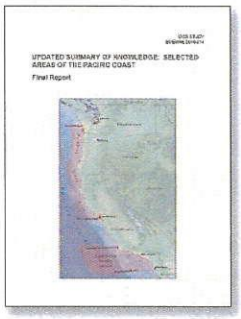
BOEM
Bureau of Ocean Energy Management

Selected BOEM-Funded Research Informing Renewable Energy Offshore California

AUGUST 2018

Information Synthesis & Socioeconomic Studies



***Completed (2010)* — Updated Summary of Knowledge: Selected Areas of the Pacific Coast**

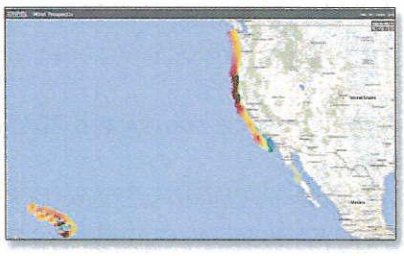
This study by Mangi Environmental Group compiled and analyzed information generated after 1977 about the coastal and marine environment from Grays Harbor, Washington to San Francisco Bay, and from Santa Barbara County to the U.S.-Mexico border. It identified early information and data gaps about oceanographic resources and potential impacts of offshore renewable energy development.

Report (BOEMRE 2010-014): https://www.boem.gov/ESPIS/4/4955.pdf

***Completed (2013)* — Oregon Marine Renewable Energy Environmental Science Conference**

This conference – coordinated by and held at Oregon State University, Corvallis – brought together an international group (including 40 Oregon specialists) to review existing and ongoing science pertinent to marine renewable energy. This expert group reviewed existing research and prioritized data gaps and needs for baseline conditions, environmental effects, and monitoring studies.

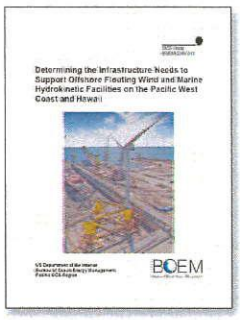
Report (BOEM 2013-0113): https://www.boem.gov/ESPIS/5/5255.pdf



***Completed (2015)* — Pacific Offshore Time Series Wind Resource Analysis**

This study by the U.S. Department of Energy/National Renewable Energy Laboratory (NREL) addressed time-series analysis of wind speed data along the coasts of Washington, Oregon, California, and Hawaii, scaled to BOEM's aliquot grid (a unit of leasing). Average wind speed is provided by month, by hours of the day, and for a long-term (17-year) time series. Data are available through Wind Prospector, NREL's web-based GIS application, which provides easy access to wind resource datasets and supports resource assessment and exploration associated with wind development.

Data: https://maps.nrel.gov/wind-prospector/

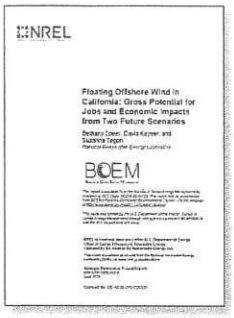


***Completed (2016)* — Determining the Infrastructure Needs to Support Offshore Floating Wind and Marine Hydrokinetic Facilities on the Pacific West Coast and Hawaii**

This study by ICF International evaluated the current infrastructure and vessel requirements and capabilities existing on the Pacific West Coast of the U.S. and the Hawaiian islands of Oahu, Maui, and Kauai to support the burgeoning offshore renewable energy industry. Understanding the infrastructure needs of the offshore renewable industry will help to identify the port-related requirements for offshore floating wind development and marine hydrokinetic industries and assess the utilization of the available marine equipment and facilities along the U.S. West Coast.

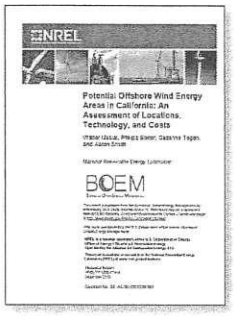
Report (BOEM 2016-011): https://www.boem.gov/ESPIS/5/5503.pdf

Completed (2016) — **Floating Offshore Wind in California: Gross Potential for Jobs and Economic Impacts from Two Future Scenarios**



This study by the U.S. Department of Energy/National Renewable Energy Laboratory conducted an analysis of the employment and economic potential for floating offshore wind in California. The study examined two scenarios: 16 GW of offshore wind by 2050 and 10 GW of offshore wind by 2050. The results of this analysis can be used to better understand the general scales of economic opportunities that could result from offshore wind development.
Report (BOEM 2016-029): https://www.boem.gov/2016-029/

Completed (2016) — **Potential Offshore Wind Energy Areas in California: An Assessment of Locations, Technology, and Costs**



This study by the U.S. Department of Energy/National Renewable Energy Laboratory (NREL) developed unsubsidized cost estimates for offshore wind power in the State of California. The cost estimates were calculated for six reference sites that were selected based on physical site conditions, wind resource quality, known existing site use, and proximity to necessary infrastructure. NREL's analyses showed significant cost-reduction potential over the target time period (2015 to 2030). The results can be used to assist decision-making by state utilities, independent system operators, government officials and policy makers, and stakeholders.
Report (BOEM 2016-074): https://www.boem.gov/2016-074/
Cost Estimates: https://www.boem.gov/Spreadsheet-for-CA-Offshore-Wind-Cost-Estimates/

Ongoing (to be completed 2018) — **Synopsis of Research Programs that can Provide Baseline and Monitoring Information for Offshore Energy Activities in the Pacific Region**

This study by the U.S. Geological Survey is identifying ongoing or completed research programs that have produced databases containing information on species and habitats sensitive to offshore energy activities in the Pacific Region. It is evaluating the capability of these programs to provide baseline and monitoring data to understand and mitigate potential impacts of conventional energy development offshore southern California and renewable energy development offshore southern California, Oregon, Washington, and Hawaii.
Study Profile: https://www.boem.gov/pr-14-dmi/

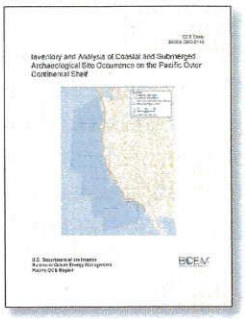
Ongoing (to be completed 2018) — **Environmental Sensitivity and Associated Risk to Habitats and Species on the Pacific West Coast and Hawaii with Offshore Floating Wind Technologies**

This study by ICF International is identifying and characterizing potential impact-causing factors to the marine environment related to offshore floating wind energy development. The study will develop an environmental sensitivity and relative risk model to assess impacts on biological and habitat resources from offshore floating wind technology.
Study Profile: https://www.boem.gov/pc-14-05/

Ongoing (to be completed 2019) — **Scenarios for Offshore Renewable Energy along the Central California Coast**

This study by California Polytechnic State University, San Luis Obispo is delineating feasible offshore renewable energy scenarios along the central coast of California. Researchers will determine information needs and evaluate scenarios, tradeoffs, and generating capacity of various facilities as well as information needed to conduct environmental reviews.
Study Profile: https://www.boem.gov/pc-16-01/

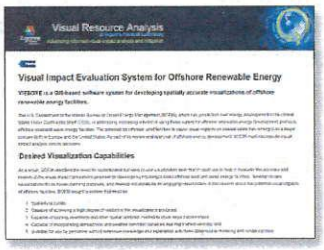
Cultural & Archaeological Studies



***Completed (2013)* — Inventory and Analysis of Coastal and Submerged Archaeological Site Occurrence on the Pacific OCS**

This study by ICF International assessed the potential for submerged prehistoric sites on the California, Oregon, and Washington Outer Continental Shelf (OCS), and identified coastal properties and significant coastal cultural resources subject to potential visual impacts from offshore energy development. It also produced a proprietary inventory of known, reported, and potential historic shipwrecks.

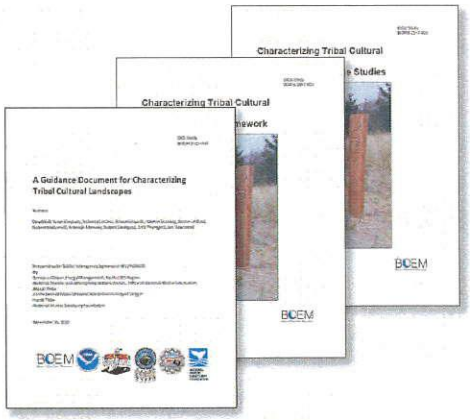
Report (BOEM 2013-0115): https://www.boem.gov/ESPIS/5/5357.pdf



***Completed (2014)* — Renewable Energy Visual Evaluations**

This study by the University of Arkansas and Argonne National Laboratory developed a GIS-based landscape-visualization tool to assess the potential viewshed effects from offshore renewable energy facilities. Visualizations included wind energy structures, lighting, and meteorological conditions.

Journal Article: http://visualimpact.anl.gov/offshorevitd/docs/OffshoreVITD.pdf
Overview: http://visualimpact.anl.gov/viesore/
Webinar: https://www.boem.gov/Science-Exchange-5/



***Completed (2017)* — Characterizing Tribal Cultural Landscapes**

This study by the National Oceanic and Atmospheric Administration used three case studies from Native American communities in California, Oregon, and Washington. It developed a methodology and process that may help all coastal tribes determine significant archaeological and cultural resources. This information will likely be important to future consideration of marine renewable energy projects.

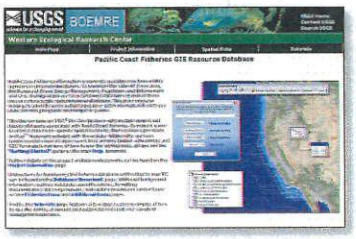
Guidance Document (BOEM 2015-047): https://www.boem.gov/2015-047/
Report (BOEM 2017-001):
Volume I: https://www.boem.gov/BOEM-2017-001-Volume-1/
Volume II: https://www.boem.gov/BOEM-2017-001-Volume-2/
Webinar: https://www.boem.gov/Science-Exchange-8/

***Ongoing (to be completed 2019)* — Archaeological and Biological Assessment of Submerged Landforms off the Pacific Coast**

This study by San Diego State University is identifying potential submerged landforms offshore southern California and central Oregon that could indicate the presence of prehistoric archaeological sites. It will also develop a model to identify and classify potential cultural landforms from existing remote sensing data and seafloor maps in areas along the Pacific Coast, and determine if the submerged features are associated with ecologically sensitive areas.

Study Profile: https://www.boem.gov/pc-14-04/
Fact Sheet: https://www.boem.gov/PC-14-04-Fact-Sheet/

Biological Studies

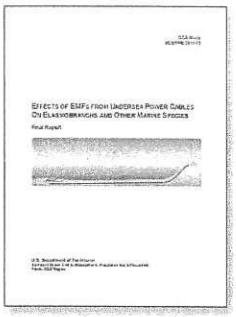


***Completed (2010)* — Pacific Coast Fisheries GIS Resource Database**

This study by the U.S. Geological Survey compiled marine fisheries and coastal spatial data from various wildlife agencies in California, Oregon, and Washington and integrated it into a single, comprehensive GIS-based system. The database includes information about Pacific Coast fish, fisheries, and active fishing, as well as southern California seabirds and marine mammals.

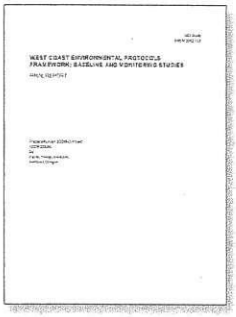
Database: http://www.werc.usgs.gov/Project.aspx?ProjectID=203

Completed (2011) — **Effects of EMF from Transmission Lines on Elasmobranchs and Other Marine Species**



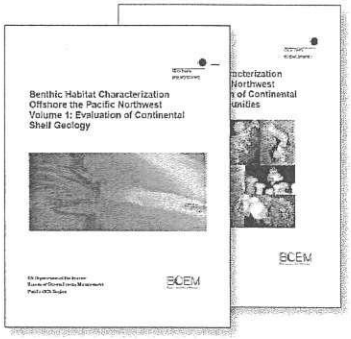
This study by Normandeau Associates synthesized data and information about subsea power-transmission cables and the sensitivity of marine organisms to electromagnetic fields (EMF) produced by the cables. It produced a database of information about potentially affected species of elasmobranchs (sharks and rays), other fishes, marine mammals, sea turtles, and invertebrates. It also recommended future research priorities and potential mitigation measures.
Report (BOEMRE 2011-09): https://www.boem.gov/ESPIS/4/5115.pdf

Completed (2012) — **West Coast Environmental Protocols Framework: Baseline and Monitoring Studies**



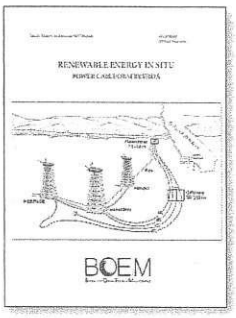
This study by Pacific Energy Ventures provides a framework for identifying natural resources and ecological issues to monitor for proposed wave, tidal, and offshore wind projects along the U.S. West Coast.
Report (BOEM 2012-013): https://www.boem.gov/ESPIS/5/5219.pdf

Completed (2014) — **Survey of Benthic Communities Near Potential Renewable Energy Sites Offshore the Pacific Northwest**



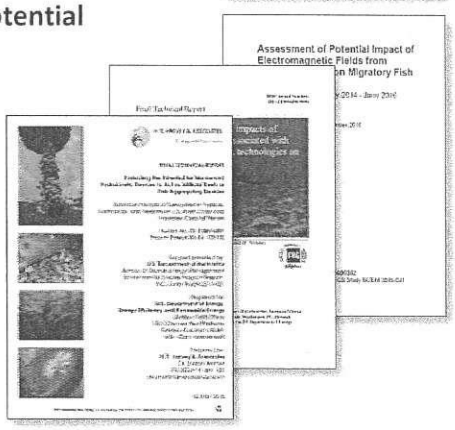
This study by Oregon State University provided baseline information about the seafloor environment and the types and distribution of benthic invertebrates in areas of potential renewable energy development on the Washington, Oregon, and northern California OCS. Knowledge of species-habitat relationships will allow for prediction of seafloor communities beyond those sampled in this study.
Report (BOEM 2014-662):
Volume 1: https://www.boem.gov/ESPIS/5/5453.pdf
Volume 2: https://www.boem.gov/ESPIS/5/5454.pdf
Webinar: https://www.boem.gov/Science-Exchange-4/

Completed (2016) — **Renewable Energy *in situ* Power Cable Observation**



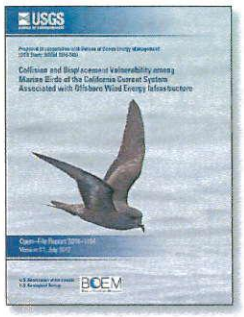
This study by the University of California, Santa Barbara measured the strength and variability of electromagnetic fields (EMF) along subsea power transmission cables in the Santa Barbara Channel, which are similar to cables used for offshore renewable energy inter-device electrical connections. It also compared fish communities in cable versus natural habitats and determined the potential effectiveness of cable burial as a mitigation measure to decrease EMF.
Report (BOEM 2016-008): https://www.boem.gov/ESPIS/5/5520.pdf
Webinar: https://www.boem.gov/Science-Exchange-3/

Completed (2016) — **Using Ongoing Activities as Surrogates to Predict Potential Ecological Impacts from Marine Renewable Energy**



BOEM and the U.S. Department of Energy partnered on this study to identify and analyze data from ongoing projects and activities (surrogates) with stressors and receptors similar to those expected from marine renewable energy projects. Two reports examined potential impacts of electromagnetic fields from operating power cables, and one examined mooring configurations of offshore aquaculture facilities and oceanographic buoys as entanglement hazards for marine mammals.
First Report (BOEM 2015-021): https://www.boem.gov/2015-021/
Second Report (BOEM 2015-042): https://www.boem.gov/2015-042/
Third Report (BOEM 2016-041): https://www.boem.gov/2016-041/

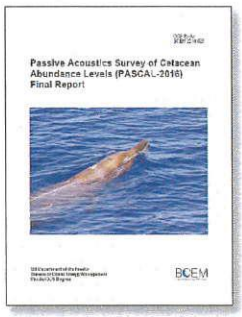
***Completed (2016)* — Developing and Applying a Vulnerability Index for Scaling the Possible Adverse Effects of Offshore Renewable Energy Projects on Seabirds on the Pacific OCS**



This BOEM-directed study, conducted and primarily funded by the U.S. Geological Survey, developed a comprehensive database to evaluate 81 marine bird species in the California Current System (CCS) in terms of their collision and displacement vulnerability from offshore wind energy infrastructure. It used existing and newly analyzed at-sea behavioral information (e.g., avian habits and activities, flight-height, and flight characteristics) and population metrics to identify species-specific vulnerabilities at the population level. The vulnerability assessment results can now be combined with recent marine bird at-sea distribution and abundance data for the CCS to help address seabird conservation during the siting and operation of offshore wind energy development projects.

Report (USGS OFR 2016-1154, BOEM 2016-043): https://pubs.er.usgs.gov/publication/ofr20161154
Webinar: https://www.boem.gov/Science-Exchange-6/

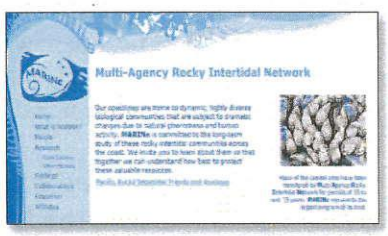
***Completed (2018)* — California Current Cetacean and Ecosystem Assessment Survey and Use of Data to Produce and Validate Cetacean and Seabird Density Maps**



This study by the National Marine Fisheries Service/Southwest Fisheries Science Center focused on listening for whale species that are difficult to detect during visual surveys because of their deep diving habits and and limited surface activity.

Report (BOEM 2018-025): https://www.boem.gov/BOEM-2018-025/

***Ongoing* — BOEM-MARINe (Multi-Agency Rocky Intertidal Network)**



This long-term and continuing study by BOEM and a network of partners provides for the monitoring of rocky intertidal habitats and communities at 32 coastal sites adjacent to existing and potential OCS energy development in California and Oregon. Site-specific data about the diversity and abundance of invertebrates are housed in a publicly available database that can be used to monitor intertidal communities.

Study Profile: https://www.boem.gov/pc-15-02/
MARINe Websites: https://www.MARINe.gov, https://pacificrockyintertidal.org

***Ongoing (to be completed 2018)* — DOI Partnership: Distinguishing between Human and Natural Causes of Change in Nearshore Ecosystems Using Long-term Data from DOI Monitoring Programs**

This study by the University of California, Santa Barbara is working to understand the natural range and sources of variability in the kelp forest ecosystem well enough to generate predictions on how it will respond to environmental change. This study will also enable scientists and managers to evaluate possible impacts from alternative energy production, and develop options to mitigate these impacts.

Study Profile: https://www.boem.gov/pc-11-02/

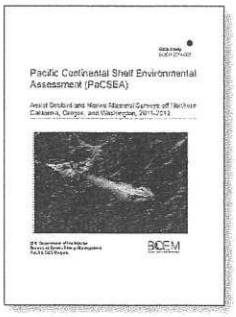
***Ongoing (to be completed 2018)* — Understanding the Role of Offshore Structures in Managing Potential *Watersipora subtorquata* Invasions**

This study by the University of California, Santa Barbara is surveying the distribution and abundance of a non-native bryozoan on 23 platforms and natural reefs in the Southern California Bight, and is elucidating the role that offshore artificial structures may have in linking and affecting biological communities. The study results will inform environmental reviews of conventional energy activities (including decommissioning of platforms) and renewable energy activities (including siting of facilities) offshore southern and central California.

Study Profile: https://www.boem.gov/pc-13-04/

***Ongoing (to be completed 2018)* — Regional Importance of Manmade Structures as Rockfish Nurseries**
This study by the U.S. Geological Survey is integrating seafloor habitat maps, current flow patterns, and field surveys to better understand the role that platform habitat may have in rebuilding stocks of overfished species. It is generating a stock assessment of juvenile fishes in the Southern California Bight, quantifying the contribution of platform habitat to regional production, and describing potential connectivity pathways between juvenile and adult habitats in the Santa Barbara Channel region and San Pedro Basin, focusing on platform-natural reef links.
Study Profile: https://www.boem.gov/pc-10-01/

***Ongoing (to be completed 2018)* — Seabird and Marine Mammal Surveys off the Northern California, Oregon and Washington Coasts**



This study by the U.S. Geological Survey and U.S. Fish and Wildlife Service provided up-to-date information on the types, distribution, abundance, seasonal variation, and habitat use of marine mammals and seabirds along the northern California, Oregon, and Washington coasts. Aerial surveys using state-of-the-art technology focused on the most likely areas of OCS renewable energy development. Additional work will determine ecosystem connections and species-habitat associations.
Study Profile: https://www.boem.gov/pc-10-05/
First Report (BOEM 2014-003): https://www.boem.gov/ESPIS/5/5427.pdf
Second Report (BOEM 2018-002): in press
Webinar: https://www.boem.gov/Science-Exchange-1/

***Ongoing (to be completed 2018)* — Visual Simulation of Whales and Renewable Energy Moorings and Cables**
This study by the U.S. Department of Energy/Pacific Northwest National Laboratory will compile information about whale movements (e.g., dive depths and swimming speed) and create a three-dimensional video animation of how whales may move through a hypothetical offshore floating wind farm. This visual simulation will help characterize the risk of whale encounters with mooring lines and electrical cables used in offshore floating wind projects.
Study Profile: https://www.boem.gov/pr-17-whl/

***Ongoing (to be completed 2019)* — Data Synthesis and High-resolution Predictive Modeling of Marine Bird Spatial Distributions on the Pacific OCS**
This study by the National Oceanic and Atmospheric Administration and U.S. Geological Survey is synthesizing 50 years of seabird survey data off California, Oregon, and Washington, and combining it with information about environmental and oceanographic conditions to predict the occurrence and abundance of seabirds at sea. The resulting predictive maps of seabird distributions will provide critical information for renewable energy siting and evaluation of potential environmental effects of management actions and project approvals.
Study Profile: https://www.boem.gov/pc-15-01/

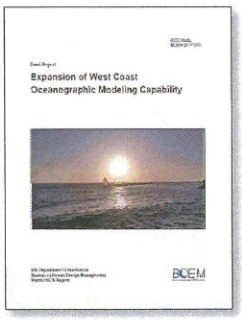
***Ongoing (to be completed 2019)* — Cross-shelf Habitat Suitability Modeling**
This study by the National Oceanic and Atmospheric Administration and Oregon State University (OSU) is expanding the geographic scope of and validating the BOEM/OSU habitat suitability model. The study will improve the applicability of the model to a wider depth range on the continental shelf and improve its predictive capabilities.
Study Profile: https://www.boem.gov/pc-15-07/

***Ongoing (to be completed 2020)* — Pacific Marine Assessment Partnership for Protected Species (PacMAPPS)**
This study is a partnership between BOEM, the National Marine Fisheries Service, and the U.S. Navy to conduct shipboard surveys of marine mammals, seabirds, and sea turtles in the Pacific. The data collected will help BOEM evaluate potential effects of proposed energy activities on protected species in an ecosystem-level context, including in areas of interest for renewable energy development (California, Oregon, and Hawaii) and for conventional energy decommissioning (California). Surveys of the Hawaiian Islands were conducted in 2017 and surveys of the California Current Ecosystem (Baja California, California, Oregon, and Washington) are scheduled for 2018.
Study Profile: https://www.boem.gov/pc-17-04/

***Ongoing (to be completed 2020)* — Potential Impacts of Submarine Power Cables on Crab Harvest**
This two-part research effort is determining whether the electromagnetic fields (EMF) emitted from subsea power-transmission cables affect the movement and harvest of commercial crab species. The first part was conducted by the University of California, Santa Barbara, which collected data on red rock crab in the Santa Barbara Channel and Dungeness crab in Puget Sound. The second part will collect and analyze additional data, and is scheduled to begin in 2019.
Study Profile: https://www.boem.gov/pc-14-02/

***Ongoing (to be completed 2021)* — Seabird and Marine Mammal Surveys Near Potential Renewable Energy Sites Offshore Central and Southern California**
This study by the U.S. Geological Survey will provide up-to-date information on species composition, distribution, abundance, and seasonal variation of seabirds and marine mammals from the Monterey Bay National Marine Sanctuary to the U.S.-Mexico border. Data generated will be used for environmental review of renewable energy projects proposed in this area. Previously collected data will be assessed and analyzed to allow for comparisons with the newly collected data to identify changes in distribution and abundance of seabirds and marine mammals over the last 40 years.
Study Profile: https://www.boem.gov/pc-17-01/

Physical Oceanography & Geology Studies



***Completed (2017)* — Expansion of West Coast Oceanographic Modeling Capability**
This study by the University of California, Los Angeles developed a multi-year hindcast (re-analysis) of winds, waves, and currents along the coast of California. The high-resolution (1 km) ROMS hindcast is for the ten-year period 2004–2013 and extends from the U.S.-Mexico border to south of Monterey Bay.
Report (BOEM 2017-055): https://www.boem.gov/ESPIS/5/5636.pdf

***Ongoing (to be completed 2018)* — Predicting the Consequences of Wave Energy Absorption from Marine Renewable Energy Facilities on Nearshore Ecosystems**
This study by the U.S. Geological Survey (USGS) is developing a statistical model that describes how wave energy may structure nearshore communities. Using 30 years of subtidal survey data from USGS, the National Park Service, and others, this study seeks ecosystem connections between nearshore communities and wave energy dynamics. The model will be used to predict nearshore ecosystem perturbations if wave energy conversion cause changes in modeled hydrodynamics.
Study Profile: https://www.boem.gov/pc-13-05/

***Ongoing (to be completed 2019)* — Collection of Metocean Resource Characterization Data off the California Coast**
This study is a partnership between BOEM and the U.S. Department of Energy in which the Pacific Northwest National Laboratory will collect information about meteorological and oceanographic conditions offshore California using a buoy that will be deployed for 12 months. Buoy instrumentation will measure wind profiles up to 200 meters above the ocean surface, wind speed and direction, directional waves, currents, salinity, and water and air temperature. The collected data will increase understanding of wind and wave energy resources.
Study Profile: https://www.boem.gov/pr-17-met/

***Ongoing (to be completed 2020)* — California Deepwater Investigations and Groundtruthing (Cal DIG) I**
This study by the U.S. Geological Survey will map and sample slope and canyon communities that are of specific interest for potential development of renewable energy offshore California, and will inform decisions regarding potential wind turbine siting, distribution of habitats and historic sites, and the sensitivity of associated biological communities to impacts. The results will help to define possible mitigations and aid in the identification of hard bottom areas, archaeological sites, and any associated sensitive deep shelf and slope communities that energy development should avoid.
Study Profile: https://www.boem.gov/pc-17-02/

For more information about BOEM-funded environmental studies:

Environmental Studies Program: https://www.boem.gov/Studies/
Pacific OCS Region Environmental Studies: https://www.boem.gov/Pacific-Studies/
Environmental Studies Program Information System (ESPIS): https://marinecadastre.gov/espis/#/
Renewable Energy Research: https://www.boem.gov/Environmental-Stewardship/Environmental-Studies/Renewable-Energy/Renewable-Energy.aspx