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Novel analyses of long-term data provide a scientific basis for chlorophyll-a thresholds in San Francisco Bay

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ABSTRACT

San Francisco Bay (SFB), USA, is highly enriched in nitrogen and phosphorus, but has been resistant to the classic symptoms of eutrophication associated with over-production of phytoplankton. Observations in recent years suggest that this resistance may be weakening, shown by: significant increases of chlorophyll- a (*chl-a*) and decreases of dissolved oxygen (DO), common occurrences of phytoplankton taxa that can form Harmful Algal Blooms (HAB), and algal toxins in water and mussels reaching levels of concern. As a result, managers now ask: what levels of *chl-a* in SFB constitute tipping points of phytoplankton biomass beyond which water quality will become degraded, requiring significant nutrient reductions to avoid impairments? We analyzed data for DO, phytoplankton species composition, *chl-a*, and algal toxins to derive quantitative relationships between three indicators (HAB abundance, toxin concentrations, DO) and *chl-a*. Quantile regressions relating HAB abundance and DO to *chl-a* were significant, indicating SFB is at increased risk of adverse HAB and low DO levels if *chl-a* continues to increase. Conditional probability analysis (CPA) showed *chl-a* of 13 mg m⁻³ as a “protective” threshold below which probabilities for exceeding alert levels for HAB abundance and toxins were reduced. This threshold was similar to *chl-a* of 13-16 mg m⁻³ that would meet a SFB-wide 80% saturation Water Quality Criterion (WQC) for DO. Higher “at risk” *chl-a* thresholds from 25 to 40 mg m⁻³ corresponded to 0.5 probability of exceeding alert levels for HAB abundance, and for DO below a WQC of 5.0 mg L⁻¹ designated for lower South Bay (LSB) and South Bay (SB). We submit these thresholds as a basis to assess eutrophication status of SFB and to inform nutrient management actions. This approach is transferrable to other estuaries to derive *chl-a* thresholds protective against eutrophication.

Full Text

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