygons at flows above 10,000 cfs.

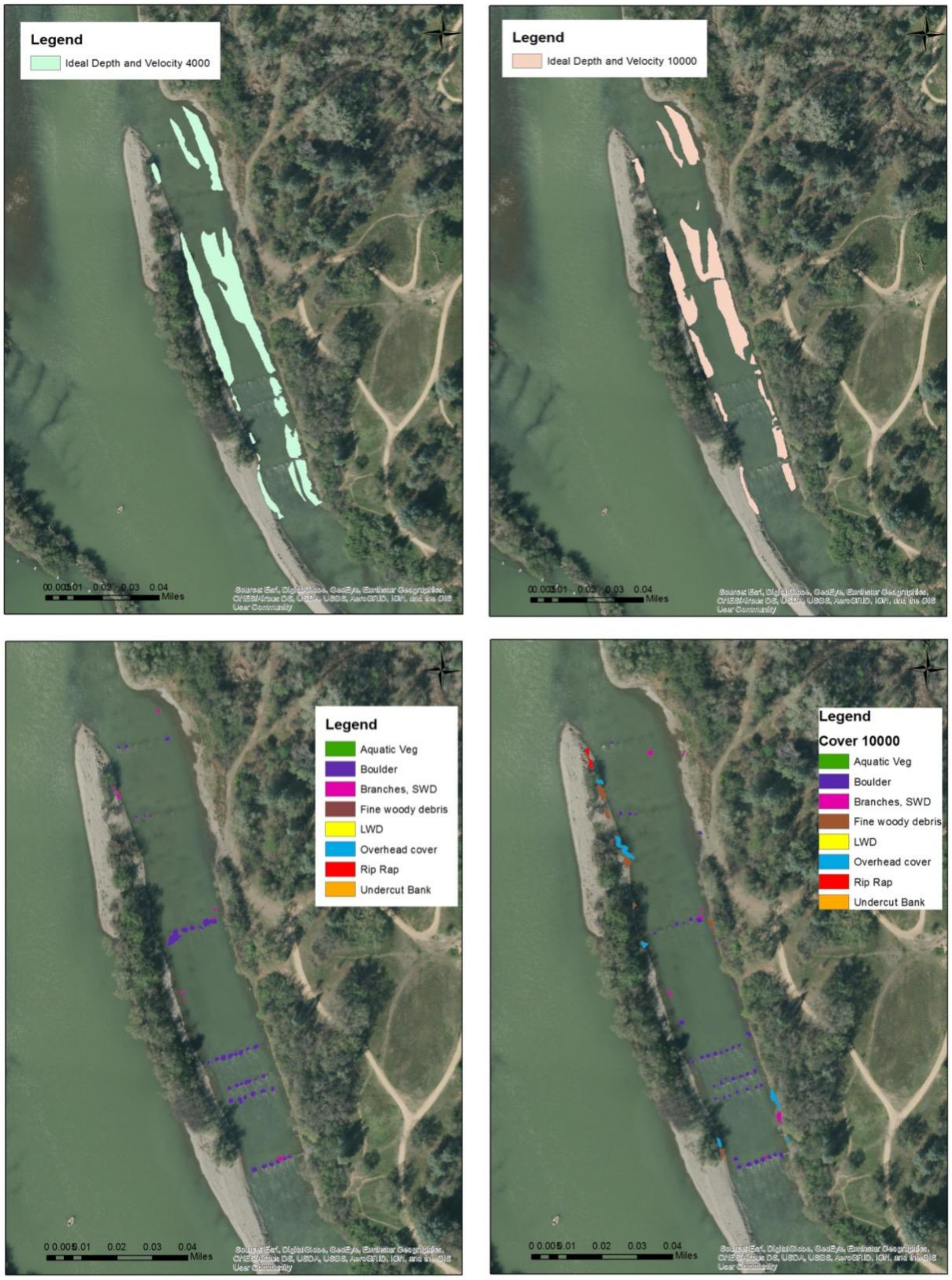

Figure 13. Examples of completed habitat mapping of Painter's Riffle side channel. In this example polygons for cover and ideal depth and velocity are represented for two of the flow regimes. Images on the left of the page represent depth and velocity, and cover polygons for flows of 3,250-4,500 cfs. Images on the right represent depth and velocity, and cover polygons at flows above 10,000 cfs.

Microhabitat Use

Microhabitat use associations for Chinook salmon and Steelhead/Rainbow trout of less than 201mm in fork length (FL) were sampled in pool, riffle and flatwater habitats on three occasions in March through June of 2018. The majority of Chinook salmon observed were fall run juveniles (> 50mm FL) and the majority of Steelhead/Rainbow trout observed were fry (</= 50mm; Table 7, Figure 14). The 50mm fork length threshold for the distinction between life stages is tentative pending further data collection and formal analysis of differences in selection of habitat attributes for the two life stages.

Table 7. Number and life stage of Chinook salmon and Steelhead/Rainbow trout observations between March and June 2018.

Species / Stock	Observations	% Fry (</= 50mm)	% Juvenile (> 50mm)
Fall run Chinook Salmon	124	19%	81%
Late-Fall run Chinook Salmon	11	82%	18%
Winter run Chinook salmon	16	0%	100%
Steelhead/Rainbow trout	143	62%	38%

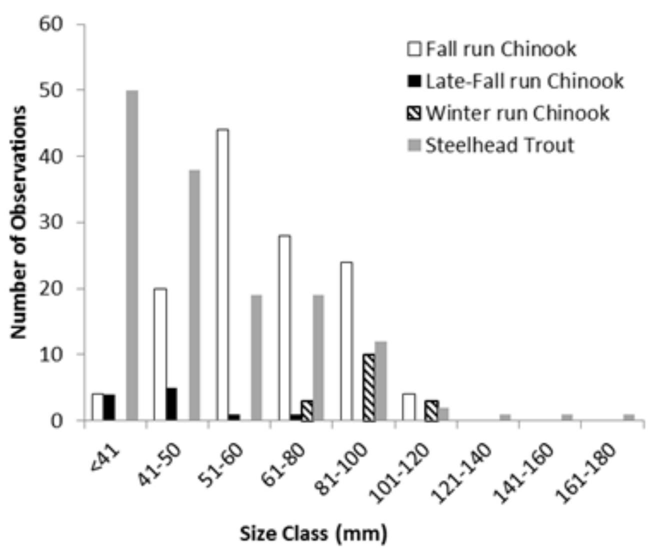

Figure 14. Size class distributions for Chinook salmon and Steelhead/Rainbow trout observations between March and June of 2018.

While the first four months of microhabitat use sampling does not provide a sufficient amount of data to formally describe habitat suitability curves and habitat preferences, it does provide an opportunity to determine if fish habitat mapping criteria are representative of habitat characteristics where fish are actually being observed. Habitat mapping criteria identify suitable habitat as meeting either: both a depth and velocity criteria; or, a distance to cover criteria. Optimal habitat is defined as areas meeting all depth, velocity and cover criteria. Habitat mapping criteria for suitable mean water column velocities range from 0.0 to 0.8 ft./sec. This range captures 91% of Chinook fry and 64% of juvenile observations, and for steelhead trout, this range captures 95% of fry and 67% of juvenile observations (Figure 15). Criteria for suitable water depths range from 0 to 3.3 feet and this range captures more than 99% of all Chinook and steelhead observed. (Figure 15). Habitat mapping criteria for distance to cover range from 0.0 to 2.0 feet. This range captures 88% of Chinook fry and 86% of juvenile observations. For steelhead trout, this range captures 94% of fry and 84% of juvenile observations (Figure 15). The majority of all fish observations occur below or within a cover element (distance to cover = 0). Relative to habitat mapping criteria and all salmonids (n = 294), 69% are observed in optimal habitats, 26% in suitable habitats, and 5% in unsuitable habitats.

Chinook Salmon All Runs **Steelhead/Rainbow trout**

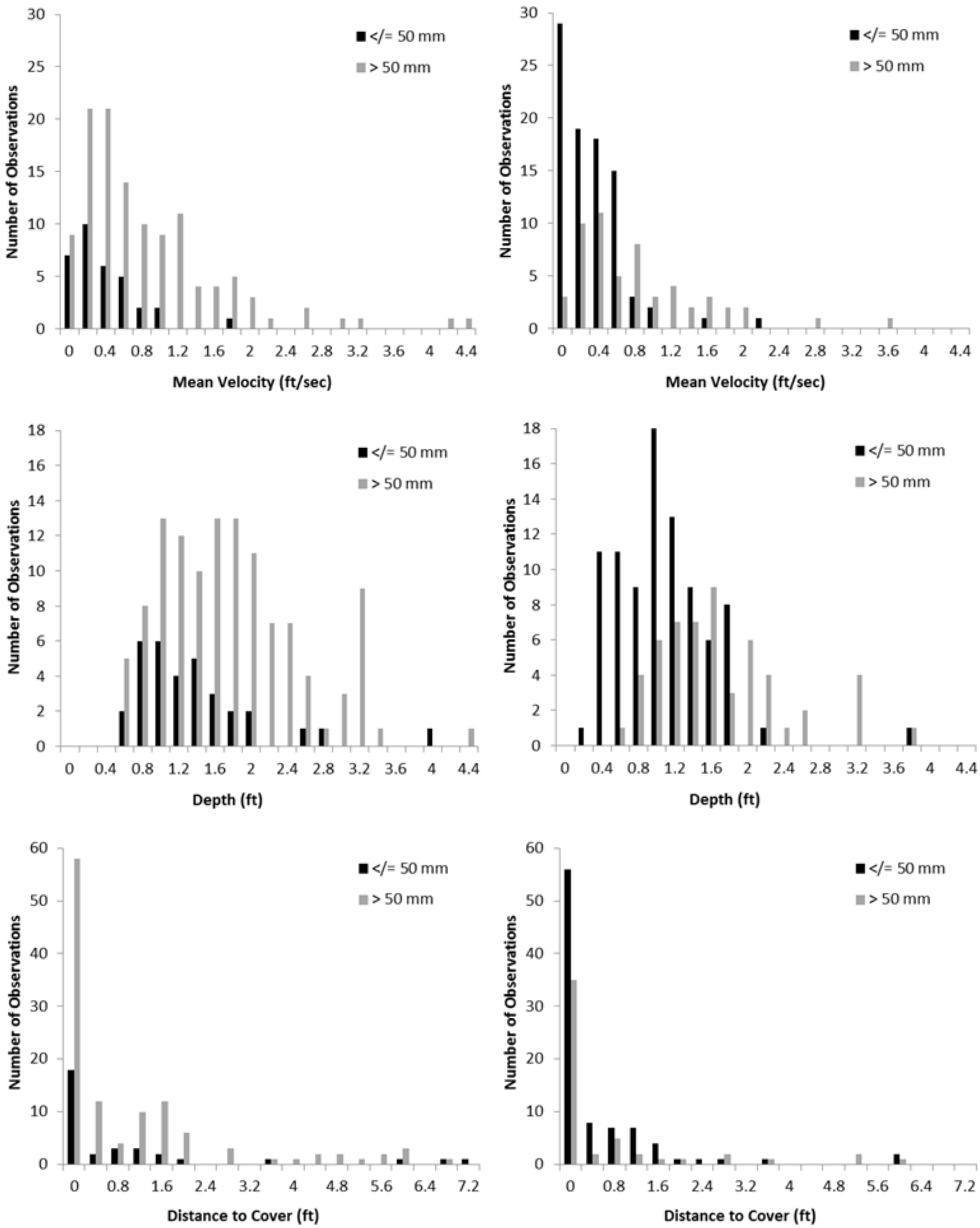

Figure 15. Mean velocity, depth and distance to cover associations for observations of fry (</= 50mm FL) and juvenile (> 50mm FL) Chinook salmon and Steelhead/Rainbow trout.

In general, small wood debris and fine woody vegetation are the primary cover types used by both Chinook salmon and Steelhead/Rainbow trout (Table 8). Steelhead/rainbow fry are the only salmonid group to utilize cobble cover to any great extent (31% of observations). Small woody debris had highest percent usage for both life stages of Chinook salmon and for steelhead/rainbow juveniles. Large woody debris largely not used by fry but has a 8% to 9% association with juvenile sized fish (Table 8).

TABLE 8. PERCENT USE OF COVER TYPES BY CHINOOK SALMON AND STEELHEAD/RAINBOW TROUT FRY (</= 50MM FL) AND JUVENILES (> 50MM FL).

COVER TYPE	Chinook salmon		Steelhead/Rainbow trout	
	Fry	Juvenile	Fry	Juvenile
Cobble	3%	4%	31%	2%
Boulder	0%	1%	2%	0%
Fine woody vegetation	39%	26%	28%	16%
Branches, small woody debris	52%	56%	31%	67%
Log, large woody debris	0%	8%	1%	9%
Overhead cover	3%	3%	2%	2%
Undercut banks	0%	0%	2%	2%
Aquatic vegetation	3%	2%	2%	2%
Rip Rap	0%	0%	0%	0%

DISCUSSION AND FUTURE PLANS

Fish Abundance Index and Associated Physical Variables

Thus far, we have collected impact data from North Cypress, Painter's Riffle, Lake California, and Kapusta Side Channels. The amount of data collected is still relatively small and is not yet amenable to statistical analyses, so we advise caution in making management decisions based on the trends seen in the data presented here. With this caveat in mind, we did see some trends worth considering as the project moves forward. Considerably fewer fish have been observed during Lake California snorkel surveys as compared to North Cypress and Painter's Riffe. One possible explanation for this could be that Lake California lacks some resource that is present in the other side channels, such food availability. Alternatively, rather than a resource limitation, there could be geographic constraints that prevent juvenile salmon from utilizing the habitat, such as distance to spawning habitat.

Future work will help distinguish these alternatives. A new CSU Chico graduate student, Drew Nielsen will be comparing food availability and juvenile growth rates in the different channels via invertebrate drift sampling, seining, and enclosure studies. More detail on this work is provided below, in future directions.

Kutras Lake Habitat Structure Snorkel Surveys

Habitat structures were added to Kutras lake with the goal of amending habitat available to juvenile salmonids at the lowest river flows. Previous to project completion, flows were near the design flows of 3,250 cfs in the upper river. During this time, the average salmonids observed per snorkel amounted to about 20 fish per site. River flows were steadily increased to maximum summer flows shortly after the project's completion. Increased summer releases resulted in many habitat structures falling out of the preferred depth criteria of 3.3 feet, possibly resulting in fewer observations of salmonids. Based on overall snorkel data there are presumably far fewer juvenile fish in the upper river during the summer months as opposed to the winter and spring. A more complete data set, with surveys done during the full range of river flows and Chinook spawning seasons is required to understand how juvenile fishes are responding to the habitat structures that were placed within the lake. Analysis of the existing post-project data did show that salmonids were observed at higher rates in areas where structures were placed compared to areas without added structure. Average salmonids observed per snorkel was calculated to about 16 fish per impact site, where as the average for control sites was only around 3 fish per site. Flows and relative juvenile abundance may play a key role in how and when these structures are utilized by juvenile fishes and more data needs to be collected to fully understand the impact these structures may have on rearing juvenile salmonids.

Juvenile Habitat Mapping

Juvenile habitat mapping has currently been conducted at two of our three target flows, and a subset of this data has been examined. Additional mapping at intermediate flows (between 4500 and 7000 cfs) will be conducted as soon as logistically feasible. Greyson Doolittle, a former PSMFC employee who joined the CSU Chico graduate program in August 2018, will be analyzing this data as part of his master's thesis. His work will determine how flow variation affects the amount of suitable and optimal habitat in the side channels.

Microhabitat Use

Microhabitat use results generally support the Goodman et al. (2015) depth, velocity and cover habitat mapping criteria currently being implemented with only 5% of all observations occupying unsuitable habitats. However, the 0.8 ft./sec maximum velocity criterion may be underestimating suitable velocities for rearing juvenile Chinook salmon and steelhead in side channel habitats as 36% and 33% respectively of juvenile life stage observations occur at greater velocities. Additional data collection in the second year of monitoring will enable analysis of whether this effect is due to a velocity preference or availability. Initial microhabitat use results for depth, velocity and cover can help inform side channel restoration design flows, bed form and placement of cover elements with a couple of caveats. The first being that juvenile life stage fish may be intentionally selecting velocities greater than 0.8 ft/sec rather than occupying those habitats because of a lack of availability of slower velocity habitats. Secondly, while zero distance to cover captures the majority of all species and life stage observations, additional microhabitat use data collection and analysis will be necessary to explore cover availability vs. cover preferences for specific cover types. In order to better inform restoration design it would also be beneficial in the coming monitoring year to collect ancillary data regarding cover types in microhabitat use surveys, such as the mechanisms for cover recruitment and the potential occurrence of both in water and overhead cover at fish observations. For example, are large, small and fine woody debris elements being recruited from the immediate bank or being recruited from upstream. Additionally, the role of unembedded cobble will require a more in depth investigation.

Future Directions: Seining and Enclosure Studies

The seining and enclosure studies are upcoming, and are included in the master's thesis research of Drew Nielsen, who was hired as a graduate student researcher in Summer 2018. Seining efforts were initially proposed to meet the objectives of estimating the average size and condition, and stomach content of salmonids within side channels and the main stem river. As high turbidity values can limit the utility of relying solely on dive counts to provide year round estimates of relative abundance, seining efforts will also explore the possibility of estimating relative abundance by catch per unit effort (CPUE) methods. To meet these multiple objectives, seining at fixed sites with beach seines will be included where habitat conditions permit, and wandering pole seine methods will be standardized as much as possible so that CPUE estimates can be generated.

Seining targeting juvenile salmonids will be performed monthly to establish species / run based average size, condition, and gut contents of fish, within control and impact side channel sites and the main stem Sacramento River. To explore the potential correlation between dive count indices and seining CPUE, seining efforts and a dive count should be performed on successive days if feasible.

Enclosure studies will be used as a supplement to seining studies to provided more controlled data on fish growth in different habitats. While less "natural" than the seine data, these studies will ensure sampled fish have been using the sampled habitat for an appreciable amount of time. Sampling will occur for a minimum of 30 days per year over a two year period. If logistically feasible, the study may extend up to 60 days. This scale has been found to be sufficient to detect growth differences in floodplain habitat (Jeffres, Opperman, & Moyle, 2008). Study timing is anticipated to be in late spring depending on flows and safety.

For both the seining and enclosure studies, gut contents will be non-lethally sampled for a subset of fish in order to compare diets of fish in different habitats.

Additional detail about the planned methodology for the seining and enclosure studies is available in the *Upper Sacramento River Anadromous Fish Habitat Restoration Project Monitoring Plan and Protocols* (Tussing & Banet, 2017).

Future Directions: Invertebrate Drift Sampling

Invertebrate drift sampling is upcoming. Permits were obtained in August 2018, and this work will be included in the master's thesis research of Drew Nielsen, who was hired as a graduate student researcher in Summer 2018.

Drift sampling of invertebrates will be performed monthly to establish food availability within control and impact side channel sites and the main stem Sacramento River. Timing (day and time of day) will be close to the timing of fish gut sampling from fish capture seining efforts.

Future Directions: Fish Abundance Calculations

The fish abundance data presented here is reported as fish per kilometer. Recently, we have been asked to provide fish abundance data as fish per area in order to inform models developed by the CVPIA Science Integration Team (SIT). The data contained in this report was not recorded in a way that facilitates this calculation; however, moving forward we plan to revise the way data is recorded in order to allow calculation of fish per area.

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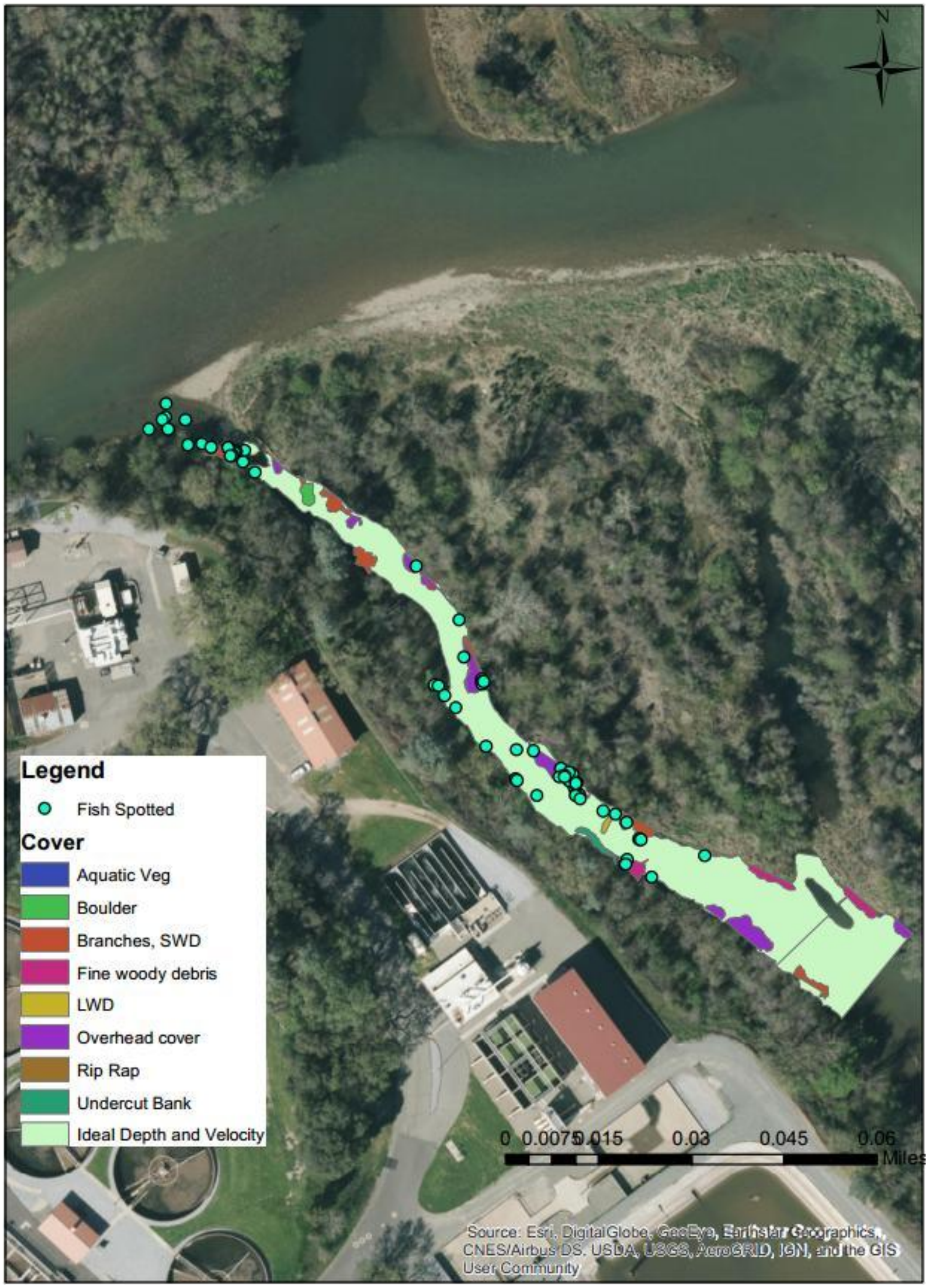
APPENDIX A: Relevant tables and figures

Appendix A Table 1. Table used in the upper Sacramento River to determine juvenile Chinook run by comparing fish fork length in millimeters to range of lengths in table on any given date.

DATE	FALL	SPRING	WINTER	LATE-FALL	All runs SEE BELOW	DATE
1-Jul	61-134	135-182	183-270	34-60	0-33	1-Jul
2-Jul	62-135	136-183	184-270	34-61	0-33	2-Jul
3-Jul	62-136	137-184	185-270	35-61	0-34	3-Jul
4-Jul	62-137	138-185	186-270	35-61	0-34	4-Jul
5-Jul	63-138	139-187	188-270	35-62	0-34	5-Jul
6-Jul	63-139	140-188	189-270	35-62	0-34	6-Jul
7-Jul	64-140	141-189	190-270	35-63	0-34	7-Jul
8-Jul	64-141	142-190	191-270	36-63	0-35	8-Jul
9-Jul	65-142	143-192	193-270	36-64	0-35	9-Jul
10-Jul	65-143	144-193	194-270	36-64	0-35	10-Jul
11-Jul	65-143	144-194	195-270	36-64	0-35	11-Jul
12-Jul	66-144	145-195	196-270	37-65	0-36	12-Jul
13-Jul	66-145	146-197	198-270	37-65	0-36	13-Jul
14-Jul	67-146	147-198	199-270	37-66	0-36	14-Jul
15-Jul	67-147	148-199	200-270	37-66	0-36	15-Jul
16-Jul	68-148	149-201	202-270	38-67	0-37	16-Jul
17-Jul	68-149	150-202	203-270	38-67	0-37	17-Jul
18-Jul	68-150	151-203	204-270	38-67	0-37	18-Jul
19-Jul	69-151	152-205	206-270	38-68	0-37	19-Jul
20-Jul	69-152	153-206	207-270	39-68	0-38	20-Jul
21-Jul	70-153	154-207	208-270	39-69	0-38	21-Jul
22-Jul	70-154	155-209	210-270	39-69	0-38	22-Jul
23-Jul	71-155	156-210	211-270	39-70	0-38	23-Jul
24-Jul	71-156	157-211	212-270	40-70	0-39	24-Jul
25-Jul	72-157	158-213	214-270	40-71	0-39	25-Jul
26-Jul	72-158	159-214	215-270	40-71	0-39	26-Jul
27-Jul	73-159	160-216	217-270	40-72	0-39	27-Jul
28-Jul	73-160	161-217	218-270	41-72	0-40	28-Jul
29-Jul	73-161	162-218	219-270	41-72	0-40	29-Jul
30-Jul	74-163	164-220	221-270	41-73	0-40	30-Jul
31-Jul	74-164	165-221	222-270	41-73	0-40	31-Jul
1-Aug	75-165	166-223	224-270	42-74	0-41	1-Aug
2-Aug	75-166	167-224	225-270	42-74	0-41	2-Aug
3-Aug	76-167	168-226	227-270	42-75	0-41	3-Aug
4-Aug	76-168	169-227	228-270	42-75	0-41	4-Aug
5-Aug	77-169	170-229	230-270	43-76	0-42	5-Aug
6-Aug	77-170	171-230	231-270	43-76	0-42	6-Aug
7-Aug	78-171	172-232	233-270	43-77	0-42	7-Aug
8-Aug	78-172	173-233	234-270	44-77	0-43	8-Aug
9-Aug	79-174	175-235	236-270	44-78	0-43	9-Aug
10-Aug	79-175	176-236	237-270	44-78	0-43	10-Aug
11-Aug	80-176	177-238	239-270	44-79	0-43	11-Aug
12-Aug	80-177	178-239	240-270	45-79	0-44	12-Aug
13-Aug	81-178	179-241	242-270	45-80	0-44	13-Aug
14-Aug	81-179	180-243	244-270	45-80	0-44	14-Aug
15-Aug	82-181	182-244	245-270	46-81	0-45	15-Aug
16-Aug	83-182	183-246	247-270	46-82	0-45	16-Aug
17-Aug	83-183	184-247	248-270	46-82	0-45	17-Aug
18-Aug	84-184	185-249	250-270	46-83	0-45	18-Aug
19-Aug	84-185	186-251	252-270	47-83	0-46	19-Aug
20-Aug	85-187	188-252	253-270	47-84	0-46	20-Aug
21-Aug	85-188	189-254	255-270	47-84	0-46	21-Aug
22-Aug	86-189	190-256	257-270	48-85	0-47	22-Aug
23-Aug	86-190	191-257	258-270	48-85	0-47	23-Aug
24-Aug	87-192	193-259	260-270	48-86	0-47	24-Aug
25-Aug	88-193	194-261	262-270	49-87	0-48	25-Aug
26-Aug	88-194	195-262	263-270	49-87	0-48	26-Aug
27-Aug	89-195	196-264	265-270	49-88	0-48	27-Aug
28-Aug	89-197	198-266	267-270	50-88	0-49	28-Aug
29-Aug	90-198	199-268	269-270	50-89	0-49	29-Aug
30-Aug	90-199	200-268	270-270	50-89	0-49	30-Aug
31-Aug	91-201	202-270	*	51-90	0-50	31-Aug

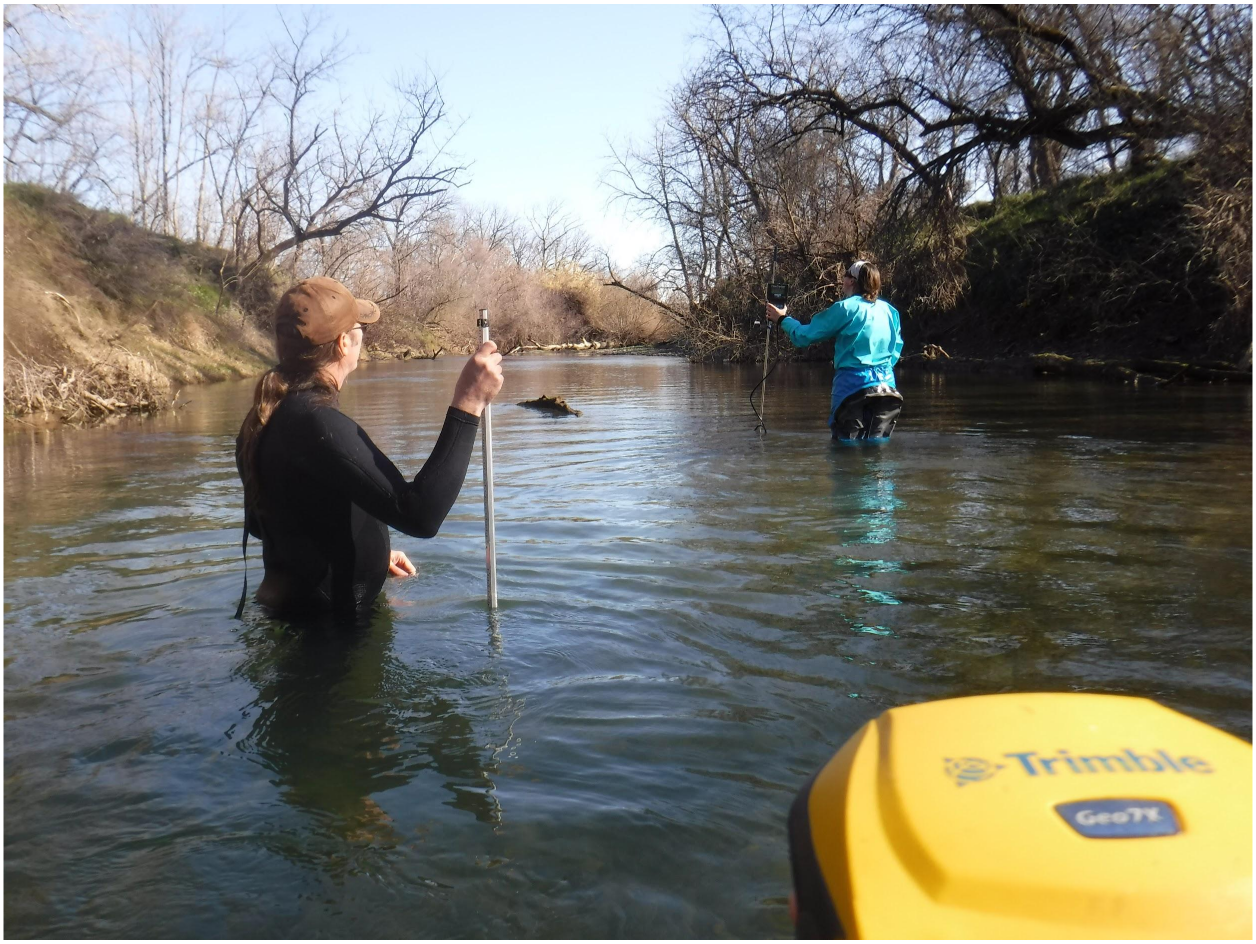


Appendix A Figure 1. Example of habitat mapping completed on Clear Creek Side Channel. Image includes the different types of juvenile fish cover and depth and velocity polygons that have been mapped along with areas where individual fish were spotted during microhabitat use surveys. Habitat polygons were captured at low Keswick release (3,250-4500 cfs).

Appendix A Figure 2. Kutras Lake restoration site. The green icons represent the habitat structures placed along the edge. Blue icons are corresponding control sites.

Appendix A Figure 3. Snorkel survey of Kapusta side channel in April 2018.

Appendix A Figure 4. Snorkel Survey being conducted on a habitat structure within Kutras Lake.



Appendix A Figure 5. Habitat mapping being conducted on the restored Lake California Side Channel.