

larval stages, with the effects particularly deleterious near inputs of acid mine drainage within the Sacramento River watershed and in the vicinity of highly industrialized near-shore areas of the lower San Francisco Bay Estuary. These metals damage gills and alter liver and nervous system functions causing death, behavioral changes, and reduced growth and reproduction (EPA 1976). These metals can have the same effects on food items of the splittail, reducing their prey base and placing additional stress on the splittail (EPA 1976). However, we are not aware of any evidence suggesting that splittail are at any higher risk of suffering direct or indirect adverse effects from metals exposure than other fish species within the Sacramento River and San Francisco Bay estuary systems. For all such species, the potential for at least periodic adverse impacts from exposure to metals is of substantive concern, but poorly understood.

Three other potential contaminant threats are of concern specifically with respect to the splittail: (1) mercury; (2) selenium; and (3) pesticides (persistent organochlorines and currently used organophosphates). In part, these contaminant threats are of concern because they may be focused, to varying degrees, on habitat features and biological characteristics tentatively identified as particularly relevant to splittail conservation (Moyle *et al.* 2001).

Recent analytical data indicate that mercury concentrations in aquatic biota in the San Joaquin River are exceeding screening thresholds and may pose ecological and human health risks (Davis *et al.*, 2000). A benthic-foraging, longer-lived fish such as splittail would be likely to acquire higher and more toxic levels of whole body mercury concentration. We are concerned the combined data from these monitoring and research efforts may indicate that mercury in the San Joaquin River poses a threat to ecological health in general, and the splittail, as a benthic forager, in particular. Some findings have linked elevated mercury to the Consumnes and Yolo Bypass (Slotten *et al.* 2000), which are both primary spawning areas for splittail (Moyle *et al.* 2001).

Furthermore, the Yolo Bypass may be hydrologically connected to Suisun Marsh, the likely core rearing area for splittail (Moyle *et al.* 2001). Suchanek *et al.* (2000) is investigating the role of wetland restoration involving re-flooding of mercury-contaminated soils.

Significant exposure to selenium could potentially pose a threat to splittail throughout much of its range,

including the Yolo Bypass. Recent samples of splittail from Montezuma Slough collected by USGS scientists (Stewart *et al.* 2000, Stewart *et al.* unpubl. data) have revealed elevated muscle selenium concentrations ranging as high as 4 to 5 mg/kg (5 ppm), and liver concentrations ranging as high as 20 mg/kg (20 ppm). The relationship between the bioaccumulation of selenium in the Asiatic clam and its predation by splittail could become significant in the near-term future because the clam, via its predation on typical splittail prey items such as estuarine copepods (*Eurytemora affinis*, and *Acartia* spp.) (Kimmerer and Peñalva 2000), is creating conditions that promotes increasing reliance of splittail on the clam as an alternate food source (Feyrer and Matern 2000). Thus, a potential scenario for the future is greater reliance of splittail on Asiatic clams as a food supply and possibly further increases of selenium concentrations in both Asiatic clams and splittail. Selenium threats to splittail are not confined to the Yolo Bypass/Suisun Marsh systems. We speculate that when splittail are exposed to this level of selenium, there is potential that a reduction in reproductive performance will occur, which would then result in poor post-hatch survivorship. This means that less splittail young would be able to recruit to adulthood. There are 1998 splittail data which confirm that these fish are being exposed to harmful levels of selenium in their range along the San Joaquin River.

Splittail apparently experience substantial post-spawning stress, and are subject to substantial stress during salvage operations at the State and Federal pumping facilities. In addition to weakening the immune defenses of fish and wildlife, excessive environmental selenium can also trigger pathogen and toxin challenges that would not otherwise have occurred. At this point, we have no direct information on the potential effects of selenium with respect to splittail. However we have considered the selenium-mediated vulnerability to non-chemical stressors when assessing the threats presented by exposure of splittail to selenium.

Several of the pesticides present in the rivers of the Central Valley have been documented to have adverse effects on animal life. However, we have no direct evidence that pesticides are a pervasive threat to the splittail throughout its range. If there is a threat it may be relatively greater in the bypasses due to the large amount of spawning and early rearing that occurs

there in wet years. All major rivers that are tributary to the Estuary are exposed to large volumes of agricultural and industrial chemicals that are applied in the Central Valley watershed (Nichols *et al.* 1986) as agricultural chemicals and their residues, as well as chemicals originating in urban runoff find their way into the rivers and estuary.

In addition, re-flooding of the Sutter and Yolo Bypasses and the use of other flooded agricultural lands by splittail for spawning can result in agricultural-related chemical exposures depending on the circumstances.

Toxicology studies of rice field irrigation drain water of the Colusa Basin Drainage Canal have documented significant toxicity of drain water to striped bass (*Morone saxatilis*) embryos and larvae, *Oryzias latipes* larvae (in the Cyprinodontidae family), and opossum shrimp, which is the major food organism of striped bass larvae and juveniles (Bailey *et al.* 1991), as well as all age classes of splittail. This drainage canal flows into the Sacramento River just north of the City of Sacramento. The majority of drain water samples collected during April and May 1990 were acutely toxic to striped bass larvae (96 hour exposures); this was the third consecutive year rice irrigation drain water from the Colusa Basin was acutely toxic (Bailey *et al.* 1991). Splittail may be similarly affected by agricultural and industrial chemical runoff, particularly, because like striped bass, adults migrate upriver to spawn and young rear upriver until waters recede in late spring.

While we have considered these contaminants as possible threats to the splittail, it must also be noted that we have no information on the splittail's thresholds for metals and pesticides. We are unwilling to accept the use of a surrogate species to determine acceptable thresholds for splittail. While there are abundant non-native cyprinids available (fathead minnows [*Pimephales promelas*] and golden shiners [*Notemigonus crysoleucas*]), we assert the splittail is behaviorally unlike these non-native fishes and most likely physiologically distinct from them as well. Further, potential surrogate native cyprinids (hardhead [*Mylopharodon conocephalus*], blackfish [*Orthodon microlepidotus*], pikeminnow [*Ptychocheilus grandis*]) are piscivorous (fish-eating) when adults, and therefore likely distinct from splittail. Splittail may have its closest relative in the Rhinichthys complex (speckled dace [*Rhinichthys osculus*] and others) but use of these diminutive, short-lived, small-stream species would be similarly unadvisable. Lastly, we would have serious concerns with results obtained