

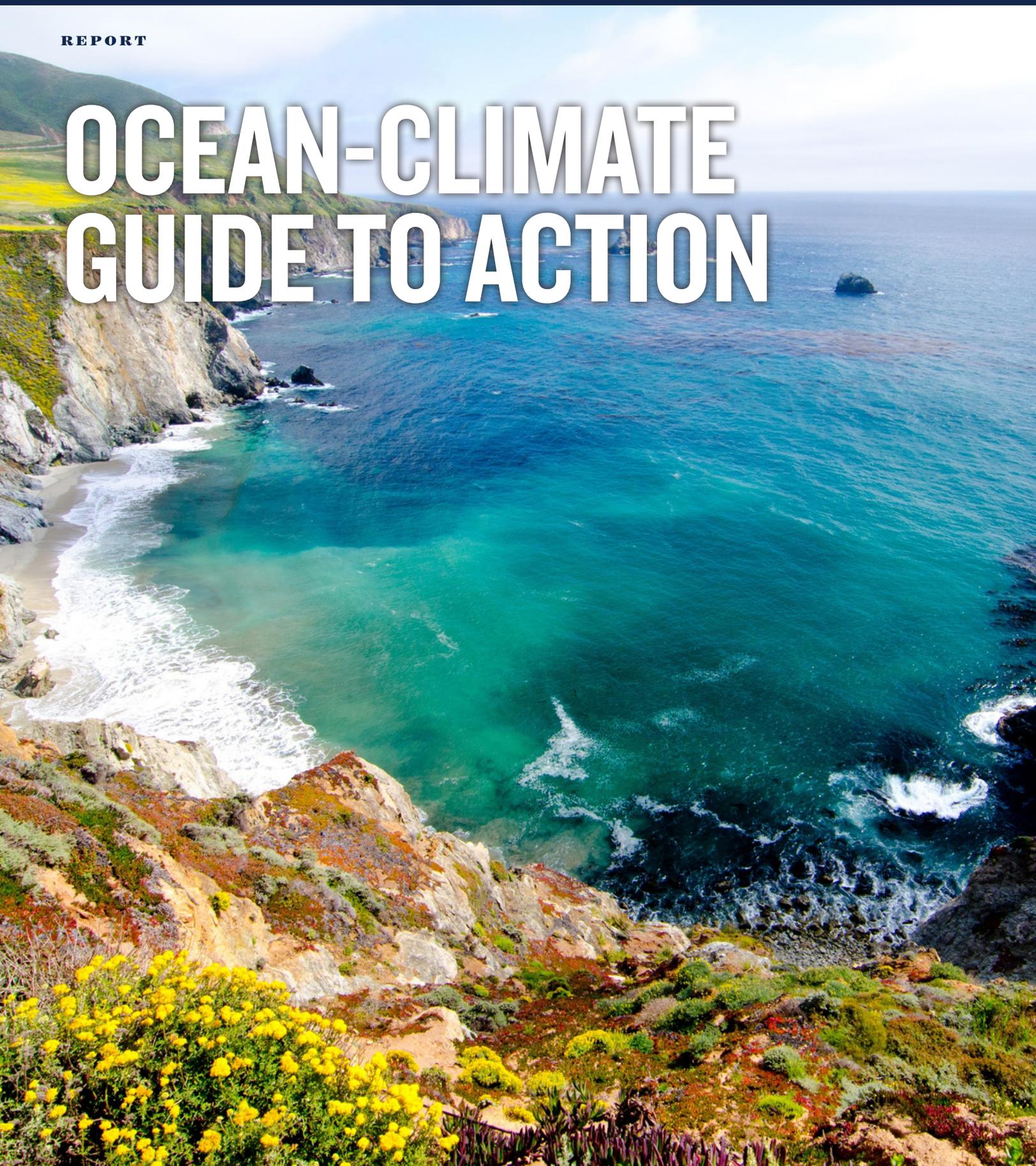


Ocean Conservancy®

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REPORT

OCEAN-CLIMATE GUIDE TO ACTION



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About NRDC

The Natural Resources Defense Council is an international nonprofit environmental organization with more than 3 million members and online activists. Since 1970, our lawyers, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. NRDC has offices in New York City, Washington, D.C., Los Angeles, San Francisco, Chicago, Montana, and Beijing. Visit us at nrdc.org.

About Ocean Conservancy

Ocean Conservancy is working to protect the ocean from today's greatest global challenges. Together with our partners, we create science-based solutions for a healthy ocean and the wildlife and communities that depend on it.

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INTRODUCTION

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In 2015 at COP21, nearly 200 countries adopted the Paris Agreement. Parties to this historic accord committed to take steps both to limit warming to well under 2 degrees Celsius above preindustrial levels and to increase resilience to the impacts of climate change. Healthy oceans are a crucial component in the global fight against climate change, but only a handful of countries currently include meaningful ocean-based mitigation and adaptation actions in their plans to meet their Paris goals.

This *Ocean-Climate Guide to Action* provides options for addressing this omission, which carries a heavy cost. Globally, ocean-based economic activities are estimated to be worth over a trillion dollars annually (USD), supporting hundreds of millions of jobs and providing protein to billions of people.¹ More fundamentally, our oceans provide services that make life on earth possible, such as producing oxygen and storing excess heat and carbon dioxide, thereby slowing the rate of catastrophic warming. The oceans are critical to the global fight against climate change.

One example of their importance in that fight is through the conservation and restoration of coastal “blue carbon” ecosystems, which is an essential pillar of a strong climate mitigation strategy. Seagrasses, mangrove forests, and salt marshes are particularly effective at capturing and sequestering carbon dioxide. When they are degraded, they not only fail to act as carbon sinks but also become sources of greenhouse gas emissions.

In addition, countries must also act to adapt to the impacts of climate change that we are observing in the oceans and along our coasts. Greenhouse gas emissions are causing an increasingly warm, deoxygenated, and acidic marine environment. Consequently, coral reefs are bleaching, marine ecosystems are degrading, and fisheries are moving poleward. We are observing more rapid and intense ice sheet melting, leading to faster and higher projections of sea level rise. We must prepare our coastal communities for these changes.

Long regarded as a leader in climate policy and ocean conservation, the state of California has become a pioneer in the intersection of these fields. Over the past two decades, California has steadily developed a comprehensive vision of ocean-climate action that could serve as a model to other subnational and national governments seeking to protect the oceans and use their power to combat climate change.

This *Ocean-Climate Guide to Action* is a partial snapshot of California's efforts to preserve natural carbon stores in marine and coastal habitats, reduce carbon emissions in ocean industries, and protect marine ecosystems and coastal communities from the most severe impacts of climate change. **These case studies are meant to introduce nations, states, local governments, and others to a wide variety of tested and effective ocean-climate actions that they might take.**

Ultimately, the oceans sustain us all. We hope this guide will inspire jurisdictions everywhere, whether coastal or not, to support policies, practices, and projects that ensure healthy and thriving oceans.

1 Organisation for Economic Co-operation and Development , *The Ocean Economy in 2030* (Paris: OECD Publishing, 2016), <https://doi.org/10.1787/9789264251724-en>.

FOUNDING INNOVATIVE INSTITUTIONS FOR OCEAN SCIENCE AND PROTECTION

California's Ocean-Climate Contribution



In 2004 the California Legislature adopted the California Ocean Protection Act (COPA), creating the Ocean Protection Council (OPC).¹ This first-of-its-kind governmental institution was intended to promote comprehensive and coordinated ocean and coastal management as the ocean program of the California Natural Resources Agency. Chaired by the secretary for Natural Resources, the seven-member council includes the secretary for Environmental Protection as well as representatives from the state legislature and the public. OPC is charged with coordinating state policy and scientific data collection related to coast and ocean resources among agencies as well as identifying and recommending changes in law to the legislature to improve coastal and ocean management. OPC helps coordinate activities of state agencies that work on ocean and coastal issues, including the California Coastal Conservancy, California Coastal Commission, the San Francisco Bay Conservation and Development Commission, State Water Board, Department of Fish and Wildlife, and others.

COPA also required OPC to establish a multidisciplinary team of science advisers to help it meet its responsibilities. Established in 2008, the Ocean Protection Council Science Advisory Team (OPC SAT) provides scientific analysis and advice to OPC and works to ensure that OPC decisions are informed by the best available science. Its members come from academic institutions, state and federal agencies, and California tribes. OPC SAT has provided scientific advice and evaluation on a wide range of topics to address issues impacting coastal and marine ecosystems in California. In addition, the California Ocean Science Trust (CalOST), an independent nonprofit, was created by statute to provide independent science to support state decisions.² Its executive director serves as a science adviser to OPC.

Key Elements of Success

- Inclusive structures that ensure coordination across all branches of government
- Significant funding that, when leveraged with additional funding and the work of partner organizations, helps to address the complex problems facing California's vast coastline³
- A foundation in and access to science via OPC SAT and CalOST, which helps to inform and shape effective policy

1 California Legislative Information, "PRC Division 26.5 California Ocean Protection Act," 2004, http://leginfo.legislature.ca.gov/faces/codes_displayText.xhtml?lawCode=PRC&division=26.5.&title=&part=&chapter=1.&article=

2 The 2000 California Ocean Resources Stewardship Act (CORSA) directs how the CalOST board is populated. California Ocean Resources Stewardship Act of 2000 (CORSA), Added by Stats. 2000, Ch. 516, Sec. 1, effective January 1, 2001, http://leginfo.legislature.ca.gov/faces/codes_displayText.xhtml?lawCode=PRC&division=27.&title=&part=&chapter=8.&article=1,

3 Related to this element is California voter support for ocean health. A 2019 poll showed that 77 percent of California voters are concerned about the state's ocean and coasts. Voters have overwhelmingly supported bond measures to fund OPC, among other environmental initiatives. Mark Baldassare et al., "PPIC Statewide Survey: Californians and the Environment," Public Policy Institute of California, 2019, <https://www.ppic.org/wp-content/uploads/ppic-statewide-survey-californians-and-the-environment-july-2019.pdf>.

CALIFORNIA'S CAP-AND-TRADE PROGRAM AND CALIFORNIA CLIMATE INVESTMENTS

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California's path to a cap-and-trade program formally began in 2006 with the passage of AB 32, the nation's first comprehensive climate change policy. AB 32, and subsequent climate legislation, set state greenhouse gas (GHG) emission reduction targets and charged the California Air Resources Board (CARB) with identifying strategies to meet those targets.¹

The cap-and-trade program is a key element of California's climate plan. It sets a statewide limit on the GHG sources responsible for 85 percent of California's emissions, with the limit declining over time. The program also establishes the carbon price signal needed to drive long-term investment in cleaner fuels and energy efficiency. CARB spent more than two years in a public process designing the initial cap-and-trade program.² It considered other examples and structured California's program to eliminate deficiencies that had plagued other initiatives.³ The result is an expansive cap-and-trade program that is regarded as one of the best designed in the world.

In addition to placing a firm limit on GHG emissions, the cap-and-trade program also generates funds for the state. Each quarter, CARB holds an auction to sell a portion of cap-and-trade emissions allowances into the market. The proceeds from the sale of the state-owned emissions allowances are deposited into the Greenhouse Gas Reduction Fund, or GGRF, to

be used by the state for California Climate Investments (CCI). In 2014, the California Legislature dedicated 60 percent of each cap-and-trade auction's proceeds to reducing GHG emissions in the transportation sector.⁴ Portions of the funds are also set aside for a manufacturer tax credit, certain fire prevention activities, coastal adaptation, and safe drinking water protections.⁵ The remaining funds are appropriated on an annual basis to a suite of programs, spanning multiple sectors of the economy that facilitate GHG emissions reductions. As required by statute, funds appropriated to CCI programs must be used to facilitate GHG emission reductions, benefit priority populations, and maximize other environmental, public health, and economic benefits. As of August 2019, almost \$12 billion in funding had been deposited into the GGRF. These have included funds for coastal planning.

Key Elements of Success

Two key factors have been critical to the success of California's cap-and-trade program:

- bold leadership
- thoughtful and detailed design

Other jurisdictions considering a cap-and-trade program should assess whether they can create the necessary leadership to drive implementation, whether and to what extent the California model or other models can serve the jurisdiction, and what priorities and safeguards should be integrated into the program to help ensure political viability and long-term success.

- 1 SB 32 (Pavley, Chapter 249, Statutes of 2016), http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB32. SB 350 (De León, Chapter 547, Statutes of 2015), http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB350. SB 375 (Steinberg, Chapter 728, Statutes of 2008), http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200720080SB375. California Legislative Information, AB 32: California Global Warming Solutions Act of 2006, http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.pdf.
- 2 California Climate Change, "Climate Action Team Working Groups," https://www.climatechange.ca.gov/climate_action_team/working_groups.html, (accessed November 21, 2019). In addition to public input, AB 32 and later legislation mandated that several groups made up of experts and stakeholders be formed to help advise CARB: the Environmental Justice Advisory Committee, Economic and Technology Advancement Advisory Committee, Economic and Allocation Advisory Committee, Regional Targets Advisory Committee, and Market Advisory Committee. Working groups from 10 sectors also provided input to CARB.
- 3 Center for Climate and Energy Solutions, "California Cap and Trade," <https://www.c2es.org/content/california-cap-and-trade/>, accessed November 21, 2019). Environmental Defense Fund, "California's Cap-and-Trade Program Step by Step," <https://www.edf.org/sites/default/files/californias-cap-and-trade-program-step-by-step.pdf>.
- 4 California Legislative Information, "SB-862 Greenhouse Gases: Emissions Reduction," June 20, 2014, https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB862.
- 5 Ibid. California State Legislature, Monning, SB 200 (Chapter 120, Statutes of 2019), http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201920200SB200; Legislative Analyst's Office, 2019-2020 Budget, Natural Resources and Environmental Protection, <https://lao.ca.gov/Publications/Report/3933>, accessed 11/25/20.

FINANCING NATURAL RESOURCE INVESTMENTS WITH BONDS

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California’s push to use bonds to finance investments in the state’s natural resources began in the late 1920s but accelerated in the late 1980s when the state struggled through two economic recessions. During those recessions it became clear that natural resource investments would fall far down the list of budget priorities when state funds were limited.¹ In response to the need for dedicated funding, California state legislators and environmental advocates began working outside the state budget process to craft language for, campaign for, and work to implement natural resource bond measures.

Since 1988 California voters have approved nearly \$26.6 billion in general obligation bonds for investment in a broad range of natural resource projects through a series of successful statewide ballot measures.² The most recently approved bond, Proposition 68 (2018), included more than \$200 million for ocean, bay, and coastal protection programs, approximately 5 percent of the total \$4 billion approved.³ California resource bonds often include efforts to protect or restore coastal and ocean areas. The two resources bonds prior to that, Proposition 1 (2014) and Proposition 84 (2006), allocated between 1 to 8 percent in ocean and coastal work, with investments largely driven by legislative priorities, environmental advocates, and campaign donors.⁴

Successful implementation of a natural resources bond requires tracking funding through the state budget process and monitoring funding program development; it may also include stakeholder advocacy to provide guidance on how to spend funds. Ideally, programs should be coordinated and leveraged across California’s state agencies.

Key Elements of Success

- Opinion research on voter priorities to guide ballot measure drafting
- Environmental advocates with expertise to pursue dedicated funding for their priorities and capacity to execute campaigns in support of bond measures
- Ocean and coastal champions in the legislature
- Capacity of California state agencies to administer funding programs and projects in partnership with community-based organizations
- Strong public support for environmental protection

Other jurisdictions interested in pursuing bond funding for ocean and coastal climate adaptation work should compare the cost of financing general obligation bonds with the cost of other potentially more sustainable and less expensive ways of investing in adaptation.⁵ Other important considerations include the need to conduct broad stakeholder outreach, and the jurisdiction's willingness and capacity to oversee and administer funding when it becomes available.

- 1 Ocean and coastal climate adaptation programs could receive funding through the state general fund, the Greenhouse Gas Reduction Fund, and a mix of other small funding sources. However, these sources also support high-priority education, housing, corrections, transportation, health care, mental health, and air quality improvement programs.
- 2 Dollar amounts are totaled for California Propositions: 70 (1988), 204 (1996), 12 (2000), 13 (2000), 40 (2002), 50 (2002), 84 (2006), 1 (2014), and 68 (2018). California Ballot Propositions for years 1988 - 2018, https://ballotpedia.org/California_1988_ballot_propositions; https://ballotpedia.org/California_1996_ballot_propositions; https://ballotpedia.org/California_2000_ballot_propositions; https://ballotpedia.org/California_2002_ballot_propositions; https://ballotpedia.org/California_2006_ballot_propositions; https://ballotpedia.org/California_2014_ballot_propositions; https://ballotpedia.org/California_2018_ballot_propositions.
- 3 Kevin DeLeon, SB-5 California Drought, Water, Parks, Climate, Coastal Protection, and Outdoor Access For All Act of 2018, (2017-2018), https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB5; California Department of Parks and Recreation, "Parks and Water Bond Act of 2018 (Proposition 68)," https://www.parks.ca.gov/?page_id=29906.
- 4 California Natural Resources Agency, Bond Accountability, Propositions 1 and 84, <http://bondaccountability.resources.ca.gov>.
- 5 California Legislative Analyst's Office, Bonds, <https://lao.ca.gov/BallotAnalysis/Bonds>.

PROMOTING BLUE CARBON SOLUTIONS TO MITIGATE CLIMATE CHANGE

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In 2015, Governor Jerry Brown proposed ambitious greenhouse gas reduction goals for the state of California and called for policies that would use the carbon storage ability of natural and working lands to help achieve those goals. In 2016 the California legislature reinforced this vision by passing Senate Bill 1386, which identifies the preservation and enhancement of natural carbon stores as a key strategy to reduce emissions.¹ In 2019 the state released the draft *2030 Natural and Working Lands Climate Change Implementation Plan*.² This plan sets out to double the pace and scale of wetland and seagrass conservation by 2030 and identifies a potential pathway to success.

On an areal basis, coastal vegetated habitats, such as wetlands and seagrass beds, hold some of the highest concentrations of organic carbon of any ecosystem on the planet and serve as globally important sinks for carbon.³ Because California is pursuing an integrated and multi-benefit approach to nature conservation, the state is prioritizing the conservation of these “blue carbon” habitats, which offer numerous co-benefits including increasing the capacity of coastal communities to withstand the impacts of storms and sea-level rise, providing critical nursery habitat for fishes, and improving water quality. Significant investments in wetland restoration are already underway in the San Joaquin Delta, for example, via the Wetlands Restoration for Greenhouse Gas Reduction Program.⁴

California is also exploring cutting-edge techniques to use natural habitats to mitigate the effects of ocean acidification. With the passage of SB 1363, the Ocean Acidification and Hypoxia Reduction Program, the Ocean Protection Council, in consultation with the California State Coastal Conservancy, was tasked with exploring how submerged aquatic vegetation (e.g., seagrass beds and kelp) might ameliorate ocean acidification and hypoxia locally through photosynthesis.⁵ The resulting report, *Emerging Understanding of the Potential Role of Seagrass and Kelp as an Ocean Acidification Management Tool in California*, is the first step toward developing local management strategies to reduce the risk of ocean acidification in select coastal habitats.⁶

Key Elements of Success

- Engagement of scientific experts, coastal partners, and leadership
- Education of policymakers on the specific attributes and benefits of a blue carbon approach

1 California Legislative Information, “SB-1386 Resource Conservation: Working and Natural Lands,” September 23, 2016, https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB1386.

2 California Environmental Protection Agency, California Natural Resources Agency, California Department of Food & Agriculture, California Air Resources Board, and California Strategic Growth Council, *2030 Natural and Working Lands Climate Change Implementation Plan*, January 2019 draft, <https://ww3.arb.ca.gov/cc/natandworkinglands/draft-nwl-ip-040419.pdf>.

3 Elizabeth Mcleod et al., “A Blueprint for Blue Carbon: Toward an Improved Understanding of the Role of Vegetated Coastal Habitats in Sequestering CO₂,” *Frontiers in Ecology and the Environment* 9, no. 10 (December 2011): 552-60, <https://doi.org/10.1890/110004>.

4 Wetlands Restoration and Greenhouse Gas Reduction Program Website, <https://www.wildlife.ca.gov/Conservation/Watersheds/Greenhouse-Gas-Reduction> (accessed November 24, 2019).

5 California Legislative Information, “SB-1363 Ocean Protection Council: Ocean Acidification and Hypoxia Reduction Program,” September 2016, https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160SB1363.

6 Karina Nielsen et al., *Emerging Understanding of Seagrass and Kelp as an Ocean Acidification Management Tool in California*, Ocean Protection Council and California Ocean Science Trust, January 2018, <http://www.oceansciencetrust.org/wp-content/uploads/2018/01/OA-SAV-emerging-findings-report-1.30.18.pdf>.

MARINE RENEWABLE ENERGY: FOSTERING OFFSHORE WIND DEVELOPMENT THROUGH MULTIAGENCY INITIATIVES

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California’s renewable energy legislation—the California Global Warming Solutions Act—became law in 2006. Spurred by California’s ambitious renewable energy targets, state agencies began to evaluate how they could harness offshore winds and waves to produce marine renewable energy alongside land-based renewables.¹ By 2018, with legislation requiring California to transition to 100 percent renewable energy by December 31, 2045, commercial and state interest in offshore wind development in California has increased greatly.² Today the California Energy Commission (CEC) leads the state’s offshore wind efforts, and the Ocean Protection Council (OPC) works to ensure that any offshore wind development minimizes impacts to marine life, fisheries, and cultural resources.

In 2010, OPC established the California Marine Renewable Energy Working Group (CMREWG). The CMREWG is comprised of state agencies working to improve regulatory coordination among state and federal agencies with jurisdiction relevant to marine renewable energy.³ In addition to addressing regulatory issues around offshore wind development, the working group is currently identifying and prioritizing information, research, and planning needs for permitting offshore wind energy projects.⁴

In 2016 then governor Jerry Brown requested that the secretary of the U.S. Department of the Interior establish a marine renewable energy task force, primarily in response to a proposal by Trident Winds LLC to build a 765-megawatt wind farm on the Outer Continental Shelf.⁵ The request was granted. California's Intergovernmental Renewable Energy Task Force (RE Task Force), is a partnership of federal, state, tribal, and local governments that is jointly led by the CEC and the Bureau of Ocean Energy Management (BOEM). The RE Task Force is a forum where members can offer critical information to inform planning efforts, raise concerns, share data, and identify information gaps.⁶ California's RE Task Force positions California to better influence BOEM's Outer Continental Shelf leasing decisions.

OPC is providing funding for a variety of studies, including an offshore wind feasibility analysis for Northern California, a synthesis of relevant environmental data for Central and Northern California, and an assessment of jobs that offshore wind could provide the state.⁷

Key Elements of Success

- Creation of a California Intergovernmental Renewable Energy Task Force with federal, state, and tribal government participation to foster collaboration at all levels of government
- Legislation to set robust renewables and emissions reductions targets
- State leadership with money to invest in environmental data collection, development of monitoring technology, and marine renewable energy technology research
- Government-funding for research institutions to undertake needed studies

Jurisdictions that are contemplating advancing marine renewables should consider how existing or new policies might drive development of marine renewables, how to create leadership necessary to drive working group and task force products, how jurisdictions can partner with research institutions to acquire information needed to make decisions, and how to engage all parties in the process.

- 1 H. T. Harvey & Associates, "Developing Wave Energy in Coastal California: Potential Socio-Economic and Environmental Effects," report prepared for California Energy Commission Public Interest Energy Research Program and California Ocean Protection Council, November 2008, <https://ww2.energy.ca.gov/2008publications/CEC-500-2008-083/CEC-500-2008-083.PDF>.
- 2 Bureau of Ocean Energy Management (hereinafter BOEM), "Nominations," <https://www.boem.gov/Nominations/>, (accessed November 18, 2019).
- 3 California Natural Resources Agency, "Memorandum of Understanding Between the Federal Energy Regulatory Commission and the California Natural Resources Agency, the California Environmental Protection Agency and the California Public Utilities Commission Regarding Coordinated Review of Hydrokinetic Facility Authorizations in Marine Waters Within the State of California," May, 4, 2010, http://www.opc.ca.gov/webmaster/ftp/project_pages/energy/FERC_CA_MOU_05_17_2010.pdf.
- 4 California Natural Resources Agency, "California Marine Renewable Energy Working Group," <http://www.opc.ca.gov/2010/05/offshore-wave-energy-development/>, (accessed November 18, 2019).
- 5 BOEM, "BOEM and State of California Launch California Offshore Renewable Energy Task Force: Meeting Initiates Planning for Ocean Renewable Energy Opportunities off California," October 13, 2016, <https://www.boem.gov/press10132016/>.
- 6 BOEM, "California Offshore Renewable Energy: BOEM California Intergovernmental Renewable Energy Task Force," February 22, 2017, <https://www.boem.gov/BOEM-Offshore-Renewables-Factsheet/>.
- 7 California Natural Resources Agency, "All Projects," <http://www.opc.ca.gov/all-projects/>, (accessed November 18, 2019).

REQUIRING CARGO SHIPS TO USE SHORESIDE POWER

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California ports handle more than 40 percent of all inbound cargo containers to the entire United States.¹ Local pollution from port emissions presents a significant air quality concern for communities because of the host of health problems to which these emissions are linked.² Pressure and litigation from communities to clean up the air led California ports to consider options to reduce port pollution. The California Air Resources Board (CARB) evaluated cold ironing—that is, having ships plug into shore power—at various ports in 2006. In its analysis, CARB estimated that ship emissions would triple by 2020 under business as usual.³ But if modified dockside facilities could allow vessels to use shoreside power, diesel particulate matter (PM) and nitrogen oxides (NOx) emissions would decrease by 95 percent and CO₂ emissions would decrease by 22 to 38 percent.⁴

In the late 2000s, the ports began implementing cold ironing options.⁵ In 2007 CARB adopted the At-Berth Regulation, applicable to the Ports of Los Angeles, Long Beach, Oakland, San Diego, San Francisco, and Hueneme.⁶ The policy provides two options of compliance: either turning off the vessel's engine and connecting to shore power, or using alternative technology that reduces emissions to the same levels as cold ironing. The regulation sets a phase-in compliance schedule with rates and dates detailing the changing requirements over time.⁷ Phase-in began with a goal of 50 percent emissions reduction by 2014 and ramps up to a final goal of 80 percent emissions reduction by 2020. To encourage early compliance, CARB created financial incentives through state grant funding. These changes have reduced the public health risk to neighboring communities and reduced regional emissions.⁸

To enforce the At-Berth Regulation, enforcement staff conducts audits of vessel fleets. For example, CARB conducted 128 fleet audits from 2014 to 2016, reviewing more than 12,000 vessel port visits.⁹ CARB has reported that, on average, ports in California have achieved their targets, with a 51 percent reduction of onboard auxiliary engine power use while at berth in 2015 and a 63 percent reduction in 2016.¹⁰ In 2016, simply by using electricity instead of diesel while at berth, fleets reduced NOx emissions by 4.3 tons per day and PM emissions by 0.066 tons per day.¹¹ CARB also estimates this policy reduces CO₂ emissions in California by 0.5 million metric tons annually.¹²

Key Elements of Success

- Persistent pressure from stakeholders to reduce port emissions and leadership to address environmental justice issues in near-port communities
- Financial incentives for early adopters of the At-Berth Regulation

Jurisdictions considering a cold-ironing regulation should keep in mind that California, beyond just creating a regulation, funded the early adoption of shore power and ship technology.

- 1 Jon D. Haveman and David Hummels, “California’s Global Gateways: Trends and Issues,” (San Francisco, Public Policy Research Institute, 2004), vi.
- 2 California Air Resources Board, “Fact Sheet: Maritime Ports and Air Quality,” November 2004, <https://ww3.arb.ca.gov/ports/marinevess/documents/portfs111804.pdf>.
- 3 California Environmental Protection Agency, Air Resources Board, “Final Emission Reduction Plan for Ports and Goods Movement in California,” (April 20, 2006): 113-114, https://www.arb.ca.gov/planning/gmerp/plan/final_plan.pdf#page=138.
- 4 California Environmental Protection Agency, Air Resources Board, Stationary Source Division Project Assessment Branch, “Evaluation of Cold-Ironing Ocean-Going Vessels at California Ports,” March 2009, <https://ww3.arb.ca.gov/ports/marinevess/documents/coldironing0306/execsum.pdf>.
- 5 Ibid.
- 6 California Air Resources Board, “Shore Power for Ocean-going Vessels,” <https://ww3.arb.ca.gov/ports/shorepower/shorepower.htm> (accessed November 13, 2019).
- 7 California Air Resources Board, “2018 Annual Enforcement Report,” June 2019, <https://ww2.arb.ca.gov/sites/default/files/2019-06/Enforcement%20Report%202018.pdf>.
- 8 San Pedro Bay Ports, “Clean Air Action Plan,” November 2017, https://www.lacity.org/sites/g/files/wph1196/f/final-2017-clean-air-action-plan-update_0.pdf.
- 9 California Air Resources Board, “2017 Annual Enforcement Report,” June 2018, https://ww3.arb.ca.gov/enf/reports/2017_enf_annual_report.pdf.
- 10 Ibid.
- 11 Ibid.
- 12 Ibid.

CLEANER FUEL IN OCEAN-GOING VESSELS

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The Fuel Sulfur Regulation, officially titled, “Fuel Sulfur and Other Operational Requirements for Ocean-Going Vessels (OGVs) within California Waters and 24 Nautical Miles of the California Baseline,” requires ships to transition to cleaner fuels before coming within 24 nautical miles (nm) of the California coast.¹

Despite opposition from the shipping industry, the California Environmental Protection Agency (CalEPA) and then governor Arnold Schwarzenegger advocated for the reduction of diesel pollution by requiring OGVs to burn cleaner fuel.² In 2007, the state approved a two-phase policy to limit sulfur; however, after 14 months of successful implementation, the regulation was suspended due to a lawsuit brought by its opponents. A federal District Court ruled that the policy was preempted by the federal Clean Air Act; therefore California would need authorization from the U.S. EPA to enforce its separate emissions standards.³ At the same time, the Ports of Los Angeles and Long Beach played an active role in addressing shipping companies’ concerns about transitioning to lower-sulfur fuel. In 2008 the Ports launched a one-year program to pay the differential between the dirtier fuel and the low-sulfur fuel, saving the shipping companies money and incentivizing them to make the switch.⁴ Maersk also provided proof of concept for other shippers by testing the lower-sulfur fuels.⁵

In 2008 the state pursued a new fuel sulfur regulation that would bypass the Clean Air Act by focusing on “use and operational requirements” instead of an “emissions limit.”⁶

Still, in 2011, the California Air Resources Board (CARB) found that many vessel operators avoided the added expense of the cleaner fuel by rerouting through parts of the ocean outside the regulation boundary. Ultimately the adjustment in these travel patterns resulted in increased emissions. To address this issue, in 2011 CARB amended the policy’s regulatory boundary to better capture traffic.⁷

California is now the world leader in enforcing marine fuel sulfur regulations. In 2017, 324 inspections were done; all but 10 ships met the 0.1 percent sulfur standard, for a compliance rate of 97 percent. The 10 failures were assessed \$87,500 in penalties.⁸

CARB has investigated alternative methods of compliance that may further reduce emissions. As of 2017, it began offering a research exemption to OGVs that agree to test an exhaust treatment device or other technology while using noncompliant fuel.⁹ This temporary exemption encourages technological exploration by shipping lines to further reduce emissions of their own accord.

Key Elements of Success

- Political leadership and funding to offer a proof of concept before the regulation went into effect
- Penalties are set so it is cheaper to comply than to pay the fines

Jurisdictions should be aware that vessels may attempt to change routes to avoid fuel switching and therefore increase emissions. Policymakers should also factor in a way for the regulatory zone to change, to allow for the possibility that shipping lanes could change.

- 1 California Air Resources Board, 13 CCR, section 2299.2. Fuel Sulfur and Other Operational Requirements for Ocean-going Vessels within California Waters and 24 Nautical Miles of the California Baseline, <https://ww3.arb.ca.gov/regact/2008/fuelogv08/frol3.pdf>.
- 2 California Air Resources Board, "2017 Annual Enforcement Report," June 2018, https://www.arb.ca.gov/enf/reports/2017_enf_annual_report.pdf.
- 3 Barry M. Hartman et al., "Ninth Circuit Holds That California's 'Marine Vessel Rules' Are Preempted by Federal Clean Air Act," K & L Gates, March 6, 2008, <http://www.klgates.com/ninth-circuit-holds-that-californias-marine-vessel-rules-are-preempted-by-federal-clean-air-act-03-06-2008/>.
- 4 Port of Long Beach, "Vessel Fuel Incentive Program Launched," July 2008, <http://www.polb.com/news/displaynews.asp?NewsID=401&TargetID=16>.
- 5 Maersk Line, "Pilot Fuel Switch Initiative," in *Maersk and APMT Environmental Initiatives*, June 18, 2008, <https://www.northeastdiesel.org/pdf/workgroup/MaerskFuelSwitchAPMTNEDC.pdf>.
- 6 California Air Resources Board (hereinafter CARB), Stationary Source Division Project Assessment Branch, "Initial Statement of Reasons for Proposed Rulemaking: Fuel Sulfur and Other Operational Requirements for Ocean-Going Vessels Within California Waters and 24 Nautical Miles of the California Baseline," June 2008, <https://www.arb.ca.gov/regact/2008/fuelogv08/ISORfuelogv08.pdf>.
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- 8 CARB, "2017 Annual Enforcement Report."
- 9 CARB, Marine Notice 2017-1, "Advisory to Owners or Operators of Ocean-Going Vessels Visiting California Ports: Guidance for the Use of the Temporary Experimental or Research Exemption in the California Ocean-Going Vessel Fuel Regulation," August 2017, https://www.arb.ca.gov/ports/marinevess/documents/marinenote2017_1.pdf.

VOLUNTARY VESSEL SPEED REDUCTION PROGRAM

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A voluntary Vessel Speed Reduction Program (VSRP) incentivizes ocean-going vessels to slow down while coming into California seaports in order to reduce emissions of climate pollutants. Ships participating in the VSRP have the option to reduce their speed at either 40 nautical miles (nm) or 20 nm from shore.¹ The first program of this kind in California stemmed from growing concerns about air pollution in areas surrounding California's ports, particularly in the South Coast Air Basin.

A broader action plan to bring the air basin into compliance with California's quality air standards first focused on reducing nitrous oxide (NOx) emissions from ocean-going vessels entering and leaving California's ports.² It was then that the California Air Resources Board (CARB) and the U.S. Environmental Protection Agency (EPA) noticed reductions in NOx emissions when ocean-going vessels slowed for safety purposes when entering ports. When vessel speed was reduced from 24 knots to 12 knots, NOx emissions dropped by as much as 56 percent.³

In 2001 the EPA, CARB, the Port of Los Angeles (POLA), the Port of Long Beach (POLB), shipping industry representatives, and the U.S. Navy entered into a memorandum of understanding outlining the first VSRP in California. The initial memorandum expired in 2004, but the POLA and the POLB have modified the VSRP to further reduce emissions and encourage voluntary participation with financial incentives.⁴ The POLA attributes much of its success in reducing vessel pollution to the VSRP strategy.

Although the desire to reduce NOx emissions drove the initial policy, the program has brought about other clean air and climate benefits.⁵ Between 2005 and 2016, by implementing the VSRP and additional air quality improvement measures for ocean-going vessels, the POLA cut NOx emissions by 40 percent, diesel particulate matter emissions by 90 percent, sulfur oxide emissions by 98 percent, and greenhouse gas emissions from ocean-going vessels by 28 percent.⁶ In 2018 the POLA found that 91 percent of the more than 3,000 ocean-going vessels entering and leaving the harbor were slowing within a 20 nm distance, and 85 percent within 40 nm.⁷

The Ports of San Diego, San Francisco Bay, and the Santa Barbara Channel region have since adopted VSRPs to reduce air pollution and protect whale populations in the area.

Key Elements of Success

- Creating a voluntary program with financial incentives rather than a mandate, to reduce pushback from the shipping industry
- Providing proper incentives, realistic guidelines, and appropriate speed-tracking systems for program implementation

1 Port of Los Angeles, “Vessel Speed Reduction Program,” <https://www.portoflosangeles.org/environment/air-quality/vessel-speed-reduction-program>, (accessed November 8, 2019).

2 U.S. Environmental Protection Agency, Air and Radiation, Environmental Fact Sheet, “Reducing Marine Vessel and Port Emissions in the South Coast,” July 1996, <https://nepis.epa.gov/Exe/ZyPDF.cgi/P100B3GG.PDF?Dockey=P100B3GG.PDF>.

3 J. Wayne Miller et al., “In-use Emissions Test Program at VSR Speeds for Oceangoing Container Ship,” June 2012, <https://ww3.arb.ca.gov/ports/marinevess/vsr/docs/vsr.pdf>.

4 San Pedro Ports, *Clean Air Action Plan 2017: Final Clean Air Action Plan Update*, November 2017, <http://www.cleanairactionplan.org/documents/final-2017-clean-air-action-plan-update.pdf/>.

5 Slowing an ocean-going vessel from 24 knots to 12 knots results in a CO₂ emissions reduction of approximately 60 percent. This also reduces sulfur oxide (SOx) and diesel particulate matter (diesel PM) emissions. See J. Wayne Miller et al. “In-Use Emissions Test Program at VSR Speeds for Oceangoing Container Ship,” prepared for California Air Resources Board, June 2012, <https://ww3.arb.ca.gov/ports/marinevess/vsr/docs/vsr.pdf>.

6 Starcrest Consulting Group, LLC, “Port of Los Angeles Inventory of Air Emissions—2015,” prepared for the Port of Los Angeles, July 2016, https://kentico.portoflosangeles.org/getmedia/dfa9ca66-0f23-40ce-9430-6e95440f8de2/2015_Air_Emissions_Inventory.

7 Port of Los Angeles, “Vessel Speed Reduction Summary Report—2018,” 2018. <https://kentico.portoflosangeles.org/getmedia/5ec34b92-1f9c-4d3c-8c07-bbec7857974/VSR-01-01-2018-to-12-31-2018-Operator-Summary>, (accessed November 25, 2019).

ADOPTING A STATEWIDE CLIMATE ADAPTATION STRATEGY

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Spurred by California’s first climate change assessment, a 2008 executive order directed state officials to develop a statewide adaptation strategy.¹ The Safeguarding California Plan outlines adaptation goals across sectors including ocean and coastal resources.² Subsequently, a 2015 executive order required that the plan be updated every three years.³ The state released its most recent assessment (its fourth) in 2018.⁴

During the initial yearlong planning process in 2009, the California Natural Resources Agency coordinated with 10 other state agencies; scientists; a consulting team; local, regional, and federal government entities; and public stakeholders to develop and adopt the first statewide, multi-sector adaptation strategy in the United States.⁵ This process has only expanded since then, with current engagement even broader, more inclusive, and more coordinated; the ocean and coastal section of the 2018 plan alone has contributions from a dozen state agencies.⁶

California’s adaptation plan is not a regulation of nonstate entities. Instead it is a directive to state agencies to complete recommended adaptation actions relevant to each agency’s existing mission and mandates; it outlines ongoing actions and identifies next steps.

Key Elements of Success

- Leadership from the governor, who directed state agencies to coordinate to address climate impacts within their respective sectors
- Significant existing resources, including California’s climate change assessments and experts, that allowed the state to focus on solutions to known impacts
- Codification and funding to ensure implementation over the long term

A jurisdiction weighing a comprehensive adaptation plan might consider how to first understand the climate change impacts unique to its jurisdiction; how adaptation efforts will complement mitigation efforts to increase resiliency; how to rally existing leadership and efforts and take advantage of infrastructure and legal mechanisms to implement recommended actions; and how it might fund implementation, including on-the-ground projects.

- 1 California Executive Order S-18-08, <http://www.climatestrategies.us/library/library/view/293> (accessed November 14, 2019). The first climate change assessment detailed climate impacts to California. Dan Cayan et al., *Scenarios of Climate Change in California: An Overview*, California Climate Change Center, 2006, <https://ww2.energy.ca.gov/2005publications/CEC-500-2005-186/CEC-500-2005-186-SF.PDF>, with further resources including appendices available at https://www.climatechange.ca.gov/climate_action_team/reports/first_assessment.html. The initial AB 32 Scoping Plan outlined the state’s climate change mitigation measures. California Air Resources Board, *Climate Change Scoping Plan: A Framework for Change*, 2006, https://ww3.arb.ca.gov/cc/scopingplan/document/adopted_scoping_plan.pdf.
- 2 Sectors include public health; biodiversity and habitat; oceans and coastal resources; water; agriculture; forestry; transportation; parks, recreation, and California culture; climate justice; land use and community development; emergency management; and energy.
- 3 California Executive Order B-30-15, <https://www.ca.gov/archive/gov39/2015/04/29/news18938/> (accessed November 25, 2019).
- 4 California Natural Resources Agency (hereinafter CNRA), *Safeguarding California Plan: 2018 Update, California’s Climate Adaptation Strategy*, January 2018, <http://resources.ca.gov/docs/climate/safeguarding/update2018/safeguarding-california-plan-2018-update.pdf>.
- 5 CNRA staff worked with other state resource management agencies to create seven sector-based Climate Adaptation Working Groups (CAWGs) made up of experts who focused on the following areas: public health, ocean and coastal resources, water supply and flood protection, agriculture, forestry, biodiversity and habitat, and transportation and energy infrastructure. To help ensure stakeholder participation, the CAWGs initiated a process that allowed for consultation with stakeholders through public workshops and review opportunities. See: CNRA, *2009 California Climate Adaptation Strategy: A Report to the Governor of the State of California in Response to Executive Order S-13-2008*, 2009, http://resources.ca.gov/docs/climate/Statewide_Adaptation_Strategy.pdf.
- 6 See *Safeguarding California Plan: 2018 Update*, p. 16, for a timeline and highlights of California’s adaptation planning.

CREATING MARINE PROTECTED AREAS

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California's marine ecosystems are facing multiple, simultaneous climate change impacts, including ocean acidification, hypoxia, marine heat waves, and disrupted patterns of seasonal upwelling.¹ These large-scale effects, combined with the more immediate and local stresses of overfishing and land-based pollution, are putting the resilience of California's marine ecosystems at risk. Effectively managed Marine Protected Areas (MPAs) can help restore ecosystems and increase their ability to withstand the stresses of climate change and ocean acidification.²

Since the early 1900s, California has used MPAs as a tool to preserve especially beautiful and biologically diverse locations along its coast. However, in 1999 the California Legislature identified the need to increase the state's effectiveness in protecting marine life, habitats, and ecosystems and passed the Marine Life Protection Act.³ This legislation mandated that the state Fish and Game Commission and the California Department of Fish and Wildlife use the latest science to redesign and expand the state's existing system of MPAs into a network that protects marine ecosystems and California's natural heritage and provides improved recreational and educational opportunities. The law also required the state agencies to ensure effective MPA management and enforcement.

From 2004 to 2010, the state worked with a nonprofit organization, the Resources Legacy Fund, to develop a public-private implementation model called the Marine Life Protection Act Initiative.⁴ The initiative relied in part on private funding from a philanthropic partner in addition to state funding, pursued a phased approach to MPA design based on four coastal

subregions, developed regional stakeholder groups, convened a Blue Ribbon Task Force composed of public policy experts to oversee MPA design and evaluation, and created regional science advisory teams to support MPA design. The process resulted in a network of 124 MPAs on the coast from the Mexican border to Oregon, covering slightly more than 16 percent of the state's waters.⁵

In 2014 the California Ocean Protection Council (OPC) was designated as the state's MPA policy lead. In that role, OPC convenes a statewide MPA leadership team composed of members of 15 organizations representing state and federal government, California and Federal Indian tribes, local community experts, and philanthropies that work together to implement the state's collaboratively developed MPA Management Program. The program, designed to facilitate adaptive management, emphasizes four major priorities: outreach and education, enforcement and compliance, research and monitoring, and policy and permitting.⁶ Initial monitoring of the network shows signs of success with larger and more numerous fish, especially in long established MPAs.⁷

Key Elements of Success

- A strong directive in the law
- A robust stakeholder engagement component
- Science guidelines that outlined criteria for MPA design to maximize ecosystem benefits
- Significant funds to launch the effort and ongoing funding to ensure management and enforcement
- Regional monitoring and management plans based on partnerships across government, nongovernmental organizations, California and Federal Indian tribes, and others

1 Hans O. Pörtner et al., *Special Report on the Ocean and Cryosphere in a Changing Climate*, Intergovernmental Panel on Climate Change, 2019, <https://www.ipcc.ch/srocc/home/>. California Natural Resources Agency, *California Climate Adaptation Strategy: A Report to the Governor of the State of California in Response to Executive Order S-13-2008*, 2009, http://resources.ca.gov/docs/climate/Statewide_Adaptation_Strategy.pdf.

2 Joanna R. Bernhardt and Heather M. Leslie, "Resilience to Climate Change in Coastal Marine Ecosystems," *Annual Review of Marine Science* 5 (January 2013): 371-92, doi: 10.1146/annurev-marine-121211-172411.

3 California Legislative Information, Marine Life Protection Act, 1999, http://leginfo.legislature.ca.gov/faces/codes_displayText.xhtml?lawCode=FGC&division=3.&title=&part=&chapter=10.5.&article=, (accessed November 25, 2019).

4 Resources Legacy Fund Foundation, *Securing California's Ocean Legacy*, 2013, http://www.resourceslegacyfund.org/wp-content/uploads/Securing_Californias_Ocean_Legacy_Final.pdf.

5 Ibid.

6 California Department of Fish and Wildlife, *California Marine Life Protection Act Master Plan for Marine Protected Areas*, adopted by the California Fish and Game Commission on August 24, 2016, www.wildlife.ca.gov/Conservation/Marine/MPAs/Master-Plan.

7 Samantha Murray and Tyler T. Hee, "A Rising Tide: California's Ongoing Commitment to Monitoring, Managing and Enforcing Its Marine Protected Areas," *Ocean & Coastal Management* 182 (December 2019), <https://doi.org/10.1016/j.ocecoaman.2019.104920>.

PREPARING FOR SEA LEVEL RISE

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Sea level rise (SLR) poses a large threat to California’s economy, infrastructure, and natural resources. Recognizing this, Governor Arnold Schwarzenegger in 2008 required state agencies to coordinate a plan to adapt to SLR.¹ In response, state agencies produced the first California SLR guidance in 2010, requiring state agencies to support the development of best-available SLR projections, and rely on these projections in their decision-making processes.²

The United Nations Intergovernmental Panel on Climate Change report issued in 2014 warned that at least some amount of sea level rise would be unavoidable.³ Drawing from the call to action in that report, in 2015 then governor Jerry Brown established new interim statewide greenhouse gas reduction goals and ordered state agencies to factor climate change into their planning and investment decisions.⁴ That same year the legislature passed SB 379, a bill that required local governments to incorporate climate adaptation and resiliency strategies into the safety element of their general plans, as well as SB 246, which created the Integrated Climate Adaptation and Resiliency Program to coordinate local and state adaptation strategies.⁵

SB 379 requires local governments to conduct a vulnerability assessment of climate change risks, set adaptation and resilience goals based on that assessment, and design an implementation process to achieve the adaptation goals.⁶ With the passage of SB 379, new direction from the governor, and increased scientific understanding of SLR, the Ocean Protection Council released a 2018 update to the state’s SLR guidance. The update included revised SLR projections, a step-by-step approach for state agencies and local governments to use in integrating those projections into risk analyses and planning, and recommended adaptation strategies.^{7,8}

Key Elements of Success

- Dedicated state agencies
- Access to scientific research, data, and information
- Commitment to updating guidance and adaptation recommendations based on the best available science.
- Funding mechanisms available at the state and local levels to support SLR adaptation work

A jurisdiction weighing how to best prepare for SLR might consider the unique hazards that SLR presents to its population and resources, seek to understand what role leadership might play in coordinating cross-sector efforts, develop a suite of tools to assist local governments in their planning efforts, provide access to best-available science and require it as a basis for decision making, and identify funds or funding mechanisms to allow ongoing support for research and on-the-ground projects that address SLR.

- 1 Adaptation Clearinghouse, “California Executive Order S-13-08 Requiring State Adaptation Strategy, November 2008, <https://www.adaptationclearinghouse.org/resources/california-executive-order-s-13-08-requiring-state-adaptation-strategy.html>. Other evidence included the United Nations Intergovernmental Panel on Climate Change (hereinafter IPCC) 2007 Fourth Assessment Report estimating the global impacts of climate change, and a University of California, Berkeley economic report showing California could suffer tens of billions of dollars in damage if the state did not take action against climate change. IPCC, *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, R. K. Pachauri and A. Reisinger, eds., 2007, <https://www.ipcc.ch/report/ar4/syr/>. David Roland-Holst and Fredrich Kahr, “California Climate Risk and Response,” Executive Summary, November 2008, https://are.berkeley.edu/~dwrh/CERES_Web/Docs/ClimateRiskandResponse_ES.pdf.
- 2 State of California, “State of California Sea-Level Rise Interim Guidance Document,” October 2010, http://opc.ca.gov/webmaster/ftp/pdf/agenda_items/20110311/12.SLR_Resolution/SLR-Guidance-Document.pdf.
- 3 IPCC, *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, R. K. Pachauri and L. A. Meyer, eds., 2015, https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf.
- 4 California Executive Order B-30-15 established “a new interim statewide greenhouse gas emission reduction target to reduce greenhouse gas emissions to 40 percent below 1990 levels by 2030 . . . in order to ensure California meets its target of reducing greenhouse gas emissions to 80 percent below 1990 levels by 2050.” California Executive Order B-30-15, April 2015, <https://www.ca.gov/archive/gov39/2015/04/29/news18938/>.
- 5 California SB 379, 2015, https://leginfo.Legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160SB379, California Legislative Information, “California SB 246 Climate Change Adaptation,” October 2015, http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB246.
- 6 The policy aligns the deadline for adoption with the revision timeline of the local general plans. Local governments with existing climate adaptation goals are able to summarize and reference these in the safety element of the general plan instead of designing a new plan.
- 7 There are two types of approaches to SLR projection research: scenario-based projections and probabilistic projections. Scenario-based SLR projections create a range of possible outcomes estimated using different greenhouse gas emissions scenarios but do not analyze the likelihood of the various outcomes. The IPCC AR5 report (2015) created probabilistic SLR projections, which estimate the likelihood of several SLR futures; the report also introduced new ice melt simulations. Although California updated its statewide SLR guidance document in 2013, the 2013 plan relied on scenario-based SLR projections. Many scientists favored the probabilistic SLR projections in IPCC AR5, and OPC has now established this as the norm. The updated SLR guidance document was created in collaboration by the Ocean Protection Council, California Natural Resources Agency, Governor’s Office of Planning and Research, and California Ocean Science Trust. See Gary Griggs et al. (California Ocean Protection Council Science Advisory Team Working Group), *Rising Seas in California: An Update on Sea-Level Rise Science*, California Ocean Science Trust, April 2017, http://www.oceansciencetrust.org/wp-content/uploads/2017/04/OST-Sea-Level-Rising-Report-Final_Amended.pdf.
- 8 Note that the state also has several interagency workgroups and initiatives, including the Coastal and Ocean Resources Working Group for the Climate Action Team, the State Coastal Leadership Group on Sea-Level Rise, and the California Collaborative on Coastal Resilience.

ADDRESSING THE THREAT OF OCEAN ACIDIFICATION AND HYPOXIA

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In 2007 the U.S. West Coast shellfish industry noticed a dramatic increase in oyster larva mortality in commercial hatcheries. The shellfish growers joined forces with government and academic scientists and determined that the larval die-offs occurred when the seawater flowing into aquaculture facilities had low pH and carbonate availability, indicating that ocean acidification was the culprit.¹ This was later verified with meticulous collaborative research.

Ocean acidification (OA) is the progressive change in ocean chemistry as excess carbon dioxide from the burning of fossil fuels dissolves into the sea, forming an acid. The California Current is naturally more acidic and lower in oxygen (i.e., more hypoxic) than most ocean surface waters because seasonal upwelling brings CO₂-enriched waters to the surface. These natural conditions make California's waters particularly vulnerable to climate-driven ocean acidification and hypoxia (OAH).²

Recognizing the risk that ocean acidification poses to their industry, shellfish growers created alliances with West Coast scientists to accelerate their understanding of the threat and to communicate concerns to government officials. In 2010 a grassroots network of industry stakeholders and researchers developed the California Current Acidification Network.³

In 2012 the governor of Washington, Christine Gregoire, created the Washington State Blue Ribbon Panel on Ocean Acidification, the first of its kind in the nation.⁴ Soon afterward, the California Ocean Protection Council recognized the need for a regional examination of OA and of climate-driven expansion of low-oxygen zones. The council asked California's Ocean Science Trust to assemble the West Coast Ocean Acidification & Hypoxia Science Panel in partnership with Oregon, Washington, and British Columbia.

Over two years, the panel of 20 leading scientists developed and released a series of reports, culminating in its *Major Findings, Recommendations, and Actions*.⁵ In 2016, in response to the panel's recommendations, the California Legislature passed two bills, one establishing an Ocean Acidification Science Task Force (AB 2139) and the other creating an Ocean Acidification and Hypoxia Reduction Program (SB 1363).⁶

The Ocean Acidification and Hypoxia Science Task Force is an interdisciplinary team of scientists from West Coast institutions that is tasked with ensuring that the state's OA and Hypoxia Reduction Program is based on the best available science. In 2018 an Ocean Acidification Action Plan was adopted, outlining a 10-year vision for addressing ocean acidification in California's waters and a series of pragmatic actions to work toward that vision.⁷ Implementation priorities for the next five years include developing a monitoring system with publicly accessible data; mitigating CO₂ emissions and reducing nutrient pollution that can exacerbate OA locally; and mitigating aquatic CO₂ by preserving seagrass meadows, salt marshes, and kelp forests.

California's work on OA and hypoxia has been facilitated and strengthened by the Pacific Coast Collaborative, a network of West Coast governance jurisdictions that are working together to build a low-carbon economy. As an early member of its West Coast OAH Monitoring Network, California has contributed to and benefited from its system-wide assessment and design of monitoring assets. Similarly, California was a co-founding member of the International Alliance to Combat Ocean Acidification. This global alliance of more than 70 members shares information on local actions that can be taken to reduce the threat of ocean acidification to industry and the environment.

Key Elements of Success

- Regional collaboration, particularly a network that provides leadership, support, shared resources, and data collaboration and ensures that solutions are broadly effective
- Ongoing funding to support scientific research and plan implementation
- Communicating—to legislators, state agencies, ocean users, and the public—the negative effects of acidification on state tourism and shellfish economies

- 1 Alan Barton et al., "Impacts of Coastal Acidification on the Pacific Northwest Shellfish Industry and Adaptation Strategies Implemented in Response," *Oceanography* 28, no. 2 (2015): 146-159, <http://dx.doi.org/10.5670/oceanog.2015.38>.
- 2 Richard Feely et al., "Evidence for Upwelling of Corrosive 'Acidified' Water Onto the Continental Shelf," *Science* 320, no. 1 (2008): 490-492, <http://dx.doi.org/10.1126/science.1155676>.
- 3 California Current Acidification Network, "Mission" page, <https://c-can.info/>, (accessed November 25, 2019).
- 4 Washington State Blue Ribbon Panel on Ocean Acidification, *Ocean Acidification: From Knowledge to Action, Washington State's Strategic Response*, H. Adelsman and L. Whitely Binder (eds.), Washington Department of Ecology, Publication no. 12-01-015, November 2012, <https://fortress.wa.gov/ecy/publications/documents/1201015.pdf>.
- 5 Francis Chan et al., *The West Coast Ocean Acidification and Hypoxia Science Panel: Major Findings, Recommendations, and Actions*. California Ocean Science Trust, April 2016. <http://westcoastoah.org/wp-content/uploads/2016/04/OAH-Panel-Key-Findings-Recommendations-and-Actions-4.4.16-FINAL.pdf>.
- 6 California Legislative Information, "AB-2139 Ocean Protection Council, Ocean Acidification and Hypoxia," September 2016, https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160AB2139. California Legislative Information, "SB-1363 Ocean Protection Council: Ocean Acidification and Hypoxia Reduction Program," September 2016, https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB1363.
- 7 Ocean Protection Council, *The State of California Ocean Acidification Action Plan*, 2018. http://www.opc.ca.gov/webmaster/_media_library/2018/10/California-OA-Action-Plan-Final.pdf.

ADAPTING FISHERIES MANAGEMENT TO THE EFFECTS OF CLIMATE CHANGE

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California's fishery resources are heavily influenced by the dynamics of the California Current, which is believed to be changing as the result of climate change and ocean acidification. Scientists have observed and predict a continuation of warmer summer temperatures, altered patterns of upwelling, more frequent heat waves, more frequent episodes of low-oxygen and lower-pH waters, and an increase in harmful algal blooms in the California Current and other eastern boundary upwelling systems.¹ California fishermen are increasingly affected by these changes, as illustrated by recent closures in the Dungeness crab fishery due to harmful algal blooms.

The Climate Adaptation Strategy mandated by former governor Arnold Schwarzenegger in 2008 tasked the Coastal and Ocean Resources Working Group—comprised of senior staff from different agencies with marine and coastal resource management responsibilities—to identify management strategies that could address changing ocean conditions, including potential alternative approaches to fisheries management dependent upon temperature regimes, protections for stressed species, or changes to fishing practices under low pH conditions.²

In 2017, in response to growing concerns about the increasingly dramatic effects of climate change on marine ecosystems, the state assembled an expert scientific panel, a working group of the Ocean Protection Council Scientific Advisory Team (OPC-SAT), to examine what steps were needed to ready California's fisheries for climate change.³ The panel's findings were used by the California Department of Fish and Wildlife to inform the Marine Life Management Act Master Plan

revision. Several report recommendations were adopted in the amended Master Plan, including routinely addressing potential climate impacts in fishery management plans, conducting vulnerability assessments for affected fisheries and coastal communities, and increasing the use of management strategy evaluation in fisheries management to explicitly account for growing uncertainties.

Although the plan adopted recommendations from OPC's report, the state still needs to develop strategies and actions to implement them. This means California will need the best available scientific information and tools to create, improve, and enforce fishery management across the state.

Key Elements of Success

- Regional academic and government experts to engage in forward thinking about traditional fisheries management practices
- Routine review of the state's fisheries policy implementation to incorporate new solutions to the growing impacts of climate change

1 Hans-Otto Pörtner et al., *Special Report on the Ocean and Cryosphere in a Changing Climate*, Intergovernmental Panel on Climate Change, 2019, <https://www.ipcc.ch/srocc/home/>.

2 California Natural Resources Agency, *California Climate Adaptation Strategy: A Report to the Governor of the State of California in Response to Executive Order S-13-2008*, 2009, http://resources.ca.gov/docs/climate/Statewide_Adaptation_Strategy.pdf.

3 Francisco Chavez et al., *Readying California Fisheries for Climate Change*, Climate Change and Fisheries Working Group and Ocean Science Trust, 2019, http://www.oceansciencetrust.org/wp-content/uploads/2016/06/Climate-and-Fisheries_GuidanceDoc.pdf.

CONCLUSION

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To combat ocean-climate impacts, California is reducing greenhouse gas emissions, building resiliency, and planning ahead for unavoidable consequences. The state’s climate programs and policies have been holistically successful, not only safeguarding the environment but also bolstering the overall economy, enriching communities, improving public health, and creating jobs.

These accomplishments were built on a strong foundation of science, with state leadership and investment, and alongside partners who shared the goal of continuously learning, improving, and sharing information to meet the unprecedented challenge of climate change. California continues to expand and develop programs on the ocean-climate nexus.

Jurisdictions that are—or will soon be—facing ocean climate-driven impacts could learn from California’s example, using lessons gleaned from the state’s experiences as a starting point to address those challenges. This *Ocean-Climate Guide to Action* offers suggestions for beginning or augmenting this process. We hope it inspires further conversation and collaboration to protect the oceans that ultimately sustain us all.

For more information or additional references about solutions included in this guide, contact:

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