SAN FRANCISCO BAY, CA: *Comprehensive ecosystem evaluation needed to discern causes of chlorophyll a increases*

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San Francisco Bay is the largest estuary on the West Coast of the U.S., encompassing about 1,325 km² of open water, with a catchment of 119,181 km². About 40% of the land area of California drains into the bay through the Sacramento-San Joaquin River Delta (a large area of diked and drained swampland in the northern estuary). The southern embayments receive less than a tenth of the freshwater flow in comparison to the northern portion of the Bay. The Bay is shallow, with approximately one-sixth of its area exposed during high tides (mean tidal height 1.5 m) and another one-third of the total area less than 1.8 m deep and an overall mean depth of 5.6 m.

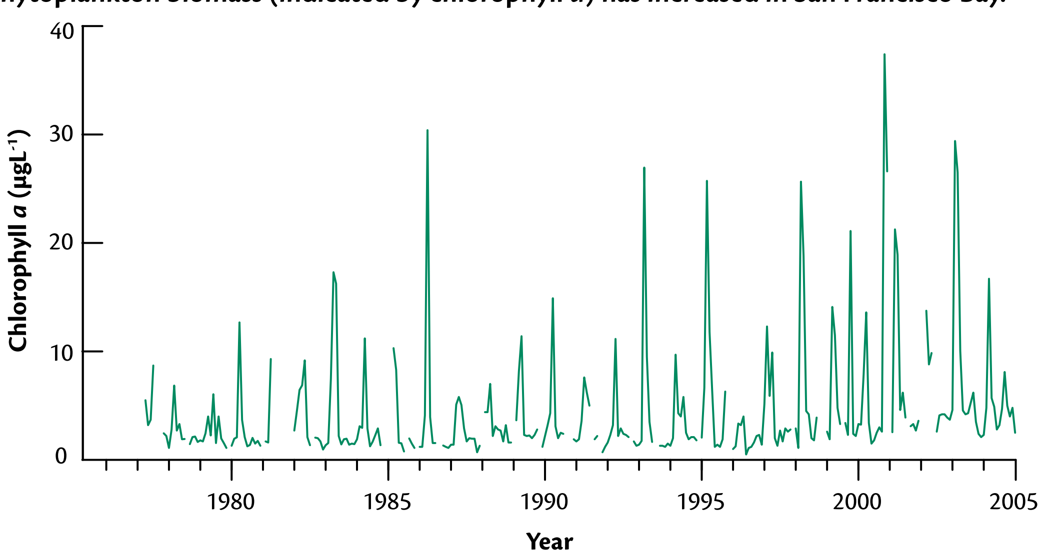
Phytoplankton biomass

Phytoplankton biomass in much of San Francisco Bay has increased by more than 5% per year from 1993–2004 (Figure 5.23) according to a new analysis by Jassby and Cloern (*www.sfei.org/rmp/pulse/2006/index.html*). They find that both the size of the bloom (particularly the fall bloom) and baseline chlorophyll *a* concentrations have significantly increased. During this time, modeled primary production has also doubled. Cloern and Jassby have listed eight possible mechanisms to account for the increased biomass (Figure 5.24). Only two of these—nutrient concentrations and stratification—can be eliminated as potential causes. Due to insufficient data, it is not possible to determine if the changes are due to introduced invertebrate carnivores. All the other possible mechanisms have changes that are consistent with the change in biomass.

History of phytoplankton biomass in this region

The U.S. Geological Survey (USGS) has conducted the San Francisco Bay Water Quality Program since 1969, one of the nation's longest-running time series of phytoplankton measurements by the USGS (*sfbay.wr.usgs.gov/access/wqdata/*). Earlier publications from Cloern et al. show that the bay had low phytoplankton biomass relative to its high nutrient concentrations. Cloern hypothesized that the Bay was not nutrient limited, but light limited because of low water clarity caused by riverine sediment inputs and tidal- and wind-resuspension in shallow habitats. In the mid-1980s, phytoplankton concentrations in brackish habitats were dramatically reduced by the introduction of the Asiatic clam (*Corbula amurensis*). Observations over the past decade reveal increased phytoplankton biomass in marine domains of the Bay.

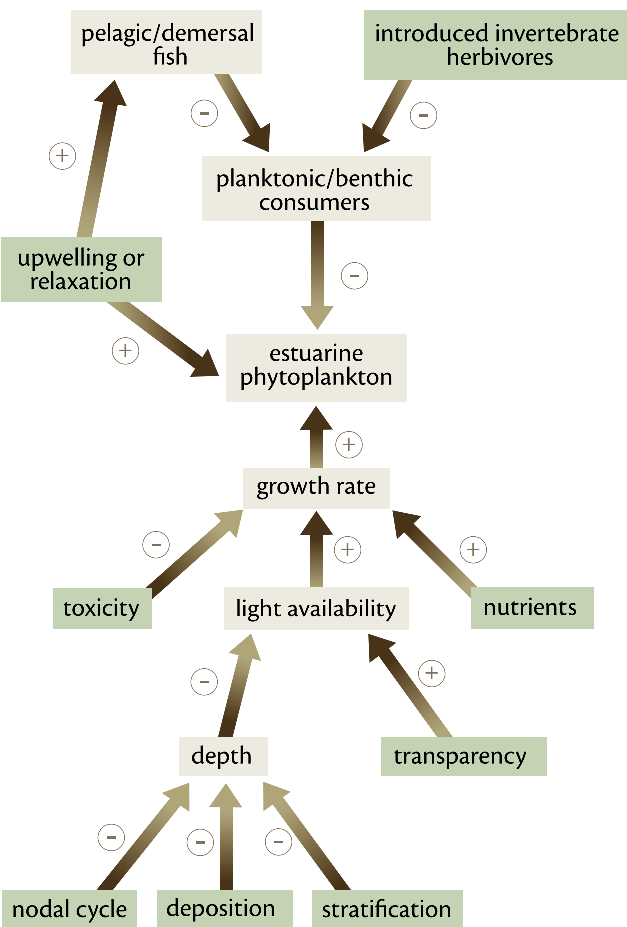
Figure 5.23. Phytoplankton biomass (indicated by chlorophyll *a*) has increased in San Francisco Bay.



Management concerns

The first question about the trend in phytoplankton biomass is whether it is desirable. There is no evidence of concomitant dissolved oxygen problems, but some evidence of increased harmful algal blooms (HABS). On the other hand, the bay fishery is quite depauperate and increased algal production at the right times of the year could be beneficial. The second question is how management actions are affecting the trend. Management actions in the past 20 years may be responsible for the trends. The loads of toxic contaminants, particularly metals and ammonium that could inhibit phytoplankton production, have declined significantly. Improved watershed management and damming of rivers are probably responsible for the reduction in sediment loads to the bay and increased light penetration.

Figure 5.24. The eight possible mechanisms affecting estuarine phytoplankton biomass.*



The eight mechanisms that may account for the increase of phytoplankton biomass in San Francisco Bay (green boxes). Changes in these mechanisms are consistent with observed changes in biomass. However, it is difficult to determine what, if any, impact introduced invertebrate herbivores have on phytoplanton biomass (Cloern et al. 2006).

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Water quality monitoring in San Francisco Bay.

Future outlook

The massive restoration of Bay Area wetlands (goal of ~100,000 acres) will potentially change the bay's light limitation and thereby its phytoplankton biomass. USGS's South Bay suspended sediment model predicts that increases in wetland area (as proposed under the South Bay Salt Pond Project) could result in increased sediment deposition onto wetlands and a subsequent decrease in suspended sediments in the water column. Increased light penetration could result in higher phytoplankton productivity.

Implications for other systems

The switch of the Bay from a light-limited to a nutrient-limited system as a result of restoration projects along its edges has implications to other systems with large-scale restoration projects.

References

Cloern, J.E. and A.D. Jassby. (In press). What is Causing the Phytoplankton Increase in San Fransico Bay? 2006 Pulse of the Estuary. San Francisco Estuary Institute.

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