Evaluating Offshore Wind Energy Feasibility off the California Central Coast

Final Report

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A Group Project submitted in partial satisfaction of the requirements for the degree of
Master of Environmental Science and Management for the
Bren School of Environmental Science & Management
by

Luke Feinberg, Zach Jylkka, Mengya Tao, Ben White, and Yingda Xu

Committee in charge:
Bruce Kendall

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TABLE OF CONTENTS

Signature Page i

Acknowledgements ii

Abstract iii

Executive Summary iv

1.0 Introduction 1
  1.1 Significance of the Project 3

2.0 Background and Literature Review 4
  2.1 Technology Development 4
  2.2 Environmental Impacts 7
  2.3 Economic and Financial Viability 9
  2.4 U.S. Department of Energy 12

3.0 Stakeholder Analysis 13
  3.1 Introduction 13
  3.2 Methods 13
    3.2.1 Stakeholder Identification 13
    3.2.2 Public Survey 14
    3.2.3 Key Stakeholder Interviews 18
  3.3 Survey Results 20
    3.3.1 Descriptive Statistics 20
    3.3.2 Statistical Relationships 25
    3.3.3 Multivariate Statistical Analysis 26
    3.3.4 Key Stakeholder Interviews 29
    3.3.5 Limitations and Recommendations for Future Research 29
    3.3.6 Conclusions 29

4.0 Spatial Analysis 31
  4.1 Introduction 31
  4.2 Marine Spatial Planning for Offshore Renewable Energy Development 31
  4.3 Stakeholder Considerations for the CalWind Region of Interest 33
    4.3.1 Department of Defense (DoD) 33
    4.3.2 Developer 34
    4.3.3 Environmental Concerns 34
    4.3.4 Commercial Fisheries 36
    4.3.5 Other Stakeholder Considerations 36
  4.4 Methodology 37
    4.4.1 Assumptions for GIS-MCDA Model 37
    4.4.2 GIS-MCDA Model 39
  4.5 Results and Discussion 41

4.5.1 Pairwise Tradeoff Plot 44
4.5.2 Sample Viewshed Analysis 45
4.6 Marxan Analysis 47
4.6.1 Introduction 47
4.6.2 Methods 47
4.6.3 Results 49
4.7 Limitations & Recommendations for Future Research 50
4.8 Conclusions 51
5.0 Permitting Offshore Wind Development in California 53
5.1 Introduction 53
5.2 Information Sources 54
5.2.1 Assumptions 54
5.3 Permitting Pathway Overview 54
5.3.1 Jurisdictions 56
5.3.2 Overview of Federal Permitting 58
5.3.3 Overview of California State Permitting 63
5.3.4 Overview of Local Permitting 66
5.3.5 Developer's Role in the Permitting Process 66
5.4 Discussion 67
5.4.1 Disproportionately Represented Entities 67
5.4.2 Considerations of Viewshed Impacts on the Permitting Process 69
5.4.3 Uncertainty in the Permitting Process 70
5.4.4 Data and Information Gaps 70
5.4.5 State and Federal Coordination Efforts 71
5.5 Synthesis of the Permitting Process for the General Public 72
5.6 Conclusions 75
6.0 Project Conclusions 76
7.0 References 77

APPENDICES

Appendix A: Stakeholder Analysis
A-1: Survey Instrument
A-2:21 pairs of two survey variable comparisons for chi-square test
A-3: Survey Category Recoding For Statistical Test
A-4: Interview Questions
A-5: Response Summary Questionnaire
A-6: Cramer's V and Gama Results
Appendix B: Spatial Analysis
Appendix C: Navigating the Offshore Wind Energy Permitting Pathway
Appendix D: Benefit Cost Analysis: Economic Feasibility of Offshore Wind Energy Development on the California Central Coast

LIST OF FIGURES

Figure 1-1: Region of Interest

Figure 3-1: Responses to the question “In your opinion, what is the most important energy issue facing the Central Coast region?”

Figure 3-2: Response to the question “What do you consider to be the most important aspect of where your energy comes from?”

Figure 3-3: Based on what you know now, would you support or oppose offshore wind energy in Santa Barbara County and/or Ventura County?

Figure 3-4: Comparison on “How much do you know about offshore wind energy?” and “Based on what you know now, would you support or oppose offshore wind energy in Santa Barbara County and/or Ventura County?”

Figure 3-5: Most and least preferred locations for offshore wind energy development

Figure 3-6: Most and least preferred locations map

Figure 3-7: Response to “How much more would you be willing to pay on your monthly electric bill to support offshore wind energy?”

Figure 3-8: Do you use the ocean for personal recreation? If so, primarily for what?

Figure 4-1: Hypothetical Wind Farm Footprint

Figure 4-2: Example Pairwise Tradeoff Analysis

Figure 4-3: GIS-MCDA Output for Four Hypothetical Weighting Scenarios

Figure 4-4: Temperature and Chlorophyll Maps for Channel Island Region

Figure 4-5: Example Pairwise Tradeoff Analysis

Figure 4-6: Viewshed Approximation for Highest Scoring Development Cells

Figure 4-7: BOEM Visualization of 200 7MW Vestas Turbines 20nm from Cape Hatteras Lighthouse

Figure 4-8: Marxan Summed Solutions

Figure 4-9: Department of Defense Atlantic OCS Wind Energy “Stoplight” map.

Figure 5-1: Coastal Jurisdictions in the United States.

Figure 5-2: Flowchart of the Federal Permitting Process.

Figure 5-3: California Permitting Process

Figure 5-4: CalWind Permitting Infographic

LIST OF TABLES

Table 3-1: Organizations Contacted as Part of Survey Outreach

Table 3-2: Stakeholder Interview List

Table 3-3: The Cramer's V test results for 1 pair of nominal survey variables and the Gamma test results for 6 pairs of ordinal survey variables with the test of statistical significance.

Table 3-4: Definition of variables in binary logistic regression.

Table 3-5: ANOVA table of possible factors influencing support. AIC=212.1

Table 3-6: Binary logistic regression of factors influencing support in the best model scenario.

Table 4-1: Multi-Criteria Decision Analysis Variables and Scores

Table 4-2: Weighting Scenarios for MCDA

Table 4-3: Marxan Input Files

Table 5-1: Possible Required Government Approvals for OSW Development

Table 5-2: Federal Approvals

Table 5-3: State Approvals

Table 5-4: Electrical Infrastructure Permitting Requirements

Signature Page

As authors of this Group Project report, we are proud to archive this report on the Bren School's website such that the results of our research are available for all to read. Our signatures on the document signify our joint responsibility to fulfill the archiving standards set by the Bren School of Environmental Science & Management.

Luke Feinberg

Zach Jylkka

Mengya Tao

Ben White

Yingda Xu

The mission of the Bren School of Environmental Science & Management is to produce professionals with unrivaled training in environmental science and management who will devote their unique skills to the diagnosis, assessment, mitigation, prevention, and remedy of the environmental problems of today and the future. A guiding principal of the School is that the analysis of environmental problems requires quantitative training in more than one discipline and an awareness of the physical, biological, social, political, and economic consequences that arise from scientific or technological decisions.

The Group Project is required of all students in the Master of Environmental Science and Management (MESM) Program. The project is a three-quarter activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Group Project Final Report is authored by MESM students and has been reviewed and approved by:

Bruce Kendall

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Abstract

If offshore wind (OSW) is to contribute to California's renewable energy goals, government agencies, developers, and the public must first understand the industry's feasibility in all coastal regions. Out of mutual interest in locally reducing fossil fuel use and expanding renewable energy production, the clients proposed this project to explore the potential of OSW off San Luis Obispo, Santa Barbara, and Ventura Counties (the region of interest, or ROI). The 'CalWind' team has spent the last year working toward this objective. The breadth of topics associated with wind energy development in California's marine environment is substantial, and performing robust studies of all OSW feasibility variables was beyond the scope of a one-year project. Therefore, CalWind focused on three facets of feasibility:

1) Stakeholder perceptions
2) Spatial analysis of wind resources and conflicting uses
3) Permitting pathways

Interviews and a public survey identify key stakeholders and show that the majority of survey respondents are supportive of OSW. However, concerns arise around possible viewshed and avian impacts. Next, commercially exploitable wind resources exist in the ROI, but spatial analyses indicate that conflicts will likely occur between OSW development and current uses of the marine environment. Lastly, the permitting process for OSW is complex and untested. The team mapped this process and concludes that regulatory synergies could be enhanced through inter-agency cooperation. Limiting consideration to the factors analyzed in this project, OSW development in the ROI is theoretically feasible, but significant development barriers currently restrict industry advancement.

Executive Summary

Increasing concentrations of anthropogenic greenhouse gases in the earth's atmosphere and associated climate change impacts have catalyzed a global paradigm shift in energy production. Specifically, concerns are rising about how future energy needs will be met with decreased exploitation of fossil fuels. Renewable energy offers the potential to meet increasing energy demands with significantly less carbon output than conventional power sources. While many forms of renewable energy have the potential to satisfy future energy requirements, onshore wind and solar power have received the greatest investment to date in the United States. At the end of 2012, California ranked second among all states (behind only Texas) in installed wind power capacity with 5.549 Gigawatts (GW).[1] However, none of that wind power is being generated offshore.

With mutual interest in reducing fossil fuel use and greenhouse gas emissions in the Santa Barbara area, the Community Environmental Council[2] and Infinity Wind Power[3]sponsored this project with the goal of exploring the feasibility of offshore wind (OSW) energy generation off the California Central Coast. Five Bren master's students (the 'CalWind' team) worked on this project from April 2013 to March 2014; our findings, conclusions and recommendations are included in this final report.

Background on Offshore Wind in California

The total estimated potential for U.S. OSW power is 4,223 GW, approximately 655 GW of which is located off the shores of California. This quantity of energy is almost double California's current electrical demand.[4,5] California's Renewable Portfolio Standard (RPS), codified by Senate Bill 2 in 2011, requires that 33 percent of state electricity sales be sourced from renewable energy production by the end of 2020.[6]As of 2012, the state's three major electrical utilities served 19.9 percent of their retail sales with renewable energy.[7] To reach the 33 percent goal, California would be remiss to ignore its vast offshore wind resources.

The effectiveness of offshore wind technology has been well demonstrated in Europe, particularly in the shallow areas off of the United Kingdom and in the Baltic Sea. Conditions differ off the California coast, where the Pacific Outer Continental Shelf (OCS)

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[1]"Wind Powering America: U.S. Installed Wind Capacity."

[2] Community Environmental Council (CEC) is a Santa Barbara based non-profit with the mission to identify, advocate, raise awareness, and develop effective programs to solve the most pressing environmental issues that affect the Santa Barbara region.

[3] Infinity Wind Power is a wind energy project developer with a specific focus on developing projects and moving them to market. Infinity's headquarters are in Santa Barbara, CA.

[4]Anthony Lopez, Billy Roberts, Donna Heimiller, Nate Blair, and GianPorro, *U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis*.

[5]Dvorak, Archer, and Jacobson, "California Offshore Wind Energy Potential."

[6]"Renewables Portfolio Standard (RPS) Proceeding."

[7]"California Renewables Portfolio Standard (RPS)."

quickly drops off to waters deeper than conventional offshore platforms (e.g., monopile, jacket) can support wind turbines with economic efficiency. Therefore, floating turbine platforms will likely be necessary in the majority of potential OSW farm locations.[8] Commercial-scale floating pilot projects have been tested successfully in Portugal, Norway, and Japan, and are beginning to prove the potential of deep-water wind development.

The Bureau of Ocean Energy Management (BOEM) is the federal agency responsible for regulating renewable energy development on the OCS and issuing leases for energy development. State governors have the ability to promote intergovernmental planning and coordination by requesting a BOEM Renewable Energy Task Force. The Task Force is generally the first step in coordinating local, state, and federal agency efforts to explore and facilitate offshore renewable energy development. In the Pacific, Hawaii and Oregon both have Task Forces, which have produced a productive platform for development and designation of Wind Energy Areas (WEAs). This level of organization encourages greater developer interest and investment, as evidenced by Principle Power's WindFloat pilot project off Coos Bay, Oregon.[9]

Outside of the political realm, offshore wind development's main obstacles in California are the uncertain environmental impacts of floating offshore wind turbines on marine mammals and birds, as well as conflicting uses of ocean space and onshore visual impacts (depending on farm location).[10]

CalWind Project Objectives & Deliverables

The project's region of interest (ROI) was limited to Ventura, Santa Barbara, and San Luis Obispo Counties. Determining the overall feasibility of offshore wind energy development in the ROI requires detailed analyses of political dynamics, regulatory frameworks, electrical infrastructure, and economic, ecological, and social considerations and impacts. Performing robust studies of all of these variables was outside the reasonable scope of a one-year master's project, so we focused our efforts on three facets of offshore wind development:

1) Stakeholder perceptions of offshore wind;
2) Spatial analysis of OSW development potential and conflicting uses; and
3) Federal, state, and local permitting pathways.

Stakeholder perceptions were gained through targeted interviews with a variety of stakeholder groups and an online general public survey that was distributed throughout

[8] Dvorak, Archer, and Jacobson, "California Offshore Wind Energy Potential."

[9] BOEM, "Oregon Activities."

[10] The uncertainty in environmental impacts to birds and marine mammals stems from incomplete data on species distribution, as well as a lack of understanding of the impact of floating wind turbines on such species when their populations coincide with wind farms.

the ROI. The spatial analysis focused on a geographic information system (GIS) based multi-criteria decision analysis (MCDA) framework for the siting of commercial-scale wind farm locations. Lastly, permitting research resulted in a review of the relevant legislation, agencies, and permits at the federal, state, and local levels for both technically oriented and general public stakeholders. Our main deliverable is a documentation of these three objectives in the final report.

Objective 1: Stakeholder Analysis Methods & Results

We approached this objective by identifying key stakeholder groups that may be interested in and/or affected by offshore wind development in the ROI. This process was greatly facilitated through engagement with the Channel Islands National Marine Sanctuary Advisory Council (SAC). This community-based council brings together individuals representing agencies, tribes, local businesses/tourism, fishermen, and the general public in a public forum to consider and advise the National Marine Sanctuary on resource management issues affecting the waters surrounding the Channel Islands. We presented the project and initial results to the Council and performed interviews with the majority of SAC members. A diverse array of findings from eighteen interviews with SAC representatives and other stakeholders were used to summarize opinions on offshore wind, enhance the accuracy of the permitting analysis, and to incorporate stakeholder concerns into the spatial analysis.

The general public survey was available online from September 16, 2013 to November 30, 2013. Questions generally focused on opinions of renewable energy and offshore wind, perceived knowledge, benefits, and concerns related to the industry, and willingness to pay for potentially increased prices of renewable energy. We carried out distribution of the 24 question survey using convenience and snowball sampling through the Community Environmental Council's email listserv, an article in the Santa Barbara Independent, social media, and targeted emails to Chambers of Commerce, real estate groups, commercial and recreational fishing groups, and other potential stakeholder groups within the ROI. With an original target of 500, we collected 475 surveys responses. Analyses were limited to the 351 surveys coming from individuals residing within the ROI. The targeted nature of the sample means that it is not representative of the general population in the study area. Compared to census data, a disproportionate number of participants were white, highly educated, high-income, individuals living in Santa Barbara County.

We provided descriptive survey statistics (e.g., frequency distribution) and statistical analysis (logistic regression). A majority of respondents (67%) support offshore wind development. One question, which asked people to rank their knowledge of the offshore wind industry, revealed that increased perceived knowledge led to polarized positions of support (i.e., as individuals' self-professed knowledge increased, their opinions on offshore wind, positive or negative, grew more pronounced). Top concerns of development were not surprisingly focused on impacts to seabirds, marine mammals, and viewsheds. Respondents also overwhelmingly relayed a ‘not in my back yard’ reaction to possible wind farm locations.

The logistic regression analysis showed that residence in Santa Barbara County, gender, self-identified knowledge of OSW, and work industry significantly affect people’s support and opposition of OSW development. Females are more likely to support OSW than males, and people from Santa Barbara County are more supportive than those from other two counties. Lastly, people who work in fisheries, nonprofit/government, and real estate industry are more likely to oppose OSW projects.

Objective 2: Spatial Analysis Methods & Results
Building on the identification of primary stakeholder groups and their respective concerns regarding offshore wind development in the ROI, we gathered available spatial data to map existing ocean uses as related to sites with the highest wind speeds. Spatially explicit data do not exist (or is not publically available) to represent all stakeholder priorities and environmental variables, so we focused on a subset of considerations. Given data and resource limitations, we decided to build a basic GIS-based multi-criteria decision analysis (MCDA) framework for siting wind energy farms in the ROI. This model was then compared with a supplementary Marxan analysis.

The GIS-MCDA model incorporated the following variables:

- Wind speed and distance to onshore interconnection;
- The Department of Defense (DoD) Sea Range;
- Marine mammal presence;
- Marine bird biodiversity;
- Benthic substrate (hard or soft);
- Salmon, rockfish, halibut, sole, sablefish, and crustacean fishing grounds.

Since there are no existing plans to develop an offshore wind farm in the ROI, we developed a hypothetical scenario in which a developer is attempting to site a 198MW (33 6MW turbines) farm in a 10km x 10km area. We then converted the ROI into 100km^2 grid cells and calculated scores for every variable within each cell. The last step involved weighting individual variable scores to come up with an overall cell value (high score=high potential for development; low score=low potential for development). Weights were adjusted to represent the impact of prioritizing different stakeholder interests.

Reviewing all four scenarios together, two significant patterns emerged. First, the area directly west of Santa Barbara County (and the southern portion of San Luis Obispo County) consistently received low scores, especially when heavily weighting bird, mammal, and fishing ground variables. This observation is not coincidental, and likely results from the region’s biological importance as an ‘upwelling’ zone. The second striking pattern is the consistently high scoring cells in the northwestern portion of the

ROI. This results from the fact that this region, despite being far from shore, has high wind, is outside of the DoD's Sea Range, has a majority of soft substrate benthic habitat, low scores of marine bird biodiversity and mammal presence, and is outside of important dragging and salmon fishery areas.

Although more accurate (i.e., based more on direct observation, not interpolation), up-to-date data are needed before siting a specific project in the region, our analysis suggests that there are developable wind resources in several areas that present low levels of conflict to the existing uses of the marine environment considered in our study.

Objective 3: Permitting Analysis Methods & Results

Permitting pathways were identified by systematically reviewing relevant legislation, agencies, and permits associated with OSW development. Although few relevant case studies of OSW development in the United States exist, interviews with agency and industry representatives allowed the team to identify salient points and gain a practitioner's perspective of environmental regulations.

Analysis of the permitting pathway revealed several issues that impact the development of OSW in the ROI. Up to 28 separate approvals may be required prior to wind farm construction. Patterns of disproportionate representation emerged; some avian species have as many as four federal statutes and associated permits. By contrast, important stakeholder groups, such as First Nation tribes and commercial fishermen, are largely absent from regulatory requirements.

Furthermore, the Department of Defense (DoD) Sea Range is a unique area used as a laboratory setting for testing military equipment and is located in the ROI. DoD concerns over the effect of wind turbines on military radar systems may limit a developer's ability to obtain Federal Aviation Administration approval for projects off the Central Coast.

Regulatory burdens on OSW could be substantially reduced if the State requested the creation of a (Bureau of Ocean Energy Management) BOEM Task Force to coordinate data collection, streamline the permitting process, and coordinate stakeholder communication.

Conclusions & Recommendations

While a comprehensive feasibility analysis of offshore wind development off the California Central Coast was beyond the scope of this project, we have contributed to the public's understanding of the industry's future viability by providing analyses of stakeholder opinions and concerns, spatial suitability of wind farm locations in the region, and permitting pathways. Limiting consideration to these components, offshore wind development is theoretically feasible. A majority of survey respondents indicated support of offshore wind, commercially exploitable wind resources exist throughout much of the study area, and the permitting path, though untested, does not represent an insurmountable hurdle. However, any developer who advances efforts to permit a wind farm faces a host of 'first mover' obstacles.

Looking forward, the creation of a California offshore wind industry will require up-to-date, spatially explicit baseline data for ecological and socioeconomic variables. These data will facilitate siting of wind energy areas (WEAs) and the completion of permitting requirements. Accompanying the assemblage of this data, stakeholders and agency officials need a clearer understanding of the anticipated ecological impacts of floating wind turbine technology at all project stages (construction, operation, and decommissioning). This understanding is imperative to inform unbiased opinions and decisions that will result in the best energy development outcomes for California residents.

1.0 Introduction

The CalWind Project

Increasing concentrations of anthropogenic greenhouse gases in the earth's atmosphere and associated climate change impacts have catalyzed a global paradigm shift in energy production. Specifically, concerns are rising about how future energy needs will be met with decreased exploitation of fossil fuels. Renewable energy offers the potential to meet increasing energy demands with significantly less carbon output than conventional power sources. While many forms of renewable energy have the potential to satisfy future energy requirements, onshore wind and solar power have received the greatest investment to date in the United States. At the end of 2012, California ranked second among all states (behind only Texas) in installed wind power capacity with 5.549 Gigawatts (GW).[11] However, none of that wind power is being generated offshore.

With mutual interest in reducing fossil fuel use and greenhouse gas emissions in the Santa Barbara area, the Community Environmental Council[12]and Infinity Wind Power[13] sponsored this project with the goal of exploring the feasibility of offshore wind (OSW) energy generation off the California Central Coast. Five Bren master's students (the 'CalWind' team) worked on this project from April 2013 to March 2014; our findings, conclusions and recommendations are included in this final report.

Project Objectives

Given the location of the Bren School and the preferences of the project's clients, the region of interest (ROI) was limited to Ventura, Santa Barbara, and San Luis Obispo Counties and associated offshore waters (as shown in Figure 1-1). Determining the overall feasibility of offshore wind energy development in the ROI requires detailed analyses of political dynamics, regulatory frameworks, electrical infrastructure, and economic, ecological, and social considerations and impacts. Performing robust studies of all of these variables was outside the scope of a one-year master's project, so we focused our efforts on three facets of offshore wind development:

1. Stakeholder perceptions of offshore wind;
2. Spatial analysis of OSW development potential and conflicting uses; and
3. Federal, state, and local permitting pathways.

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the ROI. The spatial analysis focused on a geographic information system (GIS) based multi-criteria decision analysis (MCDA) framework for the siting of commercial-scale wind farms. Lastly, permitting research resulted in a review of the relevant legislation, agencies, and permits at the federal, state, and local levels for both technically oriented and general public stakeholders. Our main deliverable is the synthesis of these three objectives in the final report.

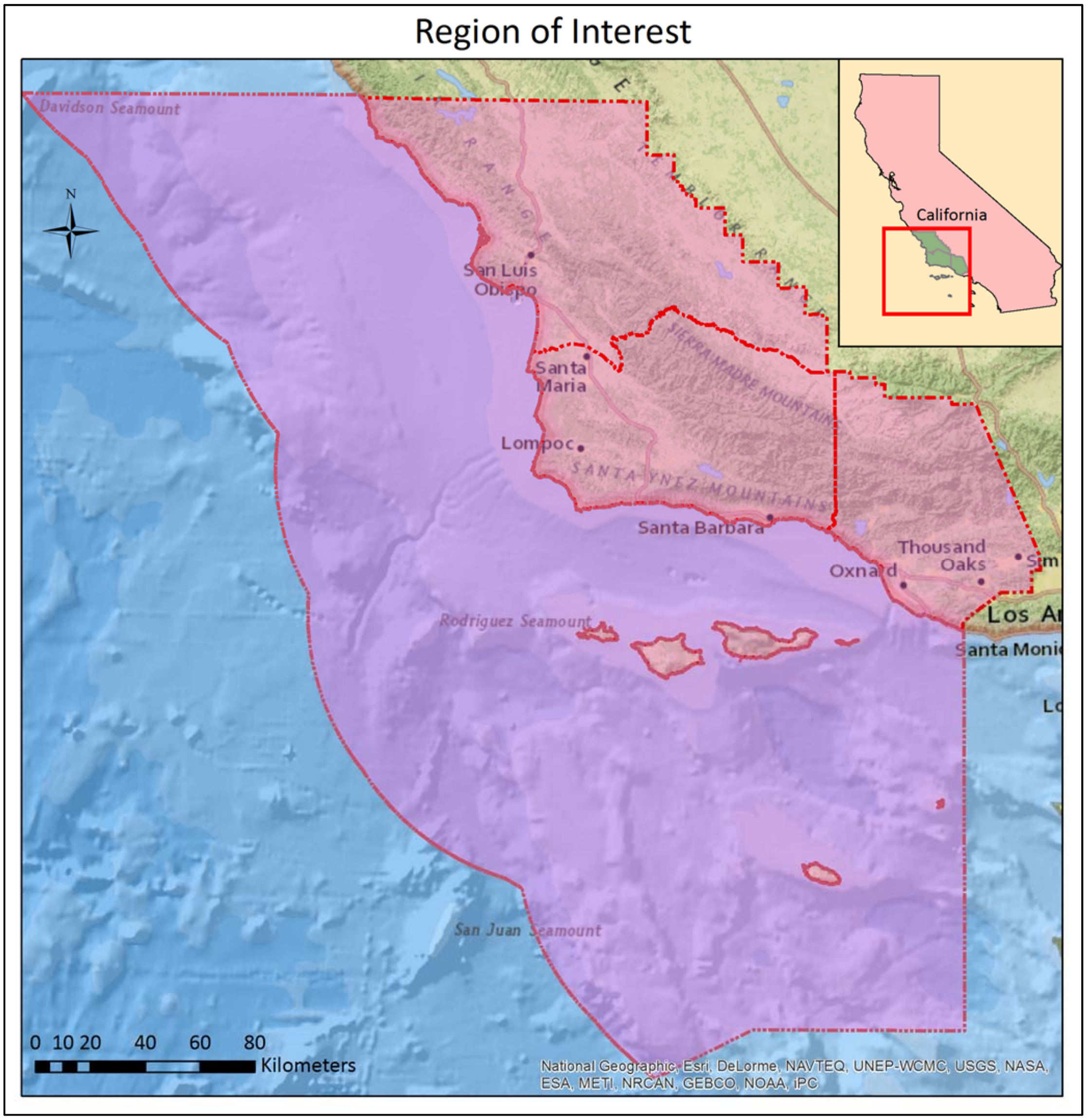

Figure 1-1: Region of Interest

Offshore Wind Assumptions for Spatial and Permitting Analyses

Currently, there are no development proposals for OSW farms in California. Therefore, conducting spatial and permitting analyses required us to generate a hypothetical development scenario. Here are our assumptions for that scenario:

1. **Floating turbine platform technology**: an offshore wind farm will occur in waters too deep for conventional (e.g., monopile or jacket structure) turbine platforms to be technologically/economically viable. Development will rely on floating turbine platforms (see Section 2.1 for more detail).
2. **33-6MW wind turbines (198MW rated capacity) in a 10km x 10km spatial array**: one of the benefits of OSW farms is the space available for larger turbine blades that are more efficient than smaller turbines. The selection of 6MW turbines reflects current industry trends for future OSW farm planning (increasing turbine size and capacity).[14] The farm size is slightly less than half that of Cape Wind (468MW) off the coast of Massachusetts, the only offshore wind farm to be permitted for construction in the United States. Turbine spacing corresponds to current literature recommendations for optimal electricity generation (see Section 4.4.1).

Several other assumptions were necessary for the spatial and permitting analyses, but are unique to those chapters, and are not discussed here.

Report Structure

In the sections that follow, we begin by presenting background information on OSW technology, environmental impacts, economic viability, and activities of the US Department of Energy. The next three chapters cover methodology, results, and conclusions for our three project objectives. We conclude the report by synthesizing project findings and providing general recommendations for parties interested in the development of an OSW industry on the California Central Coast. Several appendices provide further detail on our methodology and results, including a comprehensive summary of the statutes, regulations, and permits required for OSW as well as a simplified cost-benefit analysis of two offshore wind farm development scenarios.

1.1 Significance of the Project

The total estimated technical potential for US offshore wind power is 4,223 GW, approximately 655 GW of which is located off the shores of California, enough energy to almost double the current California electrical demand.[15,16] California's Renewable Portfolio Standard (RPS), codified by Senate Bill X1-2, requires that 33% of state electricity sales be sourced from renewable energy production by the end of 2020.[17] To reach this goal, California would be remiss to ignore its vast offshore wind resources.

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[14] European Wind Energy Association, *The European Offshore Wind Industry: Key Trends and Statistics 2013*; Department of Energy, "New Report Shows Trend Toward Larger Offshore Wind Systems, with 11 Advanced Stage Projects Proposed in U.S. Waters"; Siemens, "Latest Siemens Wind Turbine Installed at SSE in the UK."

[15] Anthony Lopez, Billy Roberts, Donna Heimiller, Nate Blair, and GianPorro, *U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis*.

[16] Dvorak, Archer, and Jacobson, "California Offshore Wind Energy Potential."

[17] "Renewables Portfolio Standard (RPS) Proceeding."

The CalWind project will assess the environmental and socioeconomic feasibility of offshore wind development on the California Central Coast. An integral element of this analysis is identifying stakeholder concerns that would influence the development of offshore wind power in this region. Summarizing relevant stakeholder opinions will allow future developers to approach projects with an appropriate level of understanding for alternative uses and values of the marine environment.

For the spatial analysis, a geographic information system (GIS) representation of the tradeoffs between ecological constraints, stakeholder impacts, regulatory boundaries, and technological limitations will be crucially important in determining the future feasibility of offshore wind development in this region. Furthermore, much of this spatial analysis may be transferable as a framework for assessing the feasibility of offshore wind energy in other regions, thus facilitating future development where desired.

The project also aims to examine potential externalities that would be caused by the installation of an OSW operation and determine the degree to which the current regulatory framework addresses those externalities. Externalities that are disproportionately represented or ignored by the regulatory process could ultimately undermine the success of future offshore wind installations.

2.0 Background and Literature Review

The objectives and deliverables of this project do not include analysis of current wind turbine technologies, potential environmental impacts, economic and financial viability or US Department of Energy activities. However, in order to fully understand the variables and issues involved in an OSW project a baseline of background knowledge is required. The following section contains a brief synopsis of the important issues concerning turbine technologies, environmental impacts, basic wind economics and the Department of Energy activities concerning OSW.

2.1 Technology Development

Offshore Wind Turbine Technology: An Overview

Generating electricity by harnessing offshore wind is not a novel concept. The first offshore wind farm was installed in Denmark in 1991. Europe has maintained a leadership role in the development and implementation of this technology, largely due to demand from coastal urban centers, limited onshore space, and the availability of exploitable wind resources in shallow waters (5-20 m).[18] The existence of economically viable wind resources in such shallow water has enabled European countries to transfer designs from land-based wind turbines to the marine environment. The United States has yet to install its first offshore wind turbine, a delay attributable to the

[18] *Technology White Paper on Wind Energy Potential on the U.S. Outer Continental Shelf*.

preponderance and cost of other energy sources (i.e., fossil fuels), vast tracts of land for onshore wind farms, a complex permitting process, and the limited space and conflicting uses for wind turbine sites in the shallow waters of the outer continental shelf (OCS).

Offshore wind turbines have both positive and negative tradeoffs compared to their land-based counterparts that warrant discussion when considering available and future technologies. Focusing first on the benefits, offshore wind farms can generally be installed closer to coastal urban centers, reducing transmission distance and onshore congestion. Secondly, offshore winds are generally stronger and more directionally consistent. Production of wind energy is proportional to the cube of the wind speed. Therefore, small increases in wind speed can result in substantially larger electricity generation. Concerning wind direction, the ocean is topographically flat relative to the land, which usually limits prevailing winds to two directions. This predictability permits more efficient spatial siting of turbines within a farm.[19] Lastly, the transport of large capacity (2 to potentially 6 MW) turbines is facilitated on water, where the width of roads and size of trucks do not inhibit the movement of large monopiles or blades.[20]

Turning to the negative implications of installing offshore wind turbines (particularly in the marine environment), ocean depths, saline water and air, and wave and wind activity during storms all pose challenges to the installation, maintenance, and decommissioning of turbines, as well as to the transmission of energy to shore. Furthermore, technology available for mounting turbines to the sea floor is constrained by depth (approximately 25m) and compared to onshore, monopile installation and transmission lines (per unit distance) are more expensive.[21,22]

Proven Turbine Foundation Technology

Three categories of offshore wind turbine foundations have been successfully installed on a commercial scale: gravity-based, monopile, and multi-leg. Gravity-based structures, limited to the shallowest waters (approximately 5m), employ large concrete or steel bases (resting on the seabed) for stability, depending on gravity to stay erect. This approach allows developers to forego most invasive substrate drilling. Monopile turbines, the most widely used design globally, are limited to depths of about 25m. Monopiles, similar to onshore turbines, require steel piles to be driven into the seafloor (10-30m below mud line, depending on ocean depth). Developers use multi-leg structures when depths exceed the range suitable for monopiles (30-50m). Designs for

[19] Ibid.; Masters, *Renewable and Efficient Electric Power Systems*.

[20] Dvorak, Archer, and Jacobson, "California Offshore Wind Energy Potential."

[21] Ibid.;*Technology White Paper on Wind Energy Potential on the U.S. Outer Continental Shelf*.

[22] Scharff and Siems, "Monopile Foundations for Offshore Wind Turbines - Solutions for Greater Water Depths."

multi-leg foundations vary, and either relies on a tripod structure or mimic the jacket (lattice) structures often utilized by the offshore oil and gas industry.[23]

All of the proven designs mentioned above share adaptations to the offshore environment, which include extra protection for the nacelle (or shell) to prevent corrosion of the gearbox and generator (e.g., high grade exterior paint), climate control (e.g., to maintain gear oil temperature), lightning protection systems, and above water lighting and bright paint (at base) to help prevent above water collisions (with both birds and vessel traffic).[24]

Developing and Future Turbine Foundation Technology

Much of the offshore wind potential in the United States exists in waters deeper than 50m, necessitating innovative floating structures to support turbines. In California, non-floating designs can provide access to enough wind energy to generate 17-31% of the state's electricity needs. Expanding this calculation to floating turbine technology, Dvorak et al. (2010) estimated that wind farm sites off the California coast (0-200m) could generate between 174% and 224% of the state's electricity needs (based on 2006 electricity use).[25] Three prevailing floating turbine designs are the floating barge or semisubmersible, the tension leg platform (TLP), and the spar buoy. Barge and semisubmersible structures maintain a shallow draft and depend on a tethered, tri-column floating platform that supports the turbine tower above the water line. TLPs use a mooring system and added buoyancy to stabilize the tower. The last model, spar buoys, is similar to TLPs, but has a much deeper tower structure draft (sometimes 100m), combined with ballast (typically concrete, rocks, and/or water).[26] A 2011 load analysis conducted by National Renewable Energy Laboratory (NREL) showed that the tri-column barge design had the highest load potential (wave and wind stress) of the three dominant designs, with negligible differences between the TLP and spar buoy structures.[27]

Two deep-water offshore wind turbines are currently operating and grid-connected in the world: the 2.3 MW Hywind (spar design) turbine in the North Sea off Norway and the WindFloat (tri-column semisubmersible) platform supporting a 2 MW turbine off Aguçadoura, Portugal.[28] These operations have been touted as successes, spurring several plans for large-scale commercial floating wind farms. Domestically, the Department of Energy funded seven offshore wind development projects in 2012, two

[23] Bureau of Ocean Energy Management, "Offshore Wind Energy BOEM"; Dvorak, Archer, and Jacobson, "California Offshore Wind Energy Potential."
[24] *Technology White Paper on Wind Energy Potential on the U.S. Outer Continental Shelf*.
[25] Dvorak, Archer, and Jacobson, "California Offshore Wind Energy Potential."
[26] Robertson and Jonkman, *Loads Analysis of Several Offshore Floating Wind Turbine Concepts*.
[27] Ibid.
[28] "Principle Power - News and Press - Press Releases"; "Hywind – the World's First Full-Scale Floating Wind Turbine."

of which involve deep-water floating turbine designs. The goal of the floating turbine projects (in Maine and Oregon) is to install commercial-scale, grid-connected floating turbines. Project leaders for the DeepCwind initiative out of the University of Maine have announced plans to begin construction and installment of the first turbine in late spring of2013.[29,30]

Other Developing Technology

Maintenance issues with offshore wind farms are always top concerns for developers. Direct-drive generator systems, which eliminate the need for a gearbox, have the potential to make offshore wind more cost-competitive with onshore facilities and other forms of energy production. Rather than depend on a gear configuration to transfer the energy produced by the blades, direct-drive systems use a steel rotor covered in coils of permanent magnets, which spin inside or around a stator, which is the stationary part of an electric rotary system (configuration depends on design). Historically, gearboxes have had frequent failures, on and offshore. The direct-drive method absolves turbines of this problem, making them up to 12 tons lighter and free of the lubrication needs associated with the gearbox. One caveat is that the generator in this system is larger, requiring installation of a wider nacelle unit.[31]

However, the permanent magnets used many direct-drive designs are constructed using rare earth metals, neodymium and dysprosium. At present, annual production of neodymium and dysprosium is limited to 18,000 and 500 tons, respectively, and 95% of the market for these metals is controlled by China. The scarcity of these resources could pose a problem in the future as offshore wind farms proliferate on a global scale.[32]

2.2 Environmental Impacts

Despite the general association between wind power and environmental benefits, careful consideration and understanding of offshore wind impacts to the coastal environment are needed. For instance, negative impacts may differ between wind farm construction and operation.[33]During construction and cable laying, noise and benthic disturbance will occur. Operations may cause long-term habitat loss or degradation, collision hazards of birds and marine vertebrates, and interference with marine animal navigation mechanisms in electromagnetic fields.[34] However, positive impacts on the marine environment stem from the potential of offshore wind farms to create artificial reefs, attract marine organisms, and increase local richness in marine fauna. The

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[29]"The Launch of the First US Floating Wind Turbine | MWII";*Maine Deepwater Offshore Wind Report: Offshore Wind Feasibility Study*.

[30]"Wind Program: Offshore Wind Technology."

[31]Fairley, "Wind Turbines Shed Their Gears"; Kleijn and van der Voet, "Scarcity: A Story of Linkages of Sustainability."

[32]Kleijn and van der Voet, "Scarcity: A Story of Linkages of Sustainability."

[33]Gill, "Offshore Renewable Energy."

[34]Inger et al., "Marine Renewable Energy."

dynamic interaction of positive and negative impacts on the marine ecosystem requires a thorough investigation to the future installation of offshore wind farms.

Inappropriate siting of wind turbines has the potential to cause harmful effects for certain taxa. At the Tuno Knob offshore wind park in Denmark, sea ducks change their flying behaviors greatly in the presence of wind turbines.[35] Their typical flight path occurs within the vertical range of the wind turbines. Since many seabirds have restricted areas to feed and live, the avoidance behavior of such marine birds in response to wind farms contributes to a reduction in habitat availability and cumulative energetic costs associated with avoidance.[36] Other studies concerning dark-night hours and conditions of poor visibility (e.g. fog and snow) indicate high risk of collision by bats with sections of turbines above water and entanglement of marine vertebrates with underwater structures.[37] Generally, wind farms have non-negligible negative impacts on bird abundance, and the cumulative impacts of longer operating wind turbines lead to a greater declines in abundance than those with short number of operating years.[38]Some actions may be taken to mitigate bird collisions, such as choosing not to site wind farms in zones with dense migration, turning off turbines at night or during adverse weather conditions, and making turbines more recognizable to birds. Even though some fixed structures may pose little collision risk, cables, power lines and other free-moving components can pose a much higher risk. However, more evidence-based studies showing biological impacts of wind farms and long-term impact assessments are required.

There have been few studies of the long-term impacts of noise from offshore wind turbines, but anthropogenic noise has been shown to impact a variety of marine organisms. Identifying the range of frequencies used by marine organisms is critical to minimize harmful construction noise. Many cetaceans utilize echolocation to find food and communicate via acoustic signals, and are very sensitive to loud noises.[39] Behavioral and physiological effects are also possible due to operational phase of wind farms. From telemetry data generated during pile driving activities, harbor seals can detect the noise and avoid the area by up to at least 40km.[40] Furthermore, high levels of anthropogenic noise in foraging areas has been shown to be detrimental to sea turtles.[41] The effects of noise may be highly variable from species to species, requiring quantitative assessment of the overall impacts of offshore wind farms.

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[35]Larsen and Guillemette, “Effects of Wind Turbines on Flight Behaviour of Wintering Common Eiders.”
[36]Masden et al., “Barriers to Movement.”
[37]Baerwald et al., “Barotrauma Is a Significant Cause of Bat Fatalities at Wind Turbines.”
[38]Stewart, Pullin, and Coles, “Poor Evidence-Base for Assessment of Windfarm Impacts on Birds.”
[39]Snyder and Kaiser, “Offshore Wind Power in the US.”
[40]Lindeboom et al., “Short-Term Ecological Effects of an Offshore Wind Farm in the Dutch Coastal Zone; a Compilation.”
[41]Samuel et al., “Underwater, Low-Frequency Noise in a Coastal Sea Turtle Habitat.”

Submarine electrical cables, such as those that transfer electricity from offshore turbines to shore, can produce electromagnetic fields (EMF) that have resulted in impacts ranging from temporary changes in swimming direction to more serious disturbance of species migration.[42] However, increases in the permeability and conductivity of the cabling armor material have been shown to reduce EMF emissions.[43]

Furthermore, the long-distance oceanic navigation of many marine animals largely depends on geomagnetic, chemical and hydrodynamic cues.[44] Studies have shown that some magneto-sensitive marine species, including bony fish, marine mammals and sea turtles, use geomagnetic field information for orientation.[45] Consequently, the magnetic component of electromagnetic fields has a negative effect on those species.

Turning to fish, offshore wind power facilities may alter the characteristics of fisheries in the surrounding area owing to construction activities, electric current and noise generation. Generally, fish aggregate under and around floating devices, to protect themselves from predators and increase the survival of eggs, larvae, and juvenile stage fish. Therefore, floating offshore wind turbines, acting as both fish aggregating devices and artificial reefs, can attract many marine organisms and increase fish densities or alter fish assemblages.[46] However, its implication on fish stocks is unclear. Since fish may concentrate around floating wind farms, the possibility of fish overexploitation is obvious. Whether wind farms can increase fish abundance in a sustainable way remains the subject of debate.

2.3 Economic and Financial Viability

The potential energy available from wind off the coast of California is immense, and if full development of this resource occurs, offshore wind can provide up to 224% of the state's electricity needs.[47] Development at this scale would turn California from an importer to a net exporter of electricity and would fundamentally alter the economics of energy in the state, home to the world's eighth largest economy. Beyond the economic effects of the transformation of the state's electricity market, the development of the offshore wind industry stands to have direct economic impacts in terms of job creation that will ripple throughout all sectors of the economy. Job creation projections associated with the growth of a renewable energy sector estimate that, "aggressive energy efficiency measures combined with a 30% RPS target in 2030 can generate over 4 million full-time-equivalent job-years by 2030…"[48] Wind energy is estimated to

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[42]Department for Buisness Enterprise and Regulatory Reform, *Review of Cabling Techniques and Environmental Effects Applicable to the Offshore Wind Farm Industry*.

[43]*A Baseline Assessment of Electromagetic Fields Generated by Offshore Windfarm Cables*.

[44]Lohmann, Lohmann, and Endres, "The Sensory Ecology of Ocean Navigation."

[45]Öhman, Sigray, and Westerberg, "Offshore Windmills and the Effects of Electromagnetic Fields on Fish."

[46]Wilhelmsson, Malm, and Öhman, "The Influence of Offshore Windpower on Demersal Fish."

[47]Dvorak, Archer, and Jacobson, "California Offshore Wind Energy Potential."

[48]Wei, Patadia, and Kammen, "Putting Renewables and Energy Efficiency to Work."

comprise approximately 5.5% of that amount, resulting in over 220,000 new jobs created by the industry directly. Large-scale development of California's offshore wind resources could ensure that these jobs are created in the state and that the associated economic benefits are realized locally.

The offshore wind industry has yet to be fully established in the United States. This lack of definition in terms of regulations, financing, personnel, and infrastructure will result in the cost of electricity generated from offshore wind to be high relative to competing methods of generating electricity. The U.S. Energy Information Administration projects that by 2018 levelized costs for electricity produced by offshore wind will be two to three times higher than for electricity produced via coal or natural gas[49], indicating that price parity is infeasible without financial support of the industry by state and federal government programs.[50] While the concept of governmental price support may be controversial, the amount of support that is required to develop the OSW industry is small relative to the support that other industries have received to pass beyond early growth phases, or that the fossil fuel industry currently receives on an annual basis.[51] Governmental support of the industry in the form of feed-in tariffs, tax incentives, or other mechanisms are estimated to be offset over the long term by increased tax revenue that will be generated by the growth of the offshore industry. As the industry matures and infrastructure, personnel, and regulations develop to accommodate it, the offshore wind industry it expected to be able to rapidly reduce costs and be capable of achieving price parity with other major forms of renewable energy, become more economical than fossil fuels in a relatively short time frame.[52] Continued innovation to incentivize the use of renewable energy development is foreseen at both the state and federal levels, with policy approaches that are successful at the state level likely to be adopted into federal-scale programs.[53]

All forms of energy production include direct and indirect costs associated with construction, maintenance, and decommissioning. The direct costs of offshore wind installations are those immediately associated with the development and operation of wind farm infrastructure, as well as the costs of electricity transmission to end-users. Government support is factored into these direct costs to arrive at a final amount. Major direct costs associated with offshore wind energy development include[54]:

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[49]U.S. Energy Information Association, "Levelized Costs of New Generation Resources in the Annual Energy Outlook 2013."
[50]Green and Vasilakos, "The Economics of Offshore Wind."
[51]Environmental Law Institute, "Estimating U.S. Government Subsidies to Energy Sources: 2002 - 2008."
[52]Schilling and Esmundo, "Technology S-Curves in Renewable Energy Alternatives."
[53]Williamson and Sayer, "Federalism in Renewable Energy Policy."
[54]Levitt et al., "Pricing Offshore Wind Power."

1. Cost of capital for project developers. OSW faces higher costs than other, more developed forms of renewable energy such as solar power due to the lack of established precedent, and therefore higher perceived capital risk.
2. Costs of permitting and leasing federal and state waters
3. Demand for products and services required for wind farm installation. If demand for OSW services, such as port facilities and boats increases, a "bottleneck" may be created by the small number of such services currently available in the U.S.
4. Technological developments in the offshore wind industry that will have direct impacts on future costs of development and operations. These technologies, such as the development of floating turbine platforms, may serve to reduce current development costs.[55,56]

Indirect costs of offshore wind energy are those that are not immediately associated with the development and operation of offshore installations. Such indirect costs can be considered externalities and may have a positive or negative impact upon individuals, groups of stakeholders, the environment, or society as a whole.

The major indirect factors affecting the full cost of delivered electricity include:

1. Economic benefits derived from job creation and increased tax revenue base
2. Economic benefits obtained from the State becoming a net energy exporter
3. Societal opportunity costs as a result of governmental support of offshore wind development.
4. Impacts to commercial fishing, shipping, and recreation opportunities.
5. Changes to land values in the viewsheds of energy development projects.[57]
6. Environmental costs associated with the entire lifecycle of offshore wind – from product manufacture to decommissioning, including impacts to ecosystems and species that may not have an economic value.[58]
7. Human health and climate benefits attributable to reduced dependence on fossil fuels.[59]

Also relevant are ongoing costs of electricity generation via fossil fuels as compared to the costs of electricity generated from offshore wind. A comparison of costs of offshore wind (which are still largely speculative in the US market) to other forms of renewables with a more established track record such as onshore wind and solar generation is important to include in order to determine the most economically viable form of

[55]Musial, Butterfield, and Ram, "Energy from Offshore Wind."
[56]Blanco, "The Economics of Wind Energy."
[57]Ladenburg and Lutzeyer, "The Economics of Visual Disamenity Reductions of Offshore Wind Farms-Review and Suggestions from an Emerging Field."
[58]Arvesen and Hertwich, "Assessing the Life Cycle Environmental Impacts of Wind Power."
[59]McCubbin and Sovacool, "Quantifying the Health and Environmental Benefits of Wind Power to Natural Gas."

alternative energy production.[60] Operational costs of existing offshore wind facilities, where available, can be used to generate such comparisons.[61]

2.4 U.S. Department of Energy

Through its Wind Program, the U.S. Department of Energy (DOE) seeks to "lead the nation's efforts to improve the performance, lower the costs, and accelerate the deployment of wind power technologies."[62] The Wind Program is heavily focused on technological innovation, industry development, and reducing market barriers to both on and offshore wind energy development. As part of the "Market Acceleration and Deployment" component of the Wind Program focuses on the following activities:

- "Partner with environmental groups and agencies to understand the impacts of wind energy on bird, bat, and insect species and their habitats
- Assist in the development of guidelines for proper wind plant siting and permitting
- Investigate and mitigate potential impacts of wind energy on society, including auditory, visual, radar, and competitive-use impacts
- Provide independent cost of energy analyses, economic assessments, and market information publications."[63]

The DOE conducts these activities through direct research and engagement as well as by providing funding to other government agencies and private sector enterprises. The net benefit of these efforts will be to fill information gaps, increase the clarity of the permitting process, and increase stakeholder engagement with the topic of OSW. For these efforts to be maximally successful, however, coordination with other federal agencies (such as BOEM, NMFS, and USFWS) and state governments should occur to minimize the duplication of efforts and to maximize the effectiveness of Department funds. The DOE's efforts are ongoing and no completion date has been established.

[60] Snyder and Kaiser, "Ecological and Economic Cost-Benefit Analysis of Offshore Wind Energy," June 2009.
[61] Weaver, "Financial Appraisal of Operational Offshore Wind Energy Projects."
[62] "Wind Program | Department of Energy."
[63] "Key Activities in Wind Energy | Department of Energy."

3.0 Stakeholder Analysis

3.1 Introduction

Our first step in evaluating the feasibility of offshore wind (OSW) development was to conduct a stakeholder analysis. Here, we define stakeholders to be those who can affect or will be affected by a decision.[64] In this case, the decision would be whether or not to pursue OSW development off the California Central Coast. Stakeholders in this context could be anyone who lives or works in the region of interest (ROI) and would be influenced by OSW development. These groups include (but are not limited to) commercial and recreational fishers, environmental groups, energy sectors (oil and gas, renewable energy), federal, tribal, state, county and local governments, businesses (shipping, tourism, aquaculture, etc.), recreational groups, education institutions, and the Department of Defense. Consultation with stakeholder groups early in the planning phases allows permitting agencies and developers to gain a holistic understanding of the proposed project's impacts, and which of those impacts are of the greatest concern to the stakeholders. The end goal of this engagement is to formulate equitable development plans and management decisions, which minimize future conflicts.[65]

After identifying stakeholder groups who would likely be involved with and/or be affected by OSW development, we transitioned to data collection. Interested in nuanced qualitative information to fill data gaps in our permitting and spatial analyses, we conducted a range of interviews. Simultaneously, we developed and distributed an online general public survey to gain an understanding of individuals' knowledge, opinions, and concerns about the possibility of OSW development. The survey was composed of four parts, aimed at collecting information across the following categories: 1) the public's general opinions on state energy issues; 2) the public's opinions and knowledge of offshore wind energy; 3) willingness to pay for higher cost renewable energy; 4) demographics of survey respondents.

The ensuing sections illustrate our data collection methodology, results and statistical analyses, limitations, conclusions, and suggestions for further research.

3.2 Methods

3.2.1 Stakeholder Identification

Stakeholder identification began through collaboration with our client, the Community Environmental Council (CEC), as the organization has substantial experience reaching out to and engaging communities in the CalWind ROI. This work generated a long list of interest groups, organizations, businesses, and agencies. Next, we engaged the Channel

[64] Reed, "Stakeholder Participation for Environmental Management"; Freeman, *Strategic Management: A Stakeholder Approach*.

[65] Maguire, Potts, and Fletcher, "The Role of Stakeholders in the Marine Planning process—Stakeholder Analysis within the Solent, United Kingdom."

Island National Marine Sanctuary Advisory Council (SAC). Authorized by the National Marine Sanctuaries Act (16U.S.C. § 1431 et seq.), the SAC was established by the Director of the Office of National Marine Sanctuaries to advise the Channel Islands National Marine Sanctuary Superintendent on the following issues:

- "Protecting natural and cultural resources, and identifying and evaluating emergent or critical issues involving Sanctuary use or resources;
- Identifying and realizing the Sanctuary's research objectives;
- Identifying and realizing educational opportunities to increase the public knowledge and stewardship of the Sanctuary environment; and
- Assisting to develop an informed constituency to increase awareness and understanding of the purpose and value of the Sanctuary and the ONMS."[66]

SAC voting members represent the interests of following community groups: tourism, business, recreation (non-consumptive), recreational fishing, commercial fishing, education, research, conservation, the public at-large, and Chumash Indian bands. The SAC also has voting seats for the following government agencies: National Marine Fisheries Service, National Park Service, U.S. Coast Guard, Bureau of Ocean Energy Management, U.S. Department of Defense, Department of Fish and Wildlife, California Natural Resources Agency, California Coastal Commission, County of Santa Barbara, County of Ventura.

The SAC's geographic position within our ROI, largely representative body of stakeholder groups connected with the marine environment, and mission which aligned well with our research objectives provided a natural venue for us to collect data and make direct connections to stakeholders. Table 3-1 and Table 3-2 list the groups identified for our stakeholder analysis.

3.2.2 Public Survey

We completed the development of the online general public survey instrument through coursework in the Survey Design class offered at the Bren School in spring 2013. Our clients, faculty advisor, and external advisors reviewed and vetted the instrument, which are approved by the University of California, Santa Barbara Human Subjects Committee on July 30, 2013.

The survey (refer to Appendix A) was designed to obtain the public's knowledge, opinions, and concerns of OSW energy along the California Central Coast. The survey was posted online using Survey Monkey, and distributed to a list of stakeholders (see

[66] Office of National Marine Sanctuaries, *Channel Islands National Marine Sanctuary, Sanctuary Advisory Council Charter*.

Section 3.2.1 and Table 3-1). The survey link was also published through social media channels and in a *Santa Barbara Independent* article.[67]

3.2.2.1 Survey Design

We split the survey into four parts, beginning with general energy questions, and advancing to questions specific to OSW, respondents' willingness to pay, and demographics. Most questions were multiple choice, following a Likert scale, with the option to provide written comments.

Part I: Energy Sources Questions

The first part asked respondents five questions, including identification of the most important state energy issue, the most concerns of energy coming from energy source, least and most preferred energy for electricity, and top three energy sectors with the most potential for future development. To avoid biasing responses to energy questions toward renewable energies, we provided a wide range of energy generation sources as options, ranging from solar to nuclear.

Part II: Offshore Wind Energy Questions

The second part included four questions focused on OSW energy, including self-identified knowledge of OSW, positive/negative impacts, and attitudes towards OSW. This section aimed to identify stakeholder groups' main concerns related to OSW development.

Part III: Personal Preference Questions

Part III was a series of questions related to personal preferences for OSW locations and willingness to pay for electricity generated by OSW energy. The location preference questions purposefully left out major marine landmarks and conflicting uses; they were designed for respondents to provide general location preferences instead of the precise geographic locations. The questions included most/least preferred areas for OSW development, willingness to pay more for OSW generated electricity (if so, how much more, or the reason for not being willing to pay more), and average monthly electricity bills.

Part IV: Demographic Questions

The last portion of the survey was questions related to general demographic information and respondents' association with the marine environment. Answers to these questions allow us to compare opinions based on demographic factors, such as educational level, gender, location, and income level.

[67]Fastman, "Wind Power Gains Momentum: Feasibility of Turbines in the Santa Barbara Channel to Be Studied."

3.2.2.2 Pilot-Testing

Before the survey's official release online, we asked friends and colleagues unfamiliar with OSW issues to test the survey and comment on clarity and the time necessary for completion. The pilot-testing phase lasted from July 30 to August 26, 2013. 23 individuals tested the survey and provided feedback on usability, content, and survey length. The student team integrated the results of the pilot test to optimize the survey in preparation for public release.

3.2.2.3 Survey Outreach

Upon conclusion of pilot-testing, we released the survey to the general public on September 16, 2013. With a goal of obtaining 500 responses, we distributed the survey using a contact list developed in the summer of 2013 (see Section 3.2.1). The list of stakeholder groups and organizations contacted is provided Table 3-1. We also provided the survey link to SAC members and asked them to take and distribute it to the parties they represent, as well as friends and family. Additionally, the survey was posted on a recreational fishing forum (fishreports.net), as a fisherman from San Luis Obispo County indicated via email that this forum was widely used by recreational fishermen on the Central Coast (particularly Morro Bay). This approach reflects convenience sampling (reaching out to contacts within an existing network or through directed efforts), supplemented with snowball sampling (asking respondents to pass the survey along to their acquaintances).

As responses accrued, it became clear that some stakeholder groups (such as fishermen and businesses related to the ocean) and geographic locations (San Luis Obispo and Ventura Counties) were under represented. At the completion of our data-gathering phase on November 30, 2013, 475 people had responded.

Table 3-1: Organizations Contacted as Part of Survey Outreach

Allan Real Estate	Pacific Corinthian Yacht Club
Arroyo Grande Chamber of Commerce	Pacific Fishery Management Council
Bayshore Realty	Pacific Marine Renewables
Bren Corporate Partners	Pierpont Bay Yacht Club
Cal State Lands Commission	Pismo Beach Chamber of Commerce
California Department of Fish & Game)	Port San Luis Harbor District
Cambria Chamber of Commerce	Real Estate - Relators association
Carpinteria Chamber of Commerce	Sailors Energy
Carpinteria Yacht Club	San Luis Obispo Association of Realtors
CAUSE	San Luis Obispo Chamber of Commerce
Channel Islands Yacht Club	San Luis Obispo Real Estate
Channel Wind.org	Santa Barbara Association of Realtors
Chumash Environmental Director	Santa Barbara Audubon Society
Channel Islands Harbor (Oxnard)	Santa Barbara Channel Keeper
Channel Islands National Marine Sanctuary	Santa Barbara Chamber of Commerce
Commercial Fishermen of Santa Barbara	Santa Barbara Community Supported Fishery
County of Santa Barbara	Santa Barbara County Action Network
Economic Development Collaborative - Ventura County	Santa Barbara County Energy Coalition
Economic Vitality Corp – SLO	Santa Barbara County Republican Party
Environmental Defense Council	Santa Barbara Harbormaster
Fairwind Yacht Club	Santa Barbara Independent
Fund for Santa Barbara	Santa Barbara Museum of Art
Goleta Chamber of Commerce	Santa Barbara Yacht Club
Gold Coast Realty	Santa Maria Association of Realtors
Harbor Island Yacht Club	Santa Maria Chamber of Commerce
Human Subjects Coordinator, UCSB	Santa Maria Economic Commission
LOA TREE	San Luis Obispo Yacht Club
Lompoc Chamber of Commerce	So Cal Yachting Association
Lompoc Valley Association of Realtors	South Coast Realty
Morro Bay Chamber of Commerce	Surfrider
Morro Bay Commercial Fisherman's Organization	The Yacht Club at Channel Islands Harbor
Morro Bay Harbor Department	UCGBC C4
Morro Bay Realty	URS Consulting
NAVAIR Ranges	Ventura Chamber of Commerce
NAVAIR Sustainability Office	Ventura Climate Care Options Organized Locally
Offshore Wind Development Coalition	Ventura Yacht Club
Outland & Associates	Village Property
Oxnard Beach Properties	Western States Petroleum Association
Oxnard Chamber of Commerce	Wiser Capital

3.2.2.4 Data Management

All raw data were exported from Survey Monkey to Microsoft Excel (Excel). To identify our respondents by county and exclude those who were not within our ROI, raw data were filtered by the zipcode of respondents' primary residence. After the filtering process, we had 351 respondents from our ROI. We used these data to conduct our analyses.

Data were stored in secure Excel documents to prevent the release of private information. They are also stored with R scripts in R statistical software for future reference.

3.2.2.5 Data Analysis

We began analysis by performing frequency distributions of responses for each question (after dropping questions skipped by respondents).

Second, cross tabulations were conducted to explore potential interrelations between a set of two survey questions. In total, 21 pairs two-survey-question tabulations were formed to analyze the underlying variables that may have influenced respondents' self-identified knowledge of OSW, attitudes toward OSW, and willingness to pay more for electricity generated by OSW energy (Appendix A-2). Next, we employed Chi-square tests to test the null hypothesis of no association between pairs of categorical variables (ordinal and nominal).[68] Where needed, categories were combined to ensure expected counts of at least five individuals (Appendix A-3). In cases where $P < 0.05$, we examined the strength and direction of the association in one of two ways, depending on the data type. To measure the strength of association, we calculated Cramer's V and Gamma values for nominal data and ordinal data respectively. The closer the value is to 0, the weaker the association; the closer the absolute value is to 1, the stronger the association.

Third, we used binary logistic regression to predict the likelihood of people's support or opposition towards OSW development under influential factors. The dependent variable is people's attitude toward OSW (support/oppose), and the independent variables include demographics (e.g., respondents county, income, education, age, gender, whether business depend on ocean, work industry) and the number of activities for which respondents use the ocean.

3.2.3 Key Stakeholder Interviews

Online surveys have the advantage of collecting information in a standardized format from a large population across unlimited geographic space. This process, however, did not generate data with the level of detail necessary to complete our spatial and permitting path analyses. Therefore, to gain an understanding of the nuanced opinions

[68] Rea and Parker, "Designing and Conducting Survey Research: A Comprehensive Guide."

and positions of key stakeholder groups on OSW in the ROI, we conducted a series of interviews (September 2013 to February 2014).

Two CalWind team members, one serving as a facilitator and one as a note taker, conducted each interview. Our interview schedule, which served as a general template for guiding discussions, also received approval from the University of California, Santa Barbara HSC on July 30th, 2013. Interviews lasted approximately 30 minutes, with some longer and shorter. Given the diverse backgrounds of interview participants, questions varied with each interview. The list of interview questions can be found in Appendix A-4.

We completed eighteen interviews covering eleven stakeholder groups. The detailed list is provided in Table 3-2. Though we did not interview all SAC members and alternates, students in a fall 2013 Bren School Course (ESM 257: Coastal and Ocean Policy and Management), including two CalWind members, interviewed SAC members and alternates for a class exercise related to the CalWind project. Members and alternates were asked to share their constituency or agency's stance and concerns with OSW development. The information gathered in these interviews was summarized in a public forum when students participated in a role-playing exercise as members of the SAC relaying their positions on OSW in/around the Channel. We took any new information gathered through this exercise and incorporated it, when relevant, to our understanding of stakeholder positions for the spatial and permitting analyses.

Table 3-2: Stakeholder Interview List

Organization	Stakeholder Group
Bureau of Ocean Energy Management U.S. Fish and Wildlife Service	Federal Government
California Coastal Commission California Department of Fish & Wildlife	State Government
Santa Barbara County Chumash Environmental Office	Local Government Tribal Government
U.S. Department of Defense Vandenberg Air Force Base	National Security Agency
Santa Barbara Adventure Company Santa Barbara Assembly Member	Business
Island Packers Environmental Defense Center	Recreational Group Conservation Organization
Sea Grant Program, USC Santa Barbara Audubon Society Santa Barbara Museum of Natural History	Education Institution
Urchin Fisher	Commercial Fishing
Natural Resource Group US Offshore Wind Collaborative	Energy Sector

3.3 Survey Results

3.3.1 Descriptive Statistics

3.3.1.1 Demographic Characteristics

Of the 475 survey responses, 73.8 percent were from the ROI. For those who are outside the ROI, most of them are from neighbor counties which are not off the Central Coast like Los Angeles County, Orange County and other California cities. All data analysis excluded respondents from outside the ROI. Among the ROI respondents, there were more males (59.1 percent) than females (40.1 percent). Most respondents indicated their race as Caucasian/White (88.3 percent) and the largest age group was "over 60" (26.5 percent). Respondents were generally highly-educated people with Bachelor's degrees (41.8 percent) and/or Master's or Doctoral degrees (42.9 percent). Household income was concentrated in the range of "$100,000 to $199,999" (33.6 percent). Detailed information for each question is summarized in Appendix A-5.

3.3.1.2 Part I: General Energy Sources

Renewable energy, reliance on fossil fuels and greenhouse gas emissions were most frequently chosen as the most important energy issue facing the region (Figure 3-1); combined, these three renewable energy-focused choices represent 64 percent of the sample. This is similar to the percentage of respondents who consider "impacts to the environment" to be the most important aspect of energy production (Figure 3-2). Solar energy was the most preferred, and coal the least preferred, source of electricity. Solar was most often chosen as the renewable energy source with the most potential for future development in the region (64 percent), and wind was the source with the second most potential (53 percent).

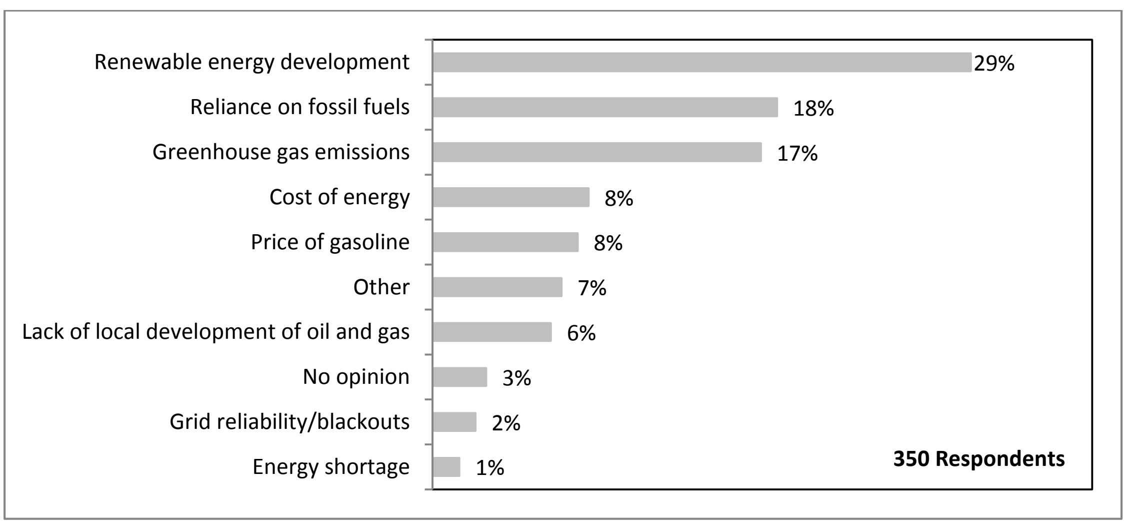

Figure 3-1: Responses to the question "In your opinion, what is the most important energy issue facing the Central Coast region?"

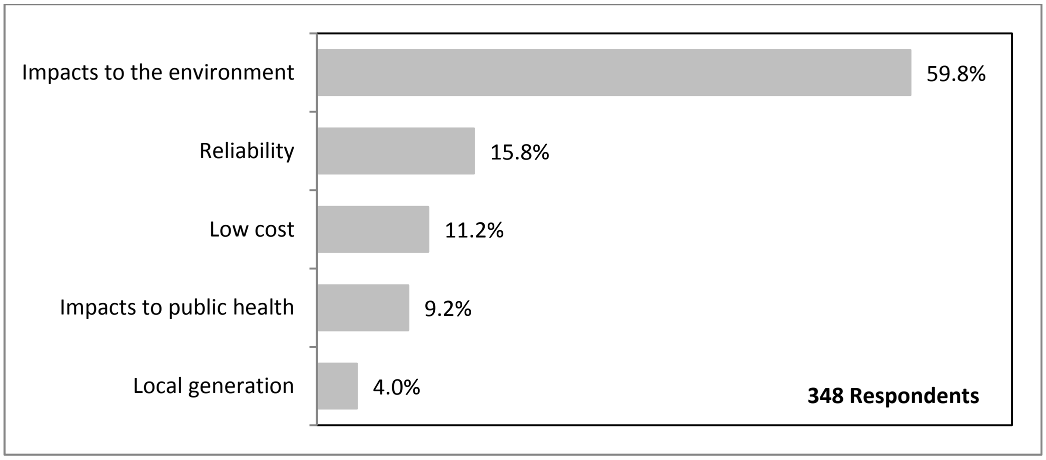

Figure 3-2: Response to the question "What do you consider to be the most important aspect of where your energy comes from?"

3.3.1.3 Part II: Offshore Wind Energy Impact

Survey results demonstrate that "Reduction of greenhouse gases"(33%), "Reduced reliance on fossil fuels"(27%), and "Supply of renewable energy"(23%) are respondents' top three potential positive impacts of offshore wind energy.

Respondents were also asked to choose potential negative impacts of OSW. Answers to this question show a focus on the balance between ecosystem and energy development. "Effect on bird species" ranks first as the most negative impact, followed by "Visual impact" and "Effect on marine species."

Next, the survey gauges support of OSW energy. A majority of respondents showed a supportive attitude (41 percent strongly support and 26 percent somewhat support) compared to those who oppose OSW (10 percent strongly oppose and 7 percent somewhat oppose) (See Figure 3-3).

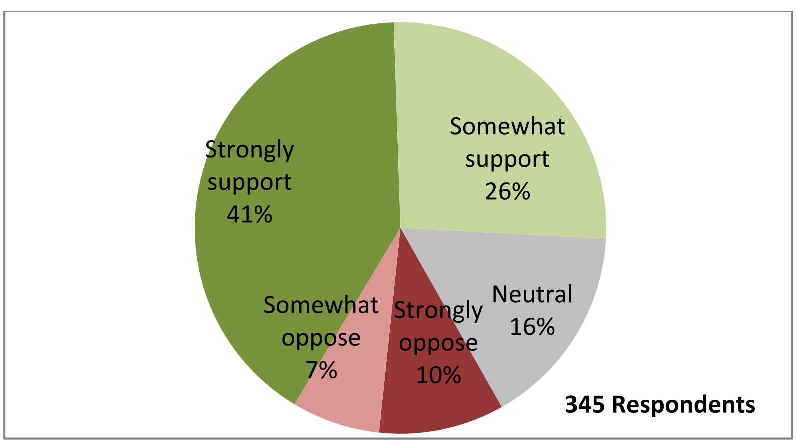

Figure 3-3: Based on what you know now, would you support or oppose offshore wind energy in Santa Barbara County and/or Ventura County?

In this section, respondents were also asked to identify their knowledge level of OSW. 43 percent of people chose somewhat knowledgeable. When we cross-tabulate knowledge level and attitudes towards OSW, the comparison produces a polarized result. As respondents' self-professed knowledge of OSW increases, the fewer people express a neutral attitude. Figure 3-4 is a mosaic plot displaying attitudinal distribution across different knowledge levels.

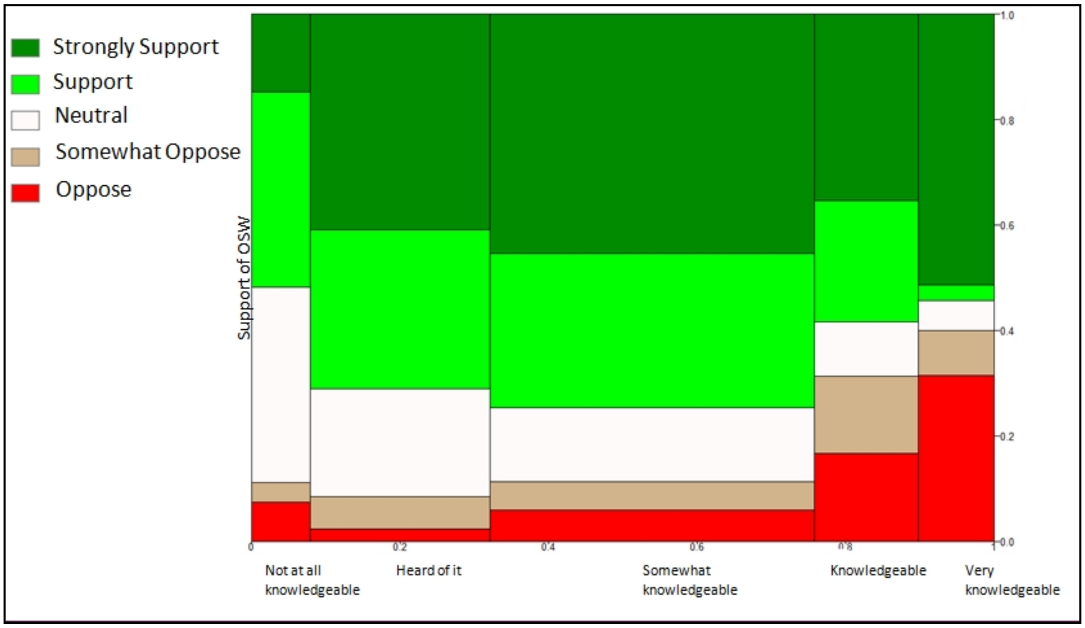

Figure 3-4: Comparison on "How much do you know about offshore wind energy?" and "Based on what you know now, would you support or oppose offshore wind energy in Santa Barbara County and/or Ventura County?"

3.3.1.3 Part III Personal preferences for offshore wind energy questions

Provided a map of the offshore environment in our ROI, we asked respondents to choose their most and least preferred areas for future offshore wind energy development. The results are summarized in Figure 3-5, and are consistent with a "Not In My Backyard" reaction (i.e., people most preferred sites that were the furthest away and least preferred sites close to shore).[69,70] This theory was further confirmed when we separate respondents by their locations, which showed the difference for preferences varying with their locations. For people from San Luis Obispo, their top least preferred areas include E, A and D, F. While for respondents from Santa Barbara and Ventura, they only choose D,E and F as the least preferred area. Since San Luis Obispo is close to area A, this result again confirmed the "NIMBY" theory.

After summing the responses of most, second most and third most preferred locations, we obtained the frequency with which each site was a top-three choice. We did the

[69] Firestone, Kempton, and Krueger, "Public Acceptance of Offshore Wind Power Projects in the USA."
[70] Wolsink, "Wind Power and the NIMBY-Myth."

same calculation for the least preferred areas, and combined these responses in Figure 3-5. To better visualize the result, a map was created to combine locations with survey results in Figure 3-5.

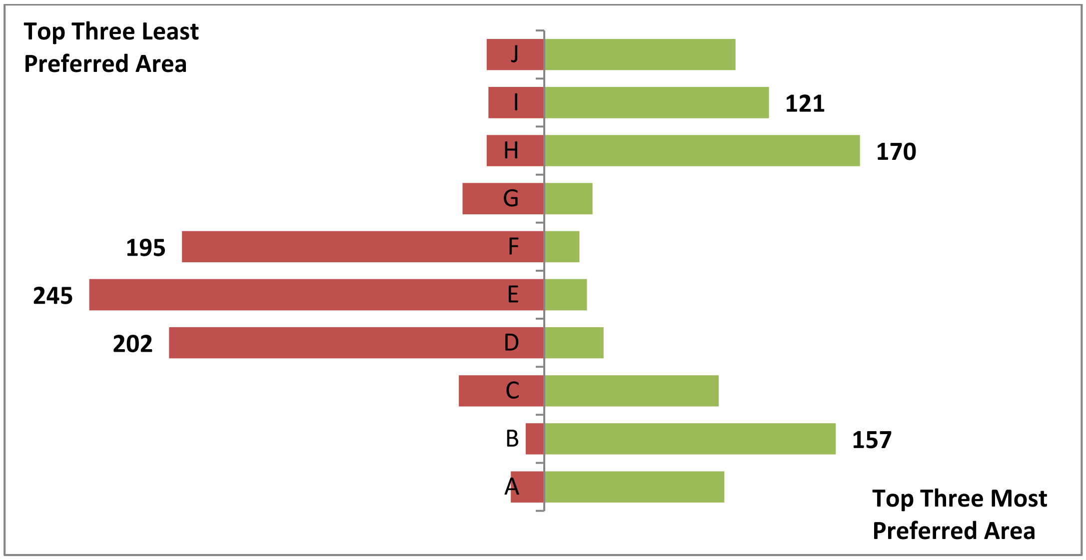

Figure 3-5: Most and least preferred locations for offshore wind energy development

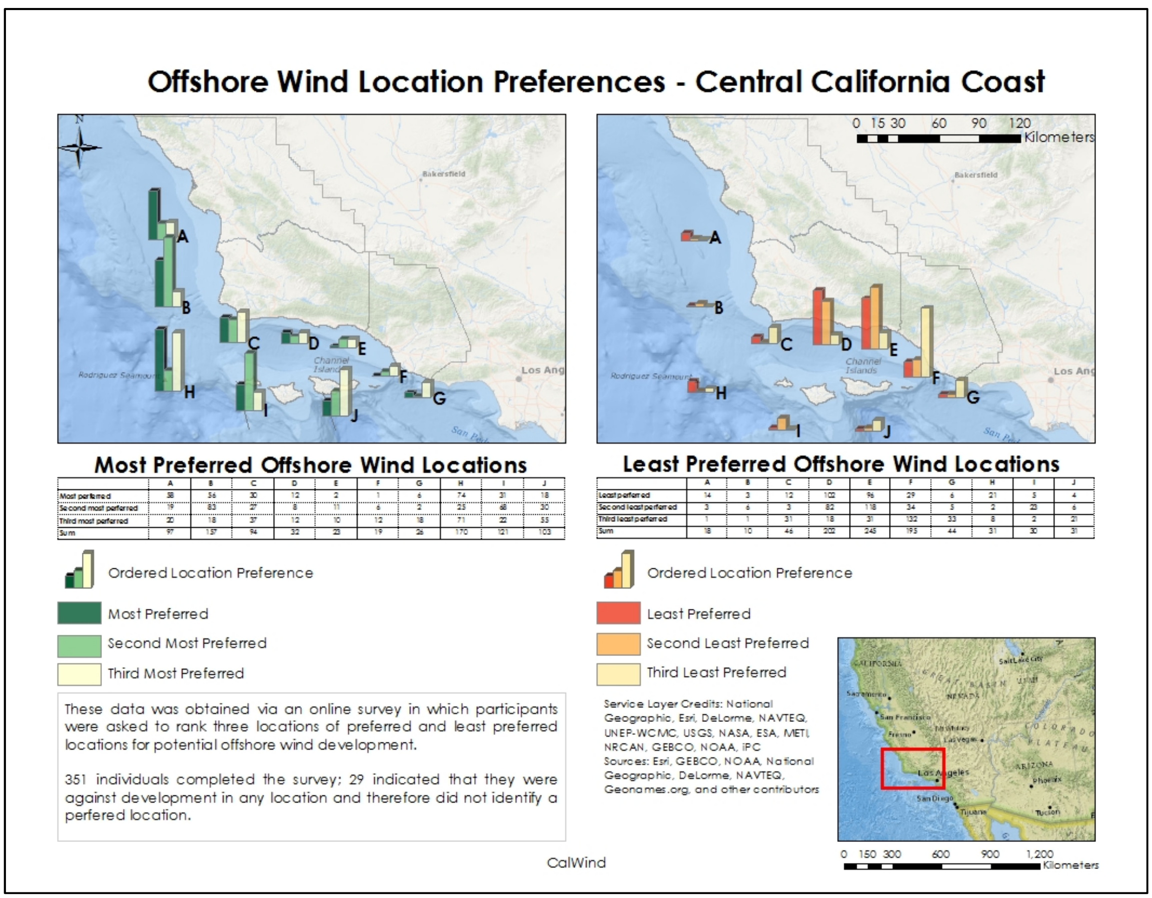

Figure 3-6: Most and least preferred locations map

Questions twelve through fifteen were a series of willingness to pay questions, addressing how respondents' attitudes change when considering possible increased costs associated with electricity generated from OSW. Below, we compare the relationship between people's willingness to pay and their average monthly electricity bill.

Around 65 percent of respondents were willing to pay more for electricity generated from OSW. Among those willing to pay more for OSW energy, a willingness to pay 5-10 percent more was the median range selected (Figure 3-7). For those not willing to pay more, respondents' primary reason was that they "simply do not want to increase the cost." The most frequently chosen (36 percent) average electric bill range was $25-50.

Multiplying the most frequently chosen electric bill range ($25-50) by the most preferred percent increase in willingness to pay (5-10 percent), we calculate that respondents are willing to pay $1.25-5 more for OSW generated electricity, per month.

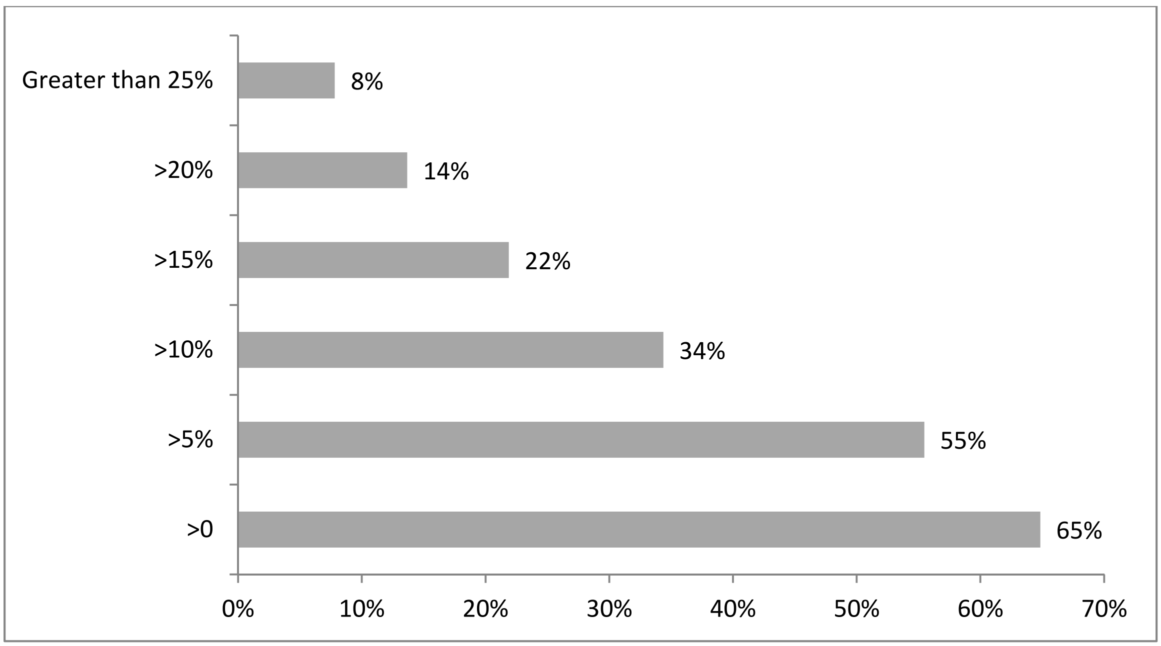

Figure 3-7: Response to "How much more would you be willing to pay on your monthly electric bill to support offshore wind energy?"

Twenty-two respondents indicated that they had a business related to ocean including commercial fishing, NGOs focusing on marine research, tourism, and real estate. 258 respondents (73 percent) indicated that they used ocean for personal recreation. Aesthetic beauty was the most frequently selected choice (81 percent), followed by swimming (48 percent), and kayaking (31 percent) (Figure 3-8). Those who only chose "aesthetic beauty" were reclassified into "I do not use the ocean for personal recreation," as we determined that this choice did not reflect active personal recreation. In total, about 24 percent of respondents do not use the ocean for active personal recreation. Some respondents also left comments for recreational activities not listed in the options, such as running, dog walking, wildlife observation, whale watching, and boating.

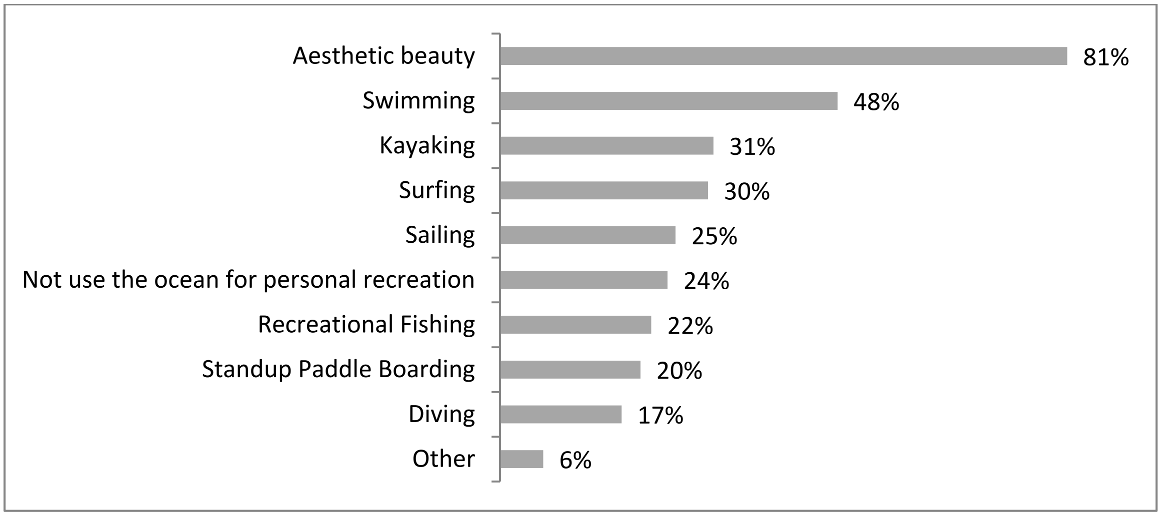

Figure 3-8: Do you use the ocean for personal recreation? If so, primarily for what? (Select all that apply)

3.3.2 Statistical Relationships

Chi-squared tests resulted in seven pairs of variables with statistically significant associations (Chi-squared test, $p<0.05$). Of the six comparisons between pairs of ordinal variables, the association was directional for four (Table 3-3). People's attitude towards OSW has a strong positive association with willingness to pay more, but a moderate negative association if their business depends on ocean. People's self-identified knowledge and willingness to pay more for OSW energy have a moderate positive correlation with people's educational level, that is, as people's educational level increases, their self-professed knowledge of OSW and willingness to pay both increase.

Table 3-3: The Cramer's V test results for 1 pair of nominal survey variables and the Gamma test results for 6 pairs of ordinal survey variables with the test of statistical significance.

Variable 1	Variable 2	Chi-square P-Value	Measure of association	Measure	Association	P-Value	Statistical Significance
Knowledge Of Offshore Wind	Educational Level	4.8E-04	Gamma	0.31	Moderate Positive	1.9E-09	Significant
Support Of Offshore Wind	Willingness To Pay More	1.2E-13	Gamma	0.79	Strong Positive	4.7E-07	Significant
Support Of Offshore Wind	Own Business Dependent On Ocean	0.007	Gamma	-0.56	Moderate Negative	7.4E-03	Significant
Support Of Offshore Wind	Educational Level	3.2E-07	Gamma	0.15	Low Positive	0.12	Not Significant
Support Of Offshore Wind	Knowledge Of Offshore Wind	6.0E-07	Gamma	-0.16	Low Negative	0.13	Not Significant
Willingness To Pay More	Work Industry	0.002	Cramer	0.25	Low Positive	2.0E-03	Significant
Willingness To Pay More	Educational Level	0.003	Gamma	0.37	Moderate Positive	5.0E-06	Significant

3.3.3 Multivariate Statistical Analysis

To further analyze the possible variables, which may have an influence on people's attitude (support or oppose) towards OSW development off the California Central Coast, we employed binary logistic regression to predict the likelihood of people's support or opposition (dependent variable) given a series of independent variables. The variables employed in the model are described in Table 3-4.

Table 3-4: Definition of variables in binary logistic regression.

Variable	Coding
Santa Barbara	"1" if Santa Barbara; "0" otherwise
Income	Five income levels assigned their midpoints, $17,500 for income <$35,000, $55,000 for income $35,000-$74,999, $87,500 for income $75,000-$99,999, $150,000 for income $100,000 to $199,999, and $250,000 for income >$200,000
Educational Level	Five educational levels assigned "1,2,3,4,5" for high school, some college, associate degree, bachelor degree, and master or doctoral degree
Age	Five age levels assigned their midpoints, 20 for age <30, 35 for age 31-40, 45 for age 41-50, 55 for age 51-60, 65 for age>60
Gender	"1" if female; "0" otherwise
Ocean Recreation	Three levels assigned "1,2,3" for number of activities <3, 3-5, >5
Knowledge of OSW	Factors (not at all knowledgeable, heard of it, somewhat knowledgeable, knowledgeable, very knowledgeable)
Work Industry	Factors
Support	"1" if "Support"; "0" if "Oppose"

Table 3-5: ANOVA table of possible factors influencing support. AIC=212.1

Variable	**P Value**
Santa Barbara	0.029
Income	0.872
Educational Level	0.579
Age	0.164
Gender	0.079
Ocean Recreation	0.936
Knowledge of OSW	0.0007
Work Industry	0.011
No. of Observations=226	

Table 3-6: Binary logistic regression of factors influencing support in the best model scenario. AIC = 206.34

Independent Variable	Coefficient	Odds Ratio	P Value
Santa Barbara	1.18	3.25	0.018
Knowledge1 (Not at all knowledgeable)	-0.75	0.47	0.377
Knowledge3 (Somewhat knowledgeable)	-0.25	0.78	0.662
Knowledge4 (Knowledgeable)	-2.32	0.10	0.0006
Knowledge5 (Very Knowledgeable)	-1.96	0.14	0.01
Gender	0.99	2.69	0.034
Industry: Education	-0.43	0.65	0.633
Industry: Energy	0.76	2.13	0.559
Industry: Fisheries	-3.11	0.04	0.0032
Industry: IT / Technology / Software	-0.08	0.92	0.950
Industry: Nonprofit/Government	1.85	0.16	0.019
Industry: Other	-1.11	0.33	0.193
Industry: Professional Services	-0.25	0.78	0.789
Industry: Real Estate and Rental and Leasing	-1.97	0.14	0.027
No. of Observations=226			

Table 3-5 displays the significance of all possible variables in the binary logistic regression model (AIC=212.1). Two variables, knowledge and work industry, are significant at the 5 percent level ($p<0.05$), and another two variables, Santa Barbara county and gender, are significant at the 10 percent level ($p<0.1$). Other variables, such as income, age, and educational level did not significantly affect support or opposition.

Table 3-6 indicates the influence of those four significant variables based on the best model scenario (AIC=206.34). A negative coefficient indicates that the variable made it less likely for an individual to support OSW, while a positive coefficient implies that the variable made it more likely. For either positive or negative coefficient, the greater the absolute value, the greater the effect.[71] The second column indicates the odds ratio of support, which is the probability of support over the probability of opposition. For example, if other variables are held constant, the odds of support increase 2.7 times if the person is a female rather than a male and 3.25 times if the person is from Santa Barbara County rather than from San Luis Obispo County or Ventura County.

Different knowledge levels were compared with the base level Knowledge2 (heard of it), and different work industries were used for comparison with the base level industry - Construction, Engineering and Manufacturing. Supporters were more likely to have a low knowledge level (heard of it or somewhat knowledgeable) and work in the energy

[71] Firestone and Kempton, "Public Opinion about Large Offshore Wind Power."

field, while opponents were more likely to be knowledgeable or very knowledgeable and work in the fields of fisheries, nonprofit/government, and real estate.

3.3.4 Key Stakeholder Interviews

Key stakeholder interviews were used to orient the team to existing information and outstanding issues associated with the research objectives. A diverse array of findings from eighteen interviews with SAC representatives and other stakeholders were used to summarize opinions on OSW, enhance the accuracy of the permitting analysis, and to incorporate stakeholder concerns into the spatial analysis.

In particular, interviews with agency and industry representatives allowed the team to identify salient points and gain a practitioner's perspective of environmental regulations. Conversations with the Department of Defense (DoD) identified their interests in the Sea Range, consequently is located within our ROI. For more information please refer to Section 4.3.1. We also identified appreciable stakeholder fatigue and resistance from the fishing community to marine spatial planning or any type of activity that would potentially impact their current business practices.

3.3.5 Limitations and Recommendations for Future Research

Due to budget and time limitations, we relied on an online survey distributed through convenience and snowball sampling. Given the location of the Bren School and our school and client's (CEC) connections to organizations and individuals associated with the environmental field, we almost certainly procured a biased response sample. Though we tried to reach residents from all three counties in our ROI, 83% percent of respondents provided zip codes within Santa Barbara County. Furthermore, compared to census data for our ROI, a disproportionately large majority of respondents were white (88 percent), highly educated, and wealthy.

Therefore, our survey sample is not fully representative of our ROI population. For future studies, we suggest a random sampling approach through mailings, phone calls, and/or on-street surveys across all three counties. Such methods would result in more robust data for extrapolation to the entire ROI population.

3.3.6 Conclusions

In sum, respondents generally support OSW development. About 67 percent of respondents within our ROI support OSW in Santa Barbara/Ventura county/ San Louis Obispo), and 17 percent respondents oppose OSW. Supporters are most concerned with possible negative impacts on bird species, while opponents care more about visual impacts. Visual impact concerns were also reflected in respondents' choices for most/least preferred locations for OSW development (a NIMBY response). Interestingly, as respondents' self-professed knowledge increases, their attitudes toward OSW become more polarized (fewer individuals with neutral responses).

People's willingness to pay is positively related to attitude towards OSW development. Supporters tend to be willing to pay more for electricity generated from OSW. Of those willing to pay more, we calculate that people would be willing to pay in $1.25-5/month in excess of current average electric bills.

The logistic regression analysis showed that residence in Santa Barbara County, gender, self-identified knowledge of OSW, and work industry significantly affect people's support and opposition of OSW development. Females are more likely to support OSW than males, and people from Santa Barbara are more supportive than those from other two counties. Lastly, people who work in fisheries, nonprofit/government, and real estate industry are more likely to oppose OSW projects.

Despite limitations associated with our survey, our stakeholder analysis provides several key findings in assessing the feasibility of OSW development in the ROI. Within the population we managed to reach, we have identified key stakeholder groups, recorded their support of and concerns with OSW, obtained their general preferences for OSW locations, and estimated their willingness to pay for electricity generated from OSW. A diverse array of findings from eighteen interviews with Sanctuary Advisory Council (SAC) representatives and other stakeholders were used to summarize opinions on offshore wind, enhance the accuracy of the permitting analysis, and to incorporate stakeholder concerns into the spatial analysis. If a developer pursues OSW development in the ROI, these findings are particularly useful in the OSW farm siting process. Taking into account stakeholder preferences and concerns before formally proposing a project can substantially reduce conflict and permitting time.

4.0 Spatial Analysis

4.1 Introduction

When considering sites for a potential wind farm, developers must consider spatial analyses to determine the best resource locations, and which conflicts may exist or appear in the future at those sites. This process typically begins before direct stakeholder engagement or permitting exploration, as a developer will not expend valuable resources if the area of interest lacks sufficient wind for commercial operation. Where scalable wind power potential exists, developers, along with government agencies and stakeholders, can create effective development decisions using an iterative spatial analysis process that begins with baseline data collection (biological, economic, and cultural) and continues through site selection, operation, and decommissioning.

To date, no developer has presented plans to create a commercial scale wind farm in the central California region of interest (ROI). However, in order to approximate a spatial analysis process, our team formulated a hypothetical scenario in which a developer proposes the creation of a 198MW wind farm in the ROI (Ventura, Santa Barbara, and San Luis Obispo Counties). The capacity of this farm would be a little less than half the total potential rated capacity of the Cape Wind project (468MW) off the coast of Massachusetts, the only offshore wind farm to be permitted for construction in the United States.[72]

This chapter begins by outlining the precedence for coastal and marine spatial planning (CMSP) in California. The following section provides background on the types of stakeholder groups who would likely be engaged in an offshore wind development planning process within the ROI. Next, the objective turns to a simplified methodology for completing a multi-criteria decision analysis (MCDA) for offshore wind development in the ROI. The remainder of the chapter then focuses on results, limitations, and conclusions.

4.2 Marine Spatial Planning for Offshore Renewable Energy Development

Facing unprecedented challenges related to climate change, overdrawn wild fisheries, and new marine uses, namely renewable energy, deep sea drilling, and aquaculture, President Obama created the Interagency Ocean Policy Task Force to improve governance of the Nation's aquatic resources. Stemming from the findings of the Task Force, the establishment of the United States National Ocean Policy, officially the "National Policy for the Stewardship of the Ocean, Our Coasts, and the Great Lakes," in 2010 crystallized growing recognition of the importance of ecosystem-based coastal and marine spatial planning (CMSP). The Policy's Implementation Plan, released in 2013, was designed to streamline the operations of federal agencies, facilitate collaboration

[72] "Cape Wind: America's First Offshore Wind Farm on Nantucket Sound."

between all levels of government and other stakeholders, and apply science-based management approaches. While it did not create new regulations nor shift the responsibilities of agencies, the Plan highlights how ecosystem-based CMSP can improve safety and security, economic performance, and coastal resilience.[73] Specifically, it subdivides US coastal regions into nine regional planning bodies (RPBs) and tasks each body with developing a CMSP approach for their region.[74]

Much of the regional-level planning promoted by the National Ocean Policy Implementation Plan will fall to the states. California's experience with the Marine Life Protection Act (MLPA), passed in 1999, leaves the state well prepared to deal with the complexities of future spatial planning initiatives. MLPA was developed to protect vital marine ecosystems through a network of marine protected areas (MPAs) focused largely on biodiversity and habitat area targets. A significant goal of this Act was to preserve and enhance the educational, cultural, recreational, and commercial (economic) activities that depend on the future persistence of marine resources.[75] The MLPA process also called for an unprecedented display of stakeholder engagement. To facilitate that initiative, government officials and individuals from the University of California, Santa Barbara's Marine Science Institute, Ecotrust, and The Nature Conservancy developed and implemented an interactive web platform for the design of the protected area network. *Marine Map* allowed for public creation of over 20,000 protected area designs, incorporating the priorities of key stakeholders into the decision-making process.[76] Participation of commercial fishermen, one of the stakeholder groups most concerned with the restriction of ocean activities, was especially critical.

Despite historic levels of participation and some evidence for biological benefits in and outside of MPAs,[77] our conversations and outreach efforts with stakeholders during this project indicated that the seven year planning process left many participants fatigued. Some fishermen, in particular, were unsatisfied with the outcomes and associated activity restrictions.

Fatigue and resentment from the MLPA process may have long-lasting repercussions. Management decisions lacking stakeholder acceptance can reduce levels of regulatory compliance.[78] More germane to this project, our requests for fishermen's time for interviews were refused several times on the basis of the project's possible connection to marine spatial planning. While there is no concrete plan for offshore wind

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[73] *National Ocean Policy Implementation Plan*.
[74] The Nature Conservancy, "Marine Planning Policy - USA Regions."
[75] "MLPA Summary."
[76] "MarineMap Consortium."
[77] Lester et al., "Biological Effects within No-Take Marine Reserves"; Botsford et al., "Connectivity, Sustainability, and Yield"; Gell and Roberts, "Benefits beyond Boundaries."
[78] Sutinen and Kuperan, "A Socio-Economic Theory of Regulatory Compliance."

development nor a formal planning process associated with this project, the legacy of the MLPA initiative still had a significant influence over fishermen's willingness to discuss alternative ocean uses in the south Central Coast of California.

This section has outlined federal and state commitment to science driven, ecosystem-based CMSP. Though institutional and technological progress has been made in the recent past to involve stakeholders in the spatial planning process, future hurdles exist for agencies and developers proposing alternative uses of ocean space that further restrict existing marine activities.

4.3 Stakeholder Considerations for the CalWind Region of Interest

Following the definition used in our stakeholder analysis, we define stakeholders to be those who can affect or will be affected by a decision.[79] Spanning the coastal environment from Ventura north to San Luis Obispo (Please refer to Figure 1-1), there are a multitude of stakeholder groups with a mixture of social, cultural, economic, and biological connections to the area that would potentially be impacted by offshore wind development. Given the absence of a wind farm development proposal, or any developer with explicit interest in pursuing offshore wind development, we chose to limit the scope of stakeholder perspectives incorporated into the spatial analysis. With numerous wind farm undefined variables (e.g., desired size, budget, etc.), we focused on a short list of assumptions, and did not attempt to present data for every stakeholder group or environmental variable. The following paragraphs describe stakeholder groups considered in the our spatial analysis, along with the spatial data used (if relevant) to represent hypothetical priorities related to offshore wind development.

4.3.1 Department of Defense (DoD)

The 'Sea Range' (see Department of Defense Sea Range in Appendix B) constitutes an area of extreme value to the DoD. The Range is the only place in the United States where the military has a controlled laboratory setting to test weaponry and defense equipment. That is to say, there are perturbations in the environment (cargo ships, flights going into Santa Barbara, etc.), but none that currently pose insurmountable obstacles to DoD operations. Our team's engagement with local offices of the Department of Defense (Vandenberg Air Force Base and the Naval Air Station at Point Mugu) revealed that horizontal axis wind turbines could have detrimental impacts on current operations, spanning most if not all of the project's ROI.

Horizontal axis wind turbines cause a Doppler effect on land and air-based radar equipment for up to 200 nautical miles. Essentially, radar noise (which can appear with signal strength larger than a Boeing 747) created by spinning turbine blades can cause a loss of radar detection in the air space above a wind farm. This problem extends to

[79] Reed, "Stakeholder Participation for Environmental Management"; Freeman, *Strategic Management: A Stakeholder Approach*.

weather detection equipment, as blade motion may result in the appearance of storm activity.[80,81]

Interviews with DoD indicate the existence of the Range does not mean that there is no future for offshore wind development in the ROI. However, relevant agencies (primarily BOEM) and developers would need to consult DoD early and often to create a plan for moving forward. It may well be the case that some level of curtailment (scheduled shut down of turbines) would be necessary for the Federal Aviation Administration (FAA) to permit a project (see Section 5.3). To capture this conflicting use in the spatial analysis, we included the Range extent GIS shapefile provided by the U.S. Naval Air Systems Command (NAVAIR).

4.3.2 Developer

When assessing a region for wind farm potential, a developer's main concern is the availability of wind and the anticipated net fiscal benefits associated with the project. While we did conduct a benefit-cost analysis (see Appendix D), these calculations were not fully incorporated into the spatial analysis. Instead, the developer's perspective was based on a combination of estimated wind speed (m/s) of an area and its distance to a possible interconnection point on land (for more details, see Wind Speeds and Interconnection Points in Appendix B). The wind data came from the National Renewable Energy Laboratory (NREL), and represents annual average 90m hub height wind speeds taken from shore and interpolated at 200m resolution. The interconnection points were generated from Platts Electric Transmission System Map data.[82]

In addition, the developer would be concerned with all stakeholder perspectives outlined in this section, as the feasibility and profitability of a project are largely dictated by the level of conflict associated with a desired development site.

4.3.3 Environmental Concerns

Permitting agencies tasked with the protection of natural resources, along with environmentally concerned stakeholder groups (e.g., Audubon Society), have an interest in the current and future preservation of important marine resources and species. Though many of these groups promote the advancement of renewable energy, the ecological impacts of an offshore wind project are complex and require extensive study. Much of the available baseline environmental data necessary to complete a robust spatial analysis of environmental conflicts with wind farms are insufficient or non-existent. Not wanting to ignore this important variable, we included three data layers for this spatial analysis: marine bird biodiversity, marine mammal presence, and hard bottom substrate coverage. Hard bottom substrate covers significantly less area in the

[80] FAA, "Testimony – Statement of Nancy Kalinowski."

[81] *Report to the Congressional Defense Committees: The Effect of Windmill Farms on Military Readiness*.

[82] Platts Electric, "North American Electric Transmission System Map: Americas Maps and Geospatial."

ROI than soft bottom, and is an important seafloor habitat for many species (see Figure 10 of the Spatial Appendix).[83]

4.3.3.1 Marine Avian Data

The primary concerns related to marine bird populations and wind turbines are the potential for collision and turbine lights distracting birds and impacting migration patterns (see Marine Bird Biodiversity in Appendix B for more information). The best available marine bird data for the ROI came from 6 sea surveys (1975-1997), which produced transect measures of diversity measured by the Shannon Index (balance of the number of species and distribution of individual species). These data were interpolated for "A Biogeographic Assessment of the Channel Islands National Marine Sanctuary" (November 2005).[84]

It is important to note that biodiversity scores are not a proxy for abundance data, and the presence of species by this metric does not necessarily mean that they are present in high numbers. There is precedence for using the Shannon Index to study threats to avian diversity,[85] which we believe justifies its inclusion in our analysis to study wind development conflicts with important avian diversity hotspots.

4.3.3.2 Marine Mammal Data

Potential impacts of an offshore wind farm on marine mammals are numerous, ranging from disturbance during construction to entanglement during operation (see Environmental Impacts Section for more information). Similar to the marine bird data, we employed transect survey data (USGS and Humboldt State University) for marine mammal presence. The data relay the percent of time that marine mammals (20 species in all) were observed in a transect area (5 minute of latitude by 5 minute of longitude) across all surveys (102 days of flights). As these data were provided as transects, we interpolated the data using ArcGIS's Empirical Bayesian Kriging tool to cover the region of interest (see Marine Mammal Presence in Appendix B for more information).

4.3.3.3 Benthic Substrate Data

Hard bottom substrate (primarily rocks and reefs) covers far less area than soft bottom (typically sand or mud) in the ROI (See Benthic Substrate in Appendix B). Given its importance as habitat for a wide range of species, permitting agencies typically prioritize its conservation. An informal conversation with the Pacific OCS Region office of BOEM relayed the opinion that offshore wind project proposals would be considered over hard bottom substrate, but, for the purposes of our simplified spatial analysis, we could consider a site's feasibility as inversely proportional to the area of hard bottom

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[83] Katz et al., *Condition Report 2009*.

[84] *A Biogeographic Assessment of the Channel Islands National Marine Sanctuary*.

[85] Bibi and Ali, "Measurement of Diversity Indices of Avian Communities at Taunsa Barrage Wildlife Sanctuary, Pakistan."

coverage. Substrate coverage was estimated from data gathered for "A Biogeographic Assessment of the Channel Islands National Marine Sanctuary" (November 2005).[86]

4.3.4 Commercial Fisheries

As outlined in Section 4.2*,* commercial fishermen will be critical stakeholders for any future marine spatial planning efforts in the ROI. Without direct stakeholder involvement, our best approach at representing commercial fishing interests would be through the mapping of spatially explicit landings data and their associated ex-vessel values. Unfortunately, such data are difficult to acquire without confidentiality agreements. Instead, we relied on spatial survey data produced by Impact Assessment, Inc. and Ecotrust (Open Ocean Map) as part of the Central Coast MPA Baseline Program. Based on available spatial layers, we focused on dragging (rockfish, halibut, sole, sablefish, and crustaceans) and gillnet (salmon) fishery data, as these gear types would likely be restricted within an offshore wind farm.[87] The logic behind this gear exclusion is the risk of entanglement of dragging nets with anchor lines of turbine platforms. Dragging fisheries and salmon layers are areas designated as important fishing grounds by fishermen who participated in the survey, and do not incorporate values based on landings.

4.3.5 Other Stakeholder Considerations

Limitations presented by data, time, and resource availability led us to include a subset of the possible stakeholder perspectives and environmental variables associated with offshore wind farm siting. The selections incorporated into the analysis do not emulate any measure of relative importance in the planning process, but rather reflect which data were readily available. A more complete spatial analysis would consider a number of other stakeholder groups and possible environmental impacts, including but not limited to: Chumash Indian bands, recreational fishers, shipping companies, and local businesses. For instance, anchoring turbine platforms and burying transmission cables both have the potential to disrupt historic Chumash sites, which have been inundated over time by the rising ocean. Similar anticipated impacts posed serious challenges for Cape Wind developers, as concerns eventually resulted in lawsuits.[88]

Potential viewshed impacts would also be important to many stakeholders, as evidenced by our survey results in Section 3.3. Digital elevation model (DEM) data were not available for the entire ocean portion of the CalWind ROI, so this was element was not fully incorporated into the spatial analysis. It is, however, referenced in greater detail in Section 4.5.1, below.

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[86] *A Biogeographic Assessment of the Channel Islands National Marine Sanctuary*.

[87] Impact Assessment Inc., "Spatial Distribution of Fisheries."

[88] Goodnough, "For Controversial Wind Farm Off Cape Cod, Latest Hurdle Is Spiritual"; Myers, "Wampanoag Tribe Preparing Cape Wind Lawsuit | CapeCodOnline.com."

4.4 Methodology

Following the selection of stakeholder perspectives and environmental variables for the spatial analysis, we decided to pursue a raster-based geographic information system (GIS) multi-criteria decision analysis (MCDA) to demonstrate a simplified framework approach to a developer's selection of potential wind farm sites. While there are several approaches to raster-based GIS-MCDA, our model essentially attempts to reach a management decision by spatially overlaying different variables and/or perspectives on a configuration of developable grid cells limited by the region of interest (ROI). For our analysis, each perspective was given a score (1-5, 5 being the best) and then weighted before combined into an overall score (1-5) for each developable cell. For instance, given the potential concern over projects sited above hard bottom substrate, a cell with 100% hard bottom would receive a score of 1, whereas a cell with 100% soft bottom would receive a score of 5. A weight would then be assigned to this score to determine how much the variable influences the overall score for each cell. Cells with the highest score represent areas with the highest wind potential and least conflict with other stakeholder priorities.

As described below, we ran several weighting scenarios to explore outcomes of variable prioritizations. Although static, the MCDA approach allows for a basic comparison of stakeholder tradeoffs through different weighting schemes. GIS-MCDA analysis has grown exponentially in published literature in the last two decades, showing its expansive use in informing management decisions.[89]

4.4.1 Assumptions for GIS-MCDA Model

As mentioned in the chapter introduction, we had to make several major assumptions about a hypothetical wind farm in the ROI to complete a spatial analysis. First, due to the drop off of the outer continental shelf and the multitude of conflicts in nearshore waters (e.g., viewshed impacts, recreational activities, etc.), we decided the turbines would likely be located in deep water (greater than 50m). At this depth, floating turbine platforms are required (see Section 2.1 for more information). Next, we selected a wind farm capacity of 198MW (33 floating 6MW turbines) to demonstrate a commercial-scale project. Given the investment of time and capital necessary to launch an offshore wind development in a state without pre-existing offshore wind farms, project members assumed a developer would be unlikely to pursue a smaller scale farm. The ideal footprint of this farm size, discussed below, is approximately 10km x 10km. For that reason, we used 10km x 10km developable grid cells in the raster of the ROI. While we initially planned to use an ROI covering the coastline of the three counties to the EEZ (200nm), the extent of the ROI was limited to available wind data. Lastly, cells within the re-defined ROI were classified as non-developable if they intersected the Channel Islands, National Marine Sanctuaries, or the commercial shipping lane within the Channel (for maps of the wind data and non-developable cells, see Region of Interest (ROI) in Appendix B).

[89] Malczewski, "GIS-based Multicriteria Decision Analysis."

Recent research suggests that optimal spacing of offshore wind turbines, for capacity and profitability, is much larger than the current 'industry standard.'[90] To date, the offshore wind industry has typically prescribed 3-7 rotor diameter spacing between turbines.[91] However, to avoid wind dampening or 'wake' effects between turbines, some experts suggest that the ideal spacing between turbines is 8-15 rotor diameters.[92] While there is clearly a spatial tradeoff associated with increased spacing, we chose a wind farm layout that employs a 10-12 rotor diameter staggered spacing technique, with a 8 rotor buffer around the farm. Within this framework, a 33 6MW turbine farm creates a footprint of approximately 11.4km x 9.9km (see Figure 4-1). To facilitate the incorporation of this footprint to the GIS-MCDA (i.e., creating a square grid cell), we adjusted the size to be 10km x 10km.

[90] Musial et al., *Assessment of Offshore Wind Energy Leasing Areas for the BOEM New Jersey Wind Energy Area*; Schlez, Neubert, and Smith, *New Developments in Precision Wind Farm Modelling*; Archer, Mirzaeisefat, and Lee, "Quantifying the Sensitivity of Wind Farm Performance to Array Layout Options Using Large-Eddy Simulation"; Meyers and Meneveau, "Optimal Turbine Spacing in Fully Developed Wind Farm Boundary Layers."

[91] Musial et al., *Assessment of Offshore Wind Energy Leasing Areas for the BOEM New Jersey Wind Energy Area*; Green et al., "Electrical Collection and Transmission Systems for Offshore Wind Power"; Snyder and Kaiser, "Ecological and Economic Cost-Benefit Analysis of Offshore Wind Energy," June 2009.

[92] Schlez, Neubert, and Smith, *New Developments in Precision Wind Farm Modelling*; Archer, Mirzaeisefat, and Lee, "Quantifying the Sensitivity of Wind Farm Performance to Array Layout Options Using Large-Eddy Simulation"; Meyers and Meneveau, "Optimal Turbine Spacing in Fully Developed Wind Farm Boundary Layers."

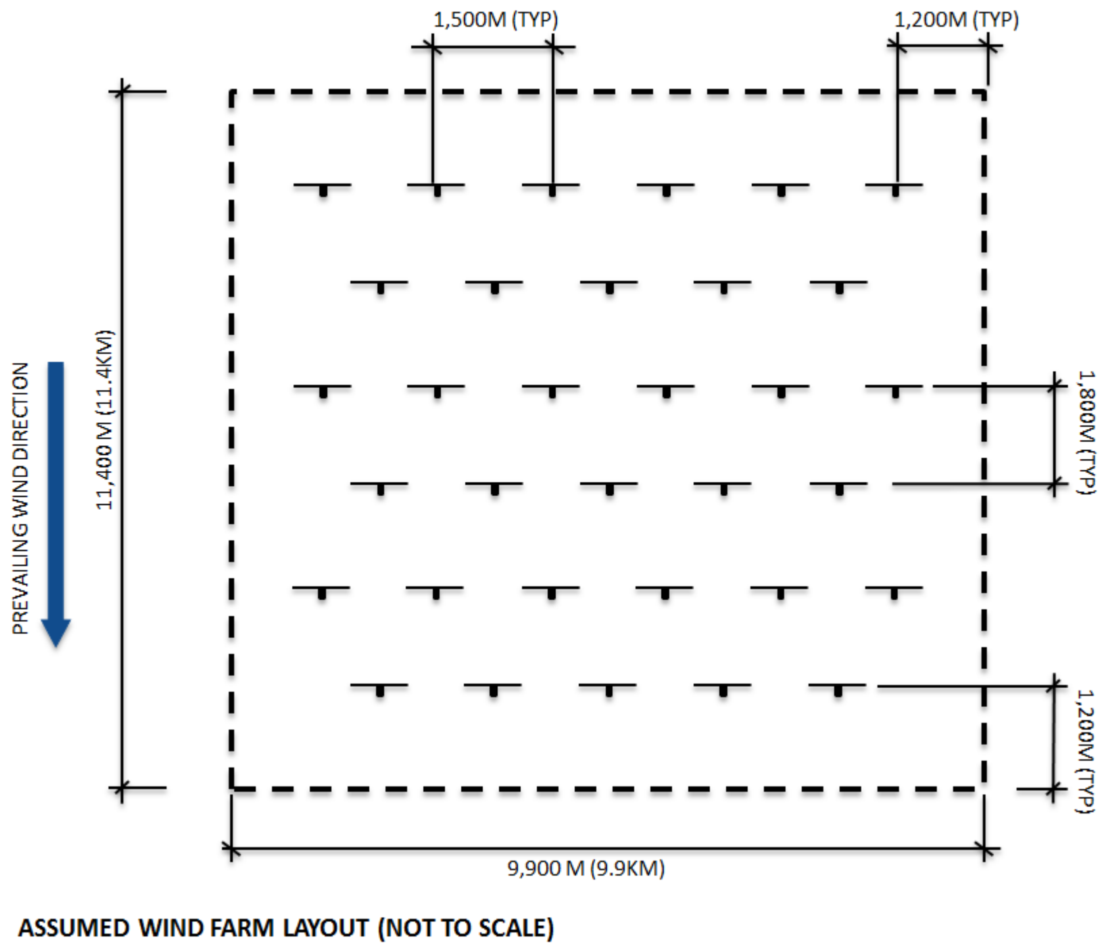

Figure 4-1: Hypothetical Wind Farm Footprint

4.4.2 GIS-MCDA Model

Employing model builder in ArcGIS 10.1, all variables were given scores and weights (see Table 4-1) for the MCDA through a uniform process of data transformation. Some data, like the marine mammal survey data, required more extensive adjustments before entering the model (see Appendix B for details on each variable). In sum, a 'union' tool was run between a polygon of developable cells in the ROI (a "fishnet") and the variable polygon (e.g., substrate, dragging territory). For each variable, this resulted in the assignment of unadjusted values, or scores, for every developable cell. The new unionized layers for each variable were then converted into rasters ('snapped' to the raster of developable cells). Next, raster values were converted into quantiles (5 classes) and then reclassified to have a score from 1-5. Lastly, reclassified scores were weighted and combined to produce final scores (1-5) for every developable cell in four separate scenarios. Each scenario represents a different hypothetical stakeholder prioritization of variable values in the wind development context (See Table 4-2).

Table 4-1: Multi-Criteria Decision Analysis Variables and Scores

Variable	Score Description	Score
Benthic Substrate	Area (m^2) of hard bottom substrate	1 (100% hard bottom) – 5 (0% hard bottom)
Commercial Dragging Fishing Grounds	Area (m^2) of fishing grounds	1 (100% fishing grounds) – 5 (0% fishing grounds)
Commercial Salmon Fishing Grounds	Area (m^2) of fishing grounds	1 (100% fishing grounds) – 5 (0% fishing grounds)
Department of Defense Sea Range	Binary (in or out)	1 (in the Range) or 5 (outside the Range)
Marine Birds	Shannon Index score of species richness and evenness	1 (highest measured biodiversity) – 5 (lowest measured biodiversity)
Marine Mammals	Average observed presence of all species across survey months	1 (highest measured presence) – 5 (lowest measured presence)
Wind Development Potential	Weighted Sum: 75% of score = average wind speed (ms^{-1}); 25% of score = distance (m) to nearest transmission substation	1 (low wind and long distance to substation) – 5 (high wind and short distance to substation)

Table 4-2: Weighting Scenarios for MCDA

Scenario	Substrate Weight	Dragging Weight	Salmon Weight	DoD Weight	Bird Weight	Mammal Weight	Wind Weight
1: DoD	10%	10%	10%	**40%**	10%	10%	10%
2: Developer	10%	10%	10%	10%	10%	10%	**40%**
3: Fishermen	10%	**30%**	**20%**	10%	10%	10%	10%
4: Bird & Mammal	10%	10%	10%	10%	**25%**	**25%**	10%

Scenario 1 demonstrates the potential impact of Department of Defense (DoD) curtailment (40% weighting) of wind farms placed within the Sea Range. Conversations with DoD indicated that wind farms outside of the Range might still negatively impact military operations, in which case they may also be subject to curtailment. However, for this hypothetical scenario, areas outside of the range were not considered to be a problem for DoD.

While each scenario is developed within the context of wind farm siting (i.e., low scores given to uses which conflict with wind development), Scenario 2 gives a higher weight (40%) to the average wind speed/distance from transmission substation metric.

Scenario 3 incorporates stronger weightings for important areas of dragging and salmon fisheries. Given that the dragging data incorporated grounds for several fisheries (rockfish, halibut, sole, sablefish, and crustaceans), it was assigned a higher weighting (30%) than the salmon fishery (20%).

Lastly, Scenario 4 demonstrates priorities of environmental groups and/or permitting agencies concerned with legislation that protects birds and mammals. Both marine bird and mammal data were given weights of 25%.

4.5 Results and Discussion

Figure 4-2 depicts the visual results of the four weighting scenarios described in Table 4-2.[93] Each weighting map produces somewhat predictable shifts in areas receiving high scores for wind development, driven by the most heavily weighted layers (e.g., Sea Range, fishing grounds). However, the exercise demonstrates the contrast in potential management decisions that are created by prioritizing certain stakeholder interests.

Beginning with the Department of Defense, the development curtailment within the Sea Range forces the highest scoring wind development cells (dark green) to the northwest and southeast, respectively. Average wind speeds are higher in the northwest region, which accounts for the darker shading of green in that region. Next, when a scenario is run to prioritize a developer's siting considerations, cells with the highest average wind speeds that are closest to onshore transmission substations (interconnection points) receive the highest scores.[94] Moving to fishermen, given the limited data used to map the extent of dragging and salmon fisheries, simulating this stakeholder prioritization produces a concentrated area of low scoring development cells west of Santa Barbara County (note that many of the cells classified as non-developable are also important fishing areas). Finally, heavily weighting marine bird and mammal variables shows that areas closest to shore and within the channel support higher levels of marine bird biodiversity and mammal presence.

Reviewing all four scenarios together, two significant patterns emerge. First, the area directly west of Santa Barbara County (and the southern portion of San Luis Obispo County) consistently received low scores, especially when heavily weighting bird,

[93] The offshore area included in the analysis extends slightly north and south of the offshore environment associated with the three counties in our ROI. This is because the team had the NREL wind data for these locations, and given the vast extent of the DoD's interest in the region, we wanted to include some space outside of the Sea Range.

[94] The red edge of cells along the ROI in the "Developer Considerations" map is a result of the cells' distance to shore, as well as the possible impact of data rasterization. When the wind data were rasterized, cells along the perimeter occasionally contained less than 50% (minority) wind speed data, and greater than 50% (majority) no data. In this case, the raster defined the cells as having 0 m/s average wind, which is almost certainly not the case.

mammal, and fishing ground variables. This observation is not coincidental, and likely results from the region's biological importance as an 'upwelling' zone.

The two maps in Figure 4-3 illuminate the upwelling in this area, which brings cold, nutrient rich waters toward the surface, catalyzing the growth of microscopic plants, particularly phytoplankton.[95] The map on the left displays surface temperature distribution (coldest waters, shown in purple, appear west of Santa Barbara County), while the map on the right shows chlorophyll concentration, a proxy for phytoplankton abundance (highest concentrations occur in the nearshore waters west of Santa Barbara County, shown in red and black). The population boom of phytoplankton cascades up the food web and supports a wide range of marine species, including those emphasized in this analysis (marine birds, marine mammals, salmon, halibut, etc.).

The second striking pattern is the consistently high scoring cells in the northwestern portion of the ROI. This results from the fact that this region, despite being far from shore, has high wind, is outside of the DoD's Sea Range, has majority soft substrate benthic habitat, low scores of marine bird biodiversity and mammal presence, and is outside of important dragging and salmon fishery areas. The five pink cells that appear in each map of Figure 4-2 were identified by highlighting the five highest scoring cells from each stakeholder scenario. Given the limitations of our MCDA, these are the cells with the highest potential for wind development, given wind speeds and low scores for conflict.

[95] NASA: Earth Observatory, "California's Channel Islands: From Shore to Sea (Jason Project)."

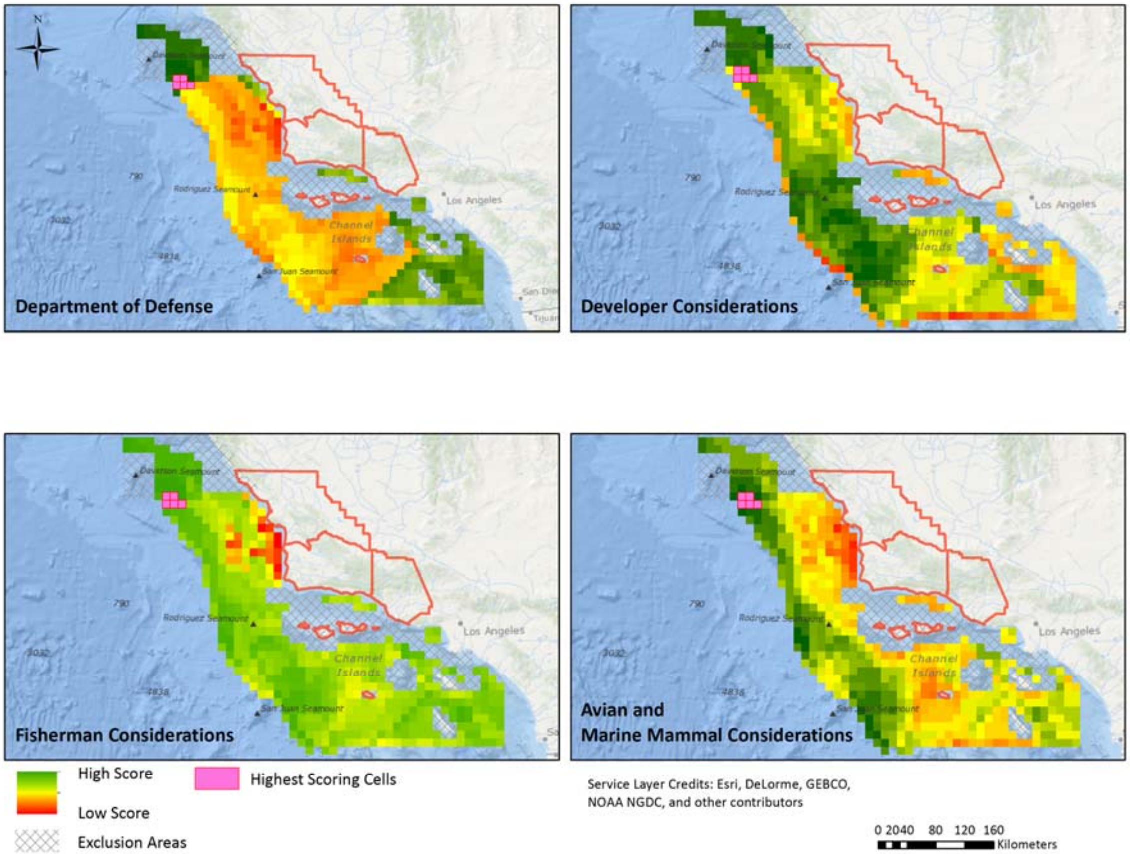

Figure 4-2: GIS-MCDA Output for Four Hypothetical Weighting Scenarios

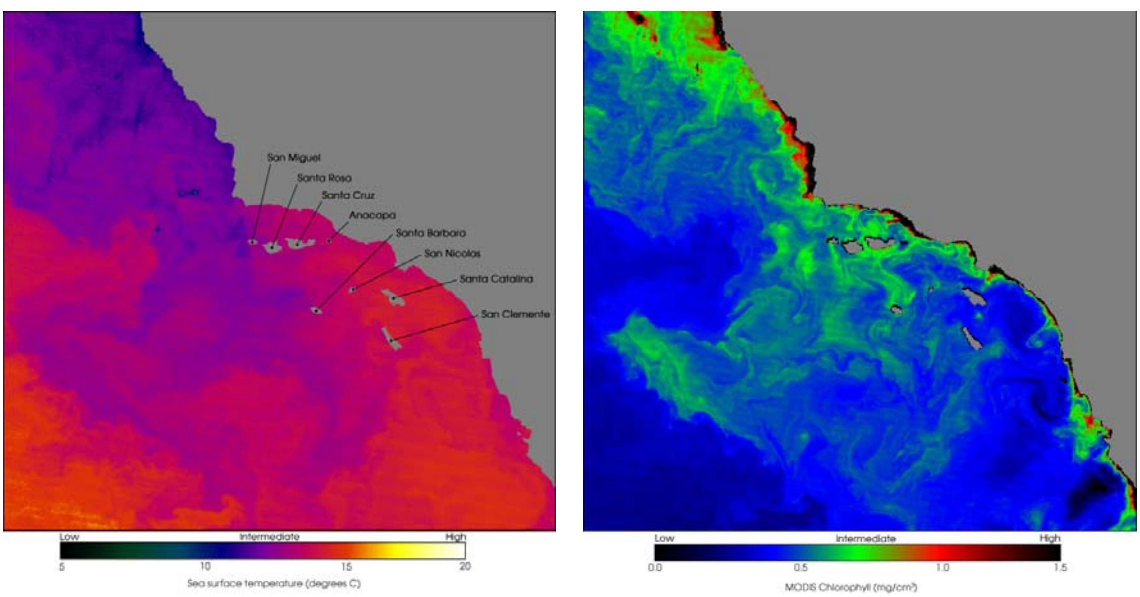

Figure 4-3: Temperature (left) and Chlorophyll (right) Maps for Channel Island Region (NASA's Earth Observatory)[96]

[96]Ibid.

Considering the simplification of this spatial analysis (ignoring many important variables) and the caveats of the data used, we cannot conclude that these are the 'best' cells for offshore wind development. However, within the limitations of this analysis, they are the cells with the highest potential for wind development. The identification of these cells demonstrates how a developer or agency might attempt to balance stakeholder priorities to create a relatively equitable development scenario.

4.5.1 Pairwise Tradeoff Plot

An alternative way to visualize the spatial data incorporated into our analysis is using pairwise tradeoff analysis. Borrowed from the field of economics, this approach plots data points for up to 3 variables to produce a production possibilities frontier (PPF) curve. This curve presents optimal solutions, and movement along the curve represents direct tradeoffs between the variables under consideration. Figure 4-4 below displays an example of this technique. Each point represents a developable cell in our analysis with corresponding scores for bird biodiversity and wind development potential (as in the MCDA analysis, a high score for bird biodiversity means low levels of biodiversity in that cell, and lower conflict with wind development). Considering only these two variables, any point below the curve is inefficient, as sites with higher wind development potential and/or lower impacts to bird biodiversity exist without additional cost. Which point you choose along the curve, however, is a more difficult decision, and must be made by incorporating the relative importance of each variable to stakeholders.

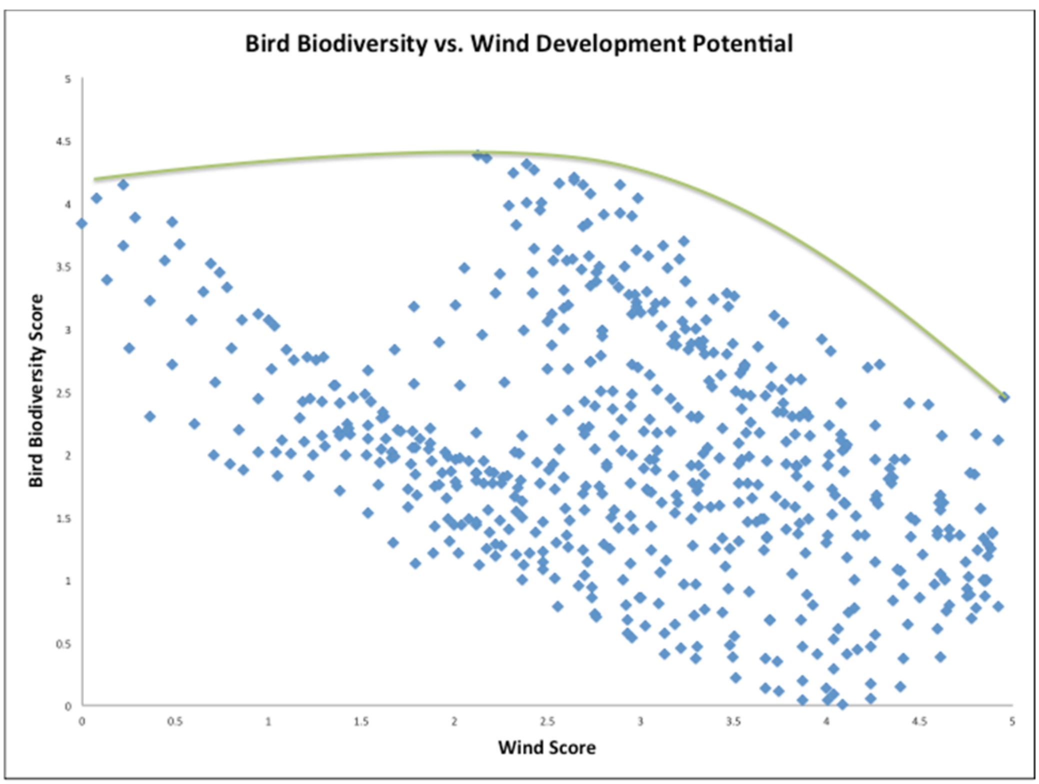

Figure 4-4: Example Pairwise Tradeoff Analysis (Bird Biodiversity vs. Wind Development Potential)

4.5.2 Sample Viewshed Analysis

Given the magnitude of viewshed concerns voiced by participants in the CalWind general public survey, we decided to provide a basic viewshed analysis for the development cells receiving the highest scores across the four scenarios (pink cells in Figure 4-2). Unfortunately, the digital elevation model (DEM) output from USGS' National Elevation Dataset (NED) did not contain data for the pink cells.[97] The closest to shore of the pink cells was approximately 65km (40nm) west of Morro Bay. With that in mind, Figure 4-2 displays the projected viewshed impact of a single turbine (90m hub height) located 65km from shore (this spot, slightly north of Morro Bay, was the closest approximation to the pink cells within the available DEM). In order to complete this analysis, the viewshed impact is conducted from the perspective of the turbine hub, which means that from a 90m hub height, everything in green is above the horizon. Whether or not a human eye could see that turbine hub from shore is not clear from this model. Ladenburg and Lutzeyer (2012) discuss Danish offshore wind farm visualizations in their study on the economics of reducing wind farm visibility. They share that, "Using visualizations of 5 MW turbines (100 m nacelle and 60 m blades, 160 m in total), a wind farm at 50 km would not be visible from the coast" (p. 6795).[98]

Determining visibility in our ROI would require a complex spatial visualization, like BOEM's simulations for various locations in North Carolina. Figure 4-7 estimates the appearance of 200 7MW Vestas turbines at a distance of 20nm (half the distance of the point in Figure 4-2) on a clear afternoon from the Cape Hatteras lighthouse. The turbines, though small, are visible above the horizon.[99]

[97] USGS, "National Elevation Dataset."

[98] Ladenburg and Lutzeyer, "The Economics of Visual Disamenity Reductions of Offshore Wind farms—Review and Suggestions from an Emerging Field."

[99] The turbines may not be visible when this document is printed (depending on the printing quality/resolution).

Viewshed Analysis from a hypothetical offshore wind development located approximately 65 km offshore.
Viewshed reflectivity coefficient=0.13
Wind Turbine height=90m

Service Layer Credits: Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

Figure 4-6: Viewshed Approximation for Highest Scoring Development Cells

Figure 4-7: BOEM Visualization of 200 7MW Vestas Turbines 20nm from Cape Hatteras Lighthouse (NC)[100]

[100] BOEM, "Offshore North Carolina Visualization Study."

4.6 Marxan Analysis

4.6.1 Introduction

To complement and corroborate the results of the GIS-MCDA analysis, we applied Marxan software to simulate optimal wind farm locations. Marxan was originally designed to be an optimization tool for identifying areas that meet biodiversity conservation targets at the lowest cost.[101] Application of the program now extends beyond planning for reserves, parks, and marine protected areas and could theoretically be applied to a variety of spatial optimization problems with clearly identified targets and costs. Particularly relevant to this study, Göke & Lamp (2012) describe how the Baltic Sea Region Programme used Marxan to map sites for future offshore wind development in the Baltic Sea.[102] While we did not strictly follow their approach, the Baltic example certainly gave foundation to Marxan's use in the offshore renewable context.

4.6.2 Methods

Running Marxan requires three input files. Described in the program's conservation planning terminology, the three files are shown in Table 4-.

[101] Ball, Possingham, and Watts, "Marxan and Relatives."

[102] Göke and Lamp, *Case Study: Systematic Site Selection for Offshore Wind Power with Marxan in the Pilot Area Pomeranian Bight*.

Table 4-3: Marxan Input Files

Marxan File	Marxan Description	CalWind Usage
1:	Species file *(typically population or habitat area of species in every planning unit)*	Potential annual wind generation per planning unit *(function of the turbine power curve as it relates to average wind speed, multiplied by the number of turbines in each cell)*
2:	Target file *(percentage of the population or habitat of the species you want to try to protect)*	Total desired annual generation of wind power
3:	Cost file *(costs associated with conserving each planning unit)*	Weighted sum calculated as development cost per planning unit (Consists of all variables described in Table 4-1, as well as distance to a onshore transmission interconnection point)

Practically all of the assumptions from the GIS-MCDA were carried over to the Marxan analysis. Developable cells became planning units, all stakeholder/environmental variables except wind speed became development costs, and the number of turbines per cell (33) remained constant. Wind generation per cell was derived from fitting an equation to the NREL power curve for a 5MW turbine (includes capacity factor, and average wind speed). Turbine efficiency data are often considered proprietary information and/or not made readily available to the public, so we were unable to secure a power curve for a 6MW turbine (the size modeled in the spatial analysis footprint) (see Marxan Analysis in Appendix B for more information).

We assigned a 200MW annual wind generation target. While the rated capacity of our modeled wind farm is 198MW, turbines do not operate at 100% capacity. Instead, a 39.7% capacity factor was assigned.[103] Therefore, it would take at least three planning units with high wind speeds (~8-9 m/s) to produce 200MW (see Figure 18 in Appendix B). We tested several cost weighting scenarios, and found results to be particularly sensitive to the distance to interconnection. Ultimately, the following cost weighting structure was included in this report: hard bottom substrate (30%); DoD Sea Range (20%); distance to interconnection (10%); marine mammal presence (10%); marine bird biodiversity (10%); dragging fishing grounds (10%); and salmon fishing grounds (10%). Lastly, a boundary length modifier of 0.0001 was used. Boundary length is the “the sum of the planning units that share a boundary with planning units outside the reserve system,” or in this case, the wind farm.[104] Marxan’s boundary length modifier setting

[103] “Energy Numbers.”
[104] University of Queensland, “Module 2: Theory Behind Marxan.”

penalizes boundary length (adds it to the planning unit cost) to encourage ‘clustering’ of planning unit selections. Clustering is desirable in the wind development context, as farms spaced far apart would increase construction and operation costs.

4.6.3 Results

After adding the Marxan input files and boundary length modifier described above, we executed 1000 Marxan simulations. Figure 4-8 displays Marxan’s ‘summed solution’ output, or the number of times each planning unit was selected when Marxan ran its optimization algorithm to achieve the target (200MW) at the lowest overall cost.

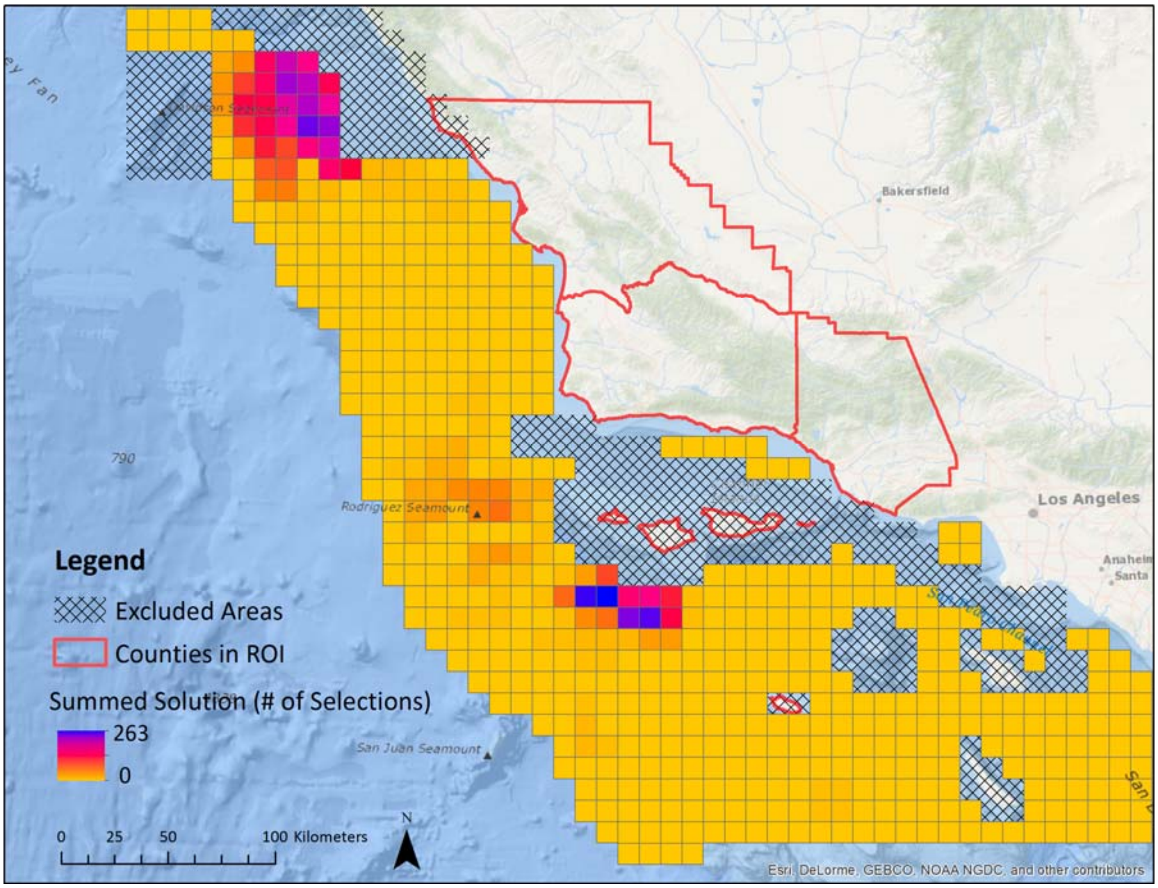

Figure 4-8: Marxan Summed Solutions

Interestingly, two wind development regions emerge. The first, in the northwest region of the ROI, overlaps the cells with the highest potential for development from the MCDA (See Figure 4-2). The second region, south of San Miguel and Santa Rosa Islands, received high scores in the ‘developer’ MCDA scenario, but otherwise received relatively low scores because of its position within the DoD Range. Reviewing the other spatial data used for the analysis, both regions have high wind (>7m/s), avoid dragging and salmon grounds, have low levels of hard bottom substrate, and relatively low values of marine mammal presence and bird biodiversity.

The Marxan exercise demonstrates an alternative approach for identifying suitable locations for offshore wind development, and to some degree verifies the previously developed GIS-MCDA model's ability to locate sites of high wind and low conflict. However, the same data limitations and reliance on weighting constraints exist for our Marxan analysis as for the MCDA (discussed further in Section 4.7 Limitations & Recommendations for Future Research).

4.7 Limitations & Recommendations for Future Research

As mentioned throughout this chapter, our simplified MCDA is a framework that can be used for a more robust analysis and relies on a number of assumptions related to wind turbine technology and stakeholder priorities. Many important variables (e.g., recreational activities, viewshed impacts, etc.) are largely or completely ignored, and the underlying spatial data for the variables that are included are mostly outdated interpolations. Also, weighting values used to produce scores for developable cells in the GIS-MCDA analysis were chosen somewhat arbitrarily (40% weighting for a single variable prioritization; 50% combined weighting for two variable prioritization) to create the desired range of stakeholder perspective maps. The weighted sum approach is useful in comparing the relative values of development cells, but the additive method fails to differentiate cells that have may have medium scores across all variables from cells that have some very high and some very low values (they simply average to the same score). Therefore, the importance of some stakeholder priorities may be lost or muted in the scoring process. A multiplicative MCDA could correct for this inadequacy, and may be worth exploring.[105]

A centralized database of publicly available, up-to-date, spatially explicit baseline data covering biological and socioeconomic variables of interest to developers, stakeholders, and agencies would advance the ability of interested individuals and institutions to spatially consider wind development scenarios. Current data for the marine environment of California, though impressive in the breadth of variables considered,[106] are decentralized and often difficult to find. Spatial planning for offshore wind development in California would be further simplified if the Department of Defense, in collaboration with the Bureau of Ocean Energy Management, created a 'stoplight' map of developable wind areas (Figure 4-9), displaying areas excluded from development consideration (red), areas where conflicts exist (e.g., some curtailment might be necessary), but development would be considered (yellow), and areas where the DoD takes no exception to wind energy development (green).[107]

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[105] Triantaphyllou and Baig, "The Impact of Aggregating Benefit and Cost Criteria in Four MCDA Methods."
[106] *A Biogeographic Assessment of the Channel Islands National Marine Sanctuary*; BOEM, "MarineCadastre.gov"; Impact Assessment Inc., "Spatial Distribution of Fisheries"; USGS, "Pacific Coast Fisheries GIS Resource Database (Fisheries Data)."
[107] The DoD did not receive external requests to evaluate the areas on the map in Figure 4-9 that have no associated color (red, yellow, or green).

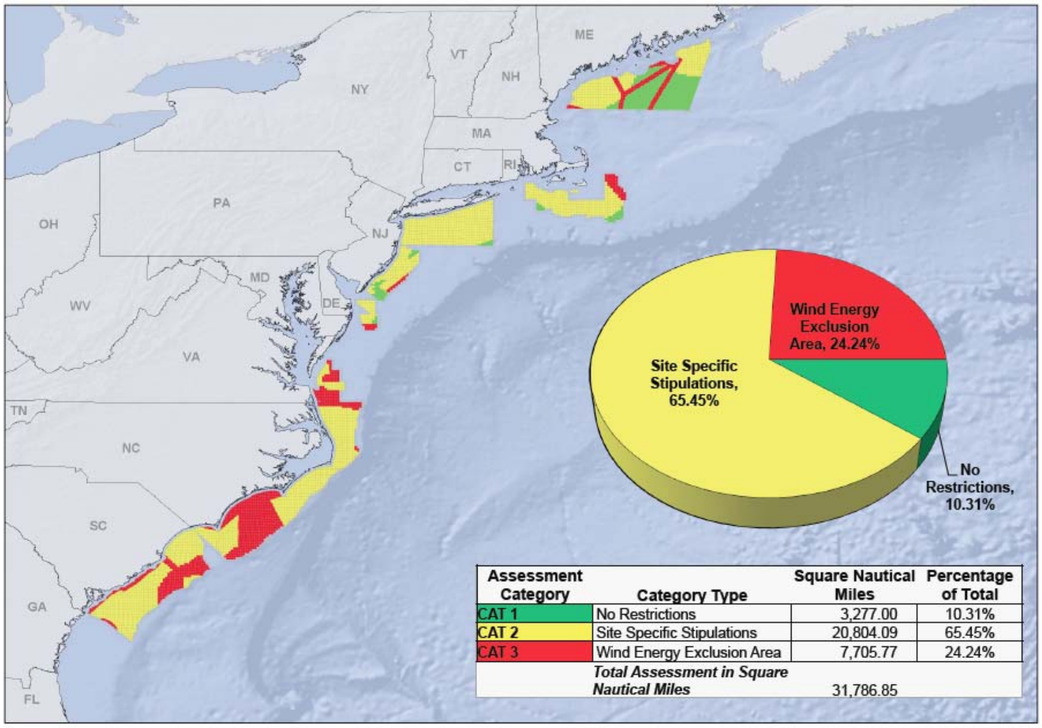


Figure 4-9: Department of Defense Atlantic OCS Wind Energy "Stoplight" map. Reproduced with permission from the US Navy.

GIS-MCDA is a static modeling technique that has useful applications, but fails to incorporate dynamic interactions between sectors and ecosystem variables. The work of White et al. (2012) analyzing possible zoning scenarios for offshore wind farms in Massachusetts highlights cross-sector efficiency gains created by dynamic, multi-sectoral site selection modeling with trade-off analyses.[108] Though data intensive and mathematically rigorous, such advances in CMSP create more effective management plans with 'win-win' scenarios for a greater number of stakeholders. This type of analysis was beyond the scope of this project, but would be an excellent next step for future spatial analyses of offshore wind development feasibility.

4.8 Conclusions

There is a consensus in the scientific community that ecosystem-based coastal and marine spatial planning (CMSP) can drastically improve biological, social, and economic outcomes of natural resource management decisions.[109] This attitude has been echoed by the current administration through the National Ocean Policy, and was previously adopted by the state of California during the Marine Life Protection Act Initiative.[110]

[108] White, Halpern, and Kappel, "Ecosystem Service Tradeoff Analysis Reveals the Value of Marine Spatial Planning for Multiple Ocean Uses."

[109] McLeod et al., "Pathway to Ocean Ecosystem-Based Management."

[110] *National Ocean Policy Implementation Plan*; "MLPA Summary."

Future efforts to site offshore wind developments in California can and should build upon past CMSP experience, and correct past inadequacies where possible.

Despite the limitations of the GIS-MCDA presented in this chapter, we have taken the first step in identifying desirable areas for wind development with lower levels of multi-use spatial conflict. Without improved data and a more thorough assessment of possible environmental variables and stakeholder priorities, our results should not be interpreted as recommendations for wind farm placement. Instead, the results produced provide evidence for the potential of an offshore wind industry, and the myriad conflicts that enshroud much of the region of interest off the Central Coast of California.

5.0 Permitting Offshore Wind Development in California

5.1 Introduction

The creation of an OSW industry in the United States is a recent development relative to other countries, and as such the regulatory process for OSW projects is still being defined in many areas, including California. Unlike several other states, California has not yet embarked on focused efforts to define the approval process for OSW and as such no projects are currently being proposed in the state. A wide range of environmental, economic, and social impacts are possible with development of OSW, and therefore it is important that the statutory and regulatory framework governing OSW development be effective, efficient, and clearly defined. The goal of this chapter is to define the existing process for obtaining approval for OSW development in the Central Coast region of the state and to identify areas of over and under-representation created by the current process that could be addressed with the adoption of an alternate regulatory approach. We will define the levels of government that have jurisdiction over OSW development, the laws that are applicable, the agencies that are responsible for developing regulations and issuing approvals, and how to navigate the approval process under the current framework.

The network of statutes and agencies that provides protection for environmental and economic interests is intended to address as many impacts of human activity as possible while still allowing for the economic development of natural resources. According to the U.S. Department of Energy, the approvals that are required for OSW development are not specific to OSW, but rather are applied from an existing framework of environmental statutes, not all which are intended to address this type of development.[111] As such, the approval process involves statutes with overlapping authority, creating the condition that some entities protected by statute are represented multiple times. Conversely, some stakeholders in the marine environment are not given representation by specific statutes. Disproportionately represented entities constitute one area of interest in OSW approvals that will be discussed in this chapter.

The intent of this chapter is to provide a concise overview of the statutory and regulatory framework that exists currently. As such, detailed information on the history, purpose, and implementation approaches for each step of the permitting process is not discussed. Appendix C contains detailed information on this material in addition to descriptions of the government agencies involved and their role in the approval process.

[111] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Wind & Water Power Program and U.S. Department of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, "A National Offshore Wind Strategy: Creating an Offshore Wind Energy Industry in the United States."

5.2 Information Sources

Information from a variety of sources, primarily written, was utilized in researching the permitting requirements for OSW development. Because comprehensive guidance that captures all of these requirements does not presently exist, we looked to the text of federal and state statues, agency interpretations of these statues, and published stakeholder commentary. Original statutes were used when appropriate. Some of these sources included:

- United States Code of Federal Regulations (CFR)
- United States Federal Register
- National Environmental Protection Act (NEPA)
- California Environmental Quality Act (CEQA)
- California State Constitution
- California Public Utilities Code
- Other federal and state legislation as indicated.

In addition to a review of available literature and statues, we conducted in-person interviews with individuals and representatives of institutions involved in the permitting process including:

- Federal Bureau of Ocean Energy Management (BOEM);
- Department of Defense (DoD);
- U.S. Fish and Wildlife Service (FWS);
- California State Lands Commission (CSLC);
- California Department of Fish and Wildlife (CDFW); and,
- National and state Audubon Societies
- Commercial fishermen
- Members of the Channel Islands Sanctuary Advisory Council

Information obtained from these sources is described in the Stakeholder Analysis chapter (Section 3.0) as well as Appendix C.

5.2.1 Assumptions

As described in the beginning of the report, it was necessary to make several assumptions regarding a hypothetical OSW project in order to create a defined scope of study. For the purposes of this chapter, we have analyzed the permitting process in reference to a project located in federal waters and using floating turbine technology.

5.3 Permitting Pathway Overview

The approval process for an OSW development requires the engagement of federal, state, and county-level (local) government authorities. The approval process at each level of government is distinct from the others, although key points exist that create overlap between federal, state, and local agencies. While the ultimate number of approvals that are required for a specific project will vary based on the details of that project, we have found that at least 17 separate federal approvals may be required in addition to 8 approvals at the state level and 3 at the local level (Table 5-1).

The primary statutory devices used approve OSW development are the National Environmental Policy Act (NEPA) at the federal level and the California Environmental Quality Act (CEQA) at the state level. Each law defines the decision making process that government must use in evaluating a project, and has prescriptive approaches to review by multiple agencies. CEQA and NEPA share many common goals, but each law has a different approach to implementation; hence, project developers could face complex and duplicative permitting requirements while attempting to satisfy all requirements of each law separately.

CEQA addresses basic approaches to conducting joint NEPA/CEQA reviews [CCR Title 14, Chapter 3, Article 14, SS 15220 to 15229].[112] In an attempt to streamline the permitting process, federal and state agencies have released a draft handbook on integrating NEPA and CEQA review processes.[113] Additionally, individual agencies within California, such as the State Lands Commission, have adopted strategies for conducting joint reviews.[114]

[112]"CEQA: Article 14. Projects Also Subject to the National Environmental Policy Act (NEPA)."
[113]"NEPA and CEQA: Integrating State and Federal Environmental Reviews   A DRAFT for Public Comment."
[114]Holly Wyer, "Offshore Wind Energy and CEQA."

Table 5-1: Possible Required Government Approvals for OSW Development. *See Appendix C for detailed description of each.*

Approval	Required?	Part of CEQA or NEPA?	Federal	State	Local
NEPA completion	Yes	-	X		
CAA Gen. Conformity Determination	Yes	NEPA	X		
OCS Air Quality	Maybe	NEPA	X		
CZMA Consistency Determination	Yes	NEPA & CEQA	X	X	X
FAA Determination	Yes	No	X	X	
Eagle Take Permit	Maybe	NEPA	X		
ITP (Section 7)	Maybe	NEPA	X		
PATON Permit	Yes	No	X		
Rivers & Harbors Section 10	Yes	NEPA	X		
Section 401 Water Quality Cert.	Maybe	NEPA & CEQA	X	X	
CWA Section 404	Maybe	NEPA	X		
Execution of OCS Lease	Yes	No	X		
Section 106 Consultation	Yes	NEPA	X		
Migratory Bird Consultation	Yes	NEPA	X		
MMPA Consultation	Yes	NEPA	X		
Essential Fish Habitat Consultation	Yes	NEPA	X		
CEQA	Yes	-		X	
State Lands Lease	Yes	No		X	X
CESA Take Permit	Maybe	CEQA		X	
Coastal Development Permit	Yes	No	X	X	X
Interconnection Permit	Yes	No		X	
Totals			**17**	**8**	**3**

5.3.1 Jurisdictions

Legal authority in coastal waters is divided into multiple zones and is separated into federal, state, and local jurisdictions (Figure 5-1). For purposes of OSW development, the primary zones of concern are;

1. The Baseline
2. State Seaward Boundaries (State Waters)
3. Territorial Sea
4. Exclusive Economic Zone

The Baseline

The baseline is defined as, "…the boundary line dividing the land from the ocean"[115] and is determined by the "mean lower low water line along the coast, as shown on official U.S. nautical charts"[116]. The Baseline serves as the point of measurement for all subsequent coastal jurisdictions.

[115]Victorov, "An Ocean Blueprint for the 21st Century: Final Report of the U.S. Commission on Ocean Policy. Final Report."
[116]Ibid.

State Seaward Boundaries

The Submerged Lands Act of 1953 granted states jurisdiction over of all submerged lands within 3 nautical miles (NM) of the baseline. State and local authorities enforce relevant laws in this zone, but the federal government may also "regulate commerce, navigation, power generation, national defense, and international affairs throughout state waters".[117]

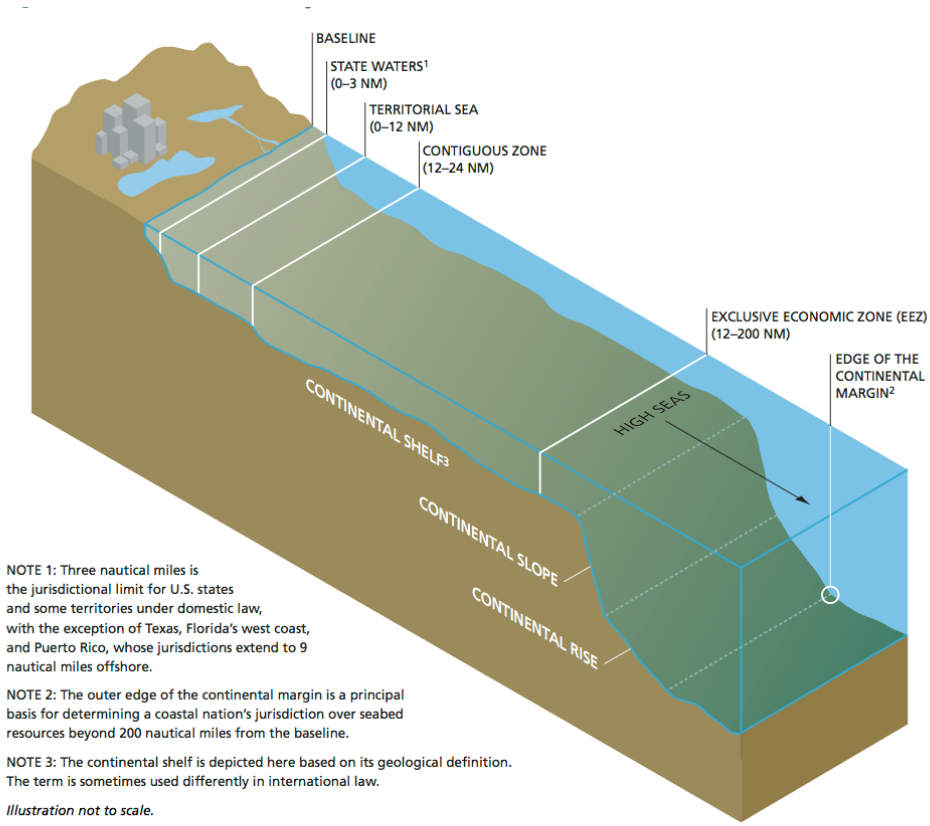
Territorial Sea

The Territorial Sea extends from 3 NM to 12NM from the Baseline. Federal laws and regulations are enforced in this zone.

The Exclusive Economic Zone

The Exclusive Economic Zone (EEZ) begins at the edge of the territorial sea (12 miles from the baseline) and extends 200 NM to sea. Energy development in this zone is subject to U.S. federal laws and regulations.

[117] Victorov, "An Ocean Blueprint for the 21st Century: Final Report of the U.S. Commission on Ocean Policy. Final Report."



Several jurisdictional zones exist off the coast of the United States for purposes of international and domestic law. Within these zones, the United States asserts varying degrees of authority over offshore activities, including living and nonliving resource management, shipping and maritime transportation, and national security. A nation's jurisdictional authority is greatest near the coast.

Figure 5-1: Coastal Jurisdictions in the United States.

Reproduced from Victorov, "An Ocean Blueprint for the 21st Century: Final Report of the U.S. Commission on Ocean Policy. Final Report."

5.3.2 Overview of Federal Permitting

The process of gaining federal approval for an offshore wind farm on the OCS may take one of two different pathways, determined by if the site is part of Wind Energy Area (WEA) or not. The Bureau of Ocean Energy Management (BOEM) is the federal agency responsible for leasing portions of the OCS for commercial energy development, and has developed a process for the identification of potential sites, processes for data gathering and dissemination, as well an organized approach to leasing and permitting. These measures have been implemented in several eastern states but have yet to be carried out in California.

By implementing the "Smart from the Start" initiative[118] on the east coast, the U.S. Department of the Interior, through BOEM, has created a comprehensive program for OSW permitting on a regional basis that reduces uncertainty in the permitting process. The Smart From the Start program includes the creation of Wind Energy Areas, or WEAs, that are predefined blocks of the OCS that have undergone NEPA reviews, including

[118] "Smart from the Start | BOEM."

preliminary Environmental Assessments (EA) to determine their suitability for OSW development.[119] The act of BOEM conducting EA's on the proposed areas serves to gather all relevant environmental and ecological data under BOEM and allows the Bureau to act as a clearinghouse for this information to concerned parties. In addition to environmental and ecological assessment, the WEAs have been analyzed by BOEM and have been determined to be development sites that provide access to desirable wind resources and minimize the impacts on concerned stakeholders such as local fishing and shipping communities and nearby residents.[120] The status of a similar program in California, and BOEM's role in coordinating OSW permitting efforts in the ROI is discussed further in Section 5.4.5.

Regardless of the status of a proposed site, a proposed OSW development will be subject to NEPA review at least twice, and possibly three times during the federal review process as indicated in Figure 5-2: Flowchart of the Federal Permitting Process.

5.3.2.1 The National Environmental Policy Act

Any project subject to federal jurisdiction must follow the NEPA process, including projects that require permits from federal agencies. To comply with the statute, federal agencies must evaluate potential environmental impacts of proposed federal actions[121], and consider reasonable alternatives before an action is authorized. The NEPA process can require considerable resources and as the regulations are currently written, there are three possible NEPA reviews;

1. before the issuance of an auction Final Sale Notice, or before issuance of a competitive or non-competitive site assessment lease
2. before the approval of a Site Assessment Plan(SAP), and
3. before the approval of the Construction and Operations Plan (COP)[122]

As the lead agency responsible for energy projects seeking a lease on the OCS, BOEM is responsible for preparation of NEPA documentation and for leading coordination and consultation with other federal and state agencies, the mechanics of which are defined in the text of NEPA.

[119] Frulla, Hagerman Jr, and Hallowell, "Found in the Wind."

[120] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Wind & Water Power Program and U.S. Department of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, "A National Offshore Wind Strategy: Creating an Offshore Wind Energy Industry in the United States."

[121] NEPA defines Federal Actions as: "…projects, activities, or programs funded in whole or in part under the direct or indirect jurisdiction of a federal agency, including those carried out by or on behalf of a federal agency; those carried out with federal financial assistance; those requiring a federal permit, license, or approval; and those subject to state or local regulation administered pursuant to a delegation or approval by a federal agency." National Park Service, "National Park Service: Directors Order 12."

[122] Details of these specific documents are discussed in Section 3.3.2 of Appendix C.

5.3.2.2 Deferral of Federal Authority to State Agencies

Several laws that are part of the federal approval process rely on the participation of state and local agencies for their implementation and regulation. The federally enacted Clean Air Act (CAA), Clean Water Act (CWA), and Coastal Zone Management Act (CZMA) are designed to provide each state with the ability to create and enforce regulations that meet the intent of federal legislation in a manner that takes local considerations into account. This deferral of authority creates a linkage between local government agencies and the federal permitting process three ways:

1. Consistency Certification through the Coastal Zone Management Act.
    a. Review at the state level is conducted by the California Coastal Commission; once this is complete BOEM assumes review responsibilities.
2. Certification under §§ 401 and 404 of the CWA,
    a. Local water quality boards create rules to enact the Clean Water Act; permits are issued by local agencies.
3. Regulation of local air quality issues by local Air Resources Boards,
    a. Local ARB's operate under air quality plans mandated, reviewed, and approved by the federal government.

To satisfy these requirements, developers applying for permit from BOEM will also need to apply for permits from the applicable state or local agencies.

Table 5-2: Federal Approvals

Required Federal Permits			
Permit	**Primary Statute**	**Regulatory Body**	**Time Duration**
General Conformity Determination	Clean Air Act	• EPA • Local Air Quality Control Boards	• No statutory time limit
OCS Air Quality Permit	Clean Air Act	• EPA • Local Air Quality Control Boards	• No statutory time limit
Consistency Determination	Coastal Zone Management Act	• California Coastal Commission • BOEM	• 6 months.
Eagle Take Permit	Bald and Golden Eagle Protection Act	• U.S. Fish and Wildlife Service	• 2 to 24 months.
FAA Determination	Federal Aviation Act	• Federal Aviation Administration	• 8 – 12 months.
Incidental Take Permit	Section 10, Endangered Species Act	• NMFS or USFWS, as applicable	• No statutory time limit.
PATON Permit	Ports and Waterways Safety Act of 1972	• U.S. Coast Guard	• Approx. 3 months.
Section 10 Permit	Rivers and Harbors Act	• Army Corps of Engineers	• 60 – 120 days.
Section 401 Water Quality Certification	Clean Water Act	• Local Water Quality Control Board • EPA	• No statutory time limit
Section 404 Permit	Clean Water Act	• Army Corps of Engineers • EPA	• No statutory time limit
Additional Approvals & Consultations Required (not permits)			
Requirement	**Primary Statute**	**Regulatory Body**	**Time Duration**
NEPA Decision	NEPA	• BOEM	• No statutory limit, impacted by duration of other processes.
OCS Lease	Outer Continental Shelf Lands Act	• BOEM	• No statutory limit, impacted by duration of other processes.
EFH Consultation	Magnuson-Stevens Act	• National Marine Fisheries Service (NMFS)	• 30 – 60 days
Migratory Bird Consultation	Migratory Bird Treaty Act	• National Marine Fisheries Service (NMFS)	• No statutory time limit
MMPA Consultation/ Incidental Take Authorization (IHA) / Letter of Auth. (LOA)	Marine Mammal Protection Act	• NMFS	• 120 days (IHA) • 6 – 24 Months (LOA)
Section 106 Consultation	National Historic Preservation Act	• State, tribal, and local Historic Preservation Offices	• Estimated at 12 months, however no formal timeline exists.
Section 7 Consultation	Endangered Species Act	• NMFS and/or • USFWS	• 135 days, or, with extensions, > 1 year.

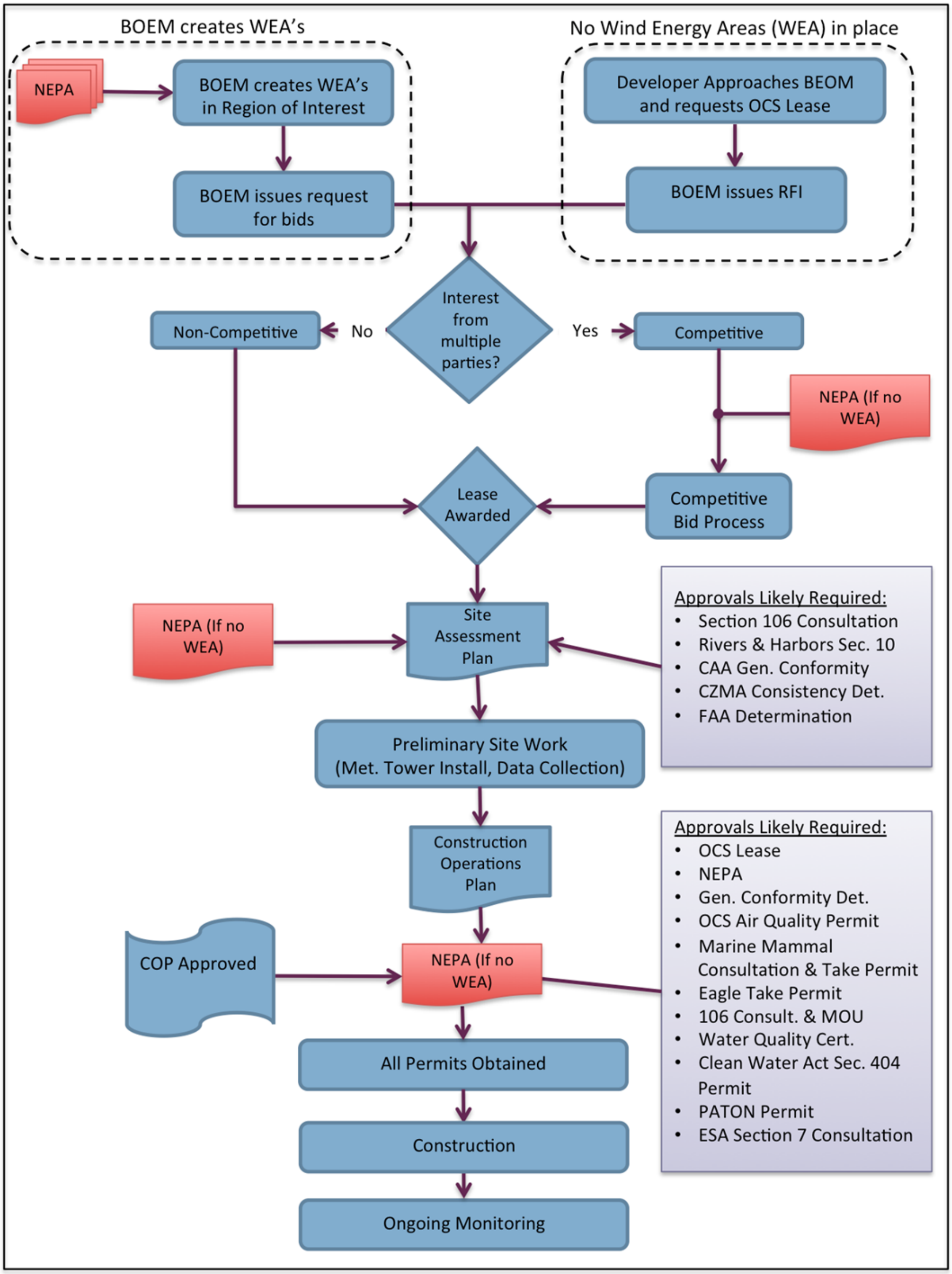


Figure 5-2: Flowchart of the Federal Permitting Process. NEPA Reviews are shown in red for emphasis. "Approvals Likely Required" for SAP are necessary regardless of whether a WEA has been previously established. BOEM conducts first NEPA review prior to developer involvement if establishing WEAs.

5.3.3 Overview of California State Permitting

California claims jurisdiction to an OSW project in federal waters because the export power cable connecting the wind turbines to shore will pass through state waters. The pathway for gaining approval for OSW development from the state of California is similar to the process used to gain federal approval in that an "umbrella" environmental regulation is used as the nexus for multiple agencies review. The California Environmental Quality Act (CEQA) provides for a methodical review process for projects subject to state action. In addition to the CEQA review process, a number of additional permits and approvals are required as shown in Figure 5-3 and described in this section.

5.3.3.1 California Environmental Quality Act

CEQA is the overarching environmental regulation in California and requires California's public agencies to identify the significant environmental impacts of their actions, and to avoid and/or mitigate those impacts where feasible.[123] Although it is a required process, there is not a specific permit associated with CEQA; rather the series of steps mandated by CEQA determines the review process that a project must undergo prior to receiving required permits from state agencies. Because of these requirements, the CEQA process unites all state agencies involved with the review of an OSW development with a common set of rules and procedures. As determined by statute these agencies have varying roles during the review cycle, ranging from Lead to Local Agency. Each of these roles contains specific responsibilities during the CEQA process.

The CEQA review process is required for the obtainment of a State Lands Lease and for a Coastal Development Permit.[124] To initiate the CEQA review process, a developer must submit applications to both the State Lands Commission (SLC) for the State Lands Lease and to the California Coastal Commission (CCC) for the Coastal Development Permit. The SLC is designated the lead agency for the CEQA review, and is responsible for preparing the applicable CEQA documentation. The CCC acts as the Responsible Agency "which [has] discretionary approval power over the project" and has the ability to reject a proposed project.[125]

Additionally, all other state agencies that can claim jurisdiction over a project must consider SLC's CEQA documentation prior to issuing their own approval for a project.

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[123] Association of Environmental Professionals, "2014 CEQA Statute and Guidelines."

[124] Robert S. Townsend et al., "California Tideland and Submerged Land Leasing for Conservation Purposes."

[125] "CEQA | Title 14 | Article 20. Definitions."

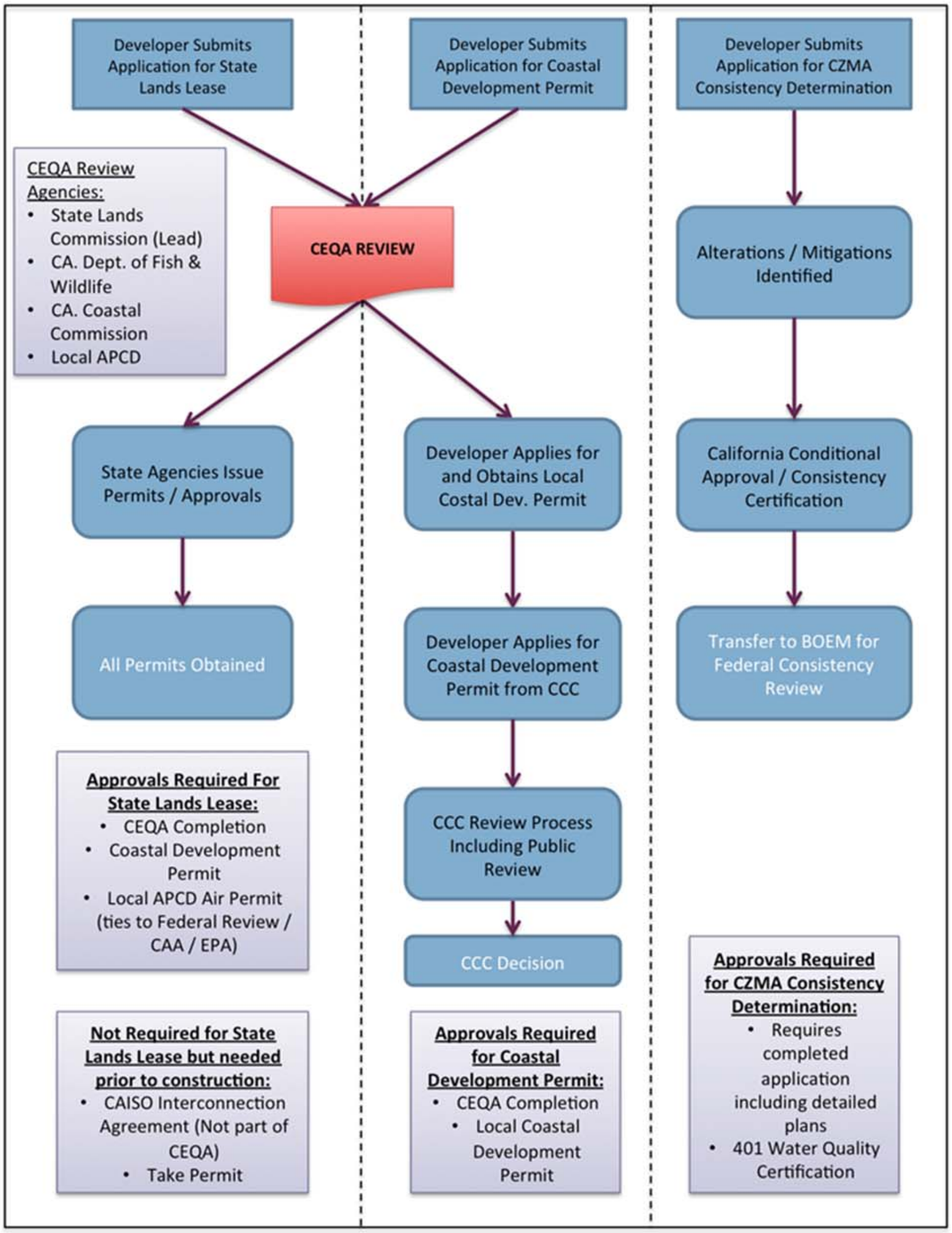

Figure 5-3: California Permitting Process

The process of obtaining approval for OSW development in California consists of three separate pathways comprised of the obtainment of a State Lands Lease (SLL), Coastal Development Permit (CDP), and CZMA Consistency Determination. The CEQA process connects the pathways for SLL and CDP, but is not required for CZMA, which reverts to federal review under NEPA following completion of state agency review and approval. Simultaneous review of each of these pathways is possible, however a State Lands Lease must be obtained prior to issuance of a Coastal Development Permit.(CEQA shown in red for emphasis only).

Table 5-3: State Approvals

State Approvals			
Permit / Approval	**Primary Statutes**	**Regulatory Body**	**Time Duration**
CEQA	CEQA	• CA State Lands Commission	• Varies – 105 days for Negative Declaration, 1 year for EIR, time limits may be waived for joint CEQA-NEPA documentation. See Appendix C.
State Lands Lease	California Constitution, Submerged Lands Act	• CA State Lands Commission	• Varies by project. No statutory time limit.
Coastal Development Permit	California Coastal Act	• California Coastal Commission	• Varies by project; once application is complete CCC staff has 49 days to present to Commission.
Coastal Zone Marine Act Consistency Determination	Coastal Zone Marine Act	• California Coastal Commission • BOEM	• 6 months
Incidental Take Permit	CA. Endangered Species Act	• CA. Dept. of Fish and Wildlife	• 135 days
401 Water Quality Certification	Clean Water Act	• Regional Water Quality Control Board	• 1 year, although states typically exceed this timeframe. See Appendix C for additional information.
Interconnection Permit	Clean Air Act, General Conformity Rule	CA Independent System Operator	• No overall time limits established, will vary based on project details.

5.3.3.2 California Coastal Act

The California Coastal Act regulates development of the Coastal Zone in California and is enforced by the CCC. A Coastal Development Permit is required from the CCC for development in the Coastal Zone, including the placement of any solid material or structure.[126,]The CCA acknowledges that, for economic reasons, coastal development that has, "…significant adverse effects on coastal resources or coastal access" may be necessary and therefore permitted by the act [CCA, §30001.2]. The CCA does not contain explicit provisions or exceptions for any form of renewable energy development, including offshore wind energy. The CCA also is designed to address non-tangible resources of coastal areas, and states that,

> *"The scenic and visual qualities of coastal areas shall be considered and protected as a resource of public importance. Permitted development shall be sited and designed to protect views to and along the ocean and scenic coastal areas, to minimize the alteration of natural land forms, to be visually compatible with the character of surrounding areas, and, where feasible, to restore and enhance visual quality in visually degraded areas"* (CCA, §30251).

[126]"California Coastal Commission: Why It Exists and What It Does."

The potential visual impact of and OSW energy development would need to be assessed through the Local Coastal Plan governing a particular region to determine consistency with the requirements of the CCA. The Local Coastal Plans of the counties within our ROI each value the scenic and visual qualities of coastal areas and direct that they should be considered and protected as an important resource.[127] Given the CCA's emphasis on public inclusion in the planning and decision making process, any objections to visual impacts will be heard, and possibly responded to, under this Act. For further elaboration on OSW viewshed impacts related to the approval process please refer to Section 7.4.2 of this chapter.

5.3.4 Overview of Local Permitting

A county will be involved with the permitting of an OSW project if the export power cable landfall or electrical infrastructure improvements such as a substation are located within county limits.

The necessary permits required to install new electrical infrastructure is highly dependent on its location. The county would maintain jurisdiction if the construction was on a parcel within the coastal zone, or on a properly zoned parcel in the inland area, defined as on-land property outside of the Coastal Zone. As shown in Table 5-4, the specific regulations and permitting requirements in this instance would be determined by the zoning status of the parcel to be developed.

Table 5-4: Electrical Infrastructure Permitting Requirements

Infrastructure Location	Applicable Regulations	Permit Required
Coastal Zone	Coastal Zoning Ordinance	Coastal Development Permit
Inland Area	Land Use Development Code	Conditional Use Permit
Utility Property	CPUC	CPUC Authorization

However, if the substation was to be built on utility company land and operated by the utility under the authority of the California Public Utilities Commission, the county would not have jurisdiction and no county permit would be required. Permitting efforts would be handled by the CPUC.

5.3.5 Developer's Role in the Permitting Process

An OSW developer is responsible for every phase of a project, from conceptualization though decommissioning. Although the developer's primary activities are related to financial support and management of a project, several areas of activity occurs for the developer prior to, and during the permitting process, including:

- Initiation of discussions about project with regulatory agencies;

[127] County of Santa Barbara Planning and Development, "Article II Coastal Zoning Ordinance 07-2013 Update"; "The City Of Santa Barbara Local Coastal Plan"; Ventura County Planning Division, "Ventura County Coastal Area Plan"; County of San Luis Obispo, "COASTAL PLAN POLICIES."

- Hiring and leading a consultant team to address legal and technical requirements (including detailed planning, engineering, and data gathering activities);
- Stakeholder engagement; and,
- Ongoing engagement with regulatory agencies

As the guiding force of an OSW project, the developer is responsible for clearly communicating the details of the project to regulators and stakeholders. The permitting process provides many opportunities for stakeholder input and influence on a project's outcomes, and it is therefore in a developer's best interest to focus communication efforts on stakeholders that may jeopardize a project's chance for success. Such stakeholder engagement may include a variety of efforts depending on the details of a particular project, and developers must be aware of the influence that stakeholders may exert.[128,129] A methodical approach to identifying significant stakeholders and conducting an analysis of their concerns will allow the developer to address these issues in a meaningful and effective manner. Such an approach is described and demonstrated in the Stakeholder Analysis chapter of this report.

Although a developer's consultant team (consisting of a variety of professional specializations including engineers, project managers, and regulatory experts) prepares much of the detailed information that is required for approval and construction, the developer is responsible for guiding their activities and, as the final decision maker, interfacing with regulatory authorities on a regular basis.

The scope of required data collection efforts by the consultant team will be impacted by the presence or absence of a BOEM Task Force, and is discussed in Section 5.4.4.

5.4 Discussion

The permitting process described above affects OSW development in California. These effects include disproportionately represented stakeholders, the effect that viewshed impacts may have on the permitting process, high levels of uncertainty for developers and regulators, and data and information gaps. These issues are discussed below, along with a discussion of current state and federal coordination efforts, and communicating the issues presented in this report to the general public.

5.4.1 Disproportionately Represented Entities

The network of statutes and agencies that provides protection for environmental and economic interests is intended to address as many impacts of human activity as possible while still allowing for the economic development of natural resources. The approvals that are required for OSW development are not specific to OSW project, but rather are applied from an existing framework of environmental statutes, some of which are

[128] Claire Haggett, "Understanding Public Responses to Offshore Wind Power."
[129] M.W. Marinakos, "A Mighty Wind: The Turbulent Times of America's First Offshore Wind Farm and the Inverse of Environmental Justice."

broadly written and may not have originally been intended for the offshore environment (such as the Bald and Golden Eagle Protection Act). While the relevance of certain laws may be debated, the laws nonetheless do apply and must be taken into consideration.

A level of redundant protection exists in the laws that are applicable to OSW development, although the amount of redundancy is not consistent between protected entities. Examples of redundant protection include some avian species (protected by the U.S. & California Endangered Species Acts, Migratory Bird Treaty Act, and Bald and Golden Eagle Protection Act) and some marine mammal species (protected by the Marine Mammal Protection Act and U.S. & California Endangered Species Acts). A developer wishing to pursue an offshore wind project must satisfy the requirements for each of these acts, and therefore in some cases will work under four separate laws for a single species, with each law containing unique requirements and timelines for completion. This level of redundant protection may be contrasted with protection for fish habitat, which outside of marine protected areas is protected by only one law, the Sustainable Fisheries Act. The possibility exists that efficiencies may be gained in the permitting process by consolidating multiple requirements for single species into a single review and approval process.

While laws that protect the environment are ostensibly intended to preserve natural resources for humanity's current and future wellbeing in line with the Public Trust Doctrine, few laws exist that provide explicit statutory protection for human stakeholders. For example, there are no laws that explicitly protect the interests of commercial fishermen, Native American tribes, or ethnic and socioeconomic minorities from the possible impacts of OSW development. The current regulatory structure does provide for these stakeholders to have a voice in the process, however, through periods of public input during the NEPA, CEQA, and California Coastal Development Permit processes. In some cases these opportunities are repeated numerous times at different stages in the planning for a project, as would be the case in the multiple NEPA reviews that are required for federal permitting.

Although stakeholder groups are able to provide input during the review process, there is no agency with discretionary power over a project that is required to act as an agent for these groups. The result is that while stakeholders may have an opportunity to voice concerns, agencies are only required to take their comments into consideration and are not required to alter the direction of a project as a result of the comments they receive. For stakeholders without the means to pursue their concerns further, public comment is the only venue available. For those stakeholders who are able to pursue their concerns using legal channels, lawsuits are the only viable legal option for influencing a project if the process of providing public comments does not create the desired outcomes. The possibility of legal challenges to projects creates uncertainty for developers and regulators alike, which translates to cost and time burdens in the approval process. As an example of the impact that such legal actions may have, Massachusetts' Cape Wind project, the first permitted OSW project in the United States, was subjected to multiple lawsuits from stakeholder groups resulting in project delays of over ten years.

While some stakeholder groups will have adequate support to pursue legal action outside of the established permitting process, others will not. Either due to limited financial resources, lack of organizational abilities, or lack of knowledge about their options, some groups will inevitably be left out of the decision-making process. As a matter of environmental justice this issue must be addressed. Outreach by government agencies and community organizations to typically underserved stakeholders may help to address this issue, as may efforts by project developers to survey and interview a large representative sample of the population to determine opinions and knowledge of OSW, similar to the work elaborated upon in Chapter 5 of this report. Gathering this data is but a first step, and would ideally be followed up with outreach efforts to groups that may be impacted by OSW but have little voice in the current regulatory process.

5.4.2 Considerations of Viewshed Impacts on the Permitting Process

Depending on the distance a wind farm is located from the coast, OSW development may create impacts to the viewshed of coastal populations. Research has indicated that these populations are highly sensitive to such impacts, and that resistance to OSW by the general public is primarily related to views, and that such resistance can pose substantial barriers for developers.[130,131,132]

Viewshed impacts are regulated by state and federal laws including the California Coastal Act and the National Historic Preservation Act, and will be considered during the NEPA, CEQA, and Coastal Development Permit review processes. Each of these processes allows the public to provide input into projects being considered, and regulators are required to take this input into account in the decision making process. Viewshed impacts were a major element of public resistance (including resistance from Native American tribes due to impacts to tribal ceremonies) to the Cape Wind project in Massachusetts, where opposition added substantial duration to the approval process.[133]

Concerns over viewshed impacts in the ROI are reflected in Section 3 and will be an important issue for developers and renewable energy proponents to address as part of the permitting process. As indicated in the literature and by the experience of Cape Wind, this opposition should not be underestimated.[134]

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[130] Claire Haggett, "Understanding Public Responses to Offshore Wind Power."

[131] Ladenburg, "Attitudes towards on-Land and Offshore Wind Power Development in Denmark; Choice of Development Strategy."

[132] Ladenburg, "Visual Impact Assessment of Offshore Wind Farms and Prior Experience."

[133] M.W. Marinakos, "A Mighty Wind: The Turbulent Times of America's First Offshore Wind Farm and the Inverse of Environmental Justice."

[134] Claire Haggett, "Understanding Public Responses to Offshore Wind Power."

5.4.3 Uncertainty in the Permitting Process

The current permitting process results in uncertainty from the standpoint of OSW developers, financers, and regulatory agencies.[135] Ambiguity in statutes and regulations leads to variable interpretation across agencies.[136] A developer's willingness to participate in OSW projects in the ROI may be limited by this ambiguity, as lack of clear costs and timelines creates uncertainty regarding the outcome of the approval process.

Uncertainty in the permitting process is not limited to the interpretation of applicable laws, but extends to determining which laws are in fact applicable. Items noted as "maybe" being required in Table 5-1 may or may not apply to a project depending on the specific details of that project. It is currently difficult to impossible for developers or regulators to determine which laws apply to a particular project until detailed plans are developed, a step which typically occurs once the approval process is well underway (see "Construction Operation Plan" on Figure 5-1).

Uncertainty within regulatory agencies and the presence of numerous laws and enforcement agencies leads to inefficiency in the approval process. The U.S. Department of Energy has identified this inefficiency as a hurdle to OSW deployment.[137]

As noted previously, a BOEM Task Force is intended to increase efficiency and reduce the uncertainty of the permitting process for developers, financers, and regulatory authorities alike.

5.4.4 Data and Information Gaps

Two levels of environmental data are required to complete the permitting and approval process. General environmental baseline data of a region under consideration for OSW development is required to determine preliminary site feasibility, and is the type of data collected by BOEM if it is performing initial NEPA and EA activities in order to define WEAs. Detailed site-specific information is required to determine environmental impacts at a particular site with a defined development plan. The latter information is the responsibility of the developer to obtain through site assessment activities. It is typical for developers to have to provide several seasons of such site-specific data before the completion of the permitting process.

[135]U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Wind & Water Power Program and U.S. Department of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, "A National Offshore Wind Strategy: Creating an Offshore Wind Energy Industry in the United States."

[136] Interview with federal employee. Name & agency withheld by request.

[137]U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Wind & Water Power Program and U.S. Department of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, "A National Offshore Wind Strategy: Creating an Offshore Wind Energy Industry in the United States."

Presently gaps exist in the amount and type of general baseline environmental data needed to support commercial OSW development in the ROI. In addition to the data gaps noted in Chapter 4, additional baseline data is needed on the effects of floating wind turbines on bird, fish, and marine mammal populations. Effects of potential concern for which no data currently exists include the effect of electromagnetic energy on marine life; information regarding entanglement with floating platform anchor chains by marine mammals, and the effects that the noise of continuously operating wind turbines will have on animal life.

In discussions with our team, BOEM officials noted that the agency is aware of these issues and that the agency's Office of Offshore Renewable Energy Programs (OREP) is currently in the process of contracting for some of this information. In the absence of a BOEM State Task Force, however, the efforts by OREP are not coordinated with state or local agencies or stakeholders.

5.4.5 State and Federal Coordination Efforts

States have variable engagement with the federal government for OSW planning. Beginning in 2010, the Department of Interior, through BOEM, has collaborated with most of the Atlantic coast states in an effort to create a comprehensive planning effort, recognizing that coastal interests and impacts extend beyond the boundaries of individual states. By implementing the coordinated effort, called Smart from the Start, BOEM aims to facilitate coordination and planning, and to implement a streamlined approvals process across multiple states and the federal government. In addition to this multistate effort on the east coast, BOEM has formed state Task Forces in Hawaii and Oregon that are leading coordination efforts between federal, state, and local governments and are working with stakeholder groups to gather data and identify major concerns related to OSW development in the state.

BOEM will create a Task Force for OSW development at the request of the Governor of the state. This has not yet occurred in California. Despite this, California is actively collaborating with neighboring states regarding ocean-based renewable energy.
In 2006, California, Oregon, and Washington created a regional ocean partnership named the West Coast Governors Alliance (WCGA) on Ocean Health. The WCGA is structured as a policy advisory entity and has no regulatory authority. Within the WCGA, the states of Washington and California are collaborating with multiple federal agencies to "evaluate the potential benefits and impacts of renewable ocean energy projects off the West Coast. An additional goal is to develop the planning and regulatory structure for these activities."[138] Because Oregon already has a BOEM Task Force in place, it is conducting similar coordination efforts with federal authorities independently of California and Washington. However, the WCGA created the Renewable Ocean Energy

[138] West Coast Governors Alliance on Ocean Health, "About us." <http://www.westcoastoceans.org/> Accessed 04.26.2014.

Action Coordination Team, which all three member states participate in. This team is working to develop,

> "…a shared strategy among the States to ensure that when renewable ocean energy development activities are proposed along the west coast, comprehensive planning will occur to increase renewable energy generation and minimize negative impacts to marine ecosystems and coastal communities."[139]

The activities of the WCGA and its Renewable Ocean Energy Action Coordination Team are oriented towards defining a framework for the planning, evaluation, and regulation of offshore energy. These activities do not obviate the need for a BOEM Task Force in the state. With jurisdiction over federal waters residing with BOEM, any actions that the WCGA may propose will be subject to BOEM's interpretation of its own authority, which may not align with the WCGA's efforts. Further, as identified previously, the large number of federal approvals required during the OSW permitting process warrants the leadership of the lead federal agency responsible for the approval of an OSW farm (BOEM) in the process of defining any new regulatory processes. While California and the WCGA states may work to create a streamlined process for OSW development, the presence of a BOEM Task Force in the state would more thoroughly address the range of issues associated with the permitting process discussed previously in this chapter.

5.5 Synthesis of the Permitting Process for the General Public

At present there does not exist a clear way to communicate the requirements of OSW permitting to a general audience. Jurisdictions of ocean regulation (Figure 5-1) and agency responsibility (Figures 5-2 & 5-3) illustrate aspects of the approval process that are likely to be unfamiliar to the general public. We recognize that this may be a barrier to understanding, and believe that developing a means of communicating the regulatory requirements of OSW will help result in an informed public. Additionally, by illustrating that stakeholders have opportunities to have their opinions heard during the decision making process, we hope to begin to reduce some effects of under representation as discussed in Section 5.4.1. The purpose of the infographic is to illustrate the permitting process in an easy to understand manner by illustrating major activities and concepts involved.

[139] West Coast Governors Alliance on Ocean Health, "Action Teams: Renewable Ocean Energy Action Coordination Team." <http://www.westcoastoceans.org/ >. Accessed 04.26.14.

The infographic, as shown in Figure 5-4, is a graphic depiction of the major elements discussed in this chapter. Designed for a general audience, it is intended to allow quick absorption of basic information about the permitting process for OSW in California. As such, the infographic does not include detailed descriptions of laws and regulations but rather seeks to provide a broad overview of jurisdictional issues, major statues involved, and the stages of OSW development. The content, layout, and appearance of the infographic are based on team preferences. The infographic is intended primarily for online publication but can also be used in print or presentation formats.

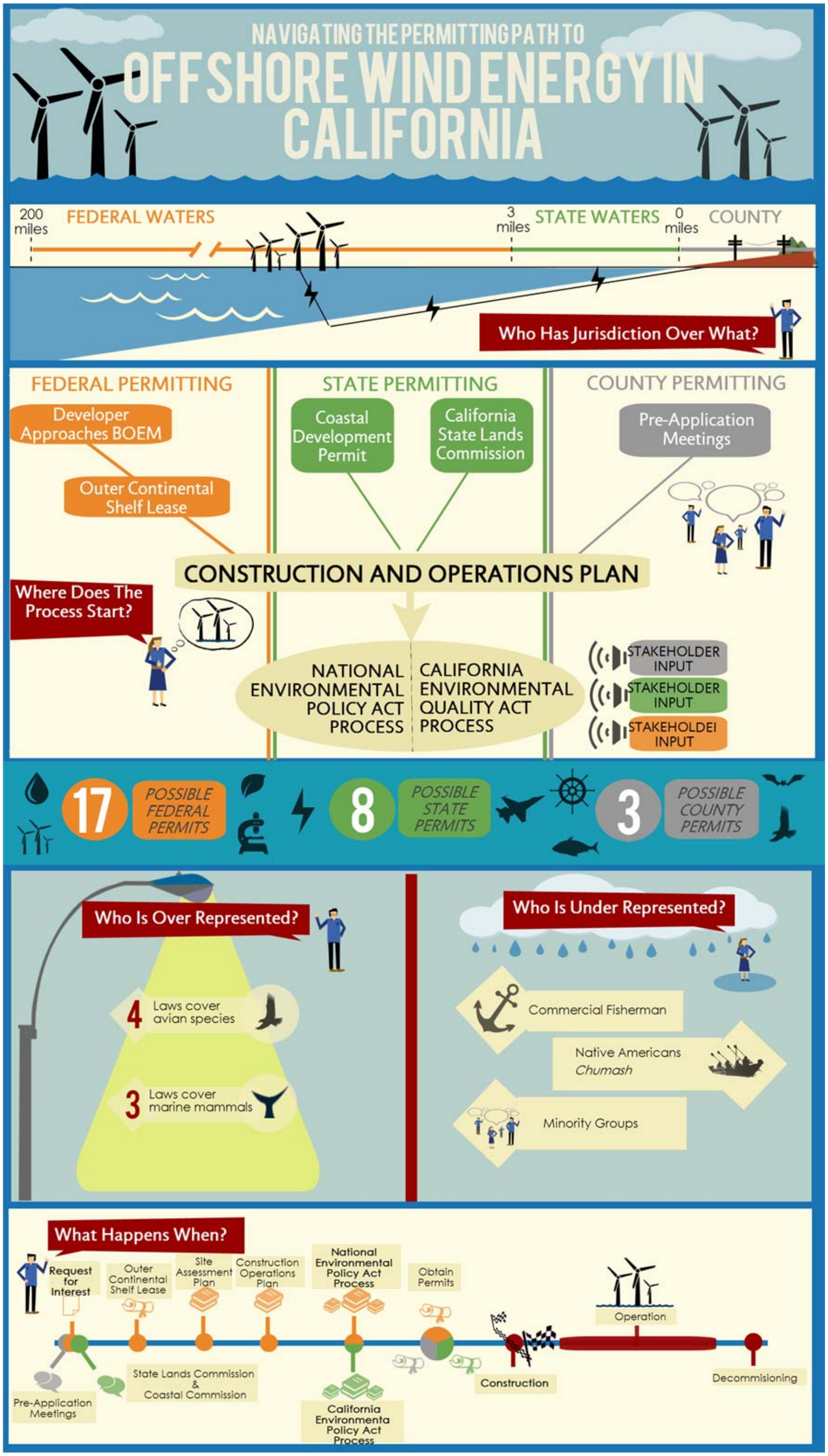

Figure 5-4: CalWind Permitting Infographic

5.6 Conclusions

Research into the statutory measures pertaining to offshore wind development has revealed several key findings, including:

Current Permitting Process Creates Uncertainty

The current process for obtaining permission to develop an OSW project on California's Central Coast results in uncertainty for developers, regulators, and stakeholders. The absence of a central organizing entity, such as a BOEM Task Force, adds to this uncertainty.

Duplication of Regulations

Multiple statutes provide protection for similar entities, while some stakeholders have no specific agency or statute representing their interests. Duplication of protection in regulations adds complexity, time, and cost burdens to developers and regulators. Lack of representation for traditionally underrepresented groups evokes issues of environmental justice.

Gaps exist in Baseline Environmental Data

Multiple elements of baseline environmental data (including, but not limited to, information on the impacts of floating offshore turbines on animal life) create barriers for conducting a thorough environmental assessment of the ROI by potential developers, and thus limit assessments of OSW project feasibility. Federal and state governments, through BOEM, could obtain this information and make it publically available, as has been done on the east coast.

Coordination is needed between state and federal regulators.

Efforts are underway in this respect[140] but additional formal coordination in the form of a BOEM Task Force would accelerate these efforts. The presence of a BOEM Task Force (created at the request of the Governor) would address many issues, including federal-state agency coordination, data gathering and dissemination, creation of Wind Energy Planning Areas. All of these activities would act to improve the conditions for OSW development in California.

First-Mover Impacts

Disproportionate burdens exist on the "first movers" of OSW development in central California. In the absence of a streamlined permitting pathway, first movers will incur added costs as a result of increased time and data gathering requirements.

Deliberative Decision Making is Needed

Despite the need for increased efficiency in the permitting process, there is merit in having a process in place that allows for deliberative decision-making and thoughtful consideration by regulators and affected stakeholders. Rigor and the opportunity for stakeholder engagement should not be sacrificed in the name of expediency. If expediting the permitting process would result in less protection, and environmental

[140] Bureau of Ocean Energy Management, "California and Washington Activities."

harm occurs that could have been avoided, it will harm the credibility of future OSW development in the region. For this reason the development and NGO community may be warranted in supporting a rigorous approvals process, albeit one with decreased uncertainty and increased transparency.

6.0 Project Conclusions

This project analyzed the feasibility of OSW development off of the California Central Coast through three lenses: a stakeholder analysis, spatial analysis, and review of the permitting process. We have determined that development is feasible, but currently, significant barriers exist.

Our stakeholder analysis serves to provide a snapshot of the most pertinent concerns that potential OSW development presents to local communities and associated parties. These concerns we highlighted permeate all of our research objectives. For instance, interviews with the Department of Defense (DoD) identified that the Department maintains a keen interest in the waters off of the California Central Coast for the purposes of military training and readiness. Any OSW project would need to be coordinated with the DoD to ensure that the development would not interfere with their mission capabilities, be placed in a location of least conflict, and complete the FAA Determination process.

We also identified appreciable stakeholder fatigue and resistance to marine spatial planning from the fishing community. We documented noticeable hesitance to any type of spatial planning that would have the potential to impact the status quo. From the perspective of the permitting analysis, the fishing community was identified as a stakeholder group that is underrepresented and does not have a statutory backing on which to rely. Potential developers would be wise to consult the fishing community and provide opportunities for identifying areas that would minimize future conflict.

Each of the lenses that we examined present potential barriers to OSW development which stem from a communication gap between stakeholders and government agencies, and limited and/or outdated environmental baseline data in our ROI. Under current conditions, developers would be responsible for addressing these issues by conducting considerable stakeholder outreach, encouraging consultation between federal and state governments, and obtaining accurate baseline data.

Should California and its residents want to facilitate the advancement of an OSW industry, a streamlined management scheme would be a positive first step. On the East Coast, the "Smart from the Start" program laid out a framework for BOEM Renewable Energy State Task Forces to act as a nexus between state and federal government and help industry overcome development barriers. Task Forces decrease developer risk by increasing stakeholder communication, collecting and updating baseline environmental data, and identifying pre-vetted Wind Energy Areas (WEAs). To date, however, the

California Governor's office has not requested a BOEM Task Force, and such a move will likely require additional public support and industry interest in the development of OSW in this region.

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