

be modified to protect endangered chinook salmon and steelhead populations.

Returning salmon are usually two to three years old, so overlapping cohorts buffer against a few bad years. The threatened delta smelt, however, which live one year, could wink out quickly. Once the most abundant fish in the delta, and found only here, the silvery finger-length smelt spend most of the year in schools eating zooplankton along the brackish edge of the freshwater–saltwater mixing zone. In winter they migrate upstream, disperse into smaller channels, spawn, and die. Unfortunately, their 38-km range overlaps an area where huge pumps divert water.

Despite fish screens and “salvage” procedures, the pumps still confuse and kill fish, and in 2007 a federal judge imposed restrictions on water exports to protect the beleaguered smelt. Before that ruling, the state and federal projects were exporting a record amount of water, and the fish count dropped to less than 3 percent of what it had been when delta smelt were listed in 1993. But the pumps are only part of the problem.

“The majority of the aquatic species that inhabit the delta are not native,” Moyle says. In fact, it’s possibly the world’s most invaded estuary, with an increasing rate of introductions. Just two examples show how invaders rob native species of food and shelter. Brazilian waterweed has taken over large parts of the delta in recent decades. Growing within channels, it slows the current and encourages sediment settling. Delta smelt and other fish that prefer some turbidity now have fewer places to hide from predators. Meanwhile, in more brackish water, the filter-feeding Asian overbite clam has become so abundant that it clears the water column of plankton, stripping the bottom out of the food web.

Delta denizens also face episodic toxic pollution ranging from agricultural runoff and overspray of fertilizers and biocides to excess ammonia from sewage. Wim Kimmerer’s lab at San Francisco State University’s marine laboratory had to change procedures for growing zooplankton when, after exchanging culture water with water taken from the delta, all the animals died. “You have to wonder—

## Bay Watch

The lower estuary, San Francisco Bay, is in fairly good shape relative to the delta. One saving grace may be that the bay is influenced more by the ocean than by freshwater flows from the delta, where human control has radically altered the hydrology. “The further upstream you go, the worse it gets,” says Tina Swanson, head of the Bay Institute, which assesses the estuary by monitoring a number of indicators and keeping an ecological scorecard.

However, because of water supply issues, research funding seems to vary inversely with salinity. More is known about the delta and North Bay; the Central and South bays are relatively neglected. “It’s shocking how little we know about what’s living out in the bay,” says Andrew Cohen of the San Francisco Estuary Institute, in Oakland.

San Francisco Bay is not prone to eutrophication or nuisance algal blooms, and the Clean Water Act made a big difference here, but pollutants persist. Fish are mostly native, but state officials advise adults to limit their sport fish consumption to at most two meals per month, because of PCBs (polychlorinated biphenyls), mercury, and a variety of biocides. Mercury occurs naturally in the Pacific Coast Ranges around the bay, and gold miners used quicksilver in the Sierras, so mercury lingers throughout the watershed.

Concern persists among some of the seven million people who live here. Urbanization was shrinking the bay until the 1960s and 1970s, when public outcry halted rampant filling. In 2007, when a cargo ship spilled more than 50,000 gallons of oily bunker fuel in the Central Bay, officials couldn’t use all the volunteers who came out to help clean beaches and birds. Lawmakers responded with about a dozen bills reforming every aspect of preventing and cleaning up oil spills.

Stanching the flow of exotic species is a current worry. “There’s still not a mature structure around it the way there is around these other issues,” Cohen says. Initial focus has centered on ballast-water tanks, which help stabilize ships. Filling tanks in one port and discharging in another has spread aquatic creatures around the globe. California began requiring midocean ballast water exchange in 2000. Washington and Oregon quickly followed, as did the federal government several years later.

“Ballast-water exchange is the law, but we have no idea whether it’s working, really, because there’s no monitoring,” Cohen says. Next steps are to set standards for how many living organisms can be released, and to rein in other sources of exotic organisms, such as bait and aquaculture. Relative to the system for regulating, monitoring, and watch-dogging chemical pollutants, societal control of biological pollutants is still in its infancy, Cohen says.



*The bellwether delta smelt (Hypomesus transpacificus) is just two to three inches long and smells like cucumbers. Once the most abundant fish in the estuary, it was listed as threatened in 1993 and is now so scarce that it could die out in the next few years. Photograph: B. Moose Peterson, US Fish and Wildlife Service.*