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Enabling and Limiting Conditions of Coastal Adaptation: Local Governments, Land Uses, and Legal Challenges

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ENABLING AND LIMITING CONDITIONS OF COASTAL ADAPTATION: LOCAL GOVERNMENTS, LAND USES, AND LEGAL CHALLENGES

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Rising seas combined with battering storms necessitate swift action from local governments charged with protecting their jurisdictions and constituents. Currently, there is a wealth of scientific data and predictive modeling information available to city planners and decision-makers, but there has been limited success in proactive coastal adaptation planning and implementation "on the ground." Furthermore, while many adaptation options for dealing with coastal changes have been identified, there remains a disconnect between many of these strategies and how they fit into an adaptation framework and long-term planning processes for specific areas, and how legally or politically feasible they are. Particularly, the potential legal hurdles and challenges to these strategies are often missing pieces of the coastal adaptation planning and implementation puzzle.

This article addresses these deficiencies in several ways. First, it provides a background of the climate science necessitating proactive and reactive coastal adaptation. Next, it explains the importance of place-based coastal adaptation decision-making and how certain conditions limit or enable the feasibility of respective adaptation strategies in certain locations. The article then turns to the strategies, organized into the following categories: (1) legal and regulatory; (2) engineered; and (3) financial. Next, the article identifies and evaluates several representative adaptation strategies, providing real-world examples of them as well as legal hurdles to their implementation and their respective advantages and disadvantages. Finally, it combines the foregoing into a pragmatic framework for future decision-making. This article focuses on coastal adaptation in California with the aim to develop transferable lessons for broader contexts.

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I. INTRODUCTION

Pacifica is a small coastal California town south of San Francisco. The area features surfing and other recreational opportunities for those seeking to escape the City's hustle and bustle. Yet the area has recently become infamous for an apartment complex on the brink of plummeting into the sea. The precarious complex was on a crumbling bluff, endangered after years of El Niño storms and King Tides. After the owner of the apartment complex declared bankruptcy, the city voted to spend money out of its discretionary fund to demolish the condemned buildings. Pacifica's story is emblematic of what might lie ahead for many of California's coastal properties if local governments do not pursue proactive planning to address rising seas, battering storms, and other erosive events.

California boasts almost 1300 miles of diverse coastline, featuring sandy beaches, rocky cliffs, bluffs, crags, and wild open ocean.[1] The coastline is constantly changing—waxing and waning—eroding here, forming new sand spits there. In this way, its coastline reflects the Earth's crust generally—subject to the whim of the cauldron shifting and roiling beneath its surface, as well as the wind, waves, and rivers sculpting above. Rising seas and a changing climate have exacerbated coastline changes. While humans have been adapting to changes in climate for millennia, the need to adapt has become even more important in the wake of accelerating sea level rise, increasing storm frequency and intensity, encroaching coastal development, and an expanding population using coastal resources than ever before. Adaptation's import will continue to grow as seas continue to rise and coastal flooding increasingly overtops critical coastal infrastructure. Undoubtedly, these changes will be problematic for coastal property owners seeking predictability, but also for government planners tasked with planning for a shifting coastline—an important role, ensuring thoughtful development options prevail, that waste is avoided, and that publicly valued locations are protected. Furthermore, as sea levels rise and coastal areas become more prone to damaging storms, flooding, and saltwater inundation, local governments will be thrust into the fray to act to protect citizens and their real estate.

Despite these challenges, local planners have tools at their disposal to assist with planning during these uncertain times. For instance, there is an expanding wealth of knowledge on predictive coastal vulnerability and sea level rise modeling available to decision-makers. Yet there remains a significant gap between this scientific information and implementation of local coastal adaptation policies. Specifically, many planners struggle with identifying or implementing appropriate measures to address increasing climate hazards given the uncertainty inherent in planning for the future. Moreover, additional uncertainty persists regarding the legal ramifications of enacting proactive coastal adaptation measures. Local governments are seeking guidance for proceeding in this unpredictable time. This article proposes an approach to link the best available climate science, spatial analysis methods, and coastal vulnerability modeling with coastal adaptation decision-making. It also identifies the legal ramifications associated with a variety of coastal adaptation strategies. Section I explains the science of climate change as well

[1] CAL. COASTAL COMM'N, COASTAL ACCESS PROGRAM—CALIFORNIA COASTAL ACCESS GUIDE, *available at* https://www.coastal.ca.gov/access/accessguide.html.

as the importance of adaptation and mitigation in addressing it. Section II explains how climate science can be linked to coastal adaptation, including existing adaptation planning and decision-making frameworks and the importance of a place-based focus in coastal adaptation decision-making. Section III introduces the importance of enabling and limiting conditions in pursuing place-based coastal adaptation decision-making. Next, Sections IV and V introduce specific adaptation strategies that coastal communities have begun to pursue and legal considerations relevant to the strategies. Finally, Section VI explains how to apply the frameworks identified in this article to specific coastal adaptation decision-making contexts. This article aims to provide demonstrative examples of coastal adaptation strategies and barriers to their implementation in California, with the hopes that these lessons can also inform coastal adaptation beyond the Golden State.

II. BACKGROUND

A. *Science of Climate Change*

Environmental changes prompted by decades of greenhouse gas emissions require planners and decision-makers to manage within a new paradigm. The year 2016 was the warmest year on record for the third year in a row.[2] This increase in temperature adds significant energy to the atmospheric-oceanic exchange resulting in rising sea levels, shifting ecosystem ranges, higher intensity precipitation events, and warmer, more acidic oceans.[3] Additionally, land-based sea ice is melting at an increasing rate causing ocean water to expand, thus leading to rising seas.[4] Broadly speaking, historic trends may no longer be indicative of future norms.

Extreme weather, sea level rise, and degraded coastal ecosystems are putting people and property at an increasing risk of damage from coastal hazards.[5] A changing climate will drive global shifts in ocean currents, upwelling events, wind and wave patterns, and storm events.[6] For instance, coastal California is projected to encounter El Niño storms at an increasing rate due to the additional atmospheric energy.[7] With combined effects from higher sea levels and high-

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[2] Nat'l Aeronautics and Space Admin., NASA, *NOAA Data Show 2016 Warmest Year on Record Globally*, GODDARD INST. FOR SPACE STUDIES (Jan. 18, 2017), *available at* https://www.giss.nasa.gov/research/news/20170118/.

[3] Lisa V. Alexander et al., *IPCC, 2013: Summary for Policymakers*, *in* CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS—CONTRIBUTION OF WORKING GROUP I TO THE FIFTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 2-3, 9 (Thomas F. Stocker et al. eds., 2013).

[4] Mark F. Meier et al., *Glaciers Dominate Eustatic Sea-Level Rise in the 21st Century*, 317 SCIENCE 1064 (2007).

[5] Katie K. Arkema et al., *Coastal Habitats Shield People and Property from Sea-Level Rise and Storms*, 3 NATURE CLIMATE CHANGE 913, 913 (2013).

[6] Andrew Bakun, *Global Climate Change and Intensification of Coastal Ocean Upwelling*, 247 SCIENCE 198 (1990); U.S. ENVTL. PROT. AGENCY, THE POTENTIAL EFFECTS OF GLOBAL CLIMATE CHANGE ON THE UNITED STATES (Joel B. Smith & Dennis A. Tirpak eds., 1989).

[7] Wenju Cai, et al., *Increasing Frequency of Extreme El Niño Events Due to Greenhouse Warming*, 4 NATURE CLIMATE CHANGE 111, 115 (2014); *see also* NICOLE RUSSELL & GARY GRIGGS, ADAPTING TO SEA-LEVEL RISE: A GUIDE FOR CALIFORNIA'S COASTAL COMMUNITIES 7 (2012), *available at* https://seymourcenter.ucsc.edu/OOB/Adapting%20to%20Sea%20Level%20Rise.pdf.

energy El Niño events, future storms will have an increased magnitude of impact on an expanding coastal population compared to historic storms.[8]

While there are many expected impacts of this new climate paradigm, this article focuses on the increase in global sea levels with a particular interest in the impacts and responses in coastal California. Global projections indicate potential future sea levels many inches higher than today.[9] Exacerbated by the baseline rise of sea levels, the impacts on coastal communities in California will include increased exposure to flooding, storm surge, waves, and erosion.[10] A majority of California's population lives in these coastal counties[11] and the coastal population is projected to increase.[12] Sea level rise in California may cause both direct loss of coastal habitats, as well as harm to coastal ecosystems caused by the human response to sea-level rise.[13]

Rising sea levels and increased recurrence of storm events caused by climate change, coupled with chronic and long-term coastal erosion problems reduce the resilience of California's coastal communities' economies and ecological infrastructure, putting them at significant risk.[14] In California, local phenomenon from El Niño Southern Oscillation (ENSO) events, Pacific decadal shifts, and tectonic rebound modify these projections slightly.[15] The National Research Council's 2012 report notes the most recent observations of an eight-inch rise in sea levels since 1900.[16] By 2100, projections for future sea levels range up to one meter above levels in 2000.[17] These projections are considered the best available scientific projections for sea level rise projections in California.[18] Climate change is projected to have far-reaching impacts

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[8] Margaret R. Caldwell et al., *Coastal Issues, in* ASSESSMENT OF CLIMATE CHANGE IN THE SOUTHWEST UNITED STATES: A REPORT PREPARED FOR THE NATIONAL CLIMATE ASSESSMENT 168, 168-69 (Gregg Garfin et al. eds., 2013).

[9] ALEXANDER, *supra* note 3, at 23 ("Global mean sea level rise for 2081–2100 relative to 1986–2005 will *likely* be in the ranges of 0.26 to 0.55 m for RCP2.6, 0.32 to 0.63 m for RCP4.5, 0.33 to 0.63 m for RCP6.0, and 0.45 to 0.82 m for RCP8.5 (*medium confidence*). For RCP8.5, the rise by the year 2100 is 0.52 to 0.98 m, with a rate during 2081 to 2100 of 8 to 16 mm yr^{-1} (*medium confidence*).").

[10] Caldwell, *supra* note 8, at 169.

[11] *See* JUDITH T. KILDOW ET AL., STATE OF THE U.S. OCEAN AND COASTAL ECONOMIES 2014 16 (2014) (showing that a large portion of the U.S. population lives near the coast).

[12] *See* Press Release, California Department of Finance, New Population Projections: California to Surpass 50 Million in 2049 (Jan. 31, 2013), *available at* http://www.cahcc.com/Portals/0/assets/pdf/2Projections_Press_Release_2010-2060.pdf (showing California's expected future population growth).

[13] *See* MATTHEW HEBERGER ET AL., THE IMPACTS OF SEA-LEVEL RISE ON THE CALIFORNIA COAST (2009), *available at* pacinst.org/app/uploads/2014/04/sea-level-rise.pdf.

[14] *See generally* KILDOW ET AL., *supra* note 11.

[15] DAN CAYAN ET AL., CLIMATE CHANGE SCENARIOS AND SEA LEVEL RISE ESTIMATES FOR THE CALIFORNIA 2008 CLIMATE CHANGE SCENARIOS ASSESSMENT (2009).

[16] NAT'L RESEARCH COUNCIL, SEA-LEVEL RISE FOR THE COASTS OF CALIFORNIA, OREGON, AND WASHINGTON: PAST, PRESENT, AND FUTURE 10 fig. 1.1 (2012).

[17] *Id.*

[18] CAL. COASTAL COMM'N, SEA LEVEL RISE POLICY GUIDANCE 17 (2015) ("The State of California supported the preparation of the 2012 National Research Council's Report, *Sea-Level Rise for the Coasts of California, Oregon and Washington: Past, Present, and Future*, which is currently considered the best available science on sea level rise for California."). These sea level rise projections are expected to increase in light of the 2017 report released by the

along California's coastline, which is often backed by seacliffs or sand dunes—much of which are actively eroding and receding.[19]

Rising seas have the potential to cause other harms to the California coastline and adjacent communities as well.[20] The United States' densely populated coastal communities directly benefit from a broad range of ecosystem services provided by the dynamic coastal zone—especially protection from coastal inundation caused by storms and heightened sea levels.[21] Marine and coastal habitats act to buffer the coastline from storms and floods, reducing the need for, as well as the investment costs of, types of 'hard' shore protection such as riprap, levees and bulkheads.[22] Coastal California habitats—including oyster reefs, marshes, dunes, seagrass, and kelp forests[23]—all play relevant roles in reducing risk from coastal hazards as well as provide many other auxiliary benefits, such as carbon sequestration, opportunities for recreation, and nursery habitat for fisheries.[24] Climate change acts as a threat multiplier, undermining the supply of those ecosystem services, which can further endanger coastal communities' economies, culture, and resilience.[25] For example, sea level rise and more intense storms might threaten wetland habitats.[26] As wetlands are degraded, so too is the protective service they provide to people and property.[27] Maintaining natural capital[28]—the global stock of natural assets that provide beneficial services to people—to protect and support vibrant coastal communities is increasingly important as climate change impacts intensify.[29] However, coastal communities face a new significant challenge—and opportunity—to proactively manage resilient coastal development in an era of rising sea levels.

Climate science and modeling climate hazards reveal the planning challenges that local governments face. Proactive planning and preparation for these likely effects should be a top priority for coastal communities on the frontlines of climate change. Linking the best available scientific information on climate hazards to adaptation policy is the vital next step in successful coastal adaptation. Available scientific information relevant to climate adaptation planning can

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California Ocean Protection Council. CAL. OCEAN PROTECTION COUNCIL SCIENCE ADVISORY TEAM WORKING GROUP, RISING SEAS IN CALIFORNIA: AN UPDATE ON SEA-LEVEL RISE SCIENCE (2017).

[19] *See, e.g.*, GARY GRIGGS ET AL., LIVING WITH THE CHANGING CALIFORNIA COAST (Gary Griggs et al. eds., 2005); David L. Revell et al., *A Methodology for Predicting Future Coastal Hazards due to Sea-Level Rise on the California Coast*, 109 CLIMATE CHANGE 251 (2011).

[20] HEBERGER ET AL., *supra* note 13; Bruce C. Douglas, *Global Sea Level Rise*, 96 J. OF GEOPHYSICAL RESEARCH OCEANS 6981 (1991).

[21] *See* Arkema et al., *supra* note 5.

[22] *See id.*

[23] *See generally* ECOSYSTEMS OF CALIFORNIA 187-226 (Harold Mooney & Erika Zavaleta eds., 2016).

[24] *Id.* at 271-75.

[25] *Id.* at 262.

[26] *See* James T. Morris et al., *Responses of Coastal Wetlands to Rising Sea Level*, 83 ECOLOGY 2869 (2002).

[27] Sarah M. Reiter et al., *Climate Adaptation Planning in the Monterey Bay Region: An Iterative Spatial Framework for Engagement at the Local Level*, 6 NATURAL RESOURCES 375, 376 (2015).

[28] *See generally* WORLD FORUM ON NATURAL CAPITAL, http://naturalcapitalforum.com/about/ (last visited Mar. 1, 2017); NATURAL CAPITAL—THEORY & PRACTICE OF MAPPING ECOSYSTEM SOURCES (Peter Kareiva et al. eds., 2011).

[29] Lisa. M. Wedding et al., *Modeling and Mapping Coastal Ecosystem Services to Support Climate Adaptation Planning, in* OCEAN SOLUTIONS, EARTH SOLUTIONS 389, 389-90 (Dawn J. Wright ed., 2016).

include projected changes in sea level and erosion rates derived from scientific models and spatial mapping tools that can characterize the geography and ecology of an area. This information may be necessary for determining the appropriate adaptation approaches for an area. Spatial mapping tools and approaches can also reveal the roles that certain habitats play in buffering against rising seas, erosion, and inundation during storms. Governments can use this information to proactively plan for rising seas and conduct their due diligence to determine what adaptation strategies might be prioritized. For instance, the coastal habitats that buffer against rising sea levels could be prioritized for protection and restoration as part of a holistic, multi-benefit coastal adaptation strategy over other single-benefit strategies.

B. *Mitigation and Adaptation*

Addressing climate change has traditionally focused on "mitigation," i.e., limiting the causes of climate change.[30] Mitigation might include reducing greenhouse gas emissions or developing certain technologies to sequester or capture them.[31] Mitigation remains essential and the only way to address the root cause of climate change. However, due to a lack of mitigation efforts, banked carbon, and already occurring changes, adaptation efforts are also essential to minimize the negative effects of climate change. As a result, "adaptation" is gaining traction as an indispensable, additional proactive method for responding to the unavoidable effects of climate change.[32] The United Nations International Panel on Climate Change (IPCC) defines adaptation as "any adjustment—whether passive, reactive, or anticipatory—that can respond to anticipated or actual consequences associated with climate change."[33] Adaptation and mitigation are complementary responses to climate change, and both must be embraced to address the changing climate and its effects.[34]

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[30] *See, e.g.*, CLIMATE CHANGE 2014: MITIGATION OF CLIMATE CHANGE CONTRIBUTION OF WORKING GROUP III TO THE FIFTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (Ottmar Edenhofer et al. eds., 2014); W. Neil Adger et al., *Assessment of Adaptation Practices, Options, Constraints and Capacity*, *in* CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY CONTRIBUTION OF WORKING GROUP II TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 717 (M.L. Parry et al. eds., 2007).

[31] *See, e.g.*, WORKING GROUP III OF THE IPCC, IPCC SPECIAL REPORT ON CARBON DIOXIDE CAPTURE AND STORAGE (Bert Metz et al. eds., 2005).

[32] Jonathan Verschuuren, *Legal Aspects of Climate Change Adaptation*, *in* CLIMATE CHANGE AND THE LAW 257, 257-58 (Erkki J. Hollo et al. eds., 2013) ("The Working Group II report of the Intergovernmental Panel on Climate Change (IPCC) concludes that adaptation will be necessary to address impacts resulting from the warming which is already unavoidable due to past emissions. For some impacts, namely those that already show or will show in the very near future, adaptation is *the only available and appropriate response*, according to the IPCC.").

[33] Timothy Carter et al., *Technical Guidelines for Assessing Climate Change Impacts and Adaptations*, *in* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 1995—IMPACTS, ADAPTATIONS AND MITIGATION OF CLIMATE CHANGE: SCIENTIFIC-TECHNICAL ANALYSES 823 (Robert T. Watson et al. eds., 1995).

[34] HARI M. OSOFSKY & LESLEY K. MCALLISTER, CLIMATE CHANGE LAW AND POLICY 26-49 (2012) (explaining mitigation and adaptation and how they are complementary).

Coastal areas where rising seas will strike first will be the frontline of adaptation efforts in the face of sea level rise.[35] Accordingly, these communities will be among the first to shift some of their attention to include adaptation efforts.[36] Policymakers should continue employing mitigation techniques where available, but should also embrace adaptation—its interdependent counterpart—to further these responsive efforts.[37]

III. LINKING CLIMATE SCIENCE TO ADAPTATION

While sea levels are projected to continue rising, so too is the rate at which they rise.[38] This phenomenon will further intensify the need for planners to keep pace. As a result, adaptation efforts are on the rise in scientific and policy agendas.[39] Likewise, many governments and non-governmental actors at the national, regional, and local levels are developing plans for response.[40] Current efforts to adapt to rising seas focus on some form of a familiar pattern of incorporating climate science into decisions.[41] This process often includes assessing vulnerability, developing adaptation strategies, and implementing adaptation actions.[42] At each step, coastal communities have made incremental progress in incorporating the best available science regarding climate impacts and impacts of potential strategies.

Despite this progress, many communities continue to wrestle with how to adapt to a changing climate and are left wondering which strategies to apply where and over what time horizon. "Road-tested" adaptation practices and strategies remain elusive, in part because scientific information accessible to decision-makers has often not reflected the complexities associated with the impacts of climate change.

Despite the efforts to date, there remains a need to link climate science to adaptation planning and implementation. In order to inform this linkage this paper next identifies the current frameworks of adaptation planning and decision-making. It then explains the importance of

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[35] THULETUVALU (HesseGruetert Film 2014) (film comparing effects of sea level rise on areas in Greenland and the South Pacific).

[36] *See* Elisabeth M. Hamin & Nicole Gurran, *Urban Form and Climate Change: Balancing Adaptation and Mitigation in the U.S. and Australia*, 33 HABITAT INT'L 238 (2009).

[37] Andrew Macintosh, *A Theoretical Framework for Adaptation Policy*, *in* ADAPTATION TO CLIMATE CHANGE: LAW AND POLICY 38, 39 (Tim Bonyhady et al. eds., 2010) (explaining this interdependence as "[a]t the macro-level, the optimal or efficient level of adaptation will depend on the level of mitigation. Generally, the greater the mitigation the less there is a need for adaptation and *vice versa*.").

[38] Sea levels have been slowly rising since the last glacial maximum. *See* Vivien Gornitz, *Sea Level Rise, After the Ice Melted and Today*, NAT'L AERONAUTICS AND SPACE ADMIN. GODDARD INST. FOR SPACE STUDIES SCIENCE BRIEFS (Jan. 2007), https://www.giss.nasa.gov/research/briefs/gornitz_09/.

[39] *See, e.g.*, Adger et al., *supra* note 30; Julia A. Ekstrom & Susanne C. Moser, *Identifying and Overcoming Barriers in Urban Climate Adaptation: Case Study Findings from the San Francisco Bay Area, California, USA*, 9 URBAN CLIMATE 54 (2014).

[40] *See infra* Part III.A.

[41] *See generally* ECOADAPT, http://www.ecoadapt.org/ (last visited Mar. 1, 2017).

[42] *See, e.g.*, Barry Smit & Johanna Wandel, *Adaptation, Adaptive Capacity and Vulnerability*, 16 GLOBAL ENVTL. CHANGE 282 (2006).

place-based adaptation decision-making. Next, it highlights several enabling and limiting conditions that inform this endeavor.

A. *Current Frameworks of Adaptation Planning and Decision-Making*

Several governmental groups have devised frameworks for adaptation planning and decision-making. At the international level, the United Nations' IPCC has identified a general framework for conducting a seven-step "climate impacts and adaptations assessment."[43] At the federal level in the United States, the National Oceanographic and Atmospheric Administration has developed an in-depth planning process for adapting to climate change along the coastline.[44] Several other U.S. agencies have devised similar frameworks for adaptation action. The U.S. Environmental Protection Agency released a Synthesis of Adaptation Options for Coastal Areas for the country's coastal and estuarine areas.[45] Similarly, the U.S. Department of the Interior has developed a Coastal Adaptation Strategies Handbook for the National Park Service, which outlines certain processes for addressing climate change in its parks.[46]

At the state level, California has made great strides in addressing climate change and is a leader in such efforts.[47] For instance, California has developed several guides and frameworks for addressing a changing climate and the resulting impacts.[48] The California Adaptation Planning Guide provides a step-by-step process for local and regional climate vulnerability assessment and for developing adaptation strategies.[49] California law also requires the state to develop an online database describing steps being taken throughout the state to prepare for, and adapt to, sea level rise.[50] The California Coastal Commission has developed the Sea Level Rise Policy Guidance, which outlines steps California local governments can take to address sea level rise in their local coastal programs[51] and coastal development permits.[52] It also features guidance

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[43] Timothy Carter et al., *supra* note 33, at 826 (These seven steps are: 1. Definition of the problem; 2. Selection of the method; 3. Testing the method; 4. Selection of scenarios; 5. Assessment of biophysical and socioeconomic impacts; 6. Assessment of autonomous adjustments; and 7. Evaluation of adaptation strategies).

[44] NOAA OFFICE OF OCEAN AND COASTAL RES. MGMT., ADAPTING TO CLIMATE CHANGE: A PLANNING GUIDE FOR STATE COASTAL MANAGERS 16 (2010); Erika Bolstad, *NOAA Unveils Tool for Coastal Planning*, CLIMATEWIRE (Jan. 23, 2017), http://www.eenews.net/climatewire/stories/1060048778 (NOAA's recently released coastal planning tool).

[45] U.S. ENVTL. PROT. AGENCY, SYNTHESIS OF ADAPTATION OPTIONS FOR COASTAL AREAS (2009).

[46] NAT'L PARK SERV., COASTAL ADAPTATION STRATEGIES HANDBOOK (Rebecca Beavers et al. eds., 2016).

[47] *See, e.g.*, Exec. Order No. S-13-08; CAL. PUB. RES. CODE § 31113 (West, Westlaw through Ch. 4 of 2017 Reg. Sess.); *id.* § 6311.5; CAL. HEALTH & SAFETY CODE §§ 38500—38599 (West, Westlaw through Ch. 4 of 2017 Reg. Sess.).

[48] *See, e.g.*, CAL. EMERGENCY MGMT. AGENCY & NATURAL RES. AGENCY, CALIFORNIA ADAPTATION PLANNING GUIDE: IDENTIFYING ADAPTATION STRATEGIES (2012), *available at* http://resources.ca.gov/docs/climate/APG_Identifying_Adaptation_Strategies.pdf.

[49] *Id.* at 2 (The nine steps in this process call for evaluating: 1. Exposure; 2. Sensitivity; 3. Potential Impacts; 4. Adaptive Capacity; 5. Risk & Onset; 6. Prioritization of Adaptive Needs; 7. Identification of Strategies; 8. Evaluation & Prioritization of Strategies; and 9. Phasing and Implementation of Strategies.).

[50] CAL. PUB. RES. CODE §§ 30961—30968 (West, Westlaw through Ch. 4 of 2017 Reg. Sess.).

[51] *See* CAL. COASTAL COMM'N, *supra* note 18, at 67-95.

[52] *Id.* at 97-119.

on incorporating the best available science into decision-making.[53] However, specific guidance on how to develop, select, and implement adaptation actions for specific locations in California remains elusive, and the Sea Level Rise Policy Guidance remains mere guidance and is not legally binding.

Responsibility for coastal adaptation planning and decision-making will fall, in large part, on California's coastal local governments. Despite this responsibility, local governments often lack the staff capacity and financial resources to pursue proactive climate change planning on their own, especially without reliable blueprints to follow. The State has stepped in to remedy these deficiencies by offering grants to local governments to update their local coastal programs (LCPs) to take into account climate change and sea level rise.[54] At the local government planning level, LCPs play a primary role in enhancing community resilience by guiding how a community prepares for and responds to sea level rise[55] and by promoting the use of site-specific adaptation practices.

With California's state and local policy frameworks largely in place, coastal communities now seek guidance and modeling that reflects the complex realities these communities face that can in turn inform their adaptation decisions. The interplay between local governments, charged with protecting public health and safety, and regulated coastal landowners represents a sharp divide between individual and collective community interests. Local governments, on one hand, must govern to protect their constituents, and might even face liability for inaction.[56] Individual property owners, on the other, often wish to cling to their preferred uses of their property and the built structures on those properties.[57] This divide implicates legal issues including the limits of local governments' police powers, the Takings Clause, sovereign immunity, as well as philosophical issues, including the role of local governments in restricting respective land uses, and even the inherent nature of property itself.[58] As a result, while local governments know they need to act, they are apprehensive about potential legal challenges to coastal adaptation planning and implementation.[59] Finally, California's Coastal Act adds another layer of considerations for

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[53] *Id.* at 221—54.

[54] *Local Coastal Program (LCP) Grants*, STATE OF CAL. OCEAN PROT. COUNCIL, http://www.opc.ca.gov/2013/05/local-coastal-program-sea-level-rise-grants/ (last visited Mar. 1, 2017); Charles Lester & Mary Matella, *Managing the Coastal Squeeze: Resilience Planning for Shoreline Residential Development*, 36 STAN. ENVTL. L.J. 23, 34 (2016) ("Most local governments have completed an LCP, although a handful (mostly in southern California) have yet to do so.").

[55] Lindsey Ward Lyles et al., *Do planners matter? Examining Factors Driving Incorporation of Land Use Approaches into Hazard Mitigation Plans*, 57 J. ENVTL PLAN & MGMT 792 (2014).

[56] JENNIFER KLEIN, COLUMBIA LAW SCHOOL SABIN CENTER FOR CLIMATE CHANGE, POTENTIAL LIABILITY OF GOVERNMENTS FOR FAILURE TO PREPARE FOR CLIMATE CHANGE (2015) (examining possible government liability under theories of negligence, fraud, and takings).

[57] Private property owners are included as constituents. Private property owners benefit from collective interests as well, although sometimes at the expense of their individual rights.

[58] CHAD J. MCGUIRE, ADAPTING TO SEA LEVEL RISE IN THE COASTAL ZONE 177—84 (2013) (explaining the jurisprudential divide between those who believe property rights preexist government and those who believe property rights are wholly created through government).

[59] Local governments also fear being out first on an issue and being challenged on that action which could result in a chilling effect for similar future efforts. *See, e.g.*, Sean Hecht, *Local Governments Feel the Heat: Principles for Local Government Adaptation to the Impacts of Climate Change*, 47 J. MARSHALL L. REV. 635, 640 (2013) (arguing

coastal adaptation in California.[60] For instance, the Act protects the collective public's right to maximum public access to the beach, while also mandating sometimes destructive coastal protection measures for "existing structures" for individual landowners.[61]

B. *Place-Based Coastal Adaptation Decision-Making*

The foregoing coastal adaptation decision-making frameworks provide a starting point, but they fail to specify the preferred coastal adaptation strategies for certain locations. There is no "one size fits all" coastal adaptation strategy or suite of strategies. Instead, the appropriate strategy for a specific location will depend on the unique characteristics of that location. In other words, coastal adaptation decision-making should proceed in a place-based way, with strategies chosen because they are tailored to that specific location. Some locations might require legal changes, such as changes to zoning ordinances. Other locations might prompt engineered solutions, such as built protective structures, but only those possible and preferable under existing legal limitations and certain characteristics of that property. Still other locations might prompt creative financial tools to help foster coastal adaptation, such as conservation easements.

Perhaps the most important determining factor is place. Place should inform what adaptation strategies are possible in a given area as well as which should be prioritized over other competing options. Location and the overarching goals should drive which options are adopted. These goals generally fall along the following lines: protect against hazards, accommodate the hazards, and retreat from the hazards. Another important decision-making consideration is time horizon. Adaptation strategies should be chosen within an overarching adaptation goal framework in order to avoid maladaptation and other unintended consequences. Decisions about which tools are used will depend on policy objectives for that specific region or parcel. Similarly, the particular characteristics of a location will inform what strategies are appropriate for that location. The next section identifies the characteristics that should be considered in order to pursue place-based coastal adaptation.

IV. ENABLING AND LIMITING CONDITIONS

Climate science and sea level rise modeling are essential elements to planning for coastal communities. However, in order to effectively pursue place-based coastal adaptation it is necessary to understand the local context. To help uncover a location's story, this article identifies several enabling and limiting conditions that might exist for properties in the crosshairs

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that local governments should not wait for complete understanding, the perfect political moment, or an infusion of resources before planning for climate change).

[60] CAL. PUB. RES. CODE §§ 30000—30900 (West, Westlaw through Ch. 4 of 2017 Reg. Sess.).

[61] *Id.* § 30210 (guaranteeing maximum public access for all); *id.* § 30235 ("Revetments, breakwaters, groins, harbor channels, seawalls, cliff retaining walls, and other such construction that alters natural shoreline processes shall be permitted when required to serve coastal-dependent uses or to protect existing structures or public beaches in danger from erosion and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply.").

of rising seas and coastal adaptation planning.[62] These conditions include spatial and non-spatial conditions, meaning some can be more readily represented on a map or in a model than others. Identifying these conditions for a certain location, combined with modeling of climate impacts and rising sea levels will inform the crucial science-to-policy linkages that will aid in determining the appropriate location for specific strategies. This section identifies several of these spatial and non-spatial enabling and limiting conditions.

A. *Spatial Enabling and Limiting Conditions*

1. Geomorphologic Features

Geomorphologic features are the landforms present at a location. Coastal geomorphology is characterized by the dynamic nature of coastal landforms.[63] California's coastline features at least three distinct geomorphic landforms: (1) steep coastal mountains and sea cliffs; (2) uplifted, almost horizontal, marine terraces and sea cliffs; and (3) shoreline areas featuring beaches, sand dunes, estuaries or lagoons.[64] In California, climate change is projected to have far-reaching impacts along a coast that is often backed by sea cliffs or sand dunes—much of which is actively eroding and experiencing loss of the coastline.[65]

Geomorphology influences the types of engineered strategies that are possible—or even preferable—for a given location.[66] For instance, some strategies might be suitable for bluff areas, while others might only be suitable where there is sandy beach.[67] Beach nourishment, for example, requires a beach, while dune restoration requires an area where dunes previously or currently exist. Legal strategies might similarly be better suited for some geomorphological areas than others based on predicted erosion rates and other factors. For example, a rolling easement would be more preferable for a currently eroding area while a setback would be better for an area expected to erode at a slower rate.

2. Current Zoning

Zoning is "[t]he legislative division of a region, [especially] a municipality, into separate districts with different regulations within the districts for land use, building size, and the like."[68] Zoning restrictions of particular locations might dictate or influence possible coastal adaptation

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[62] Local knowledge is key and every effort should be made to catalog the existing institutional knowledge about a location targeted for any of the adaptation strategies discussed in this article.

[63] *See generally* Eric Charles Bird, COASTAL GEOMORPHOLOGY: AN INTRODUCTION (2d ed. 2008) ("Coastal geomorphology deals with the shaping of coastal features (landforms), the processes at work on them and the changes taking place.").

[64] GARY GRIGGS, INTRODUCTION TO CALIFORNIA'S BEACHES AND COAST 23-25 (2010).

[65] *See, e.g.*, GRIGGS ET AL., *supra* note 19; Revell et al., *supra* note 19.

[66] MCGUIRE, *supra* note 58, at 54 ("Coastlines that are made of hard substances and include high bluffs situated well above the physical processes of the ocean will tend to have more resilience to sea level rise than coastal areas that are made of softer substances where the landmass is near sea level.").

[67] Identification of the suitable strategies and their suitable locations is beyond the scope of this article and should only be undertaken with the advice of coastal engineers.

[68] BLACK'S LAW DICTIONARY 4991 (8th ed. 2004).

strategies for those locations. For example, the current zoning of an area determines what kinds of uses are allowable for that particular area. An area currently zoned for farming might be more preferable to target for a conservation easement than a similar property zoned for more lucrative businesses or developments, such as residential or commercial properties.[69] Zoning regulations, which focus on building size and location, may also limit adaptation strategies. Because zoning regulations can impose a range of limitations on a property, the limiting conditions stemming from these regulations might similarly be broad.

3. Current Land Uses and Population Densities

Land use refers to the actual current use of a piece of property.[70] "Land use/land cover" has been mapped across the U.S., and is most commonly in a raster or grid data structure, with each cell having a value that corresponds to a certain land use or land cover classification.[71] This structure allows for creating summary tables and performing subsequent analyses. Population density refers to how densely populated an area is, mapped by the U.S. Census Bureau based on people per square mile.[72] The current land use of an area often follows directly from current zoning—i.e., the current land use will typically be one of the uses allowed under the zoning regulations for that location. But current zoning is not dispositive of current land use. Certain lots may have grandfathered uses that were allowed under a previous zoning scheme, but conflict with current zoning restrictions. Additionally, even lots zoned to allow residential homes or commercial development might be currently undeveloped. Generally, the less developed a location is the more amenable it might be to a variety of adaptation options. Furthermore, because nature-based strategies often require a larger footprint to implement than similar hard armoring, the amount of undeveloped space available in a certain location might influence the appropriateness of such nature-based strategies.

Population density determines how many people will be affected by pursuing a coastal adaptation strategy in a certain area. Strategies suitable for areas featuring existing development will likely differ from areas faced only with the prospect of new development.[73] Developed coastal areas often feature commitments of human capital that can limit the suite of adaptation strategies available.[74] Moreover, some adaptation strategies, such as downzoning, are more legally defensible in undeveloped areas than in developed areas.[75] Furthermore, high investment-

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[69] However, in California, agricultural land is priced at a premium. Furthermore, California's Coastal Act protects and prioritizes agriculture. CAL. PUB. RES. CODE § 30241 (West, Westlaw through Ch. 4 of 2017 Reg. Sess.).

[70] This "land use" is not to be confused with the permissible land uses zoned for a particular area or parcel of property.

[71] *See generally* U.S. GEOLOGICAL SURVEY, LAND COVER INSTITUTE, https://landcover.usgs.gov/ (last visited Apr. 1, 2017).

[72] *See generally Thematic Maps*, U.S. CENSUS BUREAU, https://www.census.gov/geo/maps-data/maps/thematic.html (last visited Apr. 1, 2017).

[73] *See* JUSTINE BELL, CLIMATE CHANGE AND COASTAL DEVELOPMENT LAW IN AUSTRALIA 16, 23 (THE FEDERATION PRESS) (2014).

[74] MCGUIRE, *supra* note 58, at 94.

[75] Michael Allan Wolf, *Strategies for Making Sea-Level Rise Adaptation Tools "Takings-Proof,"* 28 J. LAND USE & ENVTL. L. 157, 176 (2013) ("Neither does the typical downzoning of a group of undeveloped parcels . . . warrant serious consideration by courts in which landowners cry 'taking.'").

backed expectations of a developed location might increase a local government's potential liability for enacting regulations that restrict the future uses of those properties. Similarly, the efficacy and suitability of coastal armoring is also a function of coastal development densities.[76]

4. Existing Habitats

California's coastal habitats (e.g., sea grass, kelp forests, salt marshes, and dunes) are a valuable part of the coastal landscape and, when healthy, may provide significant protection from rising sea levels and increased storm frequency and intensity. An important challenge for decision-makers is determining the best mitigation and adaptation strategies that not only protect human lives and property, but also protect the ability of coastal habitats to provide the broad suite of benefits we rely on, including coastal protection, recreation, and wildlife habitat. Identifying and understanding existing habitats is important because it informs what options are possible for a certain area. For example, strictly speaking, wetland restoration requires areas that used to be wetlands. Similarly, beach nourishment is only possible on a beach. Dune restoration requires a beach, and other existing natural habitats make it more prone to success as well.[77]

5. Other Legal Restrictions

While zoning restrictions obviously limit what might be done on a piece of property, other legal restrictions also limit adaptation strategies, particularly in the coastal zone.[78] For instance, California's Coastal Act governs development in the coastal zone.[79] Development that falls under the permitting requirements of the Coastal Act is broad.[80] The Coastal Act generally

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[76] MCGUIRE, *supra* note 58, at 131 (recommending deciding whether to armor based on the density of development along a coastal area so that multiple objectives are achieved).

[77] *See* Arkema et al., *supra* note 5; *see also* Reiter et al., *supra* note 27.

[78] While legal restrictions are enabling/limiting conditions, this article will also address the legal considerations of each strategy in a subsequent section. *See infra* Section VI.

[79] *See* CAL. PUB. RES. CODE §§ 30000—30900 (West, Westlaw through Ch. 4 of 2017 Reg. Sess.); *see also* Megan M. Herzog & Sean B. Hecht, *Combatting Sea Level Rise in Southern California: How Local Governments Can Seize Adaptation Opportunities While Minimizing Legal Risk*, 19 HASTINGS W.-N.W. J. ENVTL. L. & POL'Y 463, 465-66 (2013) (arguing that local governments can harness the Coastal Act and certain other laws "to support aggressive, innovative strategies to achieve successful sea level rise adaptation outcomes for Southern California while minimizing legal risk.").

[80] CAL. PUB. RES. CODE § 30106 (West, Westlaw through Ch. 4 of 2017 Reg. Sess.) ("'Development' means, on land, in or under water, the placement or erection of any solid material or structure; discharge or disposal of any dredged material or of any gaseous, liquid, solid, or thermal waste; grading, removing, dredging, mining, or extraction of any materials; change in the density or intensity of use of land, including, but not limited to, subdivision pursuant to the Subdivision Map Act (commencing with Section 66410 of the Government Code), and any other division of land, including lot splits, except where the land division is brought about in connection with the purchase of such land by a public agency for public recreational use; change in the intensity of use of water, or of access thereto; construction, reconstruction, demolition, or alteration of the size of any structure, including any facility of any private, public, or municipal utility; and the removal or harvesting of major vegetation other than for agricultural purposes, kelp harvesting, and timber operations which are in accordance with a timber harvesting plan submitted pursuant to the provisions of the Z'berg-Nejedly Forest Practice Act of 1973 (commencing with Section 4511).").

requires coastal development permits (CDPs) to pursue development in the coastal zone.[81] Some coastal adaptation strategies, therefore, will require acquiring CDPs from the local government, or from the California Coastal Commission, to implement.[82] In particular, engineered hard structures like seawalls require CDPs, but greener solutions will probably also fall into the broad definition of development under the Coastal Act. Likewise, certain coastal adaptation projects will require more legal "red tape" than others, potentially including environmental assessments and other environmental studies, such as review under the California Environmental Quality Act (CEQA).[83] These additional legal restrictions will influence how preferable a certain location is for a specific adaptation strategy.

6. Political Boundaries and Jurisdictional Overlaps

Political boundaries are the state, local, and county boundaries. They sometimes correspond with natural features but other times do not. Natural features that transverse boundaries create additional challenges for planners. For instance, a proposed adaptation strategy might occur across a political boundary. In this situation, coordination across these boundaries is essential.

A similar consideration is whether a location is subject to jurisdictional oversight by multiple agencies or organizations. These jurisdictional overlaps can make coastal adaptation more costly or complicated than pursuing them in locations with a single jurisdictional authority. An example would be where NOAA's National Marine Fisheries Service (NMFS) has jurisdiction due to an area of beach being a haul-out area for marine mammals.[84] The result of these jurisdictional overlaps would be increased bureaucratic red tape under federal and state laws, as well as increased need for collaboration and potentially conflicting mandates under their respective legal authority.

B. *Non-Spatial Enabling and Limiting Conditions*

There are many non-spatial enabling and limiting conditions as well. These conditions are "non-spatial" because they are generally less amenable to spatial representation or modeling.[85] The following non-spatial conditions are some of the most common and most important.

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[81] CAL. PUB. RES. CODE § 30600 (West, Westlaw through Ch. 4 of 2017 Reg. Sess.).
[82] *Id.* § 30601 ("developments requiring coastal development permit from commission").
[83] *Id.* § 21000—21189.57. CEQA applies to private actions that require CDPs. Friends of Mammoth v. Bd. of Supervisors, 502 P.2d 1049, 1055 (Cal. 1972) ("Because of the regular involvement of public entities in the issuance of permits it would appear that requiring 'governmental agencies at all levels to develop standards and procedures necessary to protect environmental quality' (§ 21001, subd. (f)) necessarily includes not only situations in which the government itself engages in construction, acquisition or other development, but also those instances in which the state regulates private activity.").
[84] NMFS has jurisdiction over fisheries habitat and administers the Marine Mammal Protection Act. 16 U.S.C. §§ 1361–1423h (West 2006).
[85] The argument could be made that some of these conditions could be translated into spatial data, but they would require extrapolation. For instance, "NIMBY" might be spatially represented on a map by looking at how much

1. Cultural Attachment and Values

The cultural significance of a location should be considered. California's beaches, for example, are culturally important to Californians and play a large role in the state's identity. Similarly, the historical significance of a location might attach legal obligations under the National Historic Preservation Act.[86] Finally, the specific values of a community might limit the strategies that are employed there. For instance, some communities might prioritize their beaches over everything else and therefore they will plan around this priority. Others might have historic waterfronts or buildings which they might prioritize over other features. Identifying these existing cultural attachments and values can help guide a local community's adaptation efforts.

2. "NIMBY"

Not in my backyard, or "NIMBY" is another non-spatial condition referring to the grievances of individuals opposed to new development or changes in land use that occur in close proximity to—or that affect—their personal interests.[87] These opponents typically use the legal system to delay or even stop development they do not want to go forward. NIMBY is another important limiting condition to consider, but it can be hard to predict when or what will trigger this kind of opposition. Regardless of this unpredictability, local governments can look to past disputes to predict where they might unfold in the future.

3. "Takings" Issues

Takings issues are those that implicate the federal or state constitution's restrictions against the government "taking" someone's property without paying just compensation.[88] Takings issues, and particularly regulatory takings issues, remain looming specters anytime zoning regulations are enacted. A regulatory taking is a government regulation so onerous that it is tantamount to a physical taking of that property, making it compensable under the Fifth Amendment.[89] Takings concerns are not spatial because they can affect any regulation of property.

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opposition certain neighborhoods and communities have traditionally shown toward new development. But two problems exist with extrapolating that data to coastal adaptation strategies. First, coastal adaptation is passive and should not increase traffic or noise, etc. Second, NIMBY data for entire communities or neighborhoods would not be as useful for predicting how specific neighbors next to specific plots will act in the future.

[86] 54 U.S.C.A. §§ 300101—307108 (West, Westlaw through P.L. 115-22).

[87] CECILY TALBERT BARCLAY & MATTHEW S. GRAY, CALIFORNIA LAND USE & PLANNING LAW 460 (2016) ("NIMBY . . . attitudes prevail in communities that fear new development will cause traffic congestion, loss of open space, or aesthetic impacts.").

[88] U.S. CONST. amend. V; CAL. CONST. art. I, § 19.

[89] Lingle v. Chevron U.S.A. Inc., 544 U.S. 528, 537 (2005) (explaining that "government regulation of private property may, in some instances, be so onerous that its effect is tantamount to a direct appropriation or ouster-and that such 'regulatory takings' may be compensable under the Fifth Amendment."). However, regulations can avoid these challenges if they are based in background principles of property law or if they meet the rough proportionality test under relevant Supreme Court decisions; Lucas v. S.C. Coastal Council, 505 U.S. 1003, 1029 (1992) ("Any limitation so severe cannot be newly legislated or decreed (without compensation), but must inhere in the title itself, in the restrictions that background principles of the State's law of property and nuisance already place upon land

4. Cost

The cost of undertaking coastal adaptation is another factor that is always looming. Cost is a consideration in eminent domain decisions, but also in deciding between competing strategies. For instance, in relocation and eminent domain situations, projected fair-market values of properties can inform this consideration, but examples abound of property owners unwilling to sell or otherwise give up their property regardless of the amounts offered.[90] Cost highlights the importance of holistically considering competing adaptation strategies. Some strategies might cost less, but might only be effective over a limited time horizon. For instance, beach nourishment might cost less than a competing dune restoration project, but might have to be repeated as the nourished sand erodes. Some built strategies might appear cheaper than nature-based strategies, but are not after one takes into account their deleterious effects on the ecosystem and environment, as well as their unintended negative environmental and societal consequences that were not taken into account when a hard structure was planned. For example, seawalls protect structures behind them, but they erode the beaches next to them.

5. Political Will

Political will refers to the will of the government or community to act. For a planner, political will concerns whether a local government is willing to act on sensitive, potentially controversial issues such as climate change. In California, there will be varying degrees of political will throughout the state—from city to city and county to county. The willingness to act on these issues is another consideration when deciding between adaptation strategies. In particular, local government officials might find it difficult to back strategies that are unpopular among key residents or that affect politically powerful coastal residents' property.

V. ADAPTATION STRATEGIES

Coastal adaptation strategies can include enacting state legislation and local ordinances, land use plan changes, permit conditions, built infrastructure, habitat restoration, or financial tools and incentives. There are several ways to categorize coastal adaptation strategies.[91] The

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ownership."); *see also* Dolan v. City of Tigard, 512 U.S. 374, 391 (1994) (requiring a "rough proportionality" for requiring dedication of private property for some future public use as a condition of obtaining a building permit).

[90] *See, e.g.*, Kelo v. City of New London, 545 U.S. 469 (2005); *see also* Ilya Somin, *The Story Behind Kelo v. City of New London – How an Obscure Takings Case Got to the Supreme Court and Shocked the Nation*, THE WASHINGTON POST, May 29, 2015, https://www.washingtonpost.com/news/volokh-conspiracy/wp/2015/05/29/the-story-behind-the-kelo-case-how-an-obscure-takings-case-came-to-shock-the-conscience-of-the-nation/?utm_term=.9bd55464ca87 (last visited May 10, 2017).

[91] For instance, the Canadian Institute of Planners categorizes strategies as follows: planning tools; regulatory tools; land use tools; structural tools; and non-structural tools. CANADIAN INST. OF PLANNERS, SEA LEVEL RISE PRIMER SUMMARY GUIDE, *available at* https://www.cip-icu.ca/Files/Awards/Planning-Excellence/Sea_Level_Rise_Adaptation_Primer_-_Summary_Fact_Sh.aspx. One scholar organizes strategies as follows: Protection (Defense), Accommodation, Retreat, and Attack. Yumi Lee, *Coastal Planning Strategies for Adaptation to Sea Level Rise: A Case Study of Mokpo, Korea*, 2 J. BLDG. CONSTR. AND PLANNING RESEARCH 74, 76

most common delineation is the tri-partite "protect," "accommodate," and "retreat."[92] These categories generally correlate with the intended goal of adaptation in a particular area—i.e., do you wish to stay or retreat?[93] In its Sea Level Rise Guidance, the California Coastal Commission explains that a hybrid approach using strategies from multiple categories will be necessary to effectively adapt to rising seas.[94]

This article organizes strategies into three categories: legal and regulatory; engineered; and financial tools. It organizes strategies this way in order to show competing strategies next to one another, thus informing the decision-making approach outlined above. The hurdles of each strategy can be compared and contrasted to make an informed decision on the efficacy and feasibility of a strategy in a given location. The strategies are briefly introduced at the end of this section in Table 1 and then further delineated in Section V.

A. *Legal and Regulatory Strategies*

Legal and regulatory solutions include new state-level legislation, local ordinances, agency regulations, and updates to zoning documents. Typically, these legal and regulatory restrictions limit what is permissible on particular pieces of property, and they bookend the discretion that government entities have to make different decisions. Additionally, judicial decisions applying common law principles may influence adaptation options. Legal and regulatory solutions are those which are mandatory as opposed to the voluntary or participatory strategies discussed later in the financial tools section.

B. *Engineered Strategies*

Engineered strategies are structure- and nature-based coastal adaptation projects that require physical engineering and construction. Engineered solutions also encompass adaptive responses such as elevating or moving buildings away from the coastline. The engineered protective strategies in this group fall into three subgroups: green, gray, and hybrid.[95] Green infrastructure includes wetland restoration, dune restoration, or other "nature-based" strategies.[96]

(2014). Alternatively, a law scholar categorizes these strategies based on their relative risk of effecting a "taking." *See also* Wolf, *supra* note 75, at 174-85. The National Park service delineates between "Resist[ing], accommodat[ing] and direct[ing]" change. *See* NAT'L PARK SERV., *supra* note 46.

[92] J. Gilbert & P. Vellinga, *Coastal Zone Management*, *in* CLIMATE CHANGE: THE IPCC RESPONSE STRATEGIES 133, 146-47 (2005) ("Response strategies fall into three broad categories: *Retreat:* Abandonment of land and structures in vulnerable areas, and resettlement of inhabitants. *Accommodation:* Continued occupancy and use of vulnerable areas. *Protection:* Defense of vulnerable areas, especially population centers, economic activities, and natural resources.").

[93] MCGUIRE, *supra* note 58, at 94 (further dividing the two choices for staying as "(1) *protecting* against the incoming sea, or (2) *adapting* to the incoming sea.").

[94] *See* CAL. COASTAL COMM'N, *supra* note 18, at 125.

[95] *See* JOINT-INDUSTRY WHITE PAPER, THE CASE FOR GREEN INFRASTRUCTURE 2 (2013), *available at* http://www.nature.org/about-us/the-case-for-green-infrastructure.pdf.

[96] *See* CAL. COASTAL COMM'N, *supra* note 18, at 185.

Gray strategies include hard-armoring, typically using concrete and other unnatural materials. Hybrid structures include elements of both green and gray.

C. *Financial Tools*

Finally, several coastal adaptation strategies are financial tools.[97] These tools either finance coastal adaptation, work to incentivize adaptation, or disincentivize nonadaptation or maladaptation. Particularly, these tools act to incentivize retreat from the coast and other behaviors that promote and facilitate coastal adaptation. These financial tools range from insurance instruments and special assessments, to overhauling the federal national flood insurance program (NFIP), to creative uses of special hazard districts.

[97] More broadly speaking, there are also financial tools that allow the adaptation strategies listed above to be carried out. Other financial tools are themselves strategies.

Table 1. Non-Exhaustive List of Adaptation Strategies Organized in Three Categories

Legal and Regulatory	Comprehensive Plan Sea Level Rise Element	
	Deed Restrictions	
	Development Moratoria	
	Downzoning	
	Legislation Banning Seawalls	
	Overlay Zones	
	Judicial Opinions Addressing Coastal Squeeze	Erosion, Reliction, and Public Nuisance
		Public Trust Doctrine
	No Build Areas	Flood Hazard Regulations
		Rolling Easements
		Setback Requirements
	Protective Structure Permit Special Conditions	Assumption of Risk
		Indemnity
		Waiver of Liability
	Other Zoning Regulations	"Trigger" Language After an Observed Event
		Density Limits
		Redevelopment Restrictions
		Time Horizons
Engineered	Beach Nourishment and Beach Restoration	
	Breakwaters	
	Cliff Stabilization	
	Dune Restoration	
	Elevating Structures	
	Inaction (Decision not to act)	
	Jetties and Groins	
	Living Shorelines	
	Retreat and Relocation	
	Revetments and Riprap	
	Seawalls	
	Tide Gates	
	Wetland Restoration	
Financial	Amendments to the National Flood Insurance Program	
	Buyouts / Buybacks / Leasebacks	
	Catastrophe Bonds	
	Conservation Easements	
	Geologic Hazard Abatement Districts (GHADs)	
	Landbanking	
	Special Assessments for Vulnerable Properties	
	Transfer of Development Rights (TDRs)	

VI. SPECIFIC ADAPTATION STRATEGIES AND LEGAL CONSIDERATIONS

In this section, we examine more closely several representative examples of the coastal adaptation types listed above. This examination proceeds by briefly describing each strategy. Next it explains where the strategy might be used. Then it identifies an example of the strategy. Finally, it lists the legal considerations and barriers to implementing each strategy. We identify these considerations in the context of California law when appropriate, but also identify many federal and common law considerations so that these lessons can be applied beyond California's coastline.

A. *Overlay Zone*

Description: An overlay zone is an additional set of zoning restrictions that "overlay" the original zoning of a certain area.[98] Sea level rise and flooding overlay zones might be implemented according to predicted sea level rise rates, time horizons and locations. Initially, a sea level rise overlay zone might put landowners on notice of future potential danger to their properties. Likewise, building restrictions or rebuilding restrictions might be implemented for the specific overlay zones, such as new building requirements which would go into effect after some triggering event.[99]

Advantages: Overlay zones are a very flexible tool for coastal adaptation. They can be used to prompt retreat by incentivizing smart, proactive planning. They can also be combined with several other tools, such as triggering conditions or redevelopment restrictions in order to achieve coastal adaptation goals. Over the short term, they provide immediate notice to landowners in their zones that they are currently, or will soon be, in the crosshairs of rising seas or flooding waters. Over the longer term, they can help stop rebuilding in hazardous areas.[100]

Disadvantages: A major disadvantage of overlay zones is that they impose additional restrictions on certain properties. These additional regulations might spur regulatory takings claims, discussed below as a legal consideration.

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[98] BARCLAY & GRAY, *supra* note 87, at 586 (defining overlay zone as a "[s]et of zoning requirements in addition to those of the underlying district.").

[99] A major storm event that destroys some percentage of a structure could be a triggering event. The "end" of a structure's assumed economic life could be another. *See* Charles Lester, *An Overview of California's Coastal Hazards Policy*, *in* LIVING WITH THE CHANGING CALIFORNIA COAST 138, 160 (Gary Griggs et al. eds., 2005).

[100] Those properties notorious for being rebuilt in hazardous areas are also known as "repetitive loss properties." *See* RAWLE O. KING, CONG. RESEARCH SERV., RL32972, FEDERAL FLOOD INSURANCE: THE REPETITIVE LOSS PROBLEM (2005); *see also* 42 U.S.C.A. § 4121(a)(7) (West, Westlaw through P.L. 115-22) ("[T]he term 'repetitive loss structure' means a structure covered by a contract for flood insurance that—
(A) has incurred flood-related damage on 2 occasions, in which the cost of repair, on the average, equaled or exceeded 25 percent of the value of the structure at the time of each such flood event; and
(B) at the time of the second incidence of flood-related damage, the contract for flood insurance contains increased cost of compliance coverage.").

Suitable Locations: Suitable locations for sea level rise overlay zones include areas currently considered floodzones, or those likely to be affected by sea level rise over some time horizon.

Example: Currently, overlay zones are routinely used to demarcate floodzones and other special districts in California.[101] In California, work is currently underway to develop a model sea level rise overlay zone ordinance for coastal communities.[102]

Legal Considerations: Overlay districts without any additional restrictions to the delineated properties are unlikely to face legal challenges. With that said, any regulation that restricts what a landowner can do with his property may be challenged as a regulatory taking.[103] Regulations that deprive a landowner of all economic value of their land will generally be considered a taking, while regulations under that threshold will be considered according to certain judicially mandated factors.[104]

B. *Legislation or Zoning Provision Banning Seawalls*

Description: Legislation could be enacted to ban seawalls in certain locations, such as some distance from the high-tide line. Similarly, a local government could implement a seawall ban in its LCP.

Advantages: A seawall ban would help foster landward migration of beaches and would avoid potential nuisances on the beach from remnants of eroding seawalls. It would also avoid the "domino effect" prompted by seawalls fostering seawalls on neighboring properties as those properties experience increased erosion from the neighboring seawall.

Disadvantages: A seawall ban might result in avoidable property damage to houses built in hazardous areas battered by storms or subject to erosion.

Suitable Locations: Legislation or zoning ordinances in LCPs banning seawalls are appropriate wherever there are beaches a local government wishes to keep free from seawalls.

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[101] *See, e.g.*, CAPITOLA CITY, CAL., MUNICIPAL CODE §§ 17.20.010—17.20.090 (2016), *available at* http://www.codepublishing.com/CA/Capitola/ (affordable housing overlay district).

[102] Two California jurisdictions are currently in the process of voluntarily implementing ordinances of this sort with assistance from the UCLA Frankel Environmental Law Program. *See* Sean Hecht & Megan Herzog, *Developing a Model Ordinance for California Local Governments to Integrate Sea-Level Rise Adaptation into Existing Land Use Plan*, USCDORNSIFE, http://dornsife.usc.edu/uscseagrant/hecht-and-herzog (last visited Mar. 1, 2017). Researchers at Georgetown's Climate Center have developed a model sea level rise ordinance as well. *See* JESSICA GRANNIS ET AL., A MODEL SEA-LEVEL RISE OVERLAY ZONE FOR MARYLAND LOCAL GOVERNMENTS (2011).

[103] *See* Pa. Coal Co. v. Mahon, 260 U.S. 393, 415 (1922) ("The general rule at least is that while property may be regulated to a certain extent, if regulation goes too far it will be recognized as a taking.").

[104] *See* Penn Cent. Transp. Co. v. New York City, 438 U.S. 104, 124 (1978) ("In engaging in these essentially ad hoc, factual inquiries, the Court's decisions have identified several factors that have particular significance. The economic impact of the regulation on the claimant and, particularly, the extent to which the regulation has interfered with distinct investment-backed expectations are, of course, relevant considerations.").

Example: Oregon, Texas, North Carolina, South Carolina and New Jersey ban construction of new seawalls.[105] In California, the city of Solana Beach banned seawalls in its LCP.[106]

Legal Considerations: Currently, the California Coastal Act specifically permits protective structures for "existing" structures.[107] Furthermore, the Pacific Legal Foundation challenged Solana Beach's seawall ban for violating the Coastal Act and the U.S. Constitution.[108]

C. *No-Build Areas (Setbacks, Rolling Easements, etc.)*

Description: No-build zones typically restrict the building of certain structures along shorefront areas or otherwise hazardous coastal zones. Governments achieve these no-build areas through mechanisms such as shoreline setbacks, rolling easements, or through zoning restrictions.[109] Shoreline setbacks are restrictions against building within a certain distance from the shoreline. Rolling easements achieve a similar result but are rooted in common law and allow the no-build area to "roll" as seas rise and the beach recedes.[110]

Advantages: No-build areas help protect beaches, particularly the public's interest in beaches under the public trust doctrine. Setbacks are valuable tools for curtailing both new development and extensive redevelopment in hazardous areas. Specifically, setbacks can help keep development "away" from hazards. Setbacks can also help avoid the phenomenon known as "repetitive loss" by requiring them when destroyed buildings are rebuilt.[111]

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[105] *See, e.g.*, N.C. GEN. STAT. § 113A-115.1 (West, Westlaw through the end of the 2016 Regular Session, with the addition of S.L. 2016-126 from the 2016 Fourth Extra Session and through S.L 2017-4 of the 2017 Regular Session of the General Assembly); S.C. CODE ANN. § 48-39-120 (West, Westlaw through the 2016 session).

[106] CITY OF SOLANA BEACH, LOCAL COASTAL PLAN (2013), *available at* http://solana-beach.hdso.net/LCPLUP/LCPLUP-COMPLETE.pdf.

[107] CAL. PUB. RES. CODE § 30235 (West, Westlaw through Ch. 4 of 2017 Reg. Sess.). However, what "existing" means under the Act—existing as of January 1, 1977, when the Act when into effect, or existing at the time the applicant applies for a protective structure—is still up for debate. *See, e.g.*, Todd T. Cardiff, *Conflict in the Coastal Act: Sand and Seawalls*, 38 CAL. W. L. REV. 255, 261-75 (2001).

[108] Phil Diehl, *Court Rules on Seawall Restriction*, THE SAN DIEGO UNION-TRIBUNE, Dec. 13, 2016, http://www.sandiegouniontribune.com/communities/north-county/sd-no-solana-seawalls-20161213-story.html (last visited May 10, 2017); Complaint at 5-10, Beach & Bluff Conservancy v. City of Solana Beach, 37-2013-00046561-CU-WM-NC (filed Apr. 26, 2013), *available at* https://www.pacificlegal.org/old-site/document.doc?id=851.

[109] *See, e.g.*, NAT'L OCEANIC AND ATMOSPHERIC ADMIN. OFFICE OF OCEAN AND COASTAL RES. MGMT., PROTECTING THE PUBLIC INTEREST THROUGH THE NATIONAL COASTAL ZONE MANAGEMENT PROGRAM: HOW COASTAL STATES AND TERRITORIES USE NO-BUILD AREAS ALONG OCEAN AND GREAT LAKE SHOREFRONTS (2012) [hereinafter NOAA COASTAL ZONE MGMT.], *available at* https://coast.noaa.gov/czm/media/nobuildareas.pdf.

[110] Meg Caldwell & Craig Holt Segall, *No Day at the Beach: Sea Level Rise, Ecosystem Loss, and Public Access Along the California Coast*, 34 ECOLOGY L.Q. 533, 535 (2007) (describing a rolling easement as "a device, rooted in statutory or common law or in permit conditions, that allows the publicly owned tidelands to migrate inland as the sea rises, thereby preserving ecosystem structure and function.").

[111] Most building codes do not currently feature such restrictions. Instead, for instance, Sonoma's building code currently permits rebuilding within the same existing building footprint, even in areas that would otherwise be subject to setbacks. SONOMA CNTY., CAL., CODE OF ORDINANCES § 7-14.5(b)(4) (2017), *available at*

Disadvantages: Rolling easements are controversial, and it is unclear how they will be applied in relation to the California Coastal Act.[112]

Suitable Locations: Setbacks are useful buffers against dynamic hazards. They are particularly useful where sudden bluff failure is possible, or where the width of the beach fluctuates a great deal over the course of a year. Rolling easements might be used along an entire beach or parts of a beach.

Example: Most coastal States have identified shorefront no-build areas.[113] Oregon's Beach Bill, modeled on Texas's Open Beaches Act, acts as a rolling easement declaring that "Ownership of the shore of the Pacific Ocean between ordinary high tide and extreme low tide . . . is vested in the State of Oregon."[114]

Legal Considerations: Rolling easements suffered a defeat in Texas in a case regarding how major storms affect public beach easements in West Beach, Galveston.[115] Furthermore, the proliferation of rolling easements in California might interfere with California's Coastal Act which guarantees "maximum public access."[116] This would happen if lateral beach access ways along private properties were lost along with those private properties, effectively removing those public access points. Additionally, some scholars argue that setbacks might affect a taking in some circumstances,[117] while rolling easements will be more insulated from such claims.[118]

D. *Redevelopment Restrictions*

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https://www.municode.com/library/ca/sonoma_county/codes/code_of_ordinances?nodeId=CH7BURE_ARTIIRURE_S7-14.5STSESTREBUPE.

[112] *See generally* Caldwell & Segall, *supra* note 110.

[113] *See, e.g.*, NOAA COASTAL ZONE MGMT., *supra* note 109.

[114] OR. REV. STAT. ANN. § 390.615 (West, Westlaw through Ch. 13 of the 2017 Reg. Sess.). Oregon's coastal sovereign ownership is even more extensive than this statute suggests. Oregon prohibits development to the vegetation line based on custom. *See* State *ex rel*. Thornton v. Hay, 462 P.2d 671 (1969).

[115] Severance v. Patterson, 370 S.W.3d 705, 724-25 (Tex. 2012) (holding that at least major storm events do not operate to shift boundaries as under a rolling easement).

[116] CAL. PUB. RES. CODE § 30210 (West, Westlaw through Ch. 4 of the 2017 Reg. Sess.) ("maximum access, which shall be conspicuously posted, and recreational opportunities shall be provided for all the people consistent with public safety needs and the need to protect public rights, rights of private property owners, and natural resource areas from overuse."); *see also* CAL. CONST. art. X, § 4.

[117] *See, e.g.*, James G. Titus, *Rising Seas, Coastal Erosion, and the Takings Clause: How to Save Wetlands and Beaches Without Hurting Property Owners*, 57 MD. L. REV. 1279, 1388 (1998) ("A taking is more likely in areas where land is held for speculation or lots have been subdivided, because setbacks are more likely to render the property economically unusable.").

[118] *Id.* at 1389 ("The uncertainties regarding the public trust doctrine cut the other way for rolling easements. Because the law of erosion has long held that the public tidelands migrate inland as sea level rises, legislation saying that this law will apply in the future takes nothing. Even without the public trust doctrine and the law of erosion, rolling easements would rarely be takings.").

Description: Redevelopment restrictions can be achieved through additions or changes to a local government's zoning ordinance. Specifically, building codes can be amended to limit the redevelopment allowed in a certain location. Such zoning ordinances can help prompt retreat by making it difficult or impossible to rebuild in dangerous areas.

Advantages: Redevelopment restrictions work to disincentivize staying in hazardous areas.[119] They can also work to internalize the costs associated with rebuilding in areas that will soon be subject to sea level rise.

Disadvantages: One drawback of redevelopment restrictions is that they have no immediate effect. They apply only when a structure is redeveloped, and therefore are susceptible to loopholes. For instance, some current redevelopment policies allow rebuilding provided some threshold is not passed, such as monetary value or that the footprint of the previous structure is not expanded.

Suitable Locations: Redevelopment restrictions are appropriate for any areas where redevelopment should be limited, such as areas currently in floodzones or predicted to be impacted by future sea level rise. These restrictions are particularly useful where there are a lot of grandfathered structures that are not meeting current zoning regulations and perhaps where there is a danger of repetitive loss.[120]

Example: An example of redevelopment restrictions is Sonoma County's ordinance that requires rebuilt structures that were previously grandfathered in to come into compliance with all regulations upon being rebuilt.[121]

Legal Considerations: Redevelopment restrictions will generally require changes to existing local ordinances. They might also spur legal challenges when they are enforced. These policies are sometimes subject to exploitable loopholes.[122]

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[119] *See* Lester, *supra* note 99, at 160 (arguing for strengthening restrictions on the redevelopment of structures).

[120] For instance, California's Sonoma County is home to the most repetitive loss properties west of the Rockies. *See* SONOMA CNTY. PERMIT AND RES. MGMT. DEP'T., SONOMA COUNTY LOCAL COASTAL PLAN: SONOMA COUNTY HAZARD MITIGATION PLAN 109 (2011), *available at* http://www.sonoma-county.org/prmd/docs/hmp_2011/chapters/full_chapters.pdf ("Data drawn from BureauNet, FEMA's computer program that receives claims information from insurance companies, indicates as of May 3, 2011, there are 827 repetitive loss properties located in unincorporated Sonoma County. This is the largest number of repetitive loss properties in a single community west of the Rockies.").

[121] SONOMA CNTY., CAL., CODE OF ORDINANCES § 26C-351 (2017), *available at* https://www.municode.com/library/ca/sonoma_county/codes/code_of_ordinances?nodeId=CH26CCOZOREDI_ARTXXXVNOUS_S26C-351RE ("If at any time any commercial or industrial use in existence on the effective date of this chapter, which does not conform to the regulations for the district in which it is located, is damaged or destroyed by fire, explosion, act of God, tortious conduct of a third party, or act of the public enemy, to the extent of more than fifty percent (50%) of the replacement value of the structure, the land shall be subject to all the regulations specified by this chapter or the district in which such land is located.").

E. *Beach Nourishment*

Description: Beach nourishment is the artificial placing of sand on a beach to replace eroded sand or to protect against future erosion. Beach nourishment can also widen a naturally narrow beach.[123]

Advantages: Beach nourishment can maintain the status quo of an eroding beach. It can also replace sediment supply loss, such as from sand mining or from dammed rivers.[124] Nourishment is also environmentally preferable to armoring with seawalls, particularly in the short term.[125] Beach nourishment can also increase public access to beaches.

Disadvantages: Beach nourishment is touted as natural and green, but has deleterious impacts on the environment.[126] Increased turbidity is one impact. The source of the sand can cause additional environmental impacts.[127] In California, beach nourishment can cause the sediment to unnaturally accumulate in the submarine canyons along its coastline.[128] Additionally, beach nourishment has encouraged development in certain especially hazardous areas.[129] Furthermore, beach nourishment projects can prompt public opposition.[130]

Suitable Locations: Nourishment is most suitable for areas with beaches that provide natural protective services and those beaches valued for their cultural and economic value. Beach nourishment might also be preferable for beaches that experience increased erosion due to sea level rise or increased storm impacts.

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[122] *See, e.g.*, Jenni Khuu, *A Loophole to Repair: "Repair and Maintenance" as a Way Around the Coastal Act's Prohibition Against Seawalls*, 58 HASTINGS L.J. 1297 (2007).

[123] GRIGGS ET AL., *supra* note 19, at 72.

[124] *Id.* at 301 ("Another major historical loss of sand in southern Monterey Bay was due to the sand mining in the Marina and Sand City areas.").

[125] Lester, *supra* note 99, at 161 (recommending investigating beach replenishment strategies as a way of avoiding shoreline armoring); *see also* Jared Whitlock, *Coastal Commission Approves Scaled Back Sand Project*, THE COAST NEWS GROUP, Nov. 19, 2013, *available at* http://www.thecoastnews.com/2013/11/19/coastal-commission-approves-scaled-back-sand-project/ ("To manage sea level rise, Solana Beach Mayor Mike Nichols said that beach nourishments are preferred over seawalls.").

[126] For instance, biologists have found that beach nourishment leads to long-lasting declines in invertebrate abundances due to beach replenishment. *See* Tyler Wooldridge et al., *Effects of Beach Replenishment on Intertidal Invertebrates: A 15-month, Eight Beach Study*, 175 ESTUARINE, COASTAL & SHELF SCIENCE 24 (2016).

[127] *See* NAT'L RESEARCH COUNCIL, BEACH NOURISHMENT AND PROTECTION 97–99 (1995).

[128] For example, Monterey Bay has a submarine canyon. ECOSYSTEMS OF CALIFORNIA, *supra* note 23, at 393 (explaining that littoral cell sand losses can include "loss to submarine canyons").

[129] Scott B. Armstrong et al., *Indications of a Positive Feedback Between Coastal Development and Beach Nourishment*, 4 EARTH'S FUTURE 626 (2016).

[130] *See, e.g.*, Deirdra Funcheon, *Divers Protest Beach Renourishment Project in Broward*, BROWARD PALM BEACH NEW TIMES, Feb. 5, 2016, http://www.browardpalmbeach.com/news/divers-protest-beach-renourishment-project-in-broward-7557047 (last visited May 10, 2017).

Example: The Encinitas and Solana Beach storm damage reduction project includes beach nourishment in its plan.[131] There are several previous examples of beach nourishment along California's coastline as well.[132]

Legal Considerations: Usually state and federal permits are required for beach nourishment. Projects are typically subject to CEQA, National Environmental Policy Act (NEPA), and other environmental impact analyses.[133]

F. *Wetland Restoration*

Description: A wetland restoration project could allow tidal wetlands to proliferate in areas that have been diked or otherwise altered from their original conditions.

Advantages: This strategy is a "green" solution, so it has the potential to carry with it certain co-benefits, such as increased animal habitats and certain other ecosystem services.

Disadvantages: Wetland restoration projects may be costly, and may be eventually "lost" to sea level rise anyway.

Suitable Locations: Wetland restoration is appropriate for areas that were previously wetlands but have been converted to agricultural areas or other uses. Salt ponds are also suitable locations.[134]

Example: One example of a wetland restoration project was the Giacomini wetlands in Point Reyes National Seashore.[135] Another example is the Sears Point Wetland Restoration Project in Sonoma County.[136]

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[131] *See* U.S. ARMY CORPS OF ENG'RS LOS ANGELES DISTRICT, ENCINITAS-SOLANA BEACH COASTAL STORM DAMAGE REDUCTION PROJECT, *available at* http://www.spl.usace.army.mil/Missions/Civil-Works/Projects-Studies/Solana-Encinitas-Shoreline-Study/.

[132] Crescent City, Bolinas Bay, Ocean Beach in San Francisco, Seabright Beach in Santa Cruz Harbor, Twin Lakes Beach in Capitola, and Morro Bay are all examples of beach nourishment locations in California. Lisa M. Krieger, *Lines in Sand Don't Last*, SAN JOSE MERCURY NEWS, Nov. 4, 2003, at F1, F6.

[133] CAL. PUB. RES. CODE §§ 21000—21189.57 (West, Westlaw through Ch. 4 of the 2017 Reg. Sess.); 40 C.F.R. §§ 1500-1508.28 (West, Westlaw through Apr. 20, 2017).

[134] South Bay Salt Pond Restoration Project is another example. *See South Bay Salt Pond Restoration Project*, SOUTH BAY RESTORATION, http://www.southbayrestoration.org/ (last visited Apr. 2, 2017).

[135] *See* NAT'L PARK SERV., CASE STUDY 12: RESTORING THE GIACOMINI WETLANDS FROM AGRICULTURAL LANDS, POINT REYES NATIONAL SEASHORE, CALIFORNIA, *available at* https://www.nps.gov/subjects/climatechange/upload/CAS_Case_Study_12.pdf.

[136] *Sonoma Land Trust and Ducks Unlimited kick off construction of Sears Point 960-acre wetland restoration project on San Pablo Bay*, SONOMA LAND TRUST (June 6, 2014) https://www.sonomalandtrust.org/news_room/press_releases/1406-sears-point.html (last visited May 10, 2017).

Legal Considerations: Wetlands have a specific legal definition under California law.[137] Environmental impact statements and consultations with state wildlife managers would be required for locations featuring threatened or endangered species.[138] Wetlands that are also environmentally sensitive habitat areas (ESHAs) are governed under the state's wetlands protection provisions because they are more stringent.[139]

G. *Seawall*

Description: A seawall is a type of built structure designed to protect against encroaching seas. Seawalls are typically used to protect built infrastructure directly or indirectly.[140] They are built parallel to the shoreline and usually consist of concrete, wood, steel or a mixture of these materials.

Advantage: Seawalls protect a very specific region in the short term. For local governments, seawalls can be advantageous because they protect the property tax revenue generated by some of that community's most expensive homes. Seawalls often require smaller footprints than comparable protective structures, such as riprap or revetments.[141]

Disadvantage: Seawalls destroy beaches through "passive erosion"—i.e. preventing the beach from migrating inland as seas rise and erosive events occur.[142] They also prompt neighboring properties to armor in kind in order to avoid patchwork armoring.[143] Furthermore, seawalls are susceptible to failure.[144] They can also block public beach access.[145] Finally, seawalls are generally not aesthetically pleasing.[146]

Suitable Locations: Seawalls might be suitable for areas that the local government wants to protect in the short term. Particularly, seawalls might be suitable for areas that are already built

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[137] *See* CAL. PUB. RES. CODE § 30121 (West, Westlaw through Ch. 4 of the 2017 Reg. Sess.); CAL. CODE REGS. tit 14, § 13577 (Barclay's, Westlaw through 4/14/17 Register 2017, No. 15).
[138] Endangered Species Act, 16 U.S.C.A. §§ 1531—1544 (West, Westlaw through P.L. 115-22); 50 C.F.R. pts. 17, 222, 224 (West, Westlaw through Apr. 20, 2017; 82 FR 18587).
[139] Bolsa Chica Land Trust v. Superior Court, 83 Cal. Rptr. 2d 850, 862-63 (Cal. Ct. App. 1999).
[140] GRIGGS ET AL., *supra* note 19, at 117.
[141] CAL. COASTAL COMM'N, STAFF REPORT ADDENDUM FOR F8B CDP APPLICATION NUMBER 2-11-009 (CITY OF PACIFICA SHORELINE PROTECTION) 26 (2014), *available at* https://documents.coastal.ca.gov/reports/2014/7/F8b-7-2014.pdf ("A seawall is often preferable to a riprap revetment because it can occupy a smaller area of beach.").
[142] MOLLY LOUGHNEY MELIUS & MARGARET R. CALDWELL, 2015 CALIFORNIA COASTAL ARMORING REPORT: MANAGING COASTAL ARMORING AND CLIMATE CHANGE ADAPTATION IN THE 21ST CENTURY 8 (2015).
[143] Jesse Reiblich & Eric H. Hartge, *The Forty-Year-Old Statute: Unintended Consequences of the Coastal Act and How They Might Be Redressed*, 36 STAN. ENVTL. L.J. 63, 85 (2016) (explaining how formation of a GHAD can help avoid this patchwork of armoring).
[144] GRIGGS ET AL., *supra* note 19, at 118 ("Several processes have been responsible for most seawall damage or failures of the past, including overtopping, undermining, outflanking, and wave or debris battering or impact.").
[145] MELIUS & CALDWELL, *supra* note 141, at 9.
[146] *Id.* at 10.

up—such as those with a high amount of valuable infrastructure—and areas that have no surrounding beaches nearby.

Example: California's coastline features over 100 miles of seawalls or other protective structures.[147]

Legal Considerations: Constructing a protective seawall generally requires a CDP.[148] The Coastal Commission retains jurisdiction over most areas where a seawall would be feasible.[149] Accordingly, an applicant would need to seek a CDP directly from the Commission. On its face, the Coastal Act seems to mandate the construction of seawalls for "existing" structures, while requiring that "new development" be built in such a way so as not to require such protective structures.[150] Furthermore, seawalls are only permitted when they are the least environmentally-damaging feasible alternative.[151] Legislation banning seawalls would render the consideration of seawalls as coastal adaptation strategies moot.[152]

H. *Revetment*

Description: A revetment is a carefully engineered shoreline protection structure comprised of large rocks atop a durable filter cloth.[153]

Advantages: Revetments protect development and shorelines from wave action and erosion. They are more durable than riprap because they are engineered to last longer.[154]

Disadvantages: Revetments are large and effectively cause the "loss" of the beach they are placed over through "placement loss."[155] Revetments are not permanent, and sometimes are not very durable, especially if they are designed with inadequately sized materials.[156] Revetments can also reduce public beach access. Furthermore, revetments might require applicants to pay mitigation fees for the loss of the beach its construction and operation causes.[157]

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[147] Gary Griggs, *The Effects of Armoring Shorelines—The California Experience, in* PUGET SOUND SHORELINES AND THE IMPACTS OF ARMORING—PROCEEDINGS OF A STATE OF THE SCIENCE WORKSHOP 77, 77 (H. Shipman et al. eds., 2010).
[148] CAL. PUB. RES. CODE § 30600 (West, Westlaw through Ch. 4 of the 2017 Reg. Sess.).
[149] *Id.* §§ 30600—30601.5.
[150] *See* Cardiff, *supra* note 106; MELIUS & CALDWELL, *supra* note 141; Lester, *supra* note 98.
[151] Lester & Matella, *supra* note 53, at 31.
[152] *See supra* Section VI(B).
[153] GRIGGS ET AL., *supra* note 19, at 114.
[154] *Id.* at 112-15 (comparing revetments and riprap).
[155] *See* MELIUS & CALDWELL, *supra* note 141, at 8.
[156] *Chapter 6 – Coastal Revetments for Wave Attack*, PILEBUCK (Apr. 7, 2014), http://www.pilebuck.com/highways-coastal-environment-second-edition/chapter-6-coastal-revetments-wave-attack/ (last visited May 10, 2017).
[157] CAL. PUB. RES. CODE § 30253 (West, Westlaw through Ch. 4 of 2017 Reg. Sess.).

Suitable Locations: Revetments might be suitable where an area is eroding from wave attack and there is something important that must be protected. They are sometimes perceived as being preferable to seawalls because they can absorb wave energy, but studies have shown this not always to be the case.[158]

Example: The City of Ventura recently constructed an emergency rock revetment to protect the promenade at Ventura Beach's C-Street.[159]

Legal Considerations: Because they are often easier to engineer and build than seawalls, revetments are sometimes built under emergency coastal development permits.[160]

I. *Breakwater*

Description: Breakwaters are typically hard engineered structures designed to impede swells from reaching the shore. Traditionally, they have been seawalls that extend into the sea. Recently, there has been a push to engineer greener breakwaters, sometimes as part of living shorelines.

Advantages: A breakwater creates an artificial harbor where boats can moor and be protected from incoming wave attack. Breakwaters can be constructed to be "greener" than other hard armored structures by incorporating oyster reefs and other natural infrastructure.[161]

Disadvantages: Hard engineered breakwaters destroy surfbreaks by preventing swells from reaching beaches.[162] Even "greener" or "hybrid" breakwaters—i.e. those that combine built and nature-based strategies—may have some negative impacts on species diversity, as well as other deleterious ecological effects rivaling other engineered solutions.[163]

Suitable Locations: Breakwaters may be useful in locations where a harbor is necessary but a natural one does not exist.

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[158] GRIGGS ET AL., *supra* note 19, at 117.

[159] Paul Jenkin, *Surfers' Point Emergency Revetment*, VENTURA RIVER ECOSYSTEM (Feb. 7, 2017), http://www.venturariver.org/2017/02/surfers-point-emergency-revetment.html (last visited May 10, 2017).

[160] Emergency Coastal development permits carry their own drawbacks and legal considerations. *See* Reiblich & Hartge, *supra* note 142, at 81-89.

[161] Steven B. Scyphers et al., *Oyster Reefs as Natural Breakwaters Mitigate Shoreline Loss and Facilitate Fisheries*, 6 PLOS ONE 1 (2011), *available at* http://dx.doi.org/10.1371/journal.pone.0022396.

[162] Jesse Reiblich, *Greening the Tube: Paddling Toward Comprehensive Surf Break Protection*, 37 ENVIRONS ENVTL. L. & POL'Y J. 45, 52 (2013) ("[T]he construction of breakwaters prevents swells, and thus waves, from reaching otherwise surfable reef surf breaks and sandbar surf breaks.").

[163] Ariana E. Sutton-Grier, et al., *Future of Our Coasts: The Potential for Natural and Hybrid Infrastructure to Enhance the Resilience of Our Coastal Communities, Economies and Ecosystems*, ENVTL. SCIENCE & POL'Y 137, 141 (2015).

Example: There are breakwaters in several places in California, including Dana Point, Pillar Point Harbor,[164] Crescent City, Half Moon Bay, Los Angeles, Monterey, Redondo, San Luis, and Santa Barbara.[165]

Legal Considerations: Breakwaters face similar legal hurdles as the engineered structures above. They also typically require support from the U.S. Army Corps of Engineers.

J. *Dune Restoration*

Description: Dune restoration involves an engineered project to restore eroded dune systems.

Advantages: Dune restoration projects are nature-based strategies and possibly carry with them additional co-benefits and ecosystem services. Furthermore, they can be used to mitigate for development projects elsewhere.[166]

Disadvantages: Dune restoration projects are costly. They require a great deal of planning and study to determine whether they are suitable and environmentally permissible for a location.

Suitable Locations: Dune restoration is suitable in areas where dunes provide a higher role of protection than surrounding habitats.

Example: A dune restoration and enhancement project currently provides protection for the Monterey Bay Aquarium Research Institute (MBARI).

Legal Considerations: Dune restoration projects require a CDP. These projects might also require local governments to purchase easements on private property where they are pursued.

K. *Elevation of Structures*

Description: Elevating structures means literally moving homes or other infrastructure higher into the air.

Advantages: The main advantage of this strategy is that it puts the structure out of harm's way, at least temporarily.

Disadvantages: This is only a short-term solution. Further, the waves may continue to break on the elevated structure's foundation, and thus it could still be at risk. Additionally, the structures

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[164] Wendy Oram & Clay Valverde, *Legal Protection of Surf Breaks: Putting the Brakes on Destruction of Surf*, 13 STAN. ENVTL. L.J. 401, 403 (1994) (explaining how a breakwater eliminated the Killer Dana surf break in southern California).

[165] GRIGGS ET AL., *supra* note 19, at 533.

[166] CAL. COASTAL COMM'N, STAFF REPORT: APPEAL SUBSTANTIAL ISSUE DETERMINATION & COASTAL PERMIT (1999), *available at* https://documents.coastal.ca.gov/reports/2001/3/Th8a-3-2001.pdf.

might eventually be considered to be on state land and then the State Lands Commission (SLC) could charge rent or require the structures to be removed.

Suitable Locations: Elevation might be suitable where "accommodation" has been identified as the overarching goal.

Example: Marin County in Northern California features several homes that have been elevated high enough above the breaking waves that they appear to be on stilts.

Legal Considerations: Elevating buildings might trigger additional accommodations under the Americans with Disabilities Act.[167]

L. *Relocation of Structures and Retreat*

Description: Relocation and retreat can be treated as two discrete strategies. Retreat usually refers to a temporally-based, concerted effort to move away from the rising seas and not to build close to the shoreline.[168] Relocation of structures is an engineered solution whereby structures are physically relocated to safer locations upland. Relocation can help achieve retreat, but so can merely abandoning the coastline.[169]

Advantages: Relocation avoids the problems associated with protection, such as the environmental effects of seawalls, etc.

Disadvantages: One disadvantage is the possible displacement of whatever is currently in the areas to which the infrastructure is relocated.

Suitable Locations: Relocation or retreat is preferable for areas known to be in the crosshairs of sea level rise or other effects of climate change, especially areas where coastal environments and access are highly valued and where residents are amenable to long-term solutions. Furthermore, retreat might currently be most suitable in areas where private property is not at stake. Relocation of structures is especially useful for historic buildings.

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[167] 42 U.S.C.A. § 12101—12213 (West, Westlaw through P.L. 115-22).

[168] *See generally* ANNE SIDERS, COLUMBIA CENTER FOR CLIMATE CHANGE LAW COLUMBIA LAW SCHOOL, MANAGED COASTAL RETREAT (Oct. 2013), *available at* https://web.law.columbia.edu/sites/default/files/microsites/climate-change/files/Publications/Fellows/ManagedCoastalRetreat_FINAL_Oct%2030.pdf.

[169] Miyuki Hino et al., *Managed Retreat as a Response to Natural Hazard Risk*, 7 NATURE CLIMATE CHANGE 364, 364 (2017), *available* at http://www.nature.com/nclimate/journal/vaop/ncurrent/full/nclimate3252.html (describing managed retreat as "the strategic relocation of structures or abandonment of land to manage natural hazard risk.").

Example: The managed retreat at Surfer's Point and estuary restoration and managed retreat of Pacifica State Beach are two examples.[170]

Legal Considerations: The National Historic Preservation Act is a possible legal consideration for moving properties on the National Register of Historic Places.[171] Environmental justice considerations may also be present, especially where people are displaced.

M. *Conservation Easements*

Description: Conservation easements are agreements not to develop a piece of property in exchange for money or something else of value, such as a tax incentive.[172]

Advantages: These easements are flexible and usually cheaper than purchasing property in fee simple.

Disadvantages: Conservation easements can be less than ideal because they are sometimes fragmented or "patchworks" of protected properties.[173] There is sometimes concern that the landowners, who typically continue to hold and control the land itself, are not being environmental stewards of that land.[174] Also, some critics question the efficiency of purchasing mere easements to protect land.[175]

Suitable Locations: Conservation easements, especially agriculture properties, are attractive options for expensive coastal locations where outright purchases are not feasible.[176]

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[170] Margaret R. Caldwell & Molly Loughney Melius, *Coastal Issues*, *in* ENCYCLOPEDIA OF ENVIRONMENTAL LAW: VOLUME I CLIMATE CHANGE LAW 579, 586 (Daniel A. Farber & Marjan Peeters eds., 2016); *see also* Margaret R. Caldwell et al., *Coastal Issues*, *in* ASSESSMENT OF CLIMATE CHANGE IN THE SOUTHWEST UNITED STATES: A REPORT PREPARED FOR THE NATIONAL CLIMATE ASSESSMENT 168, 195 n.4 (Gregg Garfin et al. eds., 2013). *Southwest Climate Change Assessment Report*, Chapter 9, COASTAL ISSUES, Endnote iv, p. 195.

[171] 54 U.S.C. § 300101 *et seq* (West, Westlaw through P.L. 115-24).

[172] Federal tax benefits are available for donated conservation easements under 26 U.S.C.A. §170(h)(1) (West, Westlaw through P.L. 115-22).

[173] JUSTIN GUNDLACH & P. DANE WARREN, LOCAL LAW PROVISIONS FOR CLIMATE CHANGE ADAPTATION 9 (2016) ("Like land acquisition, however, conservation easement programs can result in a fragmentary approach to improving climate adaptation.").

[174] Kathe Tanner, *Hearst Ranch Conservation Project Marks 10-year Anniversary*, THE TRIBUNE, Feb. 18, 2015, http://www.sanluisobispo.com/news/local/community/cambrian/article39512742.html (last visited May 10, 2017). This concern can be alleviated by ensuring that the state or NGO holding the easement performs routine monitoring. This might be accomplished by including monitoring requirements in the contract.

[175] *See, e.g.*, Nancy A. McLaughlin, *Amending Perpetual Conservation Easements: A Case Study of the Myrtle Grove Controversy*, 40 U. RICH. L. REV. 1031 (2006); *see also* Duncan M. Greene, *Dynamic Conservation Easements: Facing the Problem of Perpetuity in Land Conservation*, 28 SEATTLE L. REV. 883 (2005).

[176] The Coastal Act prioritizes protection of agricultural land for agricultural uses, making these coastal properties especially apt for conservation easements. CAL. PUB. RES. CODE § 30241 (West, Westlaw through Ch. 4 of the 2017 Reg. Sess.) ("The maximum amount of prime agricultural land shall be maintained in agricultural production to assure the protection of the areas' agricultural economy . . . .").

Example: One example is Hearst Ranch, a $95 million deal between California and the Ranch to conserve lands west of Highway 1 in San Luis Obispo County.[177]

Legal Considerations: California law defines the requirements and limitations on conservation easements.[178] Only certain nonprofit and governmental organizations are permitted to acquire and hold conservation easements.[179] California law also features specifically agricultural conservation easements.[180] There are specific legal requirements for conservation easements to qualify for tax incentives.

N. *Special Assessments for Remaining Hazardous Areas*

Description: Special assessments are charges levied on property to pay for benefits received from some local improvement.[181] For instance, the fees might be used to construct a seawall or to implement a nature-based strategy to protect a community or condominium development from coastal hazards.[182]

Advantages: Special assessments localize the cost of risky behavior, such as remaining in hazardous areas. They can also provide funding for a project that would not be able to be funded by any single property owner.

Disadvantages: The terms and amount of the special assessment might be onerous, especially for poorer property owners or those who reap less of a benefit than others but still have to contribute the same amount as those who benefit more from the project. Additionally, special assessments might be used to armor or otherwise protect an area when retreat might be the better long-term option.

Suitable Locations: Special assessments are most applicable to condominium developments or in areas that have been designated as geological hazard abatement districts (GHADs).[183]

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[177] CALIFORNIA NATURAL RESOURCES AGENCY, THE HEARST RANCH CONSERVATION PLAN, *available at* http://resources.ca.gov/hearst_ranch.html.
[178] CAL. CIV. CODE § 815.2 (West, Westlaw through Ch. 4 of the 2017 Reg. Sess.).
[179] *Id.* § 815.3.
[180] CAL. PUB. RES. CODE §§ 10200-10277 (West, Westlaw through Ch. 4 of the 2017 Reg. Sess.).
[181] BARCLAY & GRAY, *supra* note 86, at 362; *see also Silicon Valley Taxpayers' Ass'n., Inc. v. Santa Clara Cty. Open Space Auth.*, 187 P.3d 37, 45 (Cal. 2008) (explaining that "[t]he rationale of special assessment[s] is that the assessed property has received a special benefit over and above that received by the general public.") (citations omitted).
[182] A Geological Hazard Abatement District (GHAD) could be the assessing governmental authority, for instance. *See infra* Section VI(P).
[183] *See* CAL. PUB. RES. CODE § 26525 (West, Westlaw through Ch. 4 of the 2017 Reg. Sess.) ("A geologic hazard abatement district may be formed pursuant to this division for the following purposes: (a) Prevention, mitigation, abatement, or control of a geologic hazard. (b) Mitigation or abatement of structural hazards that are partly or wholly caused by geologic hazards.").

Example: One example is the cliff stabilization project in Ocean Beach, California to protect condominiums there.[184]

Legal Considerations: California law dictates how emergency assessments are levied in common interest developments.[185] GHADs carry with them their own set of legal considerations.[186]

O. *Catastrophe Bonds*

Description: Catastrophe bonds are insurance schemes that offer more risk-bearing capacity than traditional insurance policies. These bonds are a mechanism for creating reinsurance for a set time period in a specific location.[187] Under a catastrophe bond, if a certain disaster event occurs during the period of the bond, the proceeds of it are liquidated to pay the reinsurance claims.[188] The seller is betting that the disaster will not occur, and that instead they will be repaid the face amount and interest.[189] Alternatively, the buyer is betting the disaster will occur.[190] "The bond seller is effectively acting as an insurance company collecting the equivalent of premiums but having to pay out if the catastrophe occurs."[191]

Advantages: Catastrophe bonds can help coastal governments hedge their bets when funding and insuring critical infrastructure. They can also attract additional capital into the pool of reinsurance funds—capital that can be used to finance adaptation.[192]

Disadvantages: Catastrophe bonds might end up losing money for the entity offering them if multiple unexpected catastrophes occur. They are also notoriously hard to value.[193] There is also

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[184] Marty Graham, *Property Owners to Shore up Bermuda Beach Bluff*, SAN DIEGO READER, Dec. 2, 2016, http://www.sandiegoreader.com/news/2016/dec/02/stringers-property-owners-pay-keep-bermuda-beach/# (last visited May 10, 2017) ("The 14-unit building on Bermuda Street was at the heart of creating a special assessment district called the Oceanus Geological Hazard Assessment District in 2010 to save up for precisely this kind of emergency, according to city documents.").

[185] CAL. CIV. CODE § 5610 (West, Westlaw through Ch. 4 of 2017 Reg. Sess.).

[186] *See infra* Section VI(P).

[187] Charles S. Colgan, *The Economics of Adaptation to Climate Change in Coasts and Oceans: Literature Review, Policy Implications and Research Agenda*, 3 J. OCEAN AND COASTAL ECONOMICS 1, 22 (2016).

[188] *Id.*

[189] *Id.*

[190] *Id.*

[191] *Id.*

[192] *Id.* at 23 (explaining that ("[t]he parties to the catastrophe bond have a mutual interest in avoiding the conditions requiring the bond be used to pay claims and, to the extent those conditions are defined by damage size parameters, both have an interest in using some of the bond proceeds to invest in damage-reducing adaptations.").

[193] Mike McDonald, *Cat Bonds Are The Cutest Way to Invest In The Apocalypse*, DEALBREAKER (Feb. 22, 2017, 11:56 AM), *available at* http://dealbreaker.com/2017/02/mike-mcdonald-catastrophe-bonds/.

inherent moral drawback to "financializing storms."[194] Finally, it is impossible to predict catastrophes, making them an uncertain investment offering.[195]

Suitable Locations: Catastrophe bonds are perhaps most appropriate to insure expensive critical infrastructure.

Example: New York's Metropolitan Transportation Authority, which operates New York City's subways, bridges, tunnels and bus systems, began selling a $125 million catastrophe bond to cover damage from future storms. [196]

Legal Considerations: Catastrophe bonds are typically offered by foreign reinsurance companies in the Cayman Islands or the Bahamas.[197]

P. *Formation of a Geological Hazard Abatement District (GHAD)*

Description: A Geological Hazard Abatement District (GHAD) is a special district formed to prevent, mitigate, abate or control some geologic hazard.[198] In the realm of coastal adaptation, GHADs are formed in response to actual or threatened coastal hazards.[199]

Advantages: The formation of a GHAD allows a community to protect itself and provides a way to pay for the chosen protection method or structure. GHADs function as governmental units, which provide them a great deal of freedom and power.

Disadvantages: GHADs can be costly to form and maintain.[200] GHADs are not democratic.[201]

Suitable Locations: GHADs might be most suitable in areas where a community shares a common goal for coastal protection.[202]

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[194] Michael Lewis, *In Nature's Casino,* N.Y. TIMES MAGAZINE, Aug. 26, 2007, *available at* http://www.nytimes.com/2007/08/26/magazine/26neworleans-t.html?pagewanted=print.

[195] *Id.* ("Catastrophe risk is fundamentally different from normal risk. It deals with events so rare that experience doesn't help you much to predict them. How do you use history to judge the likelihood of a pandemic killing off 1 in every 200 Americans? You can't. It has happened only once. (The Spanish flu epidemic of 1918.) You lack information. You don't know what you don't know. The further out into the tail you go—the less probable the event—the greater the uncertainty. The greater the uncertainty, the more an investor should be paid to live with it.").

[196] Sarah Mortimer, *New York's MTA to sell $125 million 'catastrophe' bond*, REUTERS (July 15, 2013, 5:37 PM), *available at* http://www.reuters.com/article/us-mta-bond-idUSBRE96E0WT20130715.

[197] Colgan, *supra* note 191, at 22 ("Catastrophe bonds are a means to create reinsurance for a short period in a specific area. The bond is issued through a 'special purpose vehicle' (SPV) under the laws of countries such as the Bahamas or Grand Cayman Islands.").

[198] CAL. PUB. RES. CODE § 26525 (West, Westlaw through Ch. 4 of the 2017 Reg. Sess.).

[199] *Id.* § 26507 ("'Geologic hazard' means an actual or threatened landslide, land subsidence, soil erosion, earthquake, fault movement, or any other natural or unnatural movement of land or earth.").

[200] *See* Gary Taylor, *Neptune Avenue on Edge*, CALIFORNIA COAST & OCEAN, Spring 1996, at 18, 21, *available at* http://scc.ca.gov/webmaster/coast_ocean_archives/1201.pdf.

[201] Instead, property owners have more clout and voting power based on their property's assessed value. *Id.* at 21-22.

Example: Broad Beach Geological Hazard Abatement District is one such example. This GHAD is comprised of 123 members who are homeowners in the Broad Beach area of Malibu, California. The GHAD was formed to perform permanent dune and beach restoration along Broad Beach.

Legal Considerations: Under California law, GHADs are formed in one of two ways: (1) a petition signed by at least 10% of the landowners within the proposed district; or (2) by resolution of the legislature.[203] GHADs are not subject to CEQA requirements.[204] They have also been a controversial topic in California for several reasons, as discussed.[205]

VII. A PRAGMATIC PATH FORWARD

We have identified specific enabling and limiting conditions for coastal adaptation, as well as specific strategies and examples of those strategies. This information can assist planners with coastal adaptation decision-making. Mapping and modeling sea level rise and other effects of climate change are important tools for local planners proactively dealing with climate change. Yet these scenario-based tools are only part of the process. Coupling these tools with other spatial factors help filter adaptation strategies to those that are feasible in a certain location. Additionally, considering factors that are not specifically spatially dependent helps determine the suitability of strategies for specific locations. These factors will vary from location to location, both because of varying physical place-based limitations but also because of unique local characteristics and values. To unearth these unique factors, engaging local residents and experts is key. There is no substitute for the unique local knowledge about the suitability and feasibility of particular adaptation strategies in particular locations. Furthermore, lessons learned from existing examples of coastal adaptation strategies should inform decision-making. Taken together, scenario-based modeling, mapping spatial factors, evaluating non-spatial factors, and considering lessons learned from past projects will allow local decision-makers to confidently and proactively face rising seas, flooding, and other effects of a changing climate. This approach allows decision-makers to compare the respective costs, benefits, and tradeoffs of choosing one strategy over another. This decision-making framework is applicable in broader adaptation planning frameworks or it can independently inform decision-makers.

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[202] However, the interests of a GHAD might not align with those of the broader community. For example, the GHAD might protect houses in a way that puts a neighboring community beach at risk.

[203] CAL. PUB. RES. CODE § 26550.5 (West, Westlaw through Ch. 4 of the 2017 Reg. Sess.) (outlining GHAD "proceedings for formation.").

[204] *Id.* § 21080(b)(4) (declaring that CEQA requirements do not apply to "[s]pecific actions necessary to prevent or mitigate an emergency."); *id.* § 26601 (Westlaw) (clarifying that "[i]mprovement caused to be undertaken pursuant to this division, and all activities in furtherance thereof or in connection therewith, shall be deemed to be specific actions necessary to prevent or mitigate an emergency within the meaning of paragraph (4) of subdivision (b) of Section 21080.").

[205] *See supra* notes 200-202.

VIII. CONCLUSION

Smart coastal adaptation will require proactive planning that takes into account the entire coastline and the goals and priorities of the local governments along the coast, as well as the existing local knowledge that can inform the decision-making process. Coastal communities can plan for climate change and its effects—such as rising seas, flooding, and saltwater inundation—by embracing the best available scientific modeling available. These models can inform the decision-making processes, but should be coupled with place-based considerations of the enabling and limiting conditions present. In addition, legal requirements under the Coastal Act and other laws can both inform and complicate adaptation planning. A robust decision-making process must incorporate all of these factors and consider the tradeoffs when choosing between possible adaptation strategies. By considering the relative enabling and limiting conditions of competing strategies and locations, decision-makers can more effectively plan for climate change, despite an uncertain future and limited resources.