From the Sierra to the Sea

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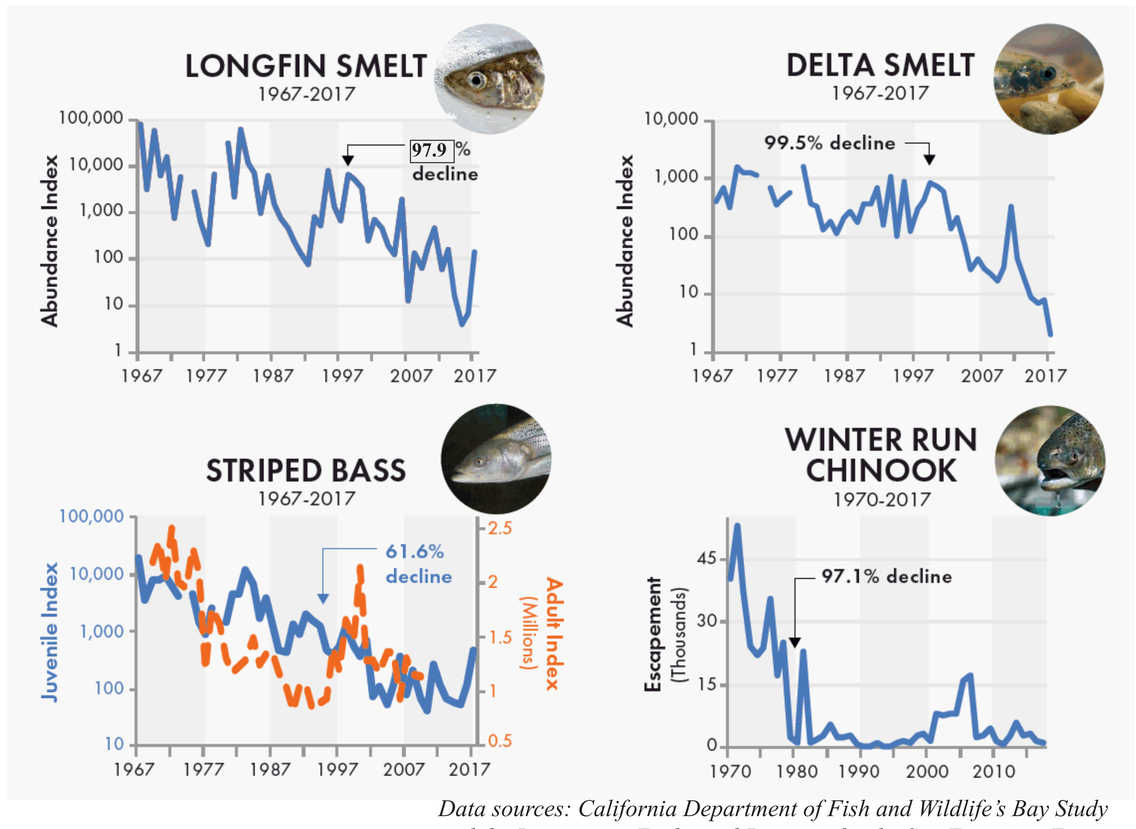
Abstract

In 1998, The Bay Institute produced the seminal report, *From the Sierra to the Sea: The Ecological History of the San Francisco Bay-Delta Watershed*. The report, produced with the support of water managers and government agencies, described the aquatic ecosystems of the Bay watershed's montane uplands, Central Valley lowlands, Delta, pelagic waters, and nearshore coastal waters as an integrated whole. The original publication provided landscape-scale analyses of:

- natural ecosystem structure, function, and organization;
- transformations of the watershed;
- ecological responses to human-induced changes, and
- recommendations for a practical framework for ecosystem restoration and management.

The Bay Institute has produced a **20th Anniversary Edition** of *From the Sierra to the Sea* with a new Foreword by award-winning author, John Hart, and an Afterword which describes major changes since the report was first published. Many watershed impacts continue to worsen, such as increasing water diversions from and decreasing freshwater flows to the estuary; these are associated with declining fish populations, degraded water quality, and the spread of invasive species. On the other hand, many habitat restoration projects have been implemented since 1998, many more are planned, and our scientific understanding of species' and ecosystem needs has improved dramatically over the past two decades. The update also reflects new understanding of future threats to the Bay and its watershed.

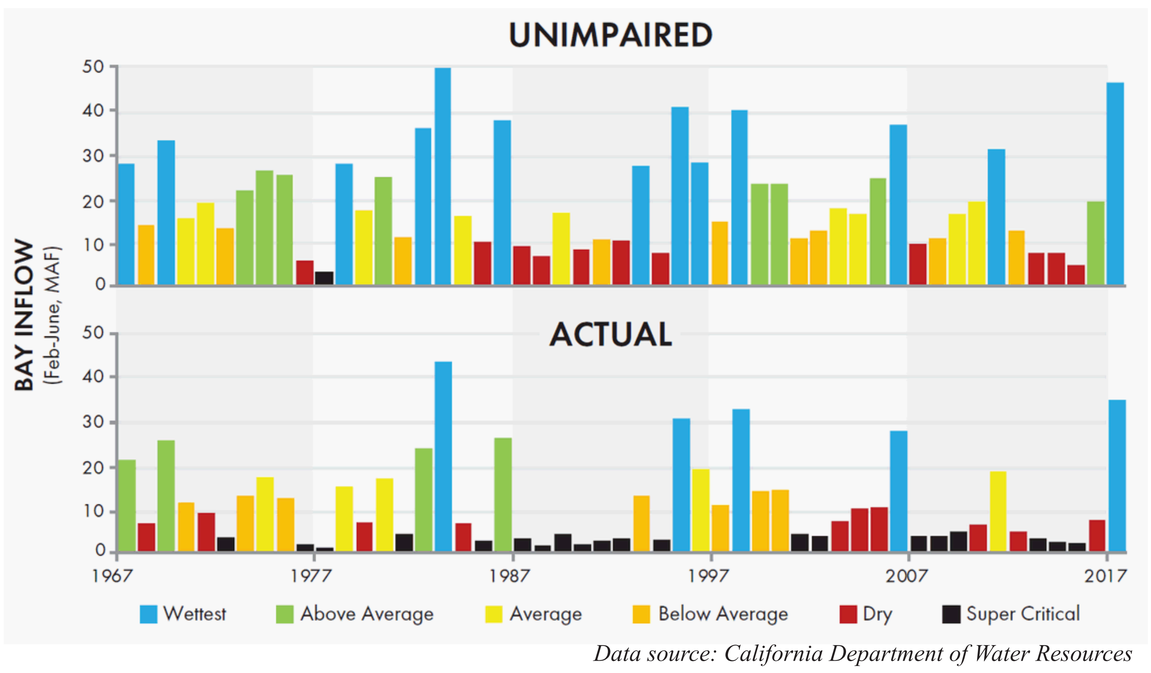
Abundance Indices for Representative Fish Species



Data sources: California Department of Fish and Wildlife's Bay Study and the Interagency Ecological Program for the San Francisco Estuary

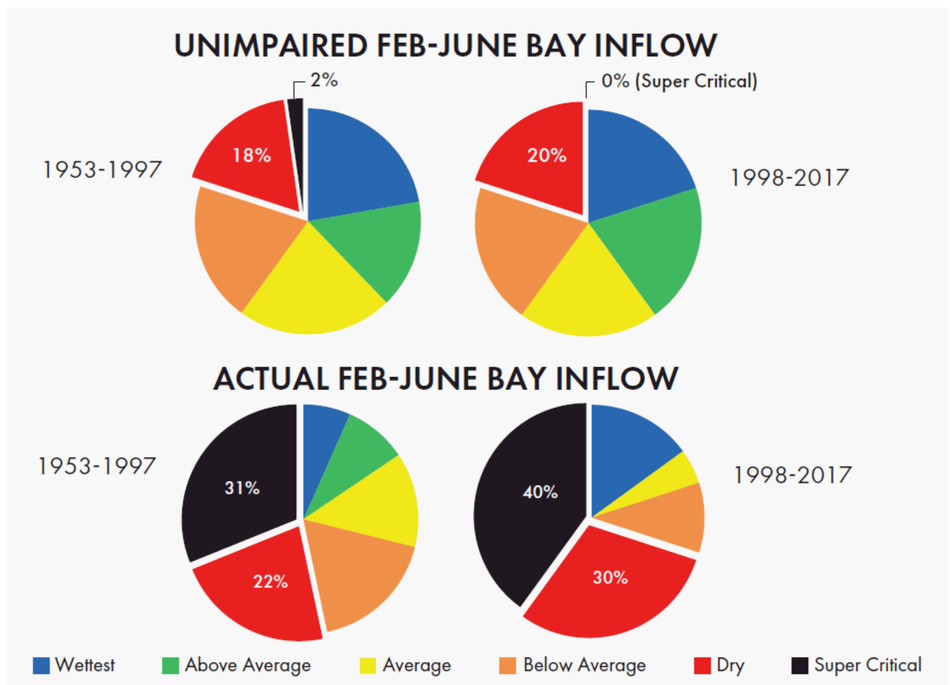
Native estuarine forage fish, such as Delta smelt and longfin smelt, experienced tremendous population declines since 1998 -- 99.5% and 97.9%, respectively. One major predatory fish, striped bass, has declined as well; the index of juvenile striped bass abundance (left axis, log-scaled) has declined by 61.6% and the adult striped bass index (right axis) nearly as much since 1998. Abundance of anadromous fish species such as Chinook salmon remains at precariously low levels, despite major investments in habitat restoration projects that were intended to double their populations over the 1967-1991 average. For example, returns of endangered winter-run Chinook salmon, which declined 97.1% between 1970-1980, have remained extremely low since the report was published, except for brief rebounds following wet years.

Permanent Drought



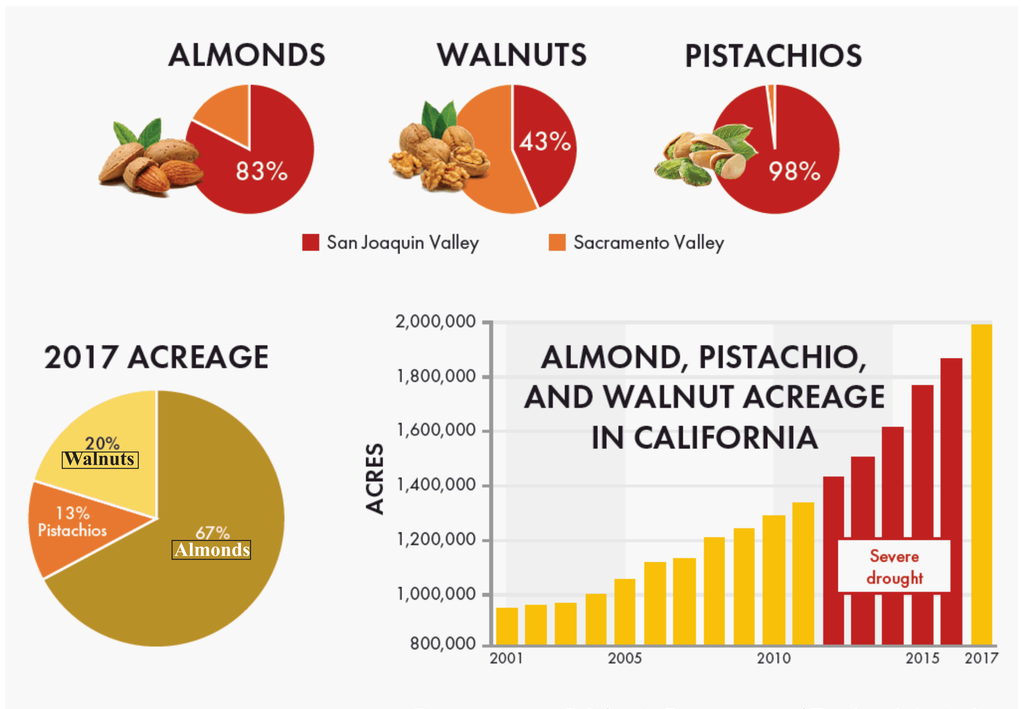
Data source: California Department of Water Resources

Actual runoff to San Francisco Bay continued to decline since 1998. We divided runoff into water year types, from Wettest to Dry, which represent quintiles of unimpaired flow. We marked years drier than 2015 – the driest 2% of years-- as "Super-critically dry," a sub-category of Dry years. In the four decades preceding 1998, "Super-critically dry" runoff conditions in the Central Valley watershed occurred only once (1977), but the estuary experienced super-critical conditions 31% of the time (20 years). Since publication, no Super-critical runoff conditions occurred, but Super-critical inflow to the estuary occurred 40% of the time (8 years). As a result of high levels of water diversion, dry conditions that would occur only in 20% of years now occur 70% of the time.



Data source: California Department of Water Resources

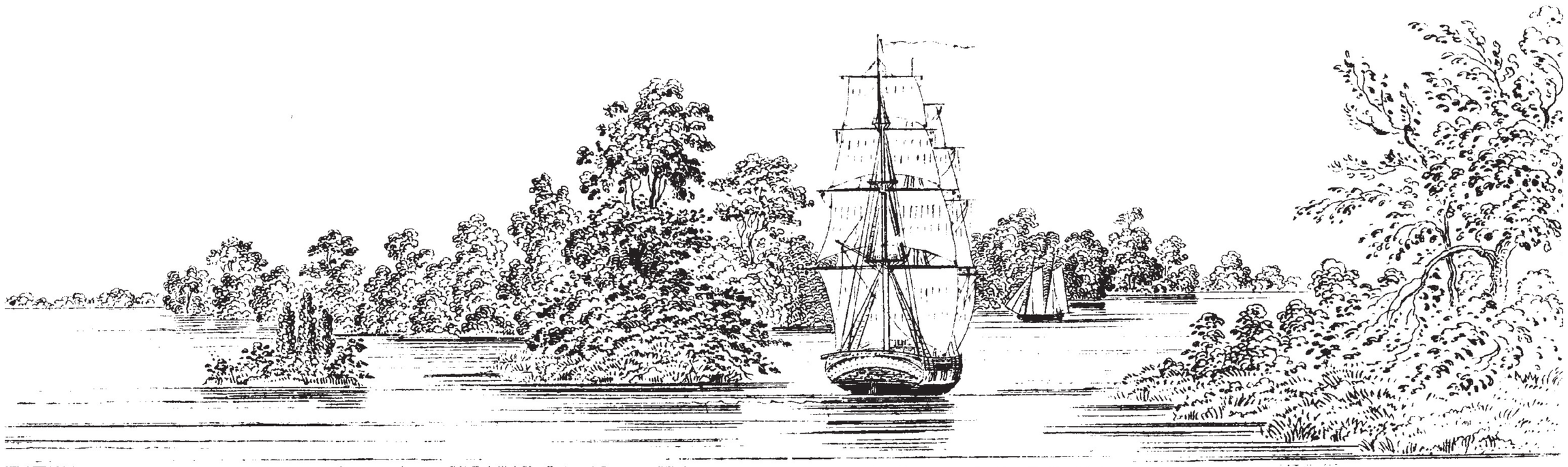
Increase in permanent crop acreage in the Central Valley



Data sources: California Department of Food and Agriculture and the Administrative Committee for Pistachios

Tree crops require irrigation throughout their lifespan, regardless of prevailing hydrological conditions. In recent decades, the acreage of Central Valley farmland devoted to tree crops, particularly nuts, has exploded, especially in the San Joaquin, where the majority of nut crops are grown. From 2001 to 2017, acreage devoted to almonds, walnuts, and pistachios more than doubled, increasing by over a million acres. The peak of the expansion in acreage devoted to growing nut crops coincided with the recent period of severe drought (red bars) further depleting over-drafted groundwater supplies and accelerating land subsidence.

The Ecological History of the San Francisco Bay-Delta Watershed



The original cover image was taken from an engraving showing the entrance to the middle fork of the Sacramento River near modern-day Steamboat Slough, in C. Ringgold's 1852 series of navigational charts and sailing directions for San Francisco Bay and Delta.

San Joaquin River Restoration Program

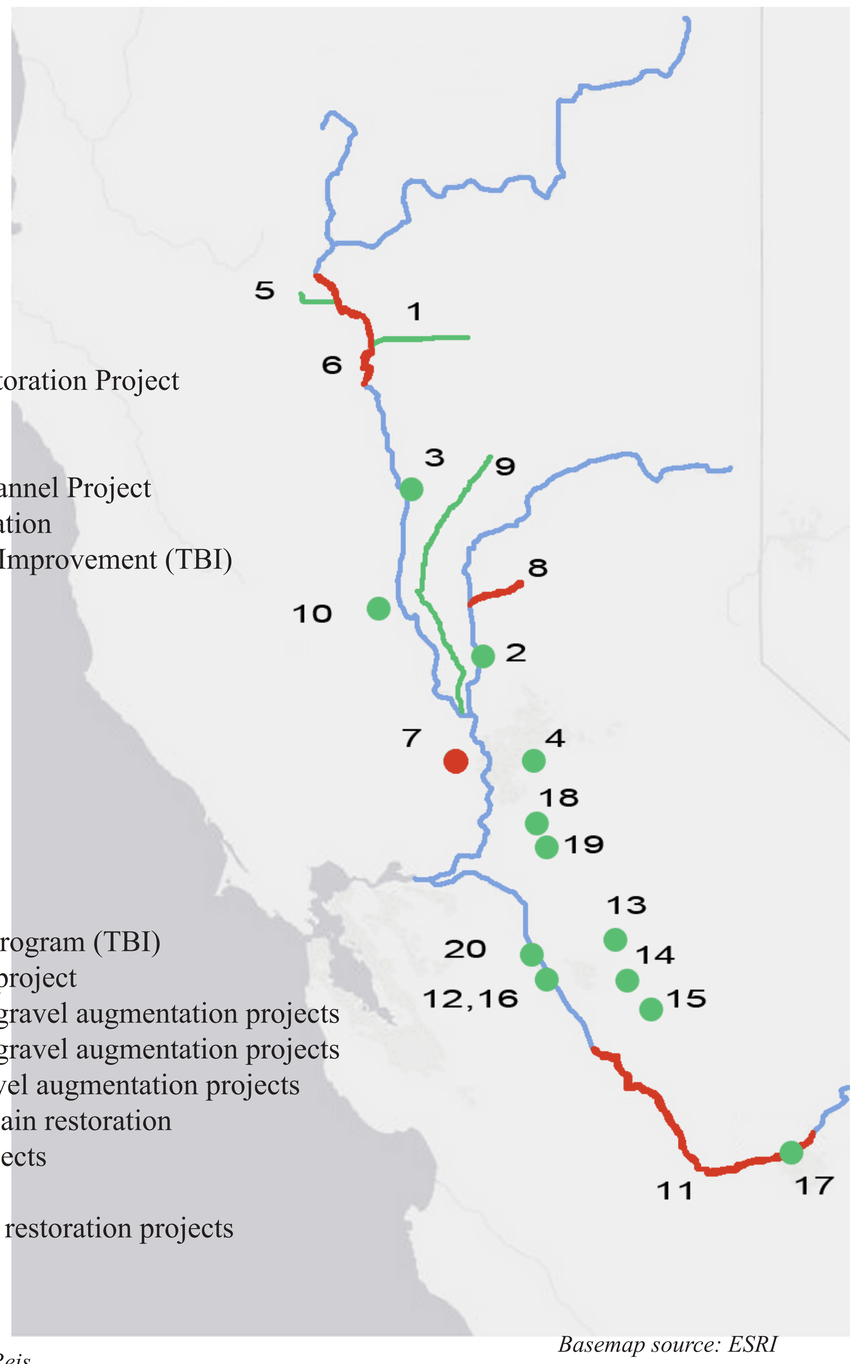
Photo courtesy of Peter Vorster

Photo © 2010 The Fresno Bee

Farmer Walt Shubin stands in the dry San Joaquin River channel in 2004, before restoration flows began, and again in 2010 after restoration flows rewatered this stretch of the San Joaquin. Restoration of flows and spring-run Chinook salmon to the 150-mile stretch of the San Joaquin River from Friant Dam to its confluence with the Merced River is the largest river restoration project in California.

Restoration Projects in the Sacramento and San Joaquin Valleys

Map showing selected significant restoration projects, or groupings of projects, in the Central Valley. Projects with significant involvement from The Bay Institute are shown in red.



Basemap source: ESRI

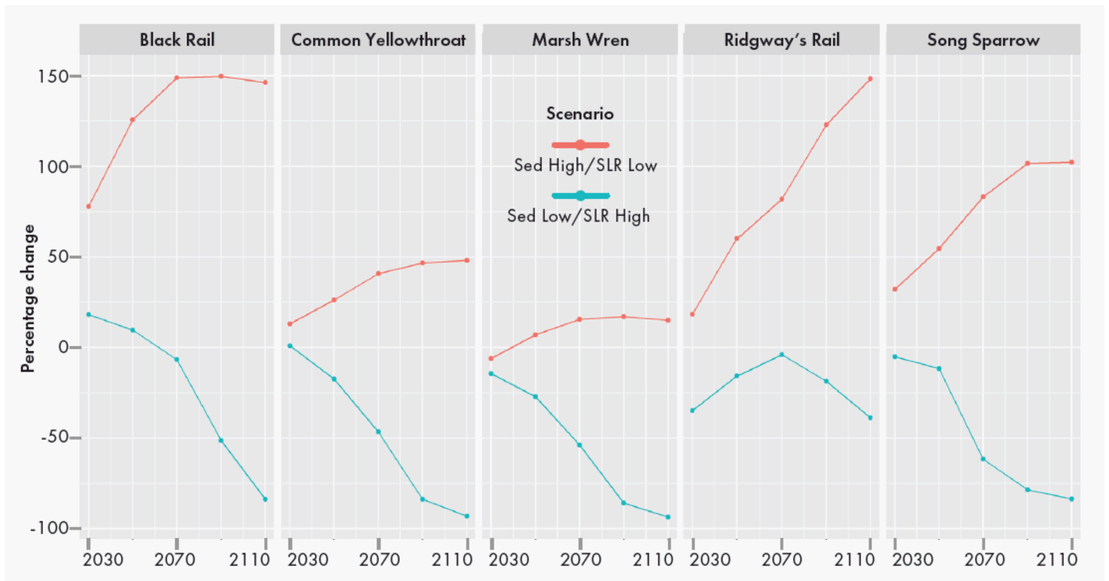
Sacramento River Projects

1. Battle Creek Salmon and Steelhead Restoration Project
2. Bear River Setback Levee Project
3. Hamilton City Levee Setback
4. Lower American River Sunrise Side Channel Project
5. Lower Clear Creek Floodway Rehabilitation
6. Red Bluff Diversion Dam Fish Passage Improvement (TBI)
7. Yolo Bypass Projects (TBI)
8. Lower Yuba River Projects (TBI)
9. Butte Creek Projects
10. Colusa Wildlife Area Projects

San Joaquin River Projects

11. San Joaquin River Restoration Program (TBI)
12. Dos Rios floodplain restoration project
13. Stanislaus River floodplain and gravel augmentation projects
14. Tuolumne River floodplain and gravel augmentation projects
15. Merced river floodplain and gravel augmentation projects
16. San Joaquin River NWR floodplain restoration
17. San Joaquin River Parkway Projects
18. Cosumnes River Projects
19. Mokelumne vineyard floodplain restoration projects
20. Paradise Cut

Contrasting Scenarios of Change in Available Habitat for Five Wetland-dependent Bird Species



Data source: Sam Veloz, Point Blue

Blue lines depict the proportional change in bird density based upon estimated future habitat extent for Black Rail, Common Yellowthroat, Marsh Wren, Ridgway's Rail (formerly Clapper Rail), and Song Sparrow under high rates of sea level rise (1.65 m) and low sedimentation rates (25 mg/L suspended sediment concentration); red lines depict estimated changes under low rates of sea level rise (0.52 m) and high sedimentation rates (300 mg/L concentration). Sea level rise threatens to permanently inundate existing tidal marshes and mudflats. Sedimentation allows these habitats to rise (accrete) along with sea level. In addition, salinity (which is a function of sea level and freshwater inflow to the Bay) determines the kind of vegetation that will dominate future marshes; freshwater marshes sustain vegetation that is better able to keep pace with rising water. Increases in river flows influences salinity and sedimentation rates that can mitigate the effects of sea level rise. studies predict 0.52 meters of sea level rise by 2050, even under low emissions scenarios, and all these studies predict 0.52 meters of sea level rise by 2100.

Marsh photo courtesy of Gregory Reis

Data source: Veloz et al 2014, CoSMoS, Our Coast Our Future

Sea Level Rise

Map showing areas projected to be inundated under 1.75 meters of sea level rise (light blue). High emissions could lead to 1.5 to 1.75 meters of sea level rise well before (Cayan et al. 2016; Griggs et al. 2017) or by the end of the 21st century (NRC 2012; see https://data.pointblue.org/apps/ocof/tools/ compare/). Some of these studies predict 0.52 meters of sea level rise by 2050, even under low emissions scenarios, and all these studies predict 0.52 meters of sea level rise by 2100.

Acknowledgements

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