Living Resources

The Bay is important spawning, nursery and rearing habitat for a host of fishes and invertebrates, a migration corridor for anadromous fishes like salmon, steelhead, and sturgeon, and breeding and nesting habitat for waterfowl and shorebirds.

Invertebrates

The Bay is important habitat for several shrimp and crab species, including Bay shrimp, which once supported an extensive commercial fishery in the Bay, and Dungeness crab, an icon of San Francisco's Fisherman's Wharf. California's commercial crab fishery relies heavily on crabs that rear in the Bay, feeding and growing in the Bay's brackish waters and tidal marshes for the first year or two of their lives before migrating to the ocean to mature and breed.

HEALTH INDICATORS

Abundance and distribution of shrimp and crabs in the Bay are affected by environmental conditions both within the Bay and in the nearby ocean, and different species use different regions of the Bay. Estuarine species like the Bay

VERNE NELSON

shrimp, which prefers low salinity waters, are strongly influenced by the amounts and timing of freshwater inflows. Other species restricted to higher salinity habitats closer to the Golden Gate may be more affected by environmental conditions in the nearby ocean. While measures of shrimp and crab abundance, distribution, and species composition within the Bay can be useful biological indicators for the Bay's health, they must be interpreted carefully.

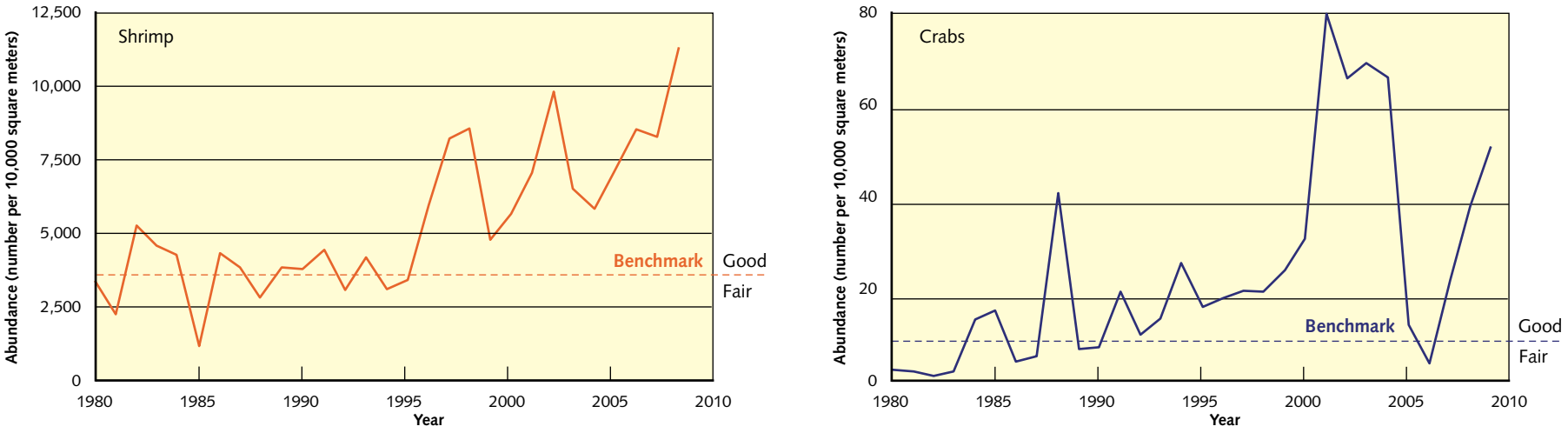
The condition of the Bay's shrimp and crab communities was assessed using several indicators. The simplest ones measure abundance—or, how many shrimp and crabs does the Bay support? For shrimp, this measurement is also made for the different regions of the Bay, from Central Bay near the Golden Gate (essentially a marine environment), to Suisun Bay, just downstream of the Sacramento and San Joaquin rivers.

Another indicator for shrimp compares the abundance (how many?) and distribution (where are they?) of species that prefer low salinity waters to those that prefer saltier waters. The final two indicators measure the prevalence of non-native species in the shrimp and crab communities in the Bay.

BENCHMARK

There are no quantitative goals for shrimp and crab populations in the Bay. In addition, there is good evidence that abundance of many shrimp and crab species in the Bay is affected by environmental conditions in the ocean rather than the Bay. Therefore, high abundance of crab and shrimp does not necessarily indicate healthy environmental conditions in the Bay. However, to evaluate the measured values for the shrimp and crab abundance indicators, we used the 1980–89 average levels, the earliest period for which comparable data were available, as the benchmark. For evaluation of the species composition indicators, the benchmark was set at 85 percent native species based on established ecological principles and the relationship between the presence of non-native species and community and ecosystem health (see Technical Appendix at www.sfestuary.org for additional information). Measured conditions that exceeded the benchmarks were interpreted to indicate good conditions while lower measurements were interpreted to indicate fair or poor conditions. As noted in the introductory section of the report, these benchmarks are references for comparison with measured values of the indicators, not recommendations for policy.

Figure 14. Abundance of shrimp and crabs has increased in the San Francisco Bay during the last 15 years.



HANS HILLEWAERT, WIKIPEDIA COMMONS

DAVE PARKER

KEY RESULTS AND TRENDS

The indicators show a shellfish community in good condition as the Bay supports larger numbers of shrimp and crabs than it did during the 1980s (Figure 14), and over 85 percent of those populations are native species.

However, for shrimp, increased abundance was driven by five to tenfold increases in the abundances of four shrimp species that prefer saltier waters and which, during the past three decades, have progressively extended their range into the upstream region of the Bay, particularly in years with low freshwater inflows. In contrast, abundance of the Bay shrimp, which lives in low salinity waters and is found most commonly in San Pablo and Suisun Bays, showed no increase and, in years with low freshwater inflows, was lower.

Regionally, shrimp abundance increased in all parts of the Bay except Suisun Bay. Increases in crab abundance reflected a sevenfold increase in rock crabs and periodic large increases in Dungeness crab numbers, most likely a response to improved ocean conditions rather than environmental conditions within the Bay.[22] Two non-native shrimp species, which both prefer low salinity waters, are present in the Bay but their numbers are low and relatively stable at about two percent, another indication that conditions in the Bay are good for the native shrimp community. The Bay's crab community is similarly dominated by native species although, for a brief period during the late 1990s, the non-native Chinese mitten crab flourished, comprising 25 percent of the Bay's crab community in 1990.

SUMMARY

Based on the shrimp and crab indicators, the health of the San Francisco Bay has improved, but only for species that use the more saline regions of the Bay. While the CCMP goal of recovering and reversing the declines of these estuarine species has been met, the results illustrate the Bay's complexity and its close connections and interdependence with adjacent ecosystems.

Upstream, chronically low freshwater inflows degrade estuarine conditions (see Freshwater Inflow Index and Estuarine Open Water Habitat section), and species like Bay shrimp that rely on these habitats are, at best, holding steady. Downstream, variable ocean conditions influence marine species' reproductive success and seed the Bay's rich nursery habitats with diverse wildlife communities.

RETURN OF THE NATIVES

As shorebirds and waterfowl have begun using newly modified salt ponds in the South Bay, so have fish. The first year of monitoring by the UC Davis Fisheries Research Team led by Jim Hobbs detected a high diversity of fish species in the ponds, with a strong preponderance of natives.

Hobbs' team monitored fish populations in the Eden Landing, Alviso, Ravenswood, and Bair Island areas, including restoration ponds like Ravenswood's SF2 and flooded "island ponds" like Alviso's A19, A20, and A21 from July through December 2010. Shallow sloughs and intertidal creeks were also surveyed.

An impressive 98 percent of all fish caught by trawling the sloughs were native species. Of 30 species, three-spined sticklebacks accounted for more than half (1,678 of over 3,300) of the captures, followed in abundance by northern anchovy (549), topsmelt (392), staghorn sculpin (253), arrow goby (142), and longfin smelt (61). "That's comparable to the open Bay," Hobbs explains. "Environmental conditions in the South Bay are a little saltier. Most invasive fish species are more freshwater tolerant, and are more common in the North Bay." The presence of small fish like sticklebacks and anchovies is good news for cormorants and other fish-eating birds.

The assemblage varied seasonally, with more sticklebacks, anchovies, sculpins, and gobies in summer and more smelt, herring, shad, and silversides in winter. "The anchovies came in late summer and fall and spawned," says Hobbs. The Pacific herring followed: "We're now seeing young herring all over the South Bay."

Hobbs also found that larger predators, notably leopard sharks and bat rays, are foraging at the outlets of the "island" ponds like A19. Like human anglers, the sharks wait for smaller fish exiting the ponds as the tide recedes. "We caught at least half a dozen sharks and rays per hour," he recalls.

JIM HOBBS

One result that caught his attention was the relative abundance of longfin smelt (*Spirinchus thaleichthys*), a species involved in the Pelagic Organism Decline phenomenon: "Longfin smelt abundance has collapsed in the pelagic ecosystem of the North Bay and Delta. They had been intermittently collected in the South Bay during various surveys, but there hadn't been enough studies using appropriate gear this far up into the sloughs. We caught quite a few up Coyote Creek and in the island ponds. During late fall, they're coming back from the nearshore ocean and either turning right and going into the South Bay or left into the North Bay and Delta. I've looked at some of the data before and during the POD, and there's a correlation between their decline in the North Bay and increase in the South Bay. If they hang out until January and February in the South Bay, they're not likely moving into the North Bay to spawn."

Hobbs was also looking for a small unprepossessing goby called the longjaw mudsucker (*Gillichthys mirabilis*.) Although it currently has no conservation status, it's a sentinel species for the Bay's much-reduced pickleweed marsh habitat. "It's the only fish species that lives intertidally in these marshes," he says. "It's an important prey species. It used to be used heavily as bait, but stopped showing up in bait shops in the 1980s. We're trying to get an assessment of what its distribution formerly was like." In much of its intertidal habitat in the Bay, the mudsucker has been displaced by the non-native yellowfin goby.

Monitoring will continue on a monthly basis for the next four years. New approaches will include a mark/recapture study of mudsuckers to determine population size and mortality and an analysis of fish otoliths (ear bones) for heavy metal contaminants like mercury and copper. The researchers will also look at the distribution and abundance of zooplankton and benthic fauna like the overbite clam (*Corbula amurensis*).

Fish

The San Francisco Bay is important habitat for more than 100 fish species, including commercially important Chinook salmon and Pacific herring, popular sport fishes like striped bass and sturgeon, and delicate Estuary-dependent species like Delta smelt. Environmental conditions in the Bay—the amounts and timing of freshwater inflows, the extent of rich tidal marsh and brackish water habitats, ecological processes that drive productivity, and pollution—affect the numbers and types of fish the Bay can support. A large, diverse fish community distributed broadly throughout the Bay and dominated by native species is a good indicator of a healthy Estuary.

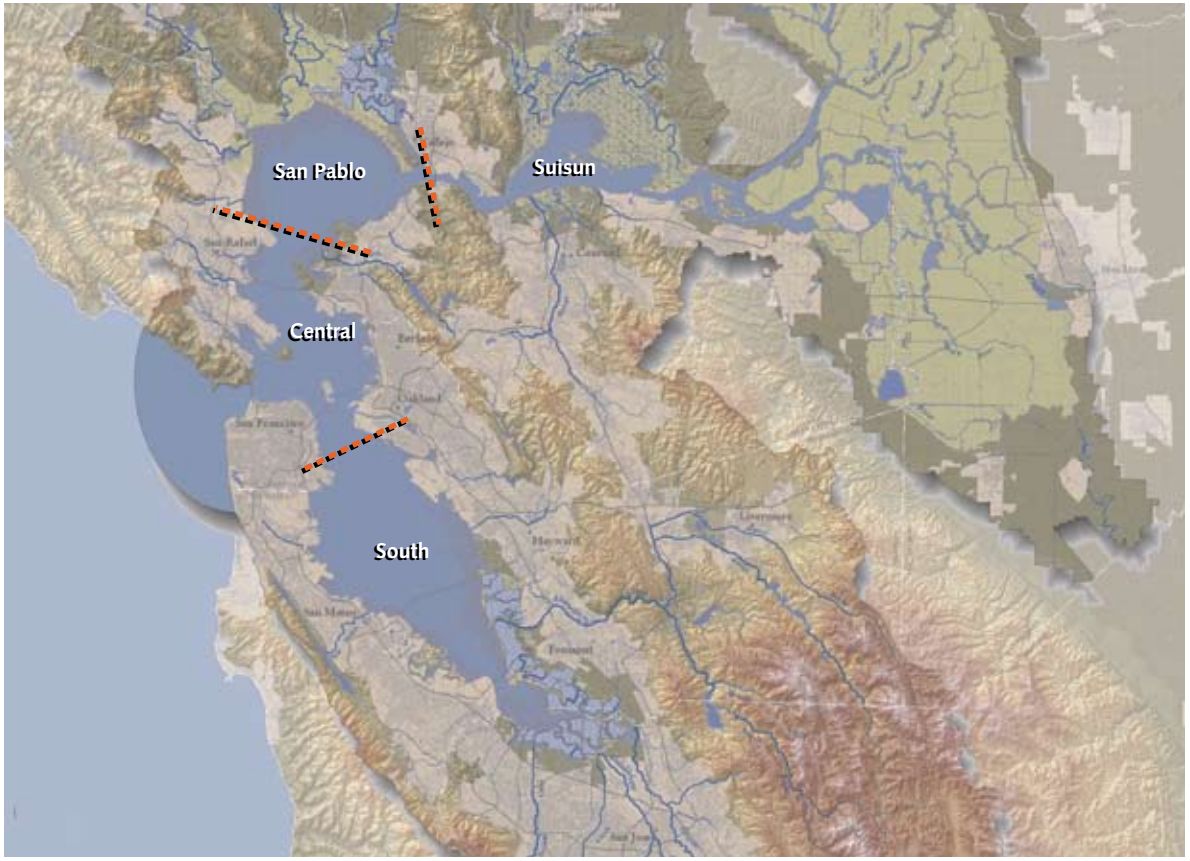
HEALTH INDICATORS

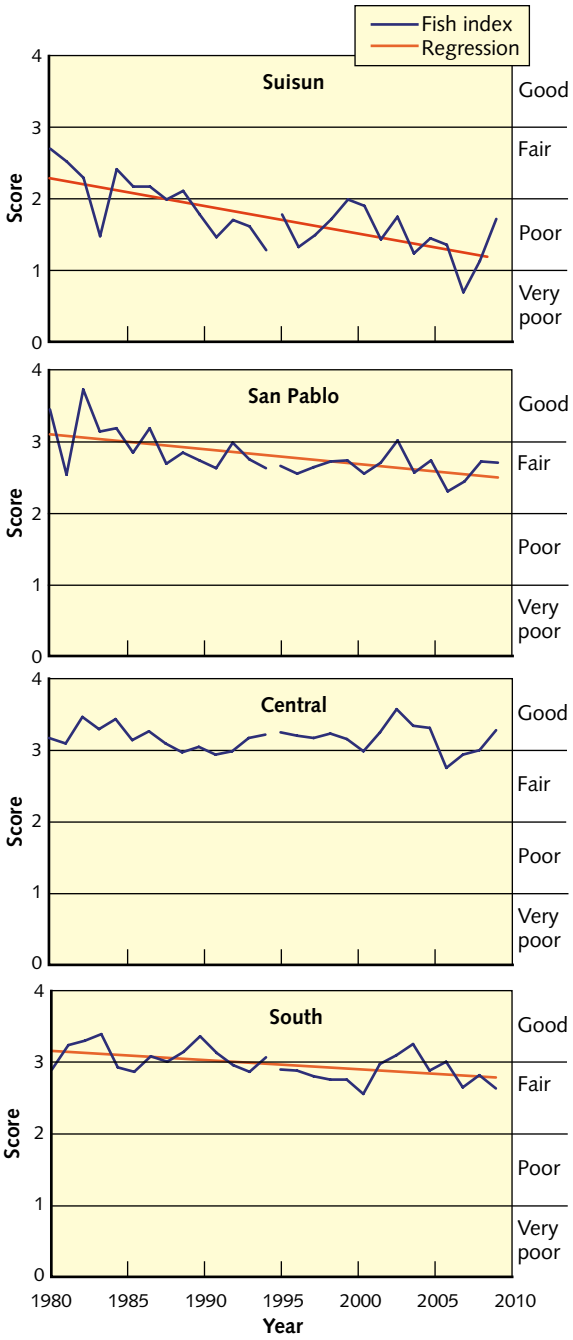
The Fish Index uses 10 indicators to assess the condition of the fish community within the Bay. Four of the indicators measure abundance (how many fish?), and two others measure the diversity of the fish community (how many species?). Another pair of indicators assesses the composition of the fish community (what kind of fish?) by measuring the percentage of fish that are native rather than invasive or introduced. The final two indicators examine the distribution of native fish within the Estuary (where are the fish?). Because the Bay is so large and its environmental conditions so different in different areas—for example, Central Bay near the Golden Gate is essentially a marine environment while Suisun Bay is dominated by freshwater inflows from the Sacramento and San Joaquin Rivers—each of the indicators and the index was calculated separately for four regions (Figure 15). For each year, the results of the 10 indicators were combined into a single score (0–4) to calculate the Fish Index.

BENCHMARK

There are no established quantitative goals or standards for fish populations in the Bay. Therefore, for each indicator we established a benchmark based on either 1980–89 average levels, the earliest period for which comparable data were available, or established ecological principles such as the relationship between the presence of non-native species and community and ecosystem health. Measured conditions that exceeded the benchmark were interpreted to indicate good conditions while lower measurements were interpreted to indicate fair, poor, or very poor

Map 4. *Because San Francisco Bay is so large and its environmental conditions so different in different areas, the Fish Index was calculated separately for four regions: Suisun, San Pablo, Central, and South Bays.*





THOMAS DUNKLIN

conditions. As noted in the introductory section of the report, these benchmarks are references for comparison with measured values of the indicators, not recommendations for policy.

KEY RESULTS AND TRENDS

Results of the Fish Index show that the health of the Bay's fish communities is different in different regions of the Bay (Figure 15).

Conditions in the Central Bay are generally good and have been mostly stable for the past 30 years. In contrast, the condition of the fish community in Suisun Bay, which was already poorer at the start of the survey, declined quickly during the 1980s and has remained poor to very poor ever since. The condition of the fish community in San Pablo Bay has declined from good to fair during the past three decades and in the South Bay a similar trend is emerging.

Declines in the Fish Index largely reflect declines in fish abundance: in the 2000s, the Bay supported far fewer fish than it did just two decades earlier. Abundance of pelagic fishes (those that live in open water habitat away from the shore) declined in all regions except the Central Bay. Compared to the abundance during the 1980s, abundance of pelagic fishes in the last five years was 88 percent lower in Suisun Bay, 68 percent lower in San Pablo Bay, and 55 percent lower in South Bay.

Figure 15. The condition of the San Francisco Bay's fish community has declined in all areas of the Bay except near the Golden Gate. The decline is worst in Suisun Bay, the eastern, upstream region of the Bay.

Abundance of sensitive Estuary-dependent species like longfin smelt, starry flounder, Pacific herring, and striped bass declined in all regions of the Bay, and abundance of bottom-dwelling fishes declined in both Suisun and San Pablo Bays. Northern anchovy, by far the most common fish in the Bay, virtually disappeared from Suisun Bay and fell by 60 percent in San Pablo Bay. Diversity, measured as the numbers of native species present, declined in San Pablo Bay and, for native Estuary-dependent species, in the South Bay as well.

As a percentage of species in the fish community, native species declined in all regions of the Bay except the Central Bay: in Suisun Bay, clearly the region with the fish populations in the poorest health, almost 30 percent of the fish species collected during the 2000s were non-native species, compared to 13 percent in the South Bay and 7 percent in the Central Bay. However, on the basis of total numbers of fish, native fishes predominate in all regions of the Bay except for Suisun Bay, where more than 60 percent of all fish caught are non-native species. The distribution of native fishes in Suisun Bay also declined. Compared to the 1980s when natives were regularly collected at all sampling stations, in recent years native fish have disappeared for much of the year from more than a third of the stations.

SUMMARY

Based on the Fish Index and its component indicators, the health of San Francisco Bay has declined since the 1980s in all regions except Central Bay, near the Golden Gate. The decline is most severe in Suisun Bay, the upstream region of the Estuary heavily influenced by the amounts, timing and quality of freshwater inflows from the Bay's Sacramento-San Joaquin watershed.

Since 1993, when the CCMP called for recovery of and reversing the declines of estuarine fish and wildlife species, none of the Bay fish communities in any part of the Bay have improved. Instead, six native fish species that rely on the Bay have been listed under the federal and/or state Endangered Species Acts.[23]

Decades of scientific research have identified the causes for these declines: degraded open water and marsh habitats, impaired water quality, reduced food availability, and increasing prevalence of harmful non-native species.

The Fish Index results underscore the need to improve Bay health and function by improving freshwater inflow conditions, restoring open water estuarine habitat and tidal marshes around the Bay's perimeter, re-establishing key ecological processes that increase productivity, and reducing pollution (see also the Freshwater Inflow Index, Water Quality Indices, Estuarine Open Water Habitat indicator, and the Flood Events section).

Birds

San Francisco Bay provides critical habitat for a wide variety of bird species. Birds are an ecologically diverse group, and this diversity is reflected in the broad spectrum of bird species dependent on different parts of the Bay ecosystem. Birds are found in tidal marshes, tidal flats, salt ponds, diked wetlands, open water, and rocky areas. Some are present year-round, while others are migratory. Many bird species feed on fish and invertebrates, using specialized hunting techniques to exploit particular prey species.

GARRETT SCALES

HEALTH INDICATORS

Five distinct indicators of bird populations were used to reflect the health of the Bay:

- abundance of breeding tidal marsh dependent birds (i.e., song sparrow, common yellowthroat, and black rail)
- tidal marsh bird reproductive success (specifically salt marsh song sparrows)
- heron and egret breeding populations
- abundance of winter waterfowl (dabbling ducks and diving ducks)

With these indicators it is possible to evaluate the degree to which the CCMP goal of stemming and reversing the decline in the health and abundance of estuarine biota (indigenous and desirable non-indigenous) and restoring healthy natural reproduction is being achieved. The benchmarks for these indicators are described below along with the key results and trends.

KEY RESULTS AND TRENDS

Our evaluation of bird-related indicators finds distinct patterns of change in the subregions of the Bay. The question that can be answered is not "how are birds (or a group of bird species) doing in the Bay?" but "how are birds (or a group of bird species) doing in each region of the Bay?" Differing results among regions are due to marked differences in species composition—not just birds, but plants, invertebrates, and other living resources—that in turn are driven in part by differences in salinity, with the Suisun region the least saline, San Francisco Bay (including Central and South Bays) region the most saline, and the San Pablo Bay region intermediate in salinity.

TIDAL MARSH BIRD ABUNDANCE

This indicator reflects density of subspecies that are especially adapted to tidal marsh habitat: the Alameda, San Pablo, and Suisun subspecies of song sparrow, the salt marsh common yellowthroat, and the California black rail. Tidal marsh bird populations, combining data across the three species, have demonstrated increases since 1996: in San Francisco Bay, the increase was in the late 1990s, but not more recently; in Suisun, increases are observed only since 2000; and in San Pablo Bay tidal marsh birds have shown a gradual increase over the entire period, 1996 to 2008 (Figures 16 and 17).

However, only San Pablo Bay tidal marsh birds demonstrate a significant increase in population density during this period (a cumulative increase of 31 percent over a 12-year period). Increases in tidal marsh bird density, such as have been observed for San Pablo Bay, are likely due in large part to better habitat quality, especially the maturation of restored habitat, which can support a higher bird density than more recently restored sites. While the recent increase in Suisun Bay is heartening, the recent decline in San Francisco Bay is cause for concern.

BENCHMARK

We evaluated change in the density of tidal marsh birds with respect to the following benchmark: the upper quartile value observed for mature tidal marsh, averaged over the three target species. Averaging over all Bay regions provided a rough benchmark of 0.93 birds per hectare. Assuming that the same benchmark can be applied to all Bay regions, we observed that for the two most recent years, San Francisco Bay (including South and Central Bay) tidal marsh birds are at 70 percent of this value, San Pablo Bay birds at 54 percent, and Suisun Bay birds at 94 percent.

TIDAL MARSH BIRD REPRODUCTIVE SUCCESS

Reproductive success of tidal marsh birds, as indicated by two subspecies of song sparrow that live exclusively in tidal marsh habitat, has been increasing in Suisun Bay since 2000, but decreasing in San Pablo Bay (Figure 18).

The level of reproductive success throughout the Bay (including information from Central and South San Francisco Bay) appears to be too low to sustain these populations over the long-term, let alone support their growth. The two most important pressures on tidal marsh birds accounting for low success are predators (especially

Figure 16. Combined species, Suisun Bay

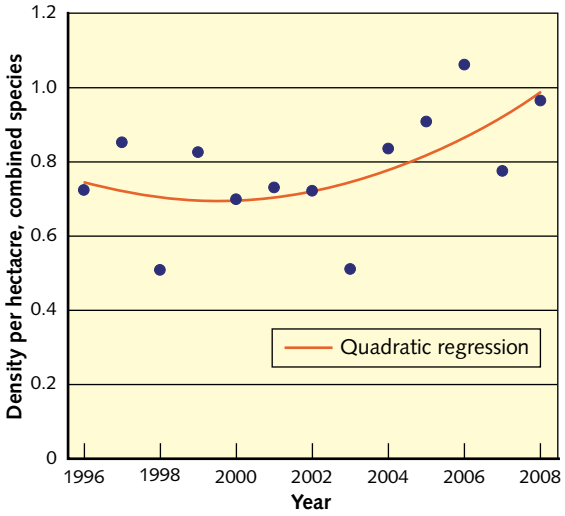


Figure 17. Combined species, San PabloBay

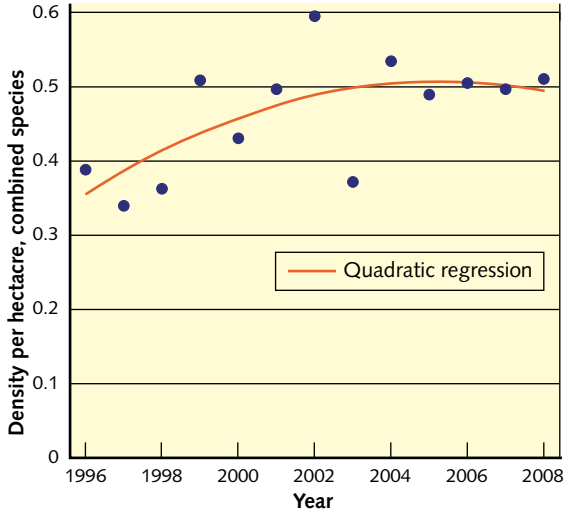
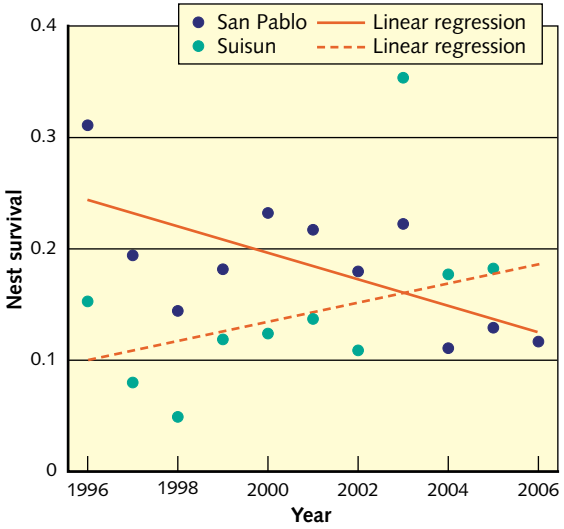


Figure 18. Reproductive success indicator, San Pablo and Suisun Bays



RICH TURNER

mammals and snakes) and nests being flooded. The impact of flooding is worse when song sparrows nest in the invasive-hybrid smooth cordgrass (*Spartina alterniflora*). Native marsh vegetation is not found at such low elevations relative to tides as is smooth cordgrass.

BENCHMARK

We used a nest success rate of 20 percent as the benchmark, the minimum success rate needed to sustain populations of tidal marsh song sparrows based on demographic analysis. Below this value, song sparrow populations are expected to exhibit long-term declines in breeding numbers. For the two most recent years, San Pablo song sparrows are at 61 percent of this value and Suisun song sparrows at 69 percent.

HERON AND EGRET BREEDING POPULATIONS

This indicator provides a measure of the breeding population size of herons and egrets, as exemplified by two species: great blue heron and great egret. The number of nests per 100 square kilometers of wetland habitat showed strong increases in San Pablo Bay (on average, 8.8 percent per year) but decreases in Central San Francisco Bay (on average, 3.8 percent per year) (Figures 19 and 20).

In fact, the San Pablo Bay nesting population has increased more than nine-fold since 1991. Nesting populations in Suisun Bay and overall in the San Francisco Bay have remained relatively stable. The increase in San Pablo Bay likely reflects increases in the amount and quality of habitat for herons and egrets.

Figure 19. Heron and egret nest density, Central San Francisco Bay

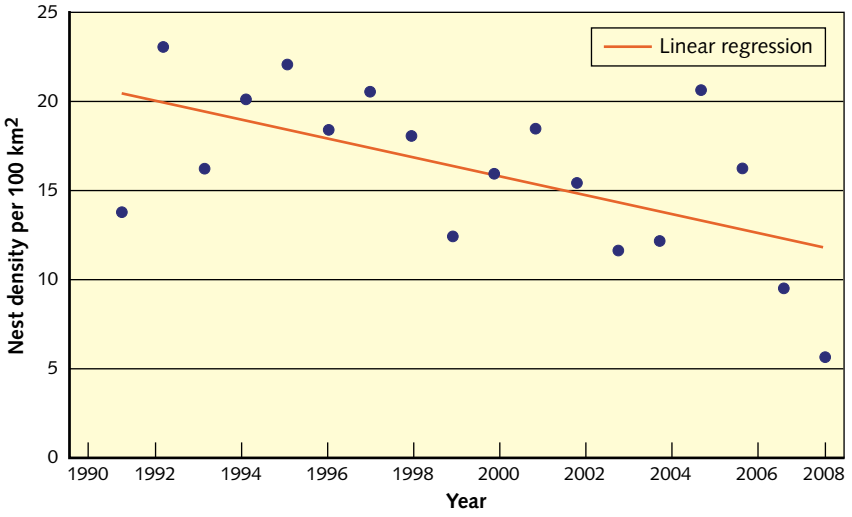
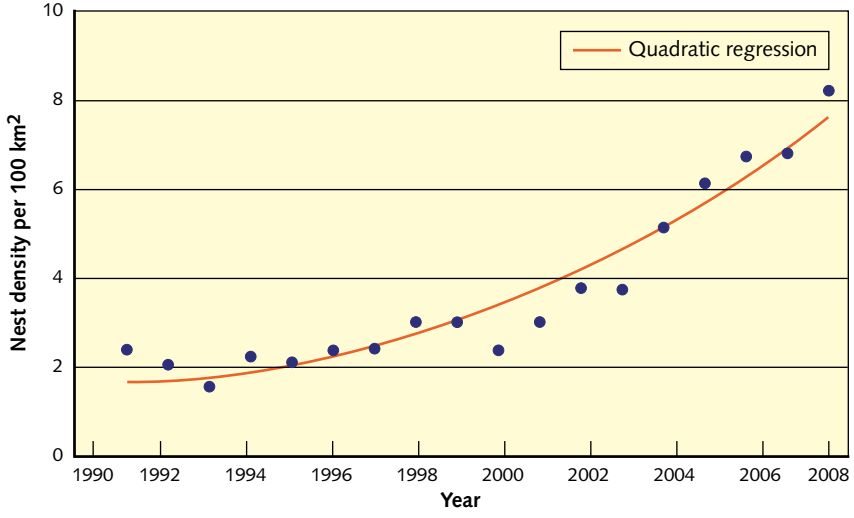


Figure 20. Heron and egret nest density, San Pablo Bay



HOPE FOR HERRING

It must have seemed like old times to Point Richmond residents as the Pacific herring came inshore to spawn. At its peak, February 2011's run attracted an estimated 20,000 gulls and an uncounted number of diving ducks. "California sea lions and harbor seals, their fur covered with herring eggs, were joining in the feast," reported birder Eric Lichtwardt.

The run brought the last urban fishery in the United States back into action for the first time in two years. Thirty boats went after the fish, whose roe is prized in Japan. "This is a year unlike any I've seen," Ernie Koepf of the *Ursula B* told the *Contra Costa Times.* "This is an epic year for harvesting." The 1,900-ton quota was filled early.

California Department of Fish and Game biologists agree that this was a good season. Most of this year's spawners were hatched in 2008, just after the *Cosco Busan* spill that contaminated many spawning sites. "Our feeling is that it was such a strong year class that it can support a fishery if managed properly for several years," says the agency's John Mello.

Some herring fishers reported the fish were avoiding oiled sites. Mello says he has heard this anec–dotally, but hard data is lacking; "I don't think we've had enough spawning events since the spill to judge that this is the case. The herring do jump around. They don't hit all the known spawning areas every year."

Along with rocky substrates and man-made structures like piers, female herring deposit their eggs on eelgrass and *Gracilaria* algae. The health of the fishery clearly depends on that of the subtidal and intertidal ecosystems.

"We're quite happy we're seeing a rebound in the population," says Fish and Game's Ryan Bartling.

A slightly different version of this article first appeared in ESTUARY NEWS, April 2011.

A gull discovers herring roe on a piling. MICHAEL BUKAY

Nesting success of great blue herons and great egrets (one of two important components of reproductive success, the other being number of young reared) displayed a modest decline between the mid 1990s and the most recent years, especially in San Pablo Bay (see the Technical Appendix, www.sfestuary.org, for more details). The observed decline in success of nesting attempts suggests that disturbance to breeding herons and egrets (whether due to humans or other sources) has increased in recent years.

BENCHMARKS

The benchmark value for heron and egret breeding populations as indicated by nest density is the average density observed from 1991–1995, calculated for each region separately: 19.1 nests per 100 square kilometers of historic tidal wetland habitat for Central San Francisco Bay; 2.09 nests per 100 square kilometers in San Pablo Bay; and 15.5 nests per 100 square kilometers in Suisun Bay. For the three most recent years, the combined heron and egret nest density for Central San Francisco Bay was 43 percent below the benchmark; San Pablo heron and egret nest density was about 250 percent above the benchmark; and Suisun heron and egret nest density was 12 percent higher.

The benchmark value for heron and egret breeding populations is the average value observed during the earliest five-year reference period, 1994 to 1998, 0.812. Applying this benchmark to all subregions indicates that heron and egret nesting success was 12 percent below this value in Central San Francisco Bay; 9.1 percent below this value for San Pablo Bay; and 4.7 percent below this value for Suisun Bay.

WINTERING WATERFOWL ABUNDANCE

Waterfowl population trends differ depending upon feeding behavior of the species and among Bay regions (Figures 21 and 22, note log scale). Ducks that feed at or just below the surface in shallow water ("dabbling" ducks) such as pintail, shoveler, and mallard, have shown healthy increases in Suisun and San Pablo Bay, increasing by 11 to 12 percent per year in both regions, but not in the Central and South San Francisco Bay, where there are no clear-cut trends. Diving ducks, which feed in deeper waters, have declined in San Pablo Bay in recent years but have been fairly stable in Suisun Bay. In particular, in San Pablo Bay, between the early 1990s and the mid-2000s, diving ducks decreased 41 percent while dabbling ducks increased 295 percent. The difference between the two types of duck species reflects the relative availability of

Figure 21. Dabbling ducks, North Bay

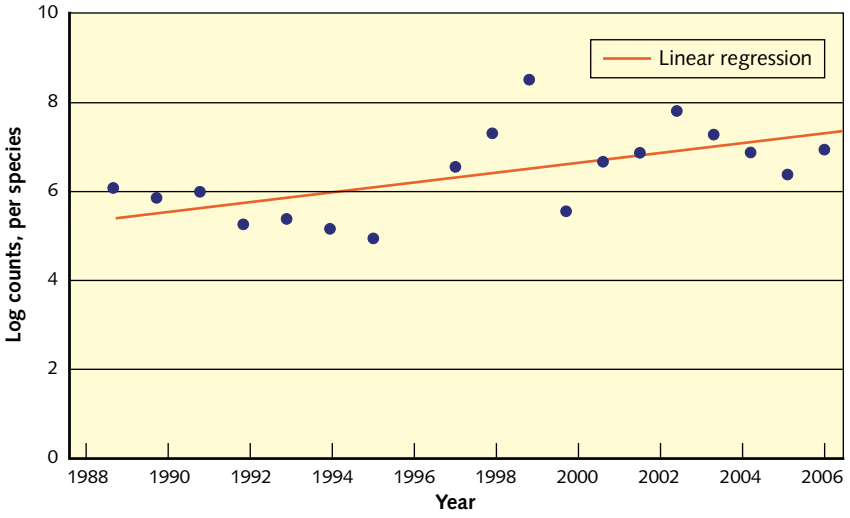
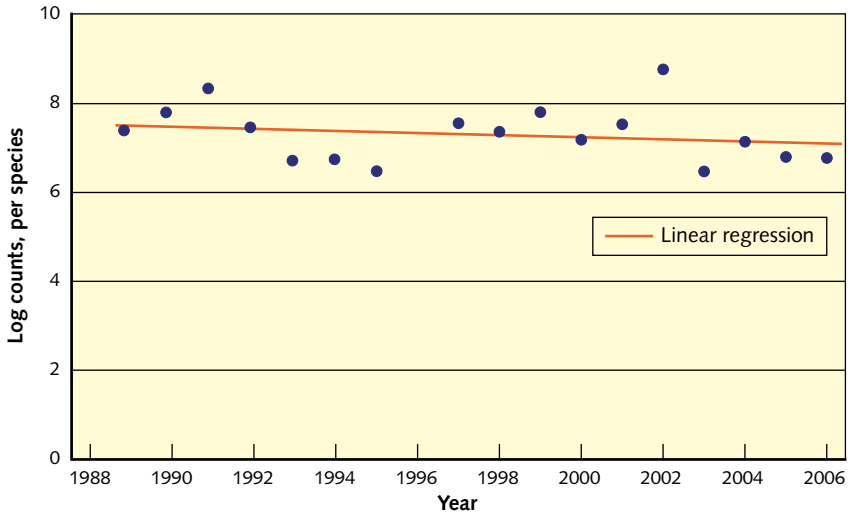


Figure 22. Diving ducks, North Bay



MICHAEL BUKAY

their different prey resources, with diving ducks feeding on large invertebrates such as clams, and dabbling ducks feeding on very small invertebrates and plant material. In addition, dabbling ducks are able to take advantage of the conversion of former salt evaporation ponds to tidal marsh habitat if it contains pannes and associated intertidal flats, whereas diving ducks are not able to use tidal marsh habitat for foraging.

BENCHMARK

For each of four regions, South San Francisco Bay, Central San Francisco Bay, North Bay (comprised mainly of San Pablo Bay), and Suisun Bay, the benchmark is the mean, per species, for the two groups of waterfowl (dabbling ducks and diving ducks).[24] For the three most recent years, this translated into percent changes in counts (after back-transforming from log values) for dabbling ducks of a 58 percent increase in South San Francisco Bay, 21 percent decrease in Central San Francisco Bay, 295 percent increase for North Bay, and 680 percent increase in Suisun Bay: the predominant pattern was a strong increase. For diving ducks, the percent change in counts comparing the most recent three years to the reference period was a 49 percent increase in South San Francisco Bay, 17 percent decrease in Central San Francisco Bay, 41 percent decrease in the North Bay, and 20 percent decrease in Suisun: the predominant pattern was a decrease in winter populations.

SUMMARY

With respect to the CCMP goal of stemming and reversing the decline in the health and abundance of estuarine biota (indigenous and desirable non-indigenous), and restoring healthy natural reproduction, the results for birds are mixed. Though some populations demonstrate increases in density, others have not shown any material gains in population during this time. Reproductive success has generally remained low or decreased since 1993.

Tidal marsh bird populations overall have increased since 1993. This is the case for common yellowthroats and black rails; however for song sparrows this is only true for San Francisco Bay, and not for Suisun or San Pablo Bay (see Technical Appendix). For great blue herons and great egrets, nesting numbers have increased in San Pablo Bay, but overall, the number of nesting herons and egrets has been fairly stable. For dabbling ducks, most Bay regions demonstrate an increase in numbers, especially San Pablo and Suisun bays. Several groups of birds have increased in part due to habitat restoration and enhancement, including tidal marsh birds (especially black rails), herons and egrets nesting in San Pablo Bay, and dabbling ducks.

Significant declines have occurred in the abundance of diving ducks and in nesting success, however, particularly for great egrets and San Pablo Bay song sparrows. Diving ducks have declined in numbers in all regions except South San Francisco Bay, possibly due to declines in prey. Increases in predator access, predator populations, or disturbances to breeding birds may be the root cause of declines in nesting success. Overall, substantial decreases in the indicators measured can be linked to excessive predation (tidal marsh bird reproduction), disturbance (heron and egret nesting success), and reduced prey availability (as suggested for diving ducks). The impact of invasive species altering wetland habitats remains a concern.