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Looking Ahead: Nutrients and Hypoxia

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4.5 Nutrients and Hypoxia

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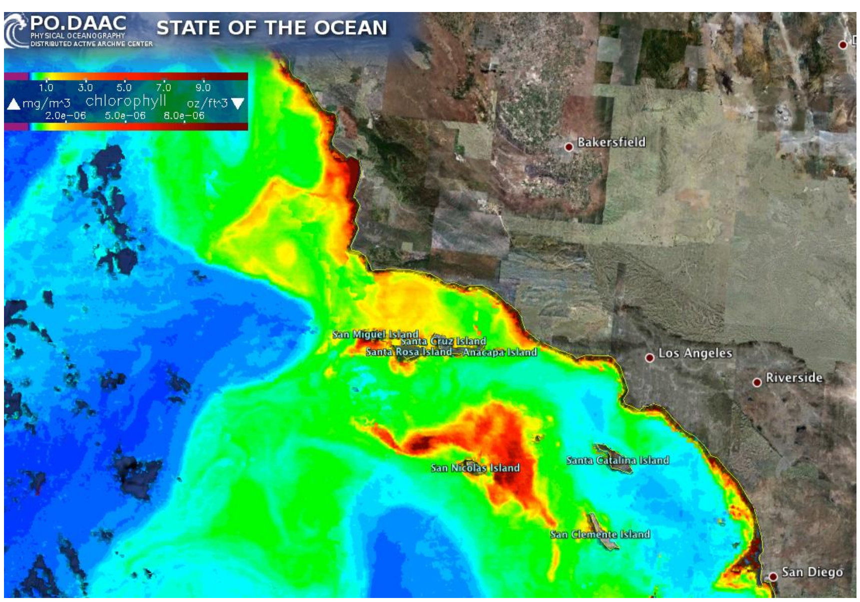
Human, or 'anthropogenic', activities have accelerated the rate and extent of **eutrophication** through both point-source discharges and non-point loadings of limiting nutrients, such as nitrogen, iron, and phosphorus, into aquatic ecosystems through urban stormwater runoff, agricultural fertilizers, livestock operations, aquaculture, atmospheric deposition, wastewater treatment plants, and septic systems. Eutrophication can lead to intense algal blooms (Figure 4.5-1) including harmful algal blooms (HABs) that result in wildlife mortality and the contamination of shellfish (Sidebar 4.5). In upwelling-dominated ecosystems like Santa Monica Bay, untangling the relative influence of natural (i.e., upwelling) versus anthropogenic nutrient sources in coastal waters has proven to be complex. For these ecosystems, there has been a perception that nutrient inputs from anthropogenic sources are small relative to upwelling, and thus can have little effect on important coastal biogeochemical processes (nearshore productivity, hypoxia, and coastal acidification). However, the results from several recent studies (described below) cast doubt on this assumption and provide multiple lines of evidence that human-derived nutrients are influencing ecological conditions in Santa Monica Bay and the rest of the Southern California Bight (SCB).

Eutrophication is characterized by excessive plant and algal growth due to the increased availability of one or more limiting growth factors needed for photosynthesis, such as sunlight, carbon dioxide, and nutrient fertilizers.

Figure 4.5-1. Example of intense algal bloom in Southern California. The yellow to red colors indicate high levels of chlorophyll (indication of phytoplankton biomass), extending well offshore as well as in narrow bands next to the coastline. In this image, the northern portion of Santa Monica Bay is impacted. *Image from Physical Oceanography Distribution Active Archive Center et al. 2011.*



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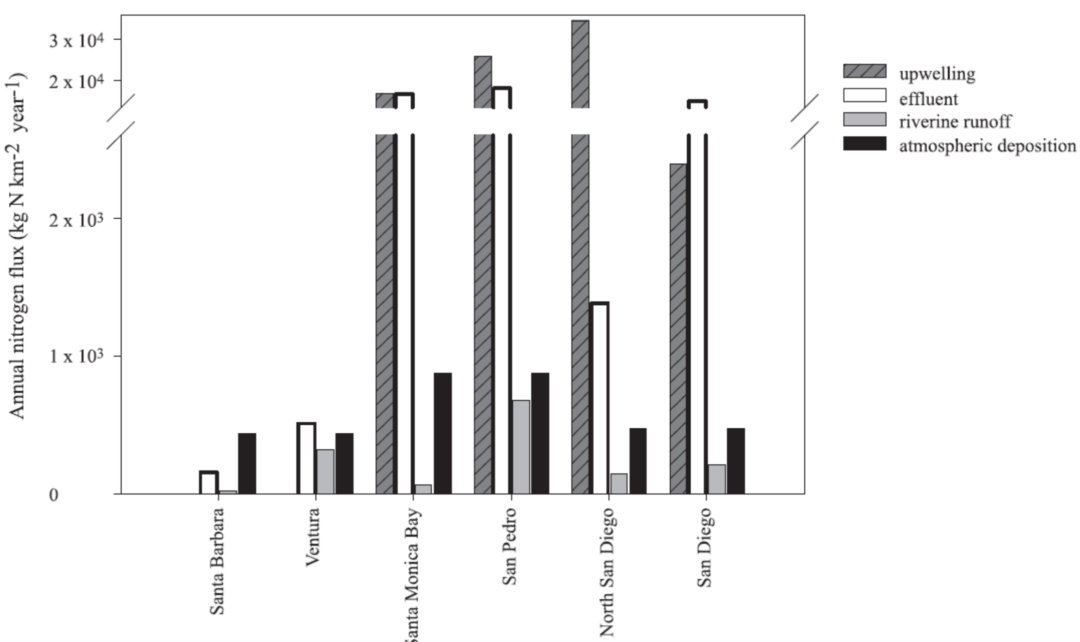
Municipal coastal wastewater dischargers, along with Southern California Coastal Water Research Project (SCCWRP), have conducted several joint special studies as part of the Southern California Bight Regional Monitoring Program (Bight) to understand the impacts of anthropogenic nutrient inputs into the SCB, including Santa Monica Bay. The Bight '03 study determined that *Pseudo-nitzschia*, a potentially harmful alga that can produce the neurotoxin domoic acid, was significantly more abundant than previously reported throughout the SCB (Nezlin et al. 2007). The Bight '08 study observed high rates of nitrification (the biological transformation of ammonia, the dominant nitrogen form in effluent, to nitrate, a more biologically usable form of nitrogen), which indicated that a significant source of nitrate came from effluent ammonia (Howard et al. 2012). Additionally, there was evidence of effluent nutrients in two trophic levels of the food web (primary producers and zooplankton), indicating that primary producers are utilizing wastewater effluent for growth. Model results also showed that on small spatial scales (~75-100 km of coastline and ~15-25 km offshore), relevant to the development of algal blooms, available nitrogen derived from effluent was comparable or greater than that from upwelling near large wastewater outfalls, whereas riverine runoff and atmospheric deposition were determined to be 1-3 orders of magnitude smaller (Howard et al. 2014, Figure 4.5-2). However, a pilot isotope study conducted in the spring of 2008, during peak upwelling, indicated that effluent nitrate comprised less than 10% of the available nitrate, suggesting that the effects of effluent nitrogen on the nearshore environment may have strong seasonality. Upcoming analysis from Bight '13 will use isotopic markers to distinguish between nitrogen sources and validate model results.

Figure 4.5-2. Total annual nitrogen inputs into each of the six subregions in the southern California Bight, attributed to different sources. Effluent and upwelling are the two most important contributions of nitrogen in Santa Monica Bay. *Figure from Howard et al., 2014.*



Algal blooms can rapidly deplete the available oxygen in surface waters. Recent historical analyses of dissolved oxygen concentrations in the Bay and elsewhere in the SCB compared data collected in the nearshore by the municipal coastal wastewater dischargers with those collected offshore by the California Cooperative Oceanic Fisheries Investigations (CalCOFI). This analysis revealed that dissolved oxygen concentrations have declined throughout the Southern California Bight. However, the rates of decline in the nearshore areas were observed to be up to four times faster than offshore waters, which were concomitant with increased phytoplankton biomass (Booth et al. 2014).

Eutrophication can stimulate hypoxic conditions *and* acidification (see Section 4.4) for more on ocean acidification) in the nearshore when aerobic bacteria break down phytoplankton after a bloom (Zhang et al. 2010, Cai et al. 2011). This process draws down oxygen and generates CO_2, lowering pH in deeper waters where aeration does not occur. However, because the increased atmospheric CO_2 is also driving decreases in pH that are observed in upwelled waters, it is unclear at this time whether the nearshore declines that have been documented are a result of upwelled or anthropogenic nutrient inputs.

The Hyperion Water Reclamation Plant (Hyperion hereafter, discharging in the middle of Santa Monica Bay) and the Joint Water Pollution Control Plant (JWPCP, discharging off Palos Verdes Shelf) recently conducted a special study in Santa Monica Bay. The study assessed existing effluent and receiving water nutrient data to quantify any direct effects of effluent nutrients on the dissolved oxygen (DO), pH, and percent light transmission (LT) of receiving waters (SDLAC and LAC-EMD 2014). A localized effluent effect was detectable, but was within regulatory compliance. It is important to emphasize that the existing dataset cannot answer questions about indirect effects of wastewater nutrient inputs into the coastal environment, which was the impetus for the focus of the Bight projects. While overall nutrient emissions have steadily declined over the last several decades, which would suggest that any recent declines in regional DO, pH, and LT are not being driven by effluent discharges, nitrogen in the form of ammonia did not decrease with the implementation of full-secondary treatment and could be a factor in the declining DO and pH.

The California Ocean Plan (SWRCB 2015) identifies regulatory limits for declines in DO, pH, light transmission, and increases in ammonia around an outfall.

In summary, these studies have provided multiple lines of evidence that anthropogenic nutrients are altering the ecological conditions in the SCB, including the Bay. However, the exact magnitude of the impact of anthropogenic nutrients, and the relative role of different sources, or forms (i.e. ammonia, nitrate, nitrite) has yet to be determined. The Southern California POTWs, including Hyperion and the JWPCP, are in the process of purchasing several ocean moorings, equipped with water quality sensors, to allow staff researchers to have their fingers on the pulse of the Southern California Bight. To insure compliance with California Ocean Plan standards, the relative influence of anthropogenic nutrients on primary production and nutrient cycling must be resolved, and is therefore the focus for the Bight ’13 Nutrients Study. The Program will assess the reliability of the existing pH time series data and collecting precise discrete pH and carbonate chemistry samples in collaboration with researchers at Scripps Institution of Oceanography, as well as working with coastal modelers across the Pacific Coast to estimate secondary effects of anthropogenic nutrient sources. This information will help inform whether further management actions are warranted.

References

Booth, J.A.T., C.B. Woodson, M. Sutula, F. Micheli, S.B. Weisberg, S.J. Bograd, A. Steele, et al. (2014). “Patterns and potential drivers of declining oxygen content along the Southern California coast.” Limnology and Oceanography 59(4):1–14. DOI:10.4319/lo.2014.59.4.0000.

Cai, W-J, X. Hu, W-J Huang, M.C. Murrell, J.C. Lehrter, S.E. Lohrenz, W-C Chou, et al. (2011). “Acidification of subsurface coastal waters enhanced by eutrophication.” Nature Geoscience 4(11):766-770. DOI:10.1038/ngeo1297.

Howard, M.D.A., G. Robertson, M. Sutula, B.H. Jones, N.P. Nezlin, Y. Chao, H. Frenzel, et al. (2012). Southern California Bight 2008 Regional Monitoring Program: VII. Water Quality. Costa Mesa, CA: Southern California Coastal Water Research Project. Technical Report #710.

Howard, M.D.A., M. Sutula, D.A. Caron, Y. Chao, J.D. Farrara, H. Frenzel, B. Jones, et al. (2014). “Anthropogenic nutrient sources rival natural sources on small scales in the coastal waters of the Southern California Bight.” Limnology and Oceanography 59(1):285–97. DOI:10.4319/lo.2014.59.1.0285.

Nezlin, N.P., P.M. DiGiacomo, S.B. Weisberg, D.W. Diehl, J.A. Warrick, M.J. Mengel, B.H. Jones, et al. (2007). Southern California Bight 2003 Regional Monitoring Program: V. Water Quality. Costa Mesa, CA: Southern California Coastal Water Research Project. Technical Report #528.

Physical Oceanography Distribution Active Archive Center, Jet Propulsion Laboratory, California Institute of Technology, and National Aeronautics and Space Administration. (2011). “Coastal upwelling and harmful algal blooms in Southern California (September-October 2011).” <http://podaac.jpl.nasa.gov/OceanEvents/HAB_SC_September-October2011> [Accessed on 3 April 2015].

Sanitation Districts of Los Angeles County (SDLAC) Ocean Monitoring and Research Group, and City of Los Angeles Bureau of Sanitation Environmental Monitoring Division (LAC-EMD) (2014). Nutrient Loading and Receiving Water Impacts: Nutrients, Treatment Levels, and Effects on DO, pH and Light Transmission of Ocean Receiving Waters at the Joint Water Pollution Control Plant and Hyperion Treatment Plant, 1994-2011. Special Study.

State Water Resources Control Board. (SWRCB) (2015). California Ocean Plan: Water Quality Control Plan, Ocean Waters of California, Appendix A (Draft 150320).

Zhang, J., D. Gilbert, A.J. Gooday, L. Levin, S.W.A. Naqvi, J.J. Middelburg, M. Scranton, et al. (2010). “Natural and human-induced hypoxia and consequences for coastal areas: Synthesis and future development.” Biogeosciences 7(5):1443–67. doi:10.5194/bg-7-1443-2010.