Evaluation of Fisheries Relating to Floodplain Restoration on the Cosumnes River Preserve[1]

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Introduction

The continuous worldwide alteration and degradation of aquatic ecosystems has stimulated interest in the multidisciplinary topic of stream restoration. Among the more important aspects of stream restoration is the maintenance of the terrestrial aquatic interface through the restoration of shallow water habitat, the loss of which has been listed as the cause of population declines for several native species including Chinook salmon, Delta smelt, and splittail (Meng and Moyle, 1995, Sommer, et al., 1997). The strongest link between food availability, food use, and growth rates of river fish is associated with the seasonal inundation of the floodplain (Schlosser, 1991). Increased availability of organic matter and invertebrates during floods, along with the expansion of the physical habitat, results in increased food intake and growth rate and improved condition for most river fish (Schlosser, 1991). The importance of shallow water habitat to the overall health of the Sacramento- San Joaquin basin has only recently been considered and its' preservation and creation is presently the focus of many state, federal, and private organizations.

Shallow water habitat has been given many definitions as there are a complexes of shallow water habitat types, all of which function in distinct ways and cater to specific fish species. Often the most challenging aspect of creating this type of habitat is doing so in a manner that is consistent with the needs of a specific species of fish while excluding non-native species. To meet this end, however, will require a level of understanding much greater than presently exists.

In 1995, The Nature Conservancy began a plan of floodplain restoration on land adjoining the lower reach of the Cosumnes River. Initial restoration of this area included the breaching of levees and the removal of small parcels of farmland from production. Since 1995, further restoration efforts have been made including additional levee breaks, levee setbacks and the reforestation of farmland. Within this area there is an abundant diversity of habitat ranging from farmland to old growth, riparian forest. In this evaluation it was attempted to study a wide range of these habitats during flood events to determine what species of fish were utilizing these inundated habitats.

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Study Area

The study area is located within the boundaries of the Cosumnes River Preserve, a large rapidly expanding tract of land owned and operated by several private and public agencies. These agencies, including The Nature Conservancy, Bureau of Land Management, Ducks Unlimited and the California Department of Fish and Game have joined to create the preserve in an effort to conserve and create additional endangered valley wetland habitats. The Cosumnes River Preserve is located along the Cosumnes River just east of Interstate 5 near the town of Franklin (Figure 1).

The Cosumnes River Preserve includes many types of habitat including fertile farmland, old growth, valley riparian forest, as well as land in various stages of wetland restoration. In this study, sample sites were chosen within an area that The Nature Conservancy has developed for seasonal flooding through the planned breaching of levees along the Cosumnes River. Ten sample sites were chosen to represent the various habitat types located within the floodplain project boundaries.

Methods

Sampling took place once a week, beginning January 22nd and ending May 22nd, a total of 17 field days. Ten sites were selected within the floodplain area and were chosen on the basis of habitat diversity as well as the ability to effectively use a beach seine within the area. A beach seine 35 feet long and 4 feet tall with 1/8-inch mesh was used to sample each site. Upon capture all fish were keyed to species, measured in millimeters (total length), observed for anomalies and released. All other organisms captured including aquatic insects and amphibians were recorded to species. A second beach seine was done at each site if the area was large enough to accommodate a second haul without having been influenced by the initial pass. Temperature and maximum depth were then taken at each site. Other factors, potentially affecting fish were also noted, including presence of flow and cover. Voucher specimens were kept in instances where uncertainty existed in the original field identification. The California Department of Fish and Game Stream Evaluation Group verified all voucher specimens.

An important component to this study was to determine if the flooded habitat was being used as spawning and rearing habitat. Fish captured during this study were broken down into two age classes for the purpose of filtering out spawning and rearing data. The first class was young of the year (YOY) fish, which included all fish less than one year old, hatched in either late winter or spring. These fish tended to be small (less than 25mm), particularly early in the sampling and very fragile to handle. The size of the fish suggests that they were hatched in or near the study area or were presently rearing in the area in which they were captured. The second class contains all other fish, including juvenile and adults.

In March, many young of the year (YOY) fish began appearing in our catches, including numerous splittail. YOY, especially ones under 25mm, are typically fragile and are subject to high mortality rates when handled. When YOY were caught they were often in

very large numbers, which would cause delays in processing and add stress and additional mortality problems to the fish. It was decided that all YOY catches would be identified to species and estimated for abundance then released immediately to minimize post release mortality. Total lengths were not recorded for YOY catches except for Chinook salmon.

Due to fluctuating flows in the Cosumnes River water depths in the study area were constantly changing. When river flows were high, overland flows through the study areas reached depths of up to 8 feet. Inversely, when flows in the river were low, water would drain off the floodplain resulting in some areas being de-watered. Consequently, during these periods of high and low flows some sites were not sampled due to flood or dry conditions.

Results

On January 12th the Cosumnes River recorded flows of 6,516 cubic feet per second (CFS) at the gauging station at Michigan Bar located at River Mile 36.1, marking the first time the river had reached 1000 CFS since the previous spring. From observations made throughout the study it was determined that flows of approximately 1100 CFS would allow water to flow into the upper levee breaches thereby flooding the study area. It is believed that a pulse of water takes approximately 2 days to reach the breaks in the levee from Michigan Bar. Using this information it is estimated that water began flowing into the study area on approximately January 14th. Water continued to inundate at least some portions of the habitat until the conclusion of the sampling on May 22nd.

Due to widely fluctuating flows in the study area not all sites were sampled each field day. In fact, out of the 17 field days, none included the sampling of all 10 sites, giving a good indication of the variable conditions. The inability to sample was caused by de-watered conditions 7 of the 17 days and by flooded conditions for the remaining 10 days. On six occasions, conditions at specific sites changed from dry to flooded or flooded to dry on consecutive sampling days.

Eighteen species of fish were caught during this study. Of these 6 (33.3%) were native species and 12 (66.6%) were non-native. Species caught in this study are listed in Table 1.

Sixteen species of adults and juvenile fish were caught. Inland silversides were the dominant species in this class accounting for 58% of all adult and juvenile fish. Other dominant species include Sacramento squawfish (17%), mosquitofish (9%), golden shiner (6%) and redear sunfish (6%).

Nine species of YOY fish were caught. Splittails were the dominant YOY species (67%) followed by Sacramento sucker (25%), inland silverside (2.3%) and Chinook salmon (1.6%).

The numbers of fish caught in both classes, including the number of sites in which each species was caught are listed in Table 1.

The ten sample sites selected varied in physical attributes as well as in location. What follows is a brief description of each site.

Site 1 was located just inside the upper most levee breach. The substrate consisted of fine sediment and sand on top of hard pan clay. No cover or instream vegetation was present. Flow occurred in Site 1 throughout the study. Depths in Site 1 averaged 0.32 meters while water temperatures averaged 11.4 C.

Site 2 was located directly adjacent to Site 1 on the north side of the setback levee and was intended to determine if stranding was occurring as a result of the setback levee. Flow was only present when high flows occurred in the river and overland flows topped the setback levee. Substrate consisted of a loam mixture. Some vegetative growth occurred near the end of sampling providing sparse cover. Average water depths were 0.47 meters and average water temperatures were 14.2 C.

Site 3 was located along the west side of the setback levee in the same field as Sites 1 and 2. Site 3 had very little drainage thereby producing conditions of no flow and warmer, stagnant water. Substrate was a loam mixture with some late season vegetation and macrophytic growth. Average depths were 0.46 meters and average water temperatures were 13.4 C.

Site 4 was located adjacent to Site 3 on the Northwest side of the setback levee. Early in the season Site 4 was similar to Site 2, however, in early March a large break occurred in the setback levee creating significant flow through the area. Substrate was hard pan clay with some fine sediment. No cover or vegetation was present in Site 4. Average water depths were 0.48 meters and average water temperatures were 14.4 C.

Site 5 was located in the Northwest corner of a field of restored farmland and was often de-watered due to its location. When Site 5 was sampled conditions consisted of submerged grass and various overhanging vegetation. Flow was usually not present except in cases of very high overland flows. Average water depths were 0.51 meters and average water temperatures were 11.2 C.

Site 6 was located adjacent to Wood Duck Slough in an area where excess water from the slough would spill onto a vegetated slope as water depths became higher. No flow occurred in Site 6. Cover only existed as a result from the submerged vegetation substrate. Average water depths were 0.42 meters and average water temperatures were 15.9 C.

Site 7 was located in the same field as Site 5 but was often flooded to a depth that made sampling unfeasible. Substrate consisted of a loam mixture with some submerged and overhanging vegetation. Very little flow occurred in Site 7. Average water depths were 0.46 meters and average water temperatures were 16.8 C.

Site 8 was located in a secondary-growth, oak-forest that contained submerged vegetation and plentiful overhead cover. Flow was usually present through the site. Average water depths were 0.53 meters and average water temperatures were 13.6 C.

Site 9 was located in the lower most field of restored farmland. Flow was present about half the time the site was sampled. Submerged vegetation was the dominant substrate with some overhanging vegetation cover present. Average water depths were 0.65 meters and average water temperatures were 13.4 C.

Site 10 was located in the same field as Site 9 at the western end. Due to its low relative elevation it was often flooded to a depth that did not allow for sampling. Substrate consisted of submerged vegetation. Average water depths were 0.64 meters. and average water temperatures were 14.0 C. Locations of all sites are located in Figure 2.

Site 1, the closest to the uppermost breach, contributed only1.6% of the total fish caught and had the greatest number of tows in which no fish were caught. Roughly one third of the total number of hauls contained no fish. Successful hauls consisted of mainly salmon and small numbers of YOY sculpin. Site 3 possessed the largest numbers of YOY fish. Sixty six percent of all YOY were captured at this site. Species composition at site 3 was dominated by splittail (74%) and Sacrament suckers (26%). Site 6 possessed the greatest species diversity with 14 species observed over the study period. Seine hauls at this site produced 54% of the total number of all adults and juvenile fish and only 4% of the YOY observed over the study period. Haul contents at Site 7 yielded 22% of the adult and juvenile catch and 0.9% of the YOY total. Species composition within this site was dominated by inland silversides (86%).

Exact numbers of days sampled, number of tows, number of tows with no fish, species diversity, and total numbers of each age class are listed in Table 2.

During this study 52 yearling Chinook salmon ranging from 37-108 mm were captured. The first salmon caught was on March 2nd and the last salmon caught was on May 7th. Salmon were caught in all but 3 of the 10 sites. Temperatures at the sites where salmon were caught ranged from 9-16.5 degrees Celsius (C). Site 8, located in the oak forest, accounted for 37 % of the salmon caught while Site 1 accounted for 29% of the total catch. One yearling salmon caught contained a coded wire tag distinguishing it as a Mokelumne River fish.

Splittail made up a large portion of the catch during this study. Although no juvenile or adult splittail were recorded it was estimated that 2145 YOY were captured, accounting for 52% of all fish caught in this study. Splittail were the only species captured in all 10 sampling sites. Site 3 accounted for 72% of the total splittail caught.

The beach seine used in this study had 1/8-inch mesh, which allowed for the capture of aquatic invertebrates during routine sampling. Since most invertebrates with time could slip through the mesh, abundance numbers were not possible. Catches of invertebrates

during regular sampling did allow for the general assessment of populations. During the initial sampling days it was noted that only red crayfish (*Procambarus sp.*) were present and that no aquatic insects were captured. On February 9th, approximately 4 weeks after the habitat was first flooded, the first aquatic insect, a backswimmer (Gerridae) was caught. Numbers of aquatic insects slowly began to increase. On March 2nd aquatic insects were captured in all sites and numbers remained high throughout the duration of the sampling. Aquatic insects captured included dipterans, amphipods, and odonate larvae. Red crayfish continued to be captured throughout the sampling period. Several pollywogs, most likely bullfrogs (Bufonidae), were also caught.

Discussion

The study area was made up of a variety of shallow water habitat types. The physical attributes (depth, substrate, vegetation, flow) of each site varied considerably and, as might be expected, we observed a corresponding difference in species composition at each site. Overall, the ratio of natives to non-native fish was skewed in favor of the non-natives (33% to 66% respectively) which agrees with Harris (1996) who found that the species composition of the Cosumnes River was dominated by non native fish (70%). However, The overall numbers of native fish were significantly higher than those of non-natives accounting for 77% of the total catch. This suggests that comparing ratios of natives vs. non-natives may not be the most accurate measure of the success or failure of shallow water habitat.

Splittail are thought to spawn in winter and spring on flooded vegetation (Sommer et al. 1997). This information agrees with the data collected in this study. Although, no adult or juvenile splittail were captured, an abundance of YOY were caught throughout the study area. Splittail was the only species out of 18 total that were captured in each of the 10 sampling sites and were often caught in schools of several hundred fish. The first splittail yearlings were captured on March 23rd coinciding with when aquatic invertebrates began showing up in the flooded habitat. Caywood (1974), and Meng and Moyle (1995) showed that terrestrial and aquatic invertebrates make up the typical diet for splittail. The literature suggests that the study area is providing both spawning habitat for adults and critical rearing habitat for larval YOY splittail.

The Cosumnes River has historically had a moderate population of Chinook salmon. However, recent data suggests that the population has been in decline since the early 1970's (Reavis 1996). Possible reasons for this decline include factors affecting the adult population, including low outflow during up migration, barriers to upstream migration and inundation of spawning gravels with fine sediment. Conditions affecting juvenile Chinook salmon on the Cosumnes River are much less understood. The abundance of juvenile salmon in streams is a function of many factors, including the quantity and quality of suitable habitat, abundance and composition of food, and interactions with other fish, birds, and mammals (Reiser and Bjorn, 1979). Studies have shown that rearing Chinook salmon prefer habitat with suitable amounts of space, habitat complexity in the form of brushy or large woody debris, adequate depth, flow and temperatures ranging from 7-14 degrees C (Reiser and Bjorn, 1979). In this study 52 yearling Chinook

salmon were caught. Salmon were collected from March 2nd through May 7th, which roughly corresponds to published migration times for fall-run Chinook salmon (Stevens and Miller, 1983). Habitat in sites where salmon were captured ranged from furrowed farmland to forest. Temperatures at sites where salmon were caught ranged from 9-16.5 degrees C. In the instances where the temperature exceeded the juvenile range, catches occurred in areas where cover nearby would allow relief from higher temperatures. Flow seemed to be much more critical than either habitat or temperature in determining if salmon used a particular site. Sites 1, 4, 8 and 9 had some movement of water through the habitat except at times of extreme low flow and consequently catches in these sites made up 90% of the total salmon caught. Site 10, which accounted for 3 of the 5 additional fish had current in the site the day salmon were caught due to high overland flows. Site 8, the flooded forest, possessed all of the preferred physical attributes and as a result had the highest numbers of juvenile salmon, accounting for 37% of all salmon captured.

On April 23rd an adipose fin clipped Chinook salmon was captured in Site 8. The fish measured 94 mm (total length) and was captured along with a small school of non-tagged salmon ranging in size from 63-108 mm. Adipose fins are clipped on salmon smolts when a coded wire tag is inserted into their snout area, giving researchers a noticeable mark to distinguish between tagged and non-tagged fish. Once tagged smolts are captured the fish are sacrificed and the tags are removed and read. The East Bay Municipal Water District is currently overseeing research aimed at the Chinook salmon population of the Mokelumne River. As part of this research rotary screw traps are placed into the river to capture outmigrating, hatchery and natural production salmon. Upon capture some fish are retained for coded wire tag insertion and promptly released back into the Mokelumne River. The fish captured in the study area was determined to be a natural production fish from the Mokelumne River. This information is noteworthy, considering that the fish swam down the Mokelumne River to its confluence with the Cosumnes River then proceeded approximately two miles up the main channel of the Cosumnes River into the area of flooded habitat. As noted earlier very little is known about juvenile Chinook salmon and their possible use of floodplain habitat for rearing, however, information such as that gained from this tagged fish will help provide the critical links needed between salmon rearing and flooded habitat use.

Flow seemed to be an important factor in determining which species used which habitats. As noted earlier, 90% of all Chinook salmon captured were in sites that always had some flow. Equally as noteworthy splittail, though caught in all 10 sites, were most abundant in sites where there was no or very little flow. Site 3, a site in which very large numbers of splittail and Sacramento sucker YOY were captured, had no flow and in fact became stagnant during periods of low river flow. Site 7, which was surrounded by the largest body of water within the study area and typically had no flow, produced large numbers of inland silversides but low species diversity. The site accounted for only six species and possessed the lowest numbers of YOY fish.

The stranding of fish in floodplain habitats is considered to be a potentially serious problem. In some instances the benefits of a natural hydrograph and the accompanying

favorable conditions are balanced with the increased risk of stranding. Stranding of fish is intrinsic in areas with variable flow conditions. Water depths in flooded habitats can fluctuate on a daily basis potentially stranding fish located in areas where conditions allow for the puddling of water. Stranding can also occur as a result of poor drainage of the floodplain habitat. In this study several instances of stranding were recorded. On March 16th, a Chinook salmon measuring 45mm was captured in Site 4. The flows in the river were down in mid March providing for dry conditions in many sites, including Site 4, which was reduced to a puddle measuring approximately 25 meters by 10 meters and 0.1 meter deep. The otherwise healthy salmon was captured in this puddle. Other instances of stranding occurred in Sites 2, 3, 5, 6, 9 and 10 as well as in other locations in the study area. Many of these stranded fish were mosquitofish, however, splittail, inland silversides and carp were among other species observed in stranded conditions. Considering the serious implications to larval and juvenile fish, stranding needs further study along the Cosumnes River. Sampling once a week did not allow for on the spot sampling of areas suddenly dewatered by lower river conditions and should be included in any further study of the habitat.

Site 6 possessed the highest diversity of fish species and 54% of the adult and juvenile fish. The high diversity may easily be explained by the proximity of the site to Wood Duck Slough. It is believed that many of the fish captured are permanent residents of the slough who temporarily utilize the inundated vegetation for feeding purposes. Therefore, observations made at this site are most likely not indicative of fish utilization of shallow water habitat and it will therefore be excluded from any future studies.

The setback levee located near Sites 1, 2, 3 and 4 (Figure. 2) created adverse conditions for fish entering the system through the upper breach. The levee was originally designed to buffer the initial flux of flow through the new levee breach located near Site 1. Early in the season as flows reached high levels the water flowed over the top of the setback levee. As flows receded fish became stranded on the other side. Later in the season a large break occurred in the levee allowing a portion of the flow that entered the system through the top breach to flow north and east into areas where fish were subjected to areas of higher temperatures, increased potential for stranding and less suitable habitats.

Recommendations

Shallow water habitat has become an important topic in the field of fisheries biology. Many researchers feel that the restoration of floodplains including the continued development of shallow water habitat is a key component to a healthy ecosystem for the San Joaquin/Sacramento Delta. Others cite a lack of data in their questioning of whether shallow water habitat can provide the spawning and rearing habitat needed by the threatened species that reside in the Delta while not increasing populations of competing non-native fish. All parties agree that additional bottom line research is needed to determine if shallow water habitat is part of the solution. Ongoing research on the subject is presently occurring in several locations including a large study on the Yolo Bypass, a projected study at Prospect Island and additional small projects located

throughout the delta. The Cosumnes River floodplain project is unique in that it is a non-tidal east delta tributary and is relatively old compared to most current projects. It is therefore a noteworthy part of the continuing research of shallow water habitat.

It was hoped that as a result of this project recommendations for improving the design and hydrology of the Cosumnes River floodplain could be proffered. However, the unique, highly variable hydrology of the system combined with the attempt to study at an ecosystem wide level made for a complicated system that often changed daily. What might have been good for the system one day could have created a problem the next. What looked to be a warm, stagnant pool one day was teeming with threatened splittail the next. Additional research is needed to properly analyze additional components of the project before any large-scale recommendations could be proffered. Therefore, the following recommendations are separated into two groups. First, minor recommendations intended for improving habitat and eliminating stranding and second recommendations for improving future studies.

Physical Improvements:

1. The setback levee located near the upper breach in the levee is problematic. Two possible solutions are offered. First, put additional breaks into the setback levee creating additional flow into the northeast side of the field. To accommodate this additional flow an upgrade to a larger standpipe would be needed for the outlet of the field into Wood Duck Slough. A second solution would be to simply remove the setback levee allowing the water to flow into the entire field and allowing it to drain in a more natural rate. This solution may require the strengthening of levees located north of the system.

2. A small irrigation valve located just inside the uppermost levee breach was often left open allowing water to flow from Site 1 under the setback levee into the area adjacent to Site 2. At low flow conditions this can potentially take fish out of a feeding eddy where many salmon gathered and carry them into an area where stranding can occur. This valve should always be closed.

Study Improvements:

1. In most projects sampling once a week is adequate. In this project certain conditions changed at such a rapid rate much was lost in not being able to note subtle changes as they occurred. Periods between weekly sampling often included several cycles of flooding and de-watering. These sampling inadequacies could be addressed by a shorter more intense period of observation to record rapidly changing conditions as they occur, including depth and direction of flow at various locations.

2. Beach seining, although cost effective, did not allow for the sampling of all types of habitat within the system. A detailed study design including the

possible use of fyke traps, purse seines and electrofishers would allow a much better ability to sample all types of aquatic habitat within the sample area.

3. Additional studies are needed to determine how and why fish are using the specific habitats within the system. These studies could include food utilization studies, an aquatic insect analysis, an in-depth multi-habitat larval fish analysis and additional studies comparing cover and substrate types to fish abundance within the various habitats.

Table 1

Species	# of Adult and Juv Fish	# of YOY fish	# of sites
Bigscale logperch (Percina caprodes)	10	37	3
Bluegill (Lepomis microlophus)	1	0	1
Carp (Cyprinus carpio)	2	20	3
Chinook salmon* (Oncorhynchus tshawytscha)	0	52	7
Crappie (black) (Pomoxis nigromaculatus)	7	0	4
Fathead minnow (Pimephales promelas)	2	0	1
Golden shiner (Notemigonus crysoleucas)	57	0	6
Goldfish (Carassius auratus)	4	0	3
Hardhead* (Mylopharadon conocephalus)	1	0	1
Inland silverside (Menidia beryllina)	547	74	9
Largemouth bass (Micropterus salmoides)	1	1	2
Mosquitofish (Gambusia affinus)	80	0	7
Prickly sculpin* (Cottus asper)	1	41	3
Redear sunfish (Lepomis microlophus)	57	32	8
Sacramento squawfish* (Ptychocheilus grandis)	162	0	8
Sacramento sucker* (Catostomus occidentalis)	1	790	9
Splittail* (Pogonichthys macrolepidotus)	0	2145	10
Threadfin shad (Dorosoma petenense)	6	0	3
Total	**939**	**3192**	**N/A**

* Denotes native species

Site	Days Sampled	# of Tows	# of tows with no fish	# of Species	# of Adults and Juv's	# of YOY fish
1	17	33	11	7	15	50
2	9	24	6	11	9	161
3	17	30	9	11	30	2105
4	13	22	9	8	14	177
5	10	16	4	8	51	292
6	17	32	3	14	506	127
7	7	13	2	6	209	28
8	11	17	5	8	26	131
9	10	18	2	11	75	77
10	4	8	3	4	4	44

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