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Ten Ways States Can Combat Ocean Acidification (and Why They Should)

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Ryan P. Kelly[1] and Margaret R. Caldwell[2,3]

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[1] Analyst for Science, Law, and Policy, Center for Ocean Solutions, Stanford University. J.D., University of California, Berkeley, School of Law (Boalt Hall), Ph.D., Columbia University. Email: rpk@stanford.edu.
[2] Executive Director, Center for Ocean Solutions, and Director, Environmental and Natural Resources Law & Policy Program, Stanford University. J.D., Stanford University. Email: megc@law.stanford.edu.
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Abstract
The ocean is becoming more acidic worldwide as a result of increased atmospheric carbon dioxide (CO_2) and other pollutants. This fundamental change is likely to have substantial ecological and economic consequences globally. In this Article, we provide a toolbox for understanding and addressing the drivers of an acidifying ocean. We begin with an overview of the relevant science, highlighting known causes of chemical change in the coastal ocean. Because of the difficulties associated with controlling diffuse atmospheric pollutants such as CO_2, we then focus on controlling smaller-scale agents of acidification, discussing ten legal and policy tools that state and local government agencies can use to mitigate the problem. This bottom-up approach does not solve the global CO_2 issue, but instead offers a more immediate means of addressing the challenges of a rapidly changing ocean. States have ample legal authority to address many of the causes of ocean acidification; what remains is to implement that authority to safeguard our iconic coastal resources.

I. Introduction
Ocean acidification is known as the *other* CO_2 problem;[4] that is, the problem that has received much less attention than climate change, but which is also caused by rising atmospheric CO_2. The ocean absorbs roughly one third of the CO_2 that humans release into the atmosphere annually,[5] and incorporating such a massive amount of that dissolved gas has made the worldwide ocean significantly more acidic than it was during the preindustrial era.[6] A more acidic ocean has begun to dissolve the shells and other hard parts of marine organisms, and threatens to fundamentally change the marine ecosystems on which a large fraction of the world depends for sustenance,[7] recreation, and a host of other services.[8]

This is thus an environmental issue with national and international implications, reaching beyond the coastal states whose shores are most directly threatened. One report estimates that "[m]ore than one third of the world's population will be strongly affected by acidification."[9] These challenges demand governmental action to mitigate the causes and

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[4] *See* S.C. Doney *et al.*, Ocean Acidification: The Other CO_2 Problem, 1 Annual Reviews of Marine Science 169 (2009).

[5] *Id*. at 170.

[6] J. Raven *et al.*, Royal Society Policy Document 12/05, Ocean Acidification Due to Increasing Carbon Dioxide, at *vi* (2005)(available at: www.royalsoc.ac.uk).

[7] The people of some countries depend upon seafood for more than 50% of their protein (including Indonesia, Cambodia, and Bangladesh); many more countries receive at least 15% of their dietary protein from seafood. *See* S.R. Cooley et al, Ocean Acidification's Potential to Alter Global Marine Ecosystem Services, 22 Oceanography 172, 177 (2009)(*citing* Food and Agriculture Organization of the United Nations (FAO), The State of Fisheries and Aquaculture 2008 (2009)).

[8] *Id*. at 172.

[9] E. Harrould-Kolieb, M. Hirshfield, and A. Brosius, Major Emitters Among Hardest Hit by Ocean Acidification: An Analysis of the Impacts of Acidification on the Countries of the World, at 2 (December 2009), available at: http://na.oceana.org/sites/default/files/reports/Acidity_Vulnerability_Risk_report.pdf.

effects of acidification to address immediate and impending harms to fisheries, shellfisheries, and the communities that depend upon them.

Ocean acidification is a large-scale environmental problem with classic externalities: rising atmospheric CO_2 causes wholesale changes to ocean chemistry worldwide, while larger CO_2-emitters do not experience greater harm than do lesser emitters.[10] Worse, the problem has been invisible until very recently. Although it has long been clear that the ocean absorbs large volumes of atmospheric CO_2,[11] only in the last decade has the resulting change in acidity received real scientific attention.[12] Those past ten years have seen an explosion of primary scientific literature,[13] but almost no legal analysis or commentary. As a result, the legal and policy options lag behind the science even as improved understanding of the phenomenon opens up new policy avenues to combat the global change.

Fixing the problem of ocean acidification will ultimately require that we fix the atmospheric CO_2 problem: humanity must stop pouring tens of billions of metric tons[14] of CO_2 into the air each year. But the CO_2 problem has been the subject of much ink over the past two decades,[15] and a legislative solution is still nowhere on the horizon in the United States. That we have failed to regulate CO_2 domestically is not surprising, given the institutional incentives and vested interests aligned against the change.[16] Kyoto and hopeful hints from Durban notwithstanding,[17] the prospects for an international accord for regulating greenhouse gases into the future is similarly bleak.[18]

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[10] That is, emitters *as individuals* do not experience harm in proportion to their emissions. As *nations*, however, the story is quite different: a 2009 Oceana report found that nations with the highest emissions tended to be the most vulnerable to harm from ocean acidification. *See generally*, *id.* Six of the top ten emitting nations were also among the top 25 most vulnerable nations. *Id*. at 2. This analysis suggests the existence of direct incentives for these and other nations to minimize their CO_2 emissions. The authors estimated vulnerability using fish consumption per capita, coral reef area as percentage of exclusive economic zone, total catch, and oceanographic parameters. *Id*. at 6.

[11] *See* R. Revelle and H. Suess, Carbon Dioxide Exchange Between Atmosphere and Ocean and the Question of an Increase of Atmospheric CO_2 During the Past Decades, 9 Tellus 18, 19 (1957)(citing Arrhenius, 1903).

[12] *See* J. Kleypas *et al.*, Geochemical Consequences of Increased Atmospheric Carbon Dioxide on Coral Reefs, 284 Science 118 (1999).

[13] 157 scientific papers on ocean acidification were published in 2011 alone. See note ##, infra.

[14] For 2008, the most recent year for which Oak Ridge National Laboratory estimates are available, the global total emissions from burning fossil fuels was 8749 million metric tons of carbon, or 32.082 billion metric tons of CO_2 equivalent. *See* http://cdiac.ornl.gov/ftp/ndp030/global.1751_2008.ems (last visited Jan 25, 2012).

[15] *See, e.g.,* Intergovernmental Panel on Climate Change, Climate Change 2007: Synthesis Report, Summary for Policymakers 1 (2007) and its many citing references.

[16] *See, e.g.,* S. Mufson, Climate Change Debate Hinges on Economics, Washington Post (Jul. 15, 2007)(discussing the then-current legislative proposals for a cap-and-trade system to limit emissions, and noting such a system "would alter the calculations of almost every business; hundreds of billions of dollars of energy investments would be redirected.")

[17] The Kyoto Protocol, an agreement among the great majority of the world's nations to attempt to stabilize greenhouse gas emissions, will begin to expire in 2012. Kyoto Protocol To The United Nations Framework Convention On Climate Change, Art. III. The recent Council of the Parties (COP-17) at Durban, South Africa, focused on moving toward a successor treaty. See http://www.cop17-cmp7durban.com/ (last visited Dec. 15, 2011).

[18] *See, e.g.,* The Economist, Climate Change: The Other Greenhouse Gases, Babbage Science & Technology Blog (Feb. 20, 2012)(www.economist.com/blogs/babbage/2012/02/climate-change, last visited Feb. 21, 2012)("The UN's climate change summit in Durban last December confirmed how far the world is from

With domestic gridlock apparent, it makes increasing sense to focus on smaller units of government as the prime movers on environmental issues. This is not a new idea, and particularly not with respect to CO_2 and climate change. Within the U.S., cities, counties, and states have moved towards more greenhouse-gas-friendly policies in the absence of federal leadership, and this trend has been well cited.[19] Regional climate initiatives play similar roles on somewhat larger spatial scales.[20] And while the jury is still out on whether these efforts will curb the stratospheric rise in emissions,[21] such sub-national progress is progress nonetheless and helps demonstrate the efficacy of mechanisms that could be adopted more widely.

What makes ocean acidification particularly amenable to smaller-scale mitigation, however, is the many existing legal tools available and up to the task. Even if we still lack the fortitude to tackle CO_2 emissions at a large spatial scale, fast-moving science—in significant part funded by the U.S. federal government—continues to reveal important details about the mechanisms by which the ocean's chemistry is changing. Those details, in turn, represent newly recognized means of ameliorating the effects of acidification using tools already in our legal toolbox.

In this article, we briefly review the science of ocean acidification and why it poses a fundamental challenge to ocean ecosystems and many of the services those systems provide. We next review federal and international actions in response, finding that most of these focus on research rather than action. To address this shortfall, we then provide a toolkit for action at the state, tribal, and local levels within the United States, discussing ten specific points of action. These points focus primarily on water quality, but also include air quality, state environmental impact statutes, common law causes of action, and changes in land use.[22]

Focusing on governance at smaller spatial scales changes the calculus of incentives. Accordingly, we emphasize actions more closely aligned with local benefits, identifying incentives tailored to the appropriate spatial scale. This bottom-up approach does not solve the global CO_2 problem, but instead offers a way forward on an otherwise (seemingly) intractable problem. We hope to provide a means of buying time and improving the quality of state waters, to minimize the economic and environmental impacts of acidification in the near term. In the background, of course, is the fact that we cannot solve ocean acidification without solving the global CO_2 emissions problem.

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limiting its emissions of carbon dioxide, the main greenhouse gas. Everyone agrees that this must be done, but not on who, exactly, should do it.")

[19] *See, e.g.,* K.H. Engel & B.Y. Orbach, Micro-Motives and State and Local Climate Change Initiatives, 2 Harv. L. & Policy Rev. 119 (2008); R.B. McKinstry, Jr., Laboratories for Local Solutions for Global Problems: State, Local and Private Leadership in Developing Strategies to Mitigate the Causes and Effects of Climate Change, 12 Penn State Environmental Law Review 15 (2004).

[20] *See, e.g.,* K.H. Engel, 14 Mitigating Global Climate Change in the United States: A Regional Approach, NYU Environmental Law Journal 54 (2005).

[21] Global emissions in 2010 were the highest on record for the industrial age, and the highest since in at least 800,000 years. See http://www.globalcarbonproject.org/carbonbudget/10/hl-compact.htm.

[22] We note that acidification also threatens the Great Lakes and other freshwater bodies. We concentrate here on marine protection, but many of the approaches to mitigating ocean acidification apply equally well to management of the Great Lakes and similar systems.

II. The Science of Ocean Acidification

Chemistry

Atmospheric CO_2 dissolves in water, making it more acidic;[23] this is why carbonated soda water is more acidic than regular tap water. Since the industrial revolution, this phenomenon has played out on a global scale: the oceans have become more acidic as they have absorbed a large portion of the anthropogenic increase in atmospheric carbon dioxide.[24] This change threatens to disrupt large-scale marine ecosystems and the economic and social activities that depend upon those ecosystems,[25] in part because the shells and other hard parts of marine animals dissolve more readily in more acidic water.[26] Acidified water from the deep ocean is also reaching into shallower depths than in the past,[27] and because the rate at which atmospheric CO_2 is increasing continues to accelerate, the rate at which we are changing the ocean's chemistry is accelerating in kind.[28] These changes are now well-documented and there is a broad scientific consensus that increasing atmospheric CO_2 is the primary mechanism driving the observed change. Deposition of sulfur oxides (SO_x) and nitrogen oxides (NO_x)—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.[29]

Indirect drivers of ocean acidification include nutrient runoff, which plays an important role in altering marine carbonate chemistry.[30] 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.[31] These processes use more oxygen than they produce, causing oxygen minimum zones ("dead zones"), and resulting in locally-acidified waters.[32] More acidic, lower-oxygen

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[23] Raven *et al.*, *supra*, at *vi*.
[24] S.C. Doney *et al.*, *supra*, at 170.
[25] *Id*.
[26] *Id*.
[27] 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 CO_2 in the ocean can lead to more pervasive intrusion of these more acidic waters into shallower depths.
[28] K. Caldeira & M.E. Wickett, Anthropogenic Carbon and Ocean pH, 425 Nature 365 (2003).
[29] 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 on the west coast.
[30] *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 CO_2-driven acidification in the Belgian Coastal Zone, and finding significantly greater effects of nutrient runoff than atmospheric CO_2 on ocean pH.)
[31] W.-J. Cai *et al.*, Acidification of Subsurface Coastal Waters Enhanced by Eutrophication, 4 Nature Geoscience 766 (2011).
[32] *See, e.g.,* R.J. Diaz and R. Rosenberg, Spreading Dead Zones and Consequences for Marine Ecosystems, 321 Science 926 (2008).

waters are likely to have both chronic and acute environmental impacts, including a decline in biomass productivity important to fisheries.[33]

These root causes of acidification—including atmospheric CO_2, nutrient runoff, and SOx / NOx deposition— then interact with oceanography to create a patchwork of coastal effects.[34] In areas along continental margins where colder, more acidic water from the deep ocean is drawn up to the surface ("upwelling zones"), such as along the west coast of the United States, local "hotspots" of ocean acidification develop.[35] Upwelling is a normal oceanographic process, but upwelled water appears to have become more acidic as a result of dissolved anthropogenic CO_2.[36] This more corrosive water is already apparent at the surface in upwelling zones near Cape Mendocino in northern California, and is likely happening at other prominent rocky headlands along the west coast.[37] Rising atmospheric CO_2 and patchy upwelling along the 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 CO_2, nutrient runoff, or other factors,[38] although in principle this will become possible as more data become available. While CO_2 is the primary driver of the global background change in ocean pH, non-CO_2 inputs may be more influential in specific coastal regions.[39]

Overall, there is a strong consensus that:

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[33] *Id*.

[34] Note, too, that changes to the hydrologic cycle—for example, the increased freshwater 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).

[35] *See* R.P. Kelly *et al.*, Mitigating Local Causes of Ocean Acidification with Existing Laws, 332 Science 1036 (2011).

[36] *See, e.g.,* Feely *et al., supra*.

[37] R. Feely *et al.*, *supra*, Fig. 1 (showing corrosive waters at several coastal locations); subsequent personal communications are in accord.

[38] 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_2 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 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 CO_2 on the $CaCO_3$ System in the Oceans, 305 Science 362 (2004).

[39] *See* Doney *et al.*, *supra* note 29; Feely *et al.*, *supra*; Cai *et al.*, *supra* note 31; Borges and Gypens, *supra* note 30.

1) Coastal acidification is more severe and more rapid in some places due to oceanographic features, biological effects, and land-based pollutants;[40]
2) The chemical changes to the coastal ocean are due to a combination of atmospheric CO_2 and other pollutants including atmospheric deposition of sulfur and nitrogen compounds, and terrestrial nutrient runoff,[41] as well as possible increases in freshwater input and upwelling;[42] and
3) Acidification adds yet another stressor to a growing list of threats to ocean health—including overfishing, habitat destruction, and climate change.[43] Acidification could alter marine food webs substantially,[44] and this may undermine the 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[45] and because humanity's CO_2 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.

Ecology and Biology

An ecosystem is the entire set of interactions among species (including humans) and nonliving components of an environment (such as temperature or sunlight).[46] It is

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[40] *See, e.g.,* Kelly *et al.*, *supra* note 35; Feely *et al.* 2008, *supra*.
[41] *See* note 38, *supra*.
[42] *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 34 (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).
[43] *See, e.g.,* R.K. Craig & J.B. Ruhl, Governing for Sustainable Coasts: Complexity, Climate Change, and Coastal Ecosystem Protection, 2 Sustainability 1361 (2010); Millennium Ecosystem Assessment, Ecosystems and Human Well-Being: Synthesis (2005).
[44] *See* UNEP Emerging Issues: Environmental Consequences of Ocean Acidification: A Threat to Food Security (2010)(*available at*: http://www.unep.org/dewa/).
[45] Ocean water absorbs CO_2 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_2 of the 1960s. This lag time postpones some of the effects of today's emissions, which are much larger than those of decades past.
[46] Arthur Tansley is credited with coining the term "ecosystem" in 1935 to include "not only the organism-complex, but also the whole complex of physical factors forming what we call the environment of the biome—the habitat factors in the widest sense." A.G. Tansley, The Use and Abuse of Vegetational Concepts and Terms, 16 Ecology 284, 299 (1935). The term has been widely re-defined since, but retains a core meaning of an inclusive concept of the factors that affect living organisms on Earth.

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_2 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.[47] 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,[48] 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.[49]

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.[50] 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.[51] 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_2 environment.[52]

Changing the chemical environment could thus change the balance of power in predator-prey relationships and in competition among species;[53] in short, it could alter the

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[47] 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 Ω_{arag} and $\Omega_{calcite}$, respectively. Aragonite is more soluable, and therefore under greater threat from ocean acidification. A primary factor of interest is therefore Ω_{arag}.

[48] *See, e.g.,* V.J. Fabry, *et al.*, *supra* note 50.

[49] *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.

[50] *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. Natn'l Acad. Sci. 17246 (2010)(decreased and slower growth in two bivalve shellfish under modern CO_2 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 **Error! Bookmark not defined.** 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).

[51] *See* note 50 (describing variable response of organisms to acidified conditions).

[52] *See* R.N. Crim *et al.*, Elevated Seawater CO_2 Concentrations Impair Larval Development and Reduce Larval Survival in Endangered Northern Abalone (*Haliotis kamtschatkana*), 400 J. Experimental Marine Biology & Ecology 272 (2011).

[53] 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

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.[54] 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_2 ocean.[55]

Of course, 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[56] estimates the different evolutionary capacities of two important nearshore species—red sea urchins and mussels[57]—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.

In short, there is little uncertainty surrounding the chemistry of ocean acidification, but the biological and ecosystem effects of those chemical changes are not yet as well understood.

III. Federal and International Response

The United States government has begun to take notice of the acidifying ocean in small but important ways. In 2009, Congress passed legislation focused squarely on ocean acidification,[58] establishing a federal interagency working group on the issue,[59] and a research program within the National Oceanographic and Atmospheric Administration.[60] An ocean acidification task force consisting of a collection of independent scientists and policymakers,[61] was convened to provide advice to the interagency working group. Finally,

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Impacts of Ocean Acidification in an Ecologically Critical Foundation Species 214 J. Experimental Biology 2586 (2011).

[54] *See* Fabry *et al.*, *supra* note 50 at 426.

[55] 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_2 and Phosphate Availability on Domoic Acid Production and Physiology of the Marine Harmful Bloom Diatom *Pseudo-nitzschia multiseries*, 56 Limnology & Oceanography 829 (2011).

[56] 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.

[57] *Strongylocentrotus franciscanus* (urchins) and *Mytilus trossulus* (mussels). *Id*.

[58] On March 30, 2009, President Obama signed the 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 also terrestrial—anthropogenic inputs. § 3702. We use the broader definition.

[59] *See* http://www.st.nmfs.noaa.gov/iwgoa/.

[60] *See* http://www.pmel.noaa.gov/co2/story/NOAA+OA+Plan.

[61] The OA Task Force operates under the purview of the Ocean Research & Resources Advisory Panel, an advisory body that "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.

the National Research Council has also issued a report[62] in response to a Congressional mandate in the 2006 Magnuson-Stevens Fishery Conservation and Management Act.[63] This report is an important marker, consolidating the available scientific information and identifying outstanding uncertainties to guide future research directions.[64]

Federal research dollars have increasingly gone to support primary research on ocean acidification in the past two years. One metric for this rise is the number of National Science Foundation grants given to ocean acidification research: of the 177 grants with the phrase "ocean acidification" in the title or abstract of the award, 176 of them (99.5%) have been awarded since 2006.[65] The overall amount of grant money awarded has increased sharply in recent years: between 2006 and 2008, NSF awarded a total of $19.7m for ocean acidification research; for 2009 to 2011, that number more than tripled, to $74.4m.[66] The results of this investment have been immediate and tangible, as the number of publications on ocean acidification has skyrocketed since 2006.[67] Fully one-third of the primary scientific literature on ocean acidification has been published in 2011 alone,[68] a sign of tremendous growth in this area of research.

Other nations have responded to ocean acidification in a similar fashion to the United States, sponsoring research and collaboration among scientists.[69] Germany's BIOACID program, for example, explores the responses of marine species to an acidifying ocean and to multiple related stressors.[70] China, Japan, and Korea have programs that do likewise.[71] The European Project on Ocean Acidification (EPOCA) is an international collaboration among 27 European member organizations, focusing on primary research issues and education.[72]

These national and international actions highlight the importance of ocean acidification, and have already proved crucial in generating the research that underpins

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[62] 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. *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.

[63] P.L. 109-479 § 701.

[64] National Research Council, *supra* note 62, at 2. The report also notes "the federal government has taken initial steps to respond to the nation's long-term needs and that the national ocean acidification program currently in development is a positive move toward coordinating these efforts." At 4.

[65] The increase in per-year awards is also striking: 11 in 2006, 9 in 2007, 14 in 2008, 37 in 2009, 58 in 2010, 47 in 2011. Data from http://nsf.gov/awardsearch/index.jsp.

[66] Data from http://nsf.gov/awardsearch/index.jsp. This total does not include $148m grant to the University of Alaska, Fairbanks, for shipyard construction costs (award number 939812).

[67] Google Scholar (scholar.google.com) reports that of 9280 total publications responding to the search term "ocean acidification," 7340 (79%) have been published since 2006. 6410 (69%) have come since 2008, and nearly half (3990, 43%) have come since 2010 (search performed Dec. 6, 2011).

[68] BIOSIS search (webofknowledge.com; an authoritative database for scientific publications), 157 of 423 total records for topic = "ocean acidification" were published in 2011 (37.1%). Another 117 (27.6%) were published in 2010, and 85 (20%) in 2009 (last searched Jan 25, 2012).

[69] *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.

[70] *See* http://www.bioacid.de (last visited Dec 6, 2011).

[71] Lamirande, *supra*, at 201-02.

[72] *See* http://www.epoca-project.eu (last visited Dec 6, 2011).

our understanding of the phenomenon. However, every one of these efforts goes towards documenting and understanding what we already know is a problem. None of these actions affirmatively begins to fix the problem of ocean acidification. In large part, this lack of action is likely due to a daunting mismatch of incentives that has plagued efforts to reduce CO_2 and other emissions.

Below, we provide some concrete first steps that local and state governments can take now to mitigate the causes and effects of coastal ocean acidification. As we note above, these smaller spatial scales offer an immediate way forward, buying time while work progresses on a global CO_2 solution. We focus on domestic laws of the United States, with a special emphasis on California because of its extensive water quality laws and economically important coastal resources.

IV. Incentives and Rationale for Sub-National Action

Environmental law often overlooks a key benefit of primary scientific research: the more we learn about the mechanisms of a particular environmental problem, the more legal hooks we can identify to address it. This is in many ways analogous to the relationship between medical research and drug development: more detail on precisely how a disease works yields more points of entry for a potential drug to disrupt the disease's progress. Taking the analogy one step further, it is much cheaper, faster, and easier to use existing drugs to fight off new diseases than it is to develop new drugs. Existing laws function in much the same way: ready-made tools that, if effective, are valuable means of addressing emerging problems such as ocean acidification.

With this analogy in mind, the importance of new data becomes clear. Most pertinent is newly-available information that auxiliary (non-CO_2) drivers contribute substantially to an acidified condition in some localities, and that these are most important in coastal regions. Near the coast is also where ecosystems are most productive,[73] where most people live,[74] and accordingly where there is the largest nexus of human-environment interaction and dependence. This is (relatively speaking) good news, because it means that the biggest problems near shore are the easier ones to fix: these stressors derive from local and identifiable sources, rather than global and diffuse CO_2.

Attacking the problem in the nearshore environment makes sense in at least two ways. First, it puts the focus on a primary site of anticipated harm. Second, it is a tenable means of mitigating acidification while international and national action on CO_2 progresses too slowly, leaving a narrowing window for avoiding high consequence impacts within this century. As we head toward a profoundly changed world, in which the chemistry of the ocean has seen a wholesale shift, we must minimize the resulting societal and ecological harms in whatever ways we can.

Fortunately, the acidification-mitigating avenues we discuss below dovetail with existing environmental priorities; there is little or no tradeoff between the demands of

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[73] *See, e.g.,* F. Chan *et al.*, Emergence of Anoxia in the California Current Large Marine Ecosystem, 319 Science 920 (2008).

[74] For example, more than half of Americans live within 50 miles of the coast. http://oceanservice.noaa.gov/facts/population.html (last visited Jan. 25, 2012).

current statutes and the means of addressing the emerging challenges of ocean acidification. Decreasing water and air pollution has been an important priority for many years; the new information about acidification simply strengthens the logic for environmental protection of our coasts. Acting to combat the observed and anticipated changes to the coastal ocean therefore represents a responsible path to safeguarding our nearshore ecosystems.

The Costs and Benefits of Action

Focusing on the state and sub-state jurisdictional levels eliminates any federalism concerns, because the states' plenary power means that they certainly have the authority to regulate discharges and other inputs to coastal waters in the interest of public health and safety.[75] So in general, a state *could* act to ameliorate acidification by creating a more stringent standard,[76] but why should it want to? The efforts we discuss below each depend upon the willingness and ability of state administrative agencies to add ocean acidification to the portfolio of issues for which they are responsible. This is not a trivial hurdle.

State environmental regulatory agencies have substantial counterincentives to tackling yet another environmental issue.[77] Limited (and shrinking) budgets may be the prime stumbling block in many cases, but institutional momentum, a workload full of existing priorities, and the significant political costs associated with any regulation all surely argue against taking on a new issue such as ocean acidification. But if this were the end of the calculation, arguably no environmental law would exist at all.

A fair treatment of incentives and economic efficiency is well beyond the scope of this article, but we note that in order to tackle ocean acidification on a local scale, a state administrative agency's immediate incentives to do so must outweigh its incentives to the contrary.[78] This creates an activation energy, of a sort: a conflict between short-term and long-term interests. Even where long-term gains are likely to outweigh the short-term costs by a large margin—such as is the case in acting to avoid environmental harms before they become expensive or impossible to rectify—an agency's immediate incentives often prevent it from acting.

Environmental regulation exists because it generates massive societal benefits. The distribution of regulation's costs and benefits, and the equity of those distributions, have

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[75] In California, for example, discharging waste into state waters is expressly a privilege, not a right; the civil code makes clear the state's intention to reserve its power to regulate discharges. Water Code § 13260.
[76] But see the brief discussion on the "no more stringent" laws that exist in some states, *infra*.
[77] The tension between agency mission and the nuts-and-bolts business of regulation is a classic administrative law problem of competing incentives. For example, agency incentives may be split between a mission to ensure the state's safe drinking water on one side, and robust political pressure from local agricultural or industrial interests to avoid onerous regulation on the other. *See, e.g.,* M.C. Blumm, Public Choice Theory and the Public Lands: Why "Multiple Use" Failed, 18 Harvard Environmental Law Review 405 (1994) for a discussion of similar tensions in the context of public lands regulation.
[78] *See, e.g.,* Hegel & Orbach, *supra*, at 128 *et seq*., for a discussion of some incentives for small-scale environmental regulation that at first glance appear to be irrational.

been much discussed,[79] and individual command-and-control rules may be economically inefficient. But on the whole, the societal value of something like the Clean Air Act far exceeds the costs of its implementation.[80] Yet the immediate political pressure to avoid regulating the industries that generate the tax revenue and political favor is crushing.

As we discuss various options for state action below, we note economic benefits that are likely to help ease the relevant actions. These benefits alone are unlikely to drive an agency decision as to whether or not to deal with acidification. This is especially the case where infrastructure upgrades are costly—as in the case of publicly owned treatment works—or where the political costs of regulation are especially high—as in the case of nonpoint source regulation of irrigated agriculture.

However, the primary function of state environmental agencies is to maintain and improve the quality of the environment in which its constituents live.[81] The harms associated with ocean acidification, though already being felt, are largely in the future—the next decade will be worse than this decade, on average. Hence, the problem will eventually force its way onto the agendas of at least coastal resource and environmental agencies. A version of the bystander effect[82] may be helpful in convincing these agencies to act, even in the absence of action on the part of peer agencies. At the state level, environmental agencies are the *only* ones whose job it is to deal with at least some cause of a worsening problem, and therefore they may be more likely to address the problem than would be the case if they were merely one among many agencies with overlapping jurisdictions.[83] Perhaps through a combination of internal institutional motivation, economic benefits of

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[79] *See generally*, David M. Driesen, Distributing the Costs of Environmental, Health, and Safety Protection: The Feasibility Principle, Cost-Benefit Analysis, and Regulatory Reform, 32 B.C. Envtl. Aff. L. Rev. 1 (2005) and refs therein.

[80] EPA, The Benefits and Costs of the Clean Air Act from 1990 to 2020, Summary Report at 2 (March 2011)(available at: http://www.epa.gov/air/sect812/prospective2.html). The report estimates the annual cost of the Clean Air Act in 2020 will reach $65billion annually, with nearly $2trillion in annual benefits. This indicates the benefits of the Act, which are mainly in public health harms avoided, outweigh its costs by a ratio of approximately 30:1.

[81] Washington State's Department of Ecology, for example, gives its mission as "protect, preserve and enhance Washington's environment, and to promote the wise management of our air, land and water for the benefit of current and future generations." http://www.ecy.wa.gov/about.html (last visited Dec. 15, 2011). South Carolina's Department of Natural Resources has a mission to "serve as the principal advocate for and steward of South Carolina's natural resources." http://www.dnr.sc.gov/admin/history.html (last visited Dec. 15, 2011). Massachusetts Department of Environmental Protection's mission is "ensuring clean air and water," among other functions. http://www.mass.gov/dep/about/ (last visited Dec. 15, 2011). Nearly all states have agencies with similar mission statements. Oklahoma's, interestingly, appears mainly concerned with aesthetics: "...for a clean, attractive, prosperous Oklahoma." http://www.deq.state.ok.us/mainlinks/aboutus.htm (last visited Dec. 15, 2011).

[82] *See* J.M. Darley and B. Latané, Bystander Intervention In Emergencies: Diffusion Of Responsibility, 8 Journal Of Personality And Social Psychology 377 (1968)(describing situation in which a woman, Kitty Genovese, was stabbed to death in the middle of a New York City street over the course of more than half an hour, and yet none of at least 38 witnesses to the murder phoned the police. The authors use this incident as a springboard for research demonstrating a general phenomenon of the diffusion of responsibility, in which the known presence of other bystanders reduces one's feelings of personal responsibility.)

[83] Anecdotal evidence suggests this phenomenon does occur. For example, staff members of California's Central Coast Regional Water Quality Control Board took on nonpoint source pollution creating toxic levels of pollutants in drinking water after being reminded that if they failed to act, no one else would. Personal communication from Michael Thomas, Deputy Executive Officer, Central Coast RWQCB, December 7, 2011.

harm avoided, and leadership from select jurisdictions with the greatest perceived threats, state and local agencies will begin to address acidification in a way that national and international governments have so far failed to do. Where available and where necessary, citizen suits could help this effort along.

State "No More Stringent" Laws

A special case of disincentives to using state law and regulation to combat environmental problems occurs where states have bound their own hands by adopting laws that link the stringency of state environmental regulation to the levels set by the federal government. These laws, known as "no more stringent" rules, effectively make federal environmental rules both a regulatory floor (under federal law) and ceiling (under state law), and function as barriers to state efforts to fill federal regulatory gaps.[84] Only five coastal states have such laws with respect to water quality.[85]

Arguably, the impact of "no more stringent" laws has little practical effect. First, in no case are these laws incorporated into state constitutions.[86] As such, state legislatures may change these statutes—or carve out exceptions to them—by the same procedural means as would be necessary to amend the focal environmental laws themselves. In some states, the laws pose only minor hurdles, merely requiring an administrative justification for proposed rules that would impose stricter pollution controls.[87] In other states, case law has limited their effect by requiring strictly comparable federal and state regulations before weighing the relative stringency of proposed rules.[88] Finally, there remains the fact that even states without "no more stringent" laws rarely impose regulations beyond federal

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[84] For a discussion of these rules, and related state efforts to bolster property rights in such a way as to hamper environmental regulation, *see generally* Andrew Hecht, Obstacles to the Devolution of Environmental Regulation, 15 Duke Envtl. L. & Pol'y F. 105 (2004); Jerome M. Organ, Limitations on State Agency Authority to Adopt Environmental Standards More Stringent than Federal Standards: Policy Considerations and Interpretive Problems, 54 Md. L. Rev. 1373 (1995). With respect to air quality, twenty-six states have similar "no more stringent" laws or policies. William L. Andreen, *Federal Climate Change Legislation and Preemption*, 3 Envt'l & Energy L. & Pol'y J. 280, 302 (2008)(noting also that, even in states that have not restricted themselves from requiring greater air quality, more stringent regulations are rare).

[85] As of 2004, a total of seventeen states had general "no more stringent" laws regarding water quality; of these, only Florida, Maine, Maryland, Mississippi, and Pennsylvania (which has a strong influence on Delaware and Chesapeake Bays) are coastal. Hecht, *supra* note 84 at note 43. Under Hecht's ranking system, the laws of Maine and Maryland pose only low barriers to heightened water quality requirements, Pennsylvania and Florida have modest barriers, and Mississippi has a significant barrier to more stringent environmental regulation. Hecht at 132-33.

[86] *Id*. at 112.

[87] Maine, for example, has such a scheme. Hecht, *supra* note 84 at 122; Me. Rev. Stat. Ann. tit. 38 § 341-H(3)(A-B)(2011).

[88] A Florida appellate court, for example, limited the application of that state's "no more stringent" statute to instances where state and federal regulations could be easily compared. *Florida Elec. Power Coordinating Group, Inc. v. Askew*, 366 So. 2d 1186, 1188 (Fla. Dist. Ct. App. 1978) ("the federal standard must be in counterpoise to the state standard.") The court found that while the Clean Air Act provided such a basis for comparison (national primary and secondary ambient air quality standards), the Clean Water Act did not (technology-based vs. water-quality-based regulations). *Id*. at 1188. *See also* Organ, *supra* note 84, discussing the Florida *Askew* case.

requirements,[89] such that as a practical matter, whether a state has or has not expressly limited its own power makes little difference.

The existence of "no more stringent" laws is therefore perhaps more a marker of a state's political attitude towards environmental regulation than an ironclad barrier to rigorous pollution control. Nevertheless, as we discuss below the options for states, tribes, and local governments to combat ocean acidification, we note that a few coastal jurisdictions will also have to surmount their own existing "no more stringent" laws.

V. Ten Suggestions for State and Local Action

1) Create More Stringent Technology-Based Clean Water Act Standards for the Most Harmful Point Sources

States and tribes implement the Clean Water Act primarily through two mechanisms: permitting specific levels of pollution from individual point sources (NPDES permits),[90] and assessing pollutant levels and allocating tolerable pollutant loads which, if achieved, will lead to protection of water quality (TMDLs).[91] These mechanisms function in tandem to apply the state's adopted water quality standards, which provide the particular targets for legally acceptable levels of water pollution.[92] Where a water body does not meet the applicable water quality standards, the state must list it as impaired and develop TMDLs for the pollutants leading to the impairment.[93] States thus implement the federal Clean Water Act[94] in part by setting water quality standards for water bodies within their jurisdictions.[95]

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.[96]

However, much of the enforcement power of pollutant-discharge permits arises from federal guidelines that establish technology-based standards[97] for a wide variety of point sources. Only when these technology-based standards are insufficient to meet the water quality standards—in particular, the designated uses of a water body—do the

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[89] *See* Anderson, *supra* note 84.
[90] National Pollution Discharge Elimination System, 33 U.S.C. § 1342.
[91] Total Maximum Daily Load; 33 U.S.C. § 1313(d)(1)(C).
[92] 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).
[93] 33 U.S.C. § 1313(d). This is known as the "303(d)" list, having been section 303(d) of the Act.
[94] 33 U.S.C. § 1251 *et seq*.
[95] 40 C.F.R. §§ 131.2, 131.6.
[96] 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). Note that under California's Porter-Cologne Act, which predates the federal Act, these first two parts are known as "beneficial uses" and "water quality objectives," respectively. *See* http://www.waterboards.ca.gov/mywaterquality/water_quality_standards/.
[97] 33 U.S.C. §1311(b)(1)(C).

quality-based metrics begin to have real effect.[98] Because technology-based standards—rather than water-quality based standards—are a primary means by which the Clean Water Act functions, using state authority to alter or augment them is one of the most direct means of controlling acidifying discharges via the Act.

Although it is not explicit in the Act, States and regional rulemaking bodies[99] have the authority to make these technology standards more stringent than the federal guidelines require. The Act contemplates a lead role for States in setting applicable clean water standards, and case law supports states' power to create more stringent standards. For example, in *Shell Oil Co. v. Train*[100] the 9th Circuit noted that

> 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.[101]

The federal guidelines accordingly operate as a floor for clean water protection, rather than a ceiling, and, in general, states may make the guidelines more stringent than the federal EPA requires.[102]

To better address the acidifying ocean, states and regional bodies could re-define the existing technology-based discharge standard for a subset of point sources that most strongly contribute to ocean acidification.[103] Those sources generating low-pH, high biological oxygen demand, or high nutrient output—such as pulp mills, concentrated animal feeding operations, and sewage outflows—are the most likely to contribute to coastal acidification through their discharges. By augmenting the federal technology-based standards to better control effluent pH of selected categories of point sources, states could therefore exploit a significant opportunity for mitigation.

This change would only address point sources, which are subject to technology-based standards, rather than nonpoint sources, which constitute the majority of terrestrial

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98 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).

99 California, for example, has regional water boards that issue NPDES permits and which have the authority to create permit limitations.

100 585 F.2d 408 (9th Cir. 1978).

101 *Id*. at 410 (citations to the federal Clean Water Act omitted; emphasis added).

102 Washington State, for example, has altered technology-based effluent standards for combined waste treatment facilities and for municipal water treatment plants. See Wash. Admin. Code § 173-220-130(a). Note that states with "no more stringent" laws face additional hurdles; see discussion *supra*.

103 The EPA provides guidance for supplementing existing categorical technology-based standards in the case of Publicly Owned Treatment Works. See http://www.epa.gov/npdes/pubs/final_local_limits_guidance.pdf at 1-3 ("EPA's promulgation of categorical standards does not relieve a POTW from its obligation to evaluate the need for and to develop local limits to meet the general and specific prohibitions in the General Pretreatment Regulations.")

input to the coastal ocean in many regions.[104] Nevertheless, greater scrutiny of the most high-risk point sources would at least partially address coastal acidification and would have the additional benefits of minimizing eutrophication, harmful algal blooms, and hypoxic ("dead") zones along the coast, ameliorating multiple ills with a single regulatory change.

2) Change Water Quality Criteria for Marine pH and Related Parameters

More stringent water quality criteria could better protect coastal ecosystems via implementation under existing NPDES and TMDL programs where technology-based standards are insufficient to safeguard the receiving waters. If enforced, these criteria could alleviate both the ultimate (e.g., nutrient loading)[105] and proximate (pH change) causes of locally-intensified ocean acidification. However, water quality standards function mainly as a set of backup rules, behind the technology-based standards that the federal EPA has promulgated for various classes of dischargers. Only where technology-based standards are insufficient to safeguard the designated uses of a water body will a NPDES permit incorporate discharge limits tied to water quality.[106]

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.[107] In practice, the burden of bringing a water body

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[104] *See generally*, O.A. Houck, The Clean Water Act Returns (Again): Part I, TMDLs and the Chesapeake Bay, 41 Envtl. L. Reporter News & Analysis 10208 (2011)(nonpoint sources as primary issue in Chesapeake Bay cleanup effort). Michael Thomas, Assistant Executive Director of California's Central Coast Regional Water Quality Control Board, reports that in his region, "the mass pollutant loading from irrigated agriculture [a nonpoint source] dwarfs all other sources." Email to RPK, Nov. 4, 2011 (on file with the author).

[105] 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 in California. *See* http://www.sccwrp.org/ResearchAreas/Nutrients/NutrientCriteriaSupportStudies.aspx.

[106] 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); 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).

[107] 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. Nastri*, 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 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

into compliance falls on the NPDES-permitted point sources rather than nonpoint sources, because NPDES permits for discharge into impaired waters grow more stringent in an attempt to remedy the impairment.[108] Unless states demand otherwise, nonpoint sources run up the bill, and point sources are stuck paying the check.

TMDLs thus have little in the way of mandatory authority over existing nonpoint sources, their prime regulatory targets.[109] States could give them teeth by imposing real limits on nonpoint source pollution. 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.[110] If accompanied by enforcement measures, TMDLs could form the basis of nonpoint source regulation that could significantly improve the quality of coastal waters.[111] Of course, this has been the case all along, and the failure of states to create enforceable TMDLs is a well-known problem.[112]

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."[113] This provision could be of particular use in impaired coastal areas with increasing urban and industrial density, forcing parties to the table to grapple with how to maintain local water quality and balance its 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 our understanding of coastal acidification has been hindered by a scarcity of reliable monitoring, the data-collection aspect of a TMDL process would also be valuable.

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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).

108 *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 Envtl. L. Reporter News & Analysis 10208, 10210 (2011)(discussing the impact of nonpoint regulation on point sources).

109 *See* Note ##, *supra*. However, note that California's Porter-Cologne Act requires even nonpoint source dischargers to file for permits; see 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).

110 *Pronsolino v. Nastri*, 291 F. 3d 1123, 1140 (9th Cir. 2002).

111 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.

112 *See* Houck, *supra* note ##, and refs therein.

113 40 C.F.R. § 122.4(i). *See also Pinto Creek*, *supra* note 108.

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. Conversely, creating many watershed-specific rules is difficult from a technical standpoint and is labor intensive. A patchwork of regulation would also erode regulatory certainty for landowners and increase their costs of gathering information. If wide swaths of coastline share particular chemical/ecological properties, regional-scale rules may make both permitting and enforcement easier while effectively improving the health of the coastal ocean.

a. TMDLs for Non-Atmospheric Drivers of Acidification

Federal guidelines exist as baseline numerical water quality criteria for pH, dissolved oxygen, nitrates, and phosphates,[114] among other acidification-relevant parameters. As with technology-based standards, states are free to make these criteria more stringent than the federal guidelines, and states are free to establish criteria for pollutants for which federal guidelines do not exist.[115] The criteria are reviewable by administrative action rather than legislation, making them easier to adjust in the face of the ocean acidification science that is developing rapidly.

Agencies have so far been slow to translate the growing mass of data on ocean acidification into action. In 2008, Washington State declined to include any marine waters on its list of impaired water bodies, resulting in a lawsuit by the Center for Biological Diversity and subsequent settlement.[116] As a result of that settlement, the federal EPA requested data on the matter and considered altering the national guideline for marine pH.[117] The EPA ultimately decided against adjusting its guidance for water quality criteria with respect to pH, citing insufficient information to change the federal standard.[118] No state has yet created a more stringent guideline. Like the federal EPA, California's state

[114] 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—particularly in stratified water columns and water bodies with long residence times—it contributes to coastal acidification.

[115] *See, e.g., PUD No. 1 of Jefferson County v. Washington Dept. of Ecology*, 511 U.S. 700, 713 (1994)("The State can only ensure that the project complies with 'any applicable effluent limitations and other limitations, under 33 U.S.C. §§ 1311, 1312' or certain other provisions of the Act, 'and with any other appropriate requirement of State law.' 33 U.S.C. § 1341(d)…. As a consequence, state water quality standards adopted pursuant to § 303 are among the 'other limitations' with which a State may ensure compliance through the § 401 certification process… [A]t a minimum, limitations imposed pursuant to state water quality standards adopted pursuant to § 303 are "appropriate" requirements of state law.")(underscoring the significant state authority to impose restrictions on applicants under the Clean Water Act, and suggesting that state water quality standards are not limited by those set out by the federal EPA.)

[116] *Center for Biological Diversity vs. EPA*, No.2:09-cv-00670-JCC (W.D.Wash.2009); 75 Fed. Reg. 13537 (March 22, 2010). Washington has since labeled the acidified Puget Sound as "waters of concern." *See* http://www.ecy.wa.gov/water.html.

[117] 75 Fed. Reg. 13537 (March 22, 2010).

[118] *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).

water board is also awaiting more data before revising the marine pH criterion,[119] and has accordingly declined to list any marine waters as impaired for pH.[120] Other coastal states appear to be doing the same.

More stringent criteria for pH and related parameters would land a greater number of water bodies on the 303(d) list of impaired waters, which would in turn require the state to develop more TMDLs. Although historically this process has been lethargic and resource-intensive,[121] it need not necessarily be so.[122] Where regional water boards develop TMDLs, such as in California, the boards could minimize their individual costs by collaborating to develop marine and estuarine TMDLs.[123] Federal dollars are available to develop TMDLs,[124] although these funds are unlikely to keep pace with a growing list of impaired waters.

However, states have some internal incentives to act. Aiding a locally-acidifying ocean by creating a more stringent standard could generate local benefits in the form of healthier state fisheries, shellfish operations, and other coastal activities dependent on water chemistry, and would guard against lawsuits alleging that the present criteria do not adequately safeguard existing beneficial uses. These benefits would mitigate and could surpass the costs of adjusting the criterion.

Precisely what the right criteria might be remains an open question. 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.[125] Because the natural variability of coastal pH is substantially larger than this interval,[126] the existing criterion has little or

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[119] State Water Resources Control Board, California Ocean Plan Triennial Review Workplan 2011-2013, at 13-14, 19 (2010)("more research, monitoring and assessment should take place, both in California and globally to address and understand decreases of pH (trends and effects) before further changes to the objective or program of implementation is amended").

[120] EPA Region IX, Memorandum: Approval of Final 303(d) List for California (Oct 11, 2011)(available at: http://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2010.shtml).

[121] *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.)

[122] *See, e.g.,* California State Water Resources Control Board, Water Quality Control Policy for Addressing Impaired Waters: Regulatory Structure and Options, Resolution 2005-0050 at 8 (June 16, 2005), *available at*: http://www.waterboards.ca.gov/water_issues/programs/tmdl/docs/iw_policy.pdf (describing different options for adopting TMDLs in California, some of which require only a single board action.) Of course, this does not accelerate the TMDL development process.

[123] One approach to such TMDLs would be to collectively assess the contribution of atmospheric CO_2 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.

[124] Clean Water Act § 319(h).

[125] 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, July, 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.")

[126] *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

no real protective effect.[127] However, any human-caused departure from an already-wide natural range has the potential to create 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[128]—rather than the widely-fluxuating natural range.[129] For example, if the vast majority[130] 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.

Criteria more stringent than the current +/- 0.2 units would help arm state resource agencies with tools to combat local acidification. Furthermore, narrower criteria face less of a technological hurdle now than in years past because 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. Finally, water quality criteria must reflect the most recent scientific knowledge,[131] 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.[132] This leaves states vulnerable to citizen suits challenging the existing criteria,[133] and states may prefer to begin revisions than to defend the existing criteria in court.

b. Criteria and TMDLs for Atmospheric Drivers of Acidification

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& F.J. Gilbert, pH Variability and CO_2 Induced Acidification in the North Sea, 64 Journal of Marine Systems 229 (2007)(finding that the coastal ocean can vary by more than 1 pH unit annually).

[127] 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).

[128] *See, e.g.,* Nutrient Numeric Endpoint values developed for estuaries, available at http://www.sccwrp.org (last visited Dec. 8, 2011).

[129] 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 125, 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.

[130] 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.

[131] 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.")

[132] *See, e.g.,* Doney *et al.* 2009, *supra*; Wootton *et al.* 2008, *supra*.

[133] Such as the Center for Biological Diversity suit, *supra*. The large amount of scientific information that has become available since that suit was filed—well over half of the total number of papers published on ocean acidification have been published since 2009—tends to support the proposition that the existing standard fails to incorporate the most recent information.

While controlling the total nutrient loadings and other anthropogenic inputs to coastal waters would help mitigate a major cause of non-atmospheric-driven acidification, developing criteria and TMDLs for $p(CO_2)$[134] and for surface fluxes of NOx and SOx could do the same for atmospheric drivers.[135] 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 factors limiting the growth of marine microorganisms locally and upon the time scale of analysis.[136] Where areas of high deposition coincide with upwelling zones—in which colder ocean waters quickly take up CO_2 and therefore acidify more rapidly—TMDLs for atmospheric drivers might be especially appropriate means of limiting inputs to the coastal ocean, guarding against "hotspots" of acidification.

Deposition of nitrogen and sulphur compounds from the atmosphere probably contribute significantly to coastal acidification.[137] Yet, because they are gases, they are not often seen as water pollutants, and agencies have rarely designated water quality criteria for them.[138] The Chesapeake Bay—in which atmospheric nitrogen deposition historically is greater than nitrogen inputs from fertilizer, manure, or any point source[139]—now has a TMDL for NOx.[140] Other coastal regions can follow suit. Similarly, developing criteria and TMDLs for dissolved CO_2 itself would give agencies a window on a major cause of acidification, and not simply its effect (that is, pH).

3) Create New Water Quality Criteria for Complementary Parameters; Create New Designated Uses

States could make two further changes to water quality standards to improve their ability to address coastal acidification. First, additional criteria for pH-related parts of the carbonate system (e.g., Total Alkalinity, Dissolved Inorganic Carbon)[141] would help monitor acidifying waters more accurately and would be valuable tools for detecting and preventing further degradation. Second, states could define new designated uses for coastal water bodies in such a way as to improve ecological resilience.

a. Additional Water Quality Criteria to Aid Carbonate Chemistry Monitoring

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[134] The partial pressure of carbon dioxide in seawater, an important parameter in the carbonate system.

[135] *See generally*, Anil J. Antony, Shotguns, Spray, and Smoke: Regulating Atmospheric Deposition of Pollutants Under the Clean Water Act, 29 UCLA J. Envtl L. & Pol'y 215 (2011)(discussing the view of courts towards such regulation, in the context of several published decisions).

[136] *See* Doney *et al.* 2007, *supra*; Feely *et al.* 2008, *supra*; Cai *et al.* 2011, *supra*; Borges and Gypens 2009, *supra*.

[137] *See* Doney *et al.* 2007, *supra*, and discussion *infra*.

[138] Note that some other airborne pollutants have TMDLs, the primary example being mercury. See http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/mercury.cfm.

[139] Chesapeake Bay TMDL, Appendix L, Setting the Chesapeake Bay Atmospheric Nitrogen Deposition Allocations, at L-1 (Dec. 29, 2010).

[140] *Id*.

[141] Total Alkalinity and Dissolved Inorganic Carbon are measurements used to characterize the overall chemical environment of the ocean with respect to calcium carbonate, the prime ingredient of which shells and other hard parts are made in marine organisms. Measuring these parameters allows a researcher to calculate the other relevant parameters of the carbonate system. For example, having these measurements improves the confidence with which the energetics of shell dissolution can be described.

Data-driven policy requires both that relevant datasets exist and that they meaningfully inform policy decisions. One step that would both generate data and explicitly tie the data to policy action is to develop additional water quality criteria for chemical parameters that are intimately linked to ocean acidification. These parameters, for which existing datasets have been sparse, include Total Alkalinity and Dissolved Inorganic Carbon, two factors in the overall seawater carbonate system in which pH plays a role.

There are at least two good reasons to include these parameters in the repertoire of coastal management tools. First, pH is difficult to measure accurately and consistently over long periods of time, and these auxiliary measures are easier. Second, these measurements give a more accurate understanding of biologically-relevant effects such as the rate at which shells and other hard parts dissolve in seawater.[142] Consequently, creating new criteria and measuring these factors simultaneously with pH would generate a more complete picture of the chemistry underlying ocean acidification and its attendant biological effects. Moreover, more precise measurements might also allow agencies to trace acidifying plumes to their point or nonpoint sources, helping to limit the spatial extent of regulation to most efficiently address the real sources of the problem.

New water quality criteria for Total Alkalinity and Dissolved Inorganic Carbon would then link explicitly to policy action where particular coastal waters fall short of a state's designated standards for these measures. Such waters would be listed as impaired under CWA §303(d) and the state would develop TMDLs, as described above. NPDES permits for existing polluters would then require monitoring and discharges appropriate for the new measurements, simultaneously improving water quality and generating a valuable dataset that would not exist otherwise.

This approach broadens the traditional Clean Water Act purview somewhat, by defining water quality standards that serve the dual purposes of information-gathering and water quality regulation. Both Total Alkalinity and Dissolved Inorganic Carbon are "pollutants" in the same sense as heat or pH: they are markers of larger changes to the chemical environment of the ocean,[143] and are useful indicators of the health of coastal waters. At present the federal EPA does not provide guidelines for these chemical water parameters (i.e, Total Alkalinity and Dissolved Inorganic Carbon) , but states could base water quality criteria on known kinetics of carbonate chemistry in seawater to derive an appropriate range.[144]

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[142] See Note ##, *supra*, describing Ω_{arag} and $\Omega_{calcite}$.

[143] Note that the Act defines "pollutant" and "pollution" in somewhat different terms. 33 U.S.C. § 1362(19)(The term 'pollution' means the man-made or man-induced alteration of the chemical, physical, biological, and radiological integrity of water); 33 U.S.C. § 1362(6)("The term 'pollutant' means dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water.") *See also Nat'l Cotton Council of Am. v. EPA*, 553 F.3d 927, 938 (6th Cir. 2009) *cert. denied*, 130 S. Ct. 1505 (2010)(discussing agency deference in classifying substances as "biological materials" with respect to the Act's definition of "pollutant.")

[144] *See, e.g.,* R.E. Zeebe, and D.A. Wolf-Gladrow, CO_2 in Seawater: Equilibrium, Kinetics, Isotopes. Elsevier Oceanography Series, 65 (2001).

b. New Designated Uses for Coastal Waters

As a final use of water quality standards to combat ocean acidification, states could use the Clean Water Act's designated uses provision as safeguard for especially sensitive areas. As described above, states must designate particular uses for each water body in their jurisdictions.[145] Where technology-based standards for point sources of pollution are insufficient to safeguard a water body's designated use, NPDES permits will limit discharges in an attempt to meet the appropriate water quality standards. Waters failing to meet these standards are then listed as impaired, as described above.

States are free to designate uses as they see fit, taking into consideration a non-exhaustive list of uses valuable to the public, including "protection and propagation of fish, shellfish and wildlife, recreation in and on the water."[146] A state concerned with ocean acidification may define new designated uses for coastal waters in order to protect their ecological resilience and ongoing value as engines of ecosystem services.

For example, Washington could designate a portion of Puget Sound as having the use "to maintain buffering capacity against chemical change" or "to preserve the structure and function of the nearshore ecosystem." These or other new uses would maintain standards appropriate for less-stringent uses; that is, the newly-designated waters would still be swimmable, but they would also be held to higher standards than merely being swimmable. Such a change would harmonize the CWA's designated use provision with a more modern understanding of ecosystem function, by explicitly incorporating one or more ecosystem services or processes as "uses" under the Act. The change would also set a higher bar for water quality in coastal areas of particular concern. Where water quality is impaired relative to the newly-designated use, the state would benefit from the increased monitoring and attention associated with the TMDL process, described above.

4) Use the Clean Air Act to Decrease SOx/NOx Deposition Near Coast

SOx and NOx are gases that form acids when dissolved in seawater, lowering the pH of receiving waters.[147] Because of short residence times in the atmosphere,[148] 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 ocean acidification near coal-fired power plants or similar heavy-industrial sources located near coastlines.

States could use the Clean Water Act to regulate these airborne pollutants as described above: technology-based standards and water-quality based standards including designated uses and water quality criteria.[149] At least some states do regulate in this way;

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[145] 40 CFR § 131.10(a)("Each State must specify appropriate water uses to be achieved and protected. The classification of the waters of the State must take into consideration the use and value of water for public water supplies, protection and propagation of fish, shellfish and wildlife, recreation in and on the water, agricultural, industrial, and other purposes including navigation.")

[146] *Id*. *See also* EPA, Water Quality Handbook - Chapter 2: Designation of Uses, available at http://water.epa.gov/scitech/swguidance/standards/handbook (last visited Dec. 13, 2011). States must provide a public hearing before adding or removing a designated use. 40 CFR 131.10(c).

[147] *See* Doney *et al.* 2007, *supra*. These gases are also the cause of acid rain.

[148] *Id*.

[149] This assumes that deposition of these compounds meets the statutory definition of a "discharge." See 33 U.S.C §1362 ("The term 'discharge of a pollutant' … means (A) any addition of any pollutant to navigable waters

Maryland, for example has developed a TMDL for NOx deposition, for waters violating the relevant criteria.[150]

However, the Clean Air Act (CAA) aims squarely at SOx and NOx, both of which are criteria pollutants under that Act.[151] The CAA has functioned for over forty years to limit the ambient concentrations of these pollutants, and has been especially effective with respect to SOx after the 1990 CAA amendments established an emissions trading scheme.[152]

In general, states may promulgate more stringent air quality standards than those required federally.[153] However, because SO_2 and NOx are subject to federal trading schemes,[154] 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_2 emissions allowances traded to out-of-state polluters, and indicated that the state scheme created an "obstacle" to the nationwide trading program.[155] This case highlights a tension between the older 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 states were to create more stringent SOx and NOx standards, they would have to

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from any point source, (B) any addition of any pollutant to the waters of the contiguous zone or the ocean from any point source other than a vessel or other floating craft.")

150 Chesapeake Bay TMDL Executive Summary at ES-7 (Dec. 29, 2010).

151 *See* 40 CFR part 50 for the national ambient air quality standards, including those for SOx and NOx.

152 The emissions-trading focused on fighting SOx as a cause of acid rain, but the same chemical principles make sulphur compounds especially powerful acidifying agents in the coastal ocean. Wringing further benefit out of this already-fairly-successful program makes a good deal of sense, but the federal government—not the states—has the authority to ratchet down the total number of emissions allowances.

153 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)("[the 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)("[the 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.")

154 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).

155 338 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).

avoid federal preemption by amending their air quality standards without restricting the transferability of emissions credits.

SOx and NOx deposition can be substantial, especially in the Eastern United States, with its high concentration of coal-fired power plants and heavy industry.[156] Where these atmospheric pollutants end up in rivers and streams, they eventually flow to the coastal Atlantic. In some states, coastal waters carry a nitrogen load from atmospheric sources comparable to that of terrestrial runoff.[157] In the Chesapeake Bay, for example, atmospheric deposition of nitrogen is greater than the contribution from manure and chemical fertilizer runoff from all agricultural lands combined.[158] In these states especially, a high percentage of coastal ocean acidification may be due to atmospheric pollutants, and the logic for increasingly stringent air pollution regulation in these states is correspondingly stronger.

Because SOx and NOx have short residence times in the atmosphere, there exist improved incentives for state and local governments to regulate them more closely. States with more stringent limits will tend to experience the benefits themselves, as smaller amounts of the pollutants will be deposited within such states.[159] Especially in cases where atmospheric deposition of these pollutants is a significant driver of coastal acidification, cleaner air could immediately improve the chemical environment of the ocean while paying dividends in local public health benefits.[160]

5) Enhance Wastewater Treatment at Publicly-Owned Treatment Works

Sewage treatment presents a special problem for water quality regulation, in part because of its absolute volume: nationwide, wastewater treatment plants process more than 32 billion gallons of wastewater daily.[161] Much of this discharge volume flows to the ocean,[162] increasing nutrient loads along the coasts and triggering the acidifying cascade described above. Implementing more stringent technology-based or water-quality-based controls through NPDES permits for Publicly-Owned Treatment Works (POTW) would reduce anthropogenic nutrient loading in the coastal ocean, in turn reducing acidification as well as associated harmful algal blooms and anoxic zones, as described above.

The federal Clean Water Act singles out POTWs as special point sources with additional NPDES requirements beyond those of ordinary permittees. For example, POTWs

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156 *See* EPA, Our Nation's Air: Atmospheric Deposition, at 35 (2010)(available at: http://www.epa.gov/airtrends/2010).

157 *See* Note ##, *supra*, regarding Chesapeake Bay NOx deposition.

158 *See* EPA, Our Nation's Air: Atmospheric Deposition, at 36 (2010)(available at: http://www.epa.gov/airtrends/2010).

159 This stands in contrast to the problem of CO_2 regulation, in which states that decrease their emissions are unlikely to directly and proportionately benefit from such regulation.

160 *See, e.g.,* http://www.epa.gov/region07/air/quality/health.htm, for a description of human health effects of criteria pollutants. Note that lowering levels of these pollutants could also ease the environmental justice issues associated with the disproportionate concentration of industrial air pollution deposited in poor and minority neighborhoods.

161 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.

162 California alone discharges 1.35 billion gallons of treated wastewater per day into the Pacific. Heal the Ocean, California Ocean Wastewater Discharge Report and Inventory 5 (Mar. 15, 2010).

are subject to heightened reporting requirements in their permit applications[163] and must limit their discharges to a greater degree than the technology-based standards alone dictate.[164] As a result, a state can require POTWs to minimize discharges by altering the prevailing water quality standards.[165] Where sewage discharge significantly contributes to coastal acidification via nutrient loading, addressing the discharge within the context of the NPDES permitting program would be an attractive way to alleviate this particular stressor.

Changing the prevailing technology-based standard[166] for POTWs to require tertiary treatment[167] including nitrification-denitrification (N-DN)[168] would be another means of addressing POTW-related eutrophication. 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.[169] States, tribes, and regional bodies could apply this same analysis to the state's coastal POTWs with respect to OA and related ocean issues.[170] For example, where marine receiving waters are especially vulnerable to

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[163] *See* 40 C.F.R. §122.21(j).

[164] Clean Water Act §301(b)(1)(C), codified at 33 U.S.C. §1311(b)(1)(C).

[165] *See* discussion, *supra*.

[166] While the Clean Water Act does not expressly give States the power to change technology-based standards, the power of States to create more stringent standards is consistent with the Act, which contemplates a lead role for States in setting applicable clean water standards, and with case law. *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).

[167] 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).

[168] *See* Forster, *supra*, at 160-68.

[169] *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

[170] California's regional water boards have required N-DN for particular facilities in the past. 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*. 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.

acidification or related water quality issues due to upwelling or freshwater input, N-DN might be particularly appropriate.[171]

Infrastructure upgrades to treatment works are expensive. And as ever, more stringent regulation will be politically difficult, especially in light of the fact that costs associated with upgrading facilities would fall to cash-strapped cities and counties.[172] But the fact that POTW regulations impact government entities rather than private industry means the hurdles to implementation are more likely to be financial than philosophical: given the financial resources, most cities and counties would probably not object to having cleaner wastewater discharges. Hence, where the benefits of upgrading accrue to the city or county in such a way as to defray the costs,[173] reform is more likely to happen.

Side benefits of more stringent wastewater treatment include improved water recycling for non-potable or indirect potable uses (e.g., recharging groundwater), a benefit probably most attractive to coastal counties in which freshwater is at a premium.[174] Reusing water in this way reduces a municipality's water demand—thus saving money annually—and simultaneously avoids the substantial greenhouse gas emissions associated with moving water from source to tap. In jurisdictions where beach closures are costly,[175] lowering the number of closures would be a further benefit, at least partially offsetting the price of upgrading infrastructure.

6) Leverage CWA § 319(h) Money to Implement Enduring Best Management Practices (BMPs) and Permanent Nutrient-Management Improvements

Motivated in part by the failure of TMDLs to achieve enforceable water quality protection, Congress passed the Coastal Zone Act Reauthorization Amendments (CZARA) in

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[171] State and regional authorities 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 (July 2004).

[172] 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 Nitritation/Anammox: Environmental And Economical Considerations, 50 Water Science & Techn. 15 (2004)(noting environmental costs as well as economic costs of different methods).

[173] For example, N-DN plants may have lower operating costs than conventional plants. *See* D. Rosso & M.K. Stenstrom, 3 Energy-Saving Benefits of Denitrification, Environmental Engineer 2 (2007).

[174] 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 that wasting sufficiently treated water—rather than recycling it—could be an unreasonable use under California law.

[175] *See generally*, e.g., Peter C. Wiley *et al.*, NOAA Report: Economic Impact of Beach Closures and Changes in Water Quality for Beaches in Southern California (2006)(modeling economic impacts of thousands to billions of dollars, depending upon the closure scenario and duration). *See also* S.J.M. Rabinovici *et al.*, Economic and Health Risk Trade-Offs of Swim Closures at a Lake Michigan Beach, 38 Environmental Science & Technology 2737, 2742 (2004)(estimating net economic loss of up to $35,000 per day per swimmer for closure at a particular beach.)

1990 in an attempt to improve nonpoint source pollution control in coastal waters.[176] The Act required states with coastal zone management programs approved under the Coastal Zone Management Act (CZMA)[177] to develop and implement coastal nonpoint source pollution control plans.[178] As with the CZMA, the federal government provided funds for planning and implementation under CZARA.[179]

The Act provided that the states' plans should be enforceable,[180] on pain of the EPA withholding its approval and the consequent loss of funding.[181] However, the actual implementation and enforcement of states' nonpoint source management plans is left to states, and is largely carrot-based: the funds authorized by §319(h) of the Clean Water Act and §306 of the CZMA serve as ongoing incentive for states to manage nonpoint source pollution in their coastal zones.

In states lacking the ability or the will to enforce nonpoint source controls, resource agencies can use the CZARA-associated funds as carrots, requiring 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. In general, however, an entirely incentive-based system leaves the state in the uncomfortable and unsustainable role of paying its constituents not to pollute.[182]

States with more enforceable nonpoint source regulation have the option of wielding either the carrot or the stick. In California, for example, the regional water boards[183] implement the CZARA[184] and Clean Water Act restrictions. 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.[185] 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

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[176] 16 U.S.C. § 1455b.
[177] 16 U.S.C. § 1451 et seq.
[178] 16 U.S.C. § 1455b.
[179] 16 U.S.C. § 1455b(f),(h).
[180] 16 U.S.C. § 1455b(b)(3) provides that each plan shall contain management measures, the implementation of which is necessary to achieve Clean Water Act standards. §1455b(c)(2) states "State **shall** implement the program, including the management measures." (emphasis added).
[181] 16 U.S.C. § 1455b(c).
[182] 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*, at 10225. Using federal dollars to pay nonpoint sources to maintain BMPs year after year raises the same ethical and practical questions.
[183] *See* http://www.swrcb.ca.gov for a description of the California state and regional water boards.
[184] California's Coastal Commission shares authority with the water boards to implement CZARA.
[185] 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).

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.[186] WDR violations may trigger abatement, cease-and-desist orders, or similar remedies including civil liability.[187] Fees associated with WDRs defray the costs of implementation and secondarily discourage avoidable discharges.[188]

These seemingly enforceable nonpoint source controls are consistent with an overarching state policy of maintaining water quality by using the full power and jurisdiction of the state to do so.[189] However, these measures still rely on identified permittees for implementation, and violations are enforceable only against those same permittees. Rather than water-quality based enforcement, the WDRs and associated rules parallel the technology- or management-practices-based measures in NPDES permits. The result is that nonpoint source problems are treated like point source problems, and most pollution is likely to remain unaccounted for.[190]

Solving this problem requires California and states with similar nonpoint source programs to be enterprising in identifying nonpoint source polluters and to have the political will to take them on. In states in which a failure to report a discharge or a failure to file for a permit can trigger an enforcement action,[191] agencies can use these state law provisions to bring nonpoint sources into the permitting system. An increase in direct enforcement could curtail nonpoint source runoff from identified sources, and could be an effective way of combating a large fraction of the runoff contributing to coastal acidification and degraded water quality.

7) Participate in the National Estuary Program and the National Estuarine Research Reserve System

States can better manage inputs into key coastal sites by enrolling them in the National Estuary Program (NEP). This program was created as part of the 1987 amendments to the Clean Water Act,[192] and provides federal funds for creating and implementing comprehensive management plans for nationally significant bays and estuaries.[193] The NEP does not set aside estuaries as protected or research areas, but

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186 *See* 2004 WL 1380112 at *3-*6.

187 See the complete list of enforcement options, Nonpoint Source Implementation Plan at 56 *et seq*.

188 Water Code § 13260(d) provides the relevant fee authority.

189 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).

190 Note that the advent of pesticide permitting under NPDES—projected to increase the number of permittees by 65%—may bring formerly nonpoint sources into the permitting process and thus allow state, tribal, and regional agencies greater opportunity to impose pollution restrictions beyond those required for pesticides alone. EPA, 2010 NPDES Pesticides General Permit Fact Sheet at 14 (available at: http://cfpub.epa.gov/npdes/pesticides/aquaticpesticides.cfm).

191 See discussion of direct enforcement actions, infra. California is one state for which every discharge likely to affect water quality—whether point or nonpoint—requires a permit from the state or regional water board. Cal. Water Code § 13261.

192 CWA § 320; 33 USC § 1330.

193 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

rather represents a means of grappling with nonpoint source pollution[194] through a collaborative, watershed-wide process that has been lauded as a model of cooperative governance.[195] 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.

Twenty-eight bays and estuaries are presently enrolled in the program—representing a total of nineteen states—and state governors can nominate new water bodies for inclusion.[196] Although reliable time-series data are not available, EPA-provided data are available and, on the whole, paint a 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.[197] The program claims to have protected or restored over 518,000 acres of national estuarine habitat between 2001 and 2005,[198] and a total of 1.3 million acres since 2000.[199] Where states have existing NEP estuaries, they can make use of federal funds to combat acidification in the estuaries' comprehensive management plans.

The National Estuarine Research Reserve System (NERRS), by contrast, is not a management program but rather a research 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."[200] After an evaluation process[201] 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.[202]

States may find the visibility, data collection, and funding that accompany designation as a NERRS site to be helpful for protecting their 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.[203] This may be

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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.

194 Lynn M. Gallagher, Clean Water Handbook, 3d ed., 129 (2003).

195 *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).

196 33 U.S.C. § 1330; for existing NEP estuaries, see http://water.epa.gov/type/oceb/nep/upload/NatGeo_24x36_final_revised.pdf.

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

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

199 http://www.epa.gov/owow_keep/estuaries/pivot/habitat/progress.htm (last visited Dec 14, 2011).

200 15 C.F.R. §921.2(f).

201 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).

202 *See* http://nerrs.noaa.gov/BGDefault.aspx?ID=61 for description of day-to-day management. (Last visited Dec. 14, 2011).

203 15 C.F.R. § 921.1(f).

particularly attractive for states such as Washington, which allow private ownership of tidelands,[204] and which therefore may have to purchase such lands in order to include them in the federal program.[205]

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.[206] Congress has consistently appropriated funds for the operation of NEP and NERRS,[207] but at least in the case of the NEP, the funding priority is to support existing estuaries rather than to enroll new ones.[208] The last new NEP designation was in 1995, when a Congressional appropriation allowed it.[209] Until this changes, states can focus their efforts on mitigating the flow of pollutants into existing NEP estuaries, which occur in the majority of coastal states.

8) Incorporate Ocean Acidification Impacts into Environmental Review under State NEPA Equivalents

Fifteen states have "little NEPAs," versions of the National Environmental Policy Act (NEPA).[210] These statutes require some kind of review of the environmental impact of proposed projects involving at least some government action.[211] States calibrate the stringency of the Acts by specifying which kinds of projects require review, which impacts those reviews must assess, and by specifying whether significant impacts must be mitigated.

Case law and the state statutes themselves have largely defined the first and third of these controls, setting a degree of state action (or a degree of potential impact) required in order for a project to trigger environmental review,[212] and a degree of necessary mitigation.[213] State environmental agencies generally set the second control—i.e., the

[204] *Caminiti v. Boyle*, 107 Wash. 2d 662, 664 (Wash. 1987)("the state of Washington has the power to dispose of, and invest persons with, ownership of tidelands and shorelands subject only to the paramount public right of navigation and the fishery.") *Washington v. Longshore*, 141 Wash. 2d 414, 421 (Wash. 2000)"once tidelands are sold to an individual, title to the clams passes to the private property owner.".

[205] Note, however, a state need not own lands in fee simple in order to enroll them in NERRS. 15 C.F.R. § 921.30(d).

[206] 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.

[207] *See* http://nerrs.noaa.gov/BGDefault.aspx?ID=492.

[208] *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.

[209] *See* http://water.epa.gov/type/oceb/nep/questions.cfm (last visited Dec. 14, 2011).

[210] D. Sive & M.A. Chertok, "Little NEPAs" and Their Environmental Impact Assessment Processes, SR045 ALI-ABA 801 (2010). Washington, D.C., and Puerto Rico also have similar statutes. *Id*. Note also that some cities may require similar emissions accounting for development projects. This is the case at least in Seattle, Washington. Ordinance 122574 (Dec 10, 2007).

[211] The Acts often refer to "state agencies," "public agencies," or use similar language. *See id.* at 805.

[212] *See, e.g., No Oil, Inc. v. City of Los Angeles*, 13 Cal. 3d 68 (1974); *H.O.M.E.S. v. New York State Urban Dev. Corp*., 69 A.D.2d 222, (4th Dept. 1979).

[213] Cal. Publ. Res. Code § 21002.1(b)("Each public agency shall mitigate or avoid the significant effects on the environment of projects that it carries out or approves whenever it is feasible to do so.")

impacts that a review must include—by regulation.[214] Because ocean acidification is a known effect of various byproducts of human development—including at least CO_2 emissions, NOx and SOx emissions, and eutrophication from coastal runoff—regulatory agencies can and should include these drivers' contributions to ocean acidification as impacts that environmental reviews must consider.

In some states, courts could already require review of acidification impacts under existing statutory language. For example, in California a court could require such analysis under the California Environmental Quality Act (CEQA)[215] guidelines' existing greenhouse gas and water quality provisions.[216] Changing these guidelines slightly to expressly require acidification analysis would highlight the growing scientific consensus on the changing ocean chemistry and its importance to the state's economy and coastal ecosystems, but would not be a major regulatory change because California already demands an accounting of greenhouse gas impacts, nutrient outflow, and erosion in environmental review.[217] Massachusetts and Washington also require some form of greenhouse gas accounting in their analogous laws.[218]

Where states lack greenhouse gas accounting requirements in their little NEPAs, courts and environmental agencies can nevertheless require acidification-impact analysis as an aspect of water quality. Again, making this connection more explicit by listing acidification expressly as an impact that project proponents must consider would highlight the issue, but is not essential. Chemical properties (including nutrient loading and pH) are essential measures of water quality, and proposed projects that degrade water quality by changing the pH of receiving waters fall squarely within the ambit of state NEPA-equivalents.[219]

Analyzing the contribution of a proposed project to ocean acidification under state NEPA-style laws would be a helpful complement to actions under the Clean Water Act in any effort to more responsibly deal with nonpoint source pollution. Moreover, this shift requires a bare minimum of new law or regulation, and would underscore the growing awareness of the real environmental threat that a fundamentally changed ocean represents.

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[214] *See, e.g.,* 6 NYCRR Part 617 (New York's State Environmental Quality Review Act regulations); 197-11 WAC (Washington's State Environmental Policy Act regulations).

[215] California Environmental Quality Act, Cal. Publ. Res. Code § 21050 et seq.

[216] *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.") Because CO_2 is a greenhouse gas, Health & Safety Code § 38505, lead agencies may consider the impacts of CO_2 on the acidifying ocean within the existing CEQA analysis.

[217] *See* APPENDIX for sample suggested text for revised CEQA guidelines.

[218] *See* MEPA Greenhouse Gas Emissions Policy and Protocol (http://www.mass.gov/envir/mepa/pdffiles/misc/GHG%20Policy%20FINAL.pdf); Washington website on greenhouse gas emissions and SEPA (http://www.ecy.wa.gov/programs/sea/sepa/climatechange/index.htm).

[219] *See, e.g.,* SEPA Project Review Form: Guidance Document at 12 (March 2000)(Washington State; listing excess nutrient runoff as a condition to be considered when listing impacts).

9) Direct Action to Enforce: Public Nuisance and Criminal Statutes

All states have the power to sue polluters as common law public nuisances, and many jurisdictions also have criminal statutes dealing with water pollution. The federal Clean Water Act does not preempt state common law nuisance claims, expressly leaving states the power to regulate water quality more stringently.[220] Federal courts have upheld state common law claims as viable, despite the preemption of federal common law claims.[221]

A public nuisance is an "unreasonable interference with a right common to the general public."[222] In general, citizens lack standing to sue for public nuisances, but where a person is particularly harmed by a public nuisance, he or she has standing to sue.[223] 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. State agencies seek the remedy in the absence of a plaintiff claiming special harm. Some instances of water pollution constitute a public nuisance *per se*,[224] and these are particularly attractive cases for either private or public enforcement because of their predictable outcomes.

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[220] 33 U.S.C. § 1251(b) ("It is the policy of the Congress to recognize, preserve, and protect the primary responsibilities and rights of States to prevent, reduce, and eliminate pollution, to plan the development and use (including restoration, preservation, and enhancement) of land and water resources.")

[221] *See, e.g., City of Milwaukee v. Illinois & Michigan*, 451 U.S. 304, 317(1981); *Comer v. Murphy Oil USA*, 585 F.3d 855, 878 (5th Cir. 2009)("the [*Milwaukee*] Court noted that the CWA preserved nuisance suits under state common law, *see City of Milwaukee v. Illinois*, 451 U.S. 304, 327-29 (1981).") *See also Int'l Paper Co. v. Ouellette*, 479 U.S. 481, 497 (1987)("nothing in the Act bars aggrieved individuals from bringing a nuisance claim pursuant to the law of the *source* State.") The more recent *Connecticut v. American Electric Power* left open the state common law issue, as it had not been briefed, even in deciding that federal common law was preempted. 131 S. Ct. 2527, 2540 (2011).

[222] Restatement (Second) of Torts § 821B (1979). Most states have followed this approach to public nuisance. David A. Grossman, *Warming Up to A Not-So-Radical Idea: Tort-Based Climate Change Litigation*, 28 Colum. J. Envtl. L. 1, 53 (2003). *See also*, *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 Cal. 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.")

[223] *See, e.g., 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 Cal. Civ. Code, § 3493). Note that some states have preempted private nuisance actions with state environmental statutes. *See, e.g., Ashtabula River Corp. Group II v. Conrail, Inc*., 549 F. Supp. 2d 981, 989 (N.D. Ohio 2008)("Courts in Ohio, however, have recognized that there is no private right of action under [state water pollution laws], but instead charges the state government with enforcing its provisions.")(citations omitted).

[224] *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).

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[225] and ocean-based[226] pollution. Nuisance actions place the costs of abatement on polluters,[227] internalizing their incentive to minimize future pollution. Further, vicarious nuisance liability may be particularly useful in actions against multi-level corporate entities, such as factory farms.[228]

Many states have clean water statutes, with civil or criminal penalties for polluting parties. In particular, these statutes are likely to focus on drinking water quality.[229] But because drinking water often derives from major sources of surface water, the laws may be more generally applicable to issues of freshwater quality and ultimately coastal water quality. California, for example, has statutes that prohibit the keeping of livestock in a manner that pollutes water used for domestic purposes.[230] Because agricultural nonpoint source runoff is such a substantial source of pollution that often otherwise goes unregulated, these code sections may be particularly valuable enforcement tools for state agencies.[231]

Most states have "right to farm" statutes that exempt the agriculture industry from many nuisance actions.[232] Some of these laws are breathtakingly broad: Delaware's, for example, states "[n]o state or local law enforcement agency may bring a criminal or civil action against an agricultural operation for an activity that is in compliance with all

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[225] *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).

[226] *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).

[227] 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 (last visited 1/2/12).

[228] Of particular interest for vicarious liability for nonpoint source pollution is *Assateague Coastkeeper v. Alan & Kristin Hudson Farm*, 727 F. Supp. 2d 433, 442 (D. Md. 2010). There, the District court denied defendant Perdue's motion to dismiss for failure to state a claim, on the basis of the corporation's alleged vicarious liability for Clean Water Act violations at a smaller CAFO. Although this case arose in the statutory—rather than common law—context, it provides a recent reminder of the power of vicarious liability in the context of environmental law.

[229] For example, Washington State code section that prohibits polluting the water supply is extremely broad. Wash. Rev. Code § 70.54.010. Polluting water supply ("Every person who shall deposit or suffer to be deposited in any spring, well, stream, river or lake, the water of which is or may be used for drinking purposes…any matter or thing whatever, dangerous or deleterious to health, or any matter or thing which may or could pollute the waters of such spring, well, stream, river, lake or water system, shall be guilty of a gross misdemeanor.") Washington also prohibits generally the discharge of "organic or inorganic matter that shall cause or tend to cause pollution" of receiving waters. Wash. Rev. Code § 90.48.080.

[230] Health & Safety Code §§ 116990; 116995.

[231] Environmental justice, and not just environmental quality more generally, stands to benefit significantly from greater enforcement of these laws.

[232] *See* ELI report, *supra* note 227, at 25-26, for a broader review of these statutes.

applicable state and federal laws, regulations, and permits."[233] Others, such as New York's, only exempts the agriculture industry from private nuisance suits, leaving the door open to public nuisance actions.[234] California's right-to-farm law leaves intact nuisance actions falling under a broad swath of statutory provisions.[235] Despite the presence of various exceptions,[236] and the right-to-farm statutes' questionable validity under some state constitutions,[237] these statutes somewhat limit states' ability to abate agricultural nonpoint source pollution.

Using either common law or statutory approaches to abate harmful discharges directly could ameliorate coastal acidification and improve water quality. In some cases, this could be the fastest and most effective means of mitigating a particular pollution source. Although it is impossible to estimate the aggregate effect of such actions with any certainty, this approach has the attractive quality of shifting the cost of pollution onto the polluters themselves,[238] and this cost-shifting helps internalize the incentive to minimize future pollution.

Criminal statutes could be of further use for state enforcement efforts, and would abate particular environmental harms.[239] All fifty states have criminal statutes for water pollution, although these vary widely in their penalties and criminal elements.[240] For example, dumping waste matter into water bodies of all kinds—or on stream banks or beaches—is a crime in California, and carries a penalty of criminal fines.[241] Failing to file for a discharge permit—whether the discharge is from a point or a nonpoint source—is also a misdemeanor under the state's Porter-Cologne Act.[242] Although such dumping is probably not a major driver of coastal water quality problems when compared to more routine point and nonpoint source discharges, enforcing these laws would be a means of deterring illegal pollution while underscoring the seriousness of environmental crimes. Depending upon the criminal fines and the disposition of the revenue from those fines, this money would at least defray the expense of enforcement.

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233 3 Del. Laws § 1401.

234 N.Y. Pub. Health L. 1300-c.

235 Cal. Civil Code § 3482.5. Note also that this law exempts only agricultural activities from common law nuisance actions when the actions is "due to any changed condition in or about the locality." *Id*. That is, the law is aimed at preserving existing farming activities despite the encroachment of urban areas, rather than aiming to exempt the agricultural industry from nuisance law generally.

236 *See* 1 Envtl. Reg. of Land Use § 6:15 (2011)(citing negligence, trespass, and strict liability as alternative means of abating agricultural runoff).

237 *Id*. (discussing Iowa Supreme Court's finding that the state's right-to-farm statute created a de facto easement, and hence constituted a taking.)

238 *See* 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.

239 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, depending upon the administrative costs of an individual enforcement action.

240 *See* A. Franz, Crimes Against Water: Non-Enforcement of State Water Pollution Laws, 56 Crime Law Soc. Change 27 (2011), discussing state laws criminalizing water pollution, and the under-enforcement of these laws.

241 Penal Code § 374.7(a). Oregon has an analogous law: O.R.S. § 468.946.

242 California Water Code § 13261.

Finally, a rarely-invoked example of abatement action would be a state agency or municipality suing another agency or municipality for failure to perform a nondiscretionary duty. Where states have waived sovereign immunity with respect to this kind of suit, such as is the case in California,[243] a coastal or downstream community would have some kind of recourse against inland or upstream government entities for failure to safeguard their water quality, so long as the responsible entity had breached an identifiable and nondiscretionary duty.[244]

10) Practice Smart Growth and Smart Land Use Change

Changes in planning and land use can reduce many of the coastal inputs likely to exacerbate ocean acidification locally, while simultaneously contributing to a larger-scale effort to minimize the CO_2 emissions that create a background level of ocean acidification worldwide. This approach has the advantage of dealing with both the short term/local and longer term/global drivers of acidification in tandem. We address these non-CO_2 drivers first, and then discuss more direct CO_2 management, below. In particular, a decrease in impermeable surfaces, an increase in riparian buffers, and efficient stormwater management could all contribute to mitigate the nonpoint source runoff that can negatively impact coastal waters.[245]

Many states have smart-growth or anti-sprawl guidelines, but ultimately land use decisions are canonical functions of local government. Hence, local jurisdictions have a significant role to play in combating ocean acidification, CO_2 emissions, and water quality.

For example, every general plan in California requires a transit-friendly circulation element,[246] and requires cities to identify streams and riparian areas that may accommodate floodwaters for purposes of stormwater management.[247] Transit-friendly circulation means greater densities, fewer vehicle miles traveled,[248] and less voracious conversion of habitat to impermeable streets and sidewalks.[249] Safeguarding streams and riparian areas functions not just to better accommodate floods, but also to form buffers between the urban street and the waters that flow directly to the ocean. Other state

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[243] California Gov't Code § 815.6. Mandatory duty of public entity to protect against particular kinds of injuries ("Where a public entity is under a mandatory duty imposed by an enactment that is designed to protect against the risk of a particular kind of injury, the public entity is liable for an injury of that kind proximately caused by its failure to discharge the duty unless the public entity establishes that it exercised reasonable diligence to discharge the duty.")

[244] For example, municipalities, counties, and public agencies may sue one another over alleged violations of the California Environmental Quality Act. *See, e.g., County Sanitation Dist. No. 2 of Los Angeles County v. County of Kern*, 127 Cal. App. 4th 1544, 1558 (2005)(finding the county was required to prepare an environmental impact report assessing impact of county ordinance).

[245] *See generally*, Patricia E. Salkin, Sustainability and Land Use Planning: Greening State and Local Land Use Plans and Regulations to Address Climate Change Challenges and Preserve Resources for Future Generations, 34 Wm & Mary Envtl L. & Pol'y Rev. 121 (2009)(reviewing land use practices and other sustainability laws in state and local jurisdictions across the United States).

[246] Government Code § 65302(b)(2)(A) (effective Jan 1, 2011).

[247] § 65302(d)(3)(effective Jan 1, 2009).

[248] Discussed *infra*, as a type of direct CO_2 management.

[249] Transit plans may be eligible for federal subsidies. *See, e.g.,* the Congestion Mitigation and Air Quality Improvement (CMAQ) Program, http://www.fhwa.dot.gov/environment/air_quality/cmaq/ (last visited Feb. 28, 2012).

statutes require that local subdivisions properly provide for erosion control,[250] and some single out special land-use cases (such as forestry) for special attention to erosion and pollution-control.[251] These and other land-use measures that prevent the waste of urban life from entering surface waters (e.g., creeks, streams, rivers) and the coastal ocean all ultimately protect nearshore ecosystems and the services they provide.[252] Local land use controls also tend to place the costs of pollution prevention measures with those best equipped to control design and costs, the project developers.

Little NEPAs can be used to affect systemic change, because county or city actions to adopt or amend general plans (also called "comprehensive" plans), or to approve tentative subdivision maps, are steps that typically trigger state environmental review statutes.[253] Therefore, a state environmental review statute that requires analysis of ocean acidification impacts would produce broader scale change in land use regulation simply because it would influence long term planning.

More than most other states, California has an additional and powerful tool with which to shape land-use decisions in favor of coastal protection. The California Coastal Commission can use its broad authority to prevent land-use practices that negatively impact the nearshore environment.[254] The Coastal Act authorizes the Commission to maintain and restore marine resources, including coastal water quality and biological productivity.[255] Proactively mitigating stressors arising from coastal land uses within the Commission's jurisdiction—which may include nutrient runoff from nonpoint sources, an

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[250] 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).

[251] 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.

[252] 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.

[253] 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.

[254] *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.")

[255] *Id.*

otherwise difficult issue to tackle—is within the Commission's mandate and is a significant policy tool that is already available without any need for change to existing law.[256]

Other coastal states have coastal management agencies with varying degrees of centralization and authority. With the exception of Alaska,[257] every coastal state has an approved coastal management program under the federal Coastal Zone Management Act (CZMA).[258] New York, for example, has a Division of Coastal Resources[259] that has developed a set of coastal policies[260] guiding some land use decisions along the shore. By contrast, Florida's coastal program weaves together eight state agencies and five water management districts.[261] To the degree that states' CZMA-implementing agencies influence coastal land-use planning and decisionmaking, these agencies can minimize inputs into the nearshore environment and ameliorate coastal acidification accordingly.

Efforts to make general plans more responsive to issues in the nearshore environment could be bolstered by the support of local marine industries and residents, all of whom should benefit from a healthier coastline. In cases where coastal industries such as shellfish, finfish fisheries, and tourism—industries most immediately affected by ocean acidification—significantly influence the local economy, politics and tax dollars are more likely to favor these changes. Similarly, where urban redevelopment funds and other anti-sprawl incentives are available, municipalities should find it easier to budget for actions to combat ocean acidification locally.

Direct CO_2 Management

Despite its critical importance, we did not include direct CO_2 management among the ten points above because of the extensive existing literature on the subject,[262] and because the relatively unfavorable alignment of incentives for state, tribal, and local governments to bear the cost of reducing emissions in exchange for a diffuse, global benefit. Nevertheless, we cannot conclude this paper without at least briefly discussing the role of subnational governments in reducing CO_2 directly. Government entities may act to manage CO_2 directly either by regulation (e.g., via the Clean Air Act), or by using governmental spending power (e.g., greener purchasing, renewable energy portfolios, etc).

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[256] 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*, at *v*. The Commission's authority is not restricted to implementation of the Plan, but rather by the Coastal Act.

[257] Alaska withdrew from the federal coastal zone management program on July 1, 2011. 76 Fed. Reg. 39857 (July 7, 2011).

[258] 33 U.S.C. §1451 et seq. See http://coastalmanagement.noaa.gov/programs/czm.html (showing locations of states and territories with approved issues, and offering details on each.)

[259] http://www.nyswaterfronts.com/index.asp

[260] http://www.nyswaterfronts.com/consistency_coastalpolicies.asp

[261] Department of Environmental Protection, Florida Coastal Management Program, Florida Coastal Management Program Guide, 11 (2011)(available at http://www.dep.state.fl.us/cmp/default.htm).

[262] Google Scholar, for example, lists 97,500 titles responding to the search terms "controlling CO_2 emissions." The Social Science Research Network listed 243 titles responding to the same search terms. *See, e.g.,* R.M. Stavins, A Meaningful U.S. Cap-and-Trade System to Address Climate Change, 32 Harv. Envtl L. R. 293 (2008); J.S. Masur and E.A. Posner, Climate Regulation and the Limits of Cost-Benefit Analysis, 99 Cal. L. Rev. 1557 (2011).

Because of the global scale of the CO_2 problem, it may be difficult to imagine municipal, tribal, county, or even state-level emissions reductions having a substantial impact on CO_2-driven acidification. However, coastal states account for a substantial portion[263] of the nation's carbon emissions, in large part generated by the states' transportation and energy sectors.[264] And of course the national emissions of the United States constitute a substantial fraction of the world's emissions.[265] Reducing the total amount of anthropogenic CO_2 that a given state adds to the atmosphere is an absolutely essential step towards mitigating the primary driver of ocean acidification globally.[266] But where the incentives to reduce emissions are so far small or nonexistent, jurisdictions are unlikely to act unless they experience some more immediate and tangible benefit.

Fortunately, some local land-use changes will pay local dividends over short time horizons while diminishing emissions as a corollary benefit. For example, increasing urban density to reduce vehicle miles travelled is likely to be an especially effective step to reduce CO_2 emissions,[267] and has many positive side benefits for cities. Greater population density can result in an increase municipal tax revenues[268] and pay cultural dividends, all while reducing emissions from vehicle miles travelled.[269] In a city like Houston, for example—which is hugely dependent upon the oil industry for much of its livelihood, and which has few natural geographic limits to confine its outward growth—denser population centers could provide an economic and cultural boost. The fact that increasing land use densities should also diminish CO_2 emissions, helping to slow both acidification and the rise of sea level,[270] need not be a primary motivation. Going beyond incentives for denser development and greener building codes—both of which largely impact future infrastructure—to reach *existing* infrastructure would provide large energy and emissions savings for many cities, and such programs can be extremely cost effective.[271]

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[263] California, Florida, Louisiana, and New York were among the top ten emitting states in 2009, according to EPA data. See http://www.epa.gov/statelocalclimate/resources/state_energyco2inv.html.
[264] *Id*.
[265] See http://cdiac.ornl.gov/trends/emis/perlim_2009_2010_estimates.html, the Carbon Dioxide Information Analysis Center. The United States accounted for approximately 16.4% of the world's emissions in 2010. 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_2-eq, of which 188 mmtCO2-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.
[266] At least in California, some reductions are also required under state law.Cal. Health & Safety Code § 38550 (requiring 1990 emissions levels in California by 2020).
[267] For example, California's Senate Bill 375 (Steinberg), Chaptered Sept. 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_2, and NOx emissions.
[268] *See, e.g.,* S. Winkelman, A. Bishins, & C. Kooshian, Planning for Economic and Environmental Resilience, 44 Transportation Research Part A 575, 581 (2010).
[269] *Id*.
[270] One might think this would be a particular selling point for a city at or near sea level.
[271] "It has been estimated that [operations and maintenance] programs targeting energy efficiency can save 5% to 20% on energy bills without a significant capital investment." Federal Energy Management Program, Operations & Maintenance Best Practices: A Guide to Achieving Operational Efficiency, Release 2.0, at 2.3

Any action that directly reduces CO_2 emissions begins to address the primary driver of global background ocean acidification. California's AB32 requires emissions reductions independent of any ocean acidification benefit;[272] 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. In some cases, moving to greener sources for government acquisitions saves substantial amounts of money,[273] freeing county and municipal revenues for other uses. Small examples of more emissions-friendly purchasing policies include many cities' and states' ban on government-purchased bottled water[274] and San Francisco's vehicle fleet reduction.[275] Cities and counties can also change their energy portfolios toward increasing renewables, as King County, Washington has done.[276]

Desalination projects, under consideration in a variety of states, will have enormous CO_2 footprints,[277] and the relevant governmental agencies must carefully weigh the value of these and other coastal industries against the impacts of CO_2 on their ocean. Water recycling and conservation is likely to be much cheaper than desalination, and comes with large emissions reductions.[278] These and other direct-CO_2-management efforts are the beginnings of the wider-scale emissions policy change necessary to combat ocean acidification globally.

(July 2004). *See also* L. Nock & C. Wheelock, Pike Research, Energy Efficiency Retrofits for Commercial and Public Buildings, Executive Summary at 1. (2010) (estimating average payback time of 1 year for energy efficiency projects).

[272] *Id*.

[273] *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).

[274] *See, e.g.,* http://www.cityofmillvalley.org/index.aspx?recordid=231&page=34 (last visited Nov. 17, 2011); T.B. Wheeler, Maryland State Offices Going off the Bottle, Baltimore Sun (Sept. 30, 2011)(available at: http://articles.baltimoresun.com/keyword/tap-water); S.P. Chan, Seattle giving bottled water the boot, Seattle Times (March 14, 2008)(available at: http://seattletimes.nwsource.com/html/politics/2004281669_water14m.html).

[275] San Francisco Office of the Mayor, Gavin Newsom, Executive Directive 09-01, Reduction of City Fleet Vehicles (Jan. 12, 2009).

[276] King County will implement its 2010 Energy Plan to achieve 50% of its energy needs from renewables by 2015, 2011 Climate Motion at 11.

[277] Depending upon the desalination process used, plants use between 4-12 kW*h of thermal energy and 1.5-7 kW*h 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.

[278] 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.rivernetwork.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.

VI. Conclusion

Ocean acidification sits at the intersection of water- and air-quality issues. Although the primary driver of worldwide acidification is atmospheric CO_2, other atmospheric (SOx/NOx) and non-atmospheric (nutrient input, e.g.) inputs lead to large chemical changes in the coastal ocean. Consequently, state, tribal, and local governments can mitigate a significant portion of acidification's harms through smaller-scale actions as we work toward global CO_2 solutions. That they can do so without serious environmental tradeoffs, in ways consistent with existing environmental priorities, is especially fortunate.

These government entities have no shortage of tools at their disposal. In this article, we have provided a short list as a starting point for action, but the list could have been much longer. New and better laws are of course welcome to help tackle this emerging environmental issue, but more valuable in actually solving the problem will be a more favorable alignment of costs and benefits as the contours of the threat become clearer.

It is difficult to persuade a local, state, or tribal government to spend money out of its very limited budget to mitigate an environmental problem when the precise harm is uncertain and lies largely in the future. Ocean acidification is not yet a priority for many jurisdictions,[279] and that is hardly surprising given the list of challenges facing all levels of government. Although there are significant benefits of acting to mitigate acidification sooner rather than later—especially given the possible nonlinear impacts of environmental change—the main benefits are in the form of future harm reduction. This kind of benefit routinely falls victim to systematic undervaluation.[280]

There are good reasons to believe that ocean acidification will become a higher priority in the future. First, the direct harm to ecosystems and industries dependent upon them is likely to get worse as the ocean becomes more acidic. As economic harms increase, we expect efforts to mitigate these harms to increase proportionately. Conversely, the benefits of combating ocean acidification will become both clearer and nearer in time as the cost of inaction grows. More certain and more immediate benefits tend to be valued more highly,[281] and therefore benefit from greater incentives for government action. Third, a wider spectrum of interests will likely find common cause as the threats of acidification become more tangible and widespread. The resulting political pressure should be a substantial incentive for governments to act.

Whether these changes will come to pass in time for coastal management to influence the environmental outcome is an open question. At present, the ocean appears to be acidifying at a rate faster than any in the geologic record.[282] We are already in a no-

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[279] A notable exception is Washington state, where the aligned interests of treaty tribes and the shellfish industry led the governor to announce the formation of a blue ribbon panel on ocean acidification. Washington Dept. of Ecology, News 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).

[280] *See, e.g.,* D.M. Driesen, The Societal Cost of Environmental Regulation: Beyond Administrative Cost-Benefit Analysis, 24 Ecology Law Quarterly 545, 587-88 (1997).

[281] In both the cases of the more certain and the more immediate benefits, this is equivalent to a decrease in the discount rate.

[282] *See* R.E. Zeebe, History of Seawater Carbonate Chemistry, Atmospheric CO_2, and Ocean Acidification, 40 Ann. Reviews of Earth & Planetary Science 141 (2012). *See also* L.R. Kump *et al.*, Ocean Acidification in Deep Time, 22 Oceanography 94, 105-06 (2009)("In other words, much of humanity is, in effect, engaged in a

analogue future.[283] We hope that with this article provides a useful set of measures for those government entities that want to combat ocean acidification now, as well as a prompt to those governments who do not yet realize the value of doing so.

collective and deliberate effort to transfer carbon from geological reservoirs to the atmosphere as CO_2. The resulting rate of environmental change very likely far exceeds that associated with past greenhouse transient events, and will have been exceeded in the geological record only by bolide impacts of the sort that caused the K/T extinction [i.e., of the dinosaurs, among many, many other species] 66 million years ago. Lesser events in the geologic past have left an indelible imprint on the geologic and biotic record. 'Business as usual' combustion of fossil fuels, unless accompanied by an aggressive and successful program of carbon capture and storage, is likely to leave a legacy of the [present] as one of the most notable, if not cataclysmic, events in the history of our planet.")

[283] See D. Fox, Back to the No-Analog Future? Science (2007); J.B. Ruhl, Climate Change and the Endangered Species Act: Building Bridges to the No-Analog Future, Boston Univ. L.R. (2008).