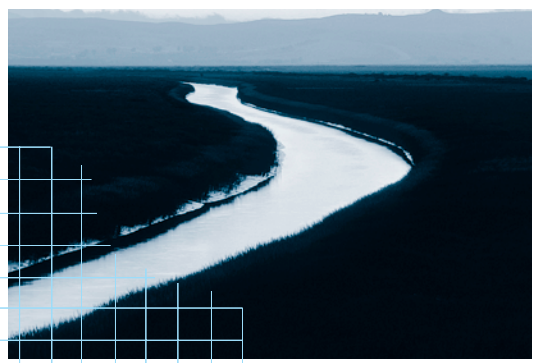
THE BAY INSTITUTE
Ecological Scorecard

SAN FRANCISCO BAY INDEX

2003



The Bay Institute (TBI) is a non-profit research, education and advocacy organization dedicated to protecting and restoring the ecosystems of San Francisco Bay, the Sacramento-San Joaquin Delta, and the estuary's tributary rivers, streams, and watersheds. Since 1981, TBI's policy and scientific experts have worked to secure stronger protections for endangered species and habitats; improve water quality; reform how California manages its water resources; and promote comprehensive ecological restoration from the Sierra to the sea.

To order copies of the 2003 Bay Index, or a CD of the report and the Technical Appendix, contact:

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The entire 2003 Bay Index report and Technical Appendix can also be downloaded from our website at www.bay.org.

The 2003 San Francisco Bay Index, and the Bay-Delta Ecological Scorecard Project of which it is a part, were made possible by the generous financial support of the Compton Foundation, Inc.; the Mary A. Crocker Trust; the Fred Gellert Family Foundation; the Richard and Rhoda Goldman Fund; the William and Flora Hewlett Foundation; the Marin Community Foundation; the Rose Foundation for Communities and the Environment; the San Francisco Foundation (Switzer Environmental Leadership Program); the San Francisco Estuary Project; the U.S. Fish and Wildlife Service; the Weeden Foundation; and the Dean Witter Foundation, as well as individual supporters of the Bay Institute.

Cover photo: Napa Slough, by David Sanger.

San Francisco Bay Index

Ecological Scorecard

			Long-term	Short-term
	D+ Score = 32	**Habitat** Bay habitat loss is slowly being reversed, but it could take nearly 200 years to reach the tidal marsh restoration goal.	↓	↑
	D Score = 29	**Freshwater Inflow** Reduced inflows are still degrading the Bay ecosystem, and recent gains from wetter years and new standards are being eroded	↓	↓
	C Score = 55	**Water Quality** Open waters are cleaner, but standards are not met in parts of the Bay. Toxic sediments and storm runoff are a major problem.	↑	↔
	F Score = 10	**Food Web** Plankton levels in the upper Bay have crashed, reducing food sources for fish and birds. Alien species are locally dominant.	↓	↔
	B- Score = 63	**Shellfish** Crab and shrimp numbers are increasing, but commercial harvest is still down from previous high levels.	↓	↑
	C- Score = 39	**Fish** After a long decline, fish populations are stable at low levels, but some species are still endangered.	↓	↔
	D+ Score = 31	**Fishable-Swimmable-Drinkable** Fish are harder to catch, and unsafe to eat. Beach closures are up, drinking water violations are down.	↓	↔
	C- Score = 43	**Stewardship** Water conservation, pollution limits, monitoring, and restoration efforts are finally underway, but progress is slow.	↓	↔

Grades based on data from 2000-2003 period

- **A** Excellent
- **B** Good
- **C** Fair
- **D** Poor
- **F** Critical

Trends over time

Long term= past 25 years or more

Short term = past five years

- ↑ improving
- ↓ declining
- ↔ stable

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Executive Summary

San Francisco Bay is a unique national treasure. The largest estuary—where ocean and fresh water meet—on the west coast of the United States provides habitat for hundreds of plant and animal species, many found nowhere else in the world. The Bay supplies seafood for businesses and anglers. Its watershed is a major source of water for cities and agriculture. Residents and tourists sail and swim in its waters, play along its shoreline and tributary creeks, and value its wildlife and scenic qualities.

But the Bay's vital signs are not good. Over the last century, once abundant native fish and wildlife populations have declined drastically, while harmful alien species have invaded the Bay. The amounts of wetland habitat and freshwater flows into the Bay have decreased dramatically, while pollution levels have risen. Commercial and recreational fisheries have collapsed, and those fish that are caught in the Bay are not safe to eat. The fair to poor grades reported in the 2003 Bay Index reflect this long-term decline in the Bay region's ecological health—but the current situation is not all bleak. In most cases, the decline has been halted and short-term conditions are relatively stable. In some cases, such as habitat and shellfish populations, there have been small but noticeable improvements.

Many efforts are underway to improve the Bay's health. The Bay Institute's Ecological Scorecard is intended to improve our understanding of how the entire Bay watershed is doing, to monitor how effective our stewardship of this vital resource is, and to identify future directions for management, monitoring, and research. The 2003 Bay Index focuses on the Bay itself, which is the first of four major ecological regions of the estuary—Bay, Delta, San Joaquin River and Sacramento River—to be assessed as part of the Ecological Scorecard project.

The Scorecard's Bay Index uses science-based indicators to grade the condition of the Bay region: how well its ecological resources are faring, how much human activities are harming or helping the Bay, and how human uses of the Bay's resources are affected by the Bay's health. These indicators are combined into eight Indexes that track the Bay's environment (Habitat, Freshwater Inflow, Water Quality), its fish and wildlife (Food Web, Shellfish, Fish), our management of its resources (Stewardship), and its direct value to the people who use it (Fishable-Swimmable-Drinkable). The grading system compares current conditions in the Bay and its watershed to historical conditions, environmental and public health standards, and restoration targets.

The Bay Institute

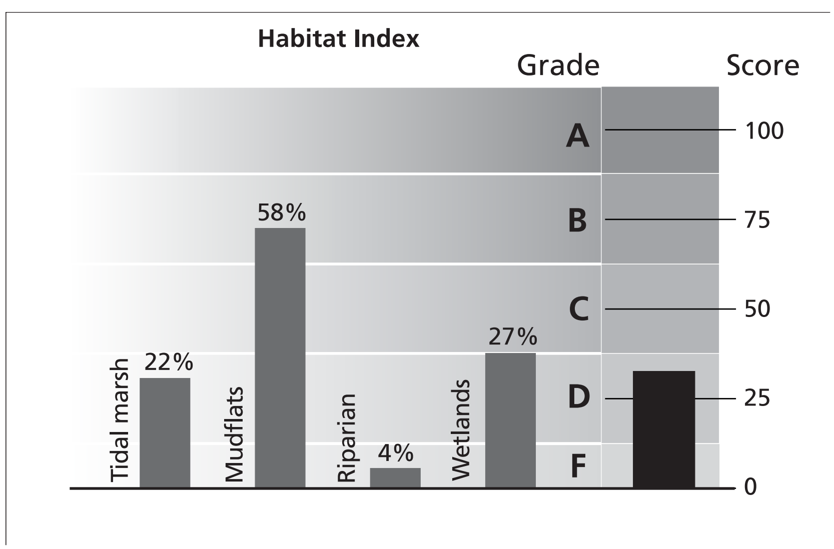
San Francisco Bay Index

Grade	Score	Long-term Trend	Short-term Trend
D+	32	↓	↑

Habitat

Wetlands, mudflats, and riparian areas are rich sources of food and nutrients, and provide critical spawning, nesting, and rearing habitat for the Bay's fish and wildlife species. These habitats also improve water quality and flood control, and support birding, fishing, hunting, and other recreational activities. Converting these areas for agriculture, salt production, and urban development has reduced the Bay's productivity and restricted the amount of habitat available for use by endangered plants and animals.

- Tidal marsh area decreased by 78% during the last 150 years, from 190,000 acres to just 40,000 acres.
- Tidal mudflats decreased by 42% in the same period.
- Seasonal wetlands decreased by nearly 75% over the 150-year period.
- Riparian habitat decreased 95% along the Bay margins, and 84% throughout the entire Bay region's watershed, from its full extent 150 years ago.
- Since 1998, restoration of 1,700 acres increased tidal marsh habitat by more than 4%. At this rate, it will take nearly 200 years to achieve the 50-100 year targets set for Bay tidal marsh restoration by the Baylands Habitat Goals Project.
- The recent acquisition of South Bay salt ponds, following similar efforts in the North Bay, created a unique opportunity to restore up to 23,000 acres of tidal marsh around the Bay. Wetland acquisitions since 1997 total 40,000 acres, and at least two-thirds of these acres are slated for restoration in the next 30 years.
- During the past 5 years, almost 500 acres of non-tidal diked wetlands have been created or enhanced, nearly 3% of the target for this habitat type.



The Habitat Index aggregates the results of the tidal marsh, tidal mudflat, seasonal wetland, and riparian habitat indicators.

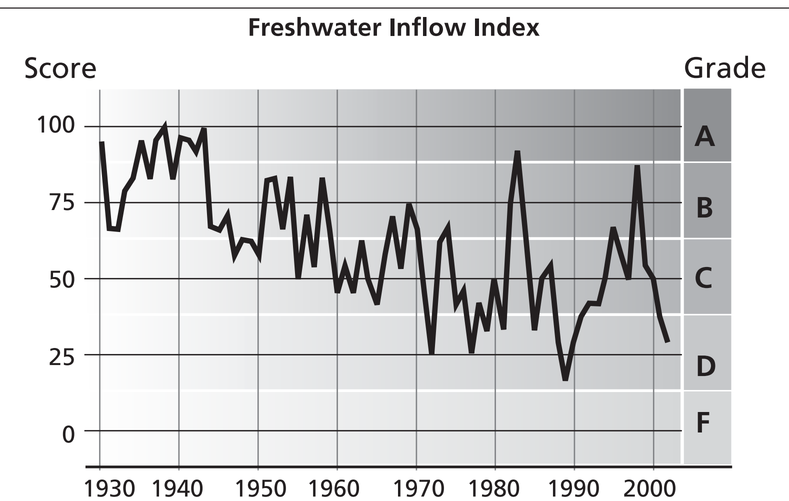
San Francisco Bay Index

Grade	Score	Long-term Trend	Short-term Trend
D	29	↓	↓

Freshwater Inflow

The amount and timing of freshwater inflow to San Francisco Bay defines the quality and quantity of its estuarine habitat. Flows transport organisms and nutrients, improve water quality, and provide the low salinity habitat on which many Bay species depend. Irrigating the Central Valley, constructing a massive system of reservoirs and canals, and exporting water directly from the rivers and Delta have reduced the amount of freshwater reaching the Bay, and changed its timing.

- In 2002, just over 50% of total annual runoff from the Sacramento-San Joaquin watersheds reached the Bay.
- In recent years, reduced freshwater inflow cut the frequency of "wet" years for the Bay by 50% and imposed drought conditions more frequently.
- In 2002, a "below normal" year in the Bay's watershed, the Bay received only the amount of freshwater as expected in a "critically dry" year.
- Freshwater flow during the ecologically sensitive spring period decreased by as much as 75% since 1940. In 2002, only 32% of the spring runoff reached the Bay, still an improvement compared to spring inflows during the 1987-1992 drought.
- Spring inflows are extremely important to Bay fish. In 2002, reduced spring inflows shifted low salinity habitat upstream by nearly 15 kilometers (9 miles) compared to historic conditions, corresponding to a predicted three-fold decrease in the abundance of several Bay fish species.
- Seasonal variation in fresh water inflow—high flows in spring and lower flows later in the year—are an important environmental signal for many Bay species. This variation was reduced by 46% in 2002, compared to historic conditions.
- Peak flows, which periodically freshen Bay waters, occurred for only eleven days in 2002, compared to the expected 58 days of peak flows under historic conditions.
- The 1940-94 downward trend in the Freshwater Inflow Index reflected increases in upstream water diversions. Wetter hydrologic conditions and increased flow requirements after 1994 temporarily improved Bay flow conditions, but the trend has been reversed in the past few years.



The Freshwater Inflow Index aggregates the results of the annual inflow, water year type, spring inflow, change in spring inflow, seasonal variation, and change in peak flow indicators.

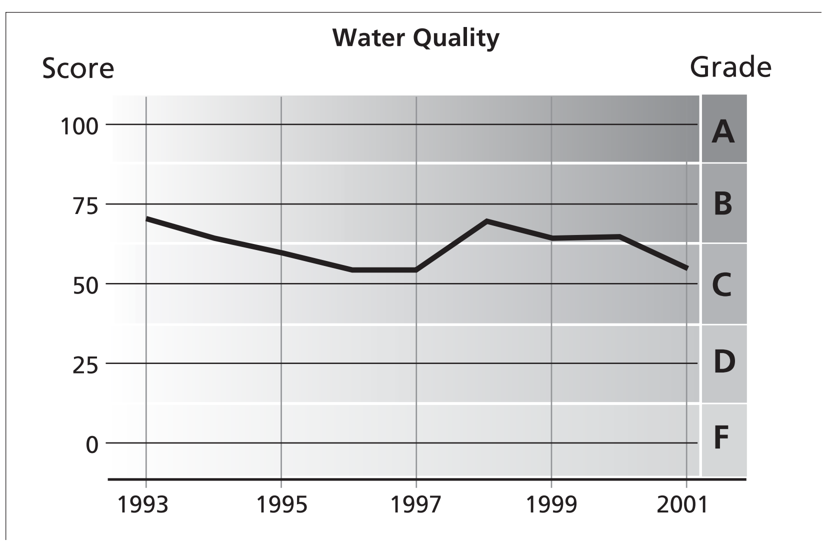
San Francisco Bay Index

Grade	Score	Long-term Trend	Short-term Trend
C	55	↑	↔

Water Quality

San Francisco Bay, one of the most urbanized estuaries in the United States, receives polluted runoff from urban, industrial, and agricultural areas along its shores and from its vast watershed. Pollution can harm the plants, animals, and people that live in and around the Bay, reduce the productivity and health of the ecosystem, and contaminate fish, birds, and shellfish to the point at which they are not safe to eat.

- The Bay's open waters are cleaner than they were thirty years ago, but during the past decade pollution levels have not changed. The less visible but more persistent toxic chemicals continue to be the main water quality problem.
- In most years, water quality standards for mercury, copper, selenium, nickel, pesticides, PCBs, hydrocarbons, and dissolved oxygen are still exceeded in some locations. Portions of the South and San Pablo Bays are the most polluted areas in the Bay.
- PCB pollution is the most widespread—nearly all water samples collected from the Bay contain unhealthy concentrations of PCBs.
- Trace element concentrations are declining in most parts of the Bay's open waters, but still exceed water quality standards in most years.
- Pesticide standards were exceeded in 16% of open water Bay samples. Contamination by diazinon, dieldrin, heptachlor epoxide and DDT compounds is much more severe in some areas. Stormwater runoff in urban creeks, and sediments at their mouths, are frequently contaminated with pesticides.
- Although the role of contaminants in affecting ecosystem productivity and population levels is not fully understood, current levels of several contaminants exceed those known to harm fish and wildlife species. The Water Quality Index tells only part of the Bay's story because it measures concentrations of contaminants in open waters, not in sediments or stormwater runoff, and does not reflect uptakes of contaminants by plants and animals (see Fishable-Swimmable-Drinkable Index).



The Water Quality Index aggregates the results of the trace element, pesticide, PCBs, PAHs, and dissolved oxygen indicators for open Bay waters.

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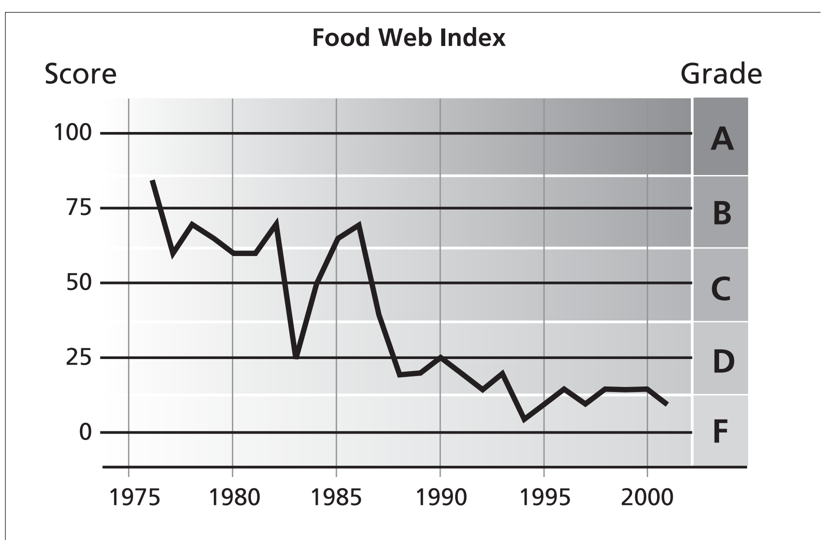
San Francisco Bay Index

Grade	Score	Long-term Trend	Short-term Trend
F	10	↓	↔

Food Web

Phytoplankton and zooplankton—microscopic plants and animals—are the foundation of the San Francisco Bay aquatic food web. Healthy populations of these organisms provide food for Bay fish and wildlife, fueling the Bay's vibrant ecosystem and supporting its recreational and commercial fisheries.

- Phytoplankton biomass declined 80% since 1976 in Suisun Bay, the upper portion of the Bay.
- Rotifers, small zooplankton, declined 98% in Suisun Bay between 1974 and 2001.
- Most copepods (medium sized zooplankton species) now found in the upper Bay are alien species.
- The Bay's largest native zooplankton species, *Neomysis*, an important food for many fish species, has nearly disappeared from its Suisun Bay habitat.
- Average zooplankton size decreased by 80% since 1974, making them less valuable as a food source for Suisun Bay species.
- The extreme food web changes since the mid-1970s are strongly associated with reduced freshwater inflow and alien species introductions.



The Food Web Index aggregates the results of the phytoplankton, rotifer, copepod, mysid, and zooplankton size indicators for Suisun Bay.

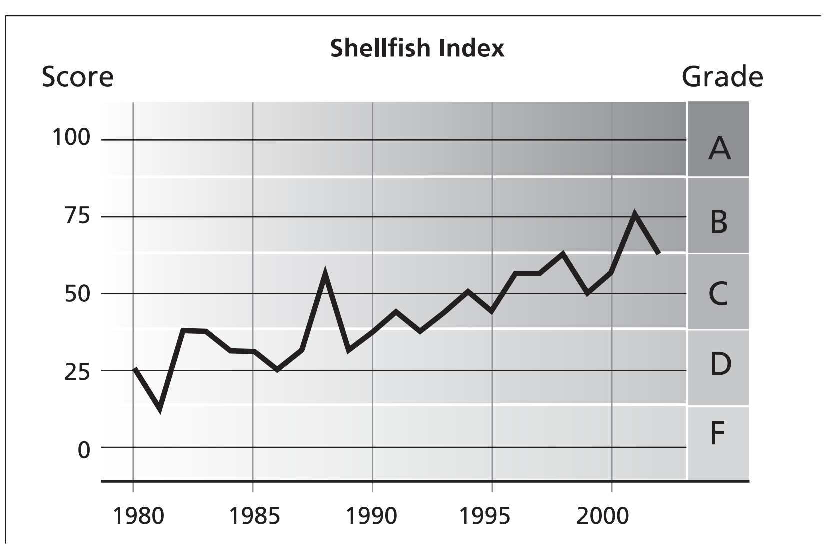
San Francisco Bay Index

Grade	Score	Long-term Trend	Short-term Trend
B-	63	↓	↑

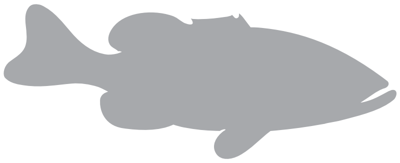
Shellfish

San Francisco Bay is an important habitat for crabs, shrimp, clams and other shellfish. Many shellfish species are consumed by Bay fish and birds and also are harvested for commercial and recreational uses.

- Juvenile Dungeness crab numbers increased dramatically over the last five years, but commercial landings are still only about 20% of the 1940s-50s levels.
- Rock crab abundance increased 900% between the early 1980s and the early 1990s but has leveled off since then. Their historic abundance is not known.
- Bay shrimp species increased 150% over the 1980–1995 average, but are still at less than 10% of historic population levels.
- Although the Bay has been invaded by a number of alien shellfish, more than 95% of shrimp collected in the Bay are native species.
- Some shellfish populations increased during the drier years of the late 1980s and early 1990s, while others such as the Bay shrimp increased in wetter years.



The Shellfish Index aggregates the results of the Dungeness crab, rock crab, native shrimp, and percent native shrimp indicators.



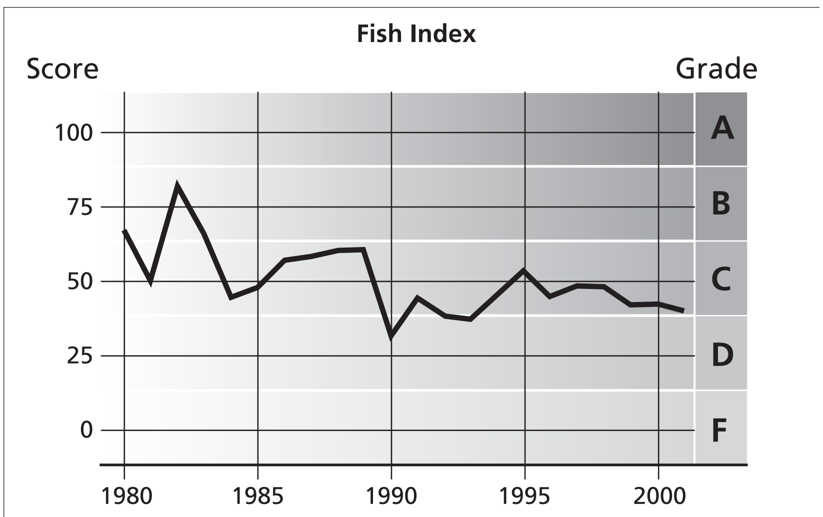
San Francisco Bay Index

Grade	Score	Long-term Trend	Short-term Trend
C-	39	↓	↔

Fish

San Francisco Bay is essential habitat for many fish species, including commercially important Pacific herring and chinook salmon, popular sport fishes like striped bass, and many sensitive estuary-dependent species like delta smelt and starry flounder.

- Between 1980 and 2001, abundance of native fish declined by 50%. In 2001, abundance still showed no sign of improvement from its previous steep decline.
- Longfin smelt and delta smelt declined by more than 90% between 1980 and 1990. In 2001, longfin numbers were 7% of former abundance and delta smelt less than 50%.
- Native species made up 82% of the Bay's fish community in 2001. In Suisun Bay, alien species are more prevalent, making up about a third of the total.
- The long-term decline in the Bay Fish Index is associated with reduced freshwater inflow, habitat loss, and the collapse of the Bay's food web in Suisun Bay.



The Fish Index aggregates the results of the abundance, diversity, percent native species, and sensitive species indicators.

San Francisco Bay Index

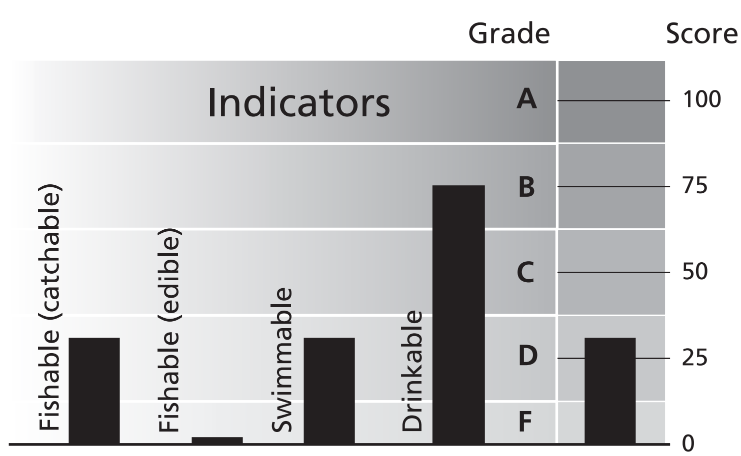
Grade	Score	Long-term Trend	Short-term Trend
D+	31	↓	↔

Fishable, Swimmable, Drinkable

San Francisco Bay is an important and heavily used resource for the Bay Area's human population. Many Bay fish and crab species are caught by recreational and subsistence anglers. Bay beaches and nearshore waters attract swimmers, kayakers, and board sailors. Surface runoff and groundwater from the Bay's many watersheds—near and far—provide drinking water to Bay Area residents.

- Sport anglers caught, on average, less than one fish per day, a 60% decline compared to the early 1960s but an improvement over the low catch of 10 years ago.
- In 2000, 94% of all Bay fish sampled were contaminated with PCBs, mercury, DDT, or chlordane pesticides at levels that made them unsafe to eat.
- In 2002, San Francisco Bay beaches were reported posted or closed for 50 days, an increase of more than 200% over 2001.
- In 2003, 10% of drinking water suppliers reported exceedences for nitrogen compounds, heavy metals, or industrial chemicals in their source water supplies—a 25% improvement compared to levels measured 10 years ago. Maximum contaminant limits for pesticides and hydrocarbons have not been exceeded for the past six years. Groundwater supplies were the most contaminated.

Fishable-Swimmable-Drinkable Index



The Fishable-Swimmable-Drinkable Index aggregates the results of the fish catch, fish consumption, beach posting, and drinking water exceedence indicators.

The Bay Institute

San Francisco Bay Index

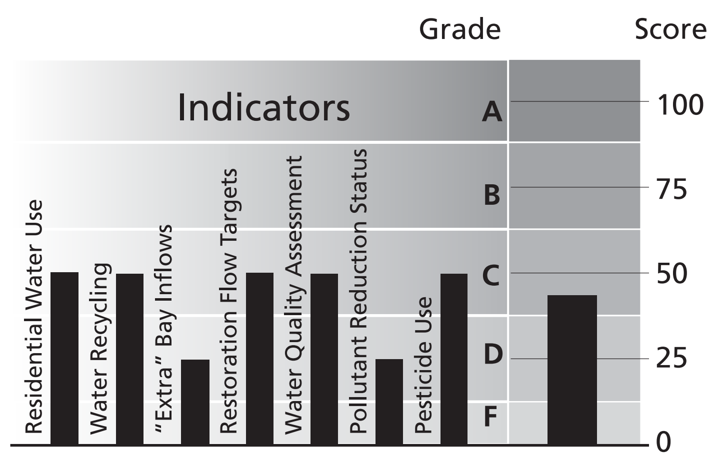
Grade	Score	Long-term Trend	Short-term Trend
C–	43	↓	↔

Stewardship

Stewardship of the Bay involves more efficient use and reuse of current water supplies; adequate monitoring and evaluation of water quality conditions; and aggressive efforts to remedy the Bay's problems by such measures as reducing pollutant loads and increasing Bay inflow.

- Bay Area residents are becoming more efficient water users, but could still reduce residential use by another 30%. In 2003, the average person used about 95 gallons per day, 43% more than the conservation target of 66 gallons each day.
- In 2003, the Bay Area recycled 68% of the amount targeted for reuse.
- Bay inflows exceeded the minimum spring requirements by only 16% in 2001, and were actually 20% less than the flow amount needed to maintain low salinity habitat at the expected position in 2002.
- Only one of the three restoration targets for enhancing Bay inflow was met in 2002. Export pumping rates were low in the April-May period, however.
- The waters of the Bay itself are adequately sampled, but only 56% of the watershed area and a third of the wetland area are monitored for ambient water quality.
- On average, government efforts to protect each of the most impaired water bodies in the Bay region have only completed two of the eight phases necessary to adopt pollutant load limits. None of the pollutant limits for high priority water bodies have been established or implemented yet.
- Use of diazinon and chlorpyrifos, two organophosphate pesticides banned for urban use, has declined by 75%, but these chemicals have been replaced by other compounds, such as pyrethroid insecticides, which are highly toxic to aquatic life and for which there are no water quality standards yet.

Stewardship Index



The Stewardship Index aggregates the results of the residential water use, water recycling, "extra" Bay inflow, restoration flow target, water quality assessment, pollutant reduction status, and pesticide use indicators.

5 Things to Do

The Five Most Important Things You Can Do To Improve the Bay's Grades

1. **Be a smart water user.** Fix leaks, replace inefficient toilets and washing machines, and switch to less water-intensive plants in your lawn and garden. Start by contacting your local water district or www.h2ouse.org.
2. **Don't pollute the Bay.** Use safe substitutes for household and lawn chemicals, adopt greener cleaning and gardening methods, and properly dispose of all toxic materials. The Pesticide Advisor (www.panna.org/resources/advisor.html) is a good place to begin.
3. **Restore your local habitat.** Join a community group helping to clean up and restore wetlands, streams and shorelines in your area. A listing of some of these groups is available at www.aoinstitute.org/creekcontacts.html. More about wetlands restoration projects can be found at the San Francisco Bay Joint Venture site (www.sfbayjv.org).
4. **Keep rivers flowing to the Bay.** Support the Bay Institute and other organizations in the Environmental Water Caucus that are working to reduce the amount of water diverted from the Bay's watersheds and change how water supplies are managed throughout the state. Visit www.bay.org to read the Caucus *Blueprint for an Environmentally and Economically Sound Water Supply Reliability Program*, and look for TBI's annual *The Year in Water* report.
5. **Vote for the environment.** Track politicians' voting records, and support legislation and ballot measures to protect the Bay. You can get the lowdown from the California League of Conservation Voters at www.ecovote.org.

It all adds up to educating yourself and others.
Congratulations – you've taken the first step by reading this!

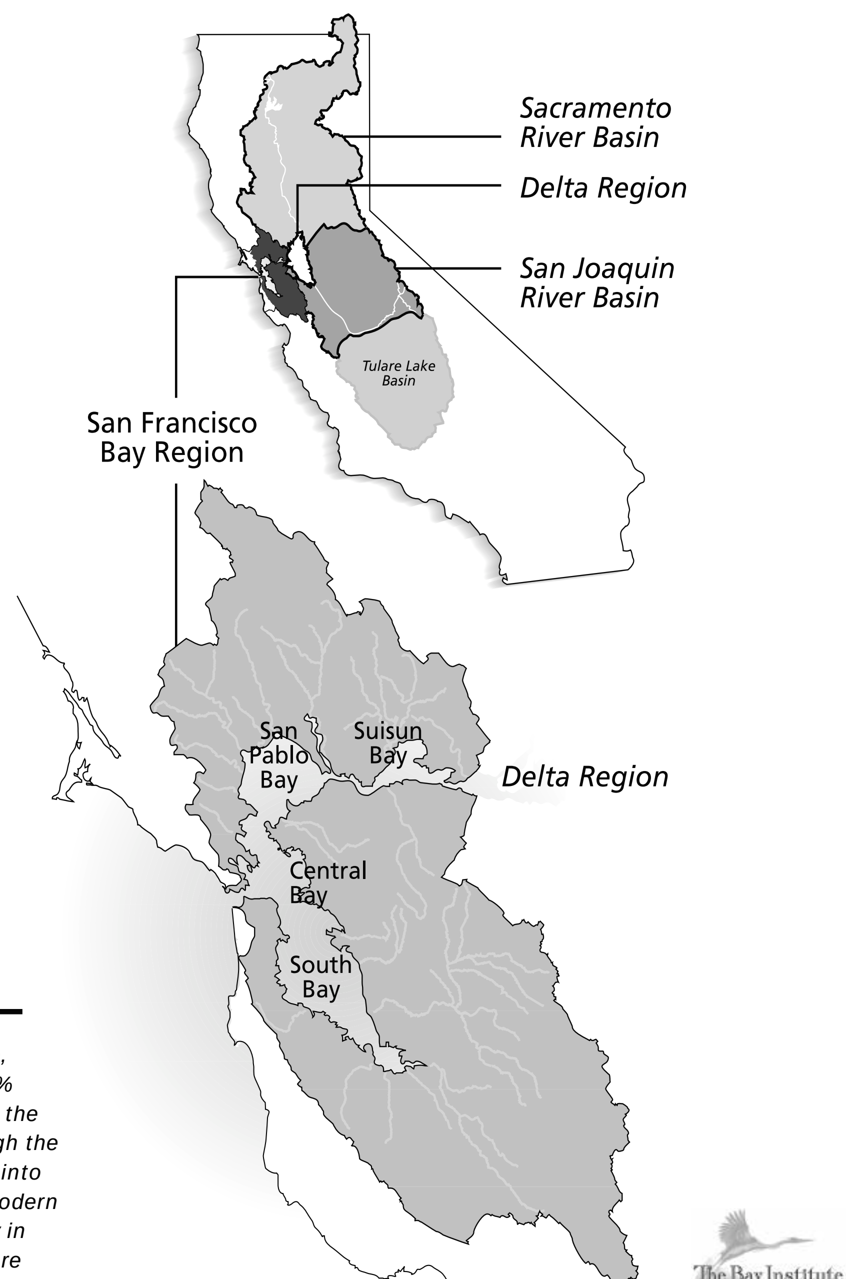
Table of Contents

Introduction

San Francisco Bay is a unique national treasure. The largest estuary—where ocean and fresh water meet—on the west coast of the United States, it provides habitat for hundreds of plant and animal species, many found nowhere else in the world. The Bay supplies seafood for businesses and anglers. Its vast watershed is a major source of water supplies for cities and agriculture. Residents and tourists sail and swim in its waters, play along its shoreline and tributary creeks, and value its wildlife and scenic qualities.

But the Bay's vital signs are not good. Over the last century, once abundant native fish and wildlife populations have declined drastically, while harmful exotic species have invaded the Bay. The amounts of wetland habitat and freshwater flows into the Bay have decreased dramatically, while pollution levels have risen. Commercial and recreational fisheries have collapsed, and those fish that are caught in the Bay are not safe to eat. The fair to poor grades reported in the 2003 Bay Index reflect this long-term decline in the Bay region's ecological health—but the current situation is not all bleak. In most cases, the decline has been halted and short-term conditions are relatively stable. In some cases, such as habitat and shellfish populations, there have been small but noticeable improvements.

Many efforts are underway to improve the Bay's health, but there is currently no set approach to measuring how the Bay—and our ef-



From the peaks of the Sierra Nevada to the Golden Gate, the San Francisco Bay Estuary watershed drains over 40% of California's land area. Most of its inflow is drained by the Sacramento and San Joaquin Rivers and funneled through the Delta. Locally important creeks and rivers drain directly into the Bay from the surrounding hills and valleys. In the modern hydroscape the Tulare Lake Basin contributes water only in the wettest years, although historically the now dry Tulare Lake would periodically overflow into the San Joaquin River.

fort to improve its condition—is doing. In 1995, following the adoption of more protective water quality and endangered species requirements and the initiation of a long-term state-federal restoration planning process, The Bay Institute identified three critical needs for managing and restoring the estuary's resources. First, a more comprehensive understanding of the historical ecosystem was desirable: this led to the publication in 1998 of *From the Sierra to the Sea: The Ecological History of the Bay-Delta Watershed*. Second, the adoption of clear, measurable objectives for ecological restoration was necessary: TBI worked extensively on crafting goals and objectives for the newly created California Bay-Delta Authority's Ecosystem Restoration Plan, finalized in 2000. Finally, measures of ecological health were essential to monitoring progress toward achieving these goals and objectives: the project to develop a Bay-Delta Ecological Scorecard was launched. The Scorecard is intended to improve our understanding of how the entire Bay watershed is doing, to monitor how effective our stewardship of this vital resource is, and to identify future directions for management and research. Because our understanding of how the Bay ecosystem works—and how to evaluate its health—is imperfect; because data sources are limited and uneven in coverage; and because the ability to collect, manipulate and interpret all the data into one comprehensive and definitive picture is beyond the resources of any single organization; the Scorecard serves as a rough estimate of the ecosystem's true condition, and will be updated on a periodic basis to reflect our changing knowledge of the entire system and its problems.

The Bay and its watersheds include four distinct ecological regions: the Bay itself, the Delta, and the Sacramento and San Joaquin River basins. The San Francisco Bay Index focuses on the Bay region, which stretches from the brackish, river-influenced waters of Suisun and San Pablo Bays in the north to the marine-dominated Central San Francisco Bay to the lagoon-like South Bay. Conditions in the Bay are affected not only by local actions but also by management of its upper watershed—including operation of a massive system of reservoirs and canals; runoff from millions of acres of irrigated agricultural lands; historic and ongoing land conversion on a vast scale; and other factors. In order to complete the Bay-Delta Ecological Scorecard and provide a more complete picture of the Bay's health, the Bay Institute will produce an Index for each of the other three regions in the coming years.

The Scorecard's Bay Index uses science-based indicators to grade the condition of the Bay region: how well its ecological resources are faring, how much human activities are harming or helping the Bay, and how human uses of the Bay's resources are affected by the Bay's health. These indicators are combined into eight Indexes that track the Bay's environment (Habitat, Freshwater Inflow, Water Quality), its fish and wildlife (Food Web, Shellfish, Fish), our management of its resources (Stewardship), and its direct value to the people who use it (Fishable-Swimmable-Drinkable). The purpose is not to provide a highly detailed, site-specific analysis, but rather a regional, landscape-level assessment of large-scale conditions and trends. There are important gaps that will be filled in future updates. These potentially include a Bird Index; an indicator of stream corridor connectivity in the Habitat Index; and indicators of land use in the Stewardship Index.

The eight indexes are based on a simplified four-tiered conceptual model (Fig. 1A) and a slightly more detailed version of that model (Fig. 1B), which illustrate how a number of human and natural factors affect biological resources, directly and by modifying the underlying ecological processes that support these resources. First, the status of some large-scale stressors (water use, pollution, and the adequacy of resource managers' responses to these stressors) is addressed in the Stewardship Index, without explicitly attempting to link these factors to specific biological and ecological conditions. Second, the underlying ecological processes (habitat, freshwater inflow, water quality)

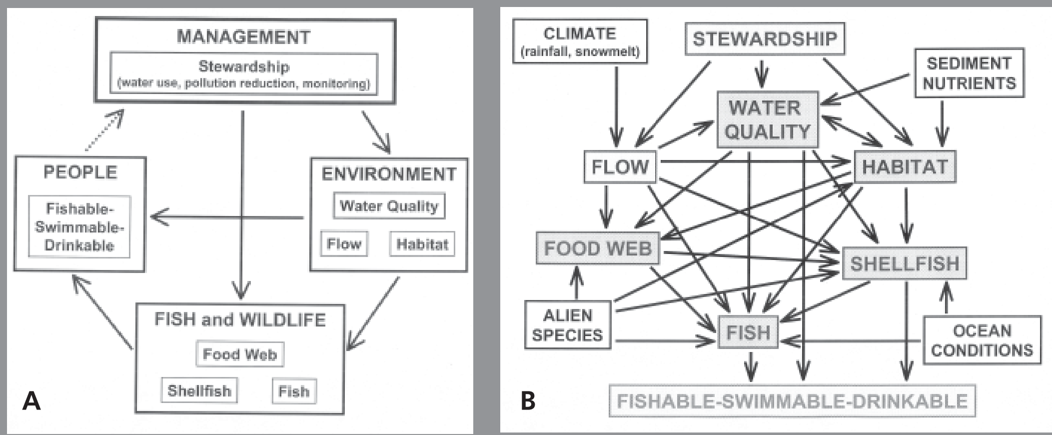


Figure 1. The Ecological Scorecard's Bay Index is based on a simple conceptual model that relates the effects of human activities on the environment, its fish and wildlife resources, and the resultant value of those resources to people. The eight indexes elaborate on the first simple model, defining the inter-relationships between natural processes, our stewardship of the watershed, multiple measures of the ecological health of the environment and biological resources, and human use of the resources. Within each index, a variation of the more complex model is presented to highlight the index and remind the reader of these important inter-relationships.

that support biological resources are examined, measuring how key ecosystem functions have been altered. Third, changes in the status of biological resources (lower food web organisms, shellfish, and fish) affected by changes in ecological processes and by direct human management are assessed. Finally, the effects on human uses of biological and water resources (fish catch and consumption, on-the-water recreation, and drinking water supply) are evaluated. The specific indicators were chosen based on the need to include both ecological and management characteristics that were consistent across all regions of the Bay, covered different levels of ecosystem function and use, were sensitive to human impacts, and for which available data were sufficient. The data were in all cases derived from existing sources. Some of these datasets do not fully cover the Bay region, and limited our results. The literature on ecological condition assessment was thoroughly reviewed, and an independent review panel of nationally recognized experts in estuarine science and indicator development was convened several times to provide guidance to the Ecological Scorecard project team.

Each Index is composed of several indicators that are graded on a letter scale of A to F. A grade of "A" represents high-quality ecological conditions in the Bay, based on known or estimated historical conditions; current environmental and public health requirements; statistical relationships between environmental or management variables and biological responses; public policy targets; and/or professional judgment, as appropriate to the specific Index and depending on information availability and quality. An "F" grade represents a critically impacted ecosystem, with species, habitats and/or functions in imminent danger of extinction; widespread exceedences of environmental or public health standards; and/or broad failure to meet policy targets. Trends over time for each Index are represented as arrows pointing up (↑ improving), down (↓ declining), or horizontally (↔ stable conditions or no trend). Information is included regarding both long-term (usually 25 years or more) and short-term (usually 5 years) trends. The overall grade, and score of 0 to 100, for each Index is derived from the grade point average of all indicators included within that Index, based on the data available for the most recent year (in most cases, 2001 or 2002). The eight indexes were not aggregated for the Bay region as a whole, because of the disparity between the parameters measured. Data sources, methods, and background information are briefly summarized for each indicator in the graph captions and endnotes. A more complete discussion of data and analyses is provided in the Bay Index Technical Appendix, available in CD format from the Bay Institute (see inside front cover for ordering information) and which also may be downloaded from the Internet at www.bay.org.

The Bay Institute

Contributors and acknowledgements

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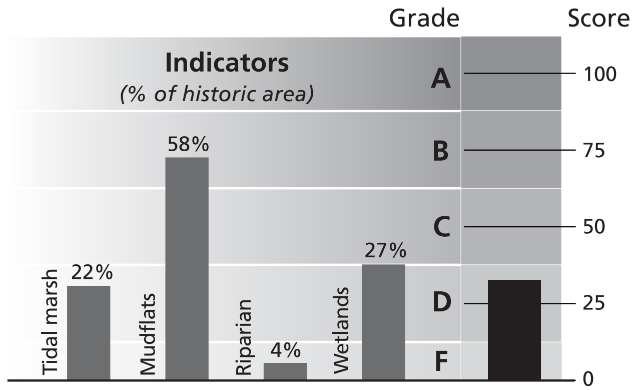
Grade	Score	Long-term Trend	Short-term Trend
D+	32	↓	↑

Habitat

Tidal, seasonal and non-tidal wetlands, mudflats and riparian areas, and salt ponds are rich sources of food and nutrients, and provide critical spawning, nesting and rearing habitat for the Bay's fish and wildlife species. These habitats also improve water quality and flood control services, and support birding, fishing, hunting and other recreational activities. Conversion of these areas for agriculture, salt production, and urban development has destroyed most of the Bay's original tidal wetlands and riparian habitat. In some areas, the salt ponds and diked wetlands that replaced the natural wetlands still provide important resources for resident and migratory species.



The Habitat Index aggregates the results of the tidal marsh, tidal mudflat, seasonal wetland, and riparian habitat indicators. Each indicator is graded separately based on the percent of historic area and then the grades are aggregated to calculate the score illustrated on the right side of the graph.

How much wetland, riparian and mudflat habitat exists around the Bay?

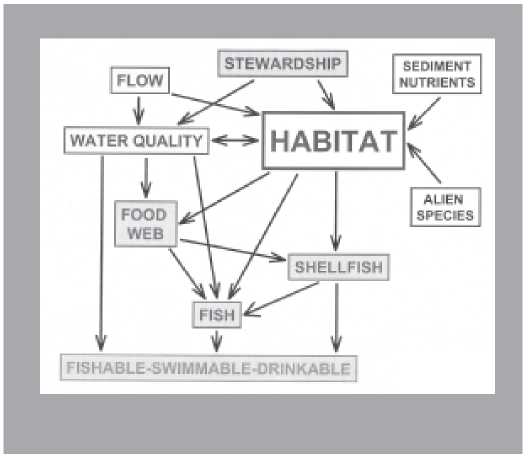
Is it increasing or decreasing in extent?

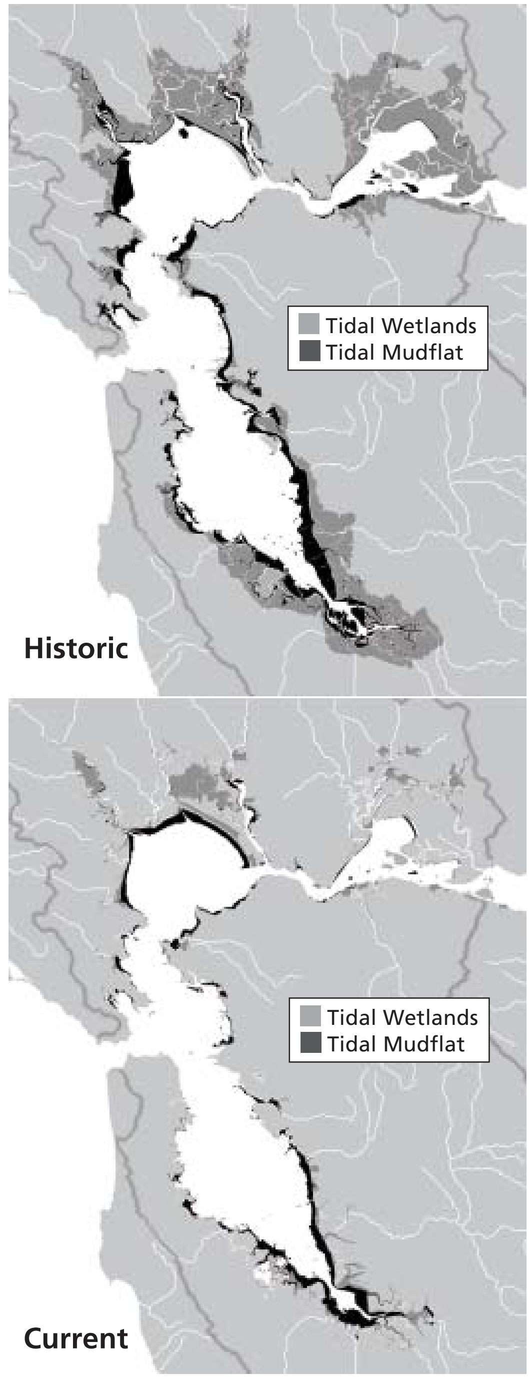
Indicator	**1998 - 2001 Result**	**Grade**	**Grade Point**
Tidal Wetland	22% of historical extent, with 4% increase from existing since 1998	D	1
Tidal Mudflat	58% of historical extent	B	3
Seasonal Wetland	27% of historical extent	D	1
Riparian	16% Bayside, 4% regional left	F	0
Non-Tidal (Diked) Wetland	Not graded	-	-
Salt Pond	Not graded	-	-
		Index Grade Point Average	**1.25 (D+)**
		Index Score	**32 (out of 100)**

The Bay Institute

Index Grade	Index Score	Long-term Trend	Short-term Trend
D+	32	↓	↑

San Francisco Bay Habitat Index > *Overview*





These maps show the historical and current extent of the Bay's tidal wetlands and mudflats. More detailed maps can be found at http://bay.org/sierra_to_the_sea.htm, Maps G12 and G13

Connecting the dots

Historically, San Francisco Bay was ringed with lush tidal marshes teeming with life. These marshes—and adjacent riparian woodlands, non-tidal wetlands and mudflats—are highly productive areas that generate vast amounts of nutrients for the Bay's food web. The Bay's wetlands and mudflats provide essential spawning, rearing, and nesting habitat for hundreds of fish and wildlife species, including both rare and threatened species and commercially important fisheries. Wetland habitat areas improve water quality by capturing sediments and absorbing pollutants, stabilizing shorelines, reducing peak flood flows, and recharging groundwater basins. They also provide a broad array of economic and social benefits such as birding, fishing, and hunting.

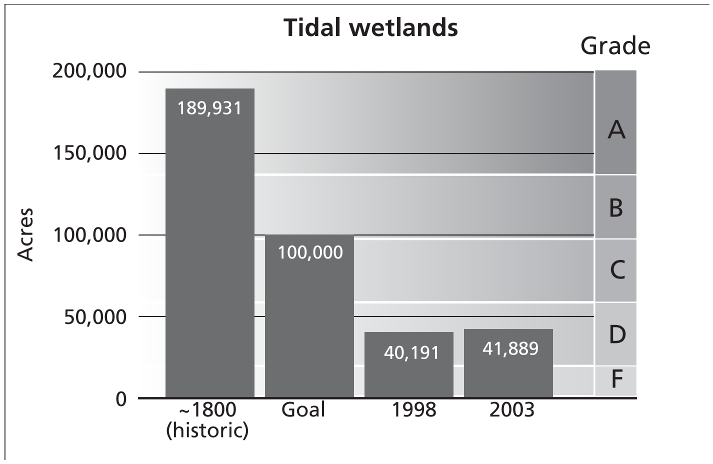
The quantity and quality of the Bay's wetlands and mudflats are affected by changes in land and water use. Converting wetlands and mudflats for agriculture, salt production, and urban development lessens the productivity of the Bay's food web and decreases the total area of usable habitat available to fish and wildlife. Water development in the Bay's upstream areas reduces freshwater inflows to brackish water wetlands and affects species composition, distribution and abundance.

Tidal wetlands

Vegetated areas open to tidal action along the Bay's margins, these wetlands are highly productive and support a diversity of wildlife. Plants vary according to salinity, from pickleweed and cordgrass in salt marsh to cattail and bulrush in brackish marsh. Rare and endangered species that inhabit tidal marsh habitat include clapper and black rails, song sparrows, salt marsh harvest mice, delta and longfin smelt, and splittail. This indicator measures the spatial extent of tidal wetlands around San Francisco Bay.[1]

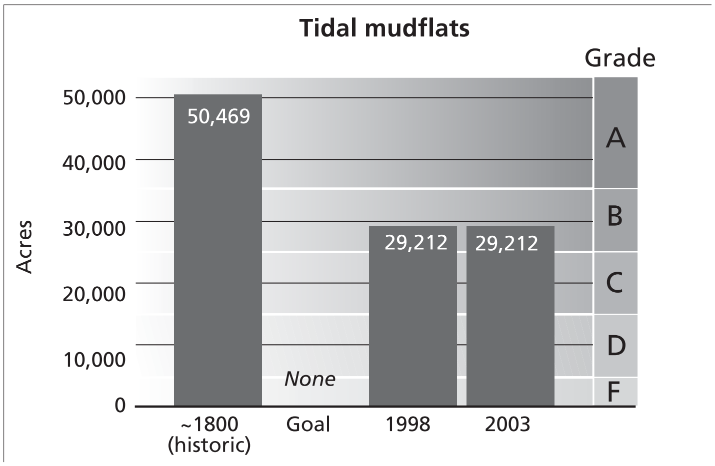
Key Findings

- Over the last 150 years tidal marshes decreased in area by 78%, from 190,000 to 40,000 acres. Most of the decline occurred prior to 1950.
- Between 1998 and 2003, tidal marsh habitat increased by 1700 acres, more than 4% over the existing amount, to 42,000 acres.[2] The amount and quality of restored habitat needs to be better monitored and reported, however.
- If the current 5-year trend holds, it will take nearly 200 years to achieve the 50–100 year targets set for Bay tidal marsh restoration by the Baylands Habitat Goals Project. Restoration of up to 23,000 acres of salt ponds to tidal marsh could significantly accelerate progress.
- Restoration efforts have mostly been concentrated in the South and San Pablo Bays.



For grading, the A-B break point was set at 70% of historic habitat area and the D-F break point at 10% of historic area. Data sources: San Francisco Estuary Institute EcoAtlas Version 1.50, Habitat Goals Project, and numerous restoration project databases.

Index Grade	Index Score	Long-term Trend	Short-term Trend
D+	32	↓	↑



For grading, the A-B break point was set at 70% of historic habitat area and the D-F break point at 10% of historic area. Data sources: San Francisco Estuary Institute EcoAtlas Version 1.50, Habitat Goals Project.

Tidal mudflats

Largely unvegetated except for algae and occasional eelgrass, tidal mudflats are highly productive habitats for bottom-dwelling (benthic) invertebrates. These areas also provide essential feeding and staging areas for hundreds of thousands of shorebirds, such as sandpipers and plovers, which migrate along the Pacific Flyway. This indicator measures the spatial extent of tidal mudflats around San Francisco Bay.

Key findings

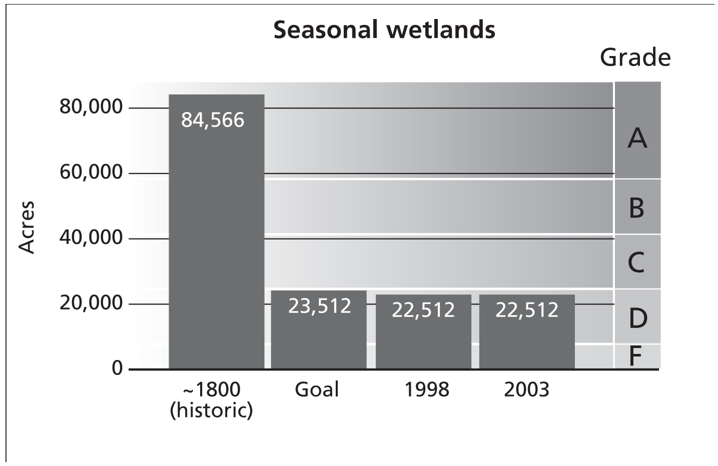
- By 1998, tidal mudflats had declined by 42%, from 50,500 to 29,000 acres. The greatest loss was in Suisun Bay. Today, the largest remnant mudflats are found in the South Bay, the most important area for shorebirds in the estuary.
- San Pablo Bay mudflats, however, actually expanded in area in the late nineteenth century, after sediments from hydraulic mining and land conversion far upstream were deposited along the Bay's shores.
- While mudflats are no longer being filled, their extent is likely to continue shrinking due to the absence of new sediments from upstream (now captured behind major Central Valley reservoirs) and to long-term sea level rise as a result of climate change.
- The introduction of the invasive salt-marsh cordgrass *Spartina alteniflora* may result in infilling and conversion of mudflat to tidal wetland if the spread of this alien species is not controlled.[3]

Seasonal wetlands

Moist grasslands and vernal pools naturally occur in upland areas along the Bay's margins that are not subject to tidal influence, especially those with clay soils, which are ponded for long periods with water during winter and spring. A number of rare plant and animal species are associated with these seasonal wetlands including goldfields, tadpole shrimp, fairy shrimp, and California tiger salamander. This indicator measures the spatial extent of seasonal wetlands around San Francisco Bay.

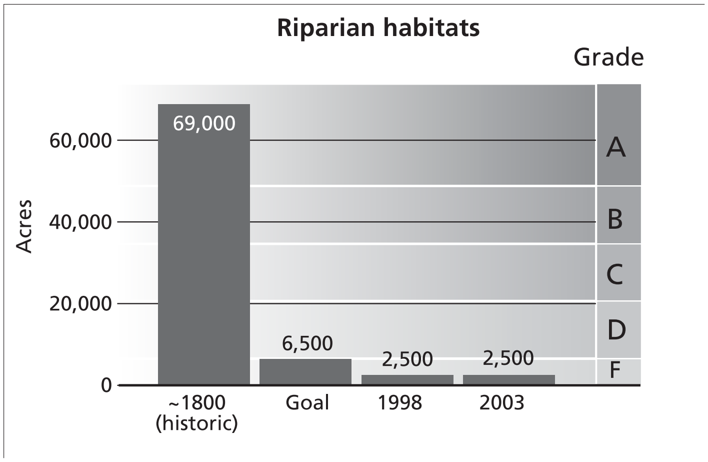
Key findings

- By 1998, seasonal wetlands had decreased by nearly 75%, from 84,500 to 22,500 acres. Historically, large areas of grasslands with vernal pools occurred near Suisun Marsh, along Sonoma Creek and in the Warm Springs area of the South Bay.
- The San Francisco Bay Joint Venture calls for increasing seasonal wetlands by 1000 acres, but progress toward reaching this goal is not well documented.[4]



For grading, the A-B break point was set at 70% of historic habitat area and the D-F break point at 10% of historic area. Data sources: San Francisco Estuary Institute EcoAtlas Version 1.50, Habitat Goals Project, San Francisco Bay Joint Venture (for Goal).

Index Grade	Index Score	Long-term Trend	Short-term Trend
D+	32	↓	↑



For grading, the A-B break point was set at 70% of historic habitat area and the D-F break point at 10% of historic area. Data source: San Francisco Bay Joint Venture.

Riparian habitat

River corridor (riparian) habitats border the edges of rivers and streams. The complexity of the habitat created by the layering of trees, shrubs, herbs and aquatic vegetation promotes high species diversity. Here fish, birds and other wildlife find shade, shelter, and a rich array of food resources. Near the Bay, riparian habitat is dominated by willow groves, while upstream areas above the tidal zone are characterized by sycamore, cottonwood, ash, bay laurel, or box elder. This indicator measures the spatial extent of riparian habitats around San Francisco Bay.

Key findings

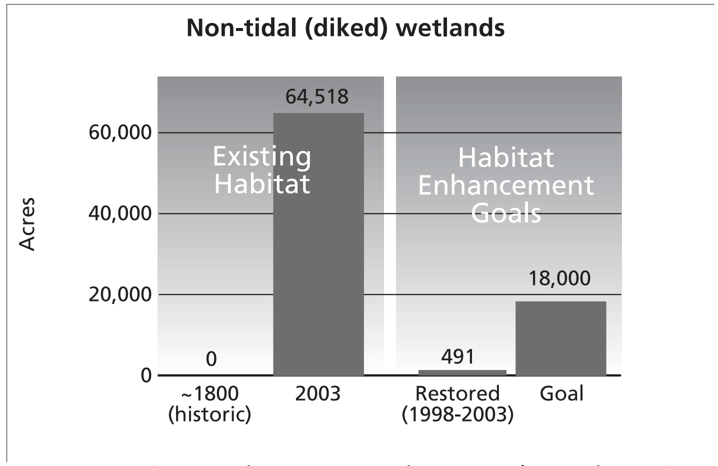
- By 1998, riparian habitat had decreased by over 84% along the Bay margins, and 96% throughout the entire Bay region's watershed, from nearly 70,000 acres 150 years ago to just 2,500 acres today.[5]
- Much of the remnant riparian habitat is believed to be highly degraded in quality.
- Current aerial imagery is not up-to-date, nor are restoration databases adequately designed to track riparian habitat extent.[6]

Non-tidal (diked and managed) wetlands

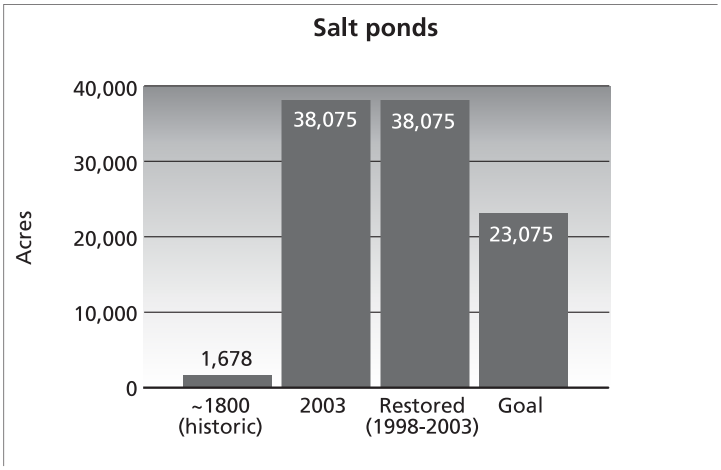
Some of the Bay's tidal marshes that were diked for agriculture still function as wetlands, even though they are no longer open to tidal action. These diked non-tidal wetlands, including managed wetlands, serve to some extent as a replacement for the natural freshwater and seasonal wetlands that have largely disappeared. Nearly 80% of these areas are duck clubs or state reserves, managed primarily for waterfowl. Fresher water is delivered through tide gates, and artificial channels distribute it to support wetland forage plants and other species. Current restoration goals of the Baylands Habitat Goals Project and the San Francisco Bay Joint Venture call for enhancing non-tidal wetlands in some areas and converting them to tidal marsh elsewhere. Non-tidal wetlands are included in the 2003 Bay Index because of their importance, but are not graded as an indicator.

Key findings

- Non-tidal (diked) wetlands now account for nearly 65,000 acres of the Bay's existing wetlands.
- The almost 500 acres of diked wetland enhancement projects undertaken in the Bay region over the last 5 years represent 3% of the 18,000 acre target for enhancing this habitat type identified by the San Francisco Bay Joint Venture. At the current rate, it will take 185 years to meet the 25-year target.



Data sources: San Francisco Estuary Institute EcoAtlas Version 1.50, Habitat Goals Project, San Francisco Bay Joint Venture, and numerous restoration project databases.



Data sources: San Francisco Estuary Institute EcoAtlas Version 1.50, Bayland Habitat Goals Project, San Francisco Bay Joint Venture. The goal is an estimated goal and subject to change.

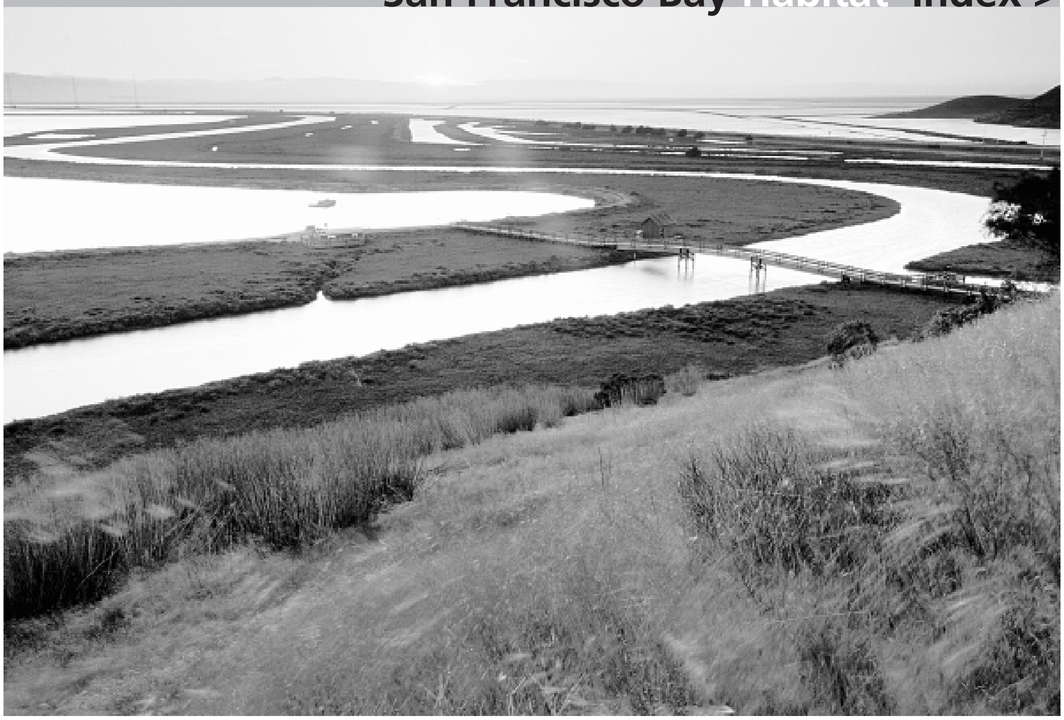
Salt ponds

Small areas of salt ponds—hypersaline water bodies periodically flooded with less salty water—naturally occurred within the tidal salt marsh zone. However, almost of all the Bay's current salt ponds are large artificial areas created to evaporate salt for commercial production. These ponds support a highly productive environment for salt-tolerant algae, bacteria and invertebrates, and provide important habitat for shorebirds, waterfowl, and other species that formerly utilized the seasonal wetlands, sloughs and mudflats of the Bay and the seasonal wetlands of the Central Valley.

The recent acquisition of South Bay salt ponds, following similar efforts in the North Bay, creates a unique opportunity to restore up to 23,000 acres of tidal marsh around the Bay. Because many species rely on the ponds as replacement areas for lost and degraded habitat, restoration plans for the Bay call for preserving some, though not all, ponds. The ecological benefits of restoring salt ponds to tidal action must be evaluated against the loss of benefits currently provided by salt pond habitat.

In the 2003 Bay Index, salt pond habitat is not graded as an indicator, since its extent is not expected to grow and will in fact diminish somewhat as a significant portion of the ponds is reconverted to tidal wetlands. However, this habitat type is included to acknowledge its importance for bird populations in the existing Bay environment. As the Index is updated to reflect changes in the Bay environment, we intend to describe and evaluate the status and trends of salt ponds within the habitat mosaic of the Bay.

Index Grade	Index Score	Long-term Trend	Short-term Trend
D+	32	↓	↑



David Sanger

Newark Slough in the Don Edwards San Francisco Bay National Wildlife Refuge, the first urban National Wildlife Refuge established in the United States.

The Bay's ring of green

Much of the Bay shoreline—and areas significantly inland from the water—now familiar to Bay Area residents was once tidal marsh, mudflat, and tidal inlet. Over 150 years of land conversion has radically rearranged the Bay's appearance, and shrunk the Bay's total area by a third.

The primary purposes for converting tidal wetlands in the early years were to create new agricultural lands and to construct salt evaporation ponds, especially in the South Bay and San Pablo Bay. As the Bay region urbanized, new residential areas, transportation projects, industrial and military facilities and landfills displaced shoreline habitats everywhere at an increasing rate. It was not until the formation of the Bay Conservation and Development Commission in the 1960s that the rate of filling decreased.

The Bay's habitats are not only threatened by development. Decreased freshwater inflow to the Bay from upstream diversion has changed the distribution and composition of salt and brackish water marshes, and decreased sediment loads prevent the rejuvenation of eroding wetlands and mudflats. In addition, wetland vegetation takes up toxic substances from polluted agricultural, industrial and urban runoff, remobilized sediments, and other sources, reducing the amounts of these contaminants that flow into the Bay but facilitating harmful accumulation of toxics in the tissues of wildlife species that feed in the marshes. And the forecast rise in sea levels could drown existing habitat on the Bay's margins, with endangered plants and animals unable to shift to adjacent higher elevation areas that have been urbanized or otherwise altered.

Today, nearly 80 percent of the Bay's original tidal wetland and riparian habitat has been destroyed. But the tide is slowly beginning to turn. Thanks to acquisitions for state and federal wildlife refuges, efforts by

Index Grade	Index Score	Long-term Trend	Short-term Trend
D+	32	↓	↑

David Sanger

Tule reeds are found in the brackish water environments of the Bay and Estuary

the San Francisco Bay Joint Venture and other initiatives, and the recent acquisition of the Cargill salt ponds by the state, about 40,000 acres are slated for restoration. And plans to reverse the trend further are ambitious: the multi-agency San Francisco Bay Habitat Goals Project has set a target of restoring 100,000 acres of tidal wetland habitat around the Bay.

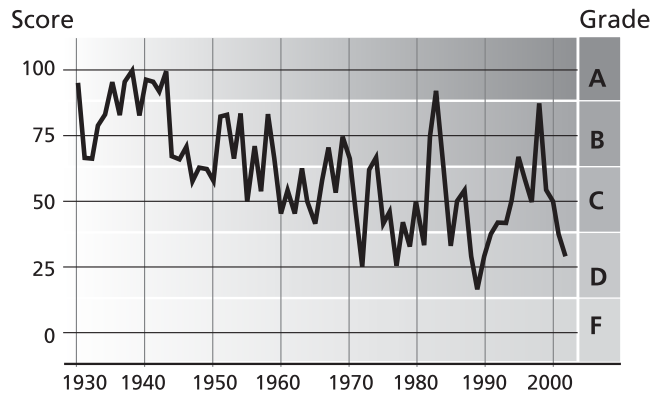
The goals may be ambitious, but the pace of restoration is slow. The Goals Project envisions meeting its tidal wetland restoration target in 50 to 100 years, but at the current rate it will take nearly 200 years. Most importantly, effective habitat restoration cannot be accomplished in baby steps by acquiring small, disconnected parcels of land. Only large areas of habitat provide adequate refugia from human disturbance, connectivity between different habitat types, and sufficient scale to test different restoration methods. Reliable long-term funding is essential: recent acquisitions have relied heavily on public bond financing, a situation that may not be sustainable given the state of today's economy. Fortunately, the acquisition of salt ponds around the Bay over the past few years affords the opportunity to restore tidal marshes at a faster rate and on a larger scale—while still preserving important salt pond habitat.

Protection for some critical habitat types has not matched the overall progress in elevating habitat restoration to the resource management agenda. Of all the Bay's remnant habitats, riparian corridors are the most endangered. But functional stream corridors provide ecological benefits disproportionate to their size, and restoring stream channel habitat represents a smart ecological and financial investment.

Grade	Score	Long-term Trend	Short-term Trend
D+	29	↓	↓

Freshwater Inflow

San Francisco Bay receives 90% of its freshwater from California's two largest rivers, the Sacramento and San Joaquin, and their vast watersheds; the balance comes from tributaries of the Bay itself. The amounts, timing, and seasonal variations of freshwater inflows into the Bay are key environmental factors that define the quality and quantity of its estuarine habitat. Irrigating the Central Valley, constructing a massive system of reservoirs and canals, and exporting water directly from the Delta have dramatically changed natural runoff patterns and volumes.



The Freshwater Inflow Index aggregates the results of the annual inflow, water year type, spring inflow, change in spring inflow, seasonal variation, and change in peak flow indicators.

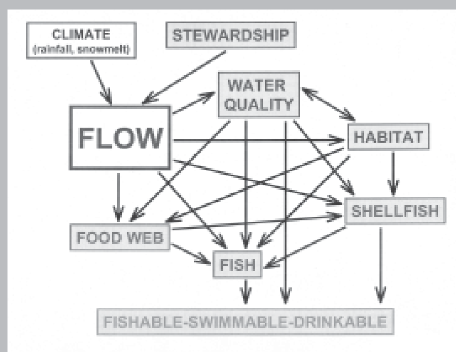
Is there enough freshwater inflow to support the Bay ecosystem?

Indicator	2002 Result	Grade	Grade Point
Annual Inflow	Overall Bay inflows reduced by 50%	D	1
Water Year Type	Bay's watershed is "below normal" but Bay is "critically dry"	F	0
Spring Inflow	32% of inflow, placing spring X2 at 74 km	C	2
Change in Spring Inflow	Spring X2 shifted 15 km farther upstream than expected	D	1
Seasonal Variation	Difference between high and low flows reduced by 46%	C	2
Change in Peak Flow	11 days of peak flow, compared to 58 expected—an 80% decline	D	1
		Index Grade Point Average	**1.2 (D+)**
		Index Score	**29 (out of 100)**

The Bay Institute

Index Grade: **D+** | Index Score: **29** | Long-term Trend: ↓ | Short-term Trend: ↓

San Francisco Bay Freshwater Inflow Index > *Overview*



Connecting the dots

Freshwater inflow conditions are one of the most critical environmental factors affecting the distribution and abundance of plants and animals in San Francisco Bay, from the simplest to the most complex. The amounts, timing, and variability of inflows define the quality and quantity of estuarine habitat: flows provide low salinity habitat for estuary-dependent species, trigger reproduction and migration, transport nutrients and organisms to and through the Bay, and flush contaminants. Most of the fresh water that flows into the Bay comes from rain and snowmelt runoff in the Sacramento and San Joaquin River basins. During the past century, flows from these watersheds have been greatly altered by upstream water development and land use changes. Offstream users now extract from one-third to two-thirds of the natural runoff for irrigation (roughly 80% of diversions) and urban water supplies (about 20%). Urbanization around the Bay region has also significantly altered the timing of runoff. These changes have, in turn, damaged the estuarine ecosystem and the organisms that depend upon it, and have degraded downstream habitat and water quality. Flow patterns may be further altered if global climate change results in a reduced snowpack in the upper watersheds.

Local, state, and federal projects dam Central Valley rivers and transport runoff from the Bay's watershed throughout the State for agricultural and urban uses.

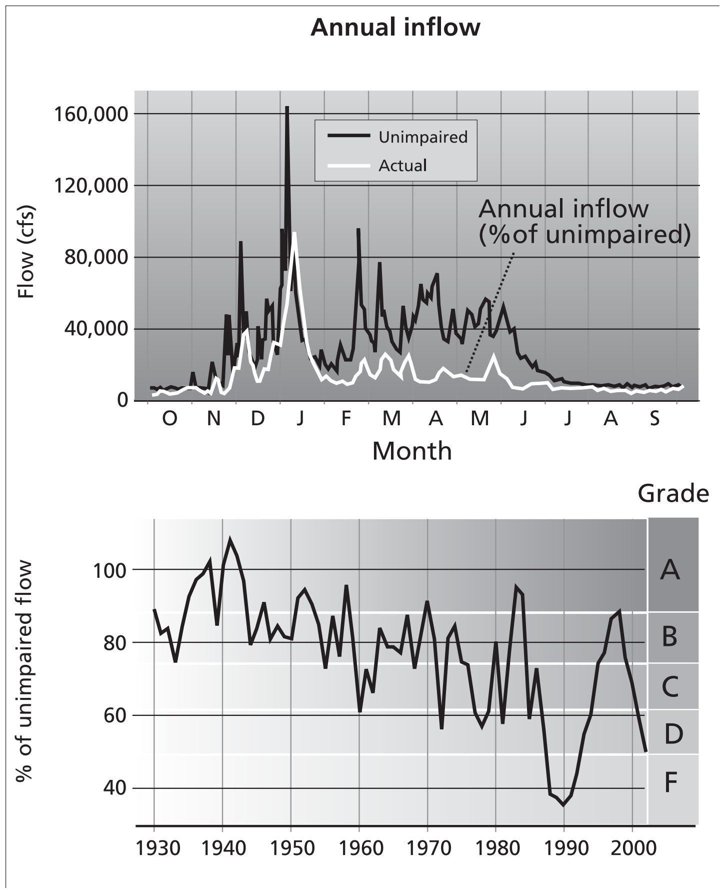
Index Grade	Index Score	Long-term Trend	Short-term Trend
D+	29	↓	↓

Annual inflow

San Francisco Bay receives most of its freshwater inflow from the Sacramento and San Joaquin River basins, which drain 40% of California's surface area. In this vast watershed, all but one of the major tributaries are dammed and much of their water is diverted for agricultural or urban use, either not reaching the Bay at all or returning at less biologically useful times and degraded by polluted runoff. This indicator measures the amount of fresh water that flowed into the Bay each year, compared to the amount that would have flowed into the Bay under "unimpaired" conditions, without the effects of dams or water diversions.[1]

Key Findings

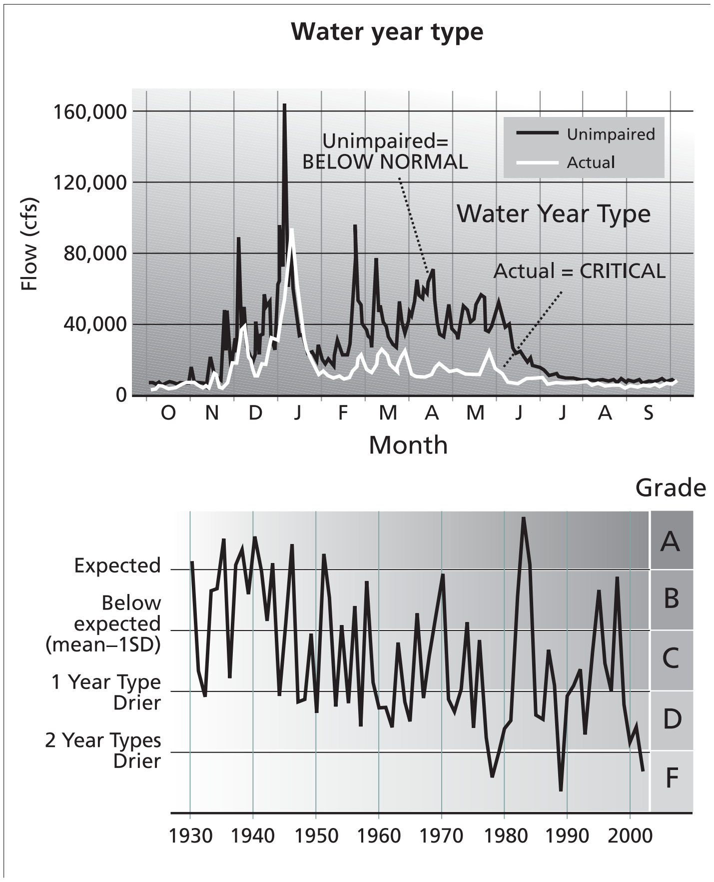
- In 2002, about 50% of total annual runoff reached the Bay.
- Freshwater inflows to the Bay have declined significantly during the past sixty years, since Shasta Dam on the Sacramento River was completed. The greatest decline occurred since the early 1970s, after the California Aqueduct was completed to Southern California and several large dams were completed in the Sacramento and San Joaquin River watersheds.
- The largest reductions in freshwater inflow occurred in dry and critically dry years. During the 1987-1992 drought, less than 42% of total runoff reached the Bay.
- During the subsequent five-year wet period (1995-1999), inflows increased to an average of 81%. In the drier years since 1999, inflows again declined to an average of 60%.



For grading, the A-B break point was set at 88.5%, less than the average actual inflow measured between 1930 and1943. The D-F break point was set at 50%. Data sources: California Department of Water Resources, Dayflow model and California Central Valley Unimpaired Flow data.

The Bay Institute

Index Grade	Index Score	Long-term Trend	Short-term Trend
D+	29	↓	↓



For grading, the A-B break point was set at flows greater than or equal to the average unimpaired flow predicted for the water year type. The D-F break point was set at flows lower than those predicted for years that were two water year types drier. Data sources: California Department of Water Resources, Dayflow model and California Central Valley Unimpaired Flow data.

Water year type

Runoff and freshwater inflow to the Bay can vary dramatically from year to year, a function of California's temperate climate and unpredictable cycle of droughts and floods. This year-to-year variation in inflow, a key feature of estuaries, creates the dynamic habitat conditions upon which Bay fish and invertebrate species depend. The amounts of runoff in different years are usually categorized by "water year types": wet, above normal, below normal, dry, and critically dry.[2] This indicator measures annual inflow in terms of water year type, and compares actual annual inflow—the water year type experienced in the Bay—with the unimpaired annual inflow water year type based on natural runoff in the Bay's watershed.

Key Findings

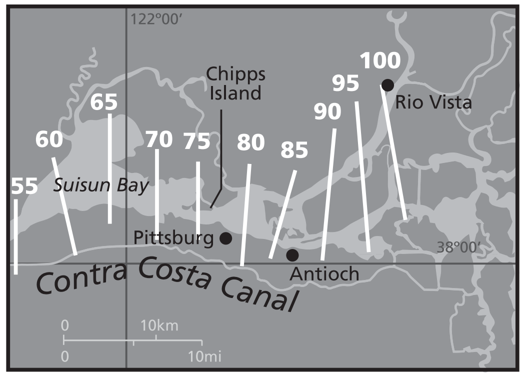
- Water Year 2002, a below normal year in the Bay's watershed, was a critically dry year for the Bay.
- For the past 60 years, reduced freshwater inflows caused drier annual conditions in the Bay than would be expected based on runoff in the watershed. In more than half of all years since the 1940s, the Bay was at least one water year type drier than its watershed.
- Year-to-year variability in annual inflows has also been reduced. Since the 1960s, the frequency of critically dry years in the Bay has doubled, now making up 42% of all years. In contrast, the frequency of wet years has been cut in half.

Spring inflow

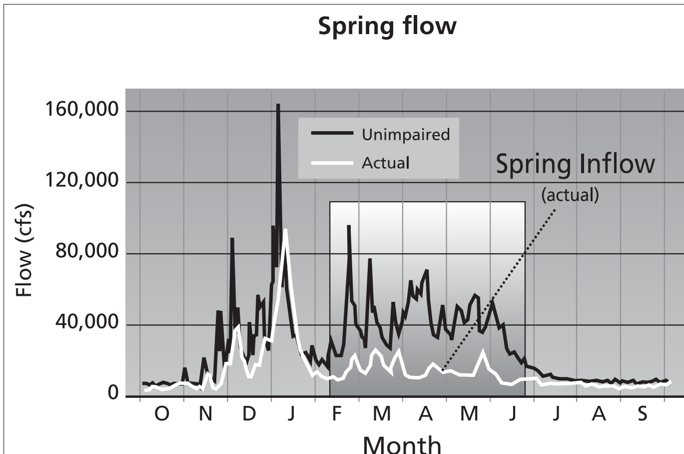
The interface between fresh waters from upstream areas and saltwater from the ocean is one of the most important ecological zones in the estuary, and its location is largely determined by the amount of freshwater inflow. This interface is measured at the point (in km upstream from the Golden Gate) in the Bay where the salinity of the water near the bottom is 2 parts per thousand (approximately 6% seawater), known in scientific shorthand as "X2".[3] During the spring, high freshwater inflows, driven by rain and snowmelt in the Bay's watershed, shift X2 downstream into the broad shallow reaches of Suisun Bay. For a number of fish and invertebrate species that depend on the Bay, population abundance and/or survival are significantly higher when X2 is in Suisun Bay, 50-60 km (30 – 36 miles) from the Golden Gate, and significantly lower when X2 is farther upstream. This indicator measures the amount of freshwater inflow, expressed as X2, during the spring.

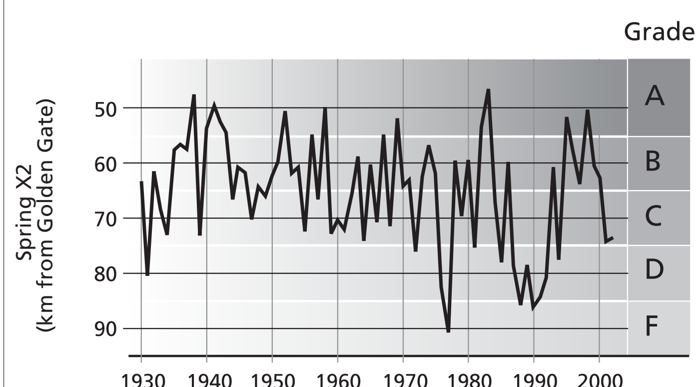
Key Findings

- In 2002, X2 was located at 74 km, a value typical for critically dry years prior to water development within the Bay's watershed. Spring inflows to the Bay were only 32% of unimpaired runoff for that season.
- Prior to the 1970s, spring X2 values rarely exceeded 75 km, even in drier years. Since then, spring X2 has been shifted upstream as far as the 90 km point, creating ecological conditions that are unfavorable to many Bay species.
- During the 1987-1992 drought, spring X2 remained upstream of 75 km for seven consecutive years, a period that also saw severe population declines in many Bay species (see Fish Index) and the highest levels of water diversion ever experienced in the Bay watershed.



Freshwater inflows to the Bay affect the location of low salinity habitat, which is often measured as X2 (shown by the white lines, numbers indicate distance, in km, from the Golden Gate).

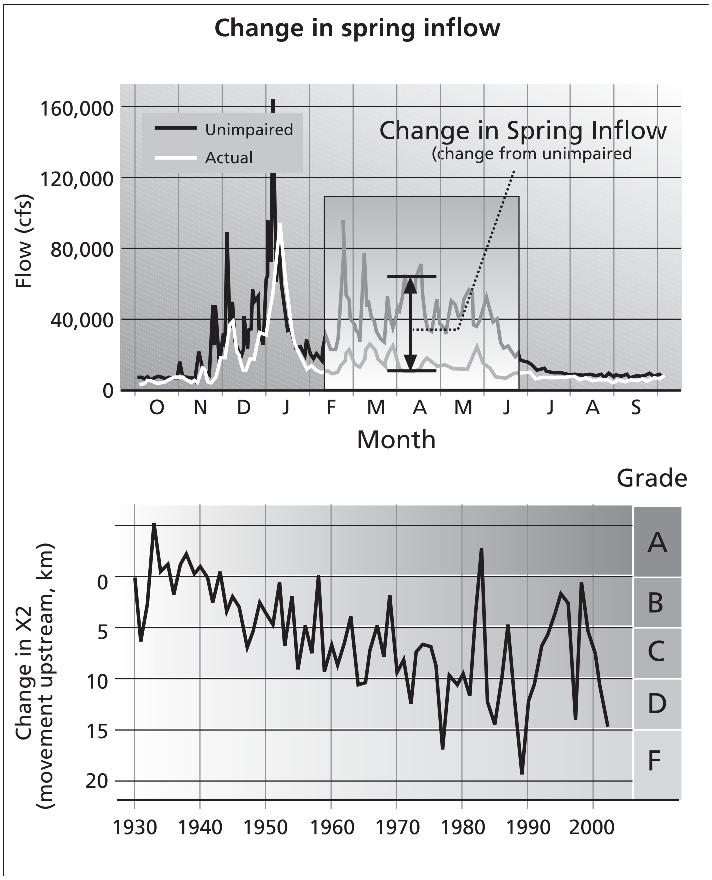




For grading, the A-B break point was set at 55 km, an X2 location that corresponds to high abundance and survival of a variety of Bay fish species. The D-F break point was set at 85 km, 11 km upstream of average X2 during critically dry years between 1930 and 1943. Data sources: California Department of Water Resources, Dayflow model and California Central Valley Unimpaired Flow data.

Index Grade	Index Score	Long-term Trend	Short-term Trend
D+	29	↓	↓

San Francisco Bay Freshwater Inflow Index > *Indicators*



For grading, the A-B break point was set at the average pre-dam location of X2 for the water year type (change in X2=0). The grade increment was set at 5 km, more than twice the within-water year type variation in X2 measured from unimpaired flows. Data sources: California Department of Water Resources, Dayflow model and California Central Valley Unimpaired Flow data.

Change in spring inflow

During the spring snowmelt period, high freshwater inflows transport organisms and nutrients and create extensive areas of low salinity habitat in the Bay. Today, large dams on the major rivers of the Bay's watershed capture and store the majority of springtime snowmelt runoff in most years, and as a result less fresh water flows into the Bay during this ecologically sensitive period. For a number of Bay fish and invertebrate species, each 10-km upstream shift in X2 corresponds to a two- to five-fold decrease in abundance or survival. This indicator measures the actual amount of spring inflow into the Bay, expressed as X2, compared to the amount that would have flowed into the Bay under unimpaired conditions.

Key Findings

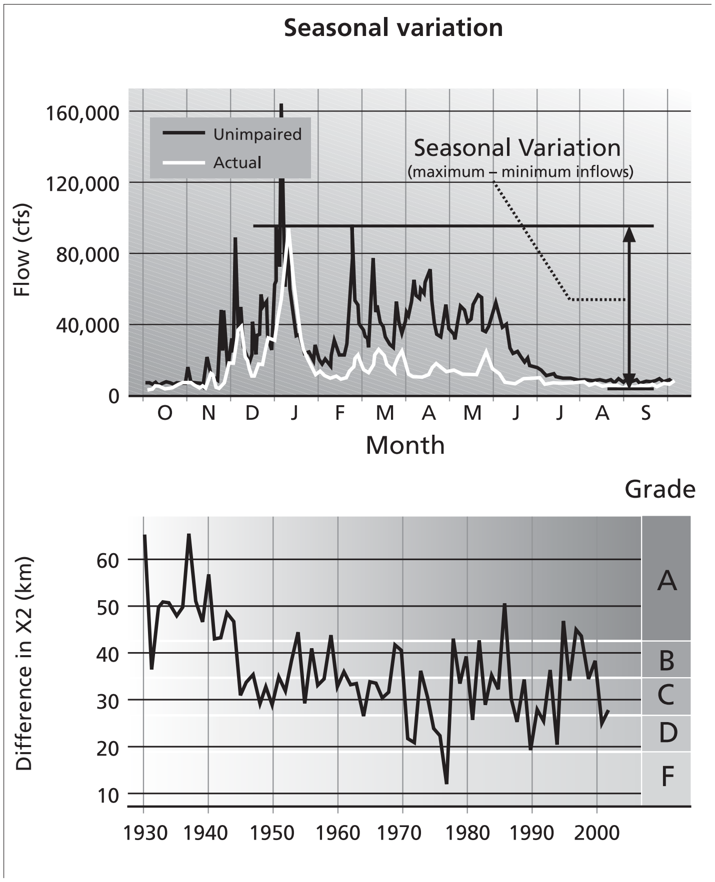
- Reductions in spring inflows have shifted X2 upstream, into less productive areas of the Bay. In 2002, spring X2 was nearly 15 km (9 miles) further upstream than predicted based on unimpaired runoff, corresponding to a predicted three-fold decrease in the abundance of several Bay fish species.
- Upstream movement of spring X2 has increased over time. In 1989, a year during which more than half of all runoff was diverted before it reached the Bay (see Annual Inflow Indicator), spring X2 was 20 km farther upstream than it would have been under unimpaired conditions.
- Spring X2 has been shifted upstream in all water year types. Since 1967, when the last major dam in the Sacramento River watershed was completed, spring X2 has moved upstream by an average of 11 km during critical, dry, and below normal years.
- Since 1995, when new water quality standards for X2 were adopted, upstream movement of spring X2 (normalized for water year type) has been restricted and even slightly reversed.

Seasonal variation

In the Bay's watershed, runoff varies dramatically throughout the year. Freshwater inflow to the Bay is high during the spring when the winter snowpack melts, and low in the fall and early winter before the first winter rainstorms arrive. This within-year variation in inflow, and the corresponding variation in ecological conditions, is a key feature of estuarine habitats. Life history patterns of many estuarine species—reproduction, rearing, or migration—are tied to this seasonal variation in habitat conditions. Reduced seasonal variability has also been linked to the spread of alien plants and animals. This indicator measures the maximum within-year variation in freshwater inflow, expressed as X2, to the Bay.

Key Findings

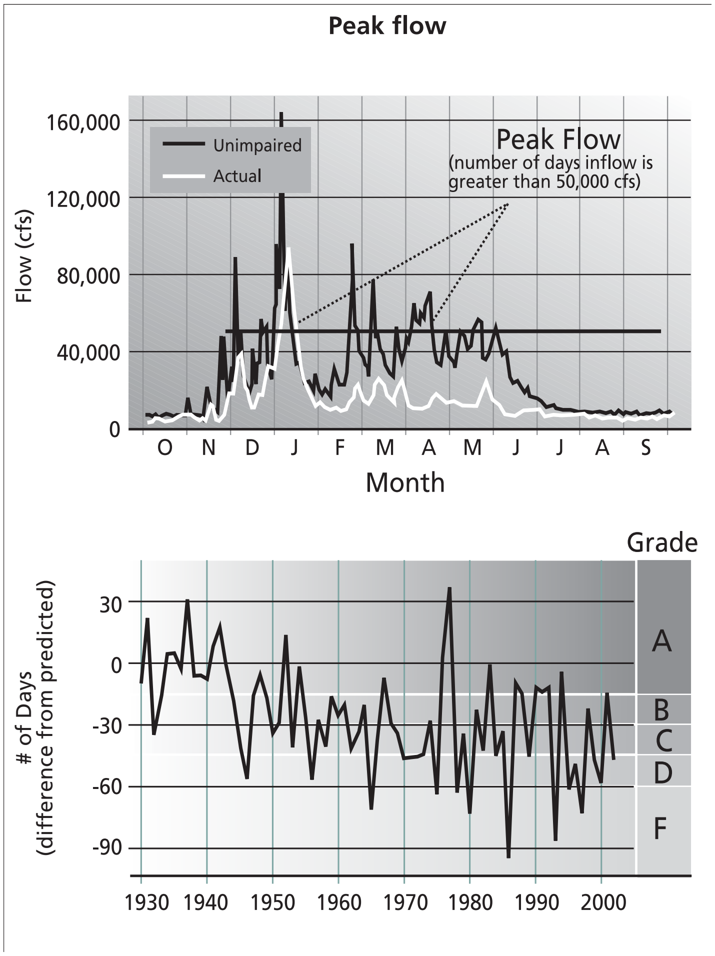
- Seasonal variation in freshwater inflows to the Bay dropped by 40% following the completion of Shasta Dam on the Sacramento River in 1944. In 2002, seasonal variation was reduced by 46%.
- Reduced seasonal variation in inflows was most pronounced in critical and dry years (e.g., 1975-1977 and 1987-1992). Only in wet years did seasonal variation values approach those measured prior to major dam construction in the Bay's watershed.
- In addition to the effects of lower spring inflows, reductions in seasonal flow variations resulted from increases in late summer and fall inflows, when irrigation runoff and upstream releases to the Delta export pumps shift X2 downstream in the fall and make the Bay's estuarine habitat fresher during this time of year when high inflows are less critical to the ecology of the Bay.



For grading, the A-B break point was set at 42 km, the average minus one standard deviation of the pre-dam within-year variation in X2. The grade increment was set at 8 km, the standard deviation of the pre-dam variation in X2 location. Data sources: California Department of Water Resources, Dayflow model and California Central Valley Unimpaired Flow data.

Index Grade: **D+** | Index Score: **29** | Long-term Trend: ↓ | Short-term Trend: ↓

San Francisco Bay Freshwater Inflow Index > *Indicators*



For grading, the A-B break point was set at the average minus 15 days (the 95% confidence limit) of the number of days of peak flows predicted under unimpaired conditions. The grade increment was set at 15 days. Data sources: California Department of Water Resources, Dayflow model and California Central Valley unimpaired flow data.

Change in peak flow

High, or peak, freshwater inflows to the Bay occur following winter rainstorms and the height of the spring snowmelt. High inflows transport organisms, sediment, and nutrients to the Bay, increase mixing of Bay waters, and create low salinity habitat in Suisun and San Pablo Bays, conditions favorable for many Bay fish and invertebrate species. This indicator measures the frequency, as number of days, of peak flows into the Bay, compared to the number of days that would be expected based on unimpaired runoff from the Bay's watershed.[4] A high grade does not imply that desirable flow conditions occurred in critical or dry years, when relatively few periods of high peak flow occurred historically, but simply that the degree of peak flow alteration was minimal.

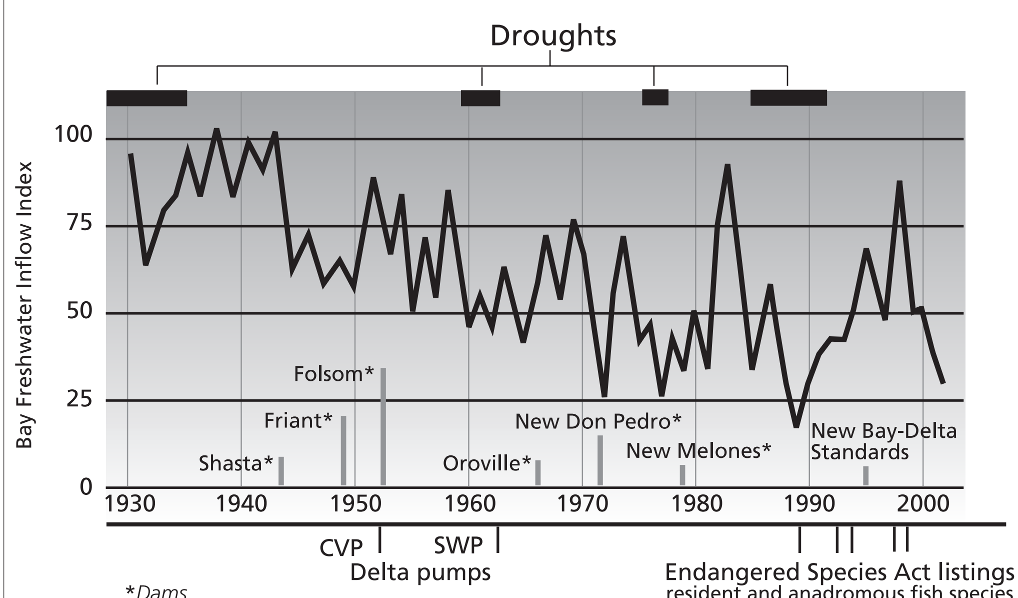
Key Findings

- In 2002, a below normal year in which 58 days of peak flow were expected, only 11 days of peak flow were measured.
- The frequency of peak flows in the Bay declined by an average of 33 days per year following completion of Shasta Dam in 1944.
- In dry, below normal and above normal years, the numbers of peak flow days were reduced, on average, by 73, 52, and 41%, respectively.

Freshwater inflow defines the estuary

During the past century, the freshwater inflows that shape the San Francisco Bay estuary, its dynamic ecosystem and its rich biological resources, have been dramatically reduced and rearranged—runoff from rainstorms and the mountain snowpack that formerly flowed into the Bay is now stored behind massive dams, diverted from rivers and streams for local and distant use into canals that radiate throughout the Central Valley, and exported through the giant pumps in the Delta to San Joaquin Valley irrigators and coastal cities. The biggest piece of perhaps the world's most extensive water storage and conveyance system is operated by the federal Central Valley Project, which captures flows on the Sacramento, American, and Stanislaus Rivers; diverts the lion's share of the Trinity River's flows to the Sacramento; completely dewaters parts of the Bay watershed's second largest river, the San Joaquin; and transfers water through giant Delta pumps; in order to deliver 8 million acre-feet principally to irrigators throughout the Central Valley (as well as cities in Contra Costa and Santa Clara Counties). The next largest water supplier, the State Water Project, exports between 2 and 3 million acre-feet of runoff from the Feather River, augmented by "surplus" Bay inflows, through its own Delta pumps to the irrigated fields of the arid Tulare Basin and to cities along the California coast.

Since 1943, when the first of the many large dams of California's huge federal and state water projects was completed, flows into the Bay have become increasingly "flat lined." High levels of natural runoff during the biologically sensitive springtime periods when many fish and invertebrate species spawn, rear and migrate have been



During the past 73 years, a period which included four major droughts, the Bay's vast watershed has been transformed by dams and diversions. By the 1990s, five fish species that use the Bay faced extinction and were listed under the Endangered Species Act, and new Bay-Delta water quality standards were implemented.

Index Grade	Index Score	Long-term Trend	Short-term Trend
D+	29	↓	↓

San Francisco Bay Freshwater Inflow Index > *The Big Picture*

replaced by minimum flow requirements to protect drinking water quality and, more recently, endangered species. Meanwhile more water is released for irrigation in the naturally drier late summer and fall when it has less ecological value. Forty years ago, the most serious impacts of water project operations on the Bay were restricted to critical and dry years, and in many wetter years the annual inflow pattern resembled more natural conditions. But as demands on the Bay's watershed increased with the addition of new dams and canals to the federal and state water projects, the expansion of irrigated agriculture to the semiarid western and southern areas of the San Joaquin Valley, and increasing urban growth, water diversions began to impact even the wetter years, subjecting the Bay to persistent drought conditions and, by the 1980s, jeopardizing many fish and invertebrate species that depend on the estuary. The 1987-1992 drought was a wake-up call—Bay fish populations plummeted (see Fish Index), Delta water quality declined and, after three years of the highest levels of water diversion from the system, stored water supplies were exhausted—signaling that this level and pattern of exploitation of the watershed and the Bay was unsustainable.

The near collapse of the Bay ecosystem prompted the federal government to intervene in California's management of the Bay: Congress passed landmark water policy reform legislation (the Central Valley Project Improvement Act of 1992), federal wildlife agencies listed winter-run chinook salmon and delta smelt as endangered species, and the U.S. Environmental Protection Agency forced the state to adopt new Bay-Delta water quality standards.[5] The most critical new protection required sufficient spring inflow to maintain low salinity habitat (X2) at specific locations for specific time periods, depending on natural runoff conditions. This requirement is intended to position the brackish water zone in Suisun Bay during the biologically sensitive spring period and to mimic natural patterns of variability.

How well are these new protections improving the health of the Bay ecosystem? It is probably too soon to tell. Most of the years since 1995 were above normal or wet—distinguishing the benefits of favorable hydrology from the effects of changes in management is difficult. The effect of the new flow requirements has been to halt and somewhat reduce the upstream movement of spring X2, which will help stabilize conditions for Bay fish and invertebrates. Compared, however, to the disparity between where low salinity habitat historically occurred and where it is now, these requirements are probably not nearly sufficient to restore ecological function to the Bay.

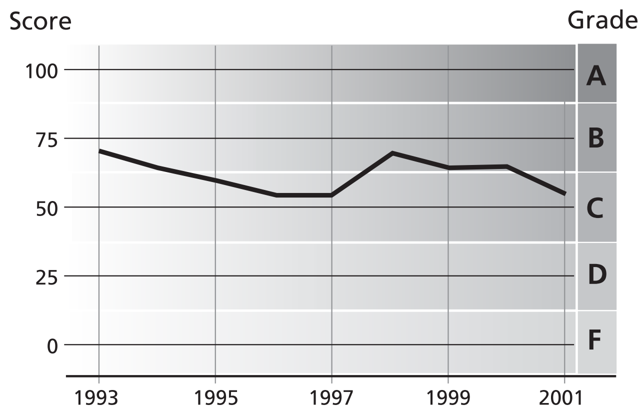
The flow protections of the last decade may be undermined by a number of proposed new water projects in the Bay's watershed. The state and federal governments are evaluating five new or expanded dams in the Sacramento and San Joaquin watersheds, as well as an increase in the amount of water that may be exported from the Delta. The cumulative impacts of these projects could reduce freshwater inflow by millions of acre-feet, further degrading habitat and water quality in the Bay.

Ultimately, efforts to secure adequate flow conditions for the Bay will fail if the pressure to increase the water supply system's capacity to divert water is successful. The only real alternative is to pursue approaches that reduce demand through the more efficient use and re-use of existing water supplies (see Stewardship Index), and that increase supply in less environmentally damaging ways, such as improving the management of California's aquifers, and coordinating use of surface and groundwater supplies.

Grade	Score	Long-term Trend	Short-term Trend
C	55	↑	↔

Water Quality

San Francisco Bay receives polluted runoff from urban, industrial, and agricultural areas along its shores and from its many watersheds. Pollution can harm the plants, animals and people that live in and around the Bay, reduce the productivity and health of the ecosystem, and contaminate fish, birds and shellfish to the point where they are not safe to eat. This Index tells only part of the Bay's water quality story because it measures only concentration of contaminants in open waters (not sediments or stormwater) and does not reflect uptake of contaminants by plants and animals (see Fishable-Swimmable-Drinkable Index).



The Water Quality Index aggregates the results of the trace elements, pesticides, PCBs, PAHs, and dissolved oxygen indicators for open Bay waters.

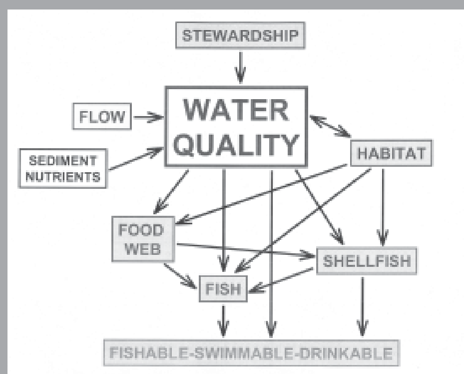
How clean is San Francisco Bay water? Is it clean enough to support the Bay's ecosystem?

Indicator	2001 Result	Grade	Grade Point
Trace Elements	Copper, selenium, mercury and nickel exceeded water quality standards	C	2
Pesticides	Standards exceeded in 16% of open water samples; sediments, stormwater a problem but not graded	B	3
PCBs	All Bay waters severely contaminated with PCBs	F	0
PAHs	Some PAH water quality standards exceeded in some open areas of the Bay	B	3
Dissolved Oxygen	Occasional low levels of dissolved oxygen in South Bay	B	3
	Index Grade Point Average		**2.2 (C)**
	Index Score		**55 (out of 100)**

The Bay Institute

Index Grade	Index Score	Long-term Trend	Short-term Trend
C	55	↑	↔

San Francisco Bay Water Quality Index > *Overview*



Connecting the dots

Contamination of San Francisco Bay waters by fertilizers, pesticides, hydrocarbons and toxic metals can harm plants and animals that live in and around the Bay. In addition, many toxic compounds accumulate in the tissues of Bay fish, shellfish and birds, making them unsafe for human consumption. Water quality in the Bay is affected by both the amounts and quality of runoff from its urbanized and agricultural watersheds (non-point sources), the extent and quality of the stream and wetland habitats that convey that runoff to the Bay, and the amounts and contamination levels of industrial and wastewater discharges made directly onto the Bay (point sources). Tidal and non-tidal wetlands in the lower reaches of the Bay's many watersheds are effective filters for many contaminants—loss of these habitats allows runoff to carry more pollutants to Bay waters.

David Sanger

California Department of Fish and Game employee takes a water sample to check salinity.

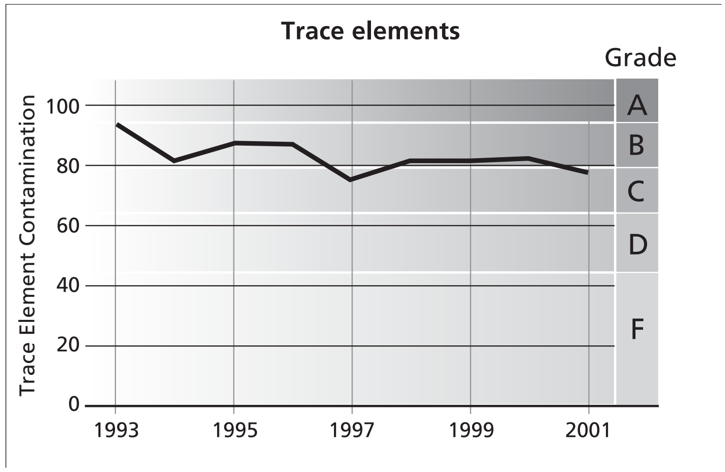
Index Grade	Index Score	Long-term Trend	Short-term Trend
C	55	↑	↔

Trace elements

Trace elements, including arsenic, mercury, copper, and selenium, are contained in some industrial and wastewater discharges, enter Bay waters from runoff during high flow events, or are reintroduced into the water column when Bay sediments are disturbed. Sediment samples commonly exceed guidelines for potential biological effects for arsenic, chromium, copper, nickel and mercury.[1] For many aquatic organisms, exposure to even slightly elevated levels of dissolved metals or other trace elements can be lethal or affect reproduction or early development. Some trace elements, such as mercury and selenium, bioaccumulate in aquatic organisms in the Bay's food web and contaminate Bay fish and shellfish. Selenium accumulates at higher concentrations in the alien clam, *Potamocorbula*, which is now an important part of the Bay food web (see Food Web Index). This indicator measures the scope, frequency and severity of contamination of open Bay waters by toxic trace elements.[2]

Key Findings

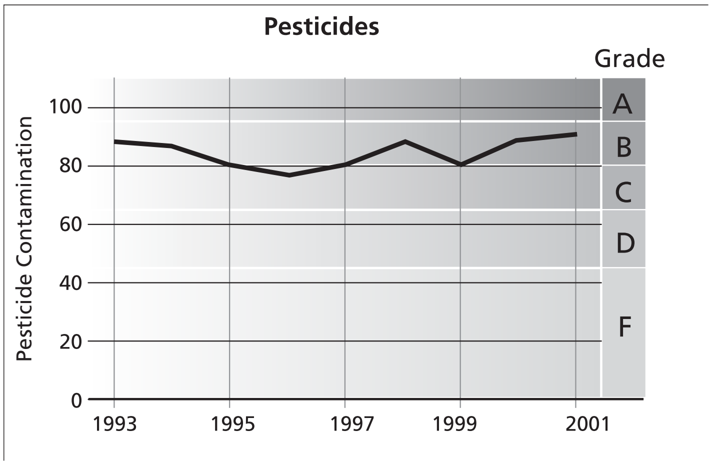
- Water quality standards for most toxic trace elements found in the Bay were met in most open water samples from most areas in the Bay. In 2001, 10% of samples failed for at least one contaminant.
- Copper, mercury, selenium, or nickel concentrations exceeded water quality standards in all years.
- Trace element contamination was most severe in the South and San Pablo Bays.
- Concentrations of most of the problem trace element contaminants are declining. However, selenium concentrations in the South Bay are increasing.



Grading scale based on ranking system developed by Canadian Council of Ministers for the Environment for water quality evaluation. Data source: San Francisco Estuary Regional Monitoring Program for Trace Substances.

Index Grade	Index Score	Long-term Trend	Short-term Trend
C	55	↑	↔

San Francisco Bay Water Quality Index > *Indicators*



Grading scale based on ranking system developed by Canadian Council of Ministers for the Environment for water quality evaluation. Data source: San Francisco Estuary Regional Monitoring Program for Trace Substances.

Pesticides

Pesticides, herbicides and fungicides used in the Bay Area and upstream watersheds enter Bay waters and sediments as runoff. These compounds, which are intended to control terrestrial pests and weeds, can be equally harmful or lethal to aquatic organisms. In Bay waters, pesticide concentrations often peak following rainstorms, and toxicity from pesticides is particularly high at the mouths of Bay tributary streams. Many of these chemicals settle in the muddy Bay bottom—sediment samples commonly exceed guidelines for potential biological effects for DDT and chlordane pesticides. (See Stewardship Index for more on pesticide use). This indicator measures the scope, frequency and severity of contamination of open Bay waters by pesticides.

Key Findings

- Water quality standards for most pesticides found in the Bay were met in most open water samples collected in most areas of the Bay. In 2001, 17% of open water samples had pesticide concentrations greater than the water quality standard.
- Diazinon, dieldrin, heptachlor epoxide, or DDT compounds exceeded water quality standards in all years.
- Pesticide contamination was most severe in South, San Pablo, and Suisun Bays.
- Concentrations of most of the problem pesticides have not declined over the nine-year sampling period. In addition, not all pesticides are monitored, and protective biological guidelines do not exist for many pesticides.

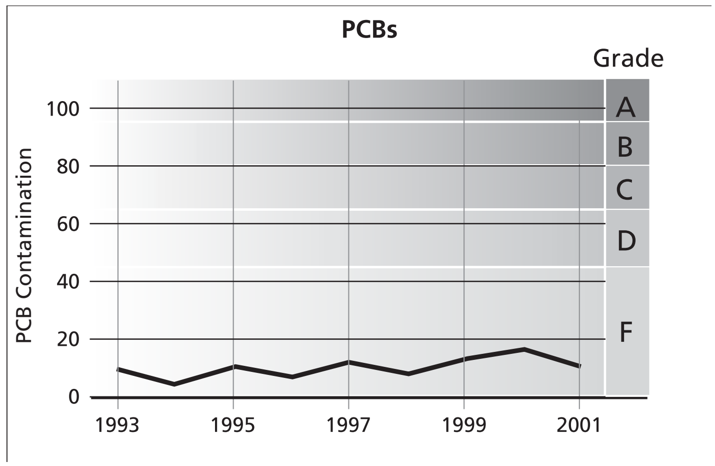
Index Grade	Index Score	Long-term Trend	Short-term Trend
C	55	↑	↔

PCBs

Polychlorinated biphenyls (PCBs) are highly toxic man-made chemicals that were used extensively by a variety of industries for more than 50 years. In 1978, manufacture of PCBs was banned but runoff from PCB-contaminated streams and urban areas continues to deliver these pollutants to the Bay. In addition to their toxic effects on animals, PCBs bioaccumulate in the food web, contaminating Bay fish and shellfish. This indicator measures the scope, frequency and severity of PCB contamination of open Bay waters.

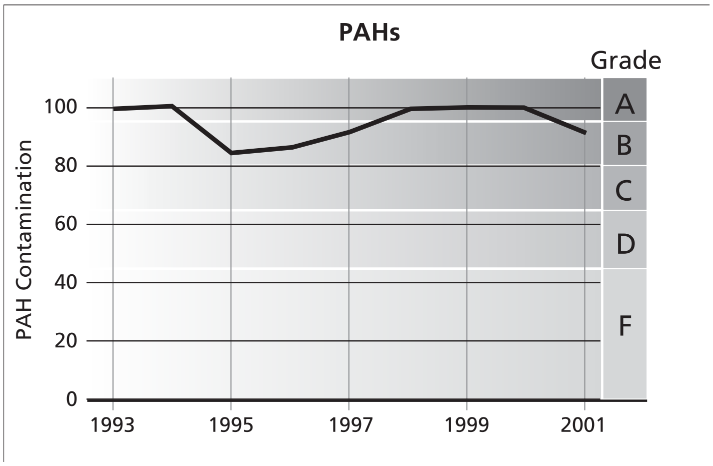
Key Findings

- PCB concentrations in San Francisco Bay exceeded water quality standards in every year, in every part of the Bay, and at nearly every sampling station. In 2001, PCB concentrations in San Francisco Bay were three times higher than the water quality standard for the protection of human health.
- PCB concentrations were highest in South Bay, intermediate in San Pablo Bay, and lowest in Central and Suisun Bays.
- PCB concentrations are declining in Central, San Pablo and Suisun Bays but not in the South Bay.



Grading scale based on ranking system developed by Canadian Council of Ministers for the Environment for water quality evaluation. Data source: San Francisco Estuary Regional Monitoring Program for Trace Substances.

Index Grade	Index Score	Long-term Trend	Short-term Trend
C	55	↑	↔



Grading scale based on ranking system developed by Canadian Council of Ministers for the Environment for water quality evaluation. Data source: San Francisco Estuary Regional Monitoring Program for Trace Substances.

PAHs

Polycyclic aromatic hydrocarbons (PAHs) occur naturally in coal, crude oil, and gasoline and enter the environment from incomplete burning of oil, wood, garbage, or coal. Exposure to PAHs can cause cancer and adverse reproductive and developmental effects. This indicator measures the scope, frequency and severity of PAH contamination of open Bay waters.

Key Findings

- PAH concentrations in open Bay waters exceeded water quality standards in four years from 1993 to 2001. In 2001, water quality standards for two of the 13 individual PAHs tested were exceeded in one water sample collected from the Bay.
- PAH pollution was most severe in the South and San Pablo Bays.
- PAH concentrations in Bay waters did not change during the nine-year survey period.

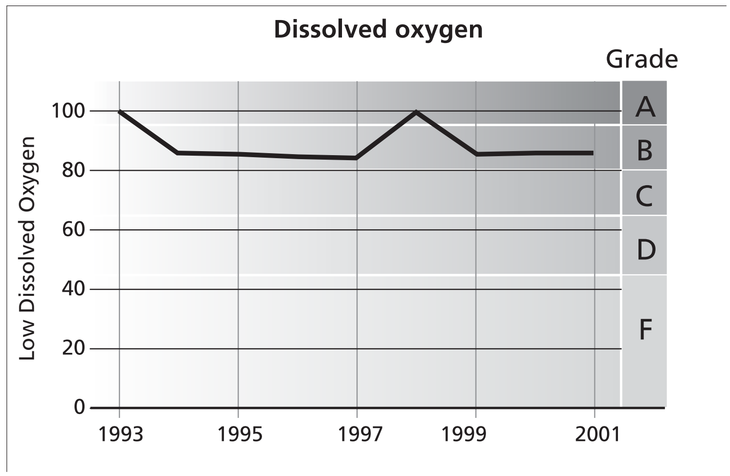
Index Grade	Index Score	Long-term Trend	Short-term Trend
C	55	↑	↔

Dissolved oxygen

Oxygen is essential for all plants and animals. Low oxygen concentrations in the water column can kill fish and invertebrates and make large areas of habitat uninhabitable. In estuaries, most oxygen is produced by phytoplankton photosynthesis. Contamination of Bay waters with large amounts of nutrients, such as fertilizers from agricultural runoff or discharges of poorly treated sewage, can trigger population explosions of bacteria and algae that may consume oxygen faster than it can be replaced by photosynthesis. This indicator measures the scope, frequency and severity of incidences of low oxygen concentration in open Bay waters.

Key Findings

- Dissolved oxygen concentrations were above the minimum standard in all areas of the Bay except the South Bay. In 2001, one water sample, collected at San Jose, failed to meet the minimum standard for dissolved oxygen.
- Dissolved oxygen concentrations were consistently lower in the South Bay than all other areas of the Bay.
- Between 1993 and 2001, overall dissolved oxygen conditions in the Bay did not change. However, chronic and periodically very low dissolved oxygen conditions measured in the South Bay thirty years ago have been reduced.[3]



Grading scale based on ranking system developed by Canadian Council of Ministers for the Environment for water quality evaluation. Data source: San Francisco Estuary Regional Monitoring Program for Trace Substances.

The Bay Institute

Sediments and stormwater

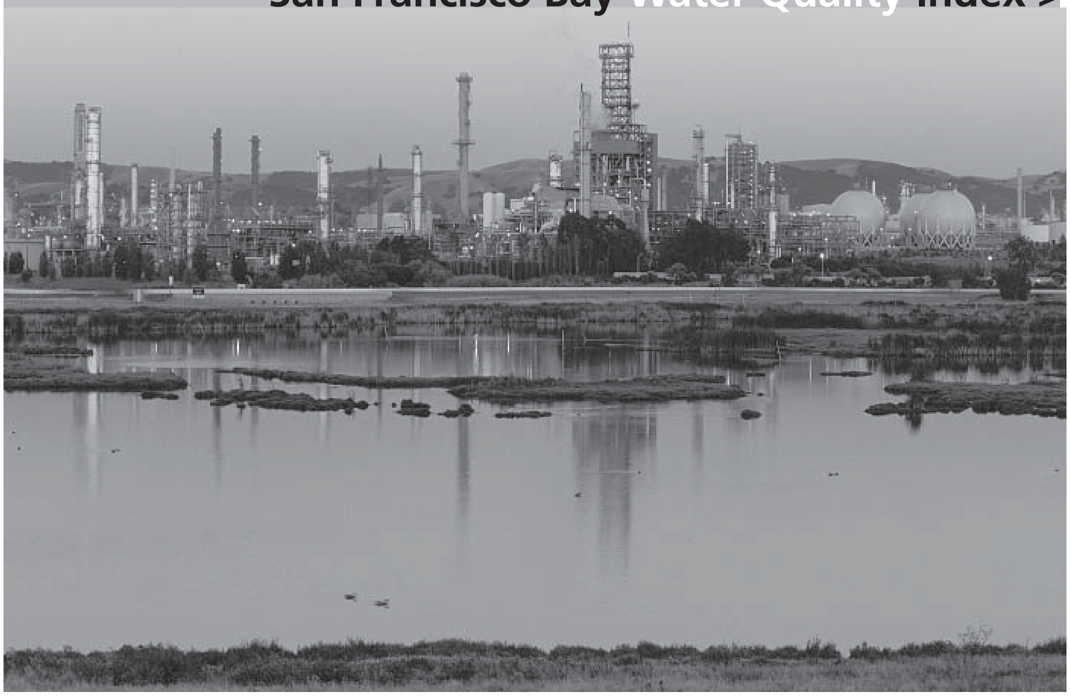
Pollutants are not only present in the Bay's open waters, but are also found in sediments and stormwater runoff from the surrounding watersheds. Contaminant-laden sediments are reintroduced into the water column when shipping channels and other areas are dredged; as a result of tidal action; and during peak rainfall events. The threshold for potential biological effects was exceeded in 90% of sediment samples collected by the Regional Monitoring Program during the 1998-2003 period, and 63% of RMP sediment samples were lethal to test organisms during the 1997-2001 period.[4] Sediment toxicity is often experienced at the mouths of Bay tributaries. Samples taken from these creeks during stormwater events were frequently toxic, particularly for organophosphate pesticides, although toxicity levels have declined somewhat since the late 1990s. The Water Quality Index measures only the severity and frequency of contamination of open Bay waters, not sediments or stormwater, which are more toxic. Future updates of the Bay Index will include indicators of sediment and stormwater toxicity.

Impaired beneficial uses

The Water Quality Index measures exceedences of water quality standards, which are intended to protect the many beneficial uses of the Bay's water. Those uses include: aquatic life support, fish consumption, shellfishing, swimmable, and secondary contact recreation (the enjoyment of the Bay that does not involve being in the water). State and federal regulators are required by law to periodically determine if the Bay is fully supporting; fully supporting (but threatened); partially supporting; or not supporting those uses. Although the use evaluation is not a rigorous analysis of all the data, it does integrate all the different types of water quality information and data to provide a qualitative assessment of the Bay's water quality. The most recent evaluation indicates that open Bay waters fully support swimmable and secondary contact recreation and only partially support aquatic life, fish consumption, and shellfishing, (indicating that it is less severely impaired and/or supports the beneficial use with occasional degradation or impairment of water quality).[5] The toxic hot spots in the harbors and coves are considered severely impaired (and thus not supporting for aquatic life use) and are not adequately assessed for the other uses.

Index Grade	Index Score	Long-term Trend	Short-term Trend
C	55	↑	↔

San Francisco Bay Water Quality Index > *The Big Picture*



David Sanger

McNabney Marsh and adjacent oil refinery. Discharges from refineries are more highly regulated and less polluting than in the past.

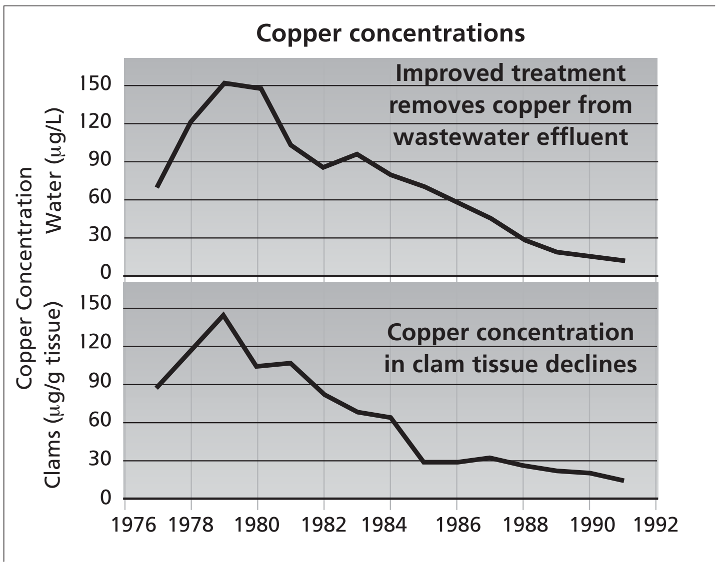
The Bay's toxic past and present

San Francisco Bay is the drain for 40 percent of California's surface area. Each year, thousands of tons of several hundred toxic chemicals flow into the Bay. Some pollutants, such as mercury from long-abandoned mining operations, arrived decades ago, settled into the Bay's muddy bottom, and continue to seep into the Bay's waters. The Water Quality Index shows that overall open Bay water quality is fair, but persistent high levels of several toxic contaminants and substantial regional differences in contamination levels clearly indicate that serious pollution problems still exist. In addition, the Index only measures contamination in open Bay waters, not in sediments and stormwater where toxicity levels are most elevated.

Are Bay waters clean enough to support a healthy ecosystem and provide a safe source of food for anglers and hunters? Despite remarkable progress cleaning up the Bay during the past three decades, the answer is "probably not." Water quality standards, this Index's primary measuring stick for water pollution, are established based on the toxicity of single contaminants—in the Bay, organisms (and people) are exposed to complex mixtures of chemicals that may interact to magnify their toxic effects. Bioassays conducted by the San Francisco Bay Regional Monitoring Program, in which two key organisms in the Bay's food web (mysid shrimp and larval fish) were exposed to water collected from various locations within the Bay, showed that water from some areas of the Bay was still lethal or caused developmental abnormalities in these organisms. Some of the most dangerous chemicals polluting the Bay, notably mercury and PCBs, bioaccumulate in the flesh of fish and shellfish that live in the Bay making them unsafe for people to eat (see Fishable-Swimmable-Drinkable Index). Furthermore, water quality standards do not adequately protect sediment quality.
The Bay's highly contaminated sediments reintroduce toxic materials into the water

Index Grade	Index Score	Long-term Trend	Short-term Trend
C	55	↑	↔

San Francisco Bay Water Quality Index > *The Big Picture*



Investments in wastewater treatment have reduced inputs of toxic metals to the Bay and improved the health of clams found near the wastewater discharge. Data sources: Redrawn from U.S. Geological Survey, San Francisco Bay Program, "Lessons Learned for Managing Coastal Water Resources," http://water.usgs/wid/html/sfb.html.

column, particularly near points of runoff and discharge into the Bay.

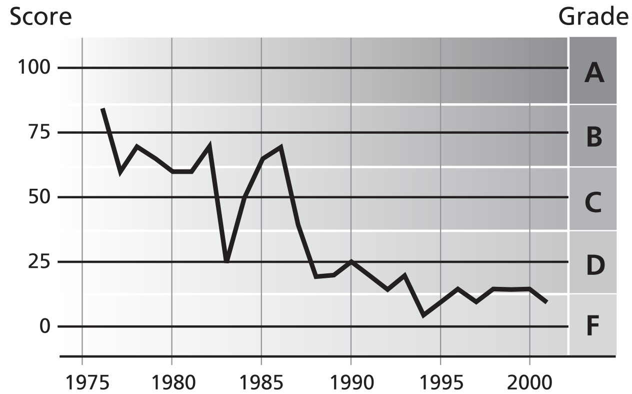
Decades ago, most toxic inputs to the Bay came from localized discharges, "point sources", usually associated with sewage treatment plants and refineries. Today, as a result of the Clean Water Act and other state and local regulations, point-source pollution has been greatly reduced. During the past three decades, concentrated discharges of many trace elements and industrial chemicals have been reduced or eliminated and, for most of these contaminants, the quality of the open waters of the Bay has improved. Control of non-point-source pollution, including runoff of PCBs, pesticides, and metals from contaminated creeks, urban storm drains, and agricultural fields surrounding the Bay, is more difficult. Progress has been slow in developing pollutant load limits (Total Maximum Daily Loads, or TMDLs) for contaminants and their sources in the Bay and its watersheds (see Stewardship Index).

Long-term improvement in Bay water quality was the result of recognizing the serious ecological and human health consequences of pollution, restricting polluted discharges into the Bay and its watersheds, investing in wastewater treatment, and monitoring permitted discharges. Many of the more easily identified "point-source" fixes have been done—what remains will require commitment of communities and individuals around and upstream of the Bay to maintain and expand these efforts. Continuing high levels of multiple toxic compounds, particularly in the urbanized South Bay and industrial and urban portions of San Pablo Bay, underscore the need for further improvement in an estuary made more vulnerable by reduced freshwater inflows (see Freshwater Inflow Index), loss of wetland and marsh habitat (see Habitat Index), and incomplete assessment of water quality conditions away from discharge points (see Stewardship Index).

Grade	Score	Long-term Trend	Short-term Trend
F	10	↓	↔

Food Web

Phytoplankton and zooplankton are the foundation of the San Francisco Bay aquatic food web. Healthy populations of these microscopic plants and animals provide food for Bay fish and wildlife, fueling the Bay's vibrant ecosystem and supporting its recreational and commercial fisheries. The Bay's food web has been profoundly altered by changes in Bay inflows and water quality and by alien species introductions, particularly in the northern, freshwater-influenced reaches. This Index measures the quality of the Suisun Bay food web, where long-term data is available.



The Food Web Index aggregates the results of the phytoplankton, rotifer, copepod, mysid, and zooplankton size indicators for Suisun Bay.

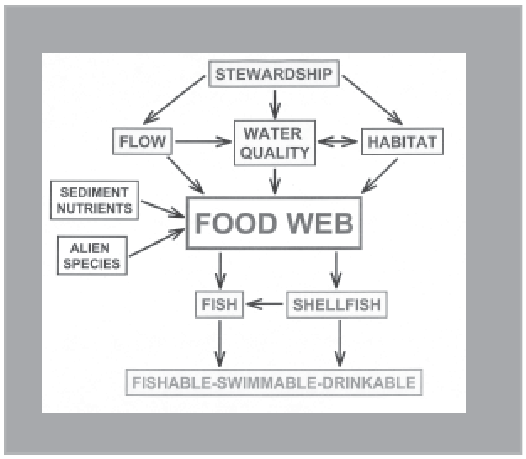
Is the food web healthy enough to support the Bay ecosystem?

Indicator	2001 Result	Grade	Grade Point
Phytoplankton	Suisun Bay numbers 20% of 1974-79 levels; rest of Bay unchanged	D	1
Rotifers	Abundance 2% of 1974-79 levels in Suisun Bay	F	0
Copepods	Only 1% are native to Suisun Bay	F	0
Mysids	Suisun abundance less than 1% of 1974-79 levels	F	0
Zooplankton Size	Size declines to 20% of 1974-79 measurements in Suisun	D	1
	Index Grade Point Average		**0.4 (F)**
	Index Score		**10 (out of 100)**

The Bay Institute

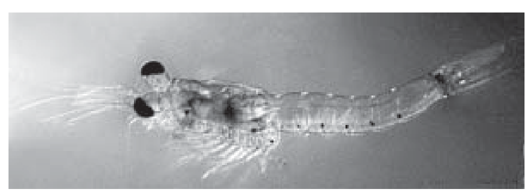
Index Grade	Index Score	Long-term Trend	Short-term Trend
F	10	↓	↔

San Francisco Bay Food Web Index > *Overview*



Connecting the dots

Phytoplankton, the Bay’s most important primary producers, are microscopic floating plants. Zooplankton, the Bay’s primary consumers, are very small floating animals that consume phytoplankton and are, in turn, consumed by the Bay’s shellfish, fish, and occasionally birds. These critically important organisms, the foundation of the Bay’s food web, are affected by many factors, including the amounts and timing of freshwater inflows, the extent and productivity of the Bay’s wetlands, sediment and nutrient inputs, and water pollution levels. Upstream water development, loss of wetland habitat, polluted runoff, and release of alien species in ballast water discharges can reduce productivity and change the composition of the Bay’s food web, and play a role in the decline of native fish and wildlife species.



Native copepods, above left, *and* Mysids, above right, *have declined precipitously in Suisun Bay.*

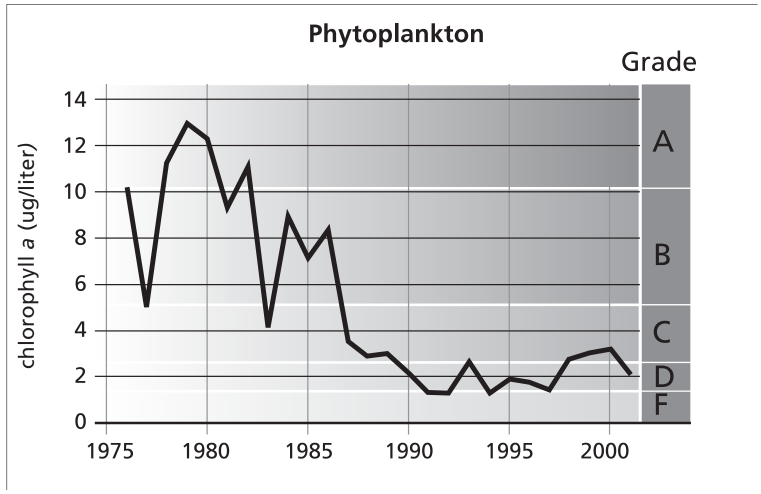
Index Grade	Index Score	Long-term Trend	Short-term Trend
F	10	↓	↔

Phytoplankton

Phytoplankton forms the base of the aquatic food web in San Francisco Bay.[1] These tiny plants use photosynthesis to convert light and nutrients absorbed from the water to make their own food. Phytoplankton production tends to be limited by light, temperature, nutrients, zooplankton grazing rates, and contaminant levels. This indicator measures the amount of phytoplankton in the water (biomass), as determined by gathering water samples and extracting chlorophyll from phytoplankton cells collected on a filter.

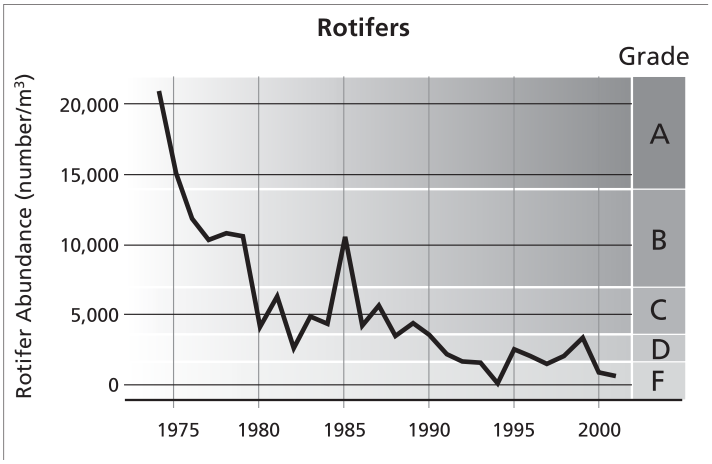
Key Findings

- Phytoplankton biomass in Suisun Bay declined by 80% from 1976 to 1990, and has not recovered in the years since.
- The decline coincided with the establishment in the mid-1980s of an alien clam, *Potamocorbula amurensis*, which consumes large amounts of phytoplankton. Since the *Potamocorbula* invasion, low phytoplankton levels have persisted.[2]
- Phytoplankton biomass is lowest in Suisun Bay. Phytoplankton biomass in other portions of the Bay is higher and has not declined during the past thirty years.[3]



For grading, the A-B break point was set at 10 ug per liter, the average chlorophyll concentration measured between 1976 and 1980. Each lower grade increment was set at 50% of the grade above. Data source: California Department of Fish and Game, Neomysis and Zooplankton survey.

Index Grade	Index Score	Long-term Trend	Short-term Trend
F	10	↓	↔



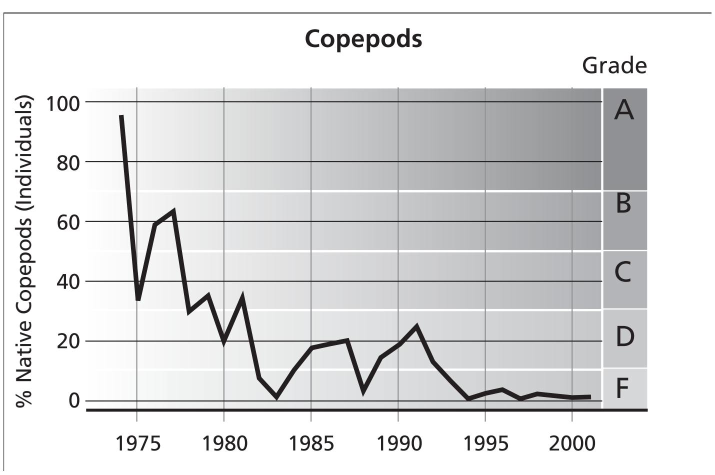
For grading, the A-B break point was set at 14,000 rotifers per cubic meter, the average rotifer abundance measured between 1974 and 1978. Each lower grade increment was set at 50% of the grade above. Data source: California Department of Fish and Game, Neomysis and Zooplankton survey.

Rotifers

Rotifers are one of the smallest, most numerous zooplankton (planktonic animals) in the Bay. Rotifers are extremely efficient at converting phytoplankton into animal biomass. This indicator measures the population abundance of several rotifer species.

Key Findings

- Rotifer abundance in Suisun Bay declined 98% between 1974 and 2001.
- Since its low point in 1994, rotifer populations have not increased significantly.
- The rotifer collapse in Suisun Bay may be associated with the decline in phytoplankton levels and with predation by alien copepods and *Potamocorbula.*



For grading, the A-B break point was set at 70% and the D-F break point at 10%. Data source: California Department of Fish and Game, Neomysis and Zooplankton survey.

Copepods

Copepods are tiny crustaceans—intermediate in size between rotifers and mysids—which are an important food source for other animals in the Bay food web. The relative abundance of native copepods compared to alien species is expected to decline if Bay habitat is degraded or altered. This indicator measures the percentage of copepods collected in Suisun Bay that are native species.[4]

Key Findings

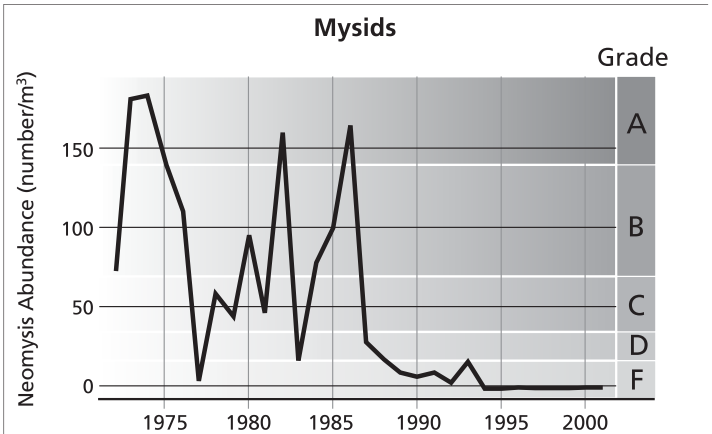
- In 2001, only 1 percent of copepod individuals in Suisun Bay were native species. Of 15 species collected, at least half are from distant estuaries, likely transported to the Bay in ballast water of ocean going ships.
- The percentage of native copepods in Suisun Bay has declined dramatically during the past thirty years. In the early 1970s, nearly 100% of copepod species were considered native, although some of these species may themselves have been introduced to the Bay before formal zooplankton surveys began.

Mysids

Mysids, small shrimp-like animals, are one of the largest zooplankton species in the Bay. The most common, *Neomysis*, was historically an important food source for many Bay fish species, including splittail and delta smelt. This indicator measures the abundance of a key mysid species, *Neomysis mercedis*.

Key Findings

- Abundance of *Neomysis* shrimp in Suisun Bay declined by more than 99% during the past three decades.
- *Neomysis* is now extremely rare in Suisun Bay and may be in danger of becoming locally extinct.
- The decline of *Neomysis* coincides with the decline in phytoplankton and the establishment of the alien clam *Potamocorbula,* which may compete for this shrimp's food.



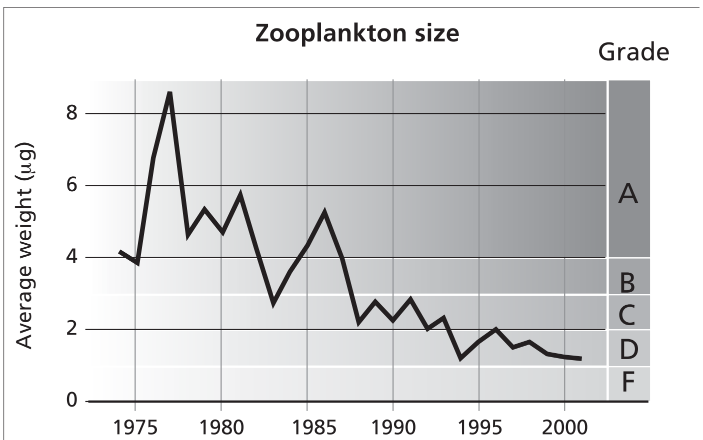
For grading, the A-B break point was set at 140 individuals per cubic meter, the average Neomysis *abundance measured between 1972 and 1976. Each lower grade increment was set at 50% of the grade above. Data source: California Department of Fish and Game, Neomysis and Zooplankton survey.*

Zooplankton size

Larger zooplankton are more visible to fish, so size is an important indicator of their accessibility as prey. Large zooplankton also contain more calories than smaller ones, and transfer energy through the food web more efficiently. Changes in zooplankton size can also indicate shifts in species composition, which may reflect an unstable ecosystem. This indicator measures the average weight of zooplankton (a surrogate for size) collected in Suisun Bay.[5]

Key findings

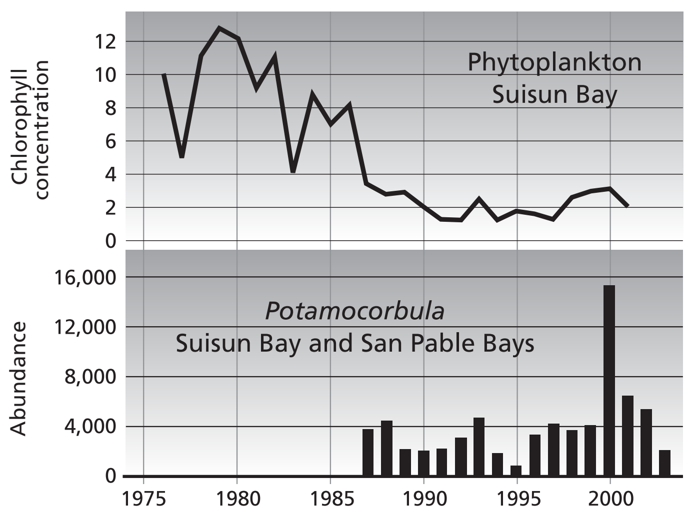
- Average zooplankton size (weight) in Suisun Bay decreased by 80% since 1974.
- Reduced zooplankton size is the result of increased abundance of smaller alien copepods and the decline of larger native copepods.



For grading, the A-B break point was set at 4 ug, 70% of the average size measured between 1974 and 1978. Data source: California Department of Fish and Game, Neomysis and Zooplankton survey.

Index Grade: **F** | Index Score: **10** | Long-term Trend: ↓ | Short-term Trend: ↔

San Francisco Bay Food Web Index > *The Big Picture*



Establishment of the filter-feeding alien clam, Potamocorbula, *decimated phytoplankton production in northern San Francisco Bay.*

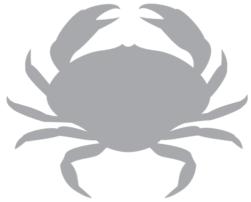
The plants and animals that feed the Bay's ecosystem

In San Francisco Bay, like many threatened ecosystems, people tend to pay the most attention to the species that are endangered, harvested, or simply most charismatic, such as wild salmon or the great water birds. But it is the humbler species, from bacteria and algae to planktonic plants and animals that serve as the foundation of the Bay's complex food web. Changes in the abundance and species composition of these primary producers and consumers can have profound impacts on the structure and composition of aquatic communities, and in some cases may be the crucial factors affecting the success of the more visible species of the Bay.

Phytoplankton growth is controlled by many factors, including light, water depth and transparency, freshwater inflow and circulation patterns, and availability of nutrients. The massive alterations of natural inflow to the Bay from the construction of the Central Valley's water supply and flood management system and reductions in nutrient inputs from the wholesale conversion of wetland and floodplain habitats during the past 150 years undoubtedly had huge impacts on food web dynamics and productivity that are now impossible to quantify. An exception to this general trend is that some aspects of productivity may have benefited from nutrient-rich sewage discharges into the Bay and may now be declining as a result of improvements in wastewater collection and treatment.

Not surprisingly, the food web has changed dramatically in the northern reaches of the Bay, which are most strongly influenced by springtime freshwater inflow and large seasonal and interannual variations in salinity (see Freshwater Inflow Index). Changes in the percent of native species were observed in the first few years of sampling and are testament to the highly invaded nature of this estuary. The recent declines in phytoplankton production coincided with an extreme wet period, with an extraordinarily high flushing flow event which may have eliminated resident native clams from bottom sediments, followed by a sharp decline in Bay inflow as upstream diversions skyrocketed and the 1987-1992 drought began. These conditions may have facilitated the rapid colonization of the Bay's upper reaches by the alien *Potamocorbula* clam, which consumes phytoplankton faster than phytoplankton can reproduce. This exotic clam is now a major component of the highly altered Suisun Bay food web. The clam also bioaccumulates selenium, a trace element that is toxic at very low levels, at higher rates than native filter feeders, increasing the risk of biomagnification of this and other contaminants in fish and birds.

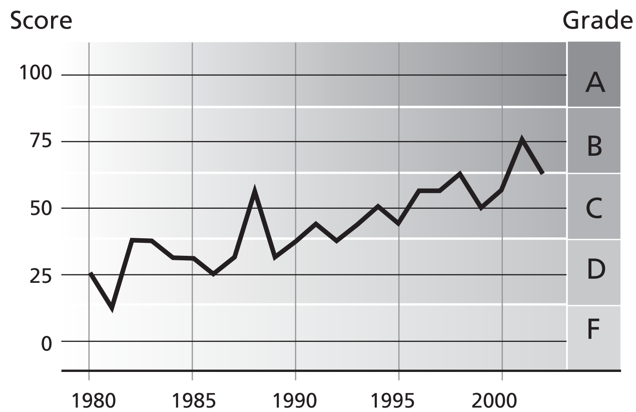
Current management initiatives to increase Bay inflow (see Stewardship Index) and expand wetland habitat (see Habitat Index) may help simulate some of the conditions that improve primary production and favor native food web species. However, these actions may be too modest to make a measurable difference as long as highly efficient alien filter feeders continue to dominate the bottom community. New water supply projects under consideration in the Delta and Central Valley that would expand the ability to store and convey upstream runoff could also negate any efforts to improve Bay inflow conditions.



Grade	Score	Long-term Trend	Short-term Trend
B-	63	↓	↑

Shellfish

San Francisco Bay is an important habitat for a variety of shellfish, including crabs, shrimp, and clams. Many species are consumed by Bay fish and birds and also are harvested for commercial and recreational uses. Shellfish also serve as important indicators of Bay pollution levels because they are highly sensitive to changes in water quality.



The Shellfish Index aggregates the results of the Dungeness crab, rock crab, native shrimp, and percent native shrimp indicators.

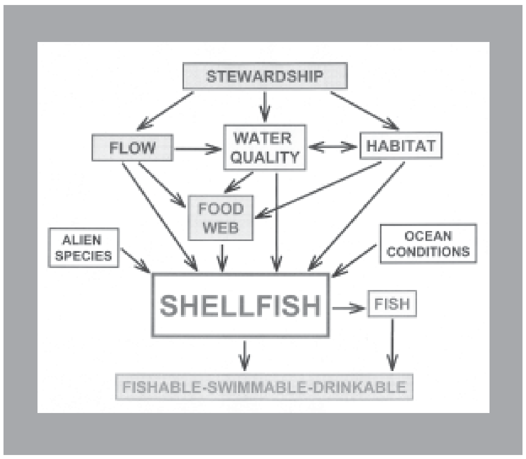
How are San Francisco Bay shellfish species doing?

Indicator	2001 Result	Grade	Grade point
Dungeness Crab	Juveniles increased dramatically over last 5 years, but commercial landings still only 20% of previous levels	C	2
Rock Crab	Abundance nine times higher than in early 1980s, but stable for past decade. Historic numbers unknown.	C	2
Shrimp	Abundance is 150% of 1980s numbers, but landings only 7% of 1920-1940	C	2
Percent Native Species	95% of all shrimp collected are native; exotic species more prevalent in northern Bay	A	4
		Index Grade Point Average	**2.5 (B-)**
		Index Score	**63 (out of 100)**

The Bay Institute

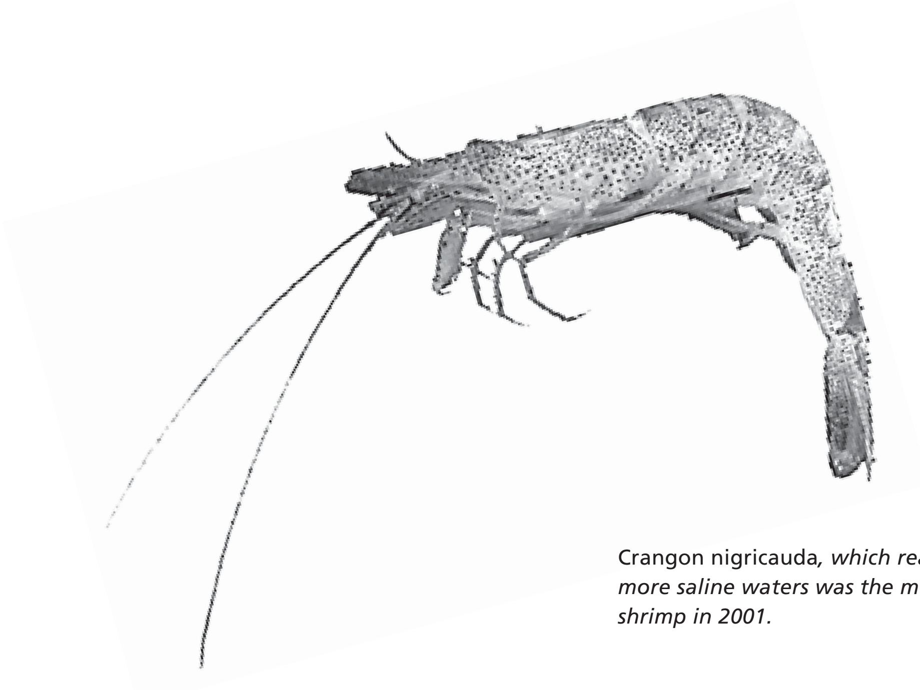
Index Grade	Index Score	Long-term Trend	Short-term Trend
B-	63	↓	↑

San Francisco Bay Shellfish Index > *Overview*



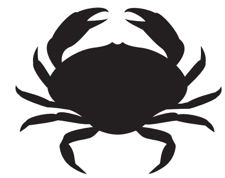
Connecting the dots

Shellfish are an important component of the Bay's ecosystem—they are a key food source for many fish and bird species and support popular commercial and recreational fisheries. Many shellfish species have life histories that disperse their populations widely between the Bay and coastal environments. As a result, their distribution and abundance is strongly affected both by ocean conditions and environmental factors in the Bay. Conditions for shellfish in the Bay are largely controlled by the amounts and timing of freshwater inflows, water pollution levels, and the introduction of exotic species. Many shellfish species are highly sensitive to poor water quality and disappear from polluted areas, others absorb and bioaccumlate toxic contaminants in their tissues, transferring those contaminants up the food chain when they are consumed by fish, birds, and people.



Crangon nigricauda*, which rears in cooler, more saline waters was the most abundant shrimp in 2001.*

Index Grade: **B-** | Index Score: **63** | Long-term Trend: ↓ | Short-term Trend: ↑

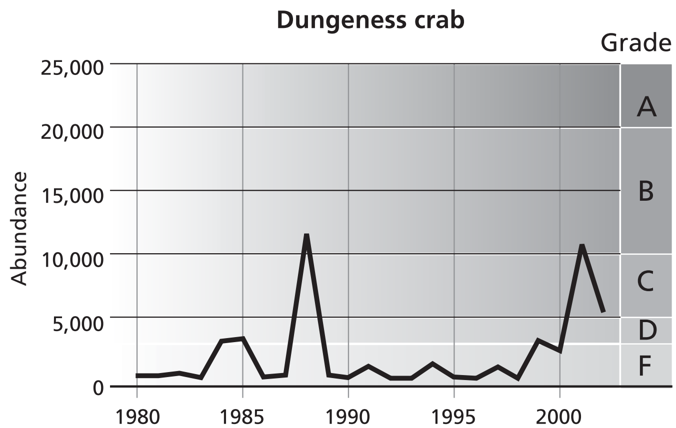


Dungeness crab

Dungeness crab, an icon of San Francisco's Fisherman's Wharf, use the Bay as nursery habitat. Young crabs feed and grow in the Bay's brackish waters and tidal marshes before moving into the ocean where the species supports the most important commercial shellfish fishery in California. This indicator measures the abundance of juvenile Dungeness crabs in the Bay.

Key Findings

- Since 1984, juvenile Dungeness crab abundance within the Bay has fluctuated dramatically. In 2001, crab abundance was 50 times higher than the average levels in the early 1980s.[1]
- Commercial landings are still less than 20% percent of levels measured 40 to 50 years ago.[2]
- Juvenile crab abundance in recent decades was highest in 1988 and 2001. Favorable oceanic conditions (temperature and currents), low predation levels and pollution have been suggested as important factors controlling crab populations.[3]



Based on commercial harvest data, local Dungeness crab populations declined more than 70% in the 1960s. Therefore, for grading, the maximum abundance measured during the past 20 years, 10,000, was set as the B-C break point. Each lower grade increment was set at 50% of the grade above. Data source: California Department of Fish and Game, Bay Study Otter Trawl survey.

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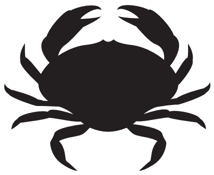
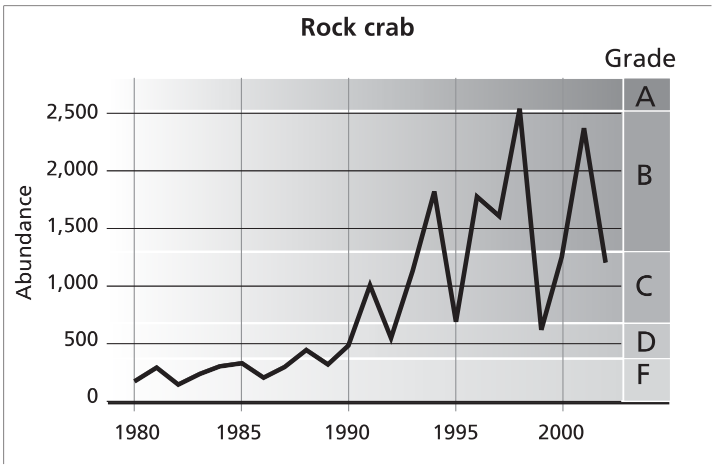


Index Grade	Index Score	Long-term Trend	Short-term Trend
B-	63	↓	↑

San Francisco Bay Shellfish Index > *Indicators*



There are no long-term historic records for rock crab abundance. Therefore, for grading, the maximum abundance measured during the past 20 years, 2,500, was set as the A-B break point. Each lower grade increment was set at 50% of the grade above. Data source: California Department of Fish and Game, Bay Study Otter Trawl survey.

Rock crab

Unlike the migratory Dungeness crab, rock crabs are Bay residents. Several rock crab species are found in the Bay and, despite their common name, they use a variety of habitats, from sandy bottoms to eelgrass beds to intertidal marshes, making them a useful indicator for a broad range of estuary habitats. Two species, red rock crab (*Cancer productus*) and brown rock crab (*C. antennarius*), support a popular recreational rock crab fishery in the Bay.[4] This indicator measures the abundance of three rock crab species that are found in different areas of the Bay.

Key Findings

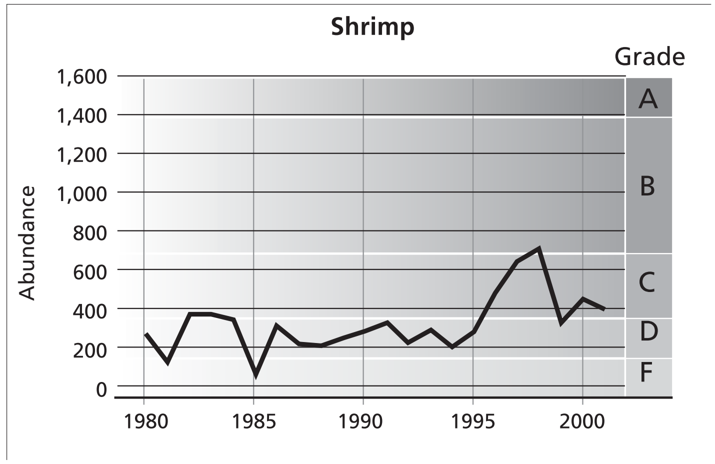
- On average, rock crab abundance increased ninefold over the early 1980s numbers, but during the past ten years populations have leveled off. No reliable information exists on previous abundance.[5]
- Unlike Dungeness crab, rock crabs appeared to respond favorably to more saline conditions during the 1987-1992 drought when their numbers increased steadily, and less favorably to more recent wet years with higher Bay inflow.

Shrimp

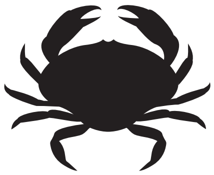
Shrimp are an important food source for the Bay's fish, crabs and marine mammals. They are also fished commercially by trawlers in the Bay and sold mainly as bait to sport anglers. Shrimp are sensitive to pollution levels and serve as important indicators of water quality. Bay shrimp, the dominant native species, also tend to be more abundant when Bay inflows are higher. This indicator measures the abundance of native shrimp species collected in the Bay.

Key Findings

- Shrimp abundance doubled in the late 1990s, following more than 15 years of moderate but stable population numbers. In 2001, shrimp numbers were 150% higher than the average abundance measured between 1980 and 1995.
- Almost all of this increase occurred in the Central and South Bay populations.
- Native shrimp populations are still a fraction of their former numbers. Current commercial landings are just 7% of 1920-1940 levels.[6]

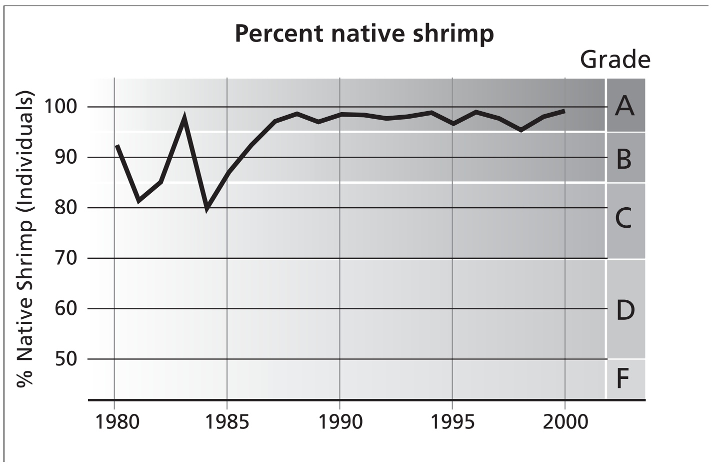


Based on commercial harvest data, local shrimp populations declined more than 80% in the 1960s. Therefore, for grading, the maximum abundance measured during the past 20 years, 700, was set as the B-C break point. Each lower grade increment was set at 50% of the grade above. Data source: California Department of Fish and Game, Bay Study Otter Trawl survey.



Index Grade	Index Score	Long-term Trend	Short-term Trend
B-	63	↓	↑

San Francisco Bay Shellfish Index > *Indicators*



For grading, the A-B break point was set at 95% and the D-F break point at 50%. Data source: California Department of Fish and Game, Bay Study Otter Trawl survey.

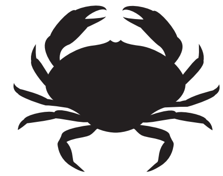
Percent native species

San Francisco Bay is the most invaded estuary of North America.[7] Some alien species hitchhike to the Bay in ballast water discharged from marine vessels; others were deliberately introduced. The large-scale alterations of freshwater inflows and wetland habitats have created many opportunities for new alien species to successfully colonize the Bay. These invaders can displace native species from their habitats, compete for their food sources, or directly prey upon them (see Food Web Index). This indicator measures the percentage of shrimp collected in the Bay's sub-tidal habitats that are native species.[8]

Key Findings

- San Francisco Bay subtidal shellfish populations are dominated by native species. Between 1980 and 2000, from 80 to 98% of the shrimp collected were native species. Nearly all of the crab species were native.
- In the early 1980s, the alien, oriental shrimp, *Paleomon*, constituted up to 20% of the shrimp catch.
- Alien shellfish are more prevalent in Suisun and San Pablo Bays, the upstream, brackish water areas of the Bay that are more directly affected by changes in freshwater inflows (see Freshwater Inflow Index).
- Although percentages of native species are relatively high in recent years, new alien shellfish species continue to enter the Bay. Measurements of shallow water and shoreline habitats would likely yield higher numbers of alien species.

Index Grade	Index Score	Long-term Trend	Short-term Trend
B-	63	↓	↑



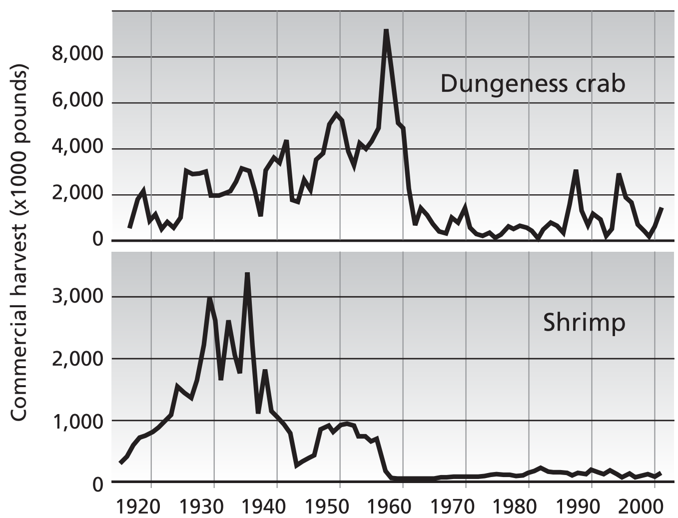
San Francisco Bay Shellfish Index > *The Big Picture*

Bay shellfish – living between two worlds

Shellfish and other benthic (bottom-dwelling) organisms are an important part of the Bay's ecosystem. Some are Bay residents, while many others spend part of their life cycle in the ocean. Most of these creatures, including clams, shrimp, crabs, oysters, and mussels, "filter feed" by straining food from the water column or graze among the bottom sediments. Thus, they are an important link in the food chain between microscopic plankton and bacteria and large predatory fish and birds. Because of their benthic, filter-feeding life-style, shellfish are highly sensitive to water-, sediment- and plankton-borne contaminants.

Most shellfish species found in the Bay are strongly affected by salinity and Bay inflows.[9] Many salt-loving bottom invertebrates move upstream in drier years, while others are more abundant when Bay inflows are high, preferring fresher water and possibly benefiting from greater dispersal of juveniles. Whatever their life history requirements, the native shellfish community undoubtedly flourished in the food-rich environment of the vast tidal marshes and mudflats that once ringed the Bay.

The long-term declining trends in shrimp and crab harvest (illustrated by the landings data), combined with increases in crab and shrimp populations from the 1980-2001 Bay study, depict a system that was once heavily impacted but is now slowly recovering from decades of disturbance. Some of this change is certainly due to oceanic conditions; however, Bay conditions also play an important role. Throughout the 20th century, the Bay and its multiple watersheds have been increasingly urbanized, eliminating important near shore habitats such as tidal marshes (see Habitat Index) and polluting Bay water with toxic agricultural, urban, and industrial runoff (see Water Quality Index). Dredging projects were common and widespread in the early 1900s, and continue on a smaller scale today.[10] These factors almost certainly impacted populations before the Bay study began; but reductions in fishing and dredging, and water quality improvements, may be having a positive effect.



Local commercial harvest of Dungeness crab and shrimp collapsed in the early 1960s. Data source: California Department of Fish and Game, Shrimp and Crab Landings Data.

At least in the subtidal shellfish community, some alien species were more abundant in the past. Twenty years ago, the introduced oriental shrimp, *Paleomon,* constituted a significant portion of the Suisun Bay community—today it is much less prevalent. In addition, most of the Bay's formerly economically important shellfish species were in fact alien species that were introduced deliberately for harvest or accidentally through ballast discharge from marine vessels. At first, these new populations of eastern oysters, soft-shelled clams, and Bay mussels supported a major commercial fishery, but collapsed in the 1930s and 1940s as sewage and other runoff severely degraded Bay water quality.[11]

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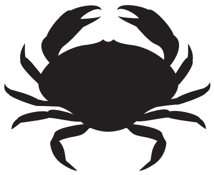
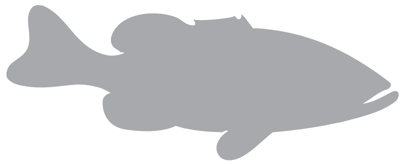


Index Grade	Index Score	Long-term Trend	Short-term Trend
B-	63	↓	↑

San Francisco Bay Shellfish Index > *The Big Picture*

The increase in the Shellfish Index over the past twenty years should be viewed both in the context of the natural variability of shrimp and crab populations and changing anthropogenic factors. Some shellfish populations increased during the drier years of the late 1980s and early 1990s, while others such as the Bay shrimp increased in wetter years.[12] The overall trend in these populations is increasing, but sustaining the improvement will likely depend on favorable oceanic and freshwater flow conditions, enhancements and increases in tidal marsh habitats, and further progress in cleaning up toxic contamination of Bay water and sediments.

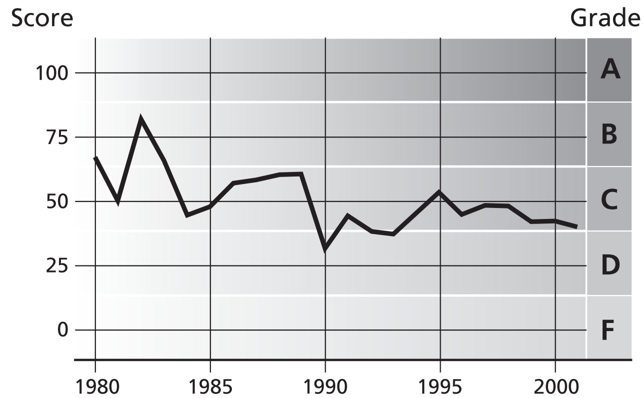


San Francisco Bay Index > Overview

Grade	Score	Long-term Trend	Short-term Trend
C-	39	↓	↔

Fish

San Francisco Bay is essential habitat for many fish species, including commercially important Pacific herring and chinook salmon, popular sport fishes like striped bass, and many sensitive estuary-dependent species like delta smelt and starry flounder. Changes in Bay inflows, habitat extent, water quality and food web productivity, have all affected fish abundance, and five fish species are now listed as endangered or threatened.



The Fish Index aggregates the results of the abundance, diversity, percent native species, and sensitive species indicators.

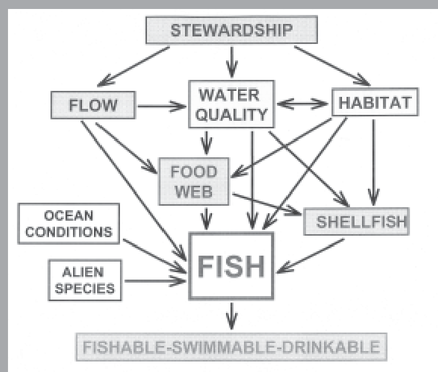
How are San Francisco Bay fish species doing?

Indicator	2001 Result	Grade	Grade point
Abundance	50% of 1967-1971 abundance	D	1
Diversity	Most Bay-dependent species still present	B	3
Percent native species	82% native to the Bay	C	2
Sensitive species	Abundance of longfin smelt and striped bass 7-13% of 1967-1971	F	0.25
		Index Grade Point Average	**1.56 (C-)**
		Index Score	**39 (out of 100)**

The Bay Institute

Index Grade	Index Score	Long-term Trend	Short-term Trend
C-	39	↓	↔

San Francisco Bay Fish Index > *Overview*



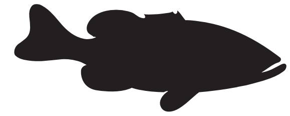
Connecting the dots

San Francisco Bay is essential habitat for dozens of fish species. Some species live in the Bay their entire lives, entirely dependent on the estuary ecosystem. Others are visitors, moving from ocean or upstream habitats to use the Bay as a spawning or nursery area. For migratory anadromous fishes, such as chinook salmon, steelhead, and sturgeon, the estuary is a key staging station on their trips between the Pacific Ocean and rivers of the Bay's watersheds. While many of the marine species that use the Bay are affected by ocean conditions, environmental and ecological conditions in the Bay, largely controlled by the amounts and timing of freshwater inflows, the quality and quantity of tidal wetlands and other habitats, water pollution levels, and the productivity of the Bay food web, affect all members of the Bay fish community. When environmental conditions are poor, the population abundance and diversity of fish species found in the Bay decline, and some of the most vulnerable species may become extinct.

David Sanger

Pacific herring, a sensitive species, has declined in recent years.

Index Grade	Index Score	Long-term Trend	Short-term Trend
C-	39	↓	↔

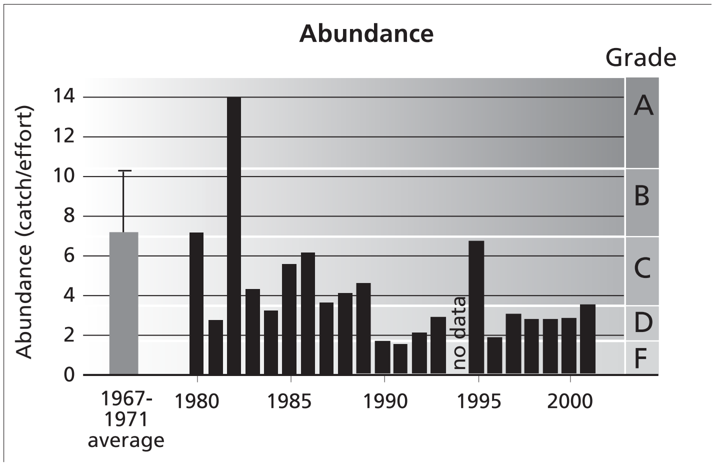


Abundance

More than 70 native fish species use San Francisco Bay for spawning, nursery and rearing habitat, and as a migration pathway between the Pacific Ocean and Central Valley rivers and Bay streams. Native fishes are more abundant in healthy aquatic ecosystems than in those impaired by altered flow regimes, toxic urban and agricultural runoff and reduced habitat.[1, 2] This indicator measures the overall population size, as catch per unit effort, of the native fish species collected in the Bay each year.[3]

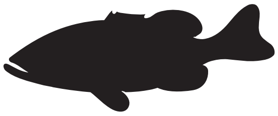
Key Findings

- In 2001, native fish abundance was just half of that measured thirty years ago.
- Between the early 1980s and the end of the 1987-1992 drought, abundance declined nearly 80% — a period during which levels of diversion from the Bay's watershed were the highest recorded.
- Since its low point in the early 1990s, native fish abundance has not significantly increased. Moderately high abundance measured in 1995 resulted from high numbers of a single species, longfin smelt. This was the first year of successful reproduction by this Bay-dependent species in more than a decade (see Sensitive Species Indicator).
- The greatest decline in abundance of native fishes occurred in Suisun Bay, the upstream portion of the Bay. In 2001, native fish populations in Suisun Bay were just 15% of the average population size measured twenty years earlier.



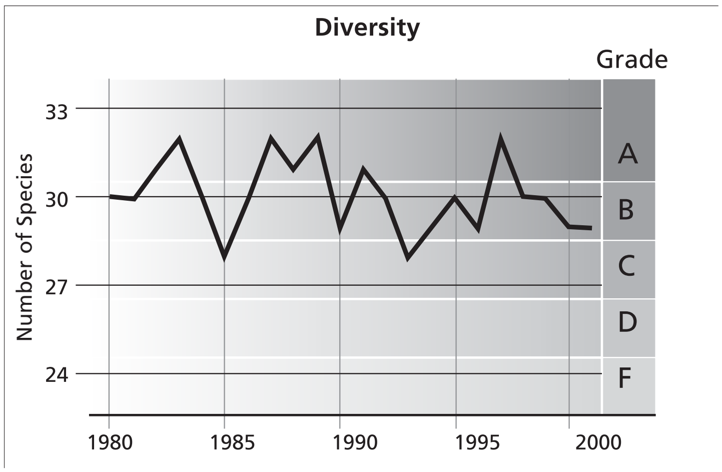
For grading, the B-C break point was set at the average abundance of native fishes measured between 1967 and 1971. Each lower grade was set at levels 50% of the grade above. Data sources: California Department of Fish and Game, Bay Study Midwater Trawl and Fall Midwater Trawl surveys.

The Bay Institute



Index Grade	Index Score	Long-term Trend	Short-term Trend
C-	39	↓	↔

San Francisco Bay Fish Index > *Indicators*



For grading, the A-B break point was set at greater than 30 species, equivalent to 90% of the Bay-dependent species assemblage. Data sources: California Department of Fish and Game, Bay Study Midwater Trawl and Otter Trawl surveys.

Diversity

Of the many native fish species that use the Bay, more than half of them, 34 species, are dependent on the Bay.[4] Some live in the Bay for their entire life cycle; for others, the Bay is critical spawning or nursery habitat. Diversity, or species richness, is typically reduced in aquatic ecosystems that have been impaired by altered flow regimes, pollution, and habitat loss, compared to healthy or less-impaired systems.[5] This indicator measures species richness, the number of Bay-dependent species that are collected in the Bay each year.

Key Findings

- In 2001, only 29 of 34 Bay-dependent species were collected.
- Although diversity of the Bay fish community has fluctuated, it did not significantly decline during the 1980-2001 period. In the early 1980s, an average of 31 species—more than 90% of the total Bay-dependent fish assemblage—were collected each year.

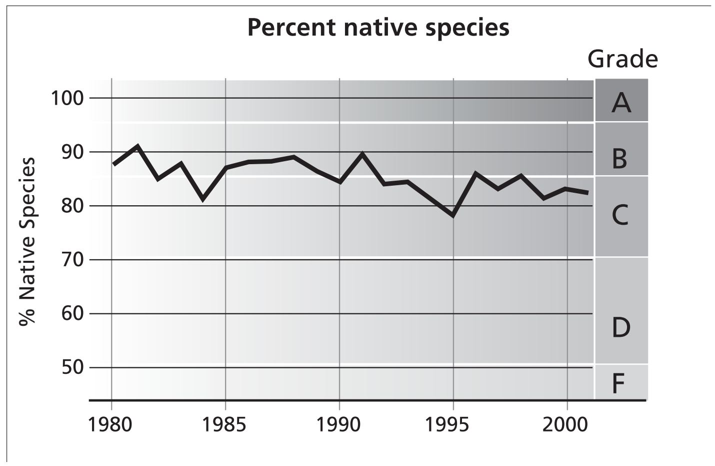
Index Grade	Index Score	Long-term Trend	Short-term Trend
C-	39	↓	↔

Percent native species

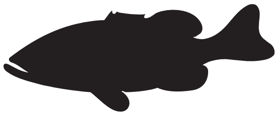
San Francisco Bay has been invaded by a number of alien fish species. Some species, such as striped bass, were intentionally introduced into the Bay. Others arrive in ballast water or from upstream habitats, usually reservoirs. The relative proportions of native and alien species in an ecosystem is an important indicator of ecosystem health. Alien species are more prevalent in altered or degraded habitats. This indicator measures the percentage of fish species collected in the Bay that are native to the estuary and its adjacent ocean and upstream habitats.

Key Findings

- The Bay fish community is dominated by native species. On average, 85% of the fish species collected in San Francisco Bay during the survey period were native to the Bay. In 2001, 82% of fish species collected in the Bay were natives.
- The percentage of native species has declined during the past 20 years. This decline resulted from the establishment of two new alien fish species, rather than a loss of native species.
- The lowest percentages of native species occurred in Suisun Bay, the upstream portion of the Bay. In 2001, one third of all fish species collected in Suisun Bay were not native to the Bay.
- The greatest rate of decline in percentage of native species also occurred in Suisun Bay, where native species percentages have declined from 75% in the early 1980s to an average of 68% in recent years.

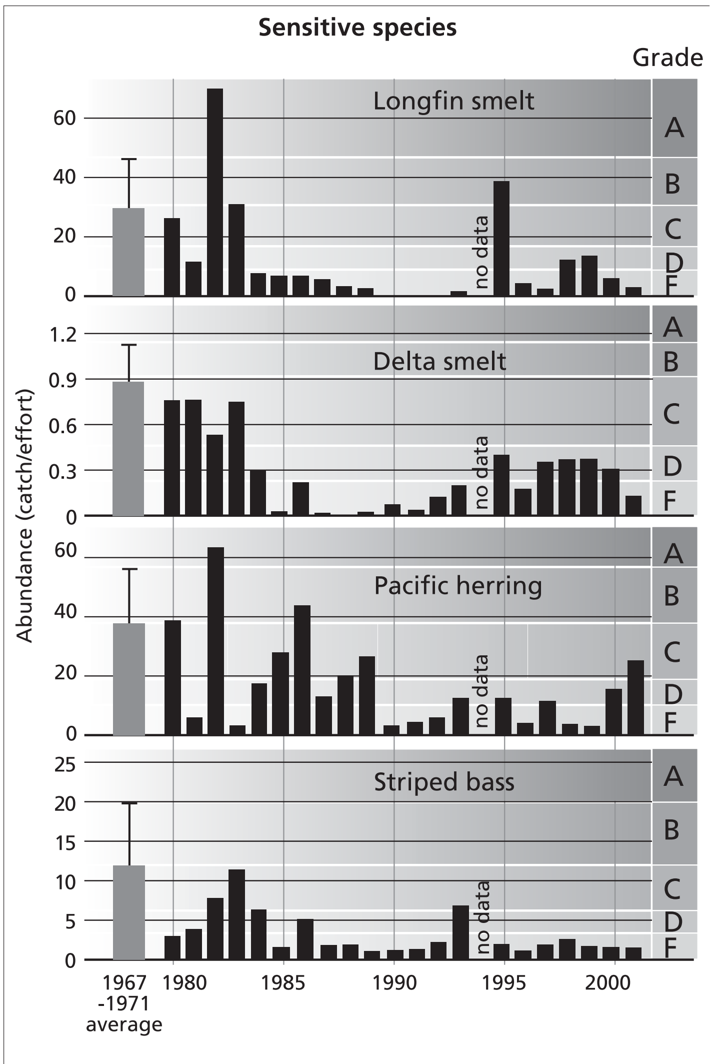


For grading, the A-B break point was set at 95% and the D-F break point at 50%. Data source: California Department of Fish and Game, Bay Study Midwater Trawl survey.



Index Grade	Index Score	Long-term Trend	Short-term Trend
C-	39	↓	↔

San Francisco Bay Fish Index > *Indicators*



For grading each species, the B-C break point was set at the average 1967-1971 abundance. Each lower grade was set at levels 50% of the grade above. Data sources: California Department of Fish and Game, Bay Study Midwater Trawl and Fall Midwater trawl surveys.

Sensitive species

Among the many fishes that rely on the Bay, different species use the Bay in different ways. Some use the Bay as spawning and nursery habitat before returning to the ocean. Others spawn upstream of the Bay and rear in the lower portions of the Bay. Some species prefer the salty waters of South, Central and San Pablo Bays, while others congregate in brackish Suisun Bay. Abundance of representative species that rely on the Bay in different ways can be a useful indicator of the health of the Bay as a "multi-purpose" habitat. This indicator measures the abundance of four fish species: longfin smelt, delta smelt, Pacific herring, and striped bass. Each of these species is relatively common and consistently present in the Bay and each is the target of environmental or fishery management in the Bay.

Key Findings

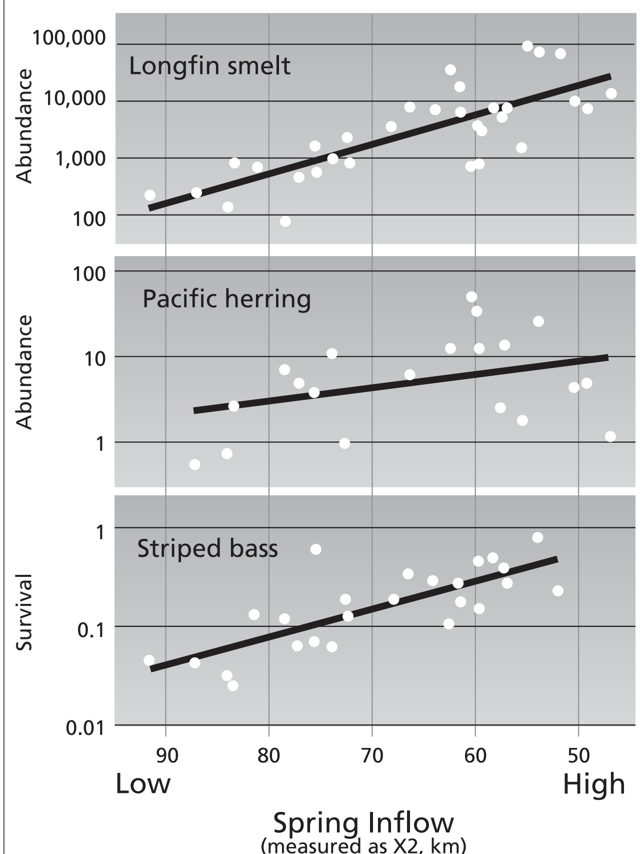
- Populations of four common fish species that depend on the Bay declined sharply during the 1980s and have shown little sign of recovery.
- Longfin smelt abundance declined 98%, to critically low levels during the 1980s. The species was denied protection under the Endangered Species Act yet, in 2001, its abundance was just 7% of that measured 30 years ago.
- Delta smelt abundance declined by 90% during the 1980s. In 1993, the species, which is found only in the San Francisco Bay and Delta, was listed under the Endangered Species Act as threatened. During the late 1990s, delta smelt population increased but abundance in recent years is less than half of that measured just 20 years ago.
- Pacific herring, which spawn in the Bay and support the Bay's last commercial finfish fishery, also declined. Although their numbers have improved somewhat in recent years, 2001 numbers were nearly 40% lower than the 1967-1971 average.
- Abundance of striped bass, a popular game fish that was introduced to the Bay more than 100 years ago, remains very low, just 13% of population levels measured 30 years ago.

Index Grade	Index Score	Long-term Trend	Short-term Trend
C-	39	↓	↔

Fish are the Bay's "canary in the coalmine"

San Francisco Bay is home, way station, and highway for dozens of fish species—a unique inland estuary with a convoluted shoreline, large shallow embayments, dozens of tributary streams, and the gateway to the mighty Sacramento and (once-mighty) San Joaquin Rivers. Until a few decades ago, the Bay supported vibrant and valuable commercial and recreational fisheries for salmon, sturgeon, herring and striped bass. Even delta smelt supported a small ethnic fishery. Perhaps the earliest signs of trouble for the Bay fish community are found in these records: in the 1930s, sport fishers regularly landed twenty striped bass per day, by the 1950s catch dropped to less than ten fish per angler and, by the 1960s, to less than two fish (see Fishable-Swimmable-Drinkable Index).[6]

The Bay's diverse fish community is affected by conditions both inside and outside the Golden Gate. However, the manmade changes in the estuary have been the most dramatic. Throughout the twentieth century, the Bay's margins and its multiple watersheds were increasingly urbanized, eliminating important nearshore habitats such as tidal marshes (see Habitat Index) and polluting Bay water with toxic agricultural, urban, and industrial runoff (see Water Quality Index). These conditions affected not only the fishes in the Bay but also the organisms upon which they feed (see Food Web Index). Since the mid-1970s, Bay water quality, which at times was lethal to fish and their zooplankton food, has improved, largely as a result of reforms required by the Clean Water Act. However, while the health of Bay waters improved, the health of the Bay's watersheds worsened as they were increasingly exploited for irrigation and urban water supply. For Bay fishes, the greatest impacts of these activities have been the reductions in springtime freshwater inflows, critical to many Bay-dependent



Bay fish species are more abundant and have higher survival rates when freshwater inflows are high during the spring. Data courtesy of W. Kimmerer, San Francisco State University.

The Bay Institute

Index Grade	Index Score	Long-term Trend	Short-term Trend
C-	39	↓	↔

San Francisco Bay Fish Index > *The Big Picture*

species, and reductions in the seasonal variation in inflows that drive the environmental variability typical of estuaries. The sharp decline observed in the Fish Index during the late 1980s and early 1990s coincided with a prolonged drought exacerbated by the highest level of water diversions and exports from the Bay's watershed ever measured (see Freshwater Inflow Index). The Bay has become less dynamic and, for estuarine species adapted to large seasonal and year-to year variations in freshwater inflows, less hospitable. In addition, the impaired environmental conditions have favored the establishment of non-native species that can prey upon or compete with native fishes, exemplified in the Bay by the alien clam, *Potamocorbula*, which has severely affected the Bay's food web by depleting phytoplankton productivity (see Food Web Index).

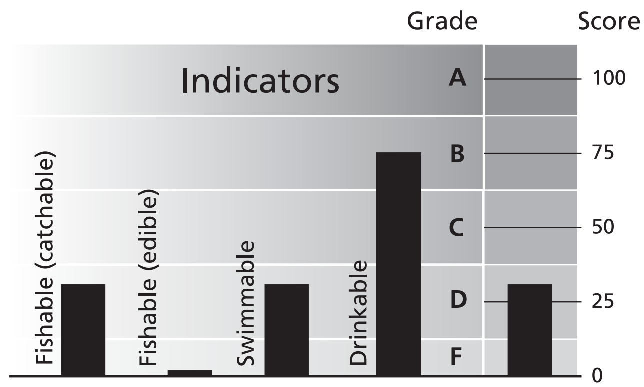
Beginning in the mid-1990s, new Bay-Delta water quality standards and Endangered Species Act protections for the five listed fish species that use the Bay[7] have moderately increased springtime freshwater inflows, and major funding has been earmarked to underwrite large-scale habitat restoration initiatives. Indeed, the first restoration projects have begun to improve habitat conditions around the Bay and in its tributary rivers.[8] However, restoration of ecological function in rehabilitated habitats takes many years. Further, because most of the years since the new standards were established have been relatively wet and produced favorable spring flow conditions, it may be premature to relate changes, or the lack of change, in the Fish Index with improved management of the Bay ecosystem.

Grade	Score	Long-term Trend	Short-term Trend
D+	31	↓	↔

San Francisco Bay Index > *Overview*

Fishable, Swimmable, Drinkable

San Francisco Bay is an important and heavily used resource for the Bay Area's human population. Many Bay fish and shellfish species are caught and consumed by recreational and subsistence anglers. Bay beaches and near-shore waters attract swimmers, kayakers, and board sailors. Surface runoff and groundwater from the Bay's many watersheds—near and far—provide drinking water to Bay Area residents. These human uses of water from the Bay and its watershed are protected by federal and state law.



The Fishable-Swimmable-Drinkable Index aggregates the results of the fish catch, fish consumption, beach posting, and drinking water exceedence indicators.

Can you catch a fish in the Bay? If you catch a fish, is it safe to eat?

Is it safe to swim at Bay beaches? How clean are local drinking water supplies?

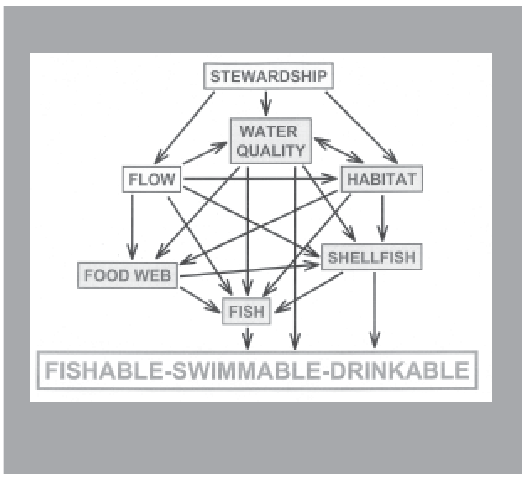
Indicator	2000-2003 Result	Grade	Grade point
Fishable (catchable)	60% decline from average 2 fish a day in 1960s, to less than one fish in 2001	D	1
Fishable (edible)	94% of fish exceeded safe consumption levels for toxics in 2000	F	0
Swimmable	Beaches posted or closed 50 days in 2002, double the previous year	D	1
Drinkable	10% of suppliers reported some elevated contaminant levels in 2003—an improvement over 10 years ago	B	3
	Index Grade Point Average		**1.25 (D+)**
	Index Score		**31 (out of 100)**

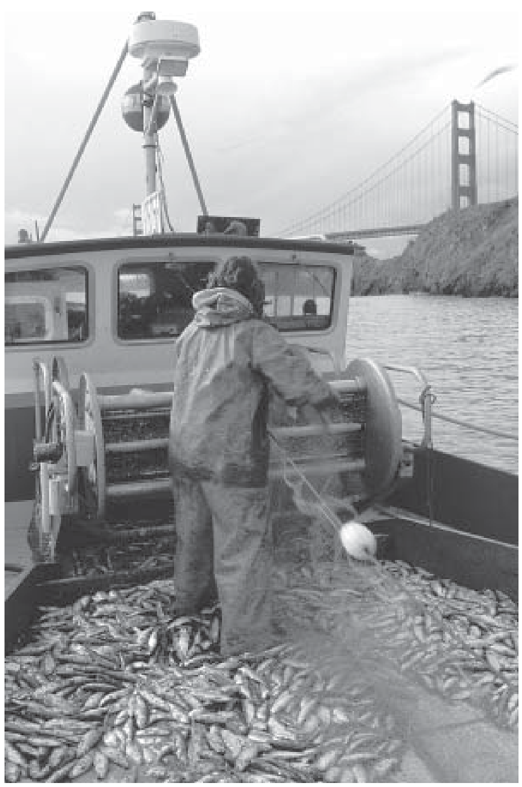
Index Grade	Index Score	Long-term Trend	Short-term Trend
D+	31	↓	↔

San Francisco Bay FSD Index > *Overview*

Connecting the dots

Human uses of the Bay and its watersheds are affected by many factors, most dramatically by contamination of Bay waters by toxic chemicals, bacteria and other harmful components of sewage, industrial discharges, and urban and agricultural runoff. Water pollution affects people directly, rendering Bay waters unsafe for recreation or contaminating drinking water supplied from the Bay's watersheds. Toxics discharged into local creeks and watersheds, and the Bay itself, are also concentrated in the food web—contaminants absorbed by plankton are magnified in fish and birds farther up the food chain and ultimately transferred to human consumers. Effects of other changes in the Bay's ecosystem have been more subtle but no less important. Reductions in inflows and wetland habitats, in addition to reducing the Bay's productivity and fish abundance, weaken the capacity of the Bay to absorb and neutralize contaminants discharged into its waters.





David Sanger

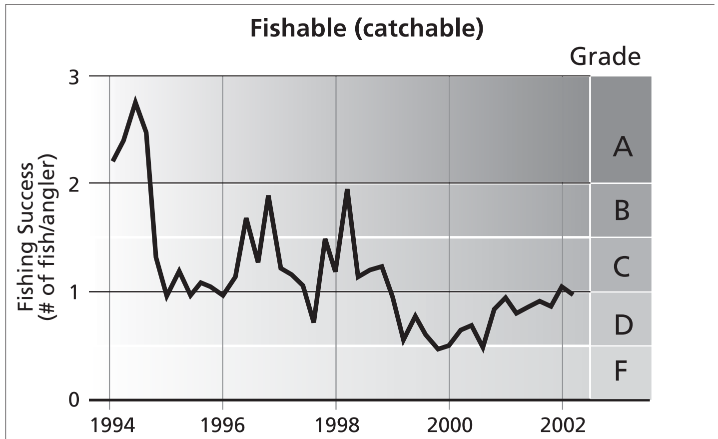
Herring fishing is the last remaining commercial fishery in the Bay.

Fishable (catchable)

The Bay once supported vibrant commercial and recreational fisheries for many species. Today, other than a small commercial fishery for Pacific herring, only recreational and subsistence fisheries remain, supported by a handful of Bay fish and shellfish species. Population abundances of many of these species have declined during the past several decades (see Fish Index), a factor than can lead to reduced fishing success, diminishing the Bay's value as a source of enjoyment and, in some cases, food for subsistence anglers. This indicator measures recreational fishing success for several dozen fish and shellfish species found in the Bay.

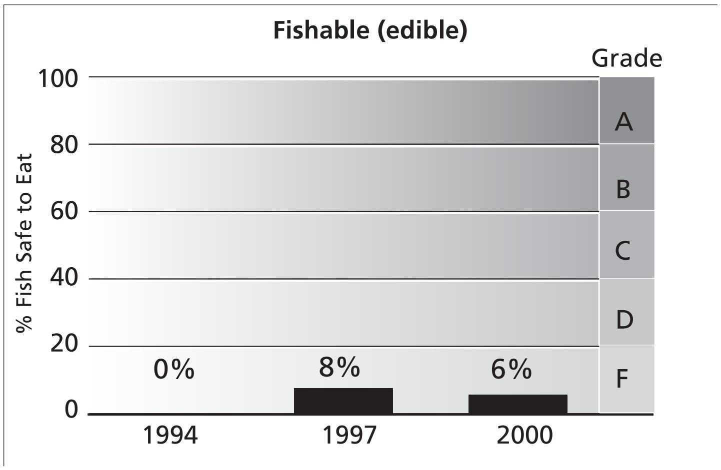
Key Findings

- In 2001 recreational anglers caught, on average, less than one fish per day. This represents a 60% decline compared to the early 1960s when anglers usually caught more than two fish per day, but a modest improvement over the historic low catch of 10 years ago, when half of all anglers did not catch any fish.
- Landings of striped bass, the most frequently caught species, declined more than 90%, falling from more than 2 fish per angler per day in the early 1960s to just 0.15 fish per angler per day in the 1990s.
- Sturgeon landings dropped by more than 50% during the past 40 years. Catch of other commonly caught species, including salmon, rockfish, halibut and croaker, varied from year to year.



For grading, the A-B break point was set at 2 fish per angler, 90% of the average catch between 1960 and 1964. The D-F break point was set at 0.5 fish per angler. Data source: California Department of Fish and Game, Commercial Passenger Fishing Vessel database.

Index Grade	Index Score	Long-term Trend	Short-term Trend
D+	31	↓	↔



For grading, the A-B break point was set at 80%, a level at which 80% of fish caught in Bay have tissue contaminant levels below screening levels for human health concerns. Data source: San Francisco Estuary Regional Monitoring Program for Trace Substances.

Fishable (edible)

The Bay was once an important source of seafood for local markets as well as export. The commercial fisheries collapsed early in the 20th century from over-harvest and other factors, but many Bay Area residents still catch and consume fish from the Bay. Because many fish species are contaminated with the toxic chemicals that pollute Bay waters, sediments, and food sources, the public is advised by the California Department of Health Services against consuming most of the fish species that reside in the Bay.[1] This indicator evaluates contaminant levels of several sport fish species that are commonly caught in the Bay, measuring the percentage of fish with tissue contaminant concentrations that are below the U.S. Environmental Protection Agency (EPA) screening levels for PCBs, mercury, DDT, or chlordanes.

Key Findings

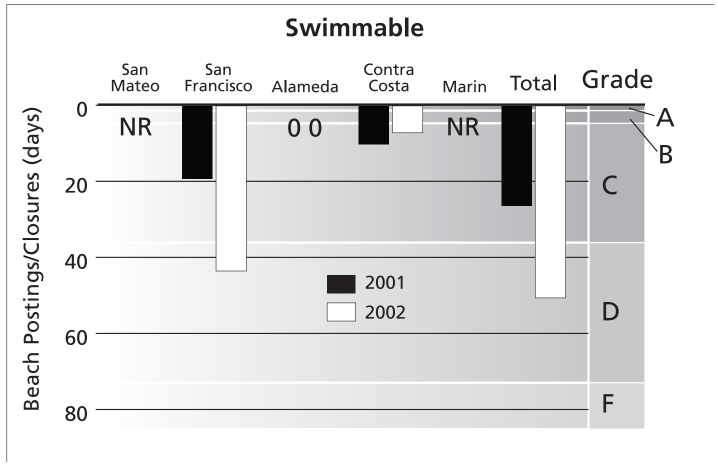
- Almost all Bay fish species are contaminated with PCBs, mercury, DDT, and/or chlordane pesticides. In 2000, 94% of all fish sampled had a tissue concentration for at least one of these contaminants that was higher than EPA screening levels for human consumption.
- PCB contamination is the most severe—in 2000, 89% of all fish had tissue PCB levels higher than the screening level.
- White croaker and shiner perch are most severely contaminated with PCBs, with 100% of sampled fish exceeding the screening level. Mercury contamination was most severe in leopard shark (98% exceeded screening levels), striped bass (55% exceeded screening levels), and white sturgeon (35% exceeded screening levels). Less than 5% of fish had excessive tissue concentrations of those pesticides which are monitored and for which screening levels exist.

Swimmable

Aquatic sports are very popular in the Bay Area. San Francisco Bay has numerous public swimming beaches and some of the finest near-shore windsurfing areas in the country. Swimmers, kayakers, board sailors, and boaters are all exposed to some degree to the constituents of Bay waters. Exposure to waters contaminated by sewage or urban runoff can cause a variety of human illness, including gastroenteritis, respiratory illness, ear, nose, and throat problems, and skin rashes. This indicator measures the number of days per year that public beaches on the Bay's shores were posted or closed because of water quality concerns.

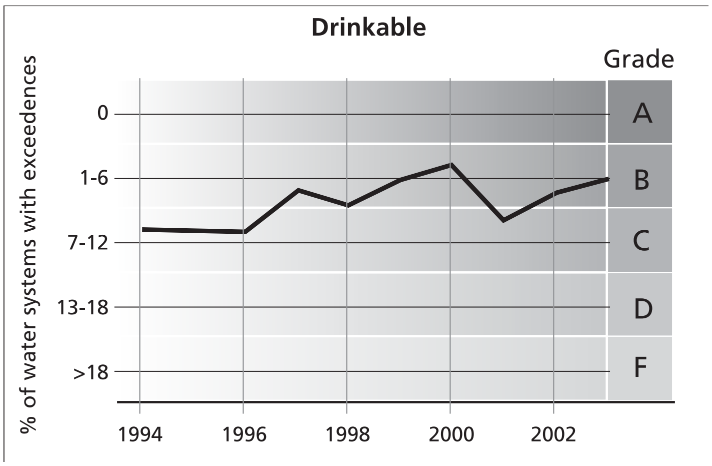
Key Findings

- In 2002, San Francisco Bay beaches were posted or closed for 50 days, nearly 14% of the year and more than double the number reported in 2001.
- Beach closures in San Francisco County were prompted by the release of poorly treated water from the combined stormwater and sewage collection system, which during heavy rainstorms exceeds the capacity of the wastewater treatment system. Beach closures at Keller Beach in Contra Costa County were the result of a malfunctioning sewage-lift station.
- Many Bay Area beaches and popular boating and windsurfing areas were not regularly monitored and/or closures were not reported in 2001 and 2002. Only three of the five counties with public Bay shore water access (San Francisco, Contra Costa, Alameda) regularly reported monitoring or closure data to the State Water Resources Control Board in 2001 and 2002.[2]



For grading, the A-B break point was set at 1 day and the D-F break point was set at 73 days, a level at which Bay beaches were closed for 20% of the year. NR = not reported; 0 = no reported postings or closures. Data source: State Water Resources Control Board.

Index Grade	Index Score	Long-term Trend	Short-term Trend
D+	**31**	↓	↔



For grading, the A-B break point was set at 0% of water systems reporting exceedences of maximum contaminant limits for the selected contaminants. The D-F break point was set at 18% of systems reporting exceedences. Data source: California Department of Health Services, Drinking Water Quality Monitoring database.

Drinkable

Bay Area residents receive their drinking water from a variety of sources, ranging from local runoff to water imported from distant parts of the Bay's watershed. The quality of that water reflects the health and management of the source watershed. Many agricultural, industrial and land management activities introduce sediments, pesticides, hydrocarbons, and toxic trace elements into the watershed. When, as a result, standards for human health are exceeded, water treatment costs can increase, service may be disrupted, or water supplies may be reduced. This indicator measures the percentage of drinking water suppliers that reported exceedences of drinking water quality standards (maximum contaminant limits, or MCLs) in their source water supplies for one of five classes of contaminants: nitrogen compounds, heavy metals, pesticides, hydrocarbons, and industrial chemicals.

Key findings

- In 2003, 10% of drinking water suppliers reported exceedences for nitrogen compounds, heavy metals, or industrial chemicals in their source water supplies. Maximum contaminant limits for hydrocarbons and monitored pesticides have not been exceeded for the past six years.
- Most water sources used by Bay Area drinking water suppliers do not exceed maximum contaminant limits for most contaminants. Since 1994, an average of 2% of water sources used by Bay Area providers were reported to have exceeded allowable limits for one or more of the five classes of contaminants.
- More than 85% of all exceedences reported from 1994 to 2003 were for groundwater sources, in each of the five contaminant categories. Problem contaminants in Bay Area surface water supplies were nitrogen compounds, hydrocarbons and pesticides.
- Based on the percentage of systems reporting exceedences, the quality of source waters used by Bay Area suppliers improved between 1994 and 2003. However, this improvement may reflect discontinued use of contaminated sources rather than clean up of the contaminated water sources.

Index Grade	Index Score	Long-term Trend	Short-term Trend
D+	31	↓	↔

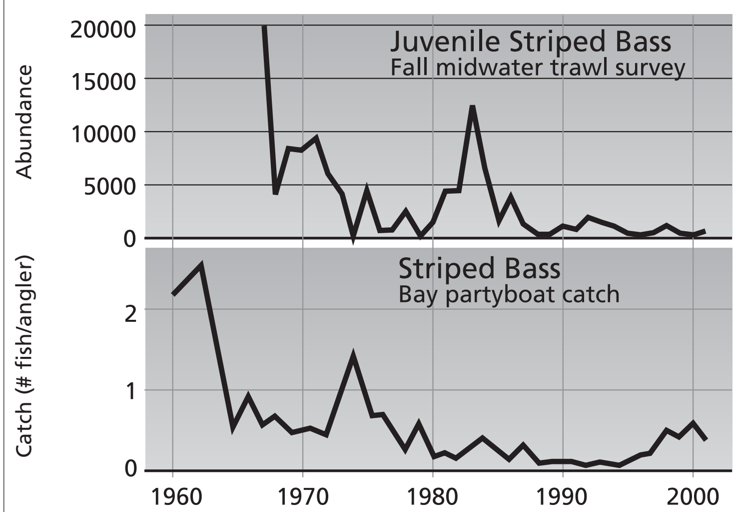
Human uses of the bay: endangered?

Some people may only see the Bay from the windshield of their automobiles during commute hour. For many local residents, however, the excitement of testing their skills against game fish, the ability to eat seafood they themselves have caught in the Bay, or the experience of water contact sports is one of the most fundamental privileges of living near the Bay. And regardless of their extracurricular interests, all Bay Area citizens depend on its watersheds to supply drinking water.

The federal Clean Water Act "provides for the protection and propagation of fish, shellfish and wildlife and provides for recreation in and on the water."[3] Sadly, this goal is not being fully achieved in the Bay. Commercial harvest of fish and shellfish was closed decades ago to over-harvest, and the Bay's last commercial fishery for Pacific herring is on the verge of being closed. Recreational and subsistence fishing success has declined, the Bay's once renowned striped bass sport fishery is a thing of the past, and most fish populations remain at low levels (see Fish Index). Those fish that are caught contain elevated levels of one or more contaminants. As well as making the fish unsafe to eat, the toxic effects of contaminants on fish—cell and tissue damage, reduced immunity to disease, and impaired reproductive success—contribute to depressed fishing catch rates. Subsistence anglers from economically marginal communities may be disproportionately exposed to contaminants in fish—fishing families with expectant or nursing mothers are especially at risk—and it is essential to continue and expand multilingual outreach programs so that the dangers associated with the consumption of Bay fish are widely known.

Despite allocating substantial management and financial resources in recent years to cleaning up the Bay's water quality, increasing freshwater inflow and restoring wetland habitat, people around the Bay still cannot catch and eat fish successfully and safely. There are two reasons for this. First, efforts to improve inflow and habitat conditions began only a decade ago, hardly enough time—and not as yet implemented at the large scale necessary—to improve water quality and reverse the severe degradation of the Bay's ecosystem (see Freshwater Inflow and Habitat Indexes).

Second, the huge sums spent on upgrading wastewater treatment and regulating industrial discharge starting in the 1970s were most successful in ridding the Bay of traditional pollutants such as sewage, but not nearly as successful in protecting the Bay from the less visible but much more persistent and more toxic substances such as industrial chemicals and trace elements. Even when discharged at permitted levels, these



Recreational fishing success for striped bass in the Bay fell as abundance of juvenile fish declined. Data sources: California Department of Fish and Game, Fall Midwater Trawl survey and Commercial Passenger Fishing Vessel database.

Index Grade	Index Score	Long-term Trend	Short-term Trend
D+	31	↓	↔

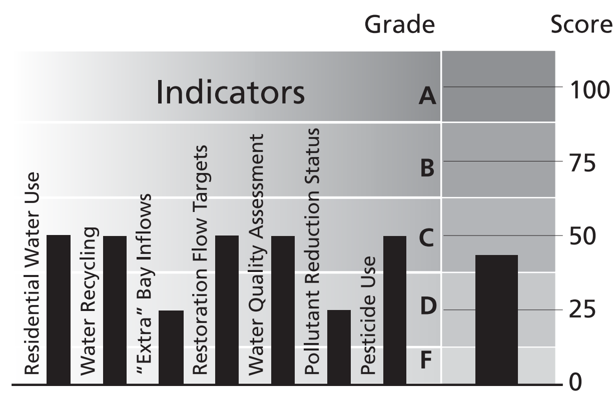
pollutants can bioaccumulate in aquatic organisms and ultimately cause lethal and sublethal effects in the Bay's fish and wildlife for years to come. To make matters worse, unregulated discharge of these toxics from agricultural and urban runoff, and remobilization from sediments where they were deposited in plumes from points of discharge and runoff, dwarfs permitted discharges. In order to effectively control toxic contamination of the Bay, limits on the total loading of pollutants into Bay waters need to be adopted and enforced—a process that is barely underway (see Stewardship Index). And the fact that Bay beaches are still being closed because of bacterial contamination suggests that even the substantial and beneficial investments in wastewater treatment have not been adequately distributed among all dischargers.

There has been more success in meeting the mandates of the Safe Drinking Water Act and other legal requirements to provide clean and safe—"drinkable"—drinking water supplies. Violations of drinking water standards by Bay Area water purveyors continue to decrease, and the trend is to adopt more stringent regulations that reduce the allowable concentrations of some drinking water constituents and to add new constituents to the list. However, if watershed managers do not pay sufficient attention to the health of the source watersheds and reduce the introduction of these constituents into runoff and groundwater, then the cost of treating supplies to maintain compliance and meet more stringent requirements may be expected to rise over time.

Grade	Score	Long-term Trend	Short-term Trend
C–	43	↓	↔

Stewardship

For over 150 years, humans have dumped sewage, toxics, sediments and other materials into the Bay, and extracted water resources from its watershed, at unsustainable rates. (We have also converted its wetlands and riparian areas into cities, ports, highways and pasture—see Habitat Index). Stewardship of the Bay means reforming our management to ensure that the Bay recovers: by diagnosing its problems fully and expeditiously; by extracting water resources from the watershed at sustainable levels, and using the amount diverted more efficiently; and by reducing or eliminating the major sources of Bay pollution.



The Stewardship Index aggregates the results of the residential water use, water recycling, "extra" Bay inflow, restoration flow target, water quality assessment, pollutant reduction status, and pesticide use indicators.

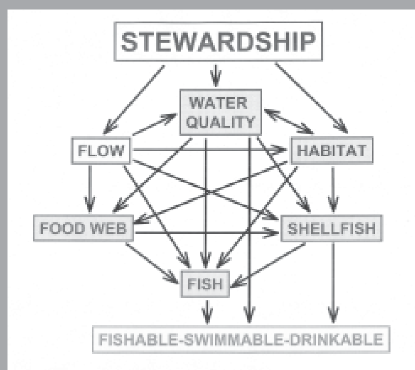
How much water do Bay Area residents use and reuse?
How much water beyond the minimum flows to the Bay?
How well do we monitor the quality of the Bay's watersheds, and respond to the problems that are identified?
How successful are we limiting the use of pesticides that can degrade Bay waters?

Indicator	2000-2003 Result	Grade	Grade point
Residential Water Use	95 gallons per person each day in 2000, 43% more than the conservation target	C	2
Water Recycling	Reuse in 2003 is 68% of regional target	C	2
"Extra" Bay Inflows	20% below flows needed to maintain low salinity habitat in 2002	D	1
Restoration Flow Targets	One of three flow targets met in 2002; export pumping also low in April-May	C	2
Water Quality Assessment	60% coverage of all water bodies in Bay region in 2003	C	2
Pollutant Reduction Status	None of 146 pollutant load limits implemented in 2003, and on average only 2 of 8 phases completed to adopt	D	1
Pesticide Use	Overall reported use of 4 pesticides types in 2001 declined to 53% of their maximum use	C	2
	Index Grade Point Average		**1.71 (C-)**
	Index Score		**43 (out of 100)**

The Bay Institute

Index Grade	Index Score	Long-term Trend	Short-term Trend
C–	43	↓	↔

San Francisco Bay Stewardship Index > *Overview*



Connecting the dots

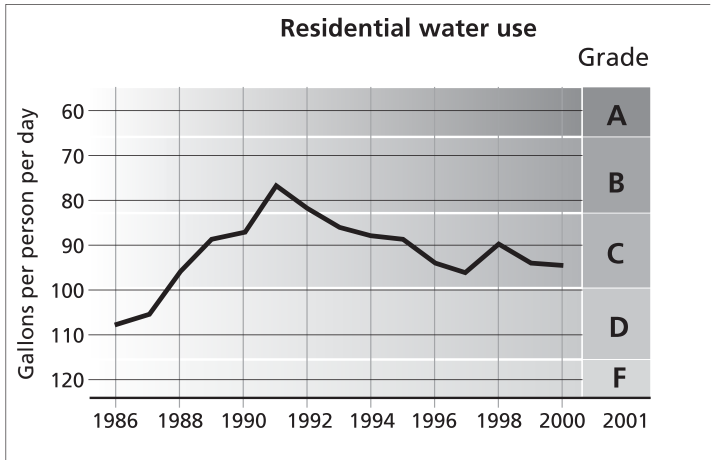
The health of ecosystems in the modern world is increasingly shaped by two overriding societal behaviors: extraction and inputs. San Francisco Bay is profoundly affected by extraction (the amount of water removed from the system, and the timing and placement of those diversions, plus the conversion of ecologically valuable habitat to other purposes) and inputs (the nature and degree of toxic and other substances, including alien species, introduced into Bay waters). Unsustainable levels of extraction create flow and habitat conditions that are not able to support healthy fish and wildlife populations. Harmful inputs degrade water quality and interfere with human uses of the Bay's resources. Stewardship of the Bay involves, among other things, reducing unsustainable levels of extraction by more efficient use and reuse of current water supplies, accompanied by measures that increase Bay inflow; limiting harmful inputs through aggressive efforts to reduce pollutant loads; improving our understanding of the effects of extractions and inputs through adequate monitoring and evaluation of water quality conditions; and reconverting selected lands around the Bay's margins to wetland and other habitats.

Residential water use

Urban use—residential, commercial, industrial, and institutional—is the dominant use of water in the Bay Area. Residential use is the factor most directly controlled by individuals and families, whose decisions to conserve water in and around the home can collectively create large-scale benefits.[1] More efficient use can reduce the financial and energy costs of wastewater treatment, transporting and storing water supplies, and developing new sources; replace ecologically harmful water diversions from streams; relieve competition for limited supplies; and reduce pollutant loads from irrigating lawns, gardens and crops. This indicator measures gallons per capita per day (gpcd)—calculated daily residential use—against the estimated target for efficient use.[2 3]

Key Findings

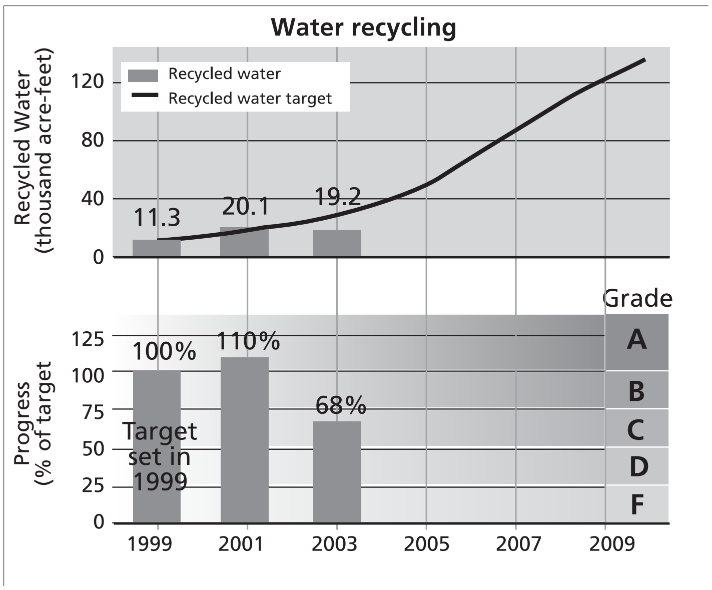
- In 2000, Bay Area residents used on average 95 gallons per person each day (gpcd), 43% more water than the conservation target of 66 gallons per day. Residential use was lowest near the Bay (62 gpcd) and highest in the hotter inland areas with more extensive irrigated landscapes (150 gpcd).
- Per capita residential use could be reduced 30% to achieve the conservation target if more efficient water-using appliances and other currently available technologies were installed throughout the Bay region. Substituting drought-tolerant landscaping for more water-intensive lawns and gardens could save even more.
- Per capita residential use decreased 12% between 1986 and 2000, although population increased 17%. The most significant reductions in water use (29%, or 31 gpcd) occurred during the 1987-92 drought, but use has increased 18 gpcd since then.



For grading, the A-B break point was set at a target use of 66 gallons per capita per day (gpcd), assuming full implementation of currently available water efficient devices for indoor use and a 20% reduction in current average outdoor use. The D-F break point was set at 116 gallons per day, the hypothetical average daily residential water use without any conservation. Data sources: BAssWAC, DWR PWSS, individual districts (measured use); EBMUD, Pacific Institute, www.h2ouse.org (targets).

Index Grade	Index Score	Long-term Trend	Short-term Trend
C–	43	↓	↔

San Francisco Bay Stewardship Index > *Indicators*



For grading, the A-B break point was set at 100% of the water recycling target. Data sources: State Water Resources Control Board Recycled Water Surveys updated and refined with individual agency data for 2003; Bay Area Regional Water Recycling Program (targets).

Water recycling

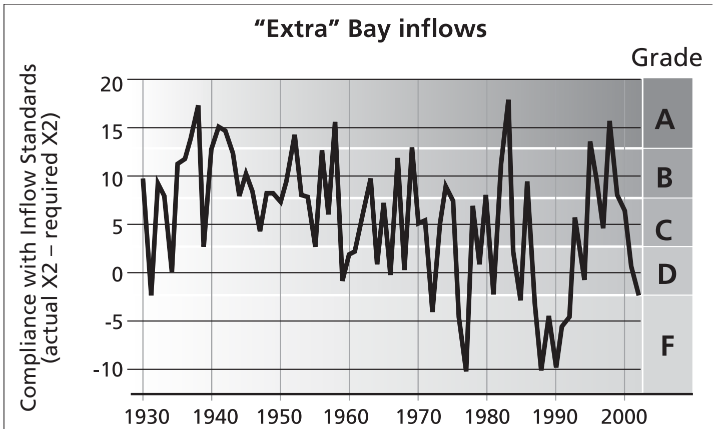
Water recycling, also known as reclamation or reuse, is a reliable and economically feasible way to replace water supplies extracted from streams and groundwater basins, limit the need for new water diversions, and reduce wastewater discharge to sensitive water bodies. Treated wastewater is mainly used to irrigate landscapes, golf courses, and crops; to replenish groundwater basins; to provide industrial cooling and process water; and to augment freshwater flow to wetlands and streams. This indicator measures actual water reuse by the five counties (Alameda, Contra Costa, San Francisco, San Mateo, and Santa Clara) covered by the Bay Area Regional Water Recycling Program (BARWRP), and compares that to the BARWRP recycling targets for the 2000 - 2010 period.[4 5]

Key Findings

- In 2003, the five counties recycled only 68% of the estimated target for reusing water supplies. Most of the gains in reuse were accomplished in previous years (1999-2001).[6]
- Current reuse represents only 3% of the discharge from treatment plants, and targets for recycled water use in 2010 represent only 20% of the potential supply available and 35% of the potential demand for reuse.
- Of the total amount recycled, 45% (8,603 acre-feet) went to irrigation, 17% (3,308 acre-feet) to industrial use, and 38% (7,317 acre-feet) to wetlands supply.

"Extra" Bay inflows

For many years, minimum Bay freshwater inflows were mostly determined by the amount of water needed to maintain upstream water quality at the Delta intakes of agricultural diverters and the giant state and federal water project pumps, which export supplies to San Joaquin Valley irrigators and coastal cities in the Bay Area and Southern California. New water quality standards that increased minimum Bay inflows for fish and wildlife were adopted in 1995 after the near collapse of the Bay-Delta ecosystem, but on average the new requirements are still only 35% of unimpaired (natural) flows.[7] In most years, Bay inflows exceed those minimums because the existing water supply system has finite capacity to store and/or divert freshwater flow before it reaches the Bay. The "extra" inflow provides important ecological benefits widely recognized at the time minimum requirements were adopted. It could be reduced significantly, however, if the capacity of water supply projects to capture and store water is expanded. This indicator measures the amount of actual spring inflow to the Bay since 1930, compared to the current minimum amount required by law.

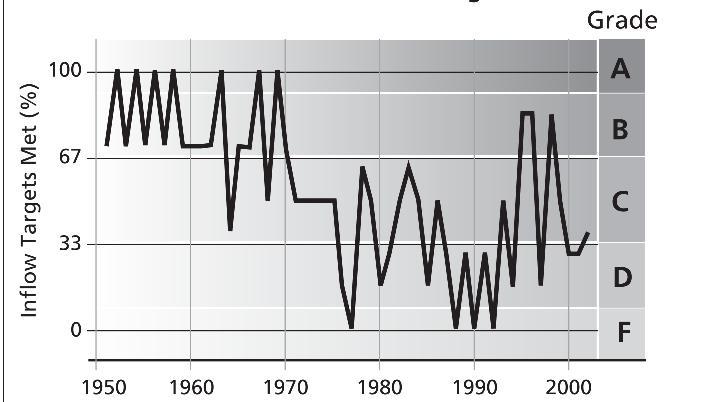


For grading, the D-F break point was set at minimal compliance with the spring X2 standard, the level at which inflows just met the required minimum. The grade increment was set at 5 km. Data sources: California Department of Water Resources, Dayflow model and California Central Valley unimpaired flow data.

Key Findings

- In 2002, springtime Bay inflows were nearly 20% lower than needed to maintain low salinity habitat, or X2 (the most important new water quality standard—see Freshwater Inflow Index), at the desired position. X2 was more than 2 km farther upstream than called for, although the standard was not technically violated.[8] The year before, spring inflows exceeded minimum flow requirements by only 16%—in 2001, 590,000 acre-feet of "extra" water flowed into the Bay, compared to the 5,086,000 acre-feet that was exported from the Delta.
- From 1960 to 1975, spring inflows were, on average, twice as high as required by the current standards.
- Pending proposals to increase Delta export pumping and construct additional Central Valley reservoirs could cumulatively decrease these "extra" inflows to the bare minimum in the intermediate years between dry and wet conditions.

Index Grade	Index Score	Long-term Trend	Short-term Trend
C–	43	↓	↔



A grade of A was assigned when each of the three Bay inflow targets and accompanying export reductions was met. An F grade was assigned when none of the inflow or export targets was met. Data source: California Department of Water Resources, Dayflow model.

Restoration flow targets

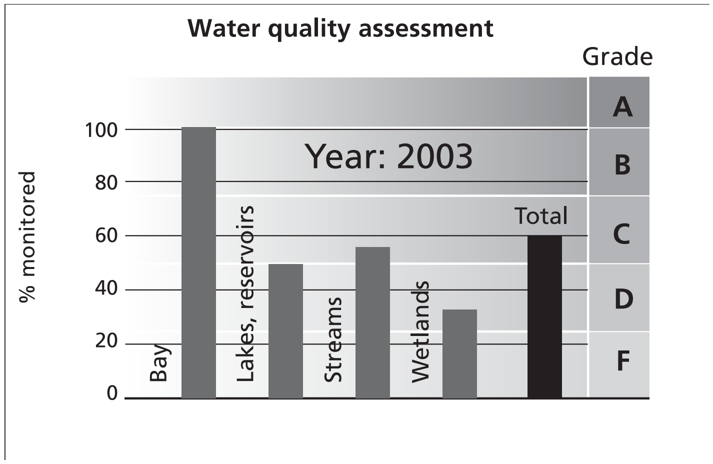
Numerous federal and state resource management initiatives, including the newly established California Bay-Delta Authority's Ecosystem Restoration Program (ERP), recognize the ecological importance of increasing the overall amount of springtime Bay inflow and more closely reproducing natural runoff patterns (see Freshwater Inflow Index). Three Bay inflow targets are included in the ERP Plan: enhancing inflows during the spring, once in March and again during late April and early May, and allowing the first winter pulse flow to pass through the Delta to the Bay.[9] To ensure that these flows actually reach the Bay, and to reduce impacts on fish moving through the estuary, these targets also require that export pumping in the Delta be reduced to low levels at the same time. This indicator measures the degree to which current Bay inflow restoration targets and export reduction targets have been met (or, prior to their establishment, would have been met) each year since 1950.

Key Findings

- In 2002, only one of the three flow targets, the winter pulse flow, was met. Neither the March nor April-May outflow objectives were achieved, although exports were held to low rates during the April-May period.
- Until the early 1970s, because of limited Delta pumping, most or all of these Bay inflow restoration targets were met. Since 1976, none of the inflow targets were fully met (e.g., flows met and exports reduced) in 58% of the years.
- During the recent six-year wet period (1995-2000), two out of three flow targets were fully met and a third partially met (e.g., flows met but exports not reduced) in only three of the six years.

Water quality assessment

Over the last quarter century, efforts to make the Bay cleaner have succeeded in improving wastewater treatment and effluent water quality, but have not been nearly as successful in addressing "non-point" discharges such as urban runoff, nor in preventing the harmful effects of persistent toxics that bioaccumulate in the environment. As a result, there is a shift away from relying solely on effluent-based standards (requiring that contaminants in a discharge are at or below allowable concentrations) towards also utilizing ambient standards (requiring that the physical, chemical and biological condition of receiving water bodies adequately protect the designated "beneficial uses" of Bay waters, such as aquatic life, water supply, fish consumption and recreation). Ambient water quality monitoring is the measurement of the appropriate biological, chemical, and physical characteristics of a water body so that its overall condition (status) and changes in its conditions over time (trends) can be assessed. Ambient monitoring is necessary to assess whether water bodies should be listed as impaired, triggering the development of more stringent pollutant source controls (see Pollutant Reduction Status Indicator).[10] This indicator measures the spatial coverage of the Bay, its rivers and creeks, its lakes and reservoirs, and its tidal wetlands, by ambient water quality monitoring programs, and compares that coverage to the total area for each.[11 12]



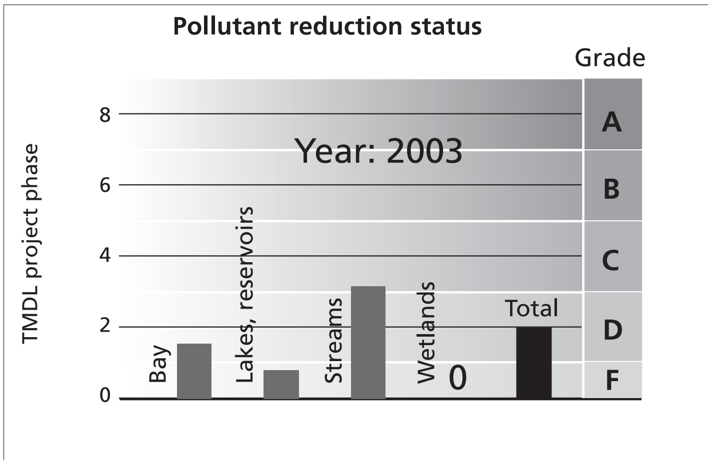
For grading, the A-B break point was set at 100%, indicating that all waters in the Bay Area are monitored for ambient water quality. Data sources: San Francisco Regional Water Quality Control Board (total water body areas); Regional Monitoring Program (Bay); WEMAP, SFEI (tidal wetlands); Regional Board, County Clean Water and Pollution Prevention Programs, watershed groups, water districts with local watersheds (streams); Regional Board and individual water districts (lakes and reservoirs).

Key Findings

- Since 1993, the Bay itself has been fully monitored by the Regional Monitoring Program for Trace Substances.
- More than 40% of the Bay's watershed areas are not monitored for ambient water quality. Of those watersheds that are, the quality and coverage of the monitoring are variable and subject to uncertain future funding.
- Bay wetlands are monitored in the intertidal zone at 30 locations in a recently initiated regional monitoring program, although ambitious plans for a far more comprehensive monitoring program are being pursued.[13]
- Bay reservoir and lake ambient monitoring is principally done by water supply agencies with drinking water supply reservoirs. The Regional Water Quality Control Board is also monitoring a few selected reservoirs for fish contaminants.[14]

Index Grade	Index Score	Long-term Trend	Short-term Trend
C–	43	↓	↔

San Francisco Bay Stewardship Index > *Indicators*



For grading, the A-B break point was set at completion of Phase 7 (regulatory approval) and initiation of Phase 8 (implementation). Data sources: San Francisco Regional Water Quality Control Board, 2002 CWA Section 303(d) list of Water Quality Limited Segments.

Pollutant reduction status

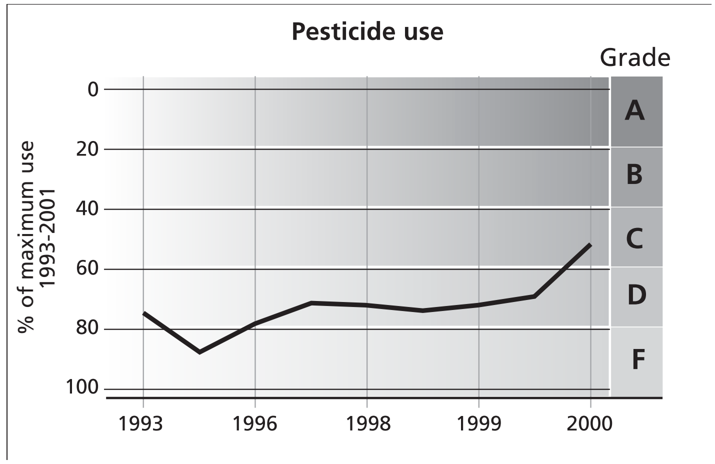
Water bodies in the Bay region—including streams, lakes, reservoirs, and the Bay itself—must meet water quality objectives in order to protect designated "beneficial uses," such as aquatic life, water supply, recreation and fish consumption. Under the Clean Water Act, the state of California is required to list which water bodies are not meeting objectives and are therefore impaired.[15] Total Maximum Daily Loads (TMDLs), which specify the maximum pollutant load that a water body can receive while still meeting water quality objectives, must be developed for the specific pollutants and water bodies that are impaired. Not all water bodies are assessed, and the assessment of those that are is uneven in coverage and quality (see Water Quality Assessment Indicator). This indicator measures progress in completing an eight-step process for developing TMDLs (from Phase 1, project definition, to Phase 8, implementation), for 146 proposed TMDLs identified in 1998 and 2002 for fifty-one water bodies (there can be more than one impaired use or TMDL for a water body).[16] [17] [18]

Key Findings

- No TMDLs have been implemented yet, even though some water bodies have been listed as impaired for seven or more years.
- On average, only two of the eight phases to implement TMDLs for impaired water bodies have been completed.
- On average, four out of the eight steps to implement the 49 high priority TMDLs have been achieved. Very little progress has been achieved on low priority TMDLs, many of which have yet to be defined as a project.
- Better progress has been made in implementing TMDLs for streams than for the Bay. TMDLs for 13 different pollutants must be developed for the Bay (many of them low priority TMDLs), while streams require TMDLs for only 5 different pollutants.

Pesticide use

More water bodies in the Bay region are classified as impaired as a result of pesticide contamination than from any other class of pollutant.[19] Unlike most areas in the Bay's heavily agricultural upper watershed, the most common use of pesticides around the Bay is in homes and gardens, schools, workplaces and other urban applications such as pest control. Residential users tend to over apply and misuse pesticides, and the impervious surfaces of the urban environment facilitate rapid transfer to Bay waters. Elevated levels of diazinon and chlorpyrifos, two commonly used insecticides, have been linked to aquatic toxicity in wastewater treatment plant effluent, storm water runoff, urban creeks and the Bay itself. This indicator measures the use of a selected group of insecticides and herbicides that may cause acute and/or chronic toxicity in Bay region waters and sediments, or that are widely used in the nine Bay Area counties.[20 21 22]



For grading, the D-F break point was set at 100% of maximum use amounts for four pesticides during the 1993-2001 period. The A-B break point was set at 20%. Data source: California Pesticide Use Reporting database, compiled by Pesticide Action Network.

Key findings

- Overall use of four selected pesticide types—diazinon, chlorpyrifos, pyrethroids and glyphosate—declined to 53% of their maximum use in 2001.
- The decline is part of a longer-term trend for diazinon and chlorpyrifos, which are 52% and 86%, respectively, lower in 2001 than their use in 1994. These two organophosphate insecticides, commonly used by homeowners and found in toxic quantities in urban runoff, have been banned for both agricultural and non-agricultural use.
- In 2001, use of pyrethroids, a group of insecticides now used in place of banned organophosphate compounds, declined 36% from year 2000; it is not known yet if this was a one-time drop or a reversal of the trend of substantially increased use since 1993. Although pyrethroids are highly toxic to aquatic organisms and bioaccumulate in their tissues, protective biological guidelines for pyrethroids have not yet been adopted, and their levels in water and sediment are not monitored.
- Use of glyphosate, commonly known as Round-up, remained high during the last decade; in 2001, more than 250,000 pounds were used. This chemical is sometimes sprayed directly on vegetation bordering watercourses, but little is known about its long-term potential chronic toxicity.
- Urban use of pesticides creates extensive water quality impairment—yet non-commercial use (such as by homeowners) is neither tracked nor accounted for.

Index Grade	Index Score	Long-term Trend	Short-term Trend
C–	43	↓	↔

San Francisco Bay Stewardship Index > *The Big Picture*

Stewardship = limiting extractions and inputs

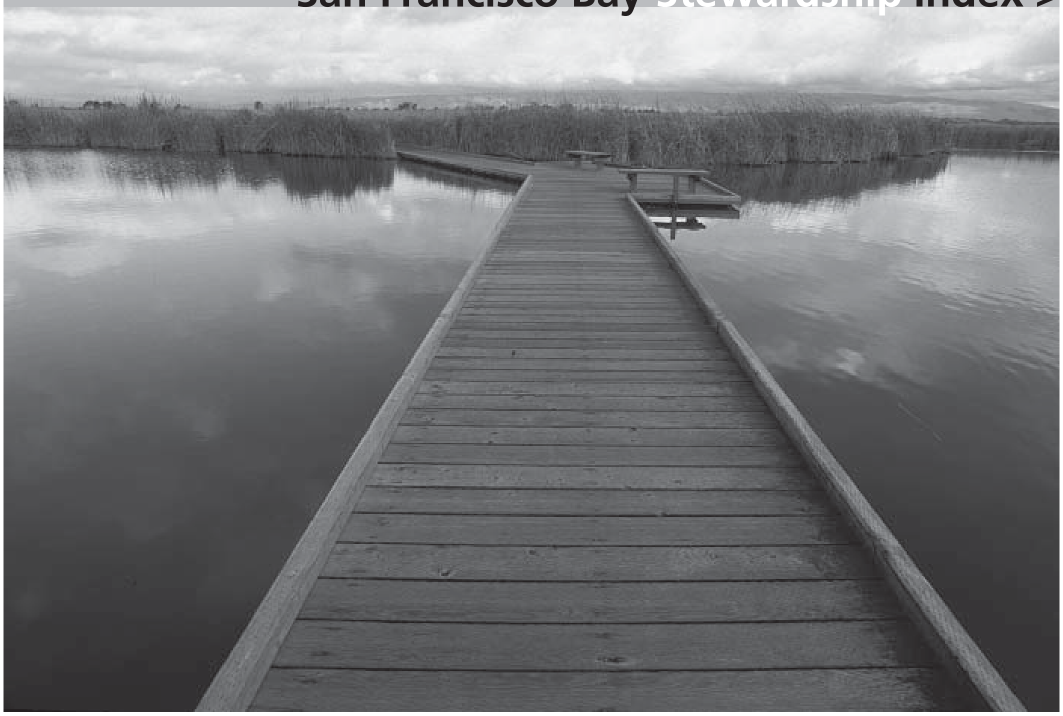
Being good stewards of the environment is an important value to residents of the Bay Area, who have a history of electing officials with strong environmental records, supporting progressive environmental legislation and regulatory actions, and pitching in when called upon to conserve water or participate in habitat clean-up activities. Until recently, government agencies, businesses and other local interests have lagged behind the public in aggressively promoting good stewardship of the Bay.

Regional water use decreased during the 1976-77 and 1987-92 droughts, but the full potential of conservation and recycling has not been pursued in the years since. The Bay Area's conservation and recycling efforts are the smallest of any of the state's major metropolitan regions. The greatest short-term potential for water savings is by retrofitting toilets and washing machines and from immediate and full implementation of widely adopted urban water conservation best management practices (BMPs) by water districts. BMPs for outdoor water conservation need to be adopted and implemented as well, especially in the new developments of the hotter, drier inland areas. One of the biggest local impediments to recycling is the need for infrastructure improvements to convey treated wastewater to areas of highest demand. Recent efforts by a consortium of Bay Area water districts to develop a system for large-scale regional recycling are encouraging, and some water districts are proceeding with projects in their own service areas.

While conservation and recycling can replace existing supply or limit new diversions, there is a need to deliberately leave some of the region's current consumptively used supplies in the environment. Bay inflows often exceed the bare minimum required by law, but are not nearly sufficient to meet restoration targets in many years. Regulatory requirements such as federal water reform law and state salmon doubling objectives that would reallocate water for restoration purposes such as Bay inflow need to be more rigorously enforced. Of equal importance, increases in the ability of existing or new water projects in the Delta and Central Valley to capture "surplus" flows should not be permitted unless and until a net increase in Bay inflows to achieve restoration targets is assured.

Millions of pounds of pesticides and other toxic chemicals are used in the Bay region each year. Runoff into surface water can create conditions of both acute and chronic toxicity for aquatic organisms, and represents the largest "non-point source" of water pollution in the United States today. More aggressive regulatory and non-regulatory efforts are necessary to reduce pollutant loading to the Bay. Ambient water

Index Grade	Index Score	Long-term Trend	Short-term Trend
C–	43	↓	↔



David Sanger

quality assessments need to be conducted for many Bay region creeks, wetlands and lakes that are not currently monitored. The process for adopting and implementing pollutant load limits for dozens of impaired water bodies needs to be completed expeditiously. New pesticides should be more rigorously tested for chronic toxicity to aquatic and other organisms before being approved, and current pesticides that do not have adequate toxicity data should be properly tested. Non-commercial pesticide sales should be reported to California's Department of Pesticide Regulation; otherwise overall use will continue to be significantly under-estimated. Tracking the amount and location of pesticide application is important for evaluating the source and control of pesticides in water and sediments. A multi-lingual campaign targeting residents and landscaping businesses regarding non-toxic or less toxic alternatives to pesticide use, and changes to lawn and garden crop selection and management that help reduce or eliminate the need for pesticide applications, would also be effective.

> *"Now comes the harder act: finding a way to inhabit this place – or any place – in a manner that does not progressively destroy, but respects and accomodates and restores . . ."*
>
> John Hart from *San Francisco Bay: portrait of an estuary*, with photographer, David Sanger.

5 Things to Do

The five most important things you can do to improve the Bay's grades

1. Be a smart water user. On average, Californians use a third more water than necessary due to leaks, inefficient appliances and overwatering. Learn how to monitor your water use so you can find and repair leaks. Replace out of date washing machines and toilets – the biggest water users in your home – with more water efficient versions. Avoid overwatering your lawn and garden, and switch to less water-intensive landscaping that is more appropriate for California's climate. For more information, visit the California Urban Water Conservation Council website (www.h2ouse.org) and contact your local water district.

2. Don't pollute the Bay. Thousands of tons of pollutants reach the Bay each year from urban and agricultural runoff, wastewater and marine ballast discharges, air pollution, and other sources. You can help cut down on Bay pollution. Use safer substitutes for household cleaners, lawn and garden chemicals, and other toxic materials. Learn about less chemically intensive ways to control weeds and pests. Properly dispose of toxic materials such as automobile oil and antifreeze, or house and garden chemicals; never dump them in storm drains or household garbage. To learn more about greener approaches to cleaning and gardening, visit the Pesticide Action Network's "Pesticide Advisor" (www.panna.org/resources/advisor.html). The U.S. Environmental Protection Agency's "Envirosense" fact sheet on safe substitutes for toxics (http://es.epa.gov/techinfo/facts/safe-fs.html) is also useful.

3. Restore your local habitat. Every city and county in the Bay region has an existing wetland, stream channel or shoreline that is under threat of development. Fortunately, most also have local projects and "creek clubs" to restore these habitats. You can join – or form – a community group and help make Bay cleanup and restoration a reality in your neighborhood. Find out more about your local opportunities by viewing the Aquatic Outreach Institute's list of community contacts at www.aoinstitute.org/creekcontacts.html. Another good place to look is the San Francisco Bay Joint Venture site (www.sfbayjv.org). The groundbreaking new book San Francisco Bay by John Hart and David Sanger also includes a comprehensive list of Bay-related organizations and can be ordered from The Bay Institute at www.bay.org/bay_book.htm .

4. Keep rivers flowing to the Bay. On average, about a third – and in dry years, double that amount – of the freshwater flow from the rivers that feed the Bay is diverted to farms and cities, degrading water quality and devastating fish and wildlife throughout the watershed. You can help reverse this trend by supporting The Bay Institute and other organizations that are working to reduce the amount of water diverted from the Bay's watershed and to change how water supplies are managed throughout the state. More information on TBI's Rivers and Delta Program activities is available at www.bay.org/rivers_and_delta.htm .

5. Vote for the environment. Pay attention to how your local, state and federal elected officials deal with environmental issues, and let them know what you think. Support legislation and ballot measures to improve water quality, restore wetlands and endangered species, and increase freshwater inflows to San Francisco Bay. For more information on politicians' voting records, visit the California League of Conservation Voters website at www.ecovote.org.

The Bay Institute

Endnotes

Index 1. Habitat

1 Information for 1998 tidal wetlands, mudflat, and diked wetland habitat extent calculations from: San Francisco Estuary Institute EcoAtlas Version 1.50 and Appendix Table 1 page A-7 in the Baylands Ecosystem Habitat Goals, A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goal Project. †First Reprint. †U.S. Environmental Protection Agency, San Francisco, CA/S.F. Bay Regional Water Quality Control Board, Oakland, CA.

2 Calculations of additional habitat added for each tidal marsh and non-tidal diked wetlands made by TBI staff from numerous database sources and personal communication. See Technical Appendix for details.

3 Simenstad, C.A. and R.M. Thom. 1995. Spartina alterniflora (smooth cordgrass) as an invasive halophyte in Pacific Northwest estuaries. Hortus Northwest 6(1):9-40.

4 Steele J.T. and N. Schaeffer 2001.Restoring the Estuary: Implementation Strategy of the San Francisco Bay Joint Venture. San Francisco Bay Joint Venture, Oakland, California. 124 pp.

5 Bay margin calculations from Goals Project (1999) and watershed calculations a rough estimate from Steele and Schaefer (2001).

6 Collins, Joshua, SF Estuary Institute. Personal communication.

Index 2. Freshwater Inflow

1 Current "actual" daily and annual runoff into the Bay is calculated by the Department of Water Resources (DWR) DAYFLOW model. Unimpaired runoff represents the flow that would occur absent any diversions or reservoir regulation, and is directly derived from the measured flows. DWR calculates monthly unimpaired Delta outflow (Bay inflow) and monthly and daily unimpaired inflow to the Central Valley from 10 major rivers in the Sacramento and San Joaquin Basins (the Sacramento, Feather, Yuba, American, Mokelumne, Cosumnes, Stanislaus, Toulumne, Merced, San Joaquin Rivers). The unimpaired runoff does not represent full natural runoff, because it does not account for changes in natural watershed runoff characteristics that have occurred in the past 150 years due to land use alterations, vegetation conversion and channelization. The cumulative effect of those changes in the Central Valley means that the DWR unimpaired Bay inflow is probably about 3 million acre-feet too high on average and that the average annual runoff from the 10 rivers was closer to what the Bay inflow was under natural conditions. A simple adjustment was made in the calculated annual unimpaired runoff to account for those changes. The cumulative effects of those alterations on the upland watersheds are relatively minor, and the unimpaired 10-river flow is a satisfactory representation of runoff into the Central Valley. The daily runoff shown in the graphs use DAYFLOW Delta outflow for the "actual", and the unadjusted 10-river daily unimpaired runoff for "unimpaired". The 10 river runoff would have likely have been attenuated by the time it reached the Bay, which would reduce short spikes in winter and increase the duration of high flows in winter and spring. There is no calculated daily unimpaired Bay inflow and the graphs are for illustrative purposes only, to show the general impact of reservoirs and exports on Bay inflow.

2 The five water year types were established based on frequency of occurrence of unimpaired runoff for the period 1921-1994, with each year type occurring in approximately 20% of years. Therefore, the driest 20% of years were designated as critical, the next driest 20% of years as dry, and so forth. The "below normal" year type is the median or middle 20% of years. Terminology for the five year types follows that used by state and federal water management agencies although, for water management purposes in the Sacramento and San Joaquin basins, water year types are determined using other factors, such as the previous year's precipitation, as well as the frequency of occurrence. The DWR year type indexes were not used because they are different for the two basins and this indicator required one index for the entire Central Valley watershed.

3 Bay inflows and X2 are highly correlated. Therefore, for some indicators Bay inflows were measured as X2 rather than in units of flow. For more information on X2, see Jassby, A.D., W. J. Kimmerer, S. G. Monismith, C. Armor, J. E. Cloern, T. M. Powell, J. R. Schubel and T. J. Vendlinski. 1995. Isohaline Position as a Habitat Indicator for Estuarine Populations. Ecological Applications 5:272-289.

4 Peak flow was defined as the 5-day running average of Bay inflow >50,000 cubic feet per second. Selection of this threshold value was based on two rationales: 1) flows of this magnitude shift X2 location downstream to 50-60 km (depending on antecedent conditions), providing favorable conditions for many Bay invertebrate and fish species (see

Spring Inflow Indicator); and 2) examination of DAYFLOW data suggested that flows above this threshold corresponded to winter rainfall events, as well as some periods during the more prolonged spring snowmelt.

5 Sacramento Basin winter-run chinook salmon was first listed as threatened in 1989, and subsequently listed as endangered in 1994. Delta smelt, a species found only in the San Francisco Bay-Delta estuary, was listed as threatened in 1993.

Index 3. Water Quality

1 The Water Quality Index's description of water quality conditions for all the indicators relies on the findings contained in the San Francisco Estuary Institute (SFEI). 2003. The Pulse of the Estuary: Monitoring and Managing Contamination in the San Francisco Estuary. SFEI Contribution 74. San Francisco Estuary Institute, Oakland CA.

2 Water quality data for all the indicators in this Index were evaluated using methods developed by the Canadian Council of Ministers for the Environment. Each indicator incorporated three different measurements: scope, the number of contaminants that exceeded water quality standards; frequency, the proportion of samples for each contaminant that exceeded water quality standards; and severity, the amount by which the samples exceeded water quality standards. CCME. 2001. Canadian water quality guidelines for the protection of aquatic life. CCME Water Quality Index 1.0 User's Manual. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers for the Environment, Winnipeg.

3 See U.S. Geological Survey, Ecology and Contaminants Project, at wwwrcamnl.wr.usgs.gov/tracel/

4 For more information, see: San Francisco Estuary Institute (SFEI). 2003. The Pulse of the Estuary: Monitoring and Managing Contamination in the San Francisco Estuary. SFEI Contribution 74. San Francisco Estuary Institute, Oakland CA.

5 Beneficial use evaluation of the 2002 CWA Section 303d list provided by Nancy Richard, State Water Resources Control Board.

Index 4. Food Web

1 Jassby, A. D., J. E. Cloern, and A. B. Muller-Solger. 2003. Phytoplankton fuels Delta food web. California Agriculture 57(4):104-110.

2 Kimmerer, W.J. 2002. Effects of freshwater flow on abundance of estuarine organisms: physical effects or trophic linkages? Marine Ecology Progress Series 243:39-55.

3 Cloern, J. E. 1996. Phytoplankton bloom dynamics in coastal ecosystems —a review with some general lessons from sustained investigation of San Francisco Bay (California, USA). Rev. Geophys. 43:127-168.

4 The list of native versus non-native species that was used for these calculations was provided by Lee Mecum, Department of Fish and Game.

5 Weight estimates for different copepod species were supplied by James Orsi, California Department of Fish and Game (retired). See Technical Appendix.

Index 5. Shellfish

1 Data for 1980-2001 crab and shrimp trends from Kathryn Hieb, California Department of Fish and Game. Also findings in: Hieb, Kathryn, Thomas Greiner, and Steven Slater. 2002. Status and Trends Report. California Department of Fish and Game.

2 Data for crab landings supplied by Kathryn Hieb, California Department of Fish and Game.

3 Wild, Paul W., and Robert N. Tasto. 1983. Department Of Fish And Game Fish Bulletin 172: Life History, Environment, and Mariculture Studies of the Dungeness Crab, Cancer Magister, With Emphasis on The Central California Fishery Resource.

4 Baxter, R., et. al. 1999. Report on the 1980-1995 Fish, Shrimp, and Crab Sampling in the San Francisco Estuary, California. Technical Report 63. The Interagency Ecological Program for the Sacramento – San Joaquin Estuary.

5 Kathryn Hieb, personal communication. Also, literature search.

6 Data for shrimp landings supplied by Kathryn Hieb, California Department of Fish and Game. Also, Becky Ota, personal communication, California Department of Fish and Game.

7 Cohen, A. N. and J. T. Carlton. 1998. Accelerating invasion rate in a highly invaded estuary. Science 279:555-558.

8 Subtidal alien crabs are virtually absent in the Bay portion of the estuary. Upstream areas experienced large increases in introduced mitten crabs during the 1990s. Bay study population data indicates that mitten crabs are usually present in the Delta region but are currently much reduced in number.

9 See Baxter et. al., op. cit., and Hieb, Greiner, and Slater, op cit.

10 Aquatic Habitat Institute/ Philip Williams & Associates. 1992. Status and trends report on dredging and waterway modification. San Francisco Estuary Project. This and other

reports can be accessed at http://www.abag.ca.gov/bayarea/sfep/reports/soe/soe8a.htm.

11 Herbold, Bruce; Alan D. Jassby; and Peter B. Moyle. 1992. Status and trends report on aquatic resources. San Francisco Estuary Project.

12 See Baxter et. al., op. cit., and Hieb, Greiner, and Slater, op cit.

Index 6. Fish

1 May, J. T. and L. R. Brown. 2002. Fish communities of the Sacramento River Basin: implications for conservation of native fishes in the Central Valley, California. Env. Biol. Fish. 63:373-388.

2 Wang, L. and J. Lyons. 2003. Fish and benthic macroinvertebrate assemblages as indicators of stream degradation in urbanizing watersheds. In Biological Response Signatures. Indicator Patterns Using Aquatic Communities, (T. P. Simon, ed.), pp. 227-249. CRC Press: New York.

3 For the Abundance Indicator, catch data for northern anchovy, a marine fish that is periodically present in the Bay in numbers that are orders of magnitude greater than those for all other species combined, were not included because they obscured the responses of all other species.

4 Bay-dependent species are: arrow goby, barred surfperch, bat ray, Bay goby, Bay pipefish, Black perch, bonehead, brown rockfish, brown smoothhound, California halibut, California tonguefish, cheekspot goby, delta smelt, diamond turbot, dwarf surfperch, English sole, jack smelt, leopard shark, longfin smelt, northern anchovy, Pacific herring, Pacific sanddab, Pacific staghorn sculpin, Pacific tomcod, pile perch, plainfin midshipman, sand sole, speckled sanddab, starry flounder, shiner perch, splittail, spiny dogfish, surfsmelt, threespine stickleback, topsmelt, tule perch, walleye surfpaerch, white croaker. Migratory fishes, such as chinook salmon, and marine and freshwater species that use the Bay only occasionally were not included in the Bay-dependent species category.

5 Karr, J. R., J. D. Allan, and A. C. Benke (2000) River conservation in the United States and Canada: science, policy and practice. In River Conservation: Science, Policy and Practice. (P. J. Boon, B. R. Davies, and G. E. Petts, eds), pp. 502-528. J. Wiley & Sons: New York.

6 Skinner, J. E. (1962) A historical view of fish and wildlife resources of the San Francisco Bay area. CDFG Water Projects Branch Report 1. 225 pp.

7 Five fish species that use the Bay, winter-run chinook salmon, spring-run chinook salmon, Central Valley steelhead, delta smelt and Sacramento splittail, have been listed under the federal Endangered Species Act.

8 Major tidal marsh and riverine habitat restoration projects have been funded by the Central Valley Project Improvement Act Restoration Fund and the CALFED Bay Delta Program/ California Bay-Delta Authority.

Index 7. Fishable, Swimmable, Drinkable

1 Information on San Francisco Bay fish consumption advisories is available from California Office of Environmental Health Hazard Assessment (www.oehha.ca.gov/fish/general/sfbaydelta.html).

2 San Mateo County monitors and posts Bay-side beach closures or warnings on www.earth911.org. It does not report the violations to the State Water Board. Marin County began regularly monitoring beaches in 2003 and also reports on the www.earth911.org web site. We recommend that the State Water Board better define their reporting requirements for beach monitoring and closure data and require that all Bay-side monitoring and closure data be reported to them.

3 The federal Clean Water Act, Title I, Sec. 101(a)(2).

Index 8. Stewardship

1 Total urban use would measure, along with the residential use, different commercial, industrial, and institutional (CII) mixes within and among regions and thus make comparisons of what we as individuals use less accurate.

2 Per capita residential use is calculated by dividing the total residential use (water districts usually track single family and multi- family accounts separately) by the population using that water (assumed to be the total population reported by the district). Residential water use and population data were compiled for Contra Costa Water District (CCWD), East Bay Municipal Utilities District (EBMUD), Alameda County Water District (ACWD), San Francisco Public Utilities District (SFPUC), Zone 7 Water Agency (Zone 7), Santa Clara Valley Water District (SCVWD), Bay Area Water Users Association (BAWUA), and Marin Municipal Water District (MMWD) which together serve about 95% of the Bay region population. Data for MMWD, CCWD, EBMUD was obtained directly from the districts; data for CCWD, EBMUD, SFPUC, Zone 7, ACWD, SCVWD, BAWUA was obtained from: Bay Area Water Agencies Coalition (BAWAC), 2003 Advancements in Water Conservation Appendices, prepared by RMC; data for EBMUD was also obtained from the Department of Water Resources Public Water System Survey (DWR PWSS) database. The collection and reporting of urban water use data can be substantially improved to increase the reliability and quality of data needed for managing urban water resources more efficiently. TBI developed a series of recommendations for improving the collection of urban water use data and is working with state agencies, NGOs and local agencies to implement those recommendations.

3 The combined indoor and outdoor use target is 66 gpcd. The indoor use target is 40 gpcd, which represents the average daily water use of an individual, “the per capita”, assuming the currently available efficient water using devices are fully implemented in all

residences (toilets, showerheads, washing machines, dishwashers). The target for outdoor use is 26 gpcd, which represents a 20% reduction in outdoor water from the current Bay region average of 32 gpcd. The indoor target is derived from an amalgamation of several end-use studies and data sources: EBMUD and USEPA, 2003, Residential Indoor Water Conservation Study, prepared by Aquacraft; Pacific Institute (draft), 2003, The Potential for Residential Water-Use Efficiency in California; data compiled in www.h2ouse.org, prepared by the California Urban Water Conservation Council (CUWCC). Outdoor target is derived from an analysis of studies in Pacific Institute (draft), 2003, The Potential for Residential Water-Use Efficiency and CUWCC, 2000, BMP Costs and Savings Study, prepared by A&N Technical Services. There is great potential to significantly reduce outdoor water use, but there is an immediate need to obtain more reliable estimates to guide conservation investments.

4 Actual water reuse was compiled from the State Water Resources Control Board Recycled Water Surveys conducted in 1999 and 2001. The usage was updated for 2003 and the 1999 and 2001 usage was corrected by contacting individual recycling agencies. The State Water Board survey and this indicator did not include water reused within the wastewater reclamation facility for industrial processes such as filtering cleaning and for landscape irrigation around the facility. There is a need for clear and consistent definitions of what constitutes recycled water use to minimize confusion about how much recycled water use occurs and how much is replacing potable supplies.

5 The five county region (Alameda, Contra Costa, San Francisco, San Mateo, and Santa Clara) established the Bay Area Regional Water Recycling Program (BARWRP) and issued the Recycled Water Master Plan in December 1999, that provides a regional examination of the supply and demand for recycled water. The North Bay Counties (Marin, Sonoma, Napa, and Solano) do not have master plans with targets that can be compared to the actual use so they were not included in this indicator. Currently the North Bay counties use about 10,000 acre-feet of recycled water annually, nearly all for agricultural and landscape irrigation. There are plans to substantially increase the use of recycled water in the North Bay region including providing recycled water for the Napa-Sonoma marsh restoration.

6 The main cause of the 2003 decline is that EBMUD decided to reduce by about half the recycled water it supplied to the Chevron-Texaco oil refinery in Richmond. The master plan targets will be reexamined in the near future to see if they can still be met.

7 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. State Water Resources Control Board, 95-1WR, May 1995.

8 The X2 standard may be measured as flow or electrical conductivity, expressed in values which are estimated to be equivalent to the desired X2 position (but which are not always so).

9 CALFED Bay-Delta Program. July 2000. Ecosystem Restoration Program Plan, Vol. 2: Ecological Management Zone Visions, pp. 98-99.

10 Ambient monitoring can be used for a range of objectives, including baseline characterization, standards compliance, or program effectiveness but it is not monitoring for a specific pollutant, or targeting a specific time (e.g. event driven) or for project compliance.

11 The Bay and estuary, rivers and creeks, lakes and reservoirs, and tidal wetlands are viewed as different water body "types" by the Regional Water Quality Control Board. The rivers and creeks exclude watersheds draining into the Pacific.

12 The indicator is not an evaluation of the quality or scope of the hundreds of water quality monitoring programs throughout the Bay region; rather, the major monitoring efforts were evaluated to determine if they qualified as ambient monitoring. The area covered by all the ambient monitoring programs for a particular water body type is then compared to the total area of that water body type in the San Francisco Bay region. The criteria for deciding whether a program qualified as an ambient water quality monitoring program includes:

a) At least one season of data has been collected, i.e. there has to be a track record for the monitoring. Plans to do monitoring, now matter how firm, do not count.
b) There is a commitment to sustain monitoring long enough to make a baseline characterization and a commitment to continue monitoring or return within a reasonable period of time (e.g. no more than 5 years) to be able to characterize trends. The commitment can be in a work plan, permit requirement, or grant application. The commitment is open to interpretation depending on how it is characterized in writing, and there is admittedly some judgment involved in evaluating it. Research monitoring does not qualify if it cannot be sustained.
c) More than one parameter or constituent is measured. Bioassessment including macroinvertebrate monitoring can be the basis of a good ambient water quality program, but there needs to be some additional physical or chemical measurements to complement biological monitoring.
d) QA/QC protocols are followed, and recognized analytical procedures are used. There are a number of citizen volunteer monitoring efforts that have technical oversight and QA/QC and conduct good ambient monitoring programs, while others may lack rigor and consistency.
e) Directed or targeted monitoring for a research or restoration project or for a specific standard (such as drinking water) can be considered an am-

bient program, if it is sustained, and monitoring a suite of constituents that allows for an evaluation of other beneficial uses and ambient conditions.

13 The San Francisco Intensification Study of the West Coast Pilot of the Environmental Monitoring and Assessment Program (WEMAP) has conducted one year of monitoring. That project sets a precedent for regional, monitoring of wetlands in the Bay Area that is likely to become the model for the ambient aspect of the regional wetland-monitoring program. Wetlands ambient monitoring and assessments efforts are coming together under the umbrella of the Wetlands Regional Monitoring Program (WRMP).

14 Water supply agencies with reservoirs that have ambient monitoring include EBMUD, ACWD, SCVWD, MMWD, and SFPUC. Recreational reservoirs may have pollutant-specific (such as bacteria) monitoring, which does not usually incorporate ambient monitoring.

15 The most recent Clean Water Act Section 303d list was finalized (approved by the State Board and U.S. EPA) in 2003, but is referred to as the 2002 CWA Section 303d list since the law requires a list every two years (an exception was made in 2000 so the previous list is the 1998 Section 303d list). The number of TMDLs in the Bay region (including the Pacific drainages) has increased from 26 on the 1996 list to 263 on the current 2002 list. This is not necessarily an indication of greater impairment. It is the result of both additional monitoring and qualitative assessments of impairment.

16 Only the water bodies that drained into the SF Bay were evaluated (Pacific coast drainages were thus excluded). Water bodies newly added to the 2002 list were not evaluated for two reasons: 1) the list was not finalized until late July 2003 and we decided to provide a grace period for initiating the TMDL process, and 2) many of the new listings for the SF Bay waters are finer delineations of already listed water bodies. A total of 146 TMDLs were evaluated out of the 263 separate TMDLs on the 2002 list.

17 The fifty-one different defined water bodies include 90 TMDLs for the eight different segments of the Bay and estuary covering its entire extent, 5 TMDLs for 4 lakes and reservoirs (Calero, Guadalupe, Lake Herman, Lake Merritt), 47 TMDLs for the 38 rivers and streams (Napa, Guadalupe, and Petaluma Rivers, Sonoma Creek and 34 urban creeks), and 4 TMDLs for 1 wetland (Suisun Marsh). A water body can have more than one TMDL, since a TMDL is developed for each pollutant that impairs the water body.

18 The phases are: Phase 1- Project definition; Phase 2 –Develop project plan ; Phase 3 – Progress report; Phase 4- Preliminary project report; Phase 5- Final report; Phase 6- Basin Plan amendment; Phase 7- State Board and EPA approval; Phase 8 – Implementation. If Phase 1, project definition, had not been initiated, then a–“0” value was assigned to that TMDL. TMDL status was obtained from reports from the San Francisco Regional Water Quality Control Board, and personal communication with staff.

19 53 out of the 64 (over 80%) of the water bodies on the Section 303d list of impaired waters for the SF Bay watershed (see TMDL response indicator) are impaired for pesticides.

20 The State requires pesticide use by farmers, structural pest control companies, commercial landscaping firms, and governmental entities to be reported to the California Department of Pesticide Regulation, which compiles the information in the Pesticide Use Reporting (PUR) database. Even though PUR reports data from 1991, 1993 is the first year of reliable data. 2001 is the last year that is publicly available. The data was retrieved from the Pesticide Action Network (PAN) database, which makes the PUR data available in a more accessible format. The different pesticides are used at widely varying rates of application, so it is necessary to convert pounds of pesticide applied to percent of maximum in order that the use of different pesticides can be averaged together.

21 The nine counties are: Alameda, Contra Costa, Santa Clara, San Mateo, San Francisco, Marin, Sonoma, Napa, Solano.

22 In the SF Bay region, the majority of the total reported use for all the selected pesticides is for non-agricultural, presumably urban use. Considering the unreported urban use along with the reported urban use, most of the selected pesticides use would occur in the urban environment.

The Bay Institute

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