

AQUATIC RESOURCE PROGRAM REPORT

Executive Summary

The fishes and invertebrates of the Cosumnes River basin and its floodplain were intensively studied from 1999 through 2002 to determine their basic distribution, abundance, and ecology. The purpose of the studies, done in conjunction with studies on fluvial geomorphology, water chemistry, and other aspects of the physical and chemical environment, was to develop the information needed for management to favor native aquatic organisms. The Cosumnes watershed was chosen for this study because (1) it is the largest river left in Central California without a dam across its mainstem, (2) it has a newly restored floodplain that was amenable to study on the basis of access and scale, (3) it was known to support a small run of chinook salmon, and (4) it could be compared with a neighboring watershed, the Mokelumne River, which is highly regulated.

Faunal inventory, lower basin. Surveys of the fauna of the tidal portion of the river (which includes the floodplain) and associated sloughs, revealed a diversity of fishes and aquatic invertebrates. The invertebrates, with the exception of crayfish, the Asian clam, and a few other rare forms, were largely native, diverse, and abundant. The fishes, on the other hand were a diverse collection of largely alien species. Resident natives, with the exception of Sacramento sucker, were uncommon and the fish fauna was largely dominated by alien fishes such as largemouth bass, sunfishes, common carp, and golden shiner.

Fish studies, upper basin. The fishes of the upper watershed were studied over a three year period to answer the following questions: 1. Was the native fish fauna still present? 2. Why were alien fishes so abundant in a river system with a 'natural' flow

regime, which elsewhere has been shown to favor native fishes? 3. Were there assemblages of fishes that reflected environmental differences created by the underlying geology? 4. Were there features of the watershed that consistently favored native fishes or that could be managed to favor native fishes? Of the 25 species collected, 17 were alien species; 14 species (5 native) were abundant or widely distributed enough to use in detailed analyses. Of the native species, only rainbow trout still occupied much of their native range in headwater streams. Other native species have been extirpated or persisted mainly above barriers to alien invasions. The most widely distributed alien species was redeye bass, previously unknown from the river, whose abundance was associated with low numbers of native species. Other aliens were found primarily in lowland habitats on the valley floor or foothills. Canonical Correspondence Analysis indicated that both native and alien species located on environmental gradients determined largely by elevation, temperature, flow, and emergent vegetation, but the associations with these variables were not strong. While most alien fishes were found in lowland sections of river flowing through agricultural regions, the general relationships between species abundance and landscape-level variables were weak. Assemblages of fishes were poorly defined mixtures of native and alien species. The strikingly distinct geological regions of the basin no longer supported distinct fish assemblages. Species distributions were highly individualistic, reflecting dynamic patterns of introductions, invasions, and local extinctions, as well as physiological tolerances and life history patterns. Most native fishes are likely to persist in the Cosumnes River only if summer flows are increased and if populations above natural barriers are protected from further invasions by alien species, especially redeye bass. General conclusions from this study include: 1. Altered habitats

can support native species under some circumstances; 2. New fish assemblages with characteristics of 'natural' communities are likely to develop in invaded systems; 3. Restoring flow regimes to favor native fishes may require restoring minimum summer flows as well as high channel-forming flows. However, reversing or even reducing, the impact of the predatory redeye bass, pre-adapted for California streams, is probably not possible.

Invertebrates, upper watershed. Aquatic invertebrates were sampled throughout the Cosumnes River watershed in 2001 and 2002. The data demonstrate that several processes acting at different spatial scales are negatively affecting the abundance and diversity of aquatic invertebrates. Processes acting on watershed or sub-watershed scales are having impacts of approximately the same magnitude as processes acting locally at individual sites. Using Canonical Correspondence Analysis, we found that the most important variables were those reflecting land use and water quality, which together explained more than 60% of the variation among sites. The most important land use features included low intensity residential development, number of small dams and transitional areas. While the mechanisms causing changes in invertebrate abundance and diversity are multiple, reduced flows during summer and early fall as the result of many diversions are likely the most important limiting factor. Reaches of the Cosumnes that became seasonally dry, in part the result of multiple water diversions, suffered the greatest reductions in biomass and diversity from high winter populations. Severe declines in water quality such as those seen on Deer Creek, which receives large inputs of agricultural waste waters, were also strongly associated with declines in invertebrate diversity and abundance.

Patterns in invertebrate abundance, floodplain. The invertebrates showed a predictable pattern of abundance and diversity that followed the cycle of initial flooding, ponding up of flood areas, drying of ponded areas, secondary spillover events, and end of season dry out. Among the most striking patterns seen was the cycle of flood, which produced an initial decline in biomass of invertebrates due to dilution and then a rapid buildup of biomass. After the initial flood event rapidly reduced the biomass of zooplankton and insects, within two weeks, the biomass of zooplankton and benthic invertebrates rose rapidly, often to a point above the levels prior to flooding. These cycles showed strong differences among sites with 10-100 times more zooplankton biomass and at least 10 times more benthic invertebrate biomass at sites with higher temperatures, higher primary production and presumably higher residence times. River sites never experienced the same cycling and degree of zooplankton abundances as did floodplain sites.

Invertebrate production, floodplain. Production of native invertebrates, particularly zooplankton showed strong temporal and spatial patterns that were influenced largely by patterns of phytoplankton production. Phytoplankton production was driven by residence time, water temperature and nutrient abundance. There were repeated cycles of increases in phytoplankton abundance followed by increases in zooplankton abundance after flooding events. After the initial period of dilution as new flood waters filled the floodplain, there were increases in nutrients (nitrate, phosphate) and new growth of phytoplankton. Water quality data indicated that nitrate and phosphate levels as well as N:P ratios resulted in periodic nitrogen and phosphorous limitation. Repeated spillover events apparently resulted in increased availability of nutrients, thus

recharging the system after a period of nutrient limitation resulting from extended periods of stagnation. Laboratory studies of zooplankton growth and reproduction confirmed that phytoplankton abundance was an important food source relative to detrital sources.

Further, increased abundance of phytoplankton at sites with higher temperatures and presumably higher residence times were also sites with rates of growth and reproduction indicating better food quality. Drift net sampling demonstrated that detrital inputs to the floodplain from the river are significant. The biomass of detrital inputs to the floodplain did not show a seasonal trend but the magnitude of these inputs were positively associated with the magnitude of the flood event. Control of secondary production of zooplankton shifted from being largely bottom up (driven by food) early in the season to increasingly influenced by top down limitation (driven by predation) as increased size and abundance of larval fishes increased. Light trap data and experimental exclosures of fishes indicated that zooplankton abundances declined rapidly in April due to fish predation but also that the size structure of the zooplankton changed as cladocerans and other larger zooplankton become depleted faster than copepods and other smaller zooplankton. These results are mirrored in experimental exclusions of fish predators where fishes decrease the numbers of zooplankton, but have the greatest impact on larger cladocerans relative to smaller copepods.

Patterns in juvenile fish abundance, floodplain. Fishes were sampled on the Cosumnes River floodplain for five years (1998-2002) during the winter-spring flooding season, typically February –May, although additional months were sampled in some years. Sampling was done with light traps (larval fish), seines (YOY and adults), and boat

electrofishing (adults and juveniles). Over the five years of sampling, 33 species of fish were captured in the floodplain and adjacent river and sloughs. 18 of the species were abundant enough to use in analyses of trends and habitat use. Eight of the abundant species were natives, while the rest were aliens. There was a fairly consistent pattern of floodplain use by fish over the five year period, although the basic pattern was modified on an annual basis by the extent of flooding. The first fish to appear on the floodplain were a few adult fish from ponds (e.g. golden shiner), some transient species (e.g., Pacific lamprey) and juvenile chinook salmon. The next fish to appear were adult floodplain spawners, principally splittail and common carp, which spawn on flooded annual vegetation, although small numbers of species resident in ponds and neighboring sloughs were continuously present. The juveniles of the splittail and carp quickly became large enough to dominate floodplain fish samples, along with juveniles of suckers and pikeminnows coming in from the river. The adult spawners left the flood as inflow decreased. The juveniles persisted on the floodplain as long as occasional new pulses of flood water kept water levels up and temperatures down, but most juveniles of native fishes left the floodplain either with the pulses or with declining inflows. Most were gone by mid-May but some persisted through June if conditions favored their presence. Usually, the floodplain disconnected from the river by mid-May. In two large shallow ponds of residual water, mosquitofish, inland silverside, and juvenile centrarchids tended to dominate catches by June. The centrarchids were abundant in adjacent sloughs and presumably colonized floodplain ponds through a combination of individuals moving in through ditches or resulting from spawning by stranded fish. In many years, the ponds dried up by August. Essentially, native fishes plus carp dominated the floodplain fish

fauna early in the season while alien fishes dominated (almost completely) late in the season. Native fishes that were abundant each year were those that could use the floodplain for rearing of juveniles. Most alien fishes had resident populations in permanent waters associated with the floodplain (sloughs, ditches, ponds) and were not dependent on the floodplain for persistence. The fish fauna of the Cosumnes River was the same as that of the neighboring Mokelumne River but species composition was markedly different as the result of permanent cool-water flows (releases from Camanche Dam) and the lack of floodplain habitat.

Patterns in larval fish abundance, floodplain. We sampled larval fish in 1999 and 2001 from the onset of flooding to when the sites dried up or when larval fish became rare. We collected over 13,000 fish, of which prickly sculpin made up the majority (73%). Eleven species made up 99% of the catch. Three native fishes (prickly sculpin, Sacramento sucker and Sacramento splittail) and two alien species (common carp and bigscale logperch) were associated with higher inundation and associated cool temperatures of early Spring. In contrast, six other alien taxa, sunfish, largemouth bass, crappie, golden shiner and inland silverside were associated with less inundation and warmer water temperatures. One native species, Sacramento blackfish was also associated with these conditions. Species did not show strong associations with habitat because of different spawning times of adults and expansion and contraction of flood waters. Most species could be found at all sites throughout the flooded areas, although river and floodplain spawning fishes usually dominated sites closest to levee breaches. Highest species richness was consistently found in two sloughs with permanent water, because they both received drainage water from the floodplain and had a complement of

resident species. Splittail, an obligate floodplain spawner, was found primarily in association with submerged annual plants. Our results suggest that a natural hydrological cycle in the Spring is important for providing flooding and cool temperatures required by many native larval fishes. Alien fishes are favored if low flows and higher temperatures prevail.

Condition factors and growth rates of postlarvae of several fish species were compared in order to determine importance of floodplain habitats for early life stages. Five sites were sampled: two on the floodplain, two in the river and one in an irrigation channel. Floodplain fish had higher condition factors than those from riverine habitats. Sacramento splittail had higher condition in floodplain habitats and lower condition in altered habitats, while Sacramento sucker did not show a distinct difference in condition between floodplain and riverine habitats. Common carp and golden shiners, two alien species that spawned on the floodplain, had high growth rates and condition factors. Splittail growth varied considerably over a 10-day period. Sacramento suckers from the floodplain had lower weights than those from the river. Thus, the early life history stages of some species grow better in floodplain habitats than in riverine habitats, suggesting that some species are more floodplain dependent than others.

Management recommendations: alien species. The Cosumnes and Mokelumne River basins have a number of distinct habitat types that require different management strategies to reduce the impact of invasive fish species. Invasive invertebrates are so far of little concern because they are rare in both systems.

For the Cosumnes River: (1) Meadow streams in the head waters that are dominated by alien brook trout and brown trout. Historically, the streams in these

meadows were most likely fishless and dominated by amphibians. Thus eradication of alien trout and management of the meadows for native aquatic life should be investigated.

(2) In the foothill reaches populations of California roach (and Sacramento suckers) exist above natural barriers to invasion by redeye bass, which need to be protected from predation by alien fishes. Annual surveys should be conducted for the presence of alien fishes, especially redeye bass and green sunfish, and if they are detected, to have a strategy in place for eradication. (3) The lower ends of the three forks and the mainstem Cosumnes are dominated by redeye bass to the detriment of native fishes. It would be highly desirable to eradicate redeye bass and other alien fishes from this area, but probability of success is low. Effort should be made to develop and evaluate eradication or reduction strategies for the reaches above Latrobe Falls, a presumed barrier to upstream movement. (4) Deer Creek is a tributary that supports several native fishes, including California roach, in its upper reaches. The native fishes reach appears to have been protected from invasion by redeye bass by the highly altered nature of the lowermost reaches. A management plan needs to be developed for this creek to prevent it from becoming just another degraded creek full of alien fish, frogs, and invertebrates. (5) The mainstem below the forks ceases to flow each summer as the result of ground water pumping. The only water is in a few large pools that are dominated by predatory basses. Restoration of permanent summer flows to the lower Cosumnes would increase shallow-water rearing habitat for the suckers and pikeminnows, not only resulting from spawning of resident fishes but from spawning of fish migrating up from the Delta. This would result in a net increase in native fishes in both Delta and stream habitats, provided a control program was also initiated for the bass. Improvement in flows and reduction in

predators would also presumably improve conditions for juvenile chinook salmon survival.

(6) Our studies of floodplain fishes indicate that (1) YOY native fishes use the floodplain in February-April for rearing, (2) splittail typically spawn on the floodplain in March-April, (3) native fishes know how to get off the floodplain to avoid being stranded, and (4) alien fishes dominate permanent habitats surrounding and in the floodplains (sloughs, ditches, ponds). Thus, a strategy for managing floodplains for native fishes and to discourage aliens is to have fairly complete and continuous flooding from January-April, followed by rapid and complete draining. All ponds and ditches on the floodplain proper should therefore be set up to drain completely. On the Cosumnes River Preserve, ponds 1 and 2 should be provided with gates on the main drainage ditches, so levels and draining can be manipulated. There is considerable potential for managing such ponds in ways to increase their potential for rearing salmon, splittail, and other native fishes, while discouraging aliens

The Mokelumne River both above and below Pardee Reservoir is a highly regulated system for production of water and power. Therefore the basic strategy to improve the Mokelumne River as habitat for native fishes by discouraging aliens should be to (1) manage flow regimes to favor native fishes wherever possible and (2) investigate and implement habitat improvement measures that favor native fishes wherever possible, such as levee setbacks and spawning gravel enhancement.

Monitoring plan: upper watershed. Trends in fish and invertebrate distribution and abundance track land use reflect degradation or improvement of the watershed at both local and watershed scales. The purpose of a monitoring program is to alert

managers to developing problems, including invasions of alien species. We recommend annual sampling for fish by snorkeling or single-pass electrofishing at a minimum of five sites in the upper watershed. Every five years, a more extensive survey should be conducted that includes rapid bioassessment using invertebrates and sampling of fish using a variety of techniques, but including quantitative 3-pass electrofishing at a minimum of 10 sites widely distributed through the watershed.

Monitoring plan: migratory fish. One of the least understood aspects of the Cosumnes River is its use by migratory fish including chinook salmon, Pacific lamprey, Sacramento suckers and Sacramento pikeminnow. The only monitoring of these populations at present is the annual carcass counts of chinook salmon, which need to be regularized. We recommend the following: 1. Annual carcass counts of salmon on at least a weekly basis, from November through December (if salmon are likely to be present, as determined by flows. 2. Investigate the possibility of setting up a video monitoring site on the lower river, to record migrations of all fish, such as has been established at Woodbridge Dam on the Mokelumne River.

Monitoring plan: floodplain fishes and invertebrates. Annual surveys of use of the Cosumnes Floodplain by juvenile fishes is a good way to determine spawning success of native fishes that are riverine and floodplain spawners. It is also a good way to determine the success of management actions on the floodplain site. We recommend the following: 1. Every year use a 1-5 x 1.5 m, 7 mm stretch mesh, bag seine to sample fish in the areas around Pond 1 and Pond 2 and at two river or slough sites, Cosumnes River Preserve. Sampling should occur at least once every two weeks from mid-February through mid-May, longer if native fishes are still abundant in May. 2. Every five years,

conduct a weekly survey, as above, through mid-June, provided the year has average or above average flows in the river. 3. Conduct weekly sampling of planktonic and benthic invertebrates at the same sites used for fish monitoring using standard protocols, from February through May, every five years, to determine if productivity of the system has changed. This should be done on a year when flooding occurs continuously during the period. On an annual basis, a “one-time” sampling of all aquatic invertebrates at several floodplain sites should be conducted and vouchers of all aquatic invertebrates prepared and compared with previous years to determine if/when non-native species become present.

Monitoring plan: Mokelumne River. The sampling now conducted by East Bay Municipal Utility District on the lower Mokelumne River should be continued on at least an annual basis, during February-June. Electrofishing and snorkeling surveys conducted by the California Department of Fish and Game on the North Fork Mokelumne should be repeated at least once every five years.