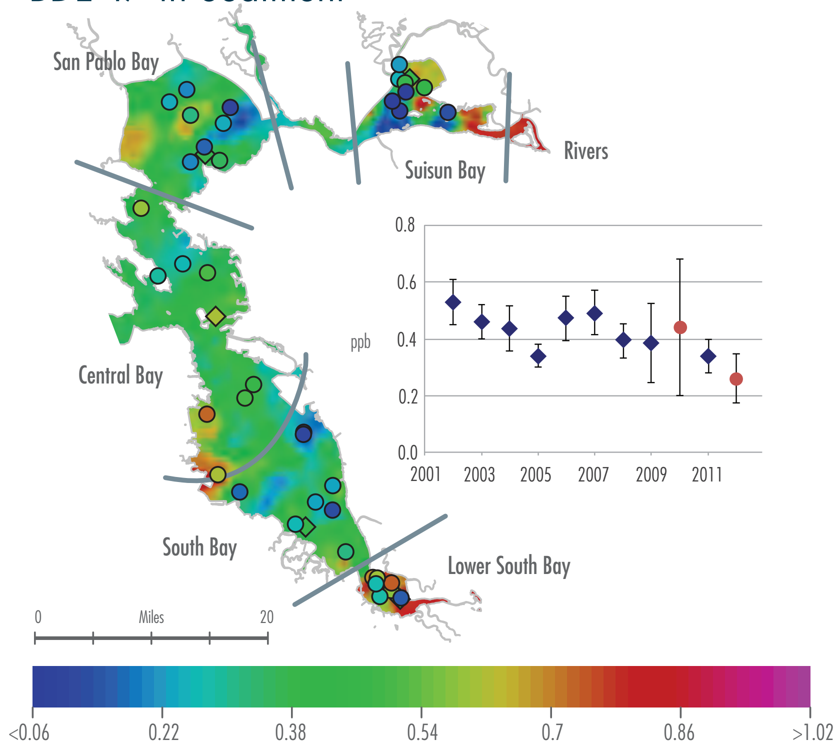
PBDEs *(cont)*

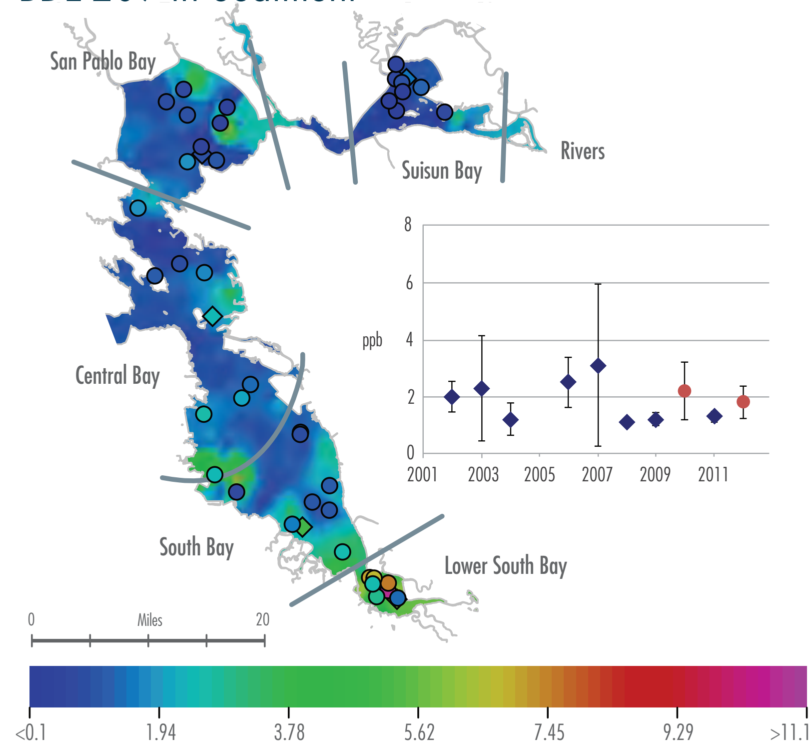
BDE-47 in Sediment



Concentrations of BDE-47 in sediment, consistent with the data for water and biota (PAGE 63**), appear to be on the decline.** The Bay-wide average for 2012 (0.26 ppb, a wet season value) was the lowest observed in the 11 years of sampling, and 50% lower than the average observed in 2002. In contrast to the results obtained from water monitoring, long-term average dry season concentrations of BDE-47 in sediment have been highest, by far, in Lower South Bay (0.71 ppb). Average concentrations in the other segments ranged from 0.36 ppb in South Bay to 0.46 ppb in Central Bay.

Footnote: BDE-47 is one of the most abundant PBDEs and was consistently quantified by the lab. Colored symbols on map show results for wet season samples collected in 2012: circles represent random sites; diamonds represent historic fixed stations. Contour plot based on 357 RMP data points from random stations collected over nine rounds of dry season sampling from 2002-2009 and 2011 (data from wet season sampling in 2010 and 2012 are excluded). Trend plot shows annual Bay-wide random station means with error bars indicating 95% confidence intervals of the means. Red circles on trend plot indicate wet season samples; blue diamonds indicate dry season samples. The maximum concentration, by far, was 3.8 ppb in Lower South Bay in 2005. Concentrations presented on a dry weight basis.

BDE-209 in Sediment



BDE-209 (also known as decabromodiphenyl ether) represents the one remaining PBDE mixture ("DecaBDE") that is still being used in California. In contrast to BDE-47, Bay-wide average concentrations of BDE-209 in sediment do not appear to be declining. The average concentration in the wet season sampling of 2012 (1.8 ppb) was slightly below the long-term dry season average of 1.9 ppb. Similar to BDE-47 in sediment, long-term average dry season concentrations of BDE-209 from 2004-2009 were highest in Lower South Bay (5.4 ppb), followed by South Bay and San Pablo Bay (2.0 ppb), Central Bay (1.8 ppb), and Suisun Bay (0.8 ppb).

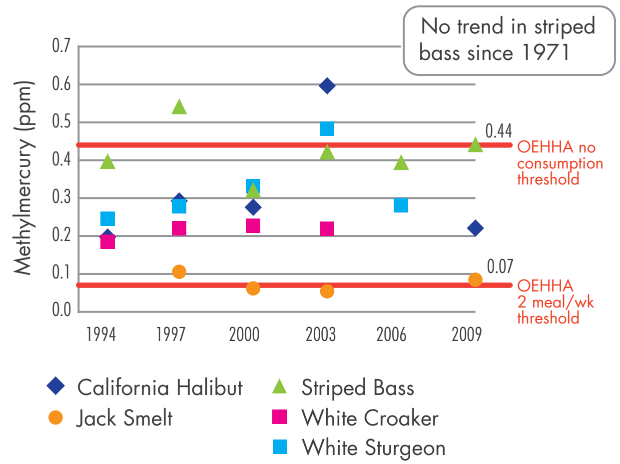
Footnote: BDE-209 shown as an index of the DecaBDE mixture. Colored symbols on map show results for wet season samples collected in 2012: circles represent random sites; diamonds represent historic fixed stations. Contour plot based on 310 RMP data points from random stations collected over eight rounds of dry season sampling from 2002-2004, 2006-2009, and 2011 (data from wet season sampling in 2010 and 2012 are excluded). Data from 2005 are not available. Trend plot shows annual Bay-wide random station means with error bars indicating 95% confidence intervals of the means. Red circles on trend plot indicate wet season samples; blue diamonds indicate dry season samples. The maximum concentration by far was 52 ppb in San Pablo Bay in 2007 (the next highest concentration was 19 ppb in South Bay in 2006). Concentrations presented on a dry weight basis.

WATER QUALITY TRENDS AT A GLANCE

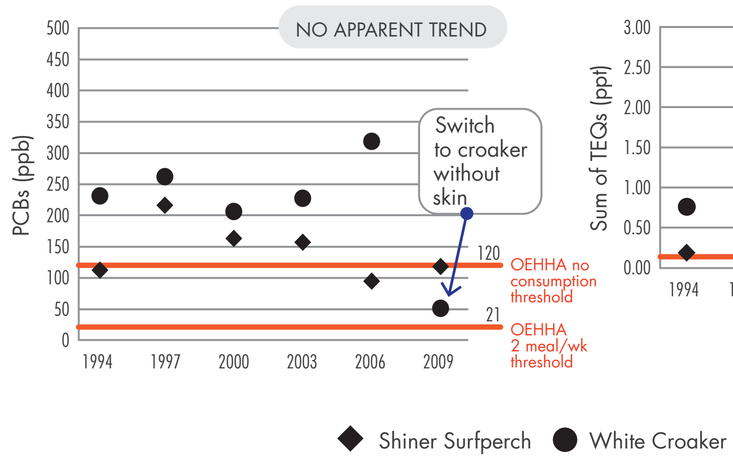
Toxics and Bacteria

SEE PAGE 45
FOR GRAPH DETAILS

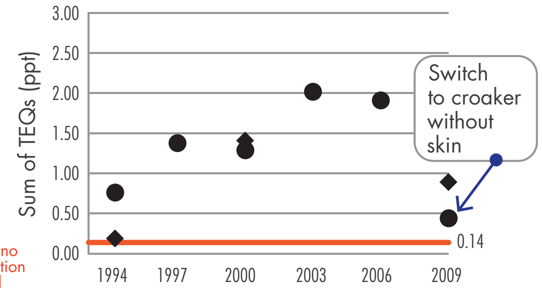
1. Methylmercury in Sport Fish



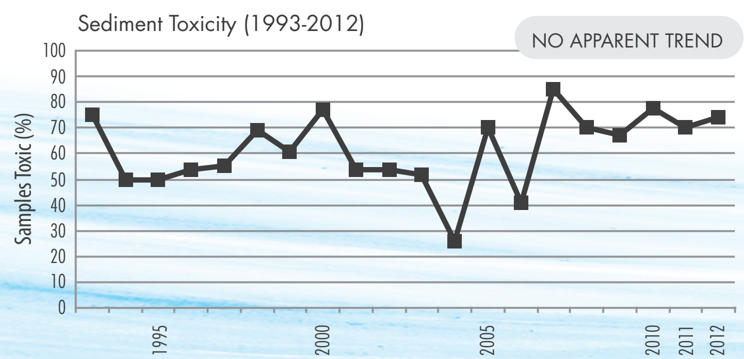
2. PCBs in Sport Fish



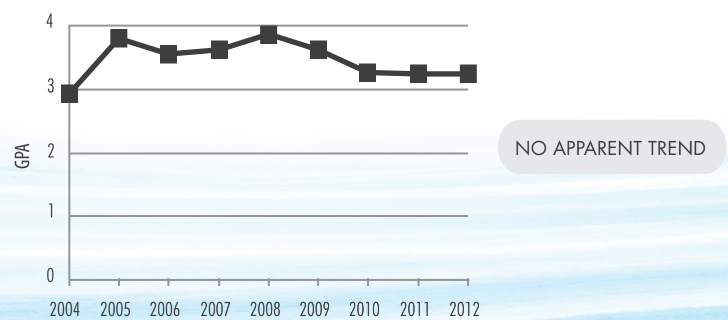
3. Dioxins in Sport Fish



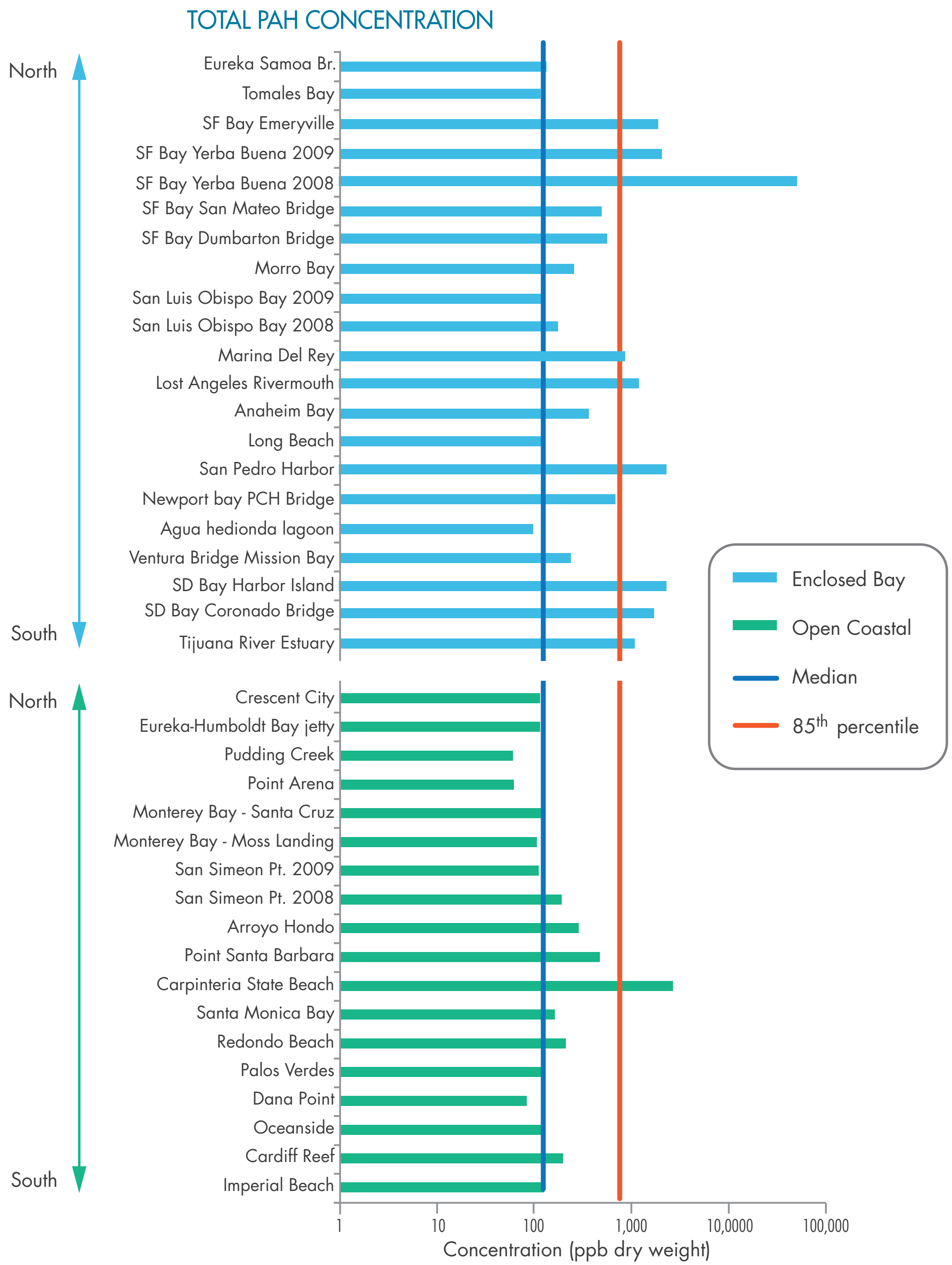
4. Percent Toxic Sediment Samples



5. Beach Report Card Grades



PAHs *(cont)*



Large But Fleeting Impact of the Cosco Busan Oil Spill on PAHs in Mussels

In November 2007, the Cosco Busan oil tanker gouged its hull on a Bay Bridge support tower, releasing 54,000 gallons of bunker fuel oil into the Bay. This resulted in a brief period in which PAH concentrations were extremely high in the parts of the Bay affected by the spill. Fortuitously, a study of contaminant accumulation in mussels, including sampling at Yerba Buena Island shortly after the spill, was underway at that time. The mussel monitoring was part of a collaboration between the State Water Board and the National Oceanic and Atmospheric Administration (NOAA) that measured PAHs and other contaminants in mussels along the California coast.

The PAH concentrations observed in mussels at Yerba Buena Island, a sampling station very close to the spill site, in early 2008 after the spill (48,000 ppb dry weight) were far higher than any others measured in the state from 2007-2009. The concentration at Yerba Buena Island in December 2007 was 18 times higher than the next highest measurement (2,700 ppb at Carpinteria State Beach). Yerba Buena Island was sampled again in December 2008. By that time, the PAH concentration fell down to 1,900 ppb, a concentration more typical for San Francisco Bay and other enclosed bays in California. Consistent with these observations, the spill resulted in a temporary advisory recommending no consumption of mussels from two nearby areas (Berkeley Marina and Rodeo Beach) impacted by the spill (Brodberg et al. 2007).

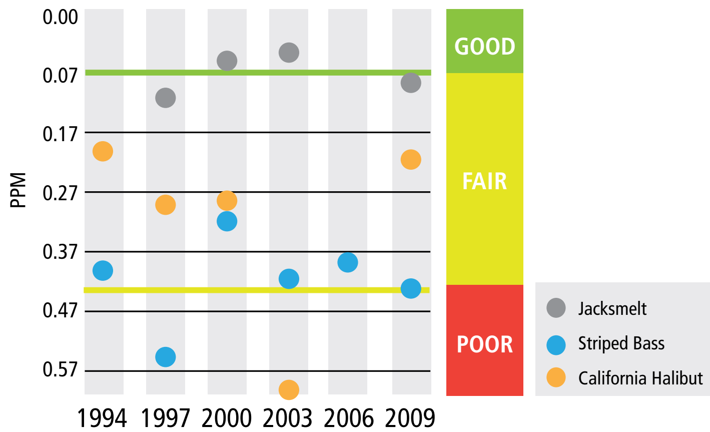
PAH concentrations observed at Yerba Buena Island in 2009 and at the other Bay locations were at the higher end of the range for enclosed bays in California, and about 10 times higher than concentrations typical for other open coast locations.

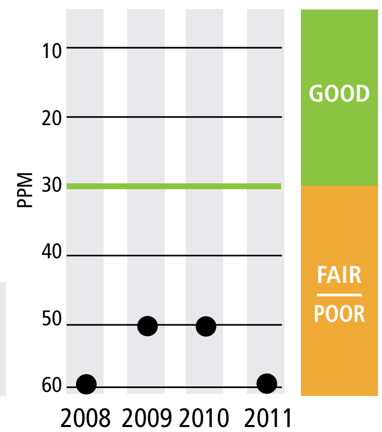
References: Brodberg et al. 2007. Report on the safety of consuming fish and shellfish from areas impacted by the M/V Cosco Busan oil spill in San Francisco Bay, California. California Office of Environmental Health Hazard Assessment, Sacramento, CA. http://oehha.ca.gov/fish/pdf/SF%20BayFishShell112907.pdf

Mercury: Summary; Recent Advances

KEY POINTS

- Mercury contamination is a high priority for Bay water quality managers due to concern for risks to humans and wildlife
- A total maximum daily load (TMDL) control plan was approved in 2008
- Reduction of mercury inputs can be expected to slowly reduce mercury in the food web
- Minimizing conversion of mercury to methylmercury in salt ponds and restored marshes could potentially reduce local-scale food web mercury more quickly
- Preliminary results from monitoring tidal marsh restoration suggest that breaching salt ponds is not causing increases in food web mercury





Note inverted vertical axes. Bay-wide average concentrations. Data from the RMP. Graph details on page 61.

RECENT ADVANCES

The RMP published a review of the latest information on mercury in the Bay in 2012 (Davis et al. 2012), as part of a broader effort to summarize the state of knowledge of mercury cycling in coastal and marine ecosystems across the globe (Chen et al. 2012). Recent measurements of mercury accumulation in sport fish indicate that human exposure from fish consumption is a continuing concern (page 34). Ackerman et al. (2014) summarized extensive studies of mercury accumulation and risks in Bay birds, which face high risks of impaired reproduction based on mercury concentrations in the tissues of several species.

Studies indicate that the large pool of mercury already present in Bay sediment is the dominant supply that is converted to methylmercury (the toxic form of mercury), which is then accumulated in the food web. Consequently, it will likely take many decades before reduced loads of mercury to the Bay result in lower mercury in the food web.

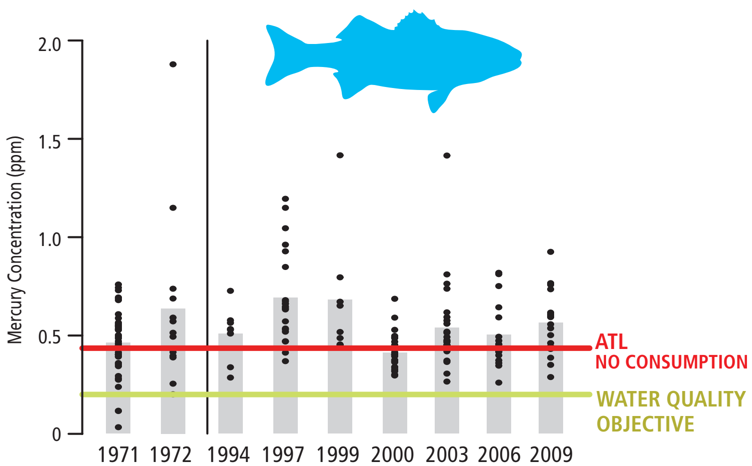
Controlling conversion of mercury to methylmercury is the second important management approach, and has the potential to reduce food web mercury within a much shorter time-frame. Options for controlling methylmercury production in the open Bay are limited, but do appear feasible in tidal marsh restoration projects and salt ponds, which are important habitats for at-risk bird species.

The RMP sponsored a forum in 2013 to review available information and data gaps relating to managing mercury in restored tidal marshes in the Bay. There was support for a regional approach to monitoring, with some sites selected for detailed investigation. Continued pilot studies and research may identify design features for some sites that minimize mercury in the food web.

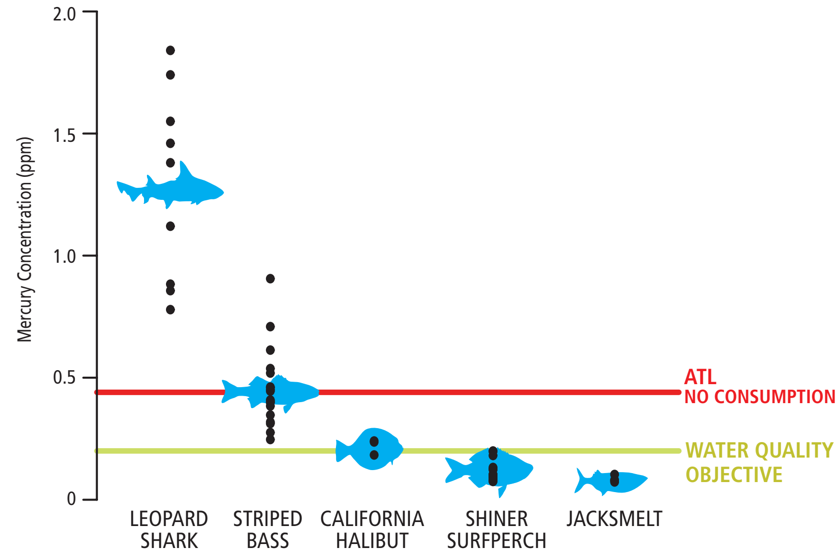
Findings to date from monitoring of marsh restoration projects in the North Bay (page 36) and South Bay indicate that opening ponds to tidal action is not leading to increases in food web mercury. Continued monitoring is needed to determine whether this can be considered a general pattern.

Mercury: Impairment

Striped bass from the Bay have the highest average mercury concentration measured for this species in US estuaries, and this degree of contamination has been constant for the past 40 years. Concern for human exposure to mercury has contributed to the need for an advisory for consumption of Bay sport fish.



Mercury concentrations (ppm) in striped bass from San Francisco Bay, 1971-2009. Bars indicate average concentrations. Points represent individual fish. Data from the RMP (1994-2009) and an earlier study (1971-1972). Additional details on page 61.



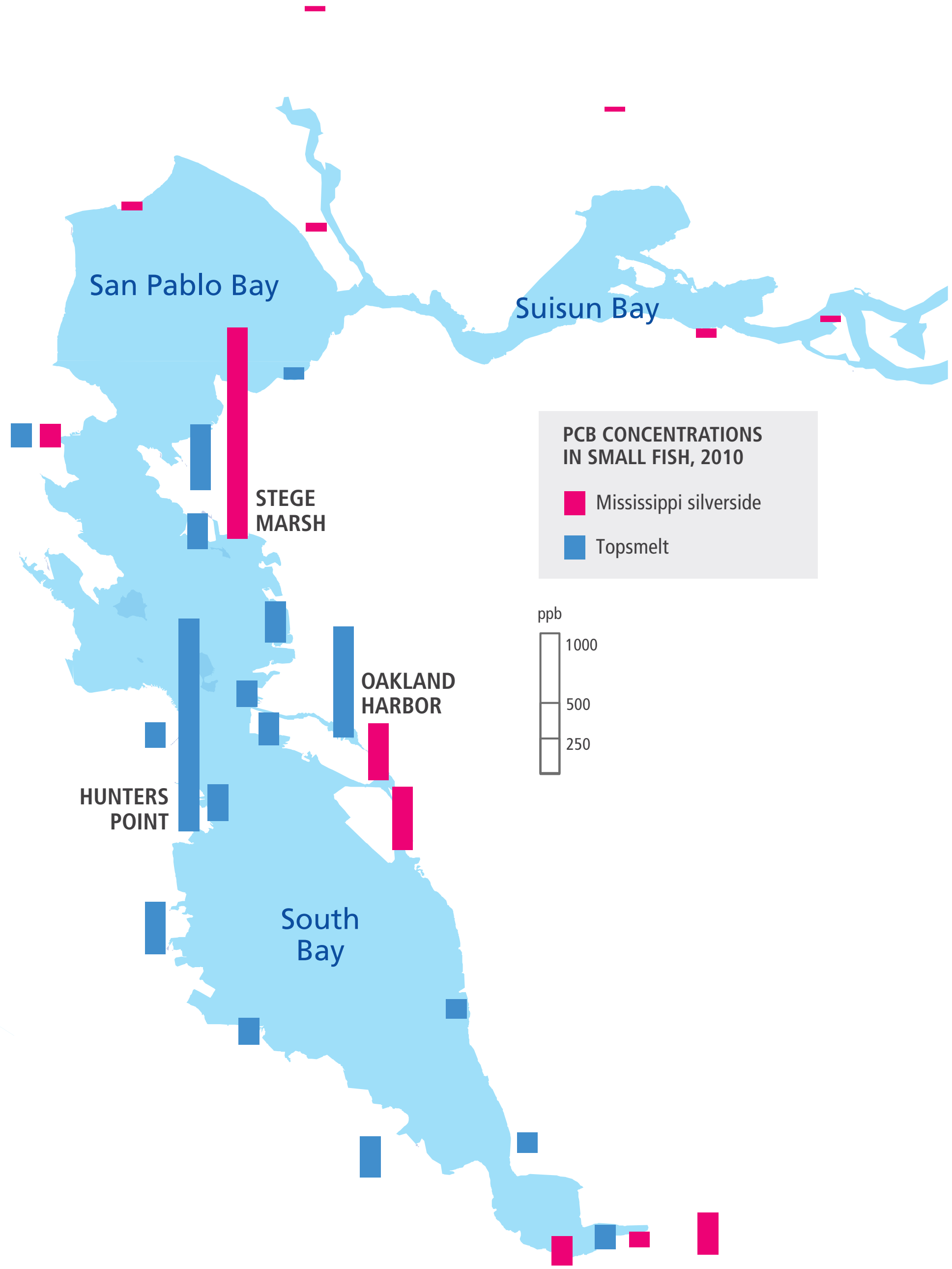
Mercury concentrations (ppm) in sport fish species in San Francisco Bay, 2009. Fish icons indicate average concentrations. Points represent individual samples (either composites or individual fish). Data from the RMP. Additional details on page 61.

In 2011 the California Office of Environmental Health Hazard Assessment (OEHHA) used RMP data collected between 1997 and 2009 to develop an updated and more comprehensive fish consumption advisory for the Bay. The advisory includes new species – Chinook salmon, jacksmelt, brown rockfish, and red rock crab – all of which had relatively low mercury levels. Only shark species exceeded OEHHA's advisory threshold for no consumption (0.44 ppm), although striped bass were close to this level. The advisory allows at least one eight ounce serving per week of all other species by women between the ages of 18 and 45 and children aged 1–17.

PCBs: Important New Findings

RMP monitoring of small fish along the margins of the Bay in 2010 enhanced our understanding of PCB contamination of the Bay food web and potential pathways of exposure for sensitive wildlife species such as birds and seals. Small fish collected on the Bay margins accumulate high concentrations of PCBs that correlate with concentrations in sediment and represent a pathway for impact on fish-eating wildlife. These data, along with data for shiner surfperch, point to several contaminated margin areas that are high priorities for management.

Recent studies identified PCB 11, a PCB that had been previously overlooked, as an ubiquitous contaminant owing to its widespread use in pigments in paint and ink in newspapers, magazines, and cardboard boxes. Based on the RMP data, PCB 11 that enters the Bay in wastewater and urban runoff is not persistent and is not accumulating in the food web. PCB 11 is a major PCB component in Bay water (3.7%, 6th most abundant congener) and urban runoff (2.8%, 8th), but is only 31st in Bay sediment (0.9%), and not in the top 40 in small fish or bivalves. PCB 11 should be considered separately from the Aroclor-derived PCBs that present risks to humans and wildlife.

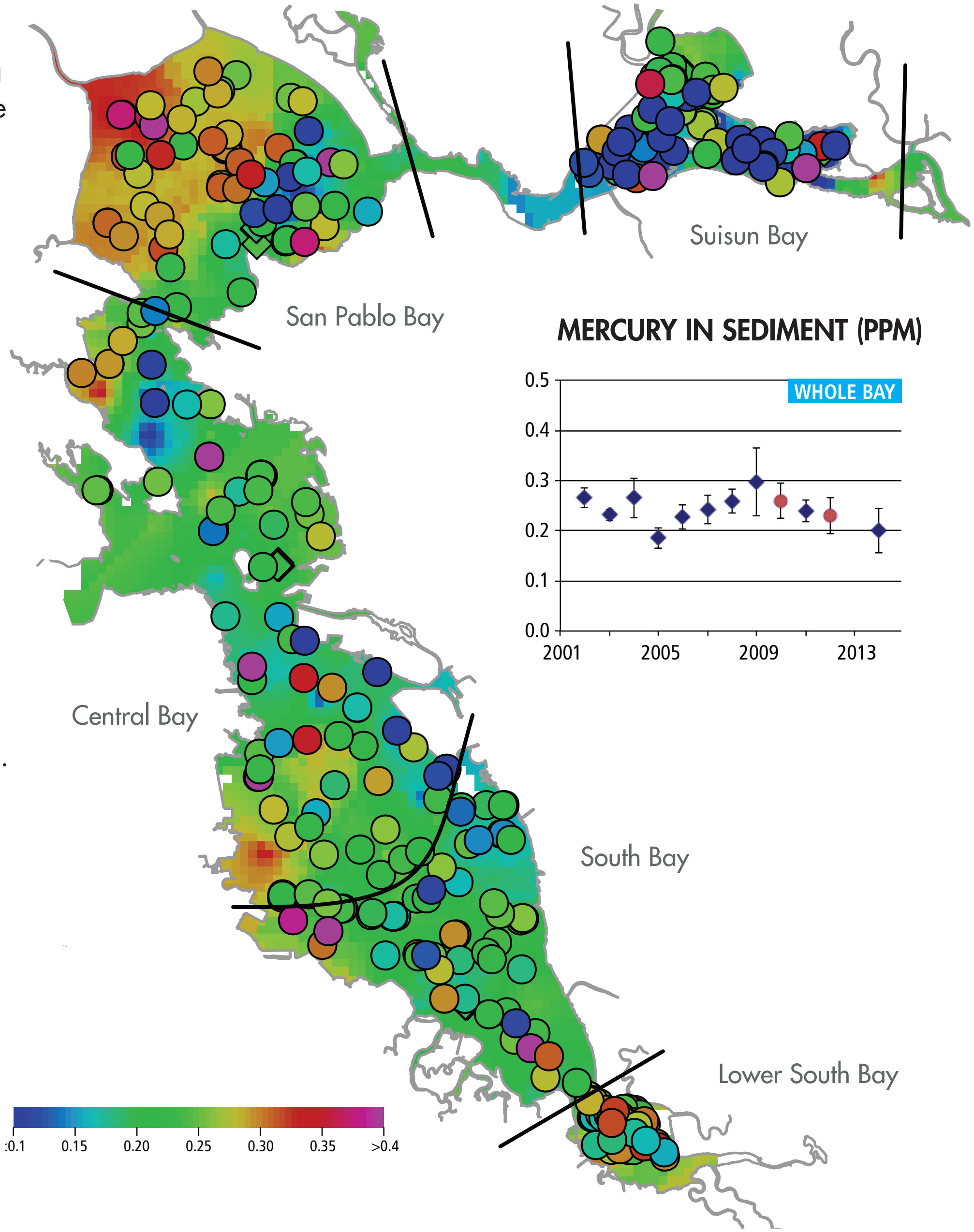


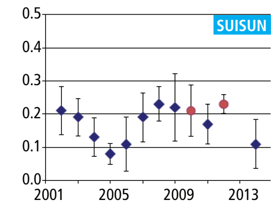
Data from the RMP. See page 61 for additional details.

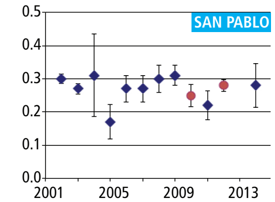
Mercury: Spatial and Temporal Patterns

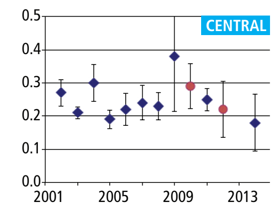
Mercury concentrations in Bay sediment do not appear to be increasing or decreasing. The Baywide average concentration in 2014 (0.20 ppm) was the second lowest over the 12 rounds of sampling, but this was largely driven by some very low values in Central Bay. The time series within the segments do not suggest trends.

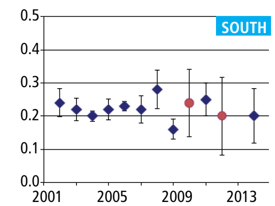
Average mercury concentrations in sediment have been highest in San Pablo Bay (0.27 ppm). Average concentrations have been slightly lower in Lower South Bay (0.26 ppm), Central Bay (0.25 ppm), and South Bay (0.22 ppm), and lowest in Suisun Bay (0.17 ppm). The Baywide average for the 10 rounds of dry season sampling was 0.24 ppm.

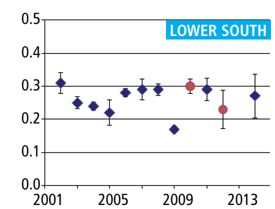








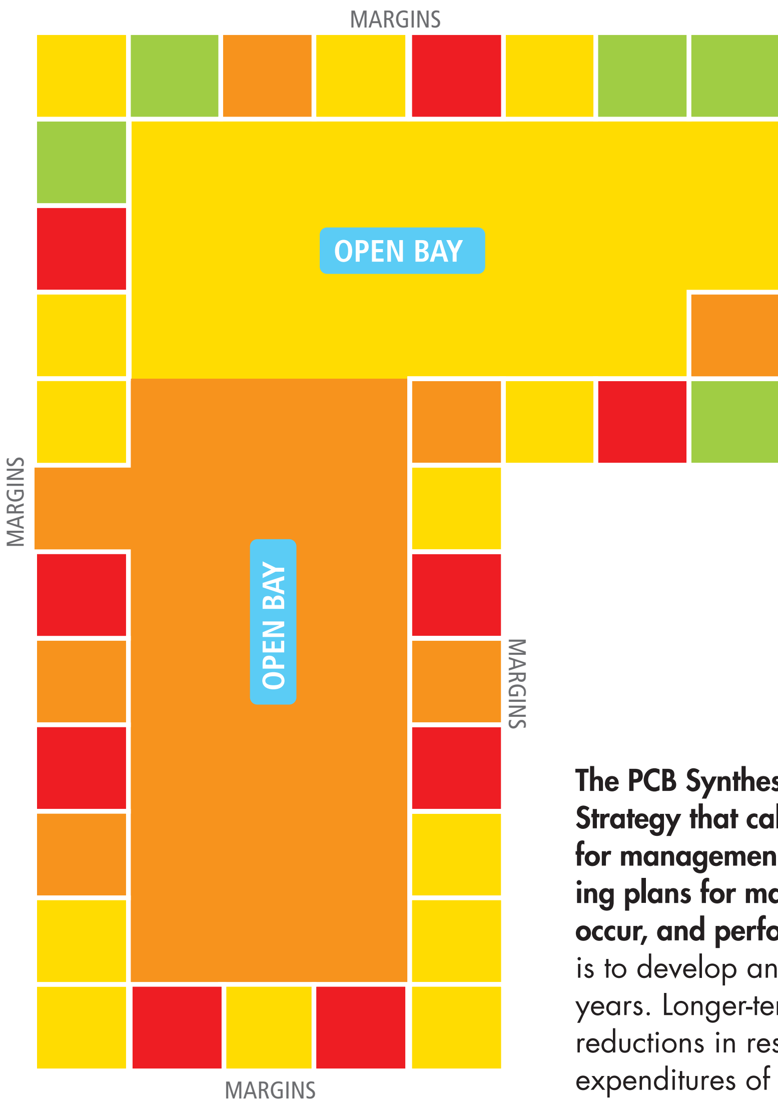


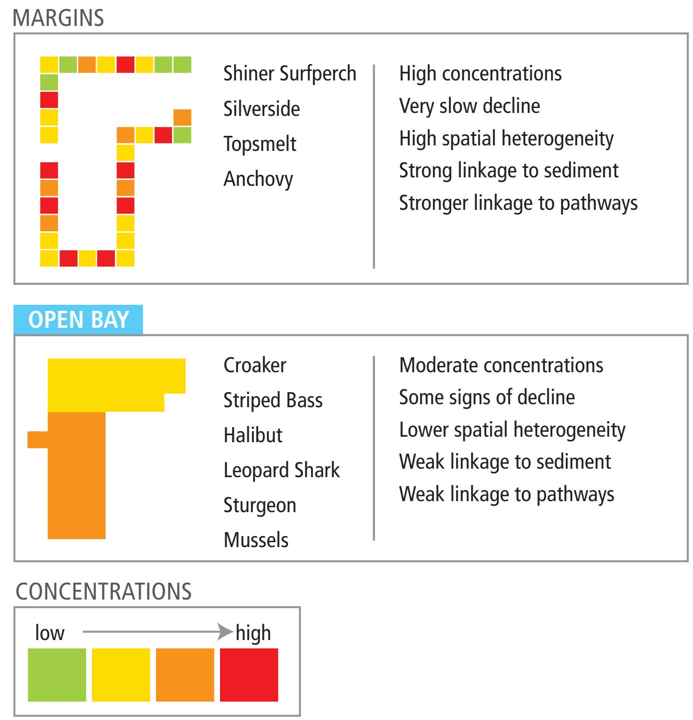


Contours and points on the map show all available dry season RMP data from 2002-2014. Trend plots show annual random-station means with error bars indicating the 95% confidence intervals of the means. Red circles on trend plots indicate wet season samples; other samples were dry season. Additional details on page 61.

PCBs: Next Steps

SCHEMATIC OF THE CONCEPTUAL MODEL FOR PCBS IN THE BAY

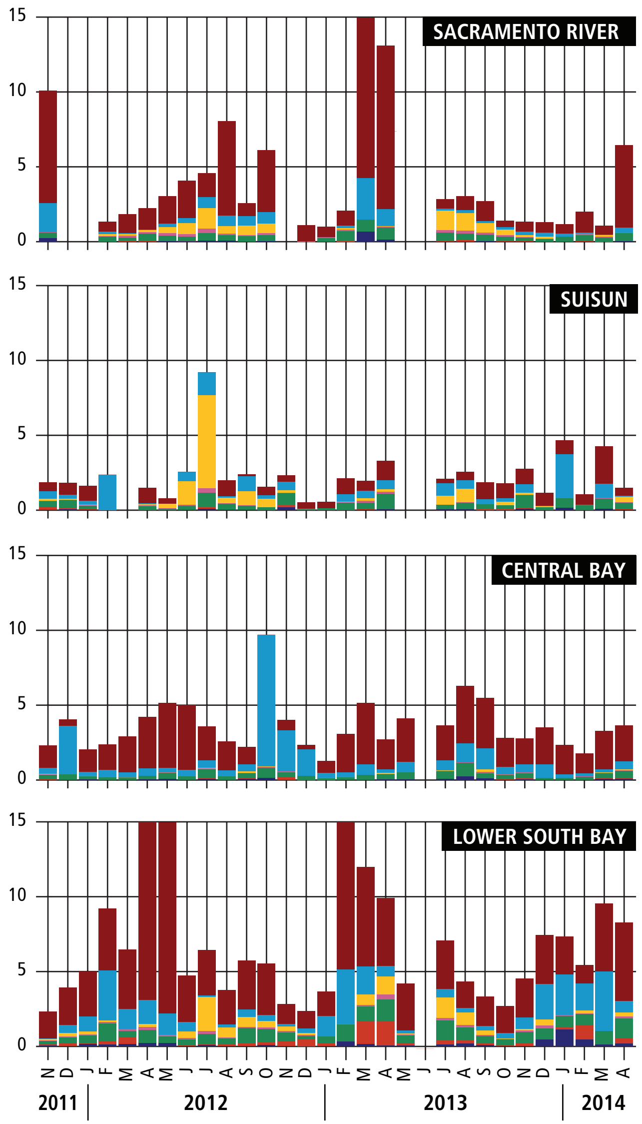




The PCB Synthesis (Davis et al. 2014) was the foundation for a 2014 update of the PCB Strategy that calls for a multi-year effort to identify margin areas that are high priorities for management and monitoring, develop site-specific assessments and optimized monitoring plans for margin areas downstream of watersheds where management actions will occur, and perform monitoring in these areas as a performance measure. The current plan is to develop and initiate monitoring for several priority margin areas over the next five years. Longer-term monitoring of these areas would then continue in order to detect PCB reductions in response to the actions taken. A thoughtful effort is warranted given the large expenditures of resources that will be needed to implement management actions to reduce PCB loads from urban stormwater.

Nutrients: Phytoplankton Community Composition and Toxins

ABUNDANCE OF PHYTOPLANKTON TYPES

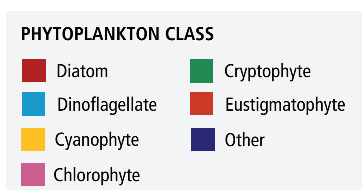


Chlorophyll a in µg/L. Data from M. Peacock (UC Santa Cruz). Additional details on page 61.

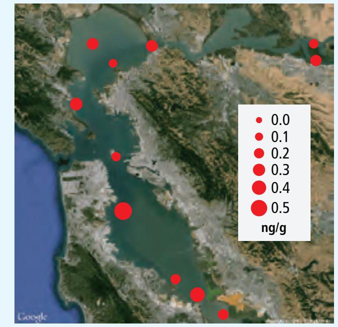
Phytoplankton are the base of the food web in San Francisco Bay. Both the amount of phytoplankton and the types of phytoplankton – the community composition – are highly relevant to the ecological status and function of the Bay, since different classes of phytoplankton can have different nutritional values. In addition, some phytoplankton produce toxins. Investigations are underway to characterize community composition in the Bay, identify the physical factors and chemical factors (including nutrients) that influence community composition and toxin production, and identify the most informative and efficient ways to monitor for these indicators of ecosystem health.

Different classes of phytoplankton have unique pigment fingerprints. Pigments can be measured in environmental samples and used to back-calculate the types of phytoplankton that are contributing to biomass. Pigment measurements are faster and more cost-effective than microscopy and also better estimate the abundance of some small classes that are difficult to see and may be underestimated by microscope (i.e., cyanophytes).

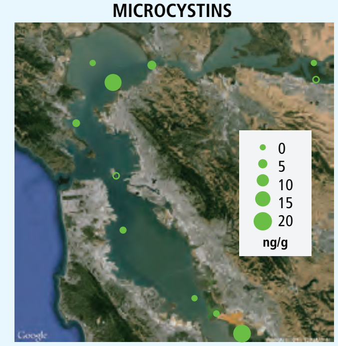
Three years of monthly phytoplankton community composition estimates (left) show considerable seasonal and spatial variability in phytoplankton assemblage. In general, diatoms tend to dominate, especially when chlorophyll is elevated, except in Suisun Bay where biomass is low and distributed among multiple classes.



DOMOIC ACID



MICROCYSTINS



Mussels were analyzed for the algal toxins domoic acid, microcystin, and saxitoxin in 2012. Domoic acid was detected at all sites, microcystin was detected at 10/11 sites, and saxitoxin (not shown) was detected at 5/11 sites. **Although these data suggest that toxins are ubiquitous, the concentrations were low relative to existing standards.** SFEI is working with UC Santa Cruz and the US Geological Survey to continue sampling for these toxins.