

# Why Ocean Acidification Matters to California, and What California Can Do About It:

A REPORT ON THE POWER OF CALIFORNIA'S STATE GOVERNMENT  
TO ADDRESS OCEAN ACIDIFICATION IN STATE WATERS



## Table of Relevant Administrative Agencies

California Air Resources Board, 5, 12, 27, 29, 31  
California Coastal Commission, 5, 12, 16, 18, 23, 24, 26, 28, 29  
California Department of Fish & Game, 5, 23, 35  
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State Water Resources Control Board, 5, 12, 13, 14, 15, 16, 18, 23, 24, 33  
U.S. Environmental Protection Agency, 12, 13, 14, 15, 16, 19, 21, 22, 24, 25, 27, 29

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# Executive Summary

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California's ocean is becoming more acidic as a result of increased atmospheric carbon dioxide (CO<sub>2</sub>) and other pollutants. This fundamental change is likely to have substantial ecological and economic consequences for California and worldwide.<sup>4</sup>

This document is intended to be a toolbox for understanding and addressing the drivers of an acidifying ocean. We first provide an overview of the relevant science, highlighting known causes of chemical change in the coastal ocean. We then feature a wide variety of legal and policy tools that California's government agencies can use to mitigate the problem.

The State has ample legal authority to address the causes of ocean acidification; what remains is to implement that authority to safeguard California's iconic coastal resources.

<sup>4</sup> See Pacific Shellfish Growers Association, Emergency Plan to Save Oyster Production on the West Coast (January, 2009), available at <http://www.pcsqa.org/pub/science/> (an industry group, citing a "critical shortage" of oyster seed for shellfish farms in Washington, Oregon, and California). See also S.R. Cooley *et al.*, Nutrition and Income from Molluscs Today Imply Vulnerability to Ocean Acidification Tomorrow, *Fish and Fisheries* 1 (2011); S.R. Cooley and S.C. Doney, Anticipating Ocean Acidification's Economic Consequences for Commercial Fisheries, 4 *Environmental Research Letters* 024007 (2009).

# Introduction

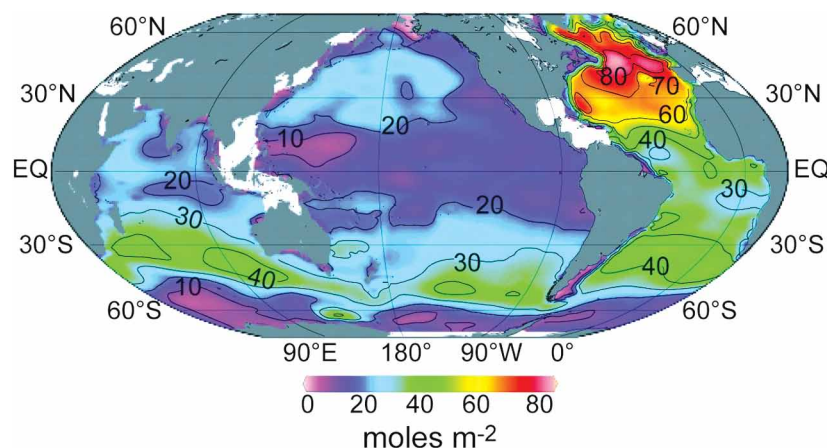


Wolcott Henry 2005/Marine Photobank

California depends heavily upon its ocean resources for economic and societal well-being. As of 2008, 75% of Californians lived in coastal counties, and the ocean economy accounted for \$39 billion and at least 434,000 jobs.<sup>5</sup> Industries that directly depend upon coastal water quality include beach tourism, scuba diving, recreational and commercial fishing, and shellfish aquaculture. Despite the importance of healthy ocean resources to California, State government agencies have taken little notice of the remarkable changes to ocean chemistry that are taking place.

The oceans function as a sink for pollutants generally, and they have absorbed roughly one-third of the CO<sub>2</sub> produced by human activities in the industrial era.<sup>6</sup> Oceans worldwide have become 30% more acidic since the Industrial Revolution, as a result of the chemical byproducts of modern industrial activity, such as CO<sub>2</sub> and other pollutants.<sup>7</sup> This process is called acidification. In California, evidence of these chemical changes is already apparent.<sup>8</sup>

California will need to work proactively to mitigate the causes and effects of ocean acidification, and to adapt to the changes that are inevitable. Fortunately, California's existing laws afford several "off-the-shelf" tools that State agencies can use towards these goals. Because CO<sub>2</sub> is the major driver of ocean acidification,<sup>9</sup> the most important weapon in California's arsenal is the ongoing effort to curb CO<sub>2</sub> emissions via AB32, SB375, and related laws; but a wide variety of auxiliary laws bearing on coastal management and water quality are important to curb the local causes that exacerbate acidification within State waters.



The ocean's inventory of anthropogenic  $\text{CO}_2$  ( $\text{mol m}^{-3}$ ). Note that the degree of  $\text{CO}_2$  absorption varies over space; deep water formation in the North Atlantic results in especially high  $\text{CO}_2$  absorption.

Source: Sabine *et al.*, The oceanic sink for anthropogenic  $\text{CO}_2$ , 305 *Science* 367 (2004).

In this document, we outline a number of strategies for combating ocean acidification, making use of State laws and State-administered Federal laws. This emerging threat is intimately tied to existing State environmental priorities including reducing  $\text{CO}_2$  emissions and improving water quality. These parallels create economic efficiencies, such that governments can apply the same remedies towards multiple complementary environmental goals with minimal additional expenditures. We hope that this Report will be of immediate practical value to State agencies and legislators trying to honor a mandate to safeguard public natural resources<sup>10</sup> while under demanding budgetary constraints. We welcome feedback on this document, especially as scientific research progresses and we develop more comprehensive information about the dimensions of ocean acidification as an environmental challenge.

<sup>5</sup> Statistics available at <http://www.oceaneconomics.org>. See also, Brian E. Baird and Amber J. Mace, *Ocean Ecosystem Management: Challenges and Opportunities for Regional Ocean Governance*, 16 *Duke Envtl. L. & Pol'y F.* 217, 291 (2006), citing J. Kildow & C. Colgan, *California's Ocean Economy: Report to the Resources Agency, State of California* 21 (2005), available at [http://resources.ca.gov/press\\_documents/CA\\_Ocean\\_Econ\\_Report.pdf](http://resources.ca.gov/press_documents/CA_Ocean_Econ_Report.pdf).

<sup>6</sup> R. Feely *et al.*, Evidence for Upwelling of Corrosive "Acidified" Water onto the Continental Shelf, 320 *Science* 1490 (2008); this represents approximately 127 billion metric tons of carbon. *Id.*

<sup>7</sup> S. Doney, The Growing Human Footprint on Coastal and Open-Ocean Biogeochemistry, 328 *Science* 1512 (2010).

<sup>8</sup> R. Feely *et al.*, *supra* note 6. Subsequent interviews with Feely and other researchers are in accord, e.g., Interview with Richard Feely, NOAA Senior Scientist, in Seattle (Nov. 8, 2011); interview with Bruce Menge, Distinguished Professor of Marine Biology, Oregon State University, at Stanford University (Jan. 19, 2012).

<sup>9</sup> S.C. Doney *et al.*, Ocean Acidification: The Other  $\text{CO}_2$  Problem, 1 *Ann. Rev. Mar. Sci.* 169 (2009).

<sup>10</sup> The list of agencies charged with conserving California's natural resources is long. It includes at least the Natural Resources Agency (<http://resources.ca.gov>), the California Coastal Commission (<http://www.coastal.ca.gov>), the Bay Conservation and Development Corporation (<http://www.bcdc.ca.gov>), the State Lands Commission (<http://www.slc.ca.gov>), the Department of Fish & Game (<http://dfg.ca.gov>), the Fish & Game Commission (<http://www.fgc.ca.gov>), the California Air Resources Board (<http://www.arb.ca.gov>), the Coastal Conservancy (<http://scc.ca.gov>), the Ocean Protection Council (<http://www.opc.ca.gov>), and the State Water Resources Control Board (<http://www.swrcb.ca.gov>).





## II ■ The Science in Brief

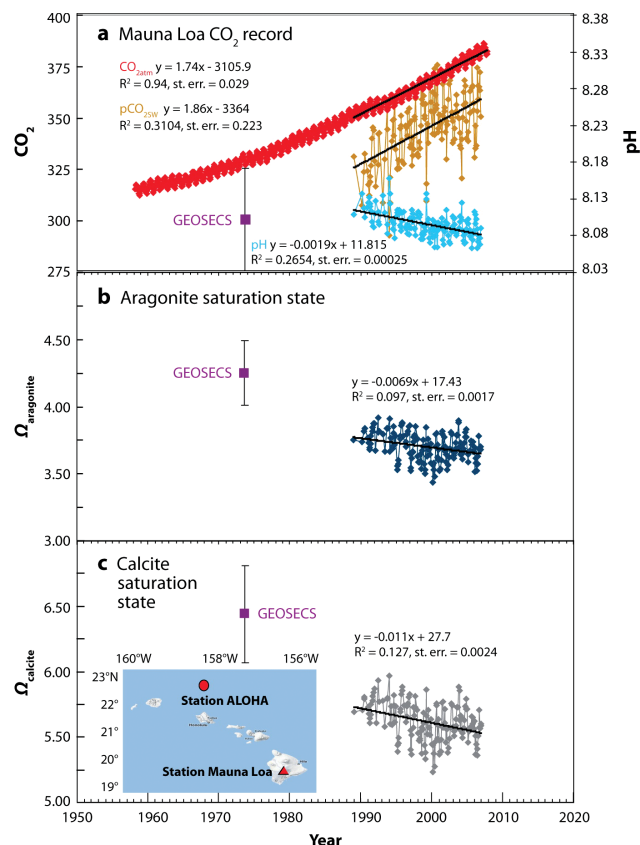
Dale Roberts/Gulf of the Farallones NIMS NOAA/CBNIMS

### Chemistry

Worldwide, oceans have become significantly more acidic in the past century.<sup>11</sup> This change threatens to disrupt large-scale marine ecosystems and the economic and social activities that depend upon those ecosystems,<sup>12</sup> in part because the shells and other hard parts of marine animals dissolve more readily in more acidic water.<sup>13</sup> Acidified water from the deep ocean is also reaching into shallower depths than in the past,<sup>14</sup> and because the rate at which atmospheric CO<sub>2</sub> is increasing continues to accelerate, the rate at which we are changing the oceans' chemistry is accelerating in kind.<sup>15</sup> These changes are now well-documented, and there is a broad scientific consensus that increasing atmospheric CO<sub>2</sub> is the primary mechanism driving the observed change. Deposition of sulfur oxides (SO<sub>x</sub>) and nitrogen oxides (NO<sub>x</sub>)—familiar as the causes of acid rain—also directly lower ocean pH, and may strongly influence the chemistry of coastal waters as a result of local production by heavy industry.<sup>16</sup>

Indirect drivers of ocean acidification include nutrient runoff, which plays an important role in altering marine carbonate chemistry.<sup>17</sup> Nutrient pollution causes local acidification through feedback loops involving biological growth, metabolism, and decay, over and above that which would occur in the absence of nutrient input from humans.<sup>18</sup> These processes use more oxygen than they produce, causing oxygen minimum zones (“dead zones”), and resulting in locally-acidified waters.<sup>19</sup> More acidic, lower-oxygen waters are likely to have both chronic and acute environmental impacts, including a decline in biomass productivity important to fisheries.<sup>20</sup>





As atmospheric carbon dioxide increases, ocean pH decreases accordingly. Time series of: (a) atmospheric  $\text{CO}_2$  at Mauna Loa (in parts per million volume, ppmv) (red), surface ocean pH (cyan), and  $\text{pCO}_2$  ( $\mu\text{atm}$ ) (tan) at Ocean Station ALOHA in the subtropical North Pacific Ocean; and (b) aragonite saturation (dark blue) and (c) calcite saturation (gray) at Station ALOHA. Note that the increase in oceanic  $\text{CO}_2$  over the past 17 years is consistent with the atmospheric increase within the statistical limits of the measurements. Mauna Loa data courtesy of Dr. Pieter Tans, National Oceanic and Atmospheric Administration/Earth System Research Laboratory (<http://www.esrl.noaa.gov/gmd/ccgg/trends/>); Hawaii Ocean Time-Series (HOT)/ALOHA data courtesy of Dr. David Karl, University of Hawaii (<http://hahana.soest.hawaii.edu>). Geochemical Ocean Section Study (GEOSECS) data are from a station near Station ALOHA collected in 1973; GEOSECS data from Takahashi et al. (1980).

Source: Doney et al. 2009. Ocean acidification: The other  $\text{CO}_2$  problem. *Annual Review of Marine Science* 1: 169–192. Reprinted, with permission, from the *Annual Review of Marine Science*, Volume 1 © 2009 by Annual Reviews [www.annualreviews.org](http://www.annualreviews.org).

<sup>11</sup> See Doney et al. (2009), *supra* note 9.

<sup>12</sup> *Id.*

<sup>13</sup> *Id.*

<sup>14</sup> This is known as “shoaling” of more corrosive waters; see, e.g., C. Hauri et al., Ocean Acidification in the California Current System, 22 *Oceanography* 61, 69 (2009). Note that more acidic water from the deep ocean routinely comes to the surface near the coastal margins as a result of normal upwelling processes, but that increased amounts of dissolved  $\text{CO}_2$  in the ocean can lead to more pervasive intrusion of these more acidic waters into shallower depths.

<sup>15</sup> K. Caldeira & M.E. Wickett, Anthropogenic Carbon and Ocean pH, 425 *Nature* 365 (2003).

<sup>16</sup> S.C. Doney et al., Impact of Anthropogenic Atmospheric Nitrogen and Sulfur Deposition on Ocean Acidification and the Inorganic Carbon System, 104 *Proceedings of the National Academy of Sciences* 14580, 14583 (2007). Note that this deposition is likely to be a larger factor on the East Coast, where coal-fired power plants are much more common than in California.

<sup>17</sup> See A.V. Borges & N. Gypens, Carbonate Chemistry in the Coastal Zone Responds More Strongly to Eutrophication than to Ocean Acidification, 55 *Limnology & Oceanography* 346 (2010) (modeling the relative impacts of nutrient loading and  $\text{CO}_2$ -driven acidification in the Belgian Coastal Zone, and finding significantly greater effects of nutrient runoff than atmospheric  $\text{CO}_2$  on ocean pH).

These root causes of acidification—including atmospheric  $\text{CO}_2$ , nutrient runoff, and  $\text{SO}_x$  /  $\text{NO}_x$  deposition—then interact with oceanography to create a patchwork of coastal effects.<sup>21</sup> In areas along continental margins where colder, more acidic water from the deep ocean is drawn up to the surface (“upwelling zones”), such as in California, local “hotspots” of ocean acidification develop.<sup>22</sup> Upwelling is a normal oceanographic process, but upwelled water appears to have become more acidic as a result of dissolved anthropogenic  $\text{CO}_2$ .<sup>23</sup> This more corrosive water is already apparent at the surface in upwelling zones near Cape Mendocino in northern California, and may be happening at other prominent rocky headlands along the State’s coast.<sup>24</sup> Rising atmospheric  $\text{CO}_2$  and patchy upwelling along California’s shore are the baseline to which we add other stressors such as nutrient runoff.

We cannot yet attribute a particular fraction of the observed change in coastal waters among atmospheric  $\text{CO}_2$ , nutrient runoff, or other factors.<sup>25</sup> While  $\text{CO}_2$  is the primary driver of the global background change in ocean pH, non- $\text{CO}_2$  inputs may be more influential in specific coastal regions.<sup>26</sup>

<sup>18</sup> W.-J. Cai et al., Acidification of Subsurface Coastal Waters Enhanced by Eutrophication, 4 *Nature Geoscience* 766 (2011).

<sup>19</sup> See, e.g., R.J. Diaz and R. Rosenberg, Spreading Dead Zones and Consequences for Marine Ecosystems, 321 *Science* 926 (2008).

<sup>20</sup> *Id.*

<sup>21</sup> Note, too, that changes to the hydrologic cycle—for example, the increased fresh-water runoff predicted in northern California due to climate change—will also influence the distribution of acidified hotspots in the coastal ocean. See M.A. Snyder and L.C. Sloan, Transient Future Climate Over the Western United States Using a Regional Climate Model, 9 *Earth Interactions* 1 (2005) (predicting large increases in precipitation in northern California during winter toward the end of the twenty-first century). However, over much longer time periods of millions of years, increased precipitation weathers terrestrial rocks more quickly and tends to buffer ocean pH. See L.R. Kump et al., Ocean Acidification in Deep Time, 22 *Oceanography* 94 (2009).

<sup>22</sup> See R.P. Kelly et al., Mitigating Local Causes of Ocean Acidification with Existing Laws, 332 *Science* 1036 (2011).

<sup>23</sup> See, e.g., Feely et al., *supra* note 6.

<sup>24</sup> R. Feely et al., *supra* note 6, Fig. 1 (showing corrosive waters at several coastal locations); subsequent personal communications are in accord. Note that California has insufficient monitoring systems in place to determine the spatial extent and severity of acidification in the nearshore region. See Appendices II and III for a discussion of monitoring vs. modeling, and for a list of available monitoring data streams.

<sup>25</sup> In part, this difficulty stems from the large natural variation in coastal waters. Shallow ocean waters, bays, and estuaries experience fluctuations of pH and related measures over the course of hours and days. These rapid swings are driven by tides, freshwater input, photosynthesis, shell formation, and respiration, among other factors. See generally R.E. Zeebe and D. Wolf-Gladrow, *CO<sub>2</sub> in Seawater: Equilibrium, Kinetics, Isotopes* (2001). For an example of these changes in the intertidal zone on the exposed Washington coast, see J.T. Wootton, C.A. Pfister, and J.D. Forester, Dynamic Patterns and Ecological Impacts of Declining Ocean pH in a High-Resolution Multi-Year Dataset, 105 *Proc. Natn’l Acad. Sci.* 18848 (2008). Daily and monthly variation in pH at a given coastal site may be of larger magnitude than the entire observed change in baseline ocean pH due to anthropogenic  $\text{CO}_2$  and such natural variability poses a challenge for discerning the effects of pollution from natural background variation at small scales. *Id.*; L.-Q. Jiang et al., Carbonate mineral saturation states along the U.S. East Coast, 55 *Limnology & Oceanography* 2424 (2010). For example, in San Francisco Bay in July 2011, the measured pH varied between 8.2 and 7.8 within a week. Data from the Romberg Tiburon Center, San Francisco State University; see Appendix III. By contrast, it is estimated that the global ocean pH change due to anthropogenic carbon dioxide input is 0.1 pH units. R.A. Feely et al., Impact of Anthropogenic  $\text{CO}_2$  on the  $\text{CaCO}_3$  System in the Oceans, 305 *Science* 362 (2004).

<sup>26</sup> See Doney et al., *supra* note 16; Feely et al., *supra* note 6; Cai et al., *supra* note 18; Borges and Gypens, *supra* note 17.

Overall, there is a strong consensus that:

1. Coastal acidification is more severe and more rapid in some places due to oceanographic features, biological effects, and land-based pollutants;<sup>27</sup>
2. The chemical changes to the coastal ocean are due to a combination of atmospheric CO<sub>2</sub> and other pollutants including atmospheric deposition of sulfur and nitrogen compounds, and terrestrial nutrient runoff,<sup>28</sup> as well as possible increases in freshwater input and upwelling;<sup>29</sup> and
3. Acidification adds yet another stressor to a growing list of threats to ocean health—including overfishing, habitat destruction, and climate change.<sup>30</sup> Acidification could alter marine food webs substantially.<sup>31</sup> This may undermine the California nearshore ecosystem's ability to produce goods and services worth billions of dollars annually.

We have already observed changes in marine ecosystems as a result of increasingly acidic waters. More change is inevitable, both because of lag time associated with ocean circulation patterns<sup>32</sup> and because humanity's CO<sub>2</sub> emissions are unlikely to decline suddenly and precipitously. However, mitigating the causes of ocean acidification at present will pay dividends immediately and in the future, safeguarding a public resource that is a critical center of biological diversity, cultural value, and economic benefit to local communities in California.

## Ecology and Biology

An ecosystem is the entire set of interactions among species and nonliving components of an environment (such as temperature or sunlight). It is therefore unsurprising that the biological and ecological effects of an acidifying ocean remain poorly understood relative to the chemistry described above. While adding dissolved CO<sub>2</sub> to the ocean has eminently predictable effects on the ocean's chemistry, there is considerably more we need to learn about the effects of the same chemical change on the network of plants and animals whose interactions constitute the coastal ecosystem.

One acidification-related metric of great importance for coastal ecosystems is the relative propensity of many marine organisms' hard parts (such as mollusc shells) to dissolve in seawater.<sup>33</sup> As waters acidify, these hard parts have a greater tendency to dissolve. A growing body of research documents the negative impacts of acidified waters on organismal development,<sup>34</sup> suggesting that acidification in the coastal ocean has the potential to disrupt a wide swath of ecosystem functions. Because juvenile oysters and related species are especially susceptible to acidification, the shellfish industry is under particularly immediate threat. Various industry groups have already taken action to understand and combat the changes that face them.<sup>35</sup>



Satellite image of stormwater plume in the coastal waters of the Southern California Bight.

Source: SCOWRP; <http://www.scowrp.org/ResearchAreas/Nutrients/IdentificationOfNutrientSources/EstimatingTerrestrialSources/EvaluationOfTheImpactOfTerrestrialRunoff.aspx>.

<sup>27</sup> See, e.g., Kelly *et al.*, *supra* note 22; Feely *et al.* 2008, *supra* note 6.

<sup>28</sup> See note 25, *supra*.

<sup>29</sup> See J. Salisbury *et al.*, Coastal Acidification by Rivers: A Threat to Shellfish? 89 Eos 513 (2008) (showing effect of acidic freshwater on coastal mollusc dissolution factor); Snyder and Sloan, *supra* note 21 (showing predicted increases in precipitation, and hence freshwater input, in northern California as a result of climate change); M. Garcia-Reyes and J. Largier, Observations of Increased Wind-Driven Coastal Upwelling Off Central California, 115 J. Geophysical Research C04011 (2010) (noting observed increases in coastal upwelling are consistent with model predictions due to climate change; more persistent or more extreme upwelling would also acidify coastal waters).

<sup>30</sup> See, e.g., R.K. Craig & J.B. Ruhl, Governing for Sustainable Coasts: Complexity, Climate Change, and Coastal Ecosystem Protection, 2 Sustainability 1361 (2010).

<sup>31</sup> See UNEP Emerging Issues: Environmental Consequences of Ocean Acidification: A Threat to Food Security (2010) (*available at* <http://www.unep.org/dewa/>).

<sup>32</sup> Ocean water absorbs CO<sub>2</sub> from the atmosphere at the surface. After being submerged and transported by deep ocean currents, a particular water molecule may take decades to again reach the surface. Upwelling along the Pacific coast brings water to the surface that was last in contact with the atmosphere perhaps 50 years ago. To some extent, we are now experiencing acidification from the atmospheric CO<sub>2</sub> of the 1960s. This lag time postpones some of the effects of today's emissions, which are much larger than those of decades past.

<sup>33</sup> The measure of this propensity is known as the saturation state of calcium carbonate, the material of which most species' hard parts are made. It is symbolized by a capital omega, and differs depending upon the particular form of calcium carbonate to which it refers. Because the principal forms are aragonite and calcite, this is written  $\Omega_{\text{arag}}$  and  $\Omega_{\text{calcite}}$ , respectively. Aragonite is more soluble, and therefore under greater threat from ocean acidification. A primary factor of interest is therefore  $\Omega_{\text{arag}}$ .

<sup>34</sup> See, e.g., V.J. Fabry, *et al.*, *supra* note 36.

<sup>35</sup> See, e.g., Eric Scigliano, The Great Oyster Crash, On Earth (Aug. 17, 2011), *available at* <http://www.onearth.org/article/oyster-crash-ocean-acidification>; see also coverage of a recent ocean acidification workshop at the Virginia Institute of Marine Science, *available at* [http://www.vims.edu/newsandevents/topstories/oyster\\_acid.php](http://www.vims.edu/newsandevents/topstories/oyster_acid.php).

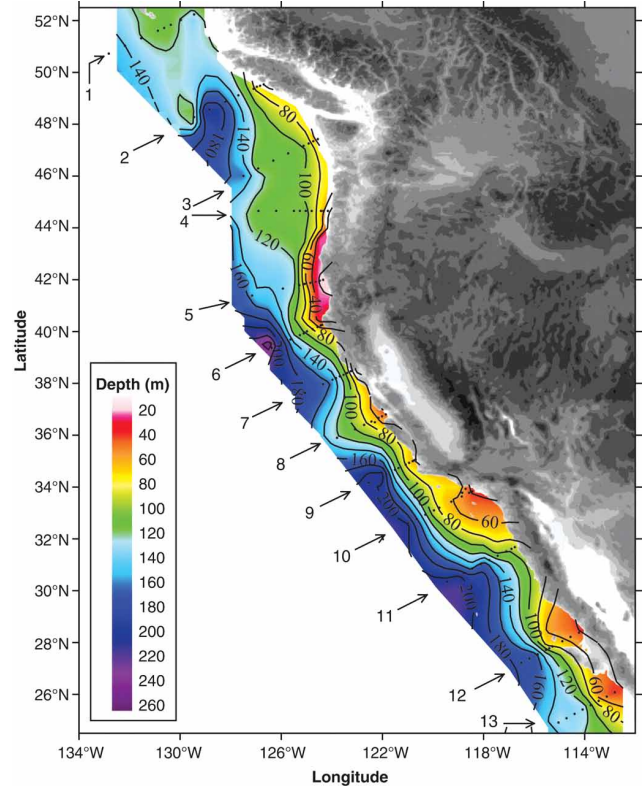


## Current Research

### Feely and Colleagues: Upwelling Zones and Acidification in Northern California













California hosts some of the best-documented sites of changing ocean chemistry. In a 2008 paper in *Science*,<sup>290</sup> NOAA scientist Richard Feely and colleagues described the corrosive waters that now seasonally reach California's coastline near Cape Mendocino and elsewhere. As a result of an increase in human-generated CO<sub>2</sub>, these waters are significantly more corrosive than they would otherwise be. Moreover, the authors found the site to be acidifying rapidly, observing changes in ocean chemistry that had not been predicted to occur until the year 2050. These changes exacerbate the natural processes of upwelling and respiration, and are likely to have widespread biological impacts of commercial importance. Feely and colleagues are now analyzing data from more recent cruises, in order to produce an updated map of upwelled acidified waters.

<sup>290</sup> R. Feely *et al.*, Evidence for Upwelling of Corrosive "Acidified" Water onto the Continental Shelf, 320 *Science* 1490 (2008).



Distribution of the depths of the undersaturated water (aragonite saturation < 1.0; pH < 7.75) on the continental shelf of western North America from Queen Charlotte Sound, Canada, to San Gregorio Baja California Sur, Mexico. On transect line 5, the corrosive water reaches all the way to the surface in the inshore waters near the coast. The black dots represent station locations.

Source: Feely *et al.* 2008. Evidence for Upwelling of Corrosive "Acidified" Water onto the Continental Shelf.

Physiological response	Major group	Species studied	Response to increasing CO <sub>2</sub>			
			a	b	c	d
Calcification						
	Coccolithophores <sup>1</sup>	4	2	1	1	1
	Planktonic Foraminifera	2	2	-	-	-
	Molluscs	4	4	-	-	-
	Echinoderms <sup>1</sup>	3	2	1	-	-
	Tropical corals	11	11	-	-	-
	Coralline red algae	1	1	-	-	-
Photosynthesis <sup>2</sup>						
	Coccolithophores <sup>1</sup>	2	-	2	2	-
	Prokaryotes	2	-	-	1	-
	Seagrasses	5	-	-	-	-
Nitrogen Fixation						
	Cyanobacteria	1	-	1	-	-
Reproduction						
	Molluscs	4	4	-	-	-
	Echinoderms	1	1	-	-	-

1) Increased calcification had substantial physiological cost; 2) Strong interactive effects with nutrient and trace metal availability, light, and temperature; 3) Under nutrient replete conditions.

Representative examples of impacts of ocean acidification on major groups of marine biota derived from experimental manipulation studies. The response curves on the right indicate four cases: (a) linear negative, (b) linear positive, (c) level, and (d) nonlinear parabolic responses to increasing levels of seawater pCO<sub>2</sub> for each of the groups. Note that in some cases strains of the same species exhibited different behavior in different experiments (cf. Fabry *et al.* 2008; Guinotte & Fabry 2008).

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More broadly, we do know that a more acidic ocean is likely to hinder growth in a wide variety of species, to increase the growth rate of some others, and to have little effect on still others.<sup>36</sup> At least under laboratory conditions, acidified seawater hampers calcification and reproduction in most animal species studied, and has either neutral or positive effects on photosynthesizing species.<sup>37</sup> Species with already marginal survival rates may be at special risk; for example, acidification further threatens the already-imperiled pinto abalone, whose larvae develop less successfully in a high-CO<sub>2</sub> environment.<sup>38</sup>

<sup>36</sup> See J.B. Ries *et al.*, 37 *Geology* 1131 (2009) (demonstrating developmental response to undersaturated seawater in eighteen species; of these, ten species had decreased calcification rates, seven had increased rates, and one had no response); S.C. Talmage and C.J. Gobler, Effects of Past, Present, and Future Ocean Carbon Dioxide Concentrations on the Growth and Survival of Larval Shellfish, 107 *Proc. Natl'l Acad. Sci.* 17246 (2010) (decreased and slower growth in two bivalve shellfish under modern CO<sub>2</sub> conditions as compared with preindustrial conditions); K. Kroeker *et al.*, Meta-Analysis Reveals Negative Yet Variable Effects of Ocean Acidification on Marine Organisms, 13 *Ecology Letters* 1419 (2010); Doney *et al.*, *supra* note 9 at 176; V.J. Fabry *et al.*, Impacts of Ocean Acidification on Marine Fauna and Ecosystem Processes, 65 *ICES Journal of Marine Science* 414, 423–24 (2008).

<sup>37</sup> See note 36 (describing variable response of organisms to acidified conditions).

<sup>38</sup> See R.N. Crim *et al.*, Elevated Seawater CO<sub>2</sub> Concentrations Impair Larval Development and Reduce Larval Survival in Endangered Northern Abalone (*Haliotis kamtschatkana*), 400 *J. Experimental Marine Biology & Ecology* 272 (2011).

Changing the chemical environment could thus change the balance of power in predator-prey relationships and in competition among species;<sup>39</sup> in short, it could alter the ecological interactions that underpin the living ocean we see today. Commercially-important effects of this phenomenon include a significant decrease in salmon biomass, where a major food source of juvenile salmon is highly susceptible to acidified waters.<sup>40</sup> Direct human health impacts may include amnesic shellfish poisoning as a result of increased frequency and severity of harmful algal blooms, spurred by a high-CO<sub>2</sub> ocean.<sup>41</sup>

Species have the capacity to evolve in response to environmental change, typically over long time horizons. One emerging question is whether and how today's species will evolve in response to ocean acidification. One recent study<sup>42</sup> estimates the different evolutionary capacities of two important nearshore species—red sea urchins and mussels<sup>43</sup>—and concludes the urchin species has a much greater capacity to adapt to acidified conditions. This work is the beginning of a larger effort to unravel the evolutionary consequences of acidification, and highlights the ecosystem changes that are inevitable as human pollution creates winners and losers among species in the coastal ocean.



Ryan P. Kelly

## Current Research

### UC Davis Bodega Ocean Acidification Research: pH Variability and Its Implications for Native California Species

Team members B. Gaylord, E. Sanford, A. Russell and T. Hill focus on the changing ocean's effect on oysters, mussels, and urchins, both by raising organisms in the laboratory under conditions expected over the next 100 years, and by extensive field and oceanographic sampling to understand modern pH variability. Oceanographic sampling includes monthly cruises offshore Bodega Head (2009–current) and monthly sampling in Tomales Bay (2008–2011). Regular sampling such as this, combined with instruments deployed offshore and in the intertidal zone, has shown that nearshore environments can experience extreme pH variability due to natural processes. For example, seasonal changes in freshwater runoff to Tomales Bay makes the Bay's habitats more acidic during heavy winter rains. Monitoring efforts like this are critically needed to separate the natural variability of the coastal zone from the human impacts on temperature, salinity, and pH. Coastal fieldwork has recently extended north and south along the U.S. West Coast, now covering 47 sampling sites from Seattle to San Diego (including 20 sites within California), and include measurements of total alkalinity, and dissolved inorganic carbon. This endeavor is beginning to shed light on the high spatial variability in pH along our coastline, including areas that are naturally “buffered” or more acidic.

<sup>39</sup> For example, decreased shell thickness and strength in mussels under acidified conditions suggests that these species are likely to be more vulnerable to predation and breaking waves. B. Gaylord *et al.*, Functional Impacts of Ocean Acidification in an Ecologically Critical Foundation Species 214 J. Experimental Biology 2586 (2011).

<sup>40</sup> See Fabry *et al.*, *supra* note 36 at 426.

<sup>41</sup> Acidified waters sponsor both faster growth rates of harmful algal species as well as greater concentrations of domoic acid—the toxin that causes amnesic shellfish poisoning in humans—within algal cells. J. Sun *et al.*, Effects of Changing pCO<sub>2</sub> and Phosphate Availability on Domoic Acid Production and Physiology of the Marine Harmful Bloom Diatom *Pseudo-nitzschia multiseries*, 56 Limnology & Oceanography 829 (2011).

<sup>42</sup> J.M. Sunday *et al.*, Quantifying Rates of Evolutionary Adaptation in Response to Ocean Acidification, 6 PLoS One e22881 (2011), available at <http://www.plosone.org>.

<sup>43</sup> *Strongylocentrotus franciscanus* (urchins) and *Mytilus trossulus* (mussels). *Id.*



# California's Legal and Policy Options to Mitigate the Causes of Ocean Acidification

California has made some noteworthy efforts surrounding ocean acidification. For example, the issue is featured in the draft strategic plan of the Ocean Protection Council,<sup>44</sup> and the Southern California Coastal Water Research Project has hosted an acidification workshop.<sup>45</sup> However, California has been slow to respond to the emerging data on its acidifying waters with policy changes or major initiatives, and as yet no marine waters are included on the State's list of waters impaired for pH under the federal Clean Water Act.<sup>46</sup> Affirmative steps to mitigate ocean acidification would be a good investment for California, dovetailing with the State's extensive efforts to combat climate change.

Other jurisdictions have started to take notice.<sup>47</sup> Washington State recently announced a Blue Ribbon Panel to develop recommendations for mitigating ocean acidification in the Hood Canal and coastal State waters.<sup>48</sup> The U.S. federal government has passed legislation focused solely on ocean acidification<sup>49</sup> and established a federal interagency working group on the issue,<sup>50</sup> along with a research program within the National Oceanographic and Atmospheric Administration.<sup>51</sup> In addition, the working group convened an ocean acidification task force consisting of a collection of independent scientists and policymakers to provide advice.<sup>52</sup> Finally, the National Research Council has issued a report<sup>53</sup> in response to a Congressional mandate in the 2006 Magnuson-Stevens Fishery Conservation and Management Act.<sup>54</sup>

<sup>44</sup> California Ocean Protection Council, Revised Draft Five-Year Strategic Plan 2012-2017 (Dec. 2011) available at <http://www.opc.ca.gov>.

<sup>45</sup> SCCWRP hosted a workshop on Jul. 7-8, 2010 to explore the impacts of ocean acidification on shellfish. See <http://www.sccwrp.org/Meetings/Workshops/OceanAcidificationWorkshop.aspx>.

<sup>46</sup> For California's 2010 §303(d) list, see [http://www.waterboards.ca.gov/water\\_issues/programs/tmdl/integrated2010.shtml](http://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2010.shtml).

<sup>47</sup> See Heidi R. Lamirande, From Sea To Carbon Cesspool: Preventing the World's Marine Ecosystems from Falling Victim to Ocean Acidification, 34 Suffolk Transnational L. Rev. 183 (2011) for a review of foreign jurisdictions' ocean acidification laws, as well as the applicability of international law.

<sup>48</sup> See Washington Dept. of Ecology, Press Release: Gov. Gregoire Announces New Initiative to Create Jobs, Restore Puget Sound (Dec. 9, 2011), available at: [http://www.ecy.wa.gov/news/2011/gov\\_20111209.html](http://www.ecy.wa.gov/news/2011/gov_20111209.html).

<sup>49</sup> Federal Ocean Acidification Research and Monitoring (FOARAM) Act, 33 U.S.C. § 3701 et seq. (authorizing funding, developing interagency plan on ocean acidification, and establishing an acidification program within the National Oceanographic and Atmospheric Administration). Note, however, that the Act defines "ocean acidification" as a change in ocean pH from atmospheric—and not terrestrial—anthropogenic inputs. § 3702. We use the broader definition.

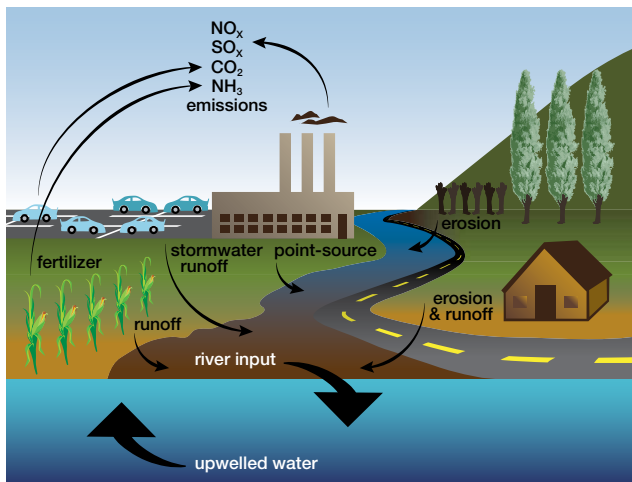
<sup>50</sup> See <http://www.st.nmfs.noaa.gov/iwgoa/>.

<sup>51</sup> See <http://www.pmel.noaa.gov/co2/story/NOAA>.

<sup>52</sup> The Ocean Acidification Task Force operates under the purview of the Ocean Research & Resources Advisory Panel, an advisory body that makes "independent advice and recommendations to the heads of federal agencies with ocean-related missions." Ocean Acidification Task Force, Summary of Work Completed and Recommendations for ORRAP to convey to the IWGOA, at 2 (2011), available at <http://www.nopp.org/wp-content/uploads/2010/03/OATF-REPORT-FINAL-4-21-11.pdf>.

<sup>53</sup> National Research Council, Ocean Acidification: A National Strategy to Meet the Challenges of a Changing Ocean (2010), available at [https://download.nap.edu/catalog.php?record\\_id=12904](https://download.nap.edu/catalog.php?record_id=12904). See also the National Science and Technology Council's Joint Subcommittee on Ocean Science and Technology, Ocean Science in the United States for the Next Decade: an Ocean Research Priorities Plan and Implementation Strategy (Jan. 26, 2007), available at <http://www.whitehouse.gov/sites/default/files/microsites/ostp/nstc-orppis.pdf>.

<sup>54</sup> P.L. 109-479 § 701.



Contributors to ocean acidification. In addition to global atmospheric CO<sub>2</sub>, this figure depicts the major local (within 100 km) sources contributing to coastal ocean acidification. Credit: Shelby Designs.

<sup>55</sup> The Commission reports that its mission is to “[p]rotect, conserve, restore, and enhance environmental and human-based resources of the California coast and ocean for environmentally sustainable and prudent use by current and future generations.” <http://www.coastal.ca.gov/whoweare.html>. The Commission has expressed strong support for the use of the Clean Water Act to address ocean acidification. See California Coastal Commission, Comments on U.S. Environmental Protection Agency (EPA) Mar. 22, 2010 Federal Register Notice on Clean Water Act Section 303(d) Program/Ocean Acidification (May 13, 2010) (“The Commission believes that using the Clean Water Act to reduce ocean acidification is both appropriate and necessary.”)

<sup>56</sup> The State Water Board’s mission is to “preserve, enhance and restore the quality of California’s water resources, and ensure their proper allocation and efficient use for the benefit of present and future generations.” [http://www.swrcb.ca.gov/about\\_us/water\\_boards\\_structure/mission.shtml](http://www.swrcb.ca.gov/about_us/water_boards_structure/mission.shtml).

<sup>57</sup> Public Resources Code § 35615(a)(1) (“The council shall... [c]oordinate activities of state agencies that are related to the protection and conservation of coastal waters and ocean ecosystems to improve the effectiveness of state efforts to protect ocean resources within existing fiscal limitations”); see also <http://www.opc.ca.gov/>.

Like many environmental challenges, the primary driver of ocean acidification—rising atmospheric CO<sub>2</sub>—is a diffuse global problem with externalized negative effects for any given emitter. That is, those who generate the most CO<sub>2</sub> do not disproportionately feel its effect. But CO<sub>2</sub> is not the only cause of acidification along California’s coast. The other drivers—including acidic runoff, erosion, and non-CO<sub>2</sub> emissions—are more likely to have local impacts near their sources. California can address its own sources of pollution that acidify waters locally, while continuing to combat CO<sub>2</sub> more broadly.

Fortunately, the acidification-mitigating avenues we discuss below dovetail with existing environmental priorities. Decreasing pollution into the nearshore environment has been an important priority for many years; the new information about acidification simply strengthens the logic for implementing environmental protection for the California coast.

The different causes of acidification implicate a variety of State administrative agencies—for example, nutrient runoff falls primarily under the jurisdiction of the State Water Resources Control Board, while atmospheric drivers fall principally to the California Air Resources Board. Because of the cross-cutting nature of ocean acidification, concerted action and interagency cooperation would be the most effective means of addressing the various causes of acidification. However, even in the absence of such cooperation, reducing stressors on the coastal ocean is squarely within the mandate of at least the California Coastal Commission<sup>55</sup> and the Water Boards,<sup>56</sup> and agencies have the authority to act individually under existing law. Further, the Ocean Protection Council<sup>57</sup> was created as a State agency to coordinate ocean policy in California, and ocean acidification is precisely the type of interagency issue to which this mandate can operate effectively. There is no shortage of State authority to control the causes of ocean acidification.



## I. Actions to Improve Water Quality

### A. Actions Primarily Aimed at Reducing Nonpoint Source Pollution

#### 1. **Acidification Driver:** Point and Nonpoint Source Runoff from Terrestrial Sources

Nonpoint source pollution is “the big enchilada,”<sup>58</sup> California’s “most serious water quality problem.”<sup>59</sup> Runoff waters contain all manner of human-created pollution that wash into the coastal ocean as a result of irrigation, rainfall, or snowmelt.<sup>60</sup> Nutrients, generally in the form of nitrogen and phosphorus compounds, are a particular concern of runoff in coastal areas. These nutrients fertilize the ocean, enriching it in excess of its natural state,<sup>61</sup> and can cause unhealthy population explosions in local plants and animals with widespread detrimental effects.<sup>62</sup> Any nutrient input that raises the net level of respiration in the nearshore waters ultimately makes those waters more acidic, exacerbating the global change in ocean chemistry at a local level.<sup>63</sup> Hypoxic (zero- or low-oxygen) zones are another known effect of nutrient loading, and dramatic changes in ecosystem state (e.g., from coral-dominated to algae-dominated) can result from a combination of eutrophication and other stresses.<sup>64</sup> Harmful algal blooms, in particular, pose a threat to public health and human welfare through neurotoxin poisoning,<sup>65</sup> and have been estimated to cost more than \$82 million annually in the United States alone.<sup>66</sup> As the oceans grow more acidic, harmful algal blooms may both increase in frequency and become more dangerous.<sup>67</sup>

**Law/Regulation:** Porter-Cologne Water Quality Control Act,<sup>68</sup> including its implementation of the Federal Clean Water Act<sup>69</sup>

<sup>58</sup> Oliver A. Houck, *The Clean Water Act TMDL Program: Law, Policy, and Implementation* 60 (2002).

<sup>59</sup> State Water Resources Control Board, *Fact Sheet: Policy for the Implementation and Enforcement of the Nonpoint Source Pollution Control Program*, available at [http://www.swrcb.ca.gov/water\\_issues/programs/nps/docs/npsfactsheet.pdf](http://www.swrcb.ca.gov/water_issues/programs/nps/docs/npsfactsheet.pdf).

<sup>60</sup> See, e.g., federal EPA guidance on runoff as nonpoint source pollution, <http://www.epa.gov/owow/keep/NPS/index.html>, and California’s analogous material, [http://www.swrcb.ca.gov/water\\_issues/programs/nps/](http://www.swrcb.ca.gov/water_issues/programs/nps/).

<sup>61</sup> This process is known as “eutrophication.” Note, too, that upwelling areas have naturally high levels of nutrients, quite apart from anthropogenic inputs.

<sup>62</sup> For an introduction to this problem, see generally S.W. Nixon, *Coastal Marine Eutrophication: A Definition, Social Causes, and Future Concerns*, 41 *Ophelia* 199 (1995).

<sup>63</sup> See, e.g., Cai *et al.*, *supra* note 18 (describing the mechanism linking surface algal blooms to bottom water acidification.)

<sup>64</sup> See T. Hughes, *Catastrophes, Phase Shifts, and Large-Scale Degradation of a Caribbean Coral Reef*, 265 *Science* 1547 (1994), and citing references.

<sup>65</sup> Human poisonings from harmful algal blooms occur primarily through shellfish contamination, and may be fatal. See, e.g., G.M. Hallegraeff, *Ocean Climate Change, Phytoplankton Community Responses, and Harmful Algal Blooms: A Formidable Predictive Challenge*, 46 *J. Phycology* 220, 220 (2010).

<sup>66</sup> <http://oceanservice.noaa.gov/hazards/hab/> (last visited Jan. 2, 2012).

<sup>67</sup> See Sun *et al.*, *supra* note 41.

<sup>68</sup> Water Code §13000.

<sup>69</sup> 33 U.S.C. §1251 et seq.

<sup>70</sup> California has a central State Water Resources Control Board, and nine Regional Water Quality Control Boards. These boards share divided jurisdiction and rulemaking authority over state waters. We refer to the boards jointly unless specifically noted.

**Agency:** State and Regional Water Boards<sup>70</sup>

**Action:** Strengthen existing water quality standards<sup>71</sup> for marine and estuarine waters in California to reflect now-available information on nutrients and carbonate chemistry<sup>72</sup> parameters including pH. Consider developing criteria for other parameters related to ocean acidification, such as total alkalinity and dissolved inorganic carbon.<sup>73</sup> Consider designating additional beneficial uses of coastal waters to improve ecological resilience.<sup>74</sup>

**Impact:** More stringent water quality criteria could better protect coastal ecosystems via implementation under existing NPDES<sup>75</sup> and TMDL<sup>76</sup> programs where existing technology-based standards are insufficient to safeguard the receiving waters. If enforced, these criteria could alleviate both the ultimate (e.g., nutrient loading)<sup>77</sup> and proximate (pH change) causes of locally-intensified ocean acidification. Designating new beneficial uses for sensitive coastal waters could more quickly trigger protection from additional point source discharges and would require limiting inputs from existing dischargers. Note, however, that Porter-Cologne provides the water boards broad powers to regulate discharges, in addition to the authority deriving from the Clean Water Act programs.<sup>78</sup>

**Discussion:** Under California’s Porter-Cologne Water Quality Control Act, “[a]ll discharges of waste into waters of the state are privileges, not rights,”<sup>79</sup> and further, all “activities and factors which may affect the quality of the waters of the state shall be regulated to attain the highest water quality which is reasonable.”<sup>80</sup> The Act implements the Federal Clean Water Act’s requirements for the State, and applies to point and nonpoint sources alike.<sup>81</sup> As such, California retains broad authority to regulate any discharges into State waters.

<sup>71</sup> Water quality standards, including numerical criteria for California water bodies, are contained in the regional Water Quality Control Plans. See [http://www.waterboards.ca.gov/mywaterquality/water\\_quality\\_standards/](http://www.waterboards.ca.gov/mywaterquality/water_quality_standards/). For marine waters, the California Ocean Plan provides the relevant criteria. See Water Code § 13170.2; State Water Resources Control Board, *California Ocean Plan 2009*, available at [http://www.waterboards.ca.gov/water\\_issues/programs/ocean/docs/2009\\_cop\\_adoptedeffective\\_usepa.pdf](http://www.waterboards.ca.gov/water_issues/programs/ocean/docs/2009_cop_adoptedeffective_usepa.pdf). Note that the Ocean Plan does not apply to enclosed Bays and Estuaries, which are subject to a separate water quality protection plan; Ocean Plan at 1.

<sup>72</sup> The carbonate chemistry of seawater includes measures such as total alkalinity, dissolved inorganic carbon, and pH. Lower pH is only one of the effects of increasing atmospheric CO<sub>2</sub> and other stressors on the oceans, and as a result, having a complete picture of these effects requires measuring multiple parameters in the carbonate system.

<sup>73</sup> *Id.*

<sup>74</sup> One definition for ecological resilience is “the extent to which ecosystems can absorb recurrent natural and human perturbations and continue to regenerate without slowly degrading or unexpectedly flipping into alternate states.” T.P. Hughes *et al.*, *New Paradigms for Supporting the Resilience of Marine Ecosystems*, 20 *Trends in Ecology & Evolution* 380, 380 (2005).

<sup>75</sup> National Pollution Discharge Elimination System, 33 U.S.C. § 1342.

<sup>76</sup> Total Maximum Daily Load; 33 U.S.C. § 1313(d)(1)(C).

<sup>77</sup> The Southern California Coastal Water Research Project is leading an effort to generate the necessary data for developing statewide nutrient criteria for use in TMDLs. See <http://www.sccwrp.org/ResearchAreas/Nutrients/NutrientCriteriaSupportStudies.aspx>.

<sup>78</sup> See discussion of Waste Discharge Requirements, *infra*.

<sup>79</sup> Water Code § 13263(g).

<sup>80</sup> Water Code § 13000.

<sup>81</sup> See Water Code § 13260; State Water Resources Control Board, *Policy for Implementation and Enforcement of the Nonpoint Source Pollution Control Program* 3 (May 20, 2004).

## Current Research

### Crain and Colleagues: Multiple Stressors

Ocean acidification is another stressor in marine ecosystems that are already under threat from overfishing, climate change, pollution, habitat loss, and invasive species. A 2008 study<sup>292</sup> by Caitlin Crain and coauthors—from multiple California institutions—found that the cumulative effects of multiple stressors on marine ecosystems were more likely to be additive or synergistic (a total of 62% of studies surveyed) than antagonistic (38%). That is, when two or more stressors alter an ecosystem, the effects of those stressors are likely to be as severe as the sum of the individual effects of each stressor (additive) or worse (synergistic). Conversely, in a substantial minority of cases, the effects of stressors tend to cancel one other out (antagonistic). The authors' analysis of three-stressor systems also suggests that synergistic effects may be very common in nature, such that as we influence ocean ecosystems in a growing number of ways, our impacts become disproportionately severe. Crain and colleagues' work creates a context in which ocean acidification is one among many environmental stressors, and one that may interact with other stressors to create complex, ecosystem effects.

<sup>292</sup> C.M. Crain, K. Kroeker, and B.S. Halpern, *Interactive and Cumulative Effects of Multiple Human Stressors in Marine Systems*, 11 *Ecology Letters* 1304 (2008).

The Porter-Cologne Act's relevant provisions work primarily through the two Clean Water Act mechanisms: permitting specific levels of pollution from individual point sources (NPDES permits), and assessing pollutant levels and allocating tolerable pollutant loads which, if achieved, will lead to protection of water quality (TMDLs). These mechanisms function in tandem to apply the State's water quality standards, which provide particular targets for legally allowed levels of water pollution.<sup>82</sup> Thus, the water quality standards are a lynchpin of water quality regulation in California. However, water quality standards function mainly as a set of backup rules, behind the technology-based standards that the federal EPA promulgated for various classes of dischargers.<sup>83</sup> Only where technology-based standards are insufficient to safeguard the designated uses of a water body does a NPDES permit incorporate discharge limits tied to water quality.<sup>84</sup>

Federal water quality standards for a particular water body consist of three parts: designated uses of the water body (e.g., swimming, shellfish culture, recreation), water quality criteria (numerical or narrative limits for particular pollutants sufficient to maintain the designated uses), and an anti-degradation policy.<sup>85</sup> Under California's Porter-Cologne Act, these first two parts are known as "beneficial uses" and "water quality objectives," respectively,<sup>86</sup> but are otherwise identical to the federal provisions. Because the water quality criteria provide the numerical and narrative yardsticks by which to assess the designated uses, the criteria offer an attractive means of combating the causes of nearshore ocean acidification by increasing the stringency of various parameters of water quality.<sup>87</sup>

Numerical criteria for pH, dissolved oxygen, nitrates, and phosphates already exist<sup>88</sup> and are reviewable by administrative action rather than legislation, making them good candidates as tools for combating acidification. Additional criteria for pH-related parts of the carbonate system (e.g., Total alkalinity, dissolved inorganic carbon) would help monitor acidifying waters more accurately and would be additional tools for detecting and preventing further degradation.

The federal EPA has so far declined to adjust its guidance for water quality criteria with respect to pH, citing insufficient information to change the federal standard.<sup>89</sup> Although states have the authority to revise the criterion independent of the federal EPA,<sup>90</sup> California's State water board is similarly awaiting more data before revising the marine pH criterion.<sup>91</sup> Acting on presently-available data to create a more stringent standard could generate local benefits in the form of healthier State fisheries, shellfish operations, and other coastal activities, and

<sup>82</sup> NPDES permit limits take the forms of technology-based limitations and water-quality-based limitations. However, water-quality-based limitations only apply if the technology-based limits are insufficient to meet the overall water quality standards. 33 U.S.C. §1311(b)(1)(C).

<sup>83</sup> *Id.*

<sup>84</sup> *Id.*; K.M. McGaffey & K.F. Moser, *Water Pollution Control Under the National Pollutant Discharge Elimination System*, in *Clean Water Act Handbook*, 3d Ed. 27, 39 (M.A. Ryan ed., 2011).

<sup>85</sup> 40 C.F.R. §§ 131.2, 131.6; see also *Nat'l Res. Def. Council, Inc. v. Envtl. Prot. Agency*, 16 F.3d 1395 (4th Cir. 1993).

<sup>86</sup> See [http://www.waterboards.ca.gov/mywaterquality/water\\_quality\\_standards/](http://www.waterboards.ca.gov/mywaterquality/water_quality_standards/) (last visited 1/2/12).

<sup>87</sup> Note that waters designated as "fishable" likely require that fish populations be biologically sustainable; if acidification or other water quality issues negatively impact fish life cycles—as is inevitable outside a window of tolerance of each fish species—then the designated uses would be threatened. Shellfish and mariculture designated uses are likely to be more sensitive to acidification than fish, and so adjusting water quality criteria to safeguard these uses may be especially time-sensitive.

<sup>88</sup> Each of these parameters is directly relevant to ocean acidification: pH measures the acidity directly, dissolved oxygen is inversely correlated with the eutrophication associated with local nutrient plumes, and both nitrates and phosphates are constituent elements of such plumes. Because eutrophication can lead to acidifying bottom waters, it contributes to coastal acidification.

<sup>89</sup> See EPA Memorandum: Decision on Re-evaluation and/or Revision of the Water Quality Criterion for Marine pH for the Protection of Aquatic Life (Apr. 15, 2010).

<sup>90</sup> Note that states may issue more stringent criteria than federal guidelines demand. See *Communities for a Better Env't v. State Water Res. Control Bd.*, 109 Cal. App. 4th 1089, 1093-94 (2003) ("NPDES permits must conform to state water quality laws insofar as the state laws impose more stringent pollution controls than the CWA") (citing 33 U.S.C. § 1370; Water Code, §§ 13263, subd. (a), 13372).

<sup>91</sup> State Water Resources Control Board, *California Ocean Plan Triennial Review Workplan 2011-2013*, at 13-14, 19 (2010).



would guard against lawsuits alleging that the present criteria do not adequately safeguard existing beneficial uses. These benefits should defray the costs of adjusting the criterion, which are likely to include having to list marine or estuarine waters as impaired, and thus having to develop TMDLs for those waters. Regional Water Boards could minimize their individual costs by collaborating to develop marine and estuarine TMDLs.<sup>92</sup>

A technological challenge to setting meaningful water quality criteria is the natural background variation in the chemistry of State waters. For example, the existing water quality criterion for marine pH is +/- 0.2 units outside the normally occurring range.<sup>93</sup> Because the natural variability of coastal pH is substantially larger than this interval,<sup>94</sup> the existing criterion has little or no real protective effect.<sup>95</sup> Any human-caused departure from an already-wide natural range creates an extreme chemical environment that may be fatal to many of the organisms living in the State's waters. In order to effectively mitigate acidification and to protect the existing beneficial uses of coastal waters, revised criteria should be more stringent and tied to an absolute value of pH—or to a hybrid of numeric and narrative criteria with data-backed benchmarks based on ecosystem response<sup>96</sup>—rather than the widely-fluxuating natural range.<sup>97</sup> For example, if the vast majority<sup>98</sup> of natural variation in a coastal region occurs within pH range 8.3-7.4, it may be that nearshore waters with pH of less than 7.4 should be designated as impaired.

More stringent criteria would help combat at least the drivers of local acidification, and narrower criteria face less of a technological hurdle now than in years past. More accurate monitoring technologies now exist, making narrower tolerances more easily enforceable than they would have been when the current water quality criteria were set in the 1970s. Water quality criteria must reflect the most recent scientific knowledge,<sup>99</sup> and a critical mass of information now indicates that the chronic changes in

pH that have already taken place can have large and detrimental effects on marine ecosystems.<sup>100</sup>

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## 2. Acidification Driver: Nonpoint Source Runoff.

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**Law/Regulation:** TMDLs; Porter-Cologne;  
Federal Clean Water Act

**Agency:** State and Regional Water Boards

**Action:** Create or adjust TMDLs—and enforce them via implementation plans with reasonable compliance assurances—to ensure acceptable levels of overall (point- and nonpoint source) pollution from terrestrial sources. This action is particularly relevant for coastal waters that are at greater risk as a result of prevailing biological or chemical conditions. For example, atmospheric nitrogen deposition is likely to exacerbate ocean acidification depending upon the factors limiting the growth of marine microorganisms locally and upon the time scale of analysis.<sup>101</sup> Upwelling zones,<sup>102</sup> where colder ocean waters quickly take up CO<sub>2</sub> and therefore acidify, are also coastal regions amenable to protection via TMDLs.

**Impact:** Controlling the total nutrient loadings and other anthropogenic inputs to coastal waters would mitigate a major cause of non-atmospheric-driven OA. Developing TMDLs for p(CO<sub>2</sub>)<sup>103</sup> and for surface fluxes of NO<sub>x</sub> and SO<sub>x</sub> would do the same for atmospheric drivers. Limiting pollution from terrestrial sources might be particularly effective to safeguard enclosed bays and estuaries, which can consolidate anthropogenic inputs more readily than open water.

**Discussion:** Creating TMDLs, or adjusting those that already exist, will depend in part upon a revision of the State's water

<sup>92</sup> One approach to such TMDLs would be to collectively assess the contribution of atmospheric CO<sub>2</sub> input on a range of marine and estuarine resources. Each Regional board could then use that assessment as an element of Regional and local TMDLs, requiring dischargers consider such loadings as well as local inputs.

<sup>93</sup> State Water Resources Control Board, Water Quality Control Plan: Ocean Waters of California ("Ocean Plan") at 6 (2009). See also U.S. EPA federally recommended water quality criteria, at 14-15, Note K ("According to page 181 of the Red Book (EPA 440/9-76-023, Jul. 1976): For open ocean waters where the depth is substantially greater than the euphotic zone, the pH should not be changed more than 0.2 units from the naturally occurring variation or any case outside the range of 6.5 to 8.5. For shallow, highly productive coastal and estuarine areas where naturally occurring pH variations approach the lethal limits of some species, changes in pH should be avoided but in any case should not exceed the limits established for fresh water, i.e., 6.5-9.0.")

<sup>94</sup> See, e.g., G.E. Hofmann *et al.*, High-Frequency Dynamics of Ocean pH: A Multi-Ecosystem Comparison, 6 PLoS One e28983 (Dec. 2011) (Fig. 2 describing pH variability in different ecosystems). See also J.C. Blackford & F.J. Gilbert, pH Variability and CO<sub>2</sub> Induced Acidification in the North Sea, 64 Journal of Marine Systems 229 (2007) (finding that coastal oceans can vary by more than 1 pH unit annually).

<sup>95</sup> Given this, current criteria may not protect many of the marine waters' designated beneficial uses, as is required under Porter-Cologne and the Clean Water Act, making them legally insufficient. See 40 CFR §§ 131.5(2); 131.6(c) (EPA approval of state water quality criteria is contingent on those criteria being sufficient to protect designated uses).

<sup>96</sup> See, e.g., Nutrient Numeric Endpoint values developed for estuaries, available at <http://www.sccwrp.org> (last visited Dec. 8, 2011).

<sup>97</sup> That is, if the natural pH range of waters in a hypothetical coastal region is pH 7 to 8.5, discharges causing a change of +/- 0.2 are likely to have a much more severe environmental impact at the margins of that natural range than in the center of the range. The Red Book guideline, *supra* note 93, implicitly notes as much in setting the absolute outer bounds of permissible pH variation at 6.5 to 8.5 or 6.5 to 9. However, even for pH-variable waters that sporadically reach an extreme pH = 6.5, inputs that chronically lower by pH 0.2 would likely jeopardize many beneficial uses. Improved monitoring efforts will continue to increase data quality and availability for pH. See Appendix III.

<sup>98</sup> With improved monitoring data, calculating a 95% confidence interval for pH of particular water bodies would be easily accomplished. This might define the boundaries of probable natural variation, and allow a static water quality standard tied to these boundaries. Note that under such a system, the classification of waters as either impaired or non-impaired would be much more dynamic than is the case at present.

<sup>99</sup> 33 U.S.C. § 1314(a)(1) ("The Administrator, after consultation with appropriate Federal and State agencies and other interested persons, shall develop and publish... criteria for water quality accurately reflecting the latest scientific knowledge.")

<sup>100</sup> See, e.g., Doney *et al.*, *supra* note 9; Wootton *et al.*, *supra* note 25.

<sup>101</sup> See Doney *et al.*, *supra* note 16; Feely *et al.*, *supra* note 6; Cai *et al.*, *supra* note 18; Borges and Gypens, *supra* note 17.

<sup>102</sup> See note 23, *supra*.

<sup>103</sup> The partial pressure of carbon dioxide in seawater, an important parameter in the carbonate system.

quality criteria (above). As part of the State implementation of the federal Clean Water Act, California must develop a list of waters that fail to meet the approved water quality standards.<sup>104</sup> The State then must develop TMDLs for that list of impaired waters, although historically this process has been sluggish and resource-intensive.<sup>105</sup>

In principle, TMDLs limit the overall amount of pollution—not just that portion coming from point sources—entering a particular water body and causing it to fall short of the published water quality standards.<sup>106</sup> In practice, the burden of bringing a water body into compliance has fallen on the NPDES-permitted point sources rather than nonpoint sources; the permitting authority incorporates more stringent requirements into NPDES permits for discharge into impaired waters in an attempt to remedy the impairment.<sup>107</sup> Unless California demands otherwise, nonpoint sources run up the bill, and point sources are stuck paying the check.

TMDLs thus establish little in the way of mandatory authority over existing nonpoint sources, their prime regulatory targets.<sup>108</sup> California could give TMDLs teeth by imposing real limits on nonpoint source pollution.<sup>109</sup> States have the sole authority to regulate nonpoint sources under the Clean Water Act, and therefore have the discretion to implement a TMDL's load allocations as they see fit.<sup>110</sup> If accompanied by enforcement measures, TMDLs could form the basis of nonpoint source regulation that could significantly improve the quality of coastal waters.<sup>111</sup>

Nevertheless, TMDLs offer some benefits even in the absence of mandatory pollution limits. Most prominent among these is greater protection for already-impaired water bodies, as the TMDL bars new point source permits for discharges that would “cause or contribute to the violation of water quality standards.”<sup>112</sup> This provision could be of particular use in impaired coastal areas with increasing urban and industrial density, forcing parties to grapple with how to maintain local water quality and balance uses appropriately. The TMDL process also generates a level of visibility that could be helpful in the case of ocean

acidification, an issue that is still emerging into regulatory consciousness. Finally, because the study of acidification has been hindered by a scarcity of reliable monitoring, the data-collection aspect of the TMDL process would also be valuable.

The most effective TMDLs for monitoring and fighting nearshore ocean acidification would address pollutants with existing water quality criteria (such as pH, NO<sub>3</sub>, dissolved oxygen, and sediment) in marine and estuarine waters. Additional TMDLs for p(CO<sub>2</sub>) and NO<sub>x</sub>/SO<sub>x</sub> flux, mentioned above, would give the State useful tools for combating atmospheric acidification drivers. Finally, monitoring or establishing maximum loads for Dissolved Inorganic Carbon or Total Alkalinity would substantially improve the State's ability to accurately understand and regulate the chemistry of its changing ocean.

Because of the spatial variability inherent in the coastal ecosystem, making blanket rules for nonpoint source pollution could be an overbroad approach to addressing acidification (although such an approach may have merit for addressing other coastal water quality problems). Conversely, creating numerous watershed-specific rules is difficult from a technical standpoint and is

goal for the level of that pollutant in the waterbody to which that TMDL applies.... The theory is that individual-discharge permits will be adjusted and other measures taken so that the sum of that pollutant in the waterbody is reduced to the level specified by the TMDL.”); *Idaho Sportsmen's Coalition v. Browner*, 951 F.Supp. 962, 966 (W.D.Wash.1996) (“TMDL development in itself does not reduce pollution.... TMDLs inform the design and implementation of pollution control measures.”); *Pronsolino*, 291 F.3d at 1129 (“TMDLs serve as a link in an implementation chain that includes ... state or local plans for point and nonpoint source pollution reduction ....”); *Idaho Conservation League v. Thomas*, 91 F.3d 1345, 1347 (9th Cir. 1996) (noting that a TMDL sets a goal for reducing pollutants). Thus, a TMDL forms the basis for further administrative actions that may require or prohibit conduct with respect to particularized pollutant discharges and waterbodies”) (emphases added).

<sup>107</sup> See *Friends of Pinto Creek*, 504 F.3d 1007, 1011–15 (9th Cir. 2007) (interpreting the Clean Water Act's TMDL provision and its impacts on point and nonpoint sources); see also O.A. Houck, *The Clean Water Act Returns (Again): Part I, TMDLs and the Chesapeake Bay*, 41 *Env't. L. Reporter News & Analysis* 10208, 10210 (2011) (discussing the impact of nonpoint regulation on point sources). Note that the Clean Water Act contains special provisions for discharge into marine waters, but that these have diminished effect because they only apply to point sources, and because many categories of point sources are exclusively governed by other sections of the Act. See 33 U.S.C. § 1343(c); 40 C.F.R. § 125.22; 45 Fed. Reg. 65942 (Oct. 3, 1980) (issuing guidelines to ensure “no NPDES permit may be issued which authorizes a discharge of pollutants that will cause unreasonable degradation of the marine environment.”)

<sup>108</sup> See note 106, *supra*. However, note that California's Porter-Cologne Act requires even nonpoint source dischargers to file for permits; Water Code §§ 13260, 13269. Although presumably these permits do not account for most nonpoint source pollution, failing to file for a permit is a misdemeanor and also punishable by civil fine. Water Code § 13261. Note also that California's Regional Water Boards and the California Coastal Commission accordingly see TMDLs as largely informational, rather than regulatory. For example, California's Nonpoint Source Implementation Plan describes TMDLs as “planning tool[s] that will enhance the State's ability to foster implementation of appropriate NPS [management measures]. By providing watershed-specific information, TMDLs will help target specific sources and corresponding corrective measures and will provide a framework for using more stringent approaches that may be necessary to achieve water quality goals and maintain beneficial uses.” State Water Resources Control Board and California Coastal Commission, *Nonpoint Source Program Strategy And Implementation Plan, 1998-2013 (PROSIP)*, Vol. I at ii (Jan. 2000).

<sup>109</sup> Note also that using Waste Discharge Requirements, under Porter-Cologne, California's water boards have other, more mandatory, means of limiting discharges beyond TMDLs.

<sup>110</sup> *Pronsolino*, 291 F.3d 1123 at 1140.

<sup>111</sup> Note that the California Nonpoint Source Implementation Plan sets out 61 management measures (akin to best practices) that bear on various sources of nonpoint source pollution. State Water Resources Control Board and California Coastal Commission, *Nonpoint Source Program Strategy And Implementation Plan, 1998-2013 (PROSIP)*, Vol. I (Jan. 2000). These are largely voluntary, with state-provided incentives for participation that include grants under CWA § 319(h) and also waivers of waste discharge requirements.

<sup>112</sup> 40 C.F.R. § 122.4(i). See also *Pinto Creek*, *supra* note 107.

<sup>104</sup> This list is known as the “303(d)” list, after the relevant provision of the Clean Water Act. The federal EPA approved the most recent list for California on Oct. 11, 2011. Approval and list available at [http://www.waterboards.ca.gov/water\\_issues/programs/tmdl/integrated2010.shtml](http://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2010.shtml).

<sup>105</sup> See, e.g., O.A. Houck, *The Clean Water Act TMDL Program: Law, Policy, and Implementation*, at 63 (2002) (citing a figure of \$1million per TMDL study and ten times that for implementation of each TMDL).

<sup>106</sup> TMDLs for a given pollutant are allocated between point sources (“wasteload allocation”) and nonpoint sources (“load allocation”), 40 C.F.R. 130.2(i), with a margin of error built in to account for uncertainty. The EPA may determine a reasonable “margin of safety” on an ad-hoc basis. See *NRDC v. Muszynski*, 268 F.3d 91, 96 (2d Cir. 2001). For a cogent encapsulation of the non-mandatory nature of TMDLs, see *City of Arcadia v. EPA*, 265 F. Supp. 2d 1142, 1144–45 (N.D. Cal. 2003) (“TMDLs established under Section 303(d)(1) of the CWA function primarily as planning devices and are not self-executing. *Pronsolino v. Natri*, 291 F.3d 1123, 1129 (9th Cir. 2002) (“TMDLs are primarily informational tools that allow the states to proceed from the identification of waters requiring additional planning to the required plans.”) (citing *Alaska Ctr. for the Env't v. Browner*, 20 F.3d 981, 984–85 (9th Cir. 1994)). A TMDL does not, by itself, prohibit any conduct or require any actions. Instead, each TMDL represents a goal that may be implemented by adjusting pollutant discharge requirements in individual NPDES permits or establishing nonpoint source controls. See, e.g., *Sierra Club v. Meiburg*, 296 F.3d 1021, 1025 (11th Cir. 2002) (“Each TMDL serves as the



labor- and time-intensive. A patchwork of regulation could also erode regulatory certainty and increase costs of gathering information. If wide swaths of coastline share particular chemical/ecological properties, regional-scale rules could make both permitting and enforcement more efficient while effectively improving the health of the coastal ocean.

### 3. Acidification Driver: Water Quality Degradation from Point and Nonpoint Sources

**Law/Regulation:** Porter-Cologne

**Agency:** Regional Water Boards

**Action:** Use Porter-Cologne's fisheries protection provisions to declare relevant waters threatened,<sup>113</sup> triggering the Boards' power to protect commercial shellfish harvesting via the Shellfish Protection Act of 1993.<sup>114</sup> This Act provides the Boards with broad authority to order remediation and abatement of point or nonpoint source pollution where such pollution threatens the health of commercial shellfish. Consider expanding the Act to include other fisheries threatened by ocean acidification and degraded water quality, such as urchin fisheries. Consider strengthening the law by eliminating its agricultural exemptions.

**Impact:** These actions could provide efficient remediation and abatement of existing water quality problems in a limited set of geographic areas: those that are both threatened and are used for shellfish farming.<sup>115</sup> In California, these regions are limited to Morro Bay, Tomales Bay, Humboldt Bay, and a small handful of other regions, a small fraction of the State's coastline. The impact of the shellfish provision in Porter-Cologne is further limited by its exemption for agricultural sources of degraded water quality; for these sources, the Water Boards' authority to require mandatory actions is curtailed.<sup>116</sup>



Shellfish farming in Tomales Bay, CA.

NOAA

**Discussion:** Because agricultural sources are a pervasive source of diffuse nutrient runoff into coastal marine waters,<sup>117</sup> the agricultural<sup>118</sup> exemption of the Shellfish Protection Act greatly weakens its utility. This is especially the case because those few areas of the State where shellfish farming is prominent are also rural; most of the



Nonpoint source runoff.

Lynn Betts USDA NRCS

coastal water quality issues are likely to stem from agricultural sources, and even more so were a court to read the statutory exemption for "agriculture" so broadly as to include ranching and livestock activities.<sup>119</sup> Nevertheless, where non-agricultural sources contribute to nutrient loading in shellfish-growing areas, and where such nutrient loading contributes to ocean acidification locally, the Act remains a viable policy lever for the Water Boards.<sup>120</sup> Eliminating the agricultural exemption by legislation would restore much of the purpose and utility of the Shellfish Protection Act.

<sup>113</sup> Water Code § 14954(d).

<sup>114</sup> Water Code § 14956(a) ("the regional board, with the advice of the local technical advisory committee, shall order appropriate remedial action, including the adoption of best management practices, to abate the pollution affecting that area. The regional board shall monitor water quality in the threatened area during the implementation of pollution abatement measures to ensure that the measures are effective and shall provide the results of the monitoring to the technical advisory committee.")

<sup>115</sup> Shellfish farming is a beneficial (ie, designated) use under the Porter-Cologne Act, and the Shellfish Protection Act applies only to designated shellfish farming areas of the state. Water Code § 14952 specifies "[f]or the purposes of this chapter, a commercial shellfish growing area is an area certified pursuant to Section 28504 of the Health and Safety Code in which shellfish are grown and harvested." The referenced Code section was repealed by statute in 1995 (S.B. 1360, § 170), but Health & Safety Code § 112155(c) provides "'(g)rowing area' means any offshore ocean, coastal estuarine, or freshwater area that may be classified by the department for natural shellfish growth or artificial shellfish propagation and includes open seawater systems." Here, "department" refers to the State Department of Health Services, Health & Safety Code § 112155(i) (now the California Department of Public Health), and thus this department would have to declare a particular geographic area to be a shellfish growing area before the Water Boards could exercise their authority pursuant to the Shellfish Protection Act.

<sup>116</sup> Water Code § 14956(b) ("If agricultural sources of pollution have been identified as contributing to the degradation of shellfish growing areas, the regional board shall invite members of the local agricultural community ... and affected shellfish growers to develop and implement appropriate short- and long-term remediation strategies that will lead to a reduction in the pollution affecting the commercial shellfish growing area.")

<sup>117</sup> Email from Michael Thomas, Central Coast Water Quality Control Board, to the author, Nov. 4, 2011. On file with the author.

<sup>118</sup> The statute is ambiguous as to whether "agricultural" is so broad as to include ranching or similar non-irrigated commercial activities. The chapter contains no definitions section, and no specific definition of "agricultural." Despite having arisen as a bill in the State Senate Agriculture and Water Resources Committee, the Act's legislative history contains no discussion of the bounds of the agricultural exemption. See, e.g., California Bill Analysis, Senate Committee, 1993–1994 Regular Session, Senate Bill 417 (Apr. 20, 1993). The Water Code division in which the Shellfish Protection Act is located does contain a definitions section, §13050, but that section also lacks a definition for "agriculture" or "agricultural."

<sup>119</sup> No case law has yet interpreted the Act, so the breadth of its agricultural exemption remains a matter of conjecture. The Act's legislative history indicates that dairy farm ranchers opposed the bill. See California Bill Analysis, Assembly Committee, 1993–1994 Regular Session, Senate Bill 417 (Jul. 14, 1993); California Bill Analysis, Senate Floor, 1993–1994 Regular Session, Senate Bill 417 (Aug. 27, 1993) (Opposition by the Western United Dairywomen and the Marin Farm Bureau). The Marin Farm Bureau's membership is dominated by dairy farms, see <http://www.cfbf.com/counties/?id=21>. The bill's agriculture exemption was added only after opposition by the Western United Dairywomen. Compare California Bill Analysis, Senate Committee, 1993–1994 Regular Session, Senate Bill 417 (Apr. 20, 1993) with California Bill Analysis, Assembly Committee, 1993–1994 Regular Session, Senate Bill 417 (Jul. 14, 1993).

<sup>120</sup> If wood pulp mills near Arcata threaten the health of shellfish there, for example, the Act may be of some value in combating their effects on nearshore water quality.

## 4. Acidification Driver: Water Quality Degradation from Point and Nonpoint Sources

**Law/Regulation:** Porter-Cologne, Federal Coastal Zone Act Reauthorization Amendments (CZARA),<sup>121</sup> and associated State law<sup>122</sup>

**Agency:** Regional Water Boards

**Action:** Use Waste Discharge Prohibitions and Waste Discharge Requirements to enforce meaningful limits on nonpoint source pollution.

**Impact:** Would reduce nonpoint source pollution into coastal waters, decreasing the frequency and intensity of eutrophication events and attendant local acidification, as described above.

**Discussion:** Motivated in part by the failure of TMDLs to achieve enforceable water quality protection, Congress passed the CZARA in 1990 in an attempt to improve nonpoint source pollution control in coastal waters. California's implementation of CZARA is a joint effort between the water boards and the Coastal Commission, and includes both carrots and sticks. The carrots are in the form of grant money;<sup>123</sup> the sticks are permitting requirements meant to ensure compliance with particular management practices.

The water boards have three tools with which to control nonpoint source pollution outside of the Clean Water Act's TMDL provision: waste discharge requirements (WDRs), waivers of WDRs, and basin plan prohibitions.<sup>124</sup> The boards can issue WDRs for general or specific discharges, for example, barring discharges outside of a particular pH range or having a particular nutrient content. Alternatively, boards can agree to waive WDRs in exchange for the discharger's application of best management practices or for other assurances; many of the coastal nonpoint source plan's management measures are administered in this way.<sup>125</sup> WDR violations may trigger abatement, cease-and-desist orders, or similar remedies including civil liability.<sup>126</sup> Fees associated with WDRs defray the costs of implementation and secondarily discourage avoidable discharges.<sup>127</sup>

These seemingly enforceable nonpoint source controls are consistent with the overarching State policy of maintaining water quality by using the full power and jurisdiction of the State to do so.<sup>128</sup> However, these measures still rely on individual permittees for implementation, and violations are enforceable only against those same permittees. Rather than water quality-based enforcement, the WDRs and associated rules are often similar to the technology or management practices-based measures in NPDES permits. The result is that nonpoint source problems are treated like point source problems, and a large portion of pollution is likely to remain unaddressed.

An exception is enforcement actions for failure to report a discharge or file for a permit. Because every discharge likely to affect water quality—whether point or nonpoint—requires a permit from the State or Regional Water Board,<sup>129</sup> the water boards can take action against those individuals legally responsible for such discharges if they have failed to file a permit application. Again, fees and fines associated with permitting and violations lower the costs of such enforcement. Where the Regional Water Boards are able to increase enforcement actions against unpermitted nonpoint source dischargers, they could curtail nonpoint source runoff from identified sources and simultaneously bring violators into the permitting and monitoring system. This could be an effective way of combating some fraction of the runoff contributing to coastal acidification and degraded water quality.

The water boards can also use federal funding as a carrot<sup>130</sup> to require durable best management practices (BMPs) and permanent nutrient management improvements. Ideally, these improvements would be more expensive to remove than to implement, such that the State would not have to continue to pay nonpoint source dischargers to maintain them. Federal money would be used to lower barriers to entry for parties who could not (or would not) otherwise adopt cleaner management practices, and the improvements would be maintained after the funds were exhausted and the barrier to entry overcome. Ensuring the durability of these measures is critical to avoiding an entirely incentive-based system, which would otherwise leave the State in the uncomfortable and unsustainable role of paying its constituents not to pollute.<sup>131</sup>

<sup>121</sup> 16 U.S.C. § 1455b.

<sup>122</sup> Water Code § 13369(a) requires the State water board to implement nonpoint source pollution controls according to the federal Clean Water Act and CZARA.

<sup>123</sup> These grants are distributed from funds derived from Clean Water Act §319(h) funds; see PROSIP, *supra* note 111, at 68. § 306 of the Coastal Zone Management Act may also provide funds.

<sup>124</sup> State Water Resources Control Board, Resolution to Adopt the Policy for the Implementation and Enforcement of the Nonpoint Source Pollution Control Program and Approve the Functional Equivalent Document, Resolution No. 2004-0030, 2004 WL 1380112 at \*4. (May 20, 2004).

<sup>125</sup> See 2004 WL 1380112 at \*3-6.

<sup>126</sup> See the complete list of enforcement options, Nonpoint Source Implementation Plan at 56 *et seq.*

<sup>127</sup> Water Code § 13260(d) provides the relevant fee authority.

<sup>128</sup> 2004 WL 1380112 at \*3 (“(1) The quality of all the waters of the State shall be protected; (2) All activities and factors that could affect the quality of State waters shall be regulated to attain the highest water quality that is reasonable; and (3) The State must be prepared to exercise its full power and jurisdiction to protect the quality of water in the State from degradation”) (citing Water Code § 13000).

<sup>129</sup> Water Code § 13261.

<sup>130</sup> §319(h) of the Clean Water Act and §306 of the Coastal Zone Management Act both provide funding appropriate for these purposes. Codified at 33 U.S.C. §1329(h) and 16 U.S.C. §1455a, respectively.

<sup>131</sup> Discussing a pollution-trading scheme between point and nonpoint source polluters, Oliver Houck recently observed “One might ask why municipal residents, many of them at the low end of the wage scale, already paying for sewage treatment of their own wastes, should have also to pay farm sources not to pollute. The agriculture sector includes some of the wealthiest (and most heavily subsidized) enterprises in America.” Houck 2011, *supra* note 107, at 10225. Using federal dollars to pay nonpoint sources to maintain BMPs year after year raises the same ethical and practical questions.



## 5. Acidification Driver: Nonpoint Source Runoff from Terrestrial Sources

**Law/Regulation:** Clean Water Act and CZMA

**Agency:** Various, including State and Regional Water Boards, other Resources Agencies, California EPA

**Action:** Increase Participation in the National Estuary Program (NEP) and the National Estuarine Research Reserve System (NERRS).

**Impact:** Better managing the inputs of nutrients and other nonpoint source pollutants to the State's estuaries would reduce an important source of acidification in these vital and productive coastal ecosystems.

**Discussion:** Congress created the NEP as part of the 1987 amendments to the Clean Water Act,<sup>132</sup> and the program provides federal funds for creating and implementing comprehensive management plans for nationally significant bays and estuaries.<sup>133</sup> The NEP does not set aside estuaries as protected or research areas, but rather represents a means of grappling with nonpoint source pollution<sup>134</sup> through a collaborative, watershed-wide process that has been lauded as a model of cooperative governance.<sup>135</sup> Focusing attention on water quality management and ecosystem health through the NEP may avoid some of the expense of developing TMDLs, and may be a more effective means of addressing the same core goals.

Nationally, twenty-eight bays and estuaries are presently enrolled in the program. Three of these are in California (San Francisco Bay, Morro Bay, and Santa Monica Bay), and state governors can nominate new water bodies for inclusion.<sup>136</sup> Although reliable time-series data are not available, EPA-provided data paint an overall picture of the program's modest success. Estuaries in the program score equal to, or better than, U.S. estuaries overall in a series of water and habitat quality measures.<sup>137</sup> The program claims to have protected or restored over 518,000 acres of national estuarine habitat between 2001 and 2005,<sup>138</sup> and a total of 1.3 million acres since 2000.<sup>139</sup> In sum, National Estuaries appear to be somewhat healthier relative to non-participating estuaries, but the real benefit of enrollment in the NEP is the platform the program provides for dealing with water and habitat quality at a large, integrated spatial scale.

California's agencies can better manage inputs into key coastal sites by revisiting the water quality aspects of the comprehensive management plans for existing National Estuaries. In the future, enrolling other important bays and estuaries in the NEP—for example, Humboldt Bay, Half Moon Bay, Monterey Bay, and San Diego Bay—would give the State a funded framework for comprehensive watershed management at these coastal sites.

The National Estuarine Research Reserve System (NERRS), by contrast, is not a management program but rather a research

## Current Research

### Hofmann and Colleagues: Temporal and Spatial Variability of Marine pH

A 2011 paper<sup>291</sup> by UC Santa Barbara professor Grechen Hofmann and colleagues documented the variability in ocean pH around the world, and included several sites in California. This work filled a crucial gap, underscoring the large chemical differences in different marine ecosystems. The authors found open ocean pH to be highly stable over the course of 30 days, in sharp contrast to highly variable estuarine or kelp forest environments, in which pH might vary up to .99 and 0.54, respectively. Just as important, the study showed that even similar environments—for example, two California kelp forests—might have pH levels that differ substantially over a 30-day period. These findings have particular relevance in light of the State and federal water quality criterion of  $\pm 0.2$  pH units outside of the water's "normally occurring range." Such a pH change would represent 50 times the study's observed standard deviation of pH in the open ocean, 2.85 times the observed standard deviation in Monterey Bay, nearly twice the observed standard deviation for the kelp forest in Santa Barbara, and almost five times the standard deviation for the kelp forest in La Jolla. Hofmann and colleagues' study also opens the door to research on the physiological adaptation of species from different marine environments to projected future pH levels.

<sup>291</sup> G.E. Hofmann *et al.*, High-Frequency Dynamics of Ocean pH: A Multi-Ecosystem Comparison, 6 PLoS One e28983 (Dec. 2011).

<sup>132</sup> CWA § 320; 33 USC § 1330.

<sup>133</sup> As defined in the National Estuary Program, an estuary is "a part of a river or stream or other body of water that has an unimpaired connection with the open sea and where the sea water is measurably diluted with fresh water derived from land drainage." 33 U.S.C. § 2902. In plain English, an estuary is a coastal site with a mix of fresh and saltwater.

<sup>134</sup> Lynn M. Gallagher, *Clean Water Handbook*, 3d ed., 129 (2003).

<sup>135</sup> See generally, Mark Lubell, *Resolving Conflict and Building Cooperation in the National Estuary Program*, 33 *Environmental Management* 677 (2004); Mark Schneider *et al.*, *Building Consensual Institutions: Networks and the National Estuary Program*, 47 *American J. Political Sci.* 143 (2003).

<sup>136</sup> 33 U.S.C. § 1330.

<sup>137</sup> EPA, *National Estuary Program Coastal Condition Report, Executive Summary at ES.14* (Jun. 2007) (*available at* <http://water.epa.gov/type/oceb/nep/index.cfm#nepccr>).

<sup>138</sup> EPA, *National Estuary Program 2004-2006 Implementation Review Report at 4* (Jun. 19, 2008) (*available at* <http://water.epa.gov/type/oceb/nep/index.cfm#nepccr>).

<sup>139</sup> [http://www.epa.gov/owow\\_keep/estuaries/pivot/habitat/progress.htm](http://www.epa.gov/owow_keep/estuaries/pivot/habitat/progress.htm) (last visited Dec. 14, 2011).

and monitoring program administered by NOAA, that sets aside designated water bodies for long-term protection. A state may request that one of its qualifying water bodies be included in the system, and the federal government provides matching funds for nominee sites. Qualifying sites are those that are “representative estuarine ecosystem[s] suitable for long-term research.”<sup>140</sup> After an evaluation process<sup>141</sup> including environmental impact analysis, sites that are included in the system are “protected for long-term research, water-quality monitoring, education and coastal stewardship,” and managed by a state agency or university with technical assistance and funding from NOAA.<sup>142</sup> California’s NERRS sites include Elkhorn Slough, a portion of San Francisco Bay, and the Tijuana River slough.<sup>143</sup>

California may find the visibility, data collection, and funding that accompany designation as a NERRS site to be helpful for protecting its coasts from acidification and other threats to water and habitat quality. Further, the NERRS program provides matching funds for states to acquire land and waters for inclusion in the system.<sup>144</sup> This may be a particularly attractive mechanism for acquiring title where private entities own critical coastal resources that the state would otherwise be unable to acquire.



Elkhorn Slough National Estuarine Research Reserve.



Both the NEP and the NERRS require Congressional appropriations in order to maintain operations, and so both are vulnerable to changes in economic and political conditions.<sup>145</sup> Congress has consistently appropriated funds for the operation of NEP and NERRS,<sup>146</sup> but at least in the case of the NEP, the funding priority is to support existing estuaries rather than to enroll new ones.<sup>147</sup> The last new NEP designation was in 1995, when the Congressional appropriation allowed it.<sup>148</sup> Until this changes, California can focus its acidification-mitigating efforts on mitigating the flow of pollutants into its existing National Estuaries and research reserves.

<sup>140</sup> 15 C.F.R. §921.2(f).

<sup>141</sup> See <http://nerrs.noaa.gov/BGDefault.aspx?ID=362> for description of the process leading to designation as NERRS site (last visited Dec. 14, 2011).

<sup>142</sup> See <http://nerrs.noaa.gov/BGDefault.aspx?ID=61> for description of day-to-day management (last visited Dec. 14, 2011).

<sup>143</sup> See <http://nerrs.noaa.gov/BGDefault.aspx?ID=602> (last visited Jan. 3, 2012).

<sup>144</sup> 15 C.F.R. § 921.1(f).

<sup>145</sup> Note that a complementary program, the West Coast Estuaries Initiative (Public Law 110-161), was appropriated no funds in 2011. See <https://www.cfda.gov>, program number 66.119.

<sup>146</sup> See <http://nerrs.noaa.gov/BGDefault.aspx?ID=492>.

<sup>147</sup> See <https://www.cfda.gov>; NEP is program number 66.456, and the funding priority for 2011 was to support the 28 existing NEP estuaries’ management plans.

<sup>148</sup> See <http://water.epa.gov/type/oceb/nep/questions.cfm> (last visited Dec. 14, 2011).



## B. Actions Primarily Aimed at Reducing Point Source Pollution

### 6. **Acidification Driver:** Outflow from Publicly-Owned Treatment Works (POTWs)

Sewage treatment presents a special problem for water quality regulation, in part because of its absolute volume: nationwide, wastewater treatment plants treat more than 32 billion gallons of wastewater daily.<sup>149</sup> Much of this discharge volume flows to the ocean, increasing nutrient loads along the coasts and triggering the acidifying cascade described above.

**Law/Regulation:** Porter-Cologne, Federal CWA

**Agency:** State and Regional Water Boards

**Action:** Implement more stringent water-quality-based controls on NPDES permits for POTWs within California. Secondly, require a more stringent technology-based standard of water treatment as necessary to more tightly control the inputs to coastal areas.

**Impact:** Each of these related actions would reduce anthropogenic nutrient loading in the coastal oceans, which can contribute to OA as well as to harmful algal blooms and anoxic zones as described above.

**Discussion:** The federal Clean Water Act, and hence the Act's State implementation, singles out POTWs as special point sources with NPDES requirements over and above those of ordinary permittees. For example, POTWs are subject to heightened reporting requirements in their permit applications<sup>150</sup> and must limit their discharges to a greater degree than the technology-based standards alone dictate.<sup>151</sup> As a result, the State can require POTWs to minimize discharges by altering the prevailing water quality standards. If sewage discharge significantly contributes to coastal acidification via nutrient loading, addressing it within the context of the NPDES permitting program would be an attractive way to alleviate this particular stressor.

The State and regional water boards could also supplement the federal technology-based standards for POTWs by requiring cleaner effluent that is less likely to eutrophy coastal receiving waters. State authority to do so rests on a solid foundation of the federal case law<sup>152</sup> and regulation,<sup>153</sup> in addition to the language of the statute itself.<sup>154</sup> Taken together, these authorities affirm the State's broad powers to require more stringent controls than the federal standards demand. In particular, the water boards could fight coastal eutrophication by requiring POTWs to apply tertiary water treatment<sup>155</sup> including nitrification-denitrification (N-DN).<sup>156</sup>

N-DN is the coupled chemical process by which bacteria remove biologically-available nitrogen from an environment. Treatment works could use N-DN to lessen the impact of millions of tons of sewage on coastal water quality, directly lowering the eutrophication that can lead to hypoxia and local

acidification. N-DN is not a standalone aspect of municipal water treatment, but can be added in order to improve the quality of already-treated effluent. Nationally, such treatment is now required on a case-by-case basis depending upon the condition of the receiving water body and the beneficial uses for which it has been designated.<sup>157</sup> California's Regional Water Boards have required N-DN for particular facilities in the past,<sup>158</sup> and could do the same for the State's coastal POTWs to address acidification and related ocean issues. For example, where marine receiving waters are especially vulnerable to acidification due to upwelling or freshwater input, N-DN might be particularly appropriate.<sup>159</sup>

<sup>149</sup> A.D. Dunn & N. Gardner-Andrews, Publicly Owned Treatment Works, in *The Clean Water Act Handbook*, 3d ed. (M.A. Ryan, ed.) at 83 (2011), citing EPA, Report to Congress: 2008 Clean Watersheds Needs Survey (CWNS), available at <http://water.epa.gov/scitech/datait/databases/cwns/upload/cwns2008rtc.pdf>.

<sup>150</sup> See 40 C.F.R. §122.21(j).

<sup>151</sup> Clean Water Act §301(b)(1)(C), codified at 33 U.S.C. §1311(b)(1)(C).

<sup>152</sup> See, e.g., *Shell Oil Co. v. Train*, 585 F.2d 408, 410 (9th Cir. 1978) ("Congress sought 'to recognize, preserve, and protect the primary responsibilities and rights of States to prevent, reduce, and eliminate pollution' ... The role envisioned for the states under the 1972 amendments is a major one, encompassing both the opportunity to assume the primary responsibility for the implementation and enforcement of federal effluent discharge limitations and the right to enact requirements which are more stringent than the federal standards...Congress clearly intended that the states would eventually assume the major role in the operation of the NPDES program.") (citations to the federal Clean Water Act omitted; emphasis added). See also *PUD No. 1 of Jefferson County v. Washington Dept. of Ecology*, 511 U.S. 700, 723 (1994) (upholding the authority of the state of Washington to exercise its authority under §401 to condition approval of a power plant on maintenance of minimum stream flows in an affected river in order to prevent impairment under §303) (Stevens, J., concurring) ("Not a single sentence, phrase, or word in the Clean Water Act purports to place any constraint on a State's power to regulate the quality of its own waters more stringently than federal law might require. In fact, the Act explicitly recognizes States' ability to impose stricter standards.") See also *U. S. Steel Corp. v. Train*, 556 F.2d 822, 830 (7th Cir. 1977) (finding that Congress "has chosen not to preempt state regulation when the state has decided to force its industry to create new and more effective pollution-control technology") (rev'd on other grounds, *City of W. Chicago v. U.S. Nuclear Regulatory Comm'n*, 701 F.2d 632, 637 (7th Cir. 1983)).

<sup>153</sup> 40 C.F.R. §123.1(i)(1) ("Nothing in this part precludes a State from adopting or enforcing requirements which are more stringent or more extensive than those required under this part.")

<sup>154</sup> 33 U.S.C. § 1370 (expressly reserving the right of states to adopt or enforce "any standard or limitation respecting discharges of pollutants," so long as these restrictions are no less stringent than those provided by the Act.)

<sup>155</sup> Note that the term "tertiary treatment" is nonspecific and may be used differently by different authors. Here, we use the term to refer to a process that removes biosolids and (critically for coastal water quality) nutrients, as well as disinfecting effluent into receiving waters. See, e.g., Christopher Forster, *Wastewater Treatment & Technology* 183 (2003). See also N.F. Gray, *Biology of Wastewater Treatment* 136 (2004).

<sup>156</sup> See Forster, *supra* note 155, at 160–68.

<sup>157</sup> See, e.g., the multi-state Chesapeake Bay TMDL plan, available at <http://www.epa.gov/reg3wapd/tmdl/ChesapeakeBay/index.html>. For example, New York State requires tertiary treatment of some combined sewer overflows into the Chesapeake River drainage. Chesapeake Bay Nitrogen, Phosphorus and Sediment Total Maximum Daily Loads, New York Draft Phase I Watershed Implementation Plan at 29 (2010), available at [http://www.epa.gov/reg3wapd/pdf/pdf\\_chesbay/NYDraftPHIWIP.pdf](http://www.epa.gov/reg3wapd/pdf/pdf_chesbay/NYDraftPHIWIP.pdf)

<sup>158</sup> For example, the Central Valley Regional Water Quality Control Board recently required N-DN for the Sacramento Regional Wastewater Treatment Plant. Order R5-2010-0114 (NPDES Permit CA0077682) (Dec. 1, 2011), available at [http://www.swrcb.ca.gov/centralvalley/board\\_decisions/adopted\\_orders/sacramento/r5-2010-0114-01.pdf](http://www.swrcb.ca.gov/centralvalley/board_decisions/adopted_orders/sacramento/r5-2010-0114-01.pdf). The Los Angeles Region had earlier required N-DN at the D.C. Tillman Water Reclamation Plant. See Order R4-2011-0196 (NPDES No. CA0056227) (Dec. 8, 2011) (describing facility and its tertiary treatment, including N-DN), available at [http://www.waterboards.ca.gov/rwqcb4/board\\_decisions/adopted\\_orders](http://www.waterboards.ca.gov/rwqcb4/board_decisions/adopted_orders).

<sup>159</sup> Regional boards may also implement local effluent limits for POTWs to ensure they meet the requirements of their NPDES permits. See EPA Office of Wastewater Management 4203, *Local Limits Development Guidance* at 1-3 (Jul. 2004).

Any more stringent regulation could be politically challenging, especially in light of the fact that costs associated with upgrading facilities would likely fall to cash-strapped cities and counties.<sup>160</sup> However, side benefits of this more stringent treatment include improved water recycling for non-potable or indirect potable uses (e.g., recharging groundwater). Therefore the approach may be attractive to coastal counties in which freshwater is at a premium.<sup>161</sup> Moreover, reusing water in this way reduces a municipality's water demand and simultaneously avoids the greenhouse gas emissions associated with water supply and treatment.<sup>162</sup>

## 7. Acidification Driver: Point Source Runoff

**Law/Regulation:** NPDES Permits: Porter-Cologne, Federal Clean Water Act

**Agency:** State and Regional Water Boards

**Action:** Review pending and future NPDES permit applications for their potential OA impacts upon reaching marine waters; include monitoring requirements<sup>163</sup> for major dischargers into the ocean—such as Municipal Separate Storm Sewer Systems (MS4s),<sup>164</sup> POTWs, and refineries—with sufficient spatial breadth and frequency to provide the statistical power to detect small changes in pH, nitrogen, and related parameters.

**Impact:** Where permitted point sources contribute significantly to direct or indirect causes of ocean acidification in the nearshore environment, the Regional Water Boards could ease the burden on impacted waters by limiting those permitted discharges.<sup>165</sup>

**Discussion:** Existing NPDES permits largely protect permit-holders from being subject to changed (i.e., more stringent) regulations adopted during the permit term.<sup>166</sup> Therefore, only applicants for permit renewal or a new permit would be subject to new conditions.<sup>167</sup> Mechanistically, the State water board would likely adopt new water quality standards—new beneficial



Road runoff.

Reuven Walder, SPAWN/Marine Photobank

uses, water quality criteria, or changed technology-based standards—to implement the change (see above).

Monitoring and reporting requirements, which are integral to NPDES permits,<sup>168</sup> have the advantage of placing some of the costs of enforcement on the polluters themselves. This is actually a three-fold benefit to the public: first, it creates an incentive for the polluter to minimize discharges; second, it creates a dataset in the public domain that could be broadly useful for applied and primary research; and finally, it lowers the public agencies' enforcement costs directly by reducing the level of monitoring the agency is required to undertake.<sup>169</sup> In the case of OA, such broad-scale, data-rich coverage of coastal nutrients and pH would be especially valuable in documenting the changing chemistry of the nearshore region.

<sup>160</sup> Marginal costs of N-DN treatment include infrastructure for aeration and raw materials for carbon-limited reaction steps, and may entail tens to hundreds of millions of dollars in expenditures. Low-cost alternatives may be available: see, e.g., J. Jokela *et al.*, Biological Nitrogen Removal From Municipal Landfill Leachate: Low-Cost Nitrification in Biofilters and Laboratory Scale In-Situ Denitrification, 36 Water Research 4079 (2002); C. Fux & H. Siegrist, Nitrogen Removal From Sludge Digester Liquids by Nitrification/Denitrification or Partial Nitrification/Anammox: Environmental And Economical Considerations, 50 Water Science & Techn. 15 (2004) (noting environmental costs as well as economic costs of different methods).

<sup>161</sup> We note also that the California Constitution, Art. X § 2, enshrines the reasonable use doctrine, forbidding unreasonable uses of water ("the waste or unreasonable use ... of water be prevented, and the conservation of such waters is to be exercised with a view to the reasonable and beneficial use thereof in the interest of the people and for the public welfare.") See also Water Code § 100 (same). While untested by case law, it may be argued that wasting sufficiently treated water—rather than recycling it—could be an unreasonable use under California law.

<sup>162</sup> The supply and treatment of water for domestic, commercial, and industrial purposes generates in excess of 85 million metric tons of CO<sub>2</sub> emissions annually in the United States. B. Griffiths-Sattenspiel & W. Wilson, The Carbon Footprint of Water 22 (2009), available at [www.rivernet.org](http://www.rivernet.org). This report estimates that implementing Low Impact Development techniques—which include conservation in Southern California and the San Francisco Bay Area would save up to 637 million kWh of electricity per year, reducing emissions by up to 202,000 metric tons of CO<sub>2</sub>. *Id.* at 3. 19% of California's electricity consumption is water-related. *Id.* at 6.

<sup>163</sup> NPDES permits may include "monitoring requirements necessary to assure that any applicant for a Federal license or permit will comply with any applicable effluent limitations." 33 U.S.C. § 1341(d).

<sup>164</sup> See <http://cfpub.epa.gov/npdes/stormwater/munic.cfm> for the federal discussion on these facilities.

<sup>165</sup> Note that TMDLs ultimately function the same way, by regulating point sources more stringently, rather than by alleviating the nonpoint sources directly.

<sup>166</sup> 33 U.S.C. § 1342(k). Note, however, that new information not available when the permit was issued can justify the modification or revocation and reissuance of NPDES permits. 40 C.F.R. § 122.62. Because the drivers of ocean acidification are just beginning to be well understood, and because research on the topic has accelerated within the last 4 years, it is quite possible that new and important information would have become available after any given NPDES permit was issued.

<sup>167</sup> But see overlay permit options and discussion of permit modification, U.S. EPA, NPDES Permit Writers' Manual 11.3.2 (Sep. 2010), available at [http://cfpub.epa.gov/npdes/writermanual.cfm?program\\_id=45](http://cfpub.epa.gov/npdes/writermanual.cfm?program_id=45). Note also that newly listing a water body as impaired under §303(d) may provide the new information (unavailable at the time the NPDES permit was issued) required for modifying a NPDES permit. See 40 C.F.R. § 122.62; Houck, *supra* note 58, at 82.

<sup>168</sup> 40 C.F.R. § 122.41(l)(4) ("Monitoring results shall be reported"); McGaffey & Moser, *supra* note 84, at 33-34.

<sup>169</sup> Note that each of these benefits assumes that the monitoring information provided is accurate and reliable.





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## 8. **Acidification Driver:** Point and Nonpoint Source Runoff, Coastal Development and Land Use Change

**Law/Regulation:** Porter-Cologne, Federal Clean Water Act

**Agency:** State and Regional Water Boards, California Coastal Commission, California Department of Fish & Game

**Action:** Designate particular State waters as deserving special protection from land-based pollution, as a result of chemical or biological properties that make those coastal waters particularly sensitive to ocean acidification. Relevant authority may be found in existing provisions of California State law: Areas of Special Biological Significance (ASBS) and other State Water Quality Protection Areas (SWQPA; Water Boards),<sup>170</sup> Critical Coastal Areas (Coastal Commission and Water Boards; program mostly dormant due to budgetary constraints),<sup>171</sup> and Environmentally Sensitive Habitat Areas (ESHA; Coastal Commission).<sup>172</sup> Treating existing marine protected areas designated under the Marine Life Protection Act (MLPA<sup>173</sup>; Fish & Game) as entitled to protection from terrestrial pollution would maximize the ecosystem-protection benefits of those areas already so designated.

**Impact:** This suite of spatially-explicit options is attractive, and is consistent with the State's recent marine spatial planning experience.<sup>174</sup> Each special designation would act in a different way to mitigate local impacts to the coastal ocean. An

ASBS would bar any point source discharges within or near the delineated area without a waiver.<sup>175</sup> Non-ASBS SWQPAs would likely offer an intermediate level of protection, less stringent than ASBS, but would operate in a similar way. The Critical Coastal Areas program would encourage full implementation of the State's nonpoint source pollution plan and would implement best management practices for select areas of coastline. An ESHA designation by the Coastal Commission would significantly restrict the permissible uses of the area, protecting against development and disruption of the habitat.<sup>176</sup> Finally, guidance treating existing marine protected areas as ESHA, ASBS, or other specially-designated habitats would vary according to the specific designation, but in any case would protect a wide swath of environmentally and economically important ecosystems. All of the above would address locally-exacerbated acidification and mitigate cumulative impacts by controlling the anthropogenic inputs to the coastal system.

**Discussion:** The ASBS provision is a powerful tool for limiting pollution to marine waters, and the new data on coastal acidification provides a strong argument for looking more carefully at inputs into upwelling zones on the outer coast, among other waters under threat from ocean acidification.<sup>177</sup> However, no new ASBS have been designated since 1975, indicating an institutional resistance to use this tool.<sup>178</sup> Alternatively, designating non-ASBS SWQPAs would highlight specific coastal regions as needing attention, but probably would lack the stringency of ASBS.

<sup>170</sup> California's Marine Managed Areas encompass State Water Quality Protection Areas, of which ASBS are one type. See Pub. Res. Code §36600 et seq.

<sup>171</sup> Protecting Coastal Waters: State of California 2002 Critical Coastal Areas Draft Strategic Plan. See <http://www.coastal.ca.gov/nps/cca-strategy.pdf>. The concept of the CCA program was to address water quality holistically, engaging the agencies responsible for upland watersheds as well as those responsible for the marine environment. While useful framework documents for this program exist, and several pilot locations selected for CCAs, there is limited ongoing work being done under the program due to budget constraints across all State agencies involved. Phone interview with Al Wanger, California Coastal Commission, Oct. 19, 2011.

<sup>172</sup> Publ. Res. Code §30240.

<sup>173</sup> Fish & Game Code § 2850 et seq.

<sup>174</sup> For example, California's Marine Life Protection Act established a series of spatially-explicit marine areas with variable levels of permissible use. See <http://www.dfg.ca.gov/mlpa/> (last visited Jan. 2, 2012).

<sup>175</sup> Publ. Res. Code § 30920. Note that in California, the Ocean Plan provides similar protections for ASBS as do federal CWA regulations for tier 3 "outstanding national resources waters," which require a higher standard of water quality. See 40 CFR § 131.12; William A. Vance, report to the State Water Resources Control Board, Role of Science and Engineering in Decision-Making at 61, Appendix C (2005).

<sup>176</sup> *Id.* See also §30107.5 ("environmentally sensitive areas"); §30116 ("sensitive coastal resource areas"); and the environmental protection goals of §§ 30230-33.

<sup>177</sup> See, e.g., R.A. Feely *et al.*, *supra* note 6. (describing California areas under particular threat); Kelly *et al.*, *supra* note 22 (noting that combinations of ocean acidification drivers create patches of more sensitive coastline).

<sup>178</sup> One illustration of this difficulty is that no new ASBS have been designated since 1975. See State Water Resources Control Board, Status Report, Areas of Special Biological Significance at 10 (Aug. 2006).



The Coastal Commission or a local jurisdiction with a certified Local Coastal Program<sup>179</sup> may find that a particular area meets the requirements of an ESHA and therefore exercise tight control over a development permit to protect ESHA.<sup>180</sup> Because the jurisdiction of the Coastal Commission extends “seaward to the state’s outer limit of jurisdiction, including all offshore islands,”<sup>181</sup> designating ESHA within marine—as opposed to terrestrial—territory is within the purview of the Commission.<sup>182</sup> Furthermore, designating ESHA in State territorial waters could be less controversial than on land, because of the lack of vested private property interests in California’s marine waters.

The Critical Coastal Areas program appears to be largely dormant due to lack of funding,<sup>183</sup> and as a result, it is difficult to know whether or how any such designation would function in reality. However, the program’s legal and administrative framework is in place and may be a useful avenue for addressing the causes of coastal OA through holistic, watershed-wide action in the future.

According to a 2010 State Water Board resolution, the Regional Water Boards are to develop standards for protecting water quality in MPA areas via the SWQPA mechanism.<sup>184</sup> However, the resolution indicates that new SWQPAs should not interfere with existing wastewater outfalls, greatly limiting the value of this approach to improving water quality in sensitive areas.<sup>185</sup> The resolution similarly limits regulation of municipal wastewater outfalls.<sup>186</sup> Given this guidance, it seems unlikely that the Water Boards will limit existing discharges near MPA areas proactively.

<sup>179</sup> Publ. Res. Code § 30510.

<sup>180</sup> See *Douda v. California Coastal Comm’n*, 72 Cal. Rptr. 3d 98, 104-05 (Cal. Ct. App. 2008) (finding that, where a local coastal program has not been certified, the Coastal Commission may designate environmentally-sensitive habitat areas.) Note that, where a local coastal program has been certified, the State Coastal Commission may not newly designate ESHA within that program’s jurisdiction. *Id.* at 105 (“Once a local coastal program is certified, the issuing agency has no choice but to issue a coastal development permit as long as the proposed development is in conformity with the local coastal program... In other words, an issuing agency cannot deviate from a certified local coastal program and designate an additional environmentally sensitive habitat area.”)

<sup>181</sup> Publ. Res. Code §30103.

<sup>182</sup> See, e.g., California Coastal Commission Staff Report Re: Application No. 1-11-004, Humboldt Bay Rowing Ass’n at 15–16 (Jul. 1, 2011) (designating particular eelgrass habitat in the waters of Humboldt Bay as ESHA).

<sup>183</sup> The Critical Coastal Areas website has not been updated since 2005, and the State of the CCAs Report, due out in 2006, is listed on the site as “coming soon.” See [http://www.coastal.ca.gov/nps/Web/CCA\\_bg.htm](http://www.coastal.ca.gov/nps/Web/CCA_bg.htm). Other available documents date from 2002–2005.

<sup>184</sup> State Water Resources Control Board, Resolution No. 2010-0057, Marine Protected Areas and State Water Quality Protection Areas, 2010 WL 505322 at Resolution 2 (Nov. 16, 2010). Note that developing such guidance is a second priority, according to the resolution, after resolving current ASBS discharge issues.

<sup>185</sup> *Id.* at Resolution 3(a).

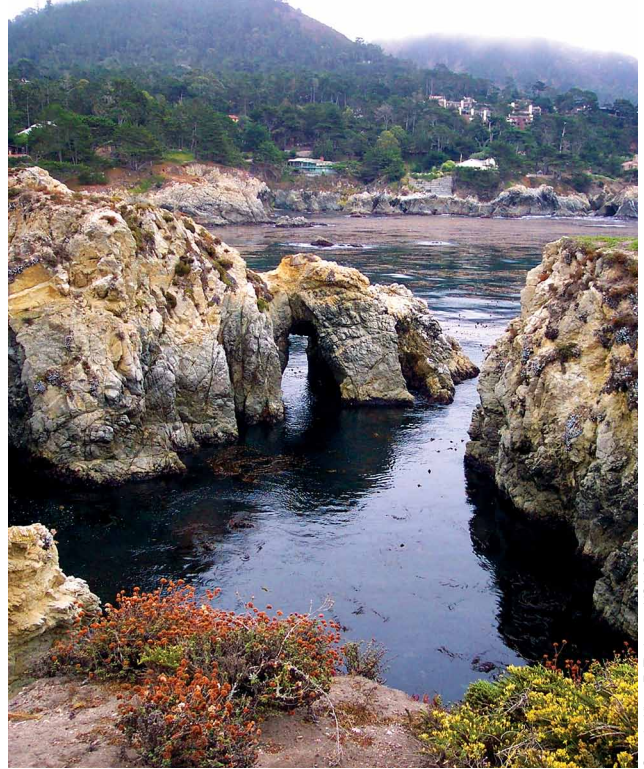
<sup>186</sup> *Id.* at Resolution 3(b).

<sup>187</sup> See note 164, *supra*

<sup>188</sup> See J. Salisbury *et al.*, *supra* note 29.

<sup>189</sup> See 33 U.S.C. §1342(p)(3)(B); EPA requires MS4s to meet both a technology-based standard (reduction to maximum extent practicable) and prevailing water quality standards via best management practices.

<sup>190</sup> See J. Salisbury, *supra* note 188.



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Point Lobos in California is an Area of Special Biological Significance. Point Lobos State Reserve, California.

## 9. Acidification Driver: Stormwater Discharge

**Law/Regulation:** Porter-Cologne, Federal Clean Water Act

**Agency:** State and Regional Water Boards

**Action:** Upgrade Municipal Separate Storm Sewer Systems (MS4s)<sup>187</sup>

**Impact:** Improved containment and/or treatment of stormwater discharge could mitigate intense pulses of freshwater and pollutants that inundate the nearshore environment. Insofar as stormwater runoff is presently more intense and has different chemistry than would be the case in the absence of anthropogenic inputs and altered terrestrial landscapes, the proposed action would ease the footprint of large-magnitude storm events along the coast.

**Discussion:** It is difficult to judge the relative importance of stormwater—as opposed to other kinds of runoff—to coastal ocean acidification.<sup>188</sup> Periodic freshwater inundation is of course a normal aspect of many nearshore ecosystems, but where polluted stormwater contributes significantly to local-scale acidification and other water quality issues, this is another avenue for potential mitigation. Although much stormwater input to the ocean occurs through nonpoint sources, MS4s are point sources subject to modified NPDES permits.<sup>189</sup> If the Water Boards were to make the water quality standards more stringent (see above), or were to otherwise limit discharges in NPDES permits, MS4s would have to limit their discharges accordingly. Because freshwater input can drastically change the pH of receiving marine waters,<sup>190</sup> a stricter pH water quality standard might require significant limitations for stormwater runoff from municipalities.



Where local benefits accrue to cities controlling inputs to their coastal waters,<sup>191</sup> these benefits would partially offset the costs of upgrading MS4 infrastructure. For example, the city of Portland, Oregon, has embarked upon a watershed-wide stormwater management program, which envisions tangibly improving social conditions in addition to reducing the load on municipal infrastructure.<sup>192</sup> In at least some cases auxiliary benefits have led private entities to capture and treat stormwater, reducing stress on municipal systems.<sup>193</sup> Lastly, the federal EPA has provided suggestions for means of funding MS4 upgrades, with case studies included.<sup>194</sup>

## 10. Acidification Driver: Water Quality Degradation from Point and Nonpoint Sources

**Law/Regulation:** Various

**Agency:** Various

**Action:** Use civil and criminal enforcement provisions in the California Code, as well as common-law public nuisance actions, to curtail water quality degradation that contributes to local ocean acidification and coastal water quality degradation.



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**Impact:** Directly abating coastal water pollution would ameliorate coastal acidification and degraded water quality in proportion to the harms avoided. In some cases, this could be the fastest and most effective means of mitigating a particular pollution source, but it is impossible to estimate the aggregate effect of such actions with any certainty.

**Discussion:** A public nuisance is the substantial and unreasonable interference with the use and enjoyment of public property.<sup>195</sup> In general, citizens lack standing to enjoin public nuisances, but where a person is particularly harmed by a public nuisance, he or she has standing to seek an injunction.<sup>196</sup> Otherwise, government agencies seek the injunction. In California, some instances of water pollution constitute a public nuisance per se,<sup>197</sup> and these are particularly attractive cases for either private or public enforcement because of their predictable outcomes. Where degraded water quality jeopardizes a coastal business, for example, the proprietor may seek to abate the cause of that degraded water quality as a public nuisance.

Examples of successful nuisance actions for marine pollution abound, arising in a large number of jurisdictions. For instance, commercial fishermen have successfully sued for damages stemming from both land-based<sup>198</sup> and ocean-based<sup>199</sup> pollution. Nuisance actions place the costs of abatement on polluters,<sup>200</sup> internalizing their incentive to minimize future pollution.

Where pollution from agricultural areas threatens the quality of domestic water supplies, existing Health and Safety Code sections<sup>201</sup> may be useful to alleviate the threat and thereby safeguard the quality of water ultimately reaching the ocean. These statutes prohibit the keeping of livestock in a manner

<sup>191</sup> See, for example, a recent overhaul of public spaces along city streets in Seattle's Barton Basin, <http://www.kingcounty.gov/environment/wtd/Construction/Seattle/BartonCSO-GSI.aspx>, in order to minimize stormwater runoff while beautifying the neighborhood. See also discussion below, regarding reducing water demand and avoiding greenhouse gas emissions associated with water transport.

<sup>192</sup> See City of Portland Bureau of Environmental Services, Tabor to the River Program: An Evaluation of Outreach Efforts and Opportunities for Engaging Residents in Stormwater Management (Oct. 2010) (available at <http://www.portlandonline.com/bes/index.cfm?a=335473&c=50500>).

<sup>193</sup> For example, in 2009, the Irvine Company's Fashion Island shopping center in Newport Beach opted to install stormwater treatment technology under its parking lot, treating pollution onsite. See <http://www.roadsbridges.com/luxury-shopping-mall-minimizes-environmental-footprint>. The University of California, Berkeley, provides a State agency example of improved stormwater management: the school installed permeable buffers of native plants surrounding parking lots to reduce runoff into Strawberry Creek, which runs through the campus. See <http://strawberrycreek.berkeley.edu/creekmgmt/restoration.html> for a description of the overall creek management effort (last visited Jan. 2, 2012).

<sup>194</sup> EPA Region 3, Factsheet: Funding Stormwater Programs (Jan. 2008), available at [http://www.epa.gov/npdes/pubs/region3\\_factsheet\\_funding.pdf](http://www.epa.gov/npdes/pubs/region3_factsheet_funding.pdf).

<sup>195</sup> *Newhall Land & Farming Co. v. Superior Court*, 19 Cal. App. 4th 334, 341 (1993) ("A public nuisance is one which affects at the same time an entire community or neighborhood, or any considerable number of persons, although the extent of the annoyance or damage inflicted upon individuals may be unequal.") (citing Civ. Code,

§ 3480). Note also that California's strong public trust doctrine reinforces the idea that the marine waters are a public good, and as such are amenable to the application of public nuisance doctrine. See *National Audubon Society v. Superior Court* (1983) 33 Cal.3d 419, 441 ("the public trust is more than an affirmation of state power to use public property for public purposes. It is an affirmation of the duty of the state to protect the people's common heritage of streams, lakes, marshlands and tidelands, surrendering that right of protection only in rare cases when the abandonment of that right is consistent with the purposes of the trust.")

<sup>196</sup> *Newhall Land & Farming Co.*, *supra*, at 341 ("[a] private person may maintain an action for a public nuisance, if it is specially injurious to himself, but not otherwise") (citing Civ. Code, § 3493).

<sup>197</sup> *Id.* at 341 ("Pollution of water constitutes a public nuisance. *Carter v. Chotiner* (1930) 210 Cal. 288, 291; *Selma Pressure Treating Co. v. Osmose Wood Preserving Co.* (1990) 221 Cal.App.3d 1601, 1619. In fact, water pollution occurring as a result of treatment or discharge of wastes in violation of Water Code section 13000, et seq. is a public nuisance per se.") (some citations omitted, emphasis added).

<sup>198</sup> *Curd v. Mosaic Fertilizer, LLC*, 39 So. 3d 1216, 1228 (Fla. 2010) (commercial fishermen may recover from terrestrial fertilizer storage facility for pollution); *Leo v. General Electric Co.*, 145 A.D.2d 291, 292-3 (N.Y.App.Div.1989) (action against General Electric Company for discharging 500,000 pounds of polychlorinated biphenyls (PCBs) into the Hudson River). *Curd* gives an extensive review of many such cases. See 39 So. 3d at 1228. But see *Holly Ridge Associates, LLC v. N. Carolina Dept. of Env't & Natural Res.*, 361 N.C. 531, 538 (2007) (finding shellfish growers lacked a direct interest sufficient for intervention as of right, where they had sought to intervene in action over civil penalty assessed against developer by state agency for violation of sediment pollution control act).

<sup>199</sup> *Louisiana v. M/V Testbank*, 524 F. Supp. 1170 (E.D. La. 1981), *aff'd sub nom. Testbank, M/V*, 767 F.2d 917 (5th Cir. 1985) (chemical cargo resulting from collision of ships giving rise to fishermen's cause of action).

<sup>200</sup> Environmental Law Institute, *Enforceable State Mechanisms for the Control of Nonpoint Source Water Pollution* (1997), available at the federal EPA's website at: [http://water.epa.gov/polwaste/nps/elistudy\\_index.cfm](http://water.epa.gov/polwaste/nps/elistudy_index.cfm) (last visited Jan. 2, 2012).

<sup>201</sup> Health & Safety Code §§ 116990; 116995.



Nathan Jongeward/Flickr Creative Commons

that pollutes water used for domestic purposes.<sup>202</sup> The laws therefore may be valuable enforcement tools where this kind of agricultural nonpoint source pollution is a main concern. Where such pollution threatens surface water quality and where surface water is used for drinking water, abating the discharge would benefit both human and environmental health.<sup>203</sup>

Criminal statutes could be of further use, and would abate particular environmental harms.<sup>204</sup> Dumping waste matter into water bodies of all kinds—on stream banks or beaches—is a crime in California, and carries a penalty of criminal fines.<sup>205</sup> Although such dumping is probably not a major driver of coastal water quality problems when compared to more routine point and nonpoint source discharges, vigilantly enforcing these laws could be a low-cost or revenue-neutral means of deterring illegal pollution while underscoring the seriousness of environmental crimes. Finally, as noted above, failing to file for a discharge permit—whether the discharge is from a point or a nonpoint source—is also a misdemeanor under the Porter-Cologne Act.<sup>206</sup>

<sup>202</sup> Note that Health & Safety Code § 116995 (“No person shall cause or permit any horses, cattle, sheep, swine, poultry, or any kind of live stock or domestic animals, to pollute the waters, or tributaries of waters, used or intended for drinking purposes by any portion of the inhabitants of this state”) is sufficiently broad that it may prohibit pollution of coastal waters that, after desalination, is destined to be drinking water. No case law is available to determine the limits of the statute’s reach.

<sup>203</sup> Note, however, that if the remedy for polluted drinking water is replacing the tainted water with treated or bottled water for domestic use, the environmental benefits disappear.

<sup>204</sup> Penal Code § 374.7(a) carries a fine of \$250–1000 for a first violation; up to \$3000 for repeated violations. It is possible enforcing these statutes may even generate a small amount of revenue.

<sup>205</sup> Penal Code § 374.7(a).

<sup>206</sup> Water Code § 13261.

## 11. Acidification Driver: Point and Nonpoint Source Pollution

**Law/Regulation:** Porter-Cologne and Federal Clean Water Act

**Agency:** Various (e.g., Coastal Commission, Fish & Game Commission)

**Action:** Issue comments on NPDES permit applications pending before the Regional Water Boards.

**Impact:** Commenting on pending discharge permits highlights ocean acidification as a water quality concern and raises awareness of the issue, encouraging explicit discussion of water pollution as an agent of nearshore ocean acidification.

**Discussion:** Interested parties may use the notice-and-comment period accompanying the issuance of a draft NPDES permit as a forum for addressing ocean acidification issues. For State agencies other than the water boards themselves, publicly commenting on pending NPDES permits may be a good strategy for creating a record of engagement on this issue. Such comments would raise the profile of ocean acidification and related water quality issues at no cost, without requiring legislative or regulatory action. This action is among the less direct means of addressing acidification, but is nevertheless an important step in establishing ocean acidification as an environmental issue that demands administrative attention.



Automobile tires wash from the Tijuana River watershed into the Tijuana River National Estuarine Research Reserve in Imperial Beach (San Diego County), California.

Photo by Marsha Gear, Copyright California Sea Grant, University of California. Marine Photobank.



## II. Actions to Reduce Acidifying Emissions

### A. Actions Primarily Aimed at Reducing Sulfur and Nitrogen Emissions

# 12. Acidification Driver: SO<sub>x</sub> and NO<sub>x</sub> emissions<sup>207</sup>

**Law/Regulation:** Federal Clean Air Act<sup>208</sup>

**Agency:** California Air Resources Board

**Action:** Revise ambient air quality standards for sulfur dioxide (SO<sub>2</sub>) and nitrogen dioxide (NO<sub>2</sub>) to be consistent with federal 1-hour standards<sup>209</sup>; consider making existing standards more stringent to guard against local deposition in coastal areas.

**Impact:** SO<sub>x</sub> and NO<sub>x</sub> are gases that form acids when dissolved in seawater, lowering the pH of receiving waters.<sup>210</sup> Because of short residence times in the atmosphere,<sup>211</sup> these compounds are most likely to contribute to ocean acidification near where they are produced as byproducts of human industrial processes. As such, tighter ambient air quality standards for these compounds would have the greatest impact on OA near heavy-industrial sources such as petroleum refineries.<sup>212</sup>

**Discussion:** Most SO<sub>x</sub> and NO<sub>x</sub> emissions are generated where California's human population is most concentrated: along the coast. Los Angeles and Contra Costa Counties alone combine to account for over half of California's SO<sub>2</sub> emissions.<sup>213</sup> These emissions are the most likely to precipitate out of the atmosphere locally and be deposited in the coastal ocean.<sup>214</sup> Thus tighter control of SO<sub>x</sub> and NO<sub>x</sub> is likely to reduce their influence on ocean chemistry, although the magnitude of the existing effect of SO<sub>x</sub> and NO<sub>x</sub> on marine water quality is spatially variable and must be locally determined.<sup>215</sup>

<sup>207</sup> These notations refer to sulfur oxides and nitrogen oxides generally. The most common of these are SO<sub>2</sub> and NO<sub>2</sub>.

<sup>208</sup> 42 U.S.C. § 7401 *et seq.*

<sup>209</sup> Due to a 2010 federal rulemaking, current state standards are less stringent than the prevailing federal standards for 1-hour time intervals, for both NO<sub>2</sub> and SO<sub>2</sub>. See 75 Fed Reg 6474 (Feb. 9, 2010); 75 Fed Reg 35520 (Jun. 22, 2010); <http://www.arb.ca.gov/research/aaqs/caaqs/caaqs.htm> (California Ambient Air Quality Standards). Because the state is required to meet or exceed the federal standard, CARB will be treating the federal standard as if it were the state standard until the next state rulemaking on the matter. Phone call with Alvaro Alvarado, California Air Resources Board, Oct. 17, 2011.

<sup>210</sup> See Doney *et al.*, *supra* note 16. These gases are also the cause of acid rain.

<sup>211</sup> *Id.*

<sup>212</sup> See data available from the EPA's National Emissions Inventory, at <http://www.epa.gov/ttn/chief/net/2008inventory.html>. The biggest stationary SO<sub>2</sub> sources near the coast are petroleum and related industries; other industrial fuel combustion also contributes significantly. The largest sources of NO<sub>x</sub> are mobile highway and off-highway vehicles.

<sup>213</sup> *Id.* In 2008, the most recent date for which data are available, Los Angeles County and Contra Costa County accounted for 25.04% and 34.08% of California's SO<sub>2</sub> emissions from industrial fuel production, respectively. In absolute terms, these were 2182.452 tons/year and 2970.14 tons/year, respectively.

<sup>214</sup> Note also that commercial marine vessels contribute more SO<sub>2</sub> than all of the state's petroleum refineries combined, but these data pre-date California's fuel rule designed to reduce emissions ocean-going vessels. *Id.* See <http://neibrowser.epa.gov/eis-public-web/geo/sector-emissions.html?jurisdiction/d=6&inventoryYear=2008>; California's Ocean-Going Vessels Fuel Rule, 13 CCR § 2299.2; 17 CCR § 93118.2, description available at <http://www.arb.ca.gov/ports/marinevess/ogv.htm>.

With the exception of the one-hour standards,<sup>216</sup> California's emissions standards for SO<sub>x</sub> and NO<sub>x</sub> already meet or exceed the national limits. Harmonizing the State one-hour standards with federal levels would bring the State into compliance with the Clean Air Act, and would clarify the enforceable limits for California's regulated parties. Because one-hour standards serve to limit short-term "spikes" of pollution, enforcing these standards ameliorates coastal acidification by limiting both the total amount of acidifying SO<sub>x</sub> and NO<sub>x</sub> precipitated into the marine environment and the maximum hourly rate of such precipitation.

When revising the one-hour standards, the California Air Resources Board could consider stricter limits on these emissions than the Clean Air Act requires. More stringent standards would have the beneficial side effects of furthering the Clean Air Act's core goals while ameliorating a driver of coastal ocean acidification where atmospheric deposition of SO<sub>x</sub> and NO<sub>x</sub> are significant contributors.

In general, states may promulgate more stringent air quality standards than those required federally.<sup>217</sup> However, because SO<sub>x</sub> and NO<sub>x</sub> are subject to federal trading schemes,<sup>218</sup> market-based programs that allow polluters to profit from emissions reductions beyond those required by law. Federal preemption concerns therefore limit states' ability to regulate these emissions somewhat.

In *Clean Air Markets Group v. Pataki*, the Second Circuit held that title IV of the 1990 Clean Air Act Amendments preempted a New York State law that collected fees for SO<sub>2</sub> emissions allowances traded to out-of-state polluters, and indicated that the state scheme created an "obstacle" to the nationwide trading program.<sup>219</sup> This case highlights a tension between the older

[gov/eis-public-web/geo/sector-emissions.html?jurisdiction/d=6&inventoryYear=2008](http://www.arb.ca.gov/ports/marinevess/ogv.htm); California's Ocean-Going Vessels Fuel Rule, 13 CCR § 2299.2; 17 CCR § 93118.2, description available at <http://www.arb.ca.gov/ports/marinevess/ogv.htm>.

<sup>215</sup> See S.C. Doney *et al.*, *supra* note 16 at 14583. (estimating that sulfur and nitrogen deposits could account for carbonate changes of up to 50% of the effect seen from atmospheric CO<sub>2</sub> in some coastal regions).

<sup>216</sup> See note 209, *supra*.

<sup>217</sup> 42 U.S.C. § 7416 ("nothing in this chapter shall preclude or deny the right of any State or political subdivision thereof to adopt or enforce (1) any standard or limitation respecting emissions of air pollutants or (2) any requirement respecting control or abatement of air pollution; except that if an emission standard or limitation is in effect under an applicable implementation plan or under section 7411 or section 7412 of this title, such State or political subdivision may not adopt or enforce any emission standard or limitation which is less stringent than the standard or limitation under such plan or section."); *State of Connecticut v. EPA*, 656 F.2d 902, 909 (2d Cir. 1981) ("[t]he Clean Air Act] provides that the states shall be free to adopt air quality standards more stringent than required by the NAAQS or other federal law provisions"); *Her Majesty The Queen In Right of the Province of Ontario v. City of Detroit*, 874 F.2d 332, 342 (6th Cir. 1989) ("[t]he Clean Air Act] displaces state law only to the extent that state law is not as strict as emission limitations established in the federal statute.")

<sup>218</sup> These include the Acid Rain Program, 42 U.S.C. § 7651 *et seq.*, and the Clean Air Interstate Rule, 70 Fed. Reg. 25162 (May 12, 2005); *North Carolina v. EPA*, 531 F.3d 896 (D.C. Cir. 2008), *vacatur stayed on reh'g* 550 F.3d. 1176 (2008).

<sup>219</sup> 338 F.3d 82 (2d Cir. 2003). Note also that the New York law may pose a Dormant Commerce Clause problem; the District Court invalidated the statute's restrictions on trading allowances to out-of-state parties both on Commerce Clause grounds and on preemption grounds, but the Circuit Court did not reach the Commerce Clause issue. *Id.* at 89. See also S.J. Rodman, Legal Uncertainties and the Future of U.S. Emissions Trading Programs, Natural Resources and the Environment 10 (discussing a power company's lack of standing to challenge Virginia's State Implementation Plan in *Mirant Potomac River LLC v. EPA*, 577 F.3d 223 (4th Cir. 2009); and an amicus brief in *North Carolina v. TVA*, 593 F. Supp. 2d 812 (2009), and arguing that courts are likely to strike down only those state laws that interfere with the actual buying, selling, or transferring of emissions allowances).

command-and-control Clean Air Act rules. And the more recent market-based rules, and the interaction between these sets of rules remains an area of active legal debate. If California were to create more stringent  $\text{SO}_x$  and  $\text{NO}_x$  standards, the State would have to avoid federal preemption by amending its air quality standards without restricting the transferability of emissions credits.

## B. Actions Primarily Aimed at Reducing Carbon Emissions

### 13. Acidification Driver: $\text{CO}_2$ and Other Drivers Related to Local Land Use Change

**Law/Regulation:** County and Municipal General Plans; State Planning and Zoning Law; Coastal Act

**Agency:** County and municipal governments; Coastal Commission

**Action:** Amend general plans to include goals and implementation programs to minimize direct and indirect stressors that are likely to contribute to global ocean acidification (e.g.,  $\text{CO}_2$  emissions) or local exacerbation of the global trend (water quality, permeable surfaces, etc.).<sup>220</sup> Ensure compliance with newer State planning requirements that require a transit-friendly circulation element,<sup>221</sup> and mandate that cities identify streams and riparian areas that may accommodate floodwaters for purposes of stormwater management.<sup>222</sup> Ensure rigorous compliance with the State statute requiring that local subdivision ordinances properly provide for erosion control,<sup>223</sup> and with the erosion and pollution-control statutes governing the special land-use case of forestry.<sup>224</sup>

In addition, the Coastal Commission could more aggressively use its broad authority to prevent land-use practices that negatively impact the nearshore environment.<sup>225</sup> The Coastal Act authorizes the Commission to maintain and restore marine resources, including coastal water quality and biological productivity.<sup>226</sup> Through local coastal program amendment review and certification, the Commission could require local jurisdictions to include proactive policies and implementation programs to minimize direct and indirect stressors, including nutrient runoff from nonpoint sources, an otherwise difficult issue to tackle.<sup>227</sup>

<sup>220</sup> For example, a San Francisco organization's proactive effort to create more permeable sidewalk areas both reduces wastewater and creates more attractive streetscapes. See <http://www.plantsf.org/PermeableLandscaping.html>. San Francisco's Board of Supervisors has commended the projects. Resolution 775-05 (Oct. 27, 2005). These measures can cost as little as \$10/ft<sup>2</sup>. See S. Coyle, Sustainable and Resilient Communities, 262 (2011). Similarly, converting urban land to functional agricultural sites can produce food while increasing permeable surfaces in the urban environment. *Id.* at 282. These and other similar efforts reduce the load on storm- and wastewater treatment facilities, and lessen the direct inputs from urban environments into coastal waters.

<sup>221</sup> Gov't Code § 65302(b)(2)(A) (effective Jan. 1, 2011).

<sup>222</sup> § 65302(d)(3) (effective Jan. 1, 2009).

<sup>223</sup> Gov't. Code §§ 65302, 65596(f), 66411 contain a variety of applicable provisions, such as "[t]he [subdivision] ordinance shall specifically provide for proper grading and erosion control, including the prevention of sedimentation or damage to offsite property." § 66411. See also § 66646.2 (encouraging the San Francisco Bay Conservation and Development Commission to identify areas subject to erosion and inundation due to sea level rise).

## Current Research

### Ocean Margin Ecosystems Group for Acidification Studies (OMEGAS): Acidification in Nearshore and Intertidal Environments

Research by this NSF-funded consortium is presently underway, measuring pH,  $\text{p}(\text{CO}_2)$ , and other parameters between Oregon and Santa Barbara, California. Partner institutions include Oregon State University, U.C. Davis, Stanford University, U.C. Santa Cruz, the University of Hawaii, the Monterey Bay Aquarium Research Institute, and U.C. Santa Barbara. Data collected to date indicate that shallow waters routinely experience low pH levels, and that the average nearshore pH is declining over time, in accord with well-documented trends in the wider ocean.<sup>293</sup> Crucially, the OMEGAS group is testing for effects of these chemical changes on marine species, presently a significant gap in our understanding of the ecosystem effects of ocean acidification. Particular study subjects include the purple sea urchin<sup>294</sup> and the California mussel,<sup>295</sup> and early results indicate significant effects of high- $\text{CO}_2$  water on larval development.<sup>296</sup>

<sup>293</sup> Interview with Bruce Menge, Distinguished Professor of Marine Biology, Oregon State University, at Stanford University (Jan. 19, 2012). Menge is one of the project's principal investigators.

<sup>294</sup> *Strongylocentrotus purpuratus*.

<sup>295</sup> *Mytilus californianus*.

<sup>296</sup> See B. Gaylord *et al.*, Functional Impacts of Ocean Acidification in an Ecologically Critical Foundation Species, 214 J. Experimental Biology 2586 (2011).

Through consistency review, the Commission could recommend project conditions to mitigate and prevent stressors arising from proposed projects. Finally, in the case of a conflict between environmental priorities in the coastal zone—as in the case of a coastal dairy wanting to fill seasonal wetland in order to improve

<sup>224</sup> Pub. Res. Code § 4581 *et seq.* Note in particular that "[a] timber harvesting plan may not be approved if the appropriate regional water quality control board finds, based on substantial evidence, that the timber operations proposed in the plan will result in a discharge into a watercourse that has been classified as impaired due to sediment pursuant to subsection (d) of Section 303 of the Federal Water Pollution Control Act." § 4582.71(a). Given the large number of State water bodies on the 303(d) list, this provision could be especially powerful to minimize sediment and nutrient loadings from forestry activities.

<sup>225</sup> See Publ. Res. Code § 30230 ("Marine resources shall be maintained, enhanced, and where feasible, restored"); § 30231 ("The biological productivity and the quality of coastal waters, streams, wetlands, estuaries, and lakes appropriate to maintain optimum populations of marine organisms and for the protection of human health shall be maintained and, where feasible, restored.")

<sup>226</sup> *Id.*

<sup>227</sup> A good example of such proactive work is the City of Portland, Oregon's "Tabor to the River" watershed-wide restoration effort. This program integrates social and environmental goals to improve water quality and riparian habitat in the Willamette River basin. See <http://www.portlandonline.com/bes/index.cfm?c=47591&a=358466> (last visited: Dec. 29, 2011). In particular, the program focuses on sewer and stormwater management, as well as tree-planting.

water quality and minimize runoff<sup>228</sup>—the Coastal Commission uses its conflict-resolving powers<sup>229</sup> to favor project decisions that are on balance most protective to coastal resources. In making such decisions, the Commission should consider ocean acidification among the environmental impacts of nutrient runoff and emissions-intensive development. Note that the Commission's mandate is a significant policy tool that is already available without changes to existing law.<sup>230</sup>

**Impact:** Proactive planning and reactive land-use decisionmaking both have the potential to avoid many of the coastal inputs likely to exacerbate ocean acidification locally, while simultaneously contributing to a larger-scale effort to minimize the CO<sub>2</sub> emissions that create a background level of ocean acidification worldwide. In particular, a decrease in impermeable surfaces, an increase in riparian buffers, and efficient stormwater management all function to mitigate the nonpoint source runoff that can negatively impact coastal waters and make them more acidic.

Note that city and county actions to adopt or amend general and specific plans, as well as to approve tentative subdivision maps, are steps that trigger CEQA review.<sup>231</sup> As such, adding to CEQA analysis a requirement for considering projects' ocean acidification impacts—either as its own distinct impact or as part of a more comprehensive cumulative impacts analysis—would enhance planning procedures directly. This is particularly significant in light of a recent California appellate court opinion holding CEQA does not require consideration of the effects of environmental changes—such as climate change and ocean acidification—on a project.<sup>232</sup>

**Discussion:** These actions cover a broad range of potential acidification drivers, and require a minimum of new law. Counties and municipalities are required to come into compliance with existing State requirements during any substantial revision of their general plans; each jurisdictional unit is on a

different schedule. In cases where coastal and marine-dependent industries such as shellfish, finfish fisheries, and tourism significantly influence the local economy, politics and local tax revenues from these economic activities are more likely to favor changes that better protect coastal ecosystems. Moreover, more protective measures may be more cost-effective than the alternatives: where local infrastructure is due for new installation, maintenance, or significant replacement, use of low-impact designs and technologies often result in substantial cost-savings.<sup>233</sup>

## 14. Acidification Driver: CO<sub>2</sub> Emissions

**Law/Regulation:** Executive orders, county and local initiatives

**Agency:** State, county, and local executive offices

**Action:** Develop broad-scale energy and land-use policies to improve building efficiency, urban density, and purchasing policies that respond to statewide emissions-reductions targets. This includes going beyond the development incentives of SB375<sup>234</sup> and greener building codes—both of which largely impact future infrastructure—to reach existing infrastructure.

**Impact:** Because of the global scale of the CO<sub>2</sub> problem, it may be difficult to imagine municipal, county, or even state-level emissions reductions having a significant impact on CO<sub>2</sub>-driven acidification. However, California accounts for a substantial fraction of the nation's carbon emissions, in large part generated by the State's transportation sector.<sup>235</sup> Reducing the total amount of anthropogenic CO<sub>2</sub> added to the atmosphere is an absolutely essential step towards mitigating the primary driver of ocean acidification globally. Such emissions reductions are also required under State law.<sup>236</sup> Increasing urban density to reduce vehicle miles travelled is likely to be an effective step to reduce

<sup>228</sup> See *In Re: James & Leslie O'Neil*, California Coastal Commission, Application 1-98-103 at 35-36 (approved Dec. 10, 1999).

<sup>229</sup> Pub. Res. Code § 30007.5 ("conflicts [shall] be resolved in a manner which on balance is the most protective of significant coastal resources.")

<sup>230</sup> Note that the Coastal Commission shares responsibility with the State and Regional Water Boards in implementing the Nonpoint Source Program Strategy And Implementation Plan. PROSIP, *supra* note 108 at v.

<sup>231</sup> See Cal. Code Reg., tit. 14, § 15378; Gov. Code, § 65456; *Christward Ministry v. Superior Court*, 184 Cal. App. 3d 180, 193-194 (4th Dist. 1986); *City of Lomita v. City of Torrance*, 148 Cal. App. 3d 1062, 1069 (2d Dist. 1983). Note that where changes to general plans are done by ballot initiative—rather than by agency approval—those changes are not subject to CEQA review. Cal. Code Reg., tit. 14, § 15378(b)(3); *DeVita v. County of Napa*, 9 Cal. 4th 763, 793-795 (1995). As to subdivision maps, Pub. Resources Code, § 21080.

<sup>232</sup> *Ballona Wetlands Land Trust v. City of Los Angeles*, \_\_\_ Cal.App.4th \_\_\_ (Nov. 9, 2011, Case No. B231965) (holding that the City, as project proponent, was not required to evaluate the impacts to a project from sea level rise due to global climate change, and noting that "the purpose of an EIR is to identify the significant effects of a project on the environment, not the significant effects of the environment on the project" (citing *City of Long Beach v. Los Angeles Unified School Dist.*, 176 Cal. App.4th 889, 905 (2009)).

<sup>233</sup> Perhaps the best-known example of this phenomenon is New York City's drinking water purification. In 1996, the City opted to restore the Catskill mountain ecosystem that filtered its water, rather than building a filtration plant to accomplish the same task. The City estimated it would save \$6-\$8 billion over ten years. G. Chichilnisky

& G. Heal, Economic Returns from the Biosphere, 391 Nature 629, 629 (1998). Low-impact development generally costs less than conventional development and produces superior environmental outcomes. See EPA Fact Sheet, Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices (Dec. 2007), available at <http://www.epa.gov/owow/nps/lid/costs07/factsheet.html> (last visited Jan. 2, 2012). California's Central Coast water board requires low-impact development, which incorporates these same principles, for municipalities' stormwater management. See [http://www.swrcb.ca.gov/rwqcb3/water\\_issues/programs/stormwater/low\\_impact.shtml](http://www.swrcb.ca.gov/rwqcb3/water_issues/programs/stormwater/low_impact.shtml) (last visited Dec. 23, 2011). King County, Washington, has developed a manual on low-impact development, available at <http://www.your.kingcounty.gov>.

<sup>234</sup> Senate Bill 375 (Steinberg), Chaptered Sep. 30, 2008, provides modest incentives for denser and more transit-friendly development in California. See also King County (Washington) Climate Motion, May 10, 2011 at 7 (similar). California's AB1613/AB2791 also encourage the use of heat & power cogeneration facilities, reducing waste, CO<sub>2</sub>, and NO<sub>x</sub> emissions.

<sup>235</sup> California's per-capita emissions are greater than those for many large nations, including Germany, Japan, Italy, France, Mexico, Brazil, and Argentina. See California Energy Commission, Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2004, Figure 11 (Dec. 2006). In 2004, California emitted a total of approximately 363.8 mmtCO<sub>2</sub>-eq, of which 188 mmtCO<sub>2</sub>-eq (51.7%) was from the transportation sector. Letter from Rosella Shapiro, California Energy Commission, to the Air Resources Board, Jan. 23, 2007, Revisions to the 1990 to 2004 Greenhouse Gas Emissions Inventory Report, Published In December 2006 (CEC-600-2006-013), Table 6.

<sup>236</sup> Cal. Health & Safety Code § 38550.





Wolcott Henry 2005/Marine Photobank

Southern California coastal development.

CO<sub>2</sub> emissions, and simultaneously increases the energy efficiency of buildings.<sup>237</sup>

**Discussion:** Any action that directly reduces CO<sub>2</sub> emissions begins to address the primary driver of global background ocean acidification. California's AB32 requires emissions reductions independent of any ocean acidification benefit;<sup>238</sup> the effect of these reductions (however small on a global scale) to slow the changing ocean chemistry is a secondary benefit from the policy changes that are already required or encouraged at the state level.

Smaller-scale, yet significant, examples of more emissions-friendly purchasing policies include the City of Mill Valley's bottled water ban for city uses<sup>239</sup> and San Francisco's vehicle fleet reduction.<sup>240</sup> Cities and counties can also alter their energy

portfolios toward increasing renewables, as King County, Washington has done.<sup>241</sup> California's desalination projects will have notable CO<sub>2</sub> footprints,<sup>242</sup> and relevant governmental agencies should carefully weigh the value of these and other coastal industries against the impacts of CO<sub>2</sub> on the ocean. Recent reports show that water recycling and conservation is much cheaper than desalination, and come with large emissions reductions.<sup>243</sup>

In some cases, moving to low-carbon-footprint sources for government acquisitions saves substantial amounts of money,<sup>244</sup> freeing county and municipal revenues for other uses. Finally, improving transit links and increasing urban density reduces sprawl in ways that can increase municipal tax revenues<sup>245</sup> and pay cultural dividends, all while reducing emissions from vehicle miles travelled.<sup>246</sup>

<sup>237</sup> See National Research Council, Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption, Driving and the Built Environment: The Effects of Compact Development on Motorized Travel, Energy Use, and CO<sub>2</sub> Emissions—Special Report 298 at 91 (2009). *But see* A.T. Moore *et al.*, The Role of VMT Reduction in Meeting Climate Change Policy Goals, 44 Transportation Research Part A 565 (2010) (arguing that policies to reduce VMT are overly blunt instruments, and favoring a carbon tax instead).

<sup>238</sup> *Id.*

<sup>239</sup> See <http://www.cityofmillvalley.org/index.aspx?recordid=231&page=34> (last visited Nov. 17, 2011).

<sup>240</sup> San Francisco Office of the Mayor, Gavin Newsom, Executive Directive 09-01, Reduction of City Fleet Vehicles (Jan. 12, 2009).

<sup>241</sup> King County will implement its 2010 Energy Plan to achieve 50% of its energy needs from renewables by 2015, 2011 Climate Motion at 11.

<sup>242</sup> Depending upon the desalination process used, plants use between 4–12 kW<sup>h</sup> of thermal energy and 1.5–7 kW<sup>h</sup> of electric energy to desalinate a single cubic meter of water. See S. Lattemann and T. Höpner, Environmental Impact and Impact

Assessment of Seawater Desalination, 220 Desalination 1, 10 (2008). The authors note a mid-sized desalination plant uses as much energy annually as 10,300 four-person households. *Id.* Emerging technologies may lower the energy demand of desalination, see, e.g., M. Busch & W.E. Mickols, Reducing Energy Consumption in Seawater Desalination, 165 Desalination 299, 299 (2004), but carbon emissions from desalination efforts in the United States are likely to remain a serious environmental cost of the process for years to come.

<sup>243</sup> Seawater desalination is roughly nine times as energy-intensive as surface water. See B. Griffiths-Sattenspiel & W. Wilson, The Carbon Footprint of Water 15 (2009), available at [www.rivernetnetwork.org](http://www.rivernetnetwork.org). Where desalination is seven times as energy as intensive as groundwater, which in turn is 30% more intensive than surface water, desalination is 7\*1.3 = 9.1 times the energy intensity of groundwater.

<sup>244</sup> See, e.g., King County, 2010 Annual Green Report at 2 (2010), available at <http://your.kingcounty.gov/dnrp/library/dnrp-directors-office/climate/2010-annual-green-report.pdf> (reporting a county savings of \$1m in 2010 alone).

<sup>245</sup> See, e.g., S. Winkelman, A. Bishins, & C. Kooshian, Planning for Economic and Environmental Resilience, 44 Transportation Research Part A 575, 581 (2010).

<sup>246</sup> *Id.*

## 15. Acidification Driver: CO<sub>2</sub> Emissions

**Law/Regulation:** CEQA Guidelines<sup>247</sup>

**Agency:** California Natural Resources Agency

**Action:** Amend existing guidelines to include ocean acidification as a specific example of environmental impact that project proponents must analyze.<sup>248</sup>

**Impact:** The change would raise awareness of ocean acidification as an issue, mitigate some of its drivers through disclosure and voluntary amelioration, and would contribute the information necessary to improve a cumulative impacts determination.

**Discussion:** Arguably, a court could already require such analysis under the guidelines' existing greenhouse gas and water quality provisions.<sup>249</sup> The proposed action is not a major change to the guidelines, but is simply a clarification to highlight the growing scientific consensus on the changing ocean chemistry and its importance to California's economy and coastal ecosystems. See Appendix I for sample text of revised CEQA guidelines.



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## 16. Acidification Driver: CO<sub>2</sub> Emissions

**Law/Regulation:** California Global Warming Solutions Act of 2006 (AB32)<sup>250</sup>

**Agency:** California Air Resources Board

**Action:** Include mitigation of ocean acidification as one of the reasons to limit greenhouse gases, as well as one of the reasons to implement cap & trade within the Western Climate Initiative.<sup>251</sup>

**Impact:** This action raises awareness of acidification as an increasingly serious environmental issue and acknowledges the explicit link between emissions and ocean acidification.

**Discussion:** AB32 and the Western Climate Initiative exist to mitigate the effects of emissions on global climate change, not ocean acidification. But each measure combats the rise of atmospheric CO<sub>2</sub>, the primary driver of background global ocean acidification. Including language on acidification strengthens the logic for both AB32 and the WCI and raises the profile of changing ocean chemistry as a separate and important effect of anthropogenic CO<sub>2</sub>. This has the added benefit of highlighting ocean acidification as an issue even in non-coastal states involved in the WCI.

<sup>247</sup> 14 CCR §15000 *et seq.*

<sup>248</sup> The Secretary of Natural Resources reviews the CEQA guidelines and considers amendments at least every two years, by statute. Pub. Res. Code § 21083(f). Amendments are adopted according to the state Administrative Procedure Act. Government Code § 11340 *et seq.*

<sup>249</sup> See, e.g., §15064.4(b) ("A lead agency should consider the following factors, among others, when assessing the significance of impacts from greenhouse gas emissions on the environment: (3) The extent to which the project complies with regulations or requirements adopted to implement a statewide, regional, or local plan for the reduction or mitigation of greenhouse gas emissions...If there is substantial evidence that the possible effects of a particular project are still cumulatively

considerable notwithstanding compliance with the adopted regulations or requirements, an EIR must be prepared for the project.") CEQA requires consideration of a project's greenhouse gas emissions and emissions-inducing effects. Nat. Res. Code § 15064.4. CO<sub>2</sub> is a greenhouse gas, Health & Safety Code § 38505, and ocean acidification is a direct effect of increased atmospheric CO<sub>2</sub>. Lead agencies may therefore consider the impacts of CO<sub>2</sub> on the acidifying ocean within the existing CEQA analysis.

<sup>250</sup> Codified at Health & Safety Code § 35500 *et seq.*

<sup>251</sup> <http://www.westernclimateinitiative.org>. See California's state factsheet on the cap & trade process and the WCI, available at <http://www.arb.ca.gov/cc/factsheets/capandtrade.pdf>.





## IV. Funding Sources for Implementing Water Quality Policies

Ryan P. Kelly

Below, we provide a description of resources for agencies, municipalities, and other interested entities to help identify funding sources for projects related to ocean acidification.

1. The California Department of Water Resources maintains a central site that links to existing State programs for projects relevant to water quality.<sup>252</sup> These programs include State bond-funded grants available to municipalities, as well as a small number of loan programs.
2. The California Natural Resources Agency provides links to track the balances of relevant bond funds and other sources of grant money for municipalities and agencies.<sup>253</sup> Particularly useful is the Agency's chart of programs, which provides detailed information about eligibility and available funds.<sup>254</sup> For example, as of December 2011, \$37.15 million was available to develop more sustainable land use plans,<sup>255</sup> \$36.6 million was available for Delta water quality improvements that protect drinking water supplies,<sup>256</sup> \$15 million for projects to improve agricultural water use efficiency,<sup>257</sup> a total of \$612.5 million for planning and implementation grants for developing integrated regional water management programs,<sup>258</sup> \$91 million for stormwater management projects,<sup>259</sup> and \$50 million for projects that improve coastal water quality.<sup>260</sup> These are among the larger sources of State funding for projects relevant to ocean acidification; many smaller programs also exist to aid government entities ameliorate the threat of acidification. Note that these are listed as active grant and loan programs within the Natural Resources Agency, but that in some cases the fate of future awards is uncertain due to California's ongoing budget crisis.<sup>261</sup>



3. The California State Controller's Office publishes an annual budget report,<sup>262</sup> with detailed information about the expenditures and remaining balances of the various State allocations. This includes several water quality programs and other expenditures relevant to ocean acidification. Interested parties may then determine whether funds are available for any particular program, for example, or whether particular bonds have been authorized or issued.
4. The California Legislative Analyst's Office provides a simplified version of the State budget, broken down by subject area.<sup>263</sup> This offers a more aggregated view of the State's environmental expenditures on an annual basis.
5. The State and Regional Water Boards may authorize some water quality projects as Supplemental Environmental Projects (SEPs).<sup>264</sup> The SEP program allows dischargers who have accrued administrative civil liability to the water boards (i.e., as a result of some violation) to satisfy a portion of their monetary assessment by completing projects that improve water quality. "SEPs are projects that enhance the beneficial uses of the waters of the State, that provide a benefit to the public at large and that ... are not otherwise required of the discharger."<sup>265</sup> While the SEP program is not a freestanding funding mechanism for water quality projects, it nevertheless bears mentioning as a means of undertaking discrete improvements that might not otherwise be practical due to budget constraints.
6. Federal funding opportunities are searchable by keyword in the Catalog of Federal Domestic Assistance.<sup>266</sup> Searches return information on funding levels for each program, as well as eligibility and application information. Hundreds of relevant programs are funded, focusing on water and air quality, erosion, and similar areas of broad environmental concern. In many cases, states and municipalities are eligible for significant funding for projects that would mitigate ocean acidification.

<sup>262</sup> <http://www.water.ca.gov/nav/nav.cfm?loc=t&id=103>

<sup>263</sup> <http://resources.ca.gov/bonds.html>.

<sup>264</sup> [http://resources.ca.gov/bond/Grants\\_and\\_Loans\\_Complete\\_12-2011.pdf](http://resources.ca.gov/bond/Grants_and_Loans_Complete_12-2011.pdf).

<sup>265</sup> *Id.*; see also [http://sgc.ca.gov/planning\\_grants.html](http://sgc.ca.gov/planning_grants.html).

<sup>266</sup> See also [http://baydeltaoffice.water.ca.gov/sdb/prop84/index\\_prop84.cfm](http://baydeltaoffice.water.ca.gov/sdb/prop84/index_prop84.cfm).

<sup>267</sup> See also <http://www.owue.water.ca.gov>.

<sup>268</sup> See also <http://www.water.ca.gov/irwm/index.cfm>.

<sup>269</sup> See also <http://www.water.ca.gov/irwm/index.cfm>.

<sup>260</sup> See also [http://www.waterboards.ca.gov/water\\_issues/programs/beaches/cbi\\_projects/index.shtml](http://www.waterboards.ca.gov/water_issues/programs/beaches/cbi_projects/index.shtml).

<sup>261</sup> For example, the state water board's Clean Beaches Initiative is still accepting grant proposals, although funding for the program was suspended Dec. 17, 2008, and it remains unclear when that funding will resume. See [http://www.waterboards.ca.gov/water\\_issues/programs/beaches/cbi\\_projects/index.shtml](http://www.waterboards.ca.gov/water_issues/programs/beaches/cbi_projects/index.shtml) (last visited Jan. 2, 2012).

<sup>262</sup> Available at [http://www.sco.ca.gov/ard\\_state\\_annual\\_budgetary.html](http://www.sco.ca.gov/ard_state_annual_budgetary.html).

<sup>263</sup> [http://www.sco.ca.gov/ard\\_state\\_annual\\_budgetary.html](http://www.sco.ca.gov/ard_state_annual_budgetary.html).

<sup>264</sup> Water Code §§ 13385(l); 13399.35.

<sup>265</sup> State Water Resources Control Board, Policy on Supplemental Environmental Projects at 1 (Feb. 3, 2009). See this policy document generally for a description of SEPs and their implementation. The water boards may also allocate funds for Regional Water Quality Improvement Projects out of the State Water Pollution Cleanup and Abatement Account, which in turn is funded by civil fines from enforcement actions. See California Regional Water Quality Control Board Central Valley Region, Resolution No. R5-2008-0180 (Dec. 16, 2008), available at [http://www.swrcb.ca.gov/rwqcb5/water\\_issues/enforcement/sep\\_list\\_qualifying\\_criteria.pdf](http://www.swrcb.ca.gov/rwqcb5/water_issues/enforcement/sep_list_qualifying_criteria.pdf).

<sup>266</sup> <http://www.cfda.gov>.

# V ■ Appendix

## Appendix I: Sample Language for CEQA Analysis

As a practical matter, mitigating the drivers of ocean acidification at a local level means considering ocean acidification during NPDES permitting, local coastal planning, county and city general plans, local coastal programs, and CEQA analysis. Below, we provide some sample text as suggested alterations to existing CEQA guidelines and sample CEQA questions used in permitting.

Suggested additions in **bold**, deletions ~~struck through~~.

Title 14. Natural Resources  
Division 6. Resources Agency  
Chapter 3. Guidelines for Implementation of the California Environmental Quality Act  
Article 5. Preliminary Review of Projects and Conduct of Initial Study

§15064.4. Determining the Significance of Impacts from Greenhouse Gas Emissions.

- (a) The determination of the significance of greenhouse gas emissions calls for a careful judgment by the lead agency consistent with the provisions in section 15064...
- (b) A lead agency should consider the following factors, among others, when assessing the significance of impacts from greenhouse gas emissions on the environment:
  - (1) The extent to which the project may increase or reduce greenhouse gas emissions as compared to the existing environmental setting;
  - (2) Whether the project emissions exceed a threshold of significance that the lead agency determines applies to the project.
  - (3) The extent to which the project complies with regulations or requirements adopted to implement a statewide, regional, or local plan for the reduction or mitigation of greenhouse gas emissions. Such requirements must be adopted by the relevant public agency through a public review process and must reduce or mitigate the project's incremental contribution of greenhouse gas emissions. If there is substantial evidence that the possible effects of a particular project are still cumulatively considerable notwithstanding compliance with the adopted regulations or requirements, an EIR must be prepared for the project.

### (4) The extent to which the project's net greenhouse gas emissions are likely to contribute to the ongoing acidification of State waters.

Title 14. Natural Resources  
Division 6. Resources Agency  
Chapter 3. Guidelines for Implementation of the California Environmental Quality Act  
Article 9. Contents of Environmental Impact Reports

§ 15126.4. Consideration and Discussion of Mitigation Measures Proposed to Minimize Significant Effects.

(a) Mitigation Measures in General.

- (1) An EIR shall describe feasible measures which could minimize significant adverse impacts, including where relevant, inefficient and unnecessary consumption of energy...
- (c) Mitigation Measures Related to Greenhouse Gas Emissions. Consistent with section 15126.4(a), lead agencies shall consider feasible means, supported by substantial evidence and subject to monitoring or reporting, of mitigating the significant effects of greenhouse gas emissions **including the potential of those emissions to increase the acidity of State waters.**

#### SAMPLE QUESTION

Issues:

VII. GREENHOUSE GAS EMISSIONS — Would the project:

- a) Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment?  
**Examples of possible environmental impacts include climate change and ocean acidification.**

IX. HYDROLOGY AND WATER QUALITY — Would the project:

- a) **Substantially contribute to a violation of** ~~Violate~~ any water quality standards or waste discharge requirements?

**k) Substantially contribute to the nutrient enrichment (eutrophication) of State waters?**



## Appendix II: Modeling and Monitoring

### Monitoring Ocean Acidification

Monitoring ocean acidification is important for a variety of reasons, including at least (1) establishing the bounds and mechanisms of natural variability, (2) documenting the changing chemistry of the planet from this baseline, (3) providing data necessary for modeling past and future conditions, and (4) gathering the necessary data to unravel the causes of acidification and to measure acidification's effects on ecosystems and their constituent species. Research and government institutions generally monitor a variety of ocean parameters relevant to their individual research agendas: oceanographers, for example, are likely to collect surface wind and ocean current velocities, while geochemists may focus on salinity or dissolved oxygen content. As a consequence, much of the existing ocean monitoring effort is fragmentary, though in recent years there has been a concerted effort in the research community to provide more unified access to data through public portals on the web.<sup>267</sup>

As the general awareness of ocean acidification has grown over the past decade, it has become clear that the number of measured<sup>268</sup> datasets of pH and related ocean carbonate chemistry in existence is insufficient for either of the primary monitoring purposes noted above.<sup>269</sup> In particular, it will be important to improve our network of monitoring devices in the future to 1) capture both long- and short-term trends in ocean chemistry, 2) document the frequency and magnitude of extreme events, 3) measure multiple, related parameters relevant to ocean acidification—such as Total Alkalinity (TA) and Dissolved Inorganic Carbon (DIC)—to minimize error and maximize understanding of the ongoing chemical and ecosystem changes.

It is important to note that maintenance of instruments and data portals requires an ongoing commitment of labor and capital. Such ongoing outlays likely deter many smaller institutions from participating in data collection, although NOAA's Volunteer Observing Ships<sup>270</sup> program is a notable solution to this problem. It may be that museums and aquaria—such as the Monterey Bay Aquarium and the California Academy of Sciences—would be amenable to partnerships that would improve the longevity of data-gathering facilities and facilitate public outreach simultaneously. Establishing small, targeted endowments could ensure the ongoing curation, maintenance, and availability of these critical long-term datasets.

### Modeling Ocean Acidification

A powerful approach to maximizing available data is oceanographic and geochemical modeling, in which researchers estimate unavailable parameters by extrapolating from known quantities. For example, Juranek and colleagues at NOAA developed a model to estimate aragonite saturation state of ocean waters, given water temperature and oxygen content.<sup>271</sup> Such efforts make existing oceanographic observations more useful by drawing conclusions from the primary measurements.<sup>272</sup> However, models are necessarily simplifications of the more complex world: for example, the Juranek model requires constant salinity in order for its output to be valid, and it is therefore only appropriate in environments with negligible freshwater input. In sum, models are important but limited tools that must be used with an understanding of their limitations.

An important caveat for coastal ocean management is that remote sensing technology and regional ocean models often do not attempt to model the complex physical, biological, and chemical interactions that occur in the several-kilometer ocean zone nearest the coast. This zone is likely to be of critical importance for evaluating the effects of terrestrial anthropogenic inputs on the coastal marine environment.

Next steps in modeling might include better incorporation of biological processes into local- and regional-scale ocean models. Because respiration and photosynthesis can influence the indicators of ocean acidification dramatically, including these parameters in models may significantly enhance efforts to understand acidification in the coastal

ocean. Similarly, a more detailed understanding of the chemical dynamics of enclosed bays and estuaries would inform research on the social and economic effects of ocean acidification, particularly due to the high anthropogenic impacts within these environments.

Finally, improved resolution of small-scale spatial variability in carbon uptake, nutrient availability, and freshwater input would be desirable from a policy standpoint. This might reveal, for example, whether particular coastal regions should be governed more carefully than others to safeguard especially fragile nearshore waters and associated human uses. Such models would then highlight particularly important areas for ground-truthing with observed monitoring data.

## Appendix III: Existing Monitoring Facilities and Data Portals

The resources listed below provide raw data for parameters relevant to ocean acidification. They do not provide the analysis that may be required to calculate other biologically-important parameters, such as aragonite saturation state, or to assess the impact of measured parameters on living coastal resources. Note that some of the sources on this list are overlapping or redundant; for example, the Ocean Observing Systems incorporate data from many of the other listed monitoring sites.

**Integrated Ocean Observing Systems (OOS):** a partially integrated data-gathering network, with regional portals making data available to the public. The individual instruments comprising the OOS vary in functionality, but record such parameters as sea surface temperature, salinity, sea surface currents, chlorophyll, and (more rarely) pH. The OOS portals include:

Northwest Association of Networked Ocean Observing Systems (NANOOS)<sup>273</sup>

Central & Northern California Ocean Observing System (CeNCOOS)<sup>274</sup>

Southern California Coastal Ocean Observing System (SCCOOS)<sup>275</sup>

### California Cooperative Oceanic Fisheries Investigations (Cal-COFI)<sup>276</sup>:

A longstanding partnership among California Department of Fish & Game, NOAA, and Scripps, founded in 1949. The cooperative does quarterly sampling along established transects running directly offshore, from San Diego to north of Point Conception,

<sup>267</sup> See Appendix III for existing resources for monitoring ocean acidification.

<sup>268</sup> It is important to distinguish here between measured data, from actual observations, and modeled or extrapolated data. Measured data are critical for ground-truthing models.

<sup>269</sup> For example, Wootton *et al.*, *supra* note 25, note that their pH data from 2000–2008 was the only such dataset available for temperate latitudes at the time of publication.

<sup>270</sup> <http://www.vos.noaa.gov>; this program receives meteorological observations from volunteer observing ships (VOS) at sea around the world. NOAA is working to add pH observations to the volunteer effort; see <http://www.pmel.noaa.gov/co2/story/OA+Observations+and+Data> ("For the last 2 decades, we have used underway sampling on research vessels and VOS to measure large-scale trends in ocean carbon chemistry. We are in the process of adding pH and additional parameters necessary to address ocean acidification using VOS.")

<sup>271</sup> L.W. Juranek *et al.*, A novel method for determination of aragonite saturation state on the continental shelf of central Oregon using multi-parameter relationships with hydrographic data, 36 *Geophysical Research Letters* L24601 (2009).

<sup>272</sup> See, e.g., C. Hauri *et al.*, Ocean Acidification in the California Current System, 22 *Oceanography* 61 (2009), for an example of coupling modeling with observed data to broaden the applicability of existing information with respect to ocean acidification.

<sup>273</sup> <http://www.nanoos.org/home.php>.

<sup>274</sup> <http://www.cencoos.org>.

<sup>275</sup> <http://www.sccoos.org>.

<sup>276</sup> <http://calcofi.org>.

and is an invaluable source of long-term data for the region. For example, the cooperative has made available a 61-year time-series of water temperature, salinity, oxygen, and phosphates.

**Monterey Bay Aquarium Research Institute (MBARI)<sup>277</sup>:**

Provides continuous data from moorings within and just outside of Monterey Bay. At least some data are available from 1989 onwards, though much more extensive datasets are available beginning in 2004 and 2005. Data collected include salinity, water temperature, wind velocity, and air temperature.

**San Francisco State University, Romberg Tiburon Center<sup>278</sup>:**

The Center hosts the San Francisco Bay Environmental Assessment and Monitoring Station (SF-BEAMS). Real-time and archived data for two points within San Francisco Bay, one nearer the open ocean and one nearer the Sacramento River input. Includes pH, chlorophyll, salinity, and water temperature. Datasets begin in 2002 and 2006, respectively, for each of the two monitoring stations. Tiburon is an example of an independent source of data collection that the OOS sites (above) include in their data portals. Similarly, many of the ocean sensing instruments listed above and below are likely accessible through multiple different data portals on the web, including the OOS.

**California Current Acidification Network (C-CAN)<sup>279</sup>:** A collaboration among scientists, tribes, public institutions, and marine-dependent industries to investigate the causes and effects of ocean acidification on nearshore organisms. The organization aims to promote rigorous science with buy-in from a variety of stakeholders. The website links to a variety of primary data sources, including NOAA and the OOS sites listed elsewhere in this appendix.

**National Oceanographic and Atmospheric Administration**

**(NOAA):** The federal agency that collects primary environmental data from the oceans and atmosphere. Since 2006, NOAA has increasingly focused on ocean acidification by collecting pH and O<sub>2</sub> saturation on some of its research cruises.<sup>280</sup> Relevant data sources from NOAA include:

PMEL Carbon program<sup>281</sup>: the Pacific Marine Environmental Laboratory, which is the administrative home for long-term and real-time monitoring that informs ocean acidification research.

NOAA OA Data<sup>282</sup>: a dedicated page for ocean acidification-related research.

**UC Davis Bodega Marine Laboratory<sup>283</sup>:** The lab maintains an off-shore mooring in approximately 30 meters of water, with instruments deployed at the surface. These instruments include sensors for temperature, salinity, oxygen, pH and pCO<sub>2</sub>. Most datasets begin in 2007, with pH and pCO<sub>2</sub> available in the near future. Sensors measure hourly variability and are in the water year-round. Cruises to the mooring and 20 kilometers offshore occur approximately monthly, which provide opportunities to take discrete water samples for comparison to automated sensors.

**California Current Ecosystem Long Term Ecological Research**

**(LTER)<sup>284</sup>:** A collaborative effort between Scripps and a variety of external researchers, focusing on chemical and biological sampling in southern California. Available datasets include phytoplankton and zooplankton concentration, chlorophyll A, primary productivity, and water temperature. Data from the Santa Barbara Channel has its own related portal.<sup>285</sup>

**Scripps Institute of Oceanography<sup>286</sup>:** Site provides links to various projects affiliated with the Ocean Time Series, including measurements of pH, salinity, O<sub>2</sub>, and temperature, in the Southern California Bight. Scripps also includes a list of active marine stations taking manual measurements of different sea surface parameters,<sup>287</sup> which range from La Jolla to Trinidad, California, in Humboldt County.

**Southern California Coastal Water Research Project<sup>288</sup>:**

A public agency that joins regulators and regulated parties in an effort to gather and provide authoritative data on water quality in coastal Southern California. The site provides data from a variety of research projects focused on the Southern California Bight, as well as a data

portal to a larger network of monitoring data. The datasets themselves overlap significantly with those available at the OOS and other sites listed above.

**California Water Quality Monitoring Council<sup>289</sup>:** An effort of the California Natural Resources Agency and the California Environmental Protection Agency to integrate their water quality data. The site is a work in progress, but is a potentially powerful portal allowing citizens to track the quality of the water on which they depend for household uses (such as drinking water), and for recreation (swimming) and other uses. Not all datasets are yet available, but the portal does already provide access to some valuable information, such as bacterial population trends at coastal sites.

## Appendix IV: Glossary of Acronyms

AB32 — Assembly Bill 32, California Global Warming Solutions Act  
 ASBS — Areas of Special Biological Significance  
 BMPs — Best Management Practices  
 CEQA — California Environmental Quality Act  
 CO<sub>2</sub> — Carbon Dioxide  
 CZARA — Coastal Zone Act Reauthorization Amendments  
 CZMA — Coastal Zone Management Act  
 EPA — Environmental Protection Agency  
 ESHA — Environmentally Sensitive Habitat Area  
 MLPA — Marine Life Protection Act  
 MS4s — Municipal Separate Storm Sewer Systems  
 N-DN — Nitrification-denitrification  
 NEP — National Estuary Program  
 NERRS — National Estuarine Research Reserve System  
 NOAA — National Oceanographic and Atmospheric Administration  
 NO<sub>x</sub> — Nitrogen oxides, including NO (nitric oxide) and NO<sub>2</sub> (nitrogen dioxide)  
 NPDES — National Pollution Discharge Elimination System  
 pH — the unit of measurement for how acidic or basic a substance is  
 POTWs — Publicly-Owned Treatment Works  
 SB375 — Senate Bill 375  
 SEPs — Supplemental Environmental Projects  
 SO<sub>x</sub> — Sulfur oxides, including SO (sulfur monoxide) and SO<sub>2</sub> (sulfur dioxide)  
 SWQPA — State Water Quality Protection Areas  
 TMDL — Total Maximum Daily Load  
 WCI — Western Climate Initiative  
 WDRs — Waste Discharge Requirements

<sup>277</sup> <http://www.mbari.org>.

<sup>278</sup> <http://rtc.sfsu.edu/about/facilities/monitoring.htm>.

<sup>279</sup> <http://hofmannlab.msi.ucsb.edu/ccan/resources/links-to-california-current-environmental-data/buoy-data>.

<sup>280</sup> See <http://www.pmel.noaa.gov/co2/story/North+American+West+Coast+uwpCO2>.

<sup>281</sup> <http://www.pmel.noaa.gov/co2/map/index>.

<sup>282</sup> <http://www.pmel.noaa.gov/co2/story/OA+Observations+and+Data>.

<sup>283</sup> <http://bml.ucdavis.edu/boon>.

<sup>284</sup> <http://cce.lternet.edu/data/>.

<sup>285</sup> <http://sbc.lternet.edu/data/dataCollectionsPortal.html>.

<sup>286</sup> <http://mooring.ucsd.edu/index.html?/projects/corc>.

<sup>287</sup> [http://shorestation.ucsd.edu/active/index\\_active.html](http://shorestation.ucsd.edu/active/index_active.html).

<sup>288</sup> <http://www.sccwrp.org>.

<sup>289</sup> <http://www.swrcb.ca.gov/mywaterquality/>.





### Who We Are

The Center for Ocean Solutions (COS) is a collaboration among Stanford University's Woods Institute for the Environment and Hopkins Marine Station, the Monterey Bay Aquarium and the Monterey Bay Aquarium Research Institute (MBARI). COS includes about 80 scholars across our three institutions who work on coastal and ocean ecosystems in the natural, physical, and social sciences. Located at Stanford and in Monterey, California, COS is uniquely placed within a premier research university and is in partnership with MBARI, a leading ocean science/engineering research institution, and the Monterey Bay Aquarium, which defines excellence in their outreach to the public and to decision makers regarding ocean issues.

### What We Do

Our first task was to synthesize the best available scientific information to document the major threats to the Pacific, the geographic focus of our work. Based on this analysis, we have launched three initiatives: Ecosystem Health, Climate Change, and Land-Sea. Through our Climate Change Initiative, COS is working with both research and decision making communities to advance our collective understanding of how climate change affects the dynamics in ocean and coastal systems. We are also working to communicate and translate these changes and to help coastal communities adapt effectively for long term sustainability. Climate change is an integrative challenge that will directly inform our strategies and approaches within the Ecosystem Health and Land-Sea Interaction focal areas.

Photo: Coastal development in Southern California. © Wolcott Henry 2005/Marine Photobank.

Back Cover Photo: A Pacific bluefin tuna in the outer bay display at the Monterey Bay Aquarium. Gerick Bergsma 2010/Marine Photobank.





### **Our Mission**

The Center for Ocean Solutions works to solve the major problems facing the ocean and prepares leaders to take on these challenges.

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