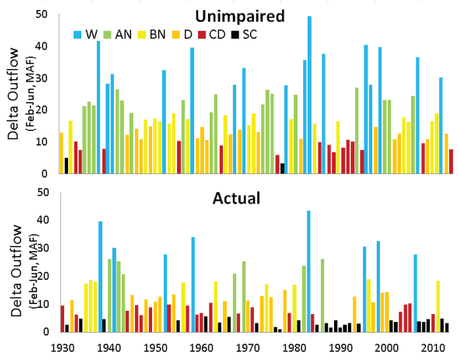
cities, and businesses. In many years, more than 50% of the Bay watershed's winter and spring fresh water flow is diverted before it reaches the Bay. In some cases, the diversions are so great that rivers actually flow backwards.

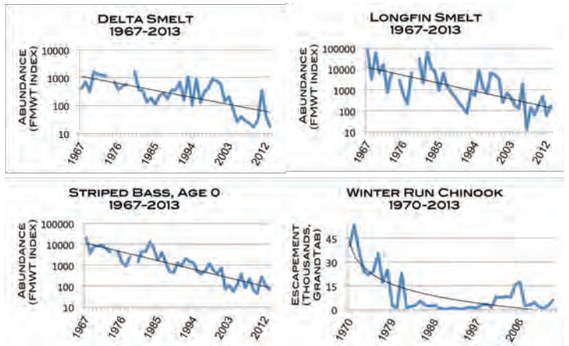
This massive system of dams, canals and diversions denies the San Francisco Bay Estuary its lifeblood – the flow of freshwater. As a result, many of our native fish and wildlife species are in danger of extinction and our commercial and sport fisheries are in sharp decline. Unless we can restore more natural pulses of fresh water at the right times of year, we may lose species that live nowhere else on Earth, valuable commercial and recreational fisheries that have supported businesses and a traditional way of life for generations, and the incredible estuarine environment that provides the Bay Area and all of California with so many ecosystem services.

The Permanent Drought in SF Bay



Above: The difference between the flow nature provides each year and flow arriving in the Bay is vast. The Bay experienced human-induced supercritically dry years (black bars, lower panel) in 26 years since 1930, while such extreme droughts occurred in the watershed only twice (black bars, upper panel).

Estuarine Fish Population Declines are Long-term and Dramatic

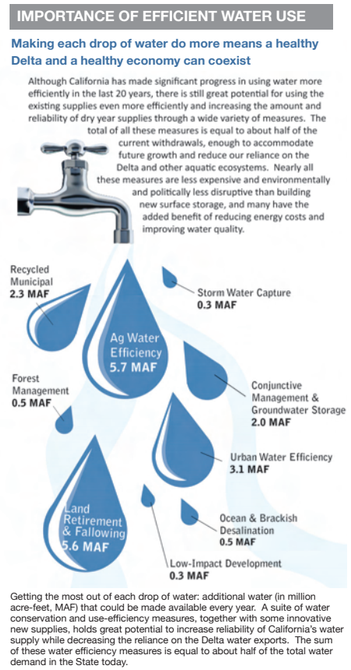


Above: Many Bay species show similar trends. For Delta smelt, longfin smelt, and young-of-year striped bass, each increment on the vertical axis is 10x the level below; thus, declines are between 90% and 99%. Vertical axis for winter-run Chinook salmon is in thousands.

Three Solutions For the Starved Estuary

There is more than enough water to restore the Bay ecosystem and still meet the water supply needs of Californians in the 21st century if we pursue three solution pathways:

- State officials charged with protecting the estuary must act now – first and foremost, by setting new water quality standards that dramatically increase flow to San Francisco Bay from 50% of the watershed's runoff toward the goal of 75% identified by the State Water Resources Control Board as necessary to fully protect the public trust values of the ecosystem.
- All users of water in California must contribute their fair share of water to restoring ecosystem flows, and for meeting water conservation targets. Cities and irrigation districts with senior water rights often have less or no obligations to release water for environmental protections than more junior water rights holders. And irrigators are not held to the same water use efficiency standards as cities, which must conserve 20% by 2020.
- Each unit of water supply must be made to work harder through reuse, recycling and other means. The most sustainable approaches to managing water supplies wisely involve using less water while providing the same goods and services (water efficiency, conservation), using water more than once before disposing of it (recycling), cleaning up degraded water so that it can be used for productive purposes (reclamation), and storing water underground in our natural groundwater reservoirs during wet years (conjunctive use, water banking, stormwater recharge).



Getting the most out of each drop of water: additional water (in million acre-feet, MAF) that could be made available every year. A suite of water conservation and use-efficiency measures, together with some innovative new supplies, holds great potential to increase reliability of California's water supply while decreasing the reliance on the Delta water exports. The sum of these water efficiency measures is equal to about half of the total water demand in the State today.

How often do diversions make the San Joaquin River flow away from the Bay?
More than 80% of days during the winter and spring since 1980

Why San Francisco Bay Can't Live Without Freshwater Flow

The Bay Institute

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San Francisco Bay: The Starved Estuary

Draining the two largest river systems in California and 40% of the state's land area, the estuary of San Francisco Bay and the Delta is the largest ecosystem of its kind on the west coast of both North and South America. The Bay's four segments (Suisun Bay, San Pablo Bay, Central Bay and South Bay) are recognized across the globe for their size, beauty, and diversity of fish and animal species.

> **Estuary:** (n) A semi-enclosed water body, open to the sea, having a high freshwater drainage and with marked cyclical fluctuations in salinity; usually the mouth of a river. (Modified from "A Dictionary of Ecology, Evolution, and Systematics, 2nd Edition" Cambridge University Press, Cambridge 1998.)

This estuary has also supported human needs for millennia. Indigenous peoples harvested abundant fish, waterfowl, and plants along its shores and these same resources supported European settlers through boom and bust cycles. Even today, the San Francisco Estuary is the nursery for several commercial fisheries.

Map of San Francisco Bay

Modern society has altered the San Francisco Estuary in many ways, including filling in or fragmenting most of its vibrant wetlands – approximately 95% of its native marshes have been lost – and introducing non-native species. But, people have also rallied to protect this ecosystem by protecting its remaining wetland habitats and beginning to restore them and by prohibiting the dumping of raw sewage and many toxic chemicals into its waters. In many respects, the estuary enjoys better protections and more positive attention now than it did just forty years ago.

Still, the estuary's ecosystem continues to decline. And human activities threaten to push this ecosystem beyond the thresholds that allow it to sustain a diverse suite of fish and animals, valuable fisheries, and the natural processes that make this area the crown jewel of California's natural environment.

Every day, without most people noticing, the Bay is being starved of its lifeblood. The mixture of fresh water and saltwater is the key element that makes an estuary an estuary – but the proportion of the watershed's natural flow that makes it to the Bay diminishes year after year. This is not a problem caused by drought (though drought exacerbates the human impact) – in fact, the estuary and

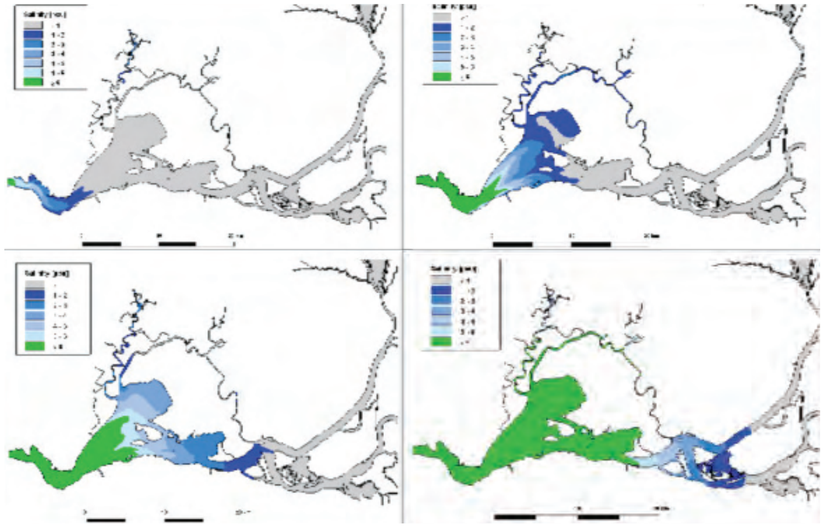
How much water does the Bay hold?
~ 8,446,000 cubic meters (~3,378 Olympic sized swimming pools)

its native organisms and diverse habitats experience a drought in most years now, almost without regard to the amount of water nature provides. Simply put, humans take too much water out of the Bay's watershed, we don't use it very efficiently, and the ecosystem is dying as a result

Why Is Freshwater Flow So Important To The Bay?

As rivers flowing from the mountains and Central Valley drain into the estuary, the fresh water and sediments they carry mix with saltier Pacific Ocean water carried in on the tides. The size and position of this low salinity, brackish water habitat has dramatic implications for all of the ecosystem's aquatic organisms and its multitude of estuarine habitats. The mixing of fresh and salt water and the shifting tides help keep sediment suspended and encourages the growth of tiny organisms (photosynthetic phytoplankton, and the shrimp and other zooplankton that feed on them, the base of the Bay's rich food web). As a result, the San Francisco Estuary is a very productive place. The flow of freshwater and tides create a dynamic gradient of salinity that shifts back and forth across the estuary's aquatic and shoreline habitats. The duration, frequency, and size of brackish water habitat also shapes the extent, location and composition of the San Francisco Bay Estuary's tidal marshes, which change over time in response to salinity levels, and the inflow of sediments, nutrients, and contaminants carried in by runoff from the Bay's watershed.

Freshwater Flow Impacts the Salinity Distribution in the Upper Estuary



Left: Estimated salinity distribution under different outflow conditions. When outflows are high (upper left cell), the salinity field (colored areas) moves to the west; in drier years (bottom right) salinity can intrude into the Delta. Distribution and abundance of many species are affected by size and location of salinity field Simulations produced for the USEPA by Delta Modeling Associates.

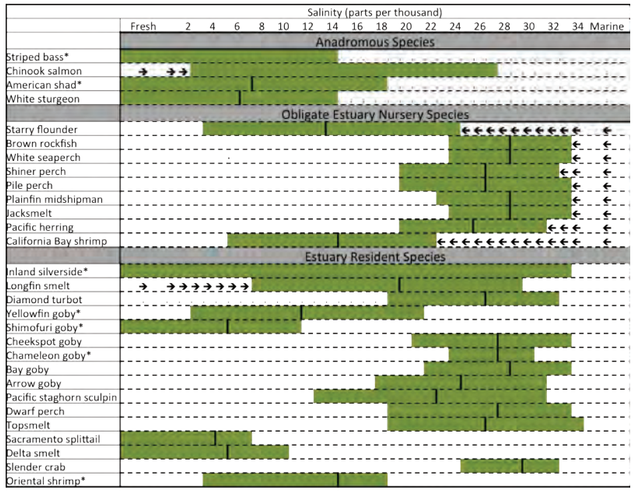
Organisms respond both to salinity levels and other ecosystem processes that are driven by the amount of fresh water inflow to the Bay. The life cycle of many native species is timed to correspond with the annual peak in fresh water runoff that occurs in the winter and spring. The abundance and distribution of these species is directly tied to the volume and duration of runoff at this time of year.

Other species respond to the flow of freshwater upstream as it inundates critical habitats, like floodplains or marshes, and produces the necessary conditions for successful reproduction. For instance, the Sacramento splittail, a native minnow species that lives nowhere else in the world, specializes in reproducing in inundated floodplains of the Bay's watershed; when river flows are high enough in the spring, splittail populations explode. Similarly, the Bay watershed's four Chinook salmon runs, steelhead, and sturgeon are most productive when rivers run high – juveniles of these species migrate downstream and into San Francisco Bay in large numbers in response to adequate freshwater flows. Furthermore, high flows of water from rivers into the estuary stimulates production of organisms near the base of the food web that salmon, sturgeon, migratory birds, and other valuable species feed upon.

In general, high volumes of freshwater entering the upper estuary during the winter and spring correspond to highly productive fisheries that were once a regular feature of the San Francisco Bay estuary. These fisheries sustain a multitude

How much water would naturally flow from its watershed to the Bay in a median year?
30,467,000,000 cubic meters

Range of Salinities for Common Fish and Invertebrate Species in the Bay



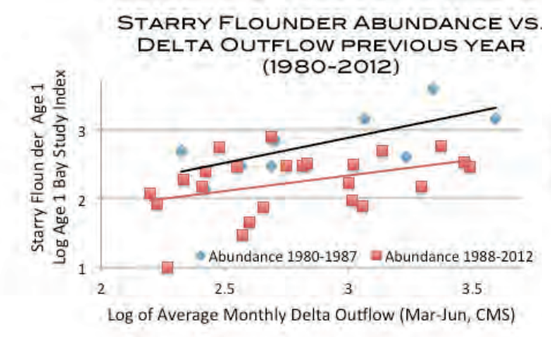
Above: Dark green bars represent the range where the species is most commonly detected by the Interagency Ecological Program's San Francisco Bay Study. Vertical lines represent mean salinity of life stage's range. Arrows indicate direction of movement into the salinity range. Asterisks indicate non-native species. Adapted from IEP Technical Report 63, 1999

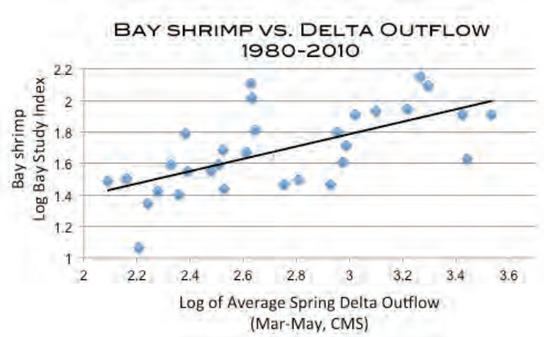
of other creatures, from migratory waterfowl and shorebirds to marine mammals that feast on shrimp, salmon, and other creatures that are born or rear in the estuary.

Higher fresh water flow rates into the estuary can also help to protect and restore productive natural habitats. Freshwater inflow carries sediments that are necessary to maintain and restore tidal marsh habitats. Also, freshwater flow pulses help flush the Bay of compounds that may become toxic if allowed to accumulate too long. Finally, mounting evidence indicates that adequate freshwater flows are essential for controlling the spread of non-native species and for preventing future invasions – non-native colonists can restructure the entire ecosystem in ways that harm native plants and animals.

Above: Splittail credit Joe Kirsh at USFWS

Populations of Many Species are Strongly Correlated with Fresh Water Flow into the Estuary





Above: Many estuarine species, including flounder and shrimp, respond strongly to increased flows to the Bay. Axes are log scaled (each integer is 10x greater than one below it, 1/10th one above it). Straight lines represent statistically significant flow-abundance relationships.

The Permanent Drought In The Bay, And Its Consequences

Current levels of fresh water flow into the estuary are not adequate to support productive fisheries, maintain healthy habitats, flush out toxic compounds, or control non-native invaders. Nor are they sufficient to transport the Bay Estuary's productivity to the nearshore ocean (the Gulf of the Farallones) where marine organisms like whales, dolphins, and rockfish live. Essentially, our estuary – the largest on the Pacific coast of North and South America - barely functions like an estuary in many years.

This decline in freshwater flow is not a result of the recent drought or previous ones. Over the past 45 years, more than one-third of years have looked like a severe drought to the organisms and habitats of the Bay Estuary that rely on freshwater flow. The water is blocked by dams on most of the Central Valley's rivers and diverted to California's farms,

What percentage of the 1987-2013 median natural freshwater flow actually made it to the Bay on average?
~ 49%