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Senate Bill 605 Wave and Tidal Energy

Report to Governor and Legislature

Gavin Newsom, Governor

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California Energy Commission

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J. Andrew McAllister, Ph.D.
Noemí Otilia Osuna Gallardo, J.D.
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Danielle Mullany
Primary Author

Eli Harland
Project/Office Manager

Jessica Eckdish
Branch Manager
CLIMATE INITIATIVES BRANCH

Sean Simon
Deputy Director
SITING, TRANSMISSION, AND ENVIRONMENTAL PROTECTION DIVISION

Regina Galer
Director
SITING, TRANSMISSION, AND ENVIRONMENTAL PROTECTION DIVISION

Drew Bohan
Executive Director

DISCLAIMER

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California Energy Commission

Rachel MacDonald

Eli Harland

California Department of Fish and Wildlife

Jay Staton

Victor Almeida

Corianna Flannery

California Coastal Commission

Tom Luster

Walt Deppe

Mark Danielson

California State Lands Commission

Amy Vierra

California Ocean Protection Council

Abby Mohan

ABSTRACT

Senate Bill 605 (SB 605, Padilla, Chapter 405, Statutes of 2023) directs the California Energy Commission to evaluate the feasibility, costs, and benefits of using wave energy and tidal energy as forms of clean energy in California. Additionally, SB 605 directs the CEC to identify suitable sea space for offshore wave and tidal energy projects in state and federal waters. This work is to be done in coordination and consultation with the California Coastal Commission, the Department of Fish and Wildlife, the Ocean Protection Council, and the State Lands Commission. Additional outreach on this work includes other state and local agencies, California Native American tribes, the offshore wave energy and tidal energy industry, the commercial and recreational fishing communities, nongovernmental organizations, and other interested parties.

The evaluation of the feasibility, costs, and benefits of wave and tidal energy was discussed in a consultant report published in November 2024 and summarized in the *2024 Integrated Energy Policy Report Update*, adopted on October 8, 2025. The sea space analysis for wave and tidal energy in California was discussed in a consultant report published in July 2025. This report includes summaries of the past SB 605 reports and additionally includes considerations that may inform legislative and executive actions to facilitate the development of technologically and economically feasible wave and tidal energy technologies, infrastructure, and facilities in California.

Keywords: Offshore renewable energy; offshore energy; offshore development; wave energy; tidal energy; renewable energy; Senate Bill 605

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EXECUTIVE SUMMARY

Senate Bill 605 (SB 605, Padilla, Chapter 405, Statutes of 2023) directs the CEC to evaluate the feasibility, costs, and benefits of using wave energy and tidal energy as forms of clean energy in the state. Wave energy refers to the process of harnessing the kinetic and potential energy of ocean waves and converting it into electricity. Tidal energy generates electricity by harnessing the movement of water driven by ocean circulation patterns, cyclical movement due to tides, or the flow of rivers and streams.

SB 605 directs the CEC to do this work in consultation with appropriate state agencies, including the California Coastal Commission, Department of Fish and Wildlife, Ocean Protection Council, and State Lands Commission. Additional outreach on this work includes other state and local agencies, California Native American tribes, the offshore wave energy and tidal energy industry, the commercial and recreational fishing industry, nongovernmental organizations, and other interested parties.

SB 605 directed the CEC to prepare three distinct work products. The first work product is the consultant report, *Wave and Tidal Energy: Evaluation of Feasibility, Costs, and Benefits* (feasibility report), which was included in the *2024 Integrated Energy Policy Report Update* (2024 IEPR Update). The second work product is the consultant report, *Sea Space Analysis for Wave and Tidal Energy* (sea space analysis), that addressed suitable sea space for wave and tidal energy resources. This *Senate Bill 605 Wave and Tidal Energy* report is the final work product, a report containing a summary of the first two work products, along with considerations for the development of wave and tidal energy in California.

The feasibility report and 2024 IEPR Update assess factors that may increase the use of wave and tidal energy resources, present findings on the latest research, technology, and economics of deploying wave and tidal technologies, and evaluate transmission, permitting, and workforce development needs. The feasibility report finds that both wave and tidal energy resources face challenges to commercial-scale deployment. Some challenges to developing these resources include advancing technologies, grid integration, understanding environmental impacts, and cost competitiveness with other renewable resources. Further, project permitting and licensing processes have the potential to be complex and lengthy depending on scale and location. While commercial-scale wave and tidal energy projects in California have not been implemented to date, the state's abundant wave resources in some regions and supportive policy environment present opportunities for further research, development, and demonstration to support deployment of these types of marine energy technologies.

The feasibility report and 2024 IEPR Update find that commercial-scale deployment, which is considered to be multiple devices in arrays that are grid-connected, could benefit from market mechanisms such as tax credits and other incentives that bring capital costs down. Additionally, clear permitting pathways and project testing and demonstrations would reduce project uncertainties. Though commercial-scale deployment faces uncertainties, opportunities exist in California for small-scale, pilot projects and distributed energy resources that could serve energy needs at nearby ports, coastal communities, and other energy users on the coast. Additional deployment opportunities include exploring the potential for colocation of wave energy projects with other marine-based infrastructure and industries.

The sea space analysis identifies suitable areas offshore California with wave and tidal energy resource potential, addresses siting considerations for wave and tidal energy technologies, and describes monitoring and adaptive management strategies for projects. The sea space analysis finds that the highest energy resources available for wave energy converters exist farther offshore (generally water depths greater than 25 meters). Tidal energy has fewer opportunities than wave energy in the state because of a limited amount of suitable tidal inlets and few areas of restricted water flow. Constraints to commercial viability include permitting, potential impacts, and proximity to ports and electric transmission infrastructure. Near-term distributed energy applications include projects that support and enhance various sectors and activities within California's rich ocean economy.

Suitable sea space is evaluated by identifying potential conflicts that exist in areas with high wave and tidal resource and generation potential. Considerations include environmental resources like marine protected areas, national marine sanctuaries, and important habitats; cultural and historical resources; ocean uses like commercial and recreational fishing, commercial shipping, military zones, recreational activities, public access; and existing ocean infrastructure like cables and pipelines. Northern California has fewer spatial restrictions and higher potential energy resources for wave and tidal energy projects than Central or Southern California.

The sea space analysis includes identification of potential environmental impacts from development of wave and tidal energy resources, and identifies protective measures to avoid or minimize potential impacts. Monitoring and adaptive management strategies are important for addressing potential interactions where uncertainty is high and risks to individuals, populations, or sensitive habitats are not well understood.

As directed by SB 605, this report focuses on "considerations that may inform legislative and executive actions to facilitate, encourage, and promote the development and increased use of technologically and economically feasible wave energy and tidal energy technologies, infrastructure, and facilities in the state." The considerations are grouped into three categories: research considerations, permitting and regulatory considerations, and engagement considerations. These considerations are informed by the recommendations listed in the 2024 IEPR Update as well as outreach conducted and comments received throughout the SB 605 proceedings, which consist of the 2024 IEPR Update proceeding and a separate SB 605 proceeding for the second phase of work.

CHAPTER 1: Introduction

Senate Bill 605

Among other requirements, SB 605 requires the CEC to evaluate the feasibility, costs, and benefits of using wave energy and tidal energy as forms of clean energy in the state in coordination and consultation with appropriate state agencies, including the California Coastal Commission, Department of Fish and Wildlife, Ocean Protection Council, and State Lands Commission. The evaluation was included in the 2024 IEPR Update and addresses the following:

1. Evaluate factors that may contribute to the increased use of wave energy and tidal energy in the state.
2. Provide findings on the latest research about the technological and economic feasibility of deploying offshore wave and tidal energy in the state.
3. Evaluate wave energy and tidal energy project potential transmission needs and permitting requirements.
4. Evaluate wave energy and tidal energy project economic and workforce development needs.
5. Identify near-term actions, particularly related to investments and the workforce for wave energy and tidal energy projects, to maximize job creation and economic development, while considering affordable electric rates and bills.
6. Identify a robust monitoring strategy designed to gather sufficient data to evaluate the impacts from wave energy and tidal energy projects to marine and tidal ecosystems and affected species, including, but not limited to, fish, marine mammals, and aquatic plants, to inform adaptive management of the projects.

Furthermore, SB 605 requires the CEC to identify suitable sea space for offshore wave and tidal energy projects in state and federal waters. This work was done in coordination and consultation with the California Coastal Commission, Department of Fish and Wildlife, Ocean Protection Council, State Lands Commission, other state and local agencies, California Native American tribes, the offshore wave and tidal energy industry, the commercial and recreational fishing communities, and nongovernmental organizations.

In identifying suitable sea space, the following were considered:

1. Existing data and information on offshore wave energy and tidal energy resource potential and commercial viability.
2. Existing transmission facilities and infrastructure, and necessary additional transmission facilities and infrastructure.
3. Protection of cultural and biological resources with the goal of prioritizing ocean areas that pose the least conflict to those resources.

This *Senate Bill 605 Wave and Tidal Energy* report serves as the final deliverable for SB 605, providing a written report to the Governor and Legislature. This report is informed by all SB 605 reports published to date. It summarizes key findings from the two prior SB 605 reports and outlines considerations to guide legislative and executive actions to support the development of feasible wave and tidal energy technologies, infrastructure, and facilities in California:

- *2024 Integrated Energy Policy Report Update*[1]
  - *Wave and Tidal Energy: Evaluation of Feasibility, Costs, and Benefits*[2]
- *Sea Space Analysis for Wave and Tidal Energy*[3]

Wave and Tidal Technology Overview

Marine renewable energy refers to renewable energy generated from the natural power of oceans and seas. It includes a variety of sources and technologies that convert ocean energy into electricity—such as wave energy, ocean and tidal currents, ocean thermal energy, and salinity gradient conversion. This report focuses on wave and tidal energy resources located in state and federal waters, with state waters defined as those within three nautical miles of the shoreline.

Wave Energy Technology

Wave energy conversion (WEC) is the process of harnessing the kinetic and potential energy present in ocean waves and converting it into usable electricity. As is common with emerging technologies, there is no industry standard on a single device type, in part due to the different characteristics of the resource areas and potential deployment sites.

WEC devices can be modular and adaptable for use in various marine environments, or they can be designed for deployment in specific locations such as onshore, nearshore, or offshore locations.

- **Onshore WECs** are fixed installations located on land or in shallow water, often integrated into breakwaters or piers, or constructed as standalone structures. While they are easier to access and maintain, they typically generate less electricity than offshore WECs due to reduced wave energy near the shore.

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1 Bailey, Stephanie, Mathew Cooper, Quentin Gee, Heidi Javanbakht, Jake McDermott, and Danielle Mullany. 2024. *Final 2024 Integrated Energy Policy Report Update*. California Energy Commission. Publication Number: CEC-100-2024-001-LCF.

2 Lee, Susan and Vida Strong. (Aspen Environmental Group). 2024. *Wave and Tidal Energy: Evaluation of Feasibility, Costs, and Benefits*. SB 605 Report. California Energy Commission. CEC Publication Number CEC-700-2024-005.

3 Lee, Susan, Vida Strong, David Anning, Nicole Buecker, Chris Flanary, Grace Chang, Erica Escajeda, Sharon Kramer, and Danielle Mullany. 2025. *Sea Space Analysis for Wave and Tidal Energy*. California Energy Commission. Publication Number: CEC-700-2025-004.

- **Nearshore WECs** are deployed within a few hundred meters of shore, in water depths of 10 to 25 meters, generally within state waters. These systems are usually mounted on the seafloor; though some include floating, semi-submerged, or submerged components.
- **Offshore WECs** are deployed in waters deeper than 25 meters and may float at the surface, be semi-submerged, or fully submerged. They are anchored to the seafloor with moorings and are designed to capture the highest wave energy. Due to their distance from shore, offshore WECs face greater mechanical stress, are more difficult and expensive to maintain, and require longer transmission lines for grid connection.

There are six primary device archetypes of WEC technologies:[4]

- Attenuators
- Point absorbers
- Pressure differentials
- Oscillating water columns
- Overtopping
- Oscillating wave surge converters

Appendix A provides examples of these wave energy technologies.

Tidal Energy Technology

Tidal and current energy is a form of marine renewable energy that harnesses the movement of water. This movement may result from ocean circulation patterns, tidal cycles, or the flow of rivers and streams. Like WECs, there is no dominant tidal energy device type in the industry. Tidal energy converter technologies vary widely in size, design, and energy capture methods, with configurations dependent on available tidal resource, deployment area, and mounting methods. There are six primary device archetypes of tidal energy converter (TEC) technologies:[5]

- Axial-flow turbines
- Crossflow turbines
- Oscillating hydrofoil
- Tidal kite
- Archimedes screw
- Vortex-induced vibration

Appendix A provides examples of these tidal energy technologies.

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4 Lee, Susan and Vida Strong. (Aspen Environmental Group). 2024. *Wave and Tidal Energy: Evaluation of Feasibility, Costs, and Benefits*. SB 605 Report. California Energy Commission. CEC Publication Number CEC-700-2024-005.

5 Ibid.

Marine Energy Applications in California

Marine energy projects can be categorized as commercial-scale or distributed energy systems.

- **Commercial-scale projects** involve the deployment of multiple devices in arrays that are connected to the electrical grid.
- **Distributed energy projects** are smaller in scale and often take the form of pilot or demonstration projects designed to serve localized energy needs and are typically owned and operated by the customer.

Currently, there are no commercial-scale wave or tidal projects operating in California. There are a limited number of commercial-scale tidal energy projects in the United States, such as Admiralty Inlet, Washington; Roosevelt Island Tidal Energy (RITE), New York; and Cobscook Bay, Maine (still in operation). The only active commercial-scale wave energy projects in the United States that have secured Federal Energy Regulatory Commission (FERC) licenses are associated with wave energy test sites: Jennette's Pier Wave Energy Test Center in Nags Head, North Carolina; PacWave South Wave Energy Test Site in Newport, Oregon; Hawai'i Wave Energy Test Site (WETS) at the Marine Corps Base in Oahu, Hawaii.[6]

Smaller-scale distributed energy resource (DER) projects have a range of potential applications across the state. These projects could be integrated into existing coastal infrastructure, such as breakwaters, shorelines, quay walls, or piers. Potential DER marine energy applications in California include:[7]

- **Ports and harbors**: Supplying localized power for port operations, harbor facilities, electric vehicles, and vessels.
- **Remote communities**: Providing reliable, sustainable energy in areas lacking robust generation infrastructure or to create redundancy.
- **Community-based initiatives**: Aligning marine energy development with local priorities to reduce reliance on fossil fuels and improve air quality and public health.
- **Military installations and operations**: Delivering decentralized, resilient power for coastal and maritime military bases and missions. As part of outreach conducted under SB 605, Vandenberg Space Force Base supported further exploration of wave energy technologies to advance energy resiliency of military operations in a public comment at an April 2025 workshop.[8] A recent example of the potential for this application is the collaboration between California Polytechnic State University, San Luis Obispo (Cal Poly) students and the Naval Facilities Engineering and Expeditionary Warfare Center to

6 Ibid.

7 Ibid.

8 Public comment provided verbally by Bill Toman at an April 2025 workshop on SB 605 Wave and Tidal Sea Space Analysis. Workshop recording available: Zoom meeting link.

develop a wave-powered device designed to replace diesel units traditionally used by Marines to charge batteries in remote coastal areas.[9]

- **Powering the "Blue Economy"**: Supporting various sectors and activities within California's ocean economy, including:
    - Ocean observation (environmental monitoring, marine research, and resource management)
    - Marine aquaculture
    - Desalination
    - Coastal resilience and disaster recovery[10]
    - Maritime transport and logistics
    - Tourism and recreation

Although distributed marine energy has many potential applications in California, the technology is in the early stages of development. Marine energy test sites play an important role in advancing wave and tidal technologies. These facilities provide opportunities to evaluate devices in real-world ocean conditions, enabling developers to assess performance, refine designs, and determine optimal deployment conditions.

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9 California Polytechnic State University. "Wave Generator Created by Engineering Teams Could Charge Marine Corps Batteries." Accessed September 2025. Available at, https://www.calpoly.edu/news/wave-generator-created-engineering-teams-could-charge-marine-corps-batteries.

10 A report from the National Laboratory of the Rockies explores the value of coastal structure integrated wave energy converters in the United States, finding that they can provide locally generated energy for a multitude of high-value applications while also increasing community defense through coastal protection and coastal hardening.

McGilton, Ben, Kelly Gjestvang, Katie Peterson, Sarah Hall, David Greene, George Hagerman, Bikram Singh, Jackson Smith, and Claire Wolgast. 2026. *Report on Coastal Structure Integrated Wave Energy Converters (CSI-WECs)*. Golden, CO: National Laboratory of the Rockies. NLR/TP-5700-90768. https://docs.nlr.gov/docs/fy26osti/90768.pdf.

CHAPTER 2: Evaluation of Feasibility, Costs, and Benefits of Wave and Tidal Energy

Challenges to Developing Marine Energy

Marine energy holds promise for a range of applications in California, but technology is still emerging and faces several hurdles on the path to becoming an established industry. Key challenges limit the feasibility, scalability, and economic viability of marine energy development. These include:

- **Technology Development**: A lack of convergence on standardized device types hinders efficiency and creates regulatory uncertainty.
- **Resource Variability**: While waves and tides are generally considered consistent energy sources, optimizing energy generation requires accurate prediction and management of environmental factors.
- **Grid Integration**: Connecting marine energy systems to the grid presents technical and logistical challenges, such as connection costs, grid stability, and regulatory frameworks.
- **Environmental Impact**: Potential impacts on marine ecosystems require further study and strategies to address those impacts.
- **Cost Competitiveness**: High capital and operational costs make it difficult to compete with more established renewable energy sources.
- **Socioeconomic Considerations**: Concerns can arise related to potential impacts on communities, livelihoods, and cultural heritage.

Factors Contributing to Increased Use of Wave and Tidal Energy in California

This section highlights the conditions and locations where marine energy technologies offer the greatest potential.

- **Market signals**: Wave and tidal energy can enhance California's clean energy mix by adding renewable energy sources that may complement other renewable resources. Historically, clean energy adoption has relied on regulatory and policy support from government, such as federal tax incentives and state policies like the Renewables

Portfolio Standard. Wave energy may have greater market potential due to having an estimated generating capacity over 120 times that of tidal energy in the state.[11]

- **Cost reductions**: Marine energy costs are expected to decline as technologies mature and deployment scales up. Significant cost reductions are still needed for wave and tidal energy to become cost competitive. Focused research and development efforts and real-world device testing would improve durability, reduce risk, and help achieve cost reductions.
- **Regional energy needs**: Marine energy is an emerging clean energy source with potential benefits such as powering remote communities, enhancing energy security, dissipating waves that cause coastal erosion, and boosting climate resilience.[12] However, realizing these potential benefits requires direct engagement with coastal communities and site-specific evaluations of marine uses.
- **Improved understanding of environmental effects**: As wave and tidal are emerging technologies, there is limited understanding of the potential environmental impacts. Scientific studies, installation and monitoring of small-scale pilot projects, and other similar initiatives are needed to help fill knowledge gaps, improve understanding, and build regulatory support for these technologies.
- **Pathway to permitting**: Multiple state and federal licensing and permitting jurisdictions and the lack of technical and environmental information can make securing regulatory approvals complex and lengthy depending on scale and location. For example, projects connected to the electricity grid require a separate FERC license regardless of the project location, whereas projects proposed in state waters that are not connected to the grid generally would not require FERC licensing. Improving the pathway to permitting with tools, such as the U.S. Department of Energy's (DOE) Marine Energy Environmental Toolkit for Permitting and Licensing, helps to provide developers information on regulations for technology deployment.[13] A similar planning tool for California permitting processes could provide additional information to support project planning and development.

Based on outreach conducted throughout the SB 605 evaluation period, CEC received many comments on considerations to advance wave and tidal energy in California. Considerations related to market signals and cost reductions included comments indicating that support is needed for targeted program pathways that advance marine renewable energy technologies through all stages of development (from research and development, to single unit

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11 Kilcher, L., M. Fogarty, and M. Lawson. 2021. *Marine Energy in the United States: An Overview of Opportunities.* National Laboratory of the Rockies, NREL/TP-5700-78773, Golden, Colorado, https://docs.nlr.gov/docs/fy21osti/78773.pdf. Accessed July 2024.

12 Ozkan, C., Mayo, T., Passeri, D. L. 2022. *The Potential of Wave Energy Conversion to Mitigate Coastal Erosion From Hurricanes*. Journal of Marine Science and Engineering 10(2):143, https://doi.org/10.3390/jmse10020143.

13 U.S. Department of Energy. "Marine Energy Environmental Toolkit for Permitting and Licensing," https://marineenergy.app/. Accessed July 2024.

demonstrations, to multi-unit project deployments).[14] Comments suggest a way of achieving this is through approaches such as tailoring energy pricing and generator capacity eligibility requirements for wave and tidal energy projects; also by integrating marine energy into the California Energy Commission's resource planning and Electric Program Investment Charge (EPIC) program investment plans.[15] Comments recommended the development of clear guidance on the requirements for introducing clean energy incentive programs at the state level to scale marine energy technologies.[16] Comments suggest establishing deployment targets for ocean energy will help attract investment.[17] Additionally, they proposed exploring policy pathways to make future marine energy projects eligible for the Resource Adequacy Program to improve their economic viability for Load Serving Entity (LSE) procurement.[18]

Regarding considerations addressing regional energy needs, comments recommended that the state engage energy consumers early in the process, such as load-serving entities, green ports, aquaculture facilities, and other large energy users near the coast, to help ensure a viable future market.[19] Multiple commenters encouraged the state to evaluate opportunities for deploying wave energy alongside other offshore energy infrastructure, including potential colocation of wave energy with offshore wind energy and aquaculture operations. Comments also suggested examining regulatory processes for onshore and nearshore marine energy

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14 AltaSea, the National Hydropower Association (NHA), CalWave Inc., and CorPower Ocean made these recommendations in docketed Public Comments in response to the Draft *Wave and Tidal Energy: Evaluation of Feasibility, Costs, and Benefits* Report as well as the SB 605 Draft *Sea Space Analysis* Report. The AltaSea comment is available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=258306&DocumentContentId=94304.

The NHA comment is available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=258357&DocumentContentId=94376.

The CalWave comment is available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=258151&DocumentContentId=94101.

The CorPower Ocean comment is available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=258632&DocumentContentId=94677.

15 Ibid.

16 Ibid.

17 Ibid.

18 Redwood Coast Energy Authority (RCEA) made these comments in docketed Public Comments in response to the IEPR workshop in August 2024 and the SB 605 Draft Sea Space Analysis Report. The comments are available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=258653&DocumentContentId=94702; and https://efiling.energy.ca.gov/GetDocument.aspx?tn=263186&DocumentContentId=99785.

19 Ibid.

projects in comparison to offshore marine energy projects, as regulatory requirements may differ.[20]

Transmission Needs

While most marine energy generation is currently small-scale (distributed generation) such as pilot projects, large-scale projects (utility generation) would require connection to the electric grid. This analysis focuses on transmission needs for utility scale projects. Any utility-scale offshore renewable energy resource, including wave and tidal, would require transmission to bring generation to shore. Transmission and the associated technologies do not depend on whether the energy converters harness wave or tidal power, but depend on water depth, export capacity, and whether the generating assets are fixed or floating. Transmission feasibility and costs are critical to commercial-scale wave and tidal energy project development in California. Transmission considerations include:

- **Cables**: Near-term projects are expected to use alternating current (AC) rather than direct current (DC), which is better suited for long distances but not yet fully commercialized for marine use. Devices would be linked by low- or medium-voltage array cables to a common collection point, like an offshore substation. From there, export cables, typically rated between 100–200 kV, deliver power to shore. For smaller projects (≤100 MW) located within 15 km (roughly 8 nautical miles) of shore, array cables may connect directly onshore without a substation.
- **Offshore substations**: Projects beyond 15 km from shore or over 100 MW capacity will likely require offshore substations to transform the voltage and reduce the number of shore landings, helping lower costs and permitting complexity. Offshore substations can be on the water's surface (fixed or floating) or seafloor-mounted, which is currently an emerging technology. Subsea hubs, which collect power from multiple devices into a single export cable, are well-suited for wave and tidal projects.
- **Transmission configurations**: While offshore wave energy holds potential, greater depths and distances increase electrical losses, physical risks, and project costs, as well as extend timelines due to construction and maintenance complexity. Colocating wave energy with floating offshore wind projects could improve efficiency and reduce costs by sharing infrastructure, operations, licensing. This approach may also enhance energy yield and predictability. Wave energy developers would need to explore the ability to interconnect their projects and coordinate with the offshore transmission owner.

Marine energy project developers must also consider the licensing and permitting required for any necessary transmission infrastructure.

20 Eco Wave Power made these comments in docketed Public Comments in response to the draft report *Wave and Tidal Energy: Evaluation of Feasibility, Costs, and Benefits.* The comment is available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=258367&DocumentContentId=94386.

Permitting Requirements

Permitting needs for wave and tidal energy projects vary based on the project type and purpose. As wave and tidal energy is an emerging industry, a range of technologies are being designed and tested which can vary from being deployed nearshore or offshore, devices that are mounted or floating, single devices or device arrays (multiple units). These technologies may provide power to a local end user or be interconnected to the electric grid. This range of characteristics results in different information needs throughout permitting review. Regulatory agencies consider the characteristics of the technology, the location of installation, and potential environmental and site-specific impacts, among other factors. For example, agencies would evaluate whether an installation is for testing and data collection, which may be of limited duration and have short-term effects, or if it is planned as a commercial project with an extended operation life and potentially having long-term temporal and spatial effects. Projects often require review by several government agencies with responsibility for administering various licenses and permits. As a result, project developers can face a complex array of permitting requirements and processes, which can take as long as 7 to 10 years for projects requiring a FERC license (grid connected),[21] and can increase project uncertainty and project costs.

To address marine energy information needs, federal agencies are collecting and sharing data through online platforms such as the DOE's Portal and Repository for Information on Marine Renewable Energy (PRIMRE).[22] The DOE's *Handbook of Marine Hydrokinetic Regulatory Processes* contains information on federal processes and authorizations needed for wave and tidal energy projects. Additionally, to support more efficient permitting of grid connected projects, the FERC and California have a memorandum of understanding in which the parties agreed to participate in coordination efforts for the National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA) requirements, and federal consistency review under the Coastal Zone Management Act.[23]

Below is a high-level list of the primary federal and state agencies that would be involved in permitting reviews. For more detailed information on each agencies' roles and requirements, as well as the list of approvals applicable to wave and tidal projects in California, see Chapter 4

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21 Grantham, K. (2024, July). "An Overview of Marine Energy Permitting and Licensing" [PowerPoint Slides]. National Renewable Energy Laboratory. https://pacificoceanenergy.org/wp-content/uploads/2022/09/Grantham-OREC-Regulatory-Presentation-091522-002.pdf.

22 U.S. DOE. "The Portal and Repository for Information on Marine Renewable Energy (PRIMRE) | Department of Energy." https://www.energy.gov/eere/water/portal-and-repository-information-marine-renewable-energy-primre. Accessed July 2024.

23 U.S. FERC. 2010. Memorandum of Understanding Between the Federal Energy Regulatory Commission and The California Natural Resources Agency, The California Environmental Protection Agency and The California Public Utilities Commission. https://www.ferc.gov/sites/default/files/2020-04/mou-ca.pdf.

of the consultant report *Wave and Tidal Energy: Evaluation of Feasibility, Costs, and Benefits.*[24]

There are four primary federal agencies involved in wave and tidal energy project approvals:

- Federal Energy Regulatory Commission (FERC)
- U.S. Army Corps of Engineers (USACE)
- U.S. Coast Guard (USCG)
- Bureau of Ocean Energy Management (BOEM)

The primary state agencies involved in wave and tidal project approvals include:

- State Lands Commission (SLC)
- California State Water Resources Control Board (SWRCB)
- California Department of Fish and Wildlife (CDFW)
- California Coastal Commission (CCC)/San Francisco Bay Conservation and Development Commission (BCDC)[25]

Workforce Development Needs

To estimate workforce development needs for wave and tidal energy projects, the consultant report, *Wave and Tidal Energy: Evaluation of Feasibility, Costs, and Benefits,* used the National Laboratory of the Rockies' (formerly the National Renewable Energy Laboratory) Job and Economic Development Impact (JEDI) model to estimate economic development impacts.[26] Two sizes of wave and tidal energy projects were modeled: distributed systems (10 MW) and small commercial systems (100 MW). The JEDI model estimates workforce and economic development impacts during the construction and installation of a project and during project operation. These impacts are categorized as:

- **Direct impacts**: onsite construction and installation labor (immediate jobs and economic impacts).
- **Indirect impacts**: equipment and supply chain impacts, and local revenues.
- **Induced impacts**: effects driven by reinvestment and spending of earnings by direct and indirect beneficiaries.

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24 Lee, Susan and Vida Strong. (Aspen Environmental Group). 2024. *Wave and Tidal Energy: Evaluation of Feasibility, Costs, and Benefits*. SB 605 Report. California Energy Commission. CEC Publication Number CEC-700-2024-005.

25 The CCC and BCDC both have permitting requirements and conduct federal consistency review. BCDC's jurisdiction is within and adjacent to San Francisco Bay, and the CCC's jurisdiction is within the coastal zone along the rest of the California coast.

26 National Laboratory of the Rockies. 2024. "JEDI Marine and Hydrokinetic Power Model," https://www.nlr.gov/analysis/jedi/marine-hydro.

For the 10 MW project size, most jobs required are in equipment and supply chain, followed by induced impacts. A 10 MW wave energy project would require roughly 584 job-years and generate $78.4 million in total value added to the economy. A job-year is defined as total full-time equivalent employment for one year. For a 10 MW tidal energy project, the total workforce impact is 243 job-years and $31.5 million of total value added to the economy. The workforce needed for a 100 MW wave energy project is about eight times greater than that of a 10 MW project. The economic impacts are roughly eight times greater for wave energy projects of 100 MW and about six times greater for tidal energy projects of 100 MW. Similarly, during the operating years, wave and tidal energy projects generate nearly the same economic impacts at each scale (roughly $2 million for a 10 MW project, and $12 million for a 100 MW project).

Job creation and economic development in wave and tidal energy are primarily driven by local labor and material sourcing, as well as overall project scale. Modeling based on a 55% local share shows that increasing local content boosts job creation and stimulates regional economies. However, California may currently lack the manufacturing capacity to fully support large-scale local production for commercial scale wave and tidal projects.

Workforce development needs for this sector could include private industry programs, community college programs, union-led programs, and registered apprenticeship programs. Workforce development could align with skillsets and training programs from existing maritime sectors, like oil and gas. Wave and tidal energy workforce development efforts could also align with the offshore wind industry, allowing for complementary workforce training and rotation of employees between marine energy sectors.

Monitoring Considerations for Evaluating Environmental Impacts

Wave and tidal energy projects may impact marine and tidal ecosystems, but there is a lack of data on these effects due to limited development. It is important to create a monitoring strategy to gather and assess potential impacts and inform adaptive management. Adaptive management is a dynamic process that helps address uncertainty by monitoring and evaluating technology and environment interactions to gain new insights used to improve plans and approaches to project siting and operation, changes to monitoring studies (if warranted), and impact mitigation. Adaptative management is particularly important for nascent industries where there may be a range of unknowns regarding interactions of equipment and operations with the environment.

Potential impacts to inform monitoring considerations for wave and tidal energy projects include:

- Collision, entrapment, entrainment, entanglement, impingement, attraction, or avoidance impacts to behavior of fish, marine mammals, sea turtles, or birds and bats.
- Disturbance to benthic habitats and species.
- Electromagnetic fields.
- Noise.

- Changes in flow and impacts to water quality, vegetation, soils, sediment transport, and ecosystem and biogeochemical processes.
- Water quality.
- Water temperature.
- Lighting.
- Impacts to sensitive habitats from transmission cables and anchored material on the sea floor.
- Introduction of new structures and Fish Aggerating Devices (FAD).
- Invasive species.

Due to the variety of wave and tidal technologies and deployment environments, potential impacts remain uncertain and are project and site-specific. To better understand these effects, insights can be drawn from related offshore industries such as wind and oil and gas, as well as from previous wave and tidal projects. Adaptive management has been applied in the approval process for wave and tidal energy demonstration projects to evaluate and respond to their environmental impacts. Examples of previous projects utilizing adaptive management include the TidGen Project in Maine, the Roosevelt Island Tidal Energy Project in New York, the PacWave South project in Oregon, the MeyGen Tidal Project in Scotland, the SeaGen Tidal Turbine in Northern Ireland, and the DeltaStream Tidal Turbine in Wales. Descriptions of these projects and their use of monitoring and adaptive management strategies are included in Chapter 6 of the consultant report titled, *Wave and Tidal Energy: Evaluation of Feasibility, Costs, and Benefits*.[27]

Additionally, the CEC published the *Assembly Bill 525 Offshore Wind Energy Strategic Plan*,[28] which outlines the necessary steps for deploying floating offshore wind energy off the coast of California. The plan includes discussions of potential impacts and mitigation strategies for marine biological resources, Native American and Indigenous people, fisheries, national defense, and underserved communities, much of which could be applied to planning for offshore wave and tidal energy projects.

Throughout outreach conducted on SB 605, environmental non-governmental organizations commented that future wave and tidal energy development should consider environmental impacts for projects at all scales, including vessel strikes, noise, entanglement of marine species, oceanographic processes, and impacts to benthic habitats. Comments support

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27 Lee, Susan and Vida Strong. (Aspen Environmental Group). 2024. *Wave and Tidal Energy: Evaluation of Feasibility, Costs, and Benefits*. SB 605 Report. California Energy Commission. CEC Publication Number CEC-700-2024-005.

28 Jones, Melissa, Jim Bartridge, and Lorelei Walker. 2024. *Assembly Bill 525 Offshore Wind Energy Strategic Plan*. California Energy Commission. Publication Number: CEC-700-2023-009-V2-F, https://www.energy.ca.gov/publications/2023/ab-525-offshore-wind-strategic-plan.

implementation of monitoring and adaptive management measures for pilot scale marine energy deployments.[29] Additionally, commenters suggest that recommendations related to offshore wind energy may be relevant to managing the impacts of wave and tidal energy development.[30]

Further information on monitoring considerations is presented in Chapter 3.

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29 These comments were submitted in response to the draft report on *Wave and Tidal Energy: Evaluation of Feasibility, Costs, and Benefits.* A joint comment letter was submitted by the Natural Resources Defense Council (NRDC), California Coastal Protection Network, Ocean Conservation Research, and Environmental Protection Information Center (EPIC). The comment is available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=258641&DocumentContentId=94686.

Individual comment letters were submitted by The Ocean Foundation and the Ocean Conservancy.

The Ocean Foundation comment letter is available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=258580&DocumentContentId=94616.

The Ocean Conservancy comment letter is available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=258655&DocumentContentId=94688.

30 These comments were submitted in a joint comment letter by the Natural Resources Defense Council (NRDC), California Coastal Protection Network, Ocean Conservation Research and Environmental Protection Information Center (EPIC) in response to the draft report on *Wave and Tidal Energy: Evaluation of Feasibility, Costs, and Benefits*.

The comment references recommendations from a Letter from Natural Resources Defense Council, *et. al.,* to Bureau of Ocean Energy Management, Comments in Response to the Bureau of Ocean Energy Management Draft Environmental Assessment for Commercial Wind Lease Grant Issuance and Site Assessment Activities on the Pacific Outer Continental Shelf, Humboldt Wind Energy Area, BOEM-2021-0085; available at https://www.regulations.gov/comment/BOEM-2023-0061-0161.

CHAPTER 3: Sea Space Analysis for Wave and Tidal Energy

Wave and Tidal Resource

The resource assessment summarizes wave and tidal resources by region, water depth, and proximity to shore. The assessment does not consider device type, therefore it does not measure technical resource potential. Instead, the assessment summarizes theoretical resource potential and evaluates opportunities and constraints to development. Potentially constrained areas include: marine disposal sites, BOEM wind energy lease areas (though there is potential for colocation), oil and gas planning and lease areas, submarine cables and pipelines, munitions areas, U.S. Department of War (formerly Department of Defense) military defense areas, danger zones,[31] and marine protected areas.

For practical and economic reasons, WEC deployment off California is likely to focus on nearshore areas within state waters (within 3 nautical miles of the shoreline). Deployment in nearshore regions reduces mooring, transmission, and maintenance costs. Most existing WECs are designed for depths of 100 meters or less, so the analysis focused on areas with a water depth of 200 meters or less to account for current technologies and potential future innovations for WECs and TECs. There is potential for WECs and TECs to be integrated with offshore infrastructure, such as offshore wind energy, in deeper waters.

There are four key steps for evaluating suitable locations for marine energy deployments:

1. **Identifying resource potential** involves measurements of wave conditions, tidal ranges, and ocean currents. For this analysis, resource availability was estimated from the National Laboratory of the Rockies' *Marine Energy Atlas*.[32] The *Sea Space Analysis for Wave and Tidal Energy* report only looks at theoretical resource potential, the annual average amount of physical energy that is hypothetically available.
2. **Analyzing power matrices and device specifications** can help estimate energy yield and identify optimal design and device configuration. A power matrix defines the expected energy output of a specific technology at varying resource levels. By mapping the resource data against the power matrix of a device, developers can forecast potential energy generation.

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31 These data represent the location of Danger Zones and Restricted Areas within coastal and marine waters, as outlined by the Code of Federal Regulations (CFR) and the Raster Navigational Charts (RNC). The CFR defines a Danger Zone as, "A defined water area (or areas) used for target practice, bombing, rocket firing or other especially hazardous operations, normally for the armed forces." The CFR defines a Restricted Area as, "A defined water area for the purpose of prohibiting or limiting public access to the area."

32 National Laboratory of the Rockies. "Marine Energy Atlas." U.S. Department of Energy. Available at, https://maps.nlr.gov/marine-energy-atlas/.

3. **Evaluating site-specific considerations** come into play for selecting the optimal sites for deploying WECs and TECs. This step involves evaluating environmental impacts, regulatory frameworks, and community receptiveness.
4. **Assessing economic viability and technological adaptation** includes calculating the levelized cost of energy[33] and evaluating factors such as capital investment, operational costs, and expected technology lifespan.

Wave Energy Resource Summary

The findings from the resource analysis highlighted that while there are abundant wave energy resources off the coast of California, the greatest resources are in the northwest of the state, far from major population centers. WECs with the highest energy potential are also located farther away from shore since wave energy dissipates as waves break in shallower water. In Southern California, wave energy is diminished by Point Conception and the Channel Islands, leading to a relatively modest wave climate. The wave resource off the Central Coast is moderate in the south and increases toward the north of the region.

There are limitations to estimating nearshore wave energy, which requires detailed modeling that large-scale models often lack. This means areas with high wave energy close to shore, and in depths of 50 meters or less, may not be accurately captured. Site-specific assessments are needed, particularly for devices built into coastal structures, where data on wave energy is limited. For more information and to view wave resource maps, see *Sea Space Analysis for Wave and Tidal Energy*.

Tidal Energy Resource Summary

Tidal energy opportunities in the state are limited due to a small number of suitable geographical features. San Francisco Bay is likely the only site that has resource potential for commercial tidal energy developments, representing 89 percent of the tidal energy resource for California. Potential distributed energy applications may exist for TECs at Humboldt Bay, the lower Eel River, and Tomales Bay, though most of these areas are subject to some form of potential constraint. Commercial-scale marine energy projects in California would likely use wave energy instead of tidal energy because of more abundant wave energy resources. For more information and to view the tidal resource maps, see *Sea Space Analysis for Wave and Tidal Energy*.

Marine Energy Project Considerations

There are many factors that influence the selection of locations, technologies, and applications to optimize wave and tidal energy resources including:

- **Device suitability**: Device design determines suitable locations for the deployment and operations of WECs and TECs. Deployment locations and deployment depths are

33 The average cost per kilowatt-hour (kWh) of electricity produced by a system over the lifetime, calculated by dividing the total cost for building and operating the system by the total electrical load served.

determined by mooring requirements, operational considerations, and capital expenditures. Due to the wide range of device types and applications, the sea space analysis does not assess every possible configuration.

- **Site selection**: Developers need to account for environmental and economic factors in selecting a project site. Transmission and grid integration costs depend on distance to shore, cable burial needs, nearby economic zones, marine protected areas, and electrical grid capacity. Remote sites may require battery storage or infrastructure upgrades. Proximity to ports affects deployment and maintenance logistics, and specialized vessels or skilled labor may need to be brought in until local capacity grows. Visual impacts, especially in areas of cultural significance, can influence permitting. Developers should engage early and often with California Native American tribes and local communities to understand and address concerns and to promote inclusive planning.
- **Applications**: Wave and tidal energy may be well-suited for near-term distributed energy applications (non-grid connected) focused on providing electricity to an end user. Deployment opportunities include ports and harbors, monitoring buoys (for example, buoys equipped with sensors to measure temperature or wind speed) and navigational buoys (for example, buoys to mark areas or zones in the waterways), aquaculture (for example, fish, shellfish, seaweed farming), and desalination (the process of removing salt and other impurities from seawater or brackish water to produce fresh water). These technologies also support the "Powering the Blue Economy" initiative, which seeks to support the sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystems.[34]
- **Colocation**: The sea space analysis explored the opportunity for colocation of wave energy devices with offshore wind energy infrastructure. While the sea space analysis is constrained to a water depth of 200 meters or less, colocation with OSW in deeper waters (up to 1,300 meters water depth) may present opportunities for reducing electrical infrastructure needs for both technologies. WECs require much of the same transmission infrastructure as offshore wind technology. Additionally, CEC received input throughout outreach on SB 605 that colocation of WECs with aquaculture sites should be explored in future studies.

Potential Sea Space Conflicts

Site selection for wave and tidal energy projects should identify areas with high energy resources while prioritizing areas with the lowest potential for conflict with existing ocean infrastructure and ocean users, and lowest risk of harm to environmental, cultural, and

34 LiVecchi A., et al. *Powering the Blue Economy; Exploring Opportunities for Marine Renewable Energy in Maritime Markets*. Available at, https://www.energy.gov/eere/water/powering-blue-economy.

historical resources. Environmental resources include marine organisms and their habitats, migratory routes, and other resources used by marine organisms, including marine mammals, fish, seabirds, and sea turtles. Cultural resources include areas that are used by or important to Native American tribes, while historical resources include archeological artifacts such as shipwrecks.

Ocean infrastructure includes subsea cables and pipelines, oil platforms, navigational, oceanographic and meteorological ("metocean") buoys, navigational buoys, and planned infrastructure associated with BOEM wind energy lease areas. Ocean uses include dredging and disposal sites, commercial and recreational fishing areas, recreational and tourism areas, commercial shipping lanes, aquaculture sites, and military operations.

The sea space analysis started by identifying specific marine resources, infrastructure, and ocean uses and determining how restrictive these are to the development of wave and tidal energy projects. The level of restriction on an area or resource for development depends on factors such as legal protections, permitting challenges, and socioeconomic factors.

Potential energy deployment sites for each California region were assessed for overlap with "no go" zones, defined as protected areas and other regions where commercial development is not permitted. Some areas may allow development but would present significant permitting challenges or risk being in direct conflict with other ocean users or ocean resources (i.e. fishing, tribal areas of cultural importance, essential habitats for marine species). In some areas, development would depend on the type of energy device.

The "no-go" zones include:

1. National marine sanctuaries (NMS) and marine protected areas (MPA)
2. Commercial shipping lanes and federal navigational channels ("Traffic Lane")
3. Ocean disposal sites (includes sediment disposal sites)

Military operation areas may present additional "no-go" zones, however that information is not readily mappable so any development near Department of War (DOW) operation areas would need to be assessed through DOW and in coordination with state agencies. The military could have use for marine energy technologies since the devices can be deployed in off-grid locations along the coast. Distributed energy systems can provide decentralized and sustainable power for military bases, installations, and operations in coastal and maritime environments.[35] To determine if a marine renewable energy project would be compatible with DOW military operations, energy developers would need to submit project information to the

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35 Lee, Susan and Vida Strong. (Aspen Environmental Group). 2024. *Wave and Tidal Energy: Evaluation of Feasibility, Costs, and Benefits*. SB 605 Report. California Energy Commission. CEC Publication Number CEC-700-2024-005.

DOW Siting Clearinghouse for review, which would then identify any challenges and operational impacts for further discussion.[36]

The following includes a high-level list of each potential sea space conflict that was assessed in the sea space analysis. For more information and to view the maps associated with each sea space conflict, see *Sea Space Analysis for Wave and Tidal Energy*.

- **Marine biological resources**: NMS and MPA, California Coastal National Monument, protected species and critical habitats, biologically important areas
- **Tribal, cultural, and historical resources**: Native American cultural sites, resources, and viewsheds; shipwrecks and archaeological sites
- **Commercial and recreational fisheries**: commercial fishing effort and catch density, recreational fishing effort, aquaculture
- **Ocean uses**: shipping lanes, dredged areas, ocean and sediment disposal sites, state/county beaches and recreational areas (i.e. surfing, sailing, diving, etc.)
- **Ocean infrastructure**: subsea cables and pipelines, oil and gas platforms, BOEM wind energy lease areas, buoys (metocean and navigation)

Based on outreach conducted throughout the SB 605 proceedings, there are fisheries-specific considerations related to sea space conflict analysis. Fisheries organizations have recommended that future fisheries specific spatial analyses should consider the following: fishing vessel traffic, navigation routes, potential financial impacts to fishing and safety issues, displacement or loss of preferred commercial and recreational fishing grounds, and potential economic and social impacts to fishing communities which include the fishermen and the shoreside businesses that support them. Additionally, fisheries organizations suggest that wave and tidal energy development should consider the cumulative effects from all major ocean activities, including offshore wind energy development.[37] Public comments received

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36 U.S. Department of War. "DOW Military Aviation and Installation Assurance Siting Clearinghouse," https://www.dodclearinghouse.osd.mil/.

37 The Alliance of Communities for Sustainable Fisheries (ACSF) and the Pacific Fisheries Management Council (PFMC) made these comments in docketed Public Comments in response to the *SB 605 Draft Sea Space Analysis Report*. The PFMC comment is available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=263176&DocumentContentId=99772.

The ACSF comment is available at https://efiling.energy.ca.gov/GetDocument.aspx?tn=263164&DocumentContentId=99760.

from environmental non-governmental organizations also support future analyses that consider the cumulative effects of offshore development.[38]

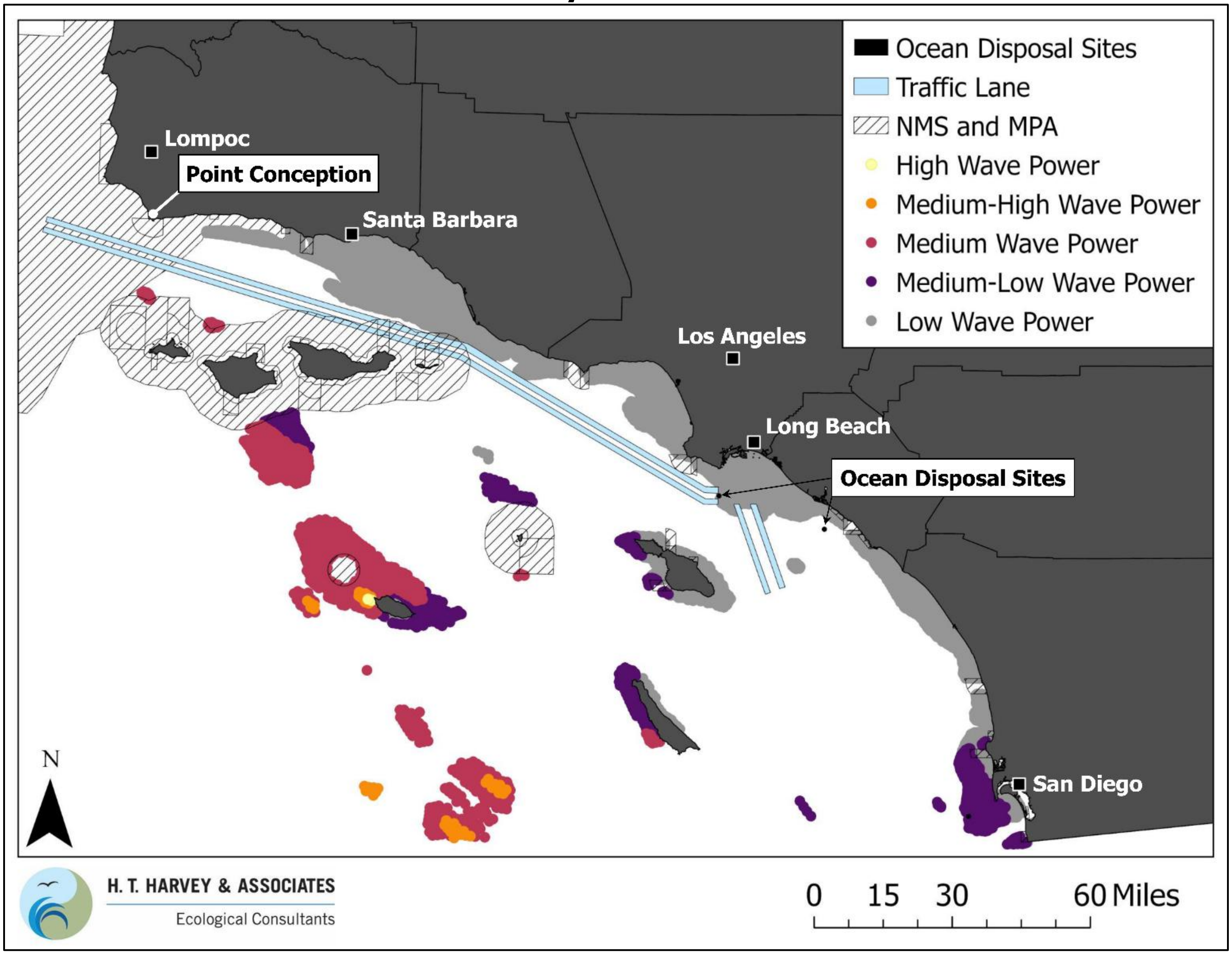
Sea Space Maps

The sea space conflict analysis maps are for informational purposes only and should not be used as a substitute for comprehensive site-specific evaluations, environmental reviews, or regulatory decisions required for project development.

In Southern California, most of the potential wave energy resources are located around the Channel Islands, as shown in **Figure 1**. However, development restrictions in marine sanctuaries and protected areas means that offshore wave energy development is feasible only in the outer Channel Islands, namely San Nicolas Island, Catalina Island, and San Clemente Island. Wave energy resources potential is low near the coastline, and developers would need to evaluate many siting considerations for projects near coastline activities, such as public beaches. There are opportunities for colocation of WECs with existing structures such as piers, breakwaters, and jetties, as well as oceanographic buoys. Tidal energy resources are low in Southern California, as shown in **Figure 2**; therefore, harnessing wave energy may be more feasible.

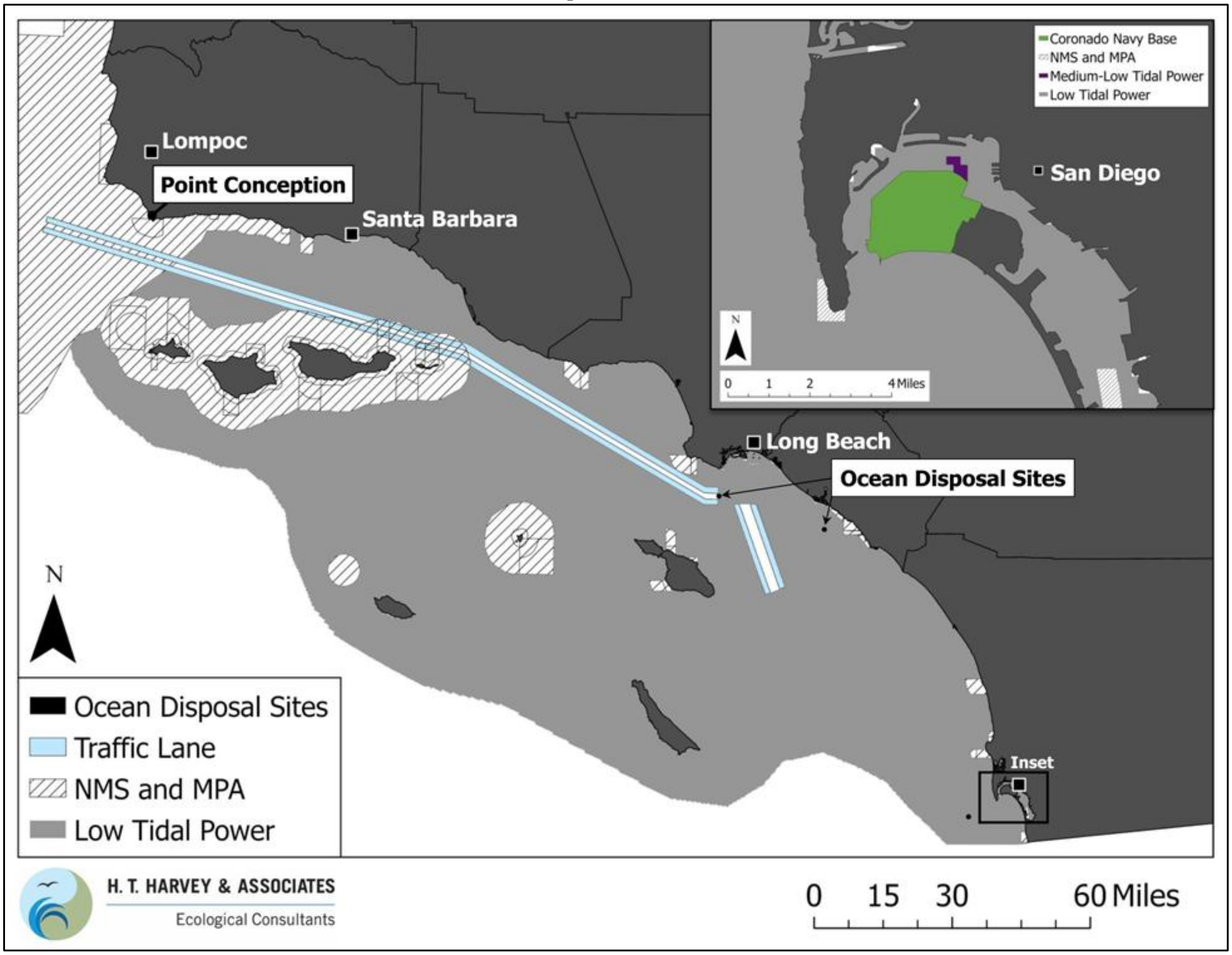
38 These comments were submitted in a comment letter by the Natural Resources Defense Council (NRDC), California Coastal Protection Network, Ocean Conservation Research, and Environmental Protection Information Center (EPIC) in response to the draft report on *Wave and Tidal Energy: Evaluation of Feasibility, Costs, and Benefits.* The comment is available at *https://efiling.energy.ca.gov/GetDocument.aspx?tn=258641&DocumentContentId=94686*.

Figure 1: Southern California Potential Wave Energy Sites Filtered by "No Go" Zones



Source: H. T. Harvey & Associates

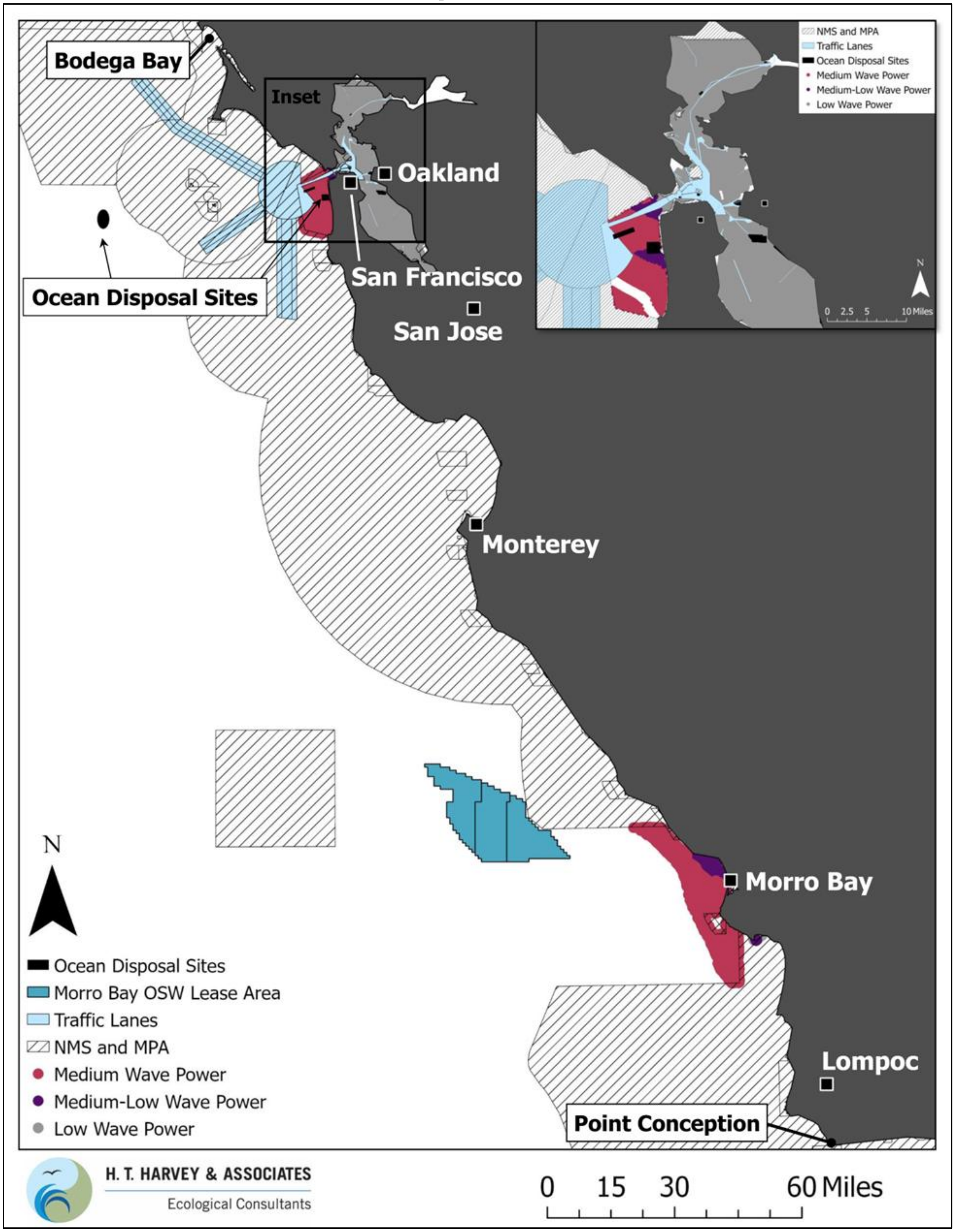
Figure 2: Southern California Potential Tidal Energy Sites Filtered by "No Go" Zones



Source: H. T. Harvey & Associates

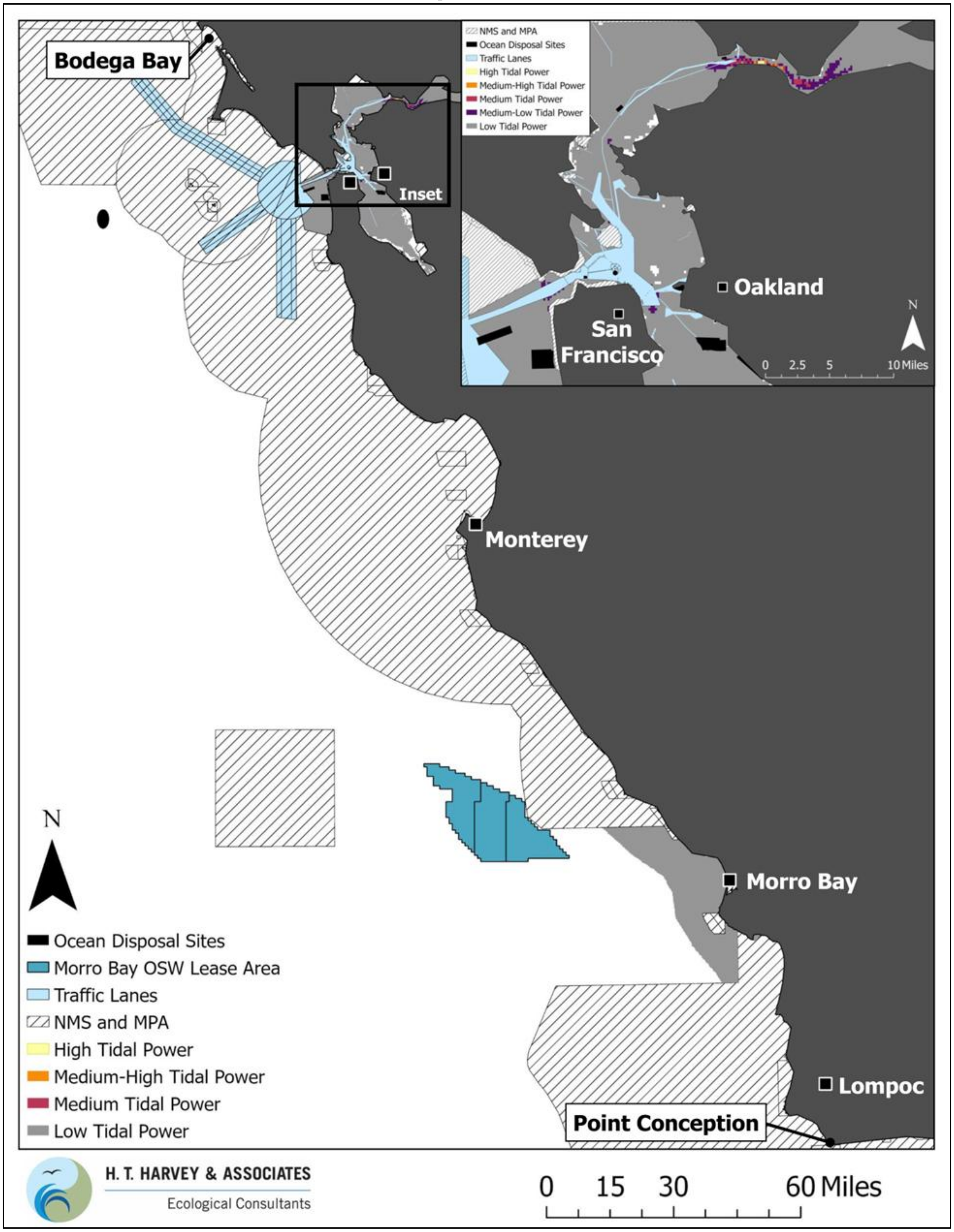
Figure 3 displays the Central California coastline which is bordered by marine sanctuaries or protected areas, limiting any potential commercial-scale wave energy developments to two areas: the Morro Bay region and the entrance to San Francisco Bay. Development near the entrance to San Francisco Bay may prove challenging as the area has multiple shipping lanes to avoid. Tidal energy resources are located within San Francisco Bay, shown in **Figure 4**, which are limited by navigational channels and the presence of listed fish species. The higher-potential tidal energy areas are a migration corridor for many listed fish species with designated critical habitat. Therefore, any development within this area would require careful consideration of environmental impacts.

Figure 3: Central California Potential Wave Energy Sites Filtered by "No Go" Zones



Source: H. T. Harvey & Associates

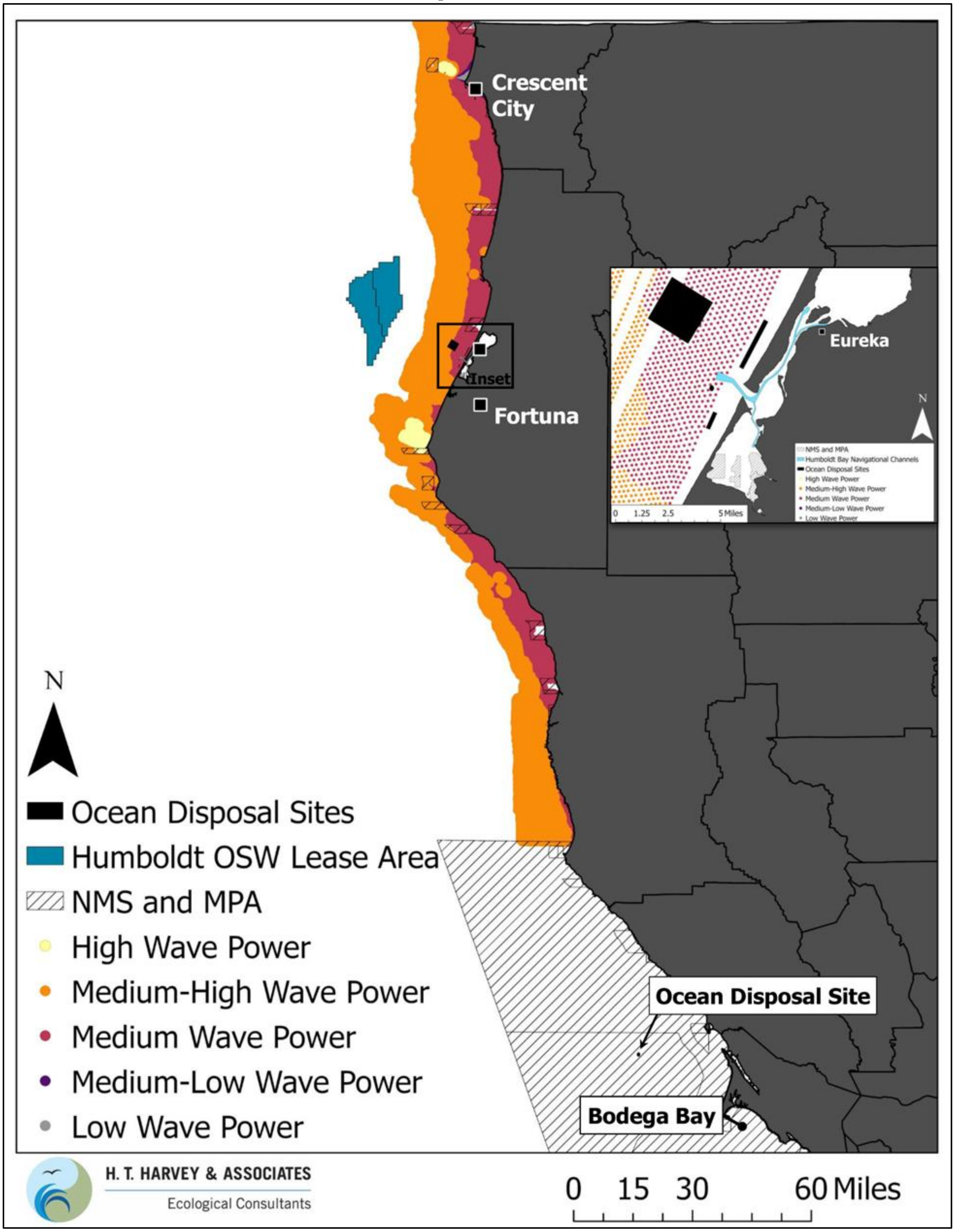
Figure 1: Central California Potential Tidal Energy Sites Filtered by "No Go" Zones



Source: H. T. Harvey & Associates

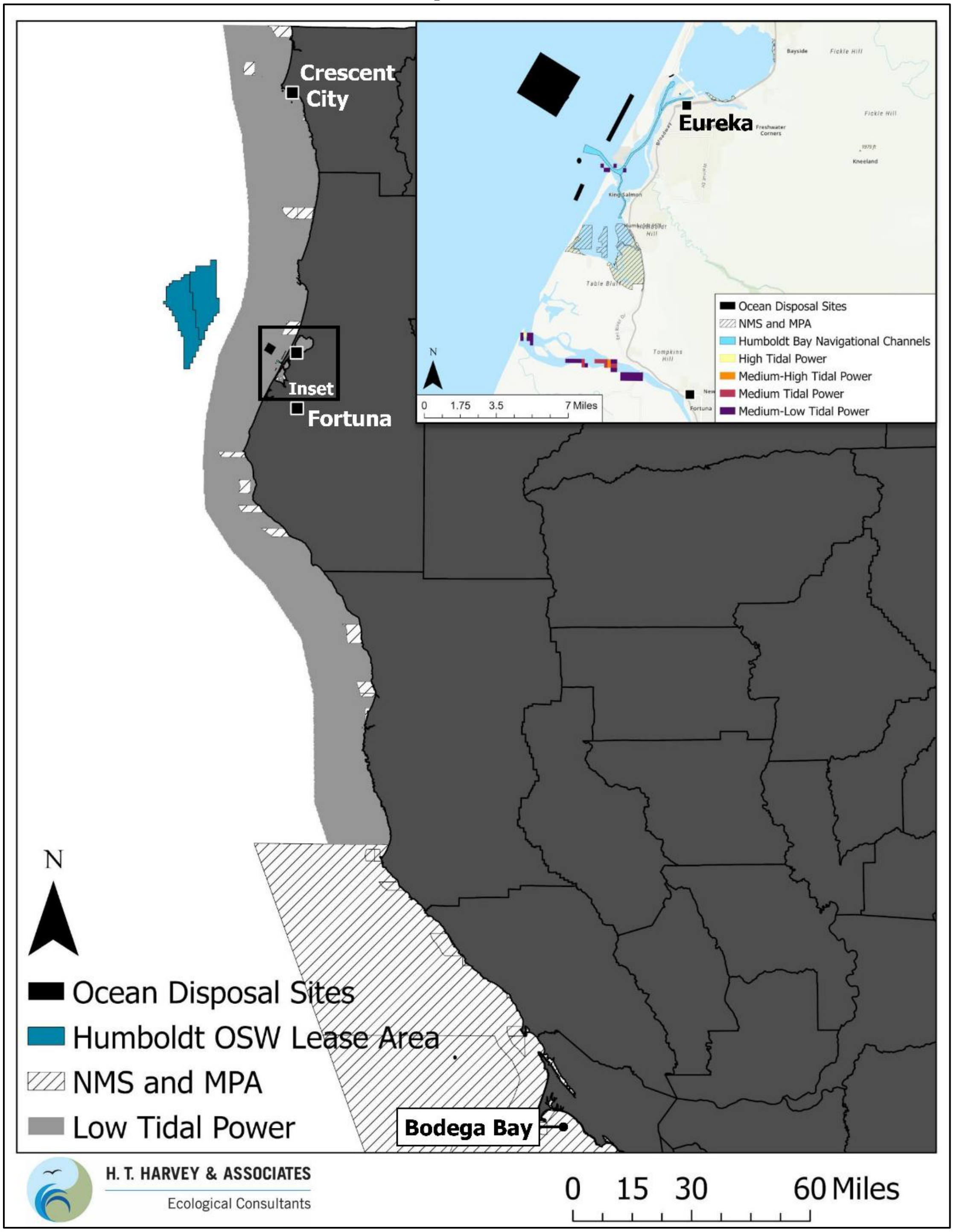
Northern California has fewer spatial restrictions and higher potential energy resources for wave and tidal energy projects. The lack of large marine sanctuaries or shipping lanes in the region likely makes marine energy development in this area more feasible than in the other two regions. As shown in **Figure 5**, wave energy resources are readily available. The highest tidal energy resources are found within Eel River, shown in **Figure 6**, which may present siting challenges given that the river is important to local salmon populations, as well as local interested parties and California Native American tribes.

Figure 5: Northern California Potential Wave Energy Sites Filtered by "No Go" Zones



Source: H. T. Harvey & Associates

Figure 6: Northern California Potential Tidal Energy Sites Filtered by "No Go" Zones



Note that the low tidal power polygons were removed from the inset map to highlight the other power categories.

Source for the basemap in the inset map: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

Source: H. T. Harvey & Associates

Electrical Infrastructure

New offshore electrical infrastructure would be needed to connect potential WECs and TECs in California waters. The generation capacity of current WECs and TECs is relatively small, so they typically operate at lower distribution-level voltages rather than high-voltage transmission. This analysis therefore refers to "electrical infrastructure" or "power lines" at the distribution scale, rather than transmission.

WECs and TECs that connect electricity to the onshore grid require FERC licensing.[39] In California, the California Public Utilities Commission (CPUC) regulates the siting and approval of utility infrastructure under General Order 131-E, which defines:

- Transmission lines: 200 kV and above
- Power lines: 50–200 kV
- Distribution lines: Below 50 kV

In this discussion, nearshore and offshore devices are considered offshore facilities due to their similar interconnection challenges. Onshore generators are addressed separately. Offshore WECs have been deployed up to 20 kilometers from shore, while onshore WECs (devices integrated into coastal structures) are projects deployed in shallow water at the shoreline.

Offshore wave and tidal energy

Offshore WECs and TECs require undersea power lines to deliver electricity to shore, unless powering at-sea applications like ocean monitoring, aquaculture, or other systems requiring energy. All offshore projects, regardless of size, follow a similar arrangement where power is collected at a cable node or offshore substation, then transmitted to shore via an export cable.

Export cables are typically buried in the seabed to avoid disturbing marine life and ocean users, with shore landings typically completed using horizontal directional drilling (a method that can minimize seafloor disruption). Once onshore, power is routed through a substation and into the existing electrical grid.

Onshore wave energy

Onshore WECs (mounted on structures like breakwaters or seawalls) can avoid the need for undersea cables, potentially reducing both environmental impact and interconnection costs. For example, EcoWave Power has operated shore-mounted facilities in Portugal, Israel, and Gibraltar, and recently installed a pilot project at the Port of Los Angeles.[40]

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39 Federal Energy Regulatory Commission. "Hydrokinetic Projects." https://ferc.gov/licensing/hydrokinetic-projects. Accessed September 2025.

40 Eco Wave Power. "Port of Los Angeles Project." Eco Wave Power, https://www.ecowavepower.com/port-of-la/. Accessed September 2025.

Tidal barrages, similar to dams, generate electricity by capturing tidal flows in coastal basins. These shore-mounted facilities can be directly connected to a utility's electric distribution or transmission grid. Since distribution-level power infrastructure is widespread along California's coast, proximity to high-voltage infrastructure would not be a constraint for deployment of onshore WECs and TECs.

Wave energy colocated with offshore wind

The high cost of stand-alone wave energy projects has limited large-scale deployment. However, integrating WECs with offshore wind infrastructure (beyond the 200m depth of this analysis) could reduce costs by sharing foundations, cables, and grid connections, while optimizing space use. Hybrid systems combining WECs with wind turbines or energy storage may improve power quality and system stability. Successful integration would require coordination with offshore wind developers, regulators, tribes, fishermen, and other interested parties.

Protective Measures for Potential Impacts

The sea space analysis identifies protective measures to avoid, minimize, and mitigate environmental impacts and ocean use conflicts from marine renewable energy projects. It highlights potential issues like viewsheds, recreation, fishing, navigation, aquaculture, and cultural resources. However, this analysis is not intended to replace a formal environmental review that would be required for any prospective project.[41]

Potential environmental effects of wave and tidal energy projects can be assessed using the framework of stressors and receptors. Stressors are the marine renewable energy components (devices, arrays, related components) that may harm the marine environment. Receptors are the marine species, habitats, and the biotic and abiotic components of marine ecosystems that could be affected by stressors.[42] Stressor-receptor interactions that apply to wave and tidal

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41 For this report, the term mitigate is not meant to replace the necessary California Environmental Quality Act (CEQA) process. Any potential project would have to go through a formal CEQA analysis to determine potential impacts and mitigation measures.

42 Copping, A. E. 2024. "Marine Renewable Energy and Ocean Energy Systems-Environmental." In L. Garavelli, A. E. Copping, L. G. Hemery, and M. C. Freeman (Eds.), OES-Environmental *2024 State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World.* Report for Ocean Energy Systems (OES). (pp. 1–7), https://tethys.pnnl.gov/publications/2024-state-science-report-chapter-1-marine-renewable-energy-ocean-energy-systems; Garavelli, L., Hemery, L. G., Rose, D. J., Farr, H., Whiting, J. M., and Copping, A. E. 2024. "Marine Renewable Energy: Stressor-Receptor Interactions." In L. Garavelli, A.E. Copping, L. G. Hemery, and M. C. Freeman (Eds.), OES-Environmental *2024 State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World. Report for Ocean Energy Systems (OES)*. (pp. 26–102). doi:10.2172/2438589, https://tethys.pnnl.gov/publications/2024-state-science-report-chapter-3-marine-renewable-energy-stressor-receptor.

energy projects were identified in the *OES-Environmental State of the Science 2024 Report* and are listed below (also see illustration in **Figure 7**):[43]

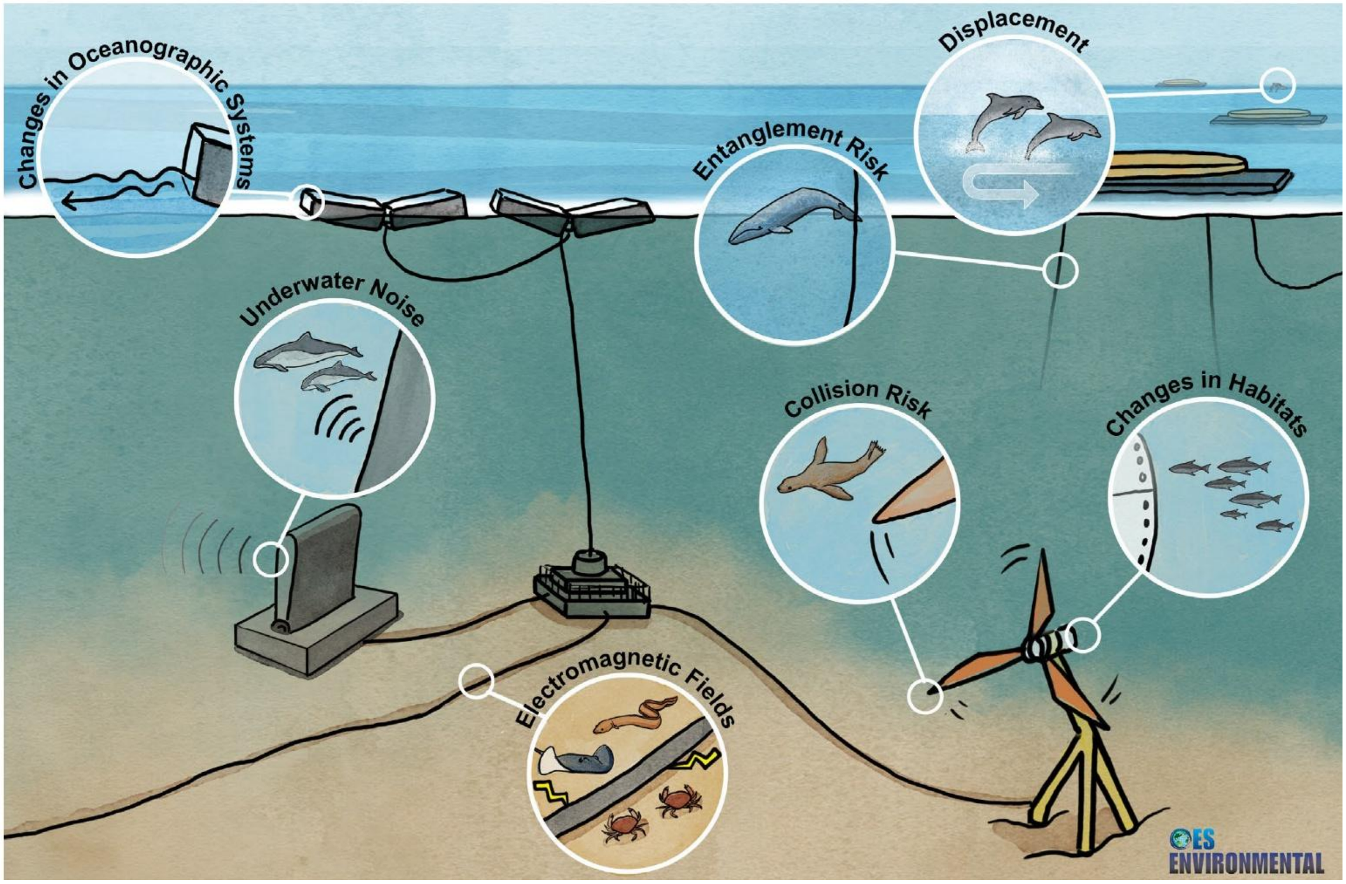
1. **Collision, entrainment, impingement, and entrapment** — Risk of marine animals colliding with or being pulled into or onto screens, rotating turbine blades, and other moving parts of WEC/TEC devices.
2. **Underwater noise** — Disruption of marine animal communication and behavior due to noise produced during installation or operation of WEC/TEC devices, or both.
3. **Electromagnetic fields (EMFs)** — Disruptions to marine animal movement and behavior due to EMF radiation from energized power export cables.
4. **Changes in habitats** — Alterations in benthic, or pelagic habitats, or both that support marine animals from the installation, presence, and operation of WEC/TEC devices.
5. **Entanglement** — Risk of large marine animals becoming entangled in mooring lines or cables, or secondarily entangled with materials such as lost fishing gear that entangles on devices or moorings.
6. **Changes in oceanographic systems** — Decreased wave heights or changes in ocean water circulation (and related effects) due to the presence and operation of WEC/TEC devices.
7. **Displacement** — Changes in the migratory pathways or other movements of marine animals due to the installation, presence, and operation of WEC/TEC devices.
8. **Water quality** — Changes to the chemical characteristics of the water, including the release of contaminants and chemicals.

Additionally, potential impacts to ocean uses would need mitigation measures. However, protective measures for avoiding ocean use conflicts are case-specific and require further site-specific analysis. Examples of potential ocean use impacts include visual impacts, impacts on recreational activities/areas, impacts on commercial and recreational fishing, navigational hazards, impacts on cultural resources and tribal uses.

For more information and the complete list of protective measures associated with these stressor-receptor interactions as well as ocean use protective measures, see *Sea Space Analysis for Wave and Tidal Energy*.

43 Ibid.

Figure 7: Stressor-Receptor Interactions and Marine Renewable Energy Installations



Potential stressor-receptor interactions between various marine renewable energy devices and marine organisms.

Source: Copping et al. (2024)

Responsible project siting can avoid or reduce interactions between marine species and marine energy projects by firstly avoiding important habitats and ecosystems, then if avoidance is not possible, putting protective measures in place for reducing conflict. Some protective measures include design considerations for devices and associated components, establishing best practices for impact avoidance and minimization during construction and operation, modeling to predict and detect impacts, and monitoring. Sea space conflicts could be avoided by careful communication and collaboration with interest groups, regulatory agencies, and tribes.

Monitoring and Adaptive Management Strategies

Monitoring and adaptive management are essential for addressing uncertainties and potential risks associated with marine renewable energy projects. Regular monitoring helps assess the frequency and scale of environmental interactions, while adaptive management enables developers to implement appropriate measures to reduce impacts and to determine whether ongoing monitoring is necessary.

Adaptive management also provides a pathway for regulators to approve novel projects while ensuring that unforeseen environmental impacts are managed. Any adaptive management plans would need to be evaluated through existing regulations and environmental laws, such as CEQA. A phased approach, beginning with small pilot projects to gather data and characterize interactions, can inform decisions on scaling up to larger commercial arrays while avoiding, minimizing, or mitigating environmental impacts. Specific adaptive management strategies include:

- Evaluating baseline environmental conditions at the proposed project site and identifying high-risk, high-uncertainty issues in need of additional monitoring and research in the pilot phase.
- Determining critical information gaps from a baseline evaluation, as well as other wave and tidal energy projects and comparisons and similarities between familiar forms of energy.
- Developing targeted monitoring and research needs to address data gaps and identify thresholds of concern.
- Developing data analysis and communication protocols for providing monitoring and research findings to adaptive management decision-makers in a timely manner.
- Identifying protection and mitigation measures and actions that would be used if thresholds of concern are exceeded. Laying out a clear path for decision-making for regulatory agencies, energy developers, and interested parties (for example, if A happens, then B. If C happens, then D).
- Agreeing on a monitoring timeline and mileposts (for example, monitor for one year and then re-evaluating monitoring findings and research new technologies to improve monitoring).

An effective adaptive management strategy would outline specific actions that would take place when thresholds are exceeded. For example, exceedances might prompt additional monitoring, scheduling device maintenance, project layout adjustments, operational changes, or trigger additional mitigation measures (such as habitat restoration of species impacts that exceed permit allowances). This allows developers to anticipate and plan for a range of potential responses based on monitoring results. It is important for these frameworks to remain flexible since methods, technologies, and protocols may change over time and as information from other projects become available.

Currently, limited guidance for adaptive management exists, although there are some examples from countries further along in marine energy deployment. Guidance from government agencies on when to apply adaptive management and what it could include may reduce permitting challenges and advance marine renewable energy deployment by providing developers a shared framework that reduces uncertainty.

Plans for floating offshore wind energy in California may serve as a model for wave and tidal energy projects' monitoring and adaptive management plans. Although offshore wind energy facilities are located farther from shore and in deeper waters, many of the same environmental monitoring and adaptive management strategies could be applied to wave and tidal projects.

The California Ocean Protection Council is working on two efforts to ensure responsible offshore wind energy development in California through avoidance, minimization, and mitigation of potential environmental impacts.

1. **Development of a comprehensive environmental monitoring guidance** document that is tailored to offshore wind development in California. This includes identifying priority environmental monitoring questions, establishing monitoring design recommendations, and recommending protocols for data sharing, data analysis, and application of new technologies in monitoring programs.
2. **Creation of a West Coast Science Collaborative** for offshore wind to provide independent and objective scientific expertise that can inform coordinated environmental monitoring and support regulatory decision making and adaptive management.

This work could be applied to inform future wave and tidal energy projects in California.

For more information on monitoring and adaptive management strategies as well as examples of wave and tidal projects with adaptive management strategies applied, see *Sea Space Analysis for Wave and Tidal Energy*.

CHAPTER 4: Next Steps and Considerations for Development

Offshore wave and tidal energy offer California an opportunity to advance its clean energy and climate goals by complementing other clean energy resources. Marine energy projects are emerging technologies and face multiple obstacles that impact their feasibility, scalability, and economic viability. The primary challenges involve advancing technology, grid integration, addressing environmental and stakeholder concerns, maintaining cost competitiveness, and navigating socioeconomic factors. Some of these challenges are based on a lack of familiarity and uncertainty with technologies and a lack of accessible scientific information and data.

Supporting marine energy test sites and pilot projects can help address these challenges by allowing developers to test their devices in real-world ocean conditions, enabling assessment of technology performance and optimal deployment conditions. Additionally, test sites and pilot projects allow for better data collection and monitoring, which may decrease uncertainty and allow for coordinated research that could be applied to other projects. In May 2025, Cal Poly was selected as the first open water research pier under the Testing Expertise and Access to Marine Energy Research Program (TEAMER), which is sponsored by the U.S. Department of Energy.[44] The Cal Poly Pier, located in San Luis Obispo Bay, will provide an easily accessible, shore-based testing facility for wave energy developers. The Cal Poly test facility will foster early-stage research and enable collaboration among technology developers, national labs, and government agencies, including the U.S. Navy. Students and faculty will also benefit from hands-on experience. The pier's 3,000-foot-long marine research station allows direct testing of wave energy devices, sensors, and autonomous vehicles.[45]

The announcement of the Cal Poly test facility follows the completed construction of the PacWave South test facility in early 2025. PacWave South, an open-ocean wave energy test site located off Newport, Oregon, could be a next step for developers testing their devices at the Cal Poly Pier test facility. The area around Cal Poly Pier is semi-protected by the Port San Luis breakwater with moderate waves as compared to the open coast, making it ideal for small-scale testing. The PacWave test facility is located further offshore in the open ocean, supporting testing of wave energy technology in real-world conditions and a high-energy environment. PacWave is pre-permitted for most wave energy technologies, allowing developers to avoid the lengthy and costly site permitting process and significantly reduce the time and cost required to test new devices. In November 2025, the Bonneville Power Administration executed a power purchase agreement to procure up to 20 megawatt-hours of

44 California Polytechnic State University. "Cal Poly Pier: TEAMER's First Open Water Pier Facility." Center for Coastal Marine Sciences, https://marine.calpoly.edu/teamer. Accessed September 2025.

45 https://www.calpoly.edu/news/cal-poly-pier-designated-wave-energy-testing-site-federally-funded-program

wave-generated electricity from the PacWave South test facility. The agreement, which covers the period from 2026 through 2030, represents the first power purchase agreement for wave energy in the continental United States.[46] The PacWave South test facility is now complete and fully operational as of August 2026.[47] These new wave energy test facilities strengthen efforts towards advancing development of WECs on the West Coast.

In addition to these test facilities, pilot projects can help advance the development of marine renewable energy in California. In August 2025, Eco Wave Power completed the installation of a wave energy pilot project at the Port of Los Angeles, hosted by AltaSea, with the project's official launch taking place in September 2025.[48] The 100 kW system is comprised of eight wave energy floaters attached to an existing concrete wharf to capture wave motion, which is then converted into electricity by a land-based unit.[49] The project aims to demonstrate scalable wave power integration into coastal infrastructure and is the first onshore wave energy project in the United States. The project concluded its wave energy pilot program in March 2026, confirming that all technical and operational objectives were met. The installation will continue to operate and serve as an educational and demonstration site for policymakers, researchers, industry stakeholders, and potential commercial partners.[50]

Another example of a pilot project in development is a wave-powered desalination buoy proposed by the City of Fort Bragg in Mendocino County. The City of Fort Bragg has partnered with Oneka Technologies to deploy the pilot project which will consist of one desalination buoy located 0.5 miles from shore, producing an average 13,200 gallons of desalinated water per day for 12 months.[51] While this technology does not generate electricity, the system uses wave-driven mechanical power to enable desalination. The purpose of this pilot project is to demonstrate the system's effectiveness to produce and deliver desalinated water to the City of

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46 CalWave. "PacWave Signs Power Purchase Agreement with Bonneville Power Administration." CalWave, https://calwave.energy/pacwave-signs-power-purchase-agreement-with-bonneville-power-administration/. Accessed July 2026.

47 OSU Today. "OSU's PacWave energy testing facility is officially open." Oregon State University, https://today.oregonstate.edu/all-stories/osu%E2%80%99s-pacwave-energy-testing-facility-officially-open. Accessed August 2026.

48 Eco Wave Power. "Eco Wave Power Hits Historic Milestone, Launches First-Ever U.S. Wave Energy Project at Port of Los Angeles." EcoWavePower.com, https://www.ecowavepower.com/eco-wave-power-hits-historic-milestone-launches-first-ever-u-s-wave-energy-project-at-port-of-los-angeles/. Accessed September 2025.

49 Eco Wave Power. "Port of Los Angeles Project." EcoWavePower.com, https://www.ecowavepower.com/port-of-la/. Accessed September 2025.

50 Offshore Energy. "Wave Energy Pilot Concludes at Port of Los Angeles." Offshore-Energy.biz, https://www.offshore-energy.biz/wave-energy-pilot-concludes-at-port-of-los-angeles/.

51 California State Lands Commission. August 2025. *Staff Report 05*. Available at https://slcprdwordpressstorage.blob.core.windows.net/wordpressdata/archive/2025/20250821/5-08-21-25_05.pdf

Fort Bragg without relying on electricity from shore, displacing the electrical demand typically required to operate pumps and other systems in conventional seawater reverses osmosis systems. The pilot project will allow for the collection of empirical data from within California waters that could be used to inform the design and permitting of a future, utility-scale array of desalination buoys.[52]

A Mitigated Negative Declaration (MND) and a Mitigation Monitoring and Reporting Program (MMRP) were prepared by the City of Fort Bragg for this project to lessen potential adverse environmental impacts.[53] The California State Lands Commission issued a lease for the project in August 2025, and the California Coastal Commission approved the Coastal Development Permit for the project in December 2025. In April 2026, Oneka announced that it had obtained all necessary permits from regulatory agencies to move forward with the pilot project.[54]

Considerations

Research indicates that marine energy installations can provide decentralized power solutions for coastal communities vulnerable to sea-level rise, storm surges, and extreme weather events, ensuring reliable and resilient energy supply and supporting disaster response and recovery efforts. Marine energy infrastructure can be leveraged to enhance coastal resilience and climate adaptation efforts in California. California's marine energy sector can contribute to sustainable economic development and job creation in coastal regions. Marine energy projects can create opportunities for innovation, entrepreneurship, and workforce development in areas like technology development, manufacturing, installation, operations, and maintenance.

Projects must be developed in a way that protects the state's underserved communities, California Native American tribes, tribal cultural resources, ratepayers, and coastal resources, including marine wildlife, habitat, commercial and recreational fisheries, water oriented recreational activities (such as surfing, sailing, diving), and public access. The considerations below are intended to inform legislative and executive actions to facilitate, encourage, and promote the development and increased use of technologically and economically feasible wave energy and tidal energy technologies, infrastructure, and facilities in the state, per SB 605.

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52 Ibid.

53 City of Fort Bragg. March 2025. *Initial Study/Mitigated Negative Declaration*. Available at https://files.ceqanet.lci.ca.gov/314223-1/attachment/fyqt9q3qINkzunGX2Ni9aB2B6efF_wDumffgWw3UUsbFCny5CnxDN5AimEEu4Y2CUBovowGXJ4Aqvl210

54 Oneka Technologies. "Announcement of permit approvals for Fort Bragg desalination pilot." LinkedIn, https://www.linkedin.com/posts/oneka_waterscarcity-desalination-california-activity-7455617773730250752-_ARA. Accessed July 2026.

Research Considerations

- Continued research and development of wave and tidal energy technologies, including generation profiles, exploration of market signals to support investments, environmental and ocean-use impacts, transmission alternatives, and cost-benefit analysis will help assess their potential role in the state's renewable energy resource portfolio.
- Learnings from pilot projects and marine energy testing and research facilities can reduce technological and environmental uncertainty in wave and tidal energy development. Data collected from these initiatives can be leveraged to advance development by supporting convergence and standardization of technologies, reducing environmental uncertainty, and informing adaptive management strategies. These efforts contribute to more efficient and effective permitting processes.
- Future spatial analyses should incorporate site-specific and regional considerations, including project-level impacts on marine ecosystems, with extra consideration for threatened and endangered species and sensitive habitats, commercial and recreational fishing, and other ocean uses, to inform equitable siting decisions and mitigation strategies.
- Further analysis and feasibility assessments on distributed energy resource applications (such as environmental monitoring equipment, scientific research infrastructure, and powering remote coastal communities) as well as colocation of wave and tidal energy technologies with other ocean uses (such as ports and harbors, marine aquaculture, and offshore energy infrastructure) could facilitate development of wave and tidal energy.

Permitting/Regulatory Considerations

- Support a coordinated, multi-agency (federal, state, and local) permitting framework to improve the efficiency and clarity of permitting for DER installations (non-grid connected) and pilot-scale deployments off the California coast. Examples of existing guidance documents include the *DOE Marine Hydrokinetic Regulatory Processes Handbook*[55] and the *California Permitting Guidance for Ocean Renewable Energy Test and Pilot Projects*.[56] Development of a permitting framework could benefit from including California-specific processes across a range of project scales, technologies, and locations/jurisdictions.
- Include baseline monitoring requirements and adaptive management thresholds in permitting and regulatory processes to improve efforts to assess, avoid, minimize, and mitigate environmental impacts.

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55 U.S. DOE. 2020. *Handbook of Marine Hydrokinetic Regulatory Processes*, https://www.energy.gov/sites/prod/files/2020/09/f78/mhk-regulatory-processes-handbook-2020.pdf.

56 California Ocean Protection Council. 2011. *California Permitting Guidance for Ocean Renewable Energy Test and Pilot Projects*, https://opc.ca.gov/webmaster/ftp/project_pages/energy/CA%20Ocean%20Energy%20Guidance%20Paper_Final_12-15-11.pdf

Engagement Considerations

- Continue coordination and collaboration among federal and state governments, California Native American tribes, commercial and recreational fishing groups, coastal communities, labor unions, industry, environmental justice organizations, environmental organizations, and others. This ongoing coordination is essential to ensure that diverse perspectives are meaningfully integrated throughout the wave and tidal energy planning and decision-making process.
- Promote early and ongoing coordination and consultation with California Native American tribes to inform siting considerations and ensure Traditional Ecological Knowledge and cultural values are meaningfully incorporated into future planning efforts.

APPENDIX A: Examples of Wave and Tidal Energy Devices

A.1 Summary of Six Main Wave Energy Converter Devices

Device Archetype	Configuration	Optimal Conditions
Attenuator  *Mocean Energy Blue X* Source: Mocean Energy	Generally floating with mooring line(s) and bottom anchor(s)	Offshore swell, tens of meters water depth (outside breaker zone)
Point absorber  *CalWave xWave™* Source: CalWave	Floating, semi-submerged, or submerged with mooring line(s) and bottom anchor(s)	Moderate to high wave energy densities (offshore)

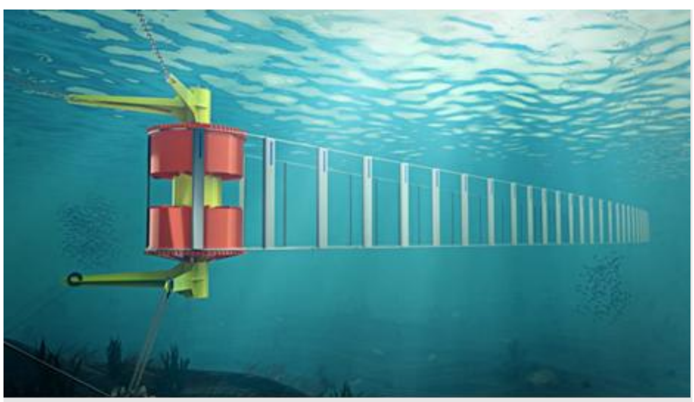
Device Archetype	Configuration	Optimal Conditions
Pressure differential	Submerged with mooring line(s) and bottom anchor(s)	Flexible
Oscillating water column  *Ocean Energy OE Buoy* Source: Ocean Energy	Shore-based, fixed structure, or floating, moored offshore	Flexible
Overtopping  *Wave Dragon* Source: Wave Dragon	Shore-based, fixed structure, or floating, moored offshore	Flexible

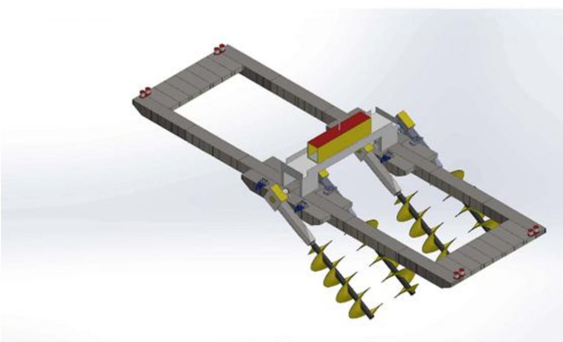
Device Archetype	Configuration	Optimal Conditions
Oscillating wave surge  *Resolute Marine Energy WEC* Source: Resolute Marine Energy	Surface floating or subsurface and moored and/or bottom-mounted	Relatively shallow water depths (10-12 m)

Source: Lee, Susan and Vida Strong. (Aspen Environmental Group). 2024. *Wave and Tidal Energy: Evaluation of Feasibility, Costs, and Benefits*. SB 605 Report. California Energy Commission. CEC Publication Number CEC-700-2024-005.

A.2 Summary of Six Main Tidal Energy Current Device Archetypes

Device Archetype	Configuration	Optimal Conditions
Axial Flow Turbines  *MeyGen Project by SAE Renewables* Source: SAE Renewables	Multiple blades attached to a rotor. Can be deployed as single or multiple units on a base.	Water depths are dependent on turbine size. Can operate in systems with both tidal and unidirectional flow.

Device Archetype	**Configuration**	**Optimal Conditions**
Cross Flow Turbines  *Ocean Renewable Power Company TidGen* Source: Ocean Renewable Power Company	Floating, semi-submerged, or submerged with mooring line(s) and bottom anchor(s).	When oriented horizontally, channelized flow with predictable direction. When oriented vertically, direction agnostic. Can operate in systems with both tidal and unidirectional flow.
Oscillating Hydrofoil  *BeamReach Reciprocating Device* Source: Tidal Sails	Fixed to sediment bed with one or multiple foils oriented perpendicular to flow direction.	Strong tidal oscillations
Tidal Kite	Submerged generating unit with cable affixed to sediment bed.	Can be optimized to meet range of tidal conditions

Device Archetype	Configuration	Optimal Conditions
 *Tidal Kite Conceptual Device* Source: Minesto		
Archimedes Screw  *Conceptual Design of Archimedes Screw Array* Source: Jupiter Hydro	Helix screw oriented in line with flow attached to floating platform.	Water depths are dependent on turbine size. Can operate in systems with both tidal and unidirectional flow.
Vortex Induced Vibration	Spherical or tubular units attached to generator.	Can be affixed to pilings or other submerged structures in turbulent areas. Can be direction agnostic depending on shape.

Source: Lee, Susan and Vida Strong. (Aspen Environmental Group). 2024. *Wave and Tidal Energy: Evaluation of Feasibility, Costs, and Benefits*. SB 605 Report. California Energy Commission. CEC Publication Number CEC-700-2024-005.

APPENDIX B: Glossary

Alternating current (AC): Electrical current that changes direction periodically. Most transmission lines in the United States transport AC power because electricity is generated and used as alternating current.[57]

Attenuator: A single surface-floating bodies or multiple connected bodies that rise and fall with wave motion, and electricity is generated through mechanical turbine rotation or hydraulic pumps that are driven by the flexing motion of the device.

Aquaculture: The breeding, rearing, and harvesting of fish, shellfish, algae, and other organisms in all types of water environments.[58]

Axial-flow turbines have spinning blades whose axis of rotation is oriented with the direction of the current. They mimic wind turbines in shape and energy extraction method.

Bureau of Ocean Energy Management (BOEM): The federal agency under the U.S. Department of Interior that manages development of U.S. Outer Continental Shelf energy and mineral resources. BOEM manages overall offshore wind processes, which include four phases: planning and analysis, leasing, site assessment, and construction and operation.

Crossflow turbines have a set of blades that spin in the direction of flow and can be mounted horizontally or vertically. As these turbines spin, the design of the blades must minimize the flow across the blade as it returns to face the flow.

Desalination: The process of removing dissolved salts from saline water to produce freshwater.[59]

Direct current (DC): Electrical current that flows in one direction and is useful to transmit electricity over very large distances and between asynchronous grids.[60]

57 CPUC. Electric Transmission Fact Sheet. Accessed at https://ia.cpuc.ca.gov/Environment/info/aspen/cltp/archive/Files_8_26_14/_2ElectricTransmissionFactSheet.pdf. January 16, 2025.

58 NOAA. 2025. "What Is Aquaculture?" Accessed at https://oceanservice.noaa.gov/facts/aquaculture.html. January 16, 2025.

59 USGS. 2019. "Desalination." Accessed at https://www.usgs.gov/special-topics/water-science-school/science/desalination. January 16, 2025.

60 CPUC. Electric Transmission Fact Sheet.

Distributed energy resources (DER): Typically smaller generation units that are on the consumer's side of the meter or providing generation to serve nearby load.

Distribution lines: These electric power lines cover much shorter distances, and are typically energized at 16 kV, 12 kV, or 4 kV. Distribution lines carry electricity to neighborhoods on shorter wooden poles or underground.[61]

Floating offshore wind: Offshore wind turbines deployed in water depths that necessitate floating structures and are stabilized by moorings and anchors. Floating offshore wind technology allows offshore wind to be deployed in deeper waters where fixed-bottom offshore wind is not feasible. Due to the nearshore water depth of the Pacific Continental Shelf, floating offshore wind is the only feasible option for California.

Kilovolt (kV): One-thousand volts (1,000). Distribution lines in residential areas are usually 12 kV (12,000 volts).

Kilowatt (kW): One thousand (1,000) watts. A unit of measure of the amount of electricity needed to operate given equipment. On a hot summer afternoon a typical home, with central air conditioning and other equipment in use, might have a demand of 4 kW each hour.

Levelized cost of energy (LCOE): The average total cost of an energy generation project per unit of total electricity generated. Also referred to as the levelized cost of electricity, LCOE is a measurement to assess and compare alternative methods of energy production.

Marine protected areas (MPA): A named, discrete geographic marine or estuarine area seaward of the high tide line or the mouth of a coastal river, including any area of intertidal or subtidal terrain, together with its overlying water and associated flora and fauna that has been designated by law, administrative action, or voter initiative to protect or conserve marine life and habitat.[62]

Megawatt (MW): One thousand kilowatts (1,000 kW) or 1 million (1,000,000) watts. One MW is enough electrical capacity to power 1,000 average California homes. (Assuming a loading factor of 0.5 and an average California home having a 2 kilowatt peak capacity.)

National Marine Sanctuaries (NMS): Protected waters that include habitats such as rock reefs, kelp forests, deep-sea canyons, and underwater archaeological sites.[63]

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61 Ibid.

62 CDFW. 2025. "Marine Protected Areas: Definitions." Accessed at https://wildlife.ca.gov/Conservation/Marine/MPAs/Definitions. March 10, 2025.

63 NOAA. 2025. "What Is a National Marine Sanctuary?" Accessed at https://oceanservice.noaa.gov/facts/nms.html#:~:text=National%20marine%20sanctuaries%20are%20protected%20waters%20that%20include,located%20off%20the%20northern%20and%20central%20California%20coast. January 16, 2025.

National Oceanic and Atmospheric Administration (NOAA): A federal agency whose mission is to understand and predict changes in climate, weather, ocean, and coasts, share that knowledge and information, and conserve and manage coastal and marine ecosystems and resources.[64]

National Laboratory of the Rockies (NLR): Formerly the National Renewable Energy Laboratory, the federal laboratory performs research, development, and deployment of renewable energy and energy efficiency technologies.[65]

Nearshore wave energy converter (WEC): Deployed within a few hundred meters (m) of shore, in water depths of 10–25 m. They are generally mounted directly to the seafloor; however, some devices have floating, semi-submerged, or submerged components as well.

Offshore wave energy converter (WEC): Deployed in waters deeper than 25 m. These devices may float at the surface, be near the surface (semi-submerged), or be submerged. As such, they require moorings and anchors to hold them in place.

Onshore wave energy converter (WEC): Typically, fixed structures that are deployed on coastal structures or in shallow water. These can be integrated into breakwaters or piers or built as stand-alone structures.

Oscillating water column wave energy converters generate electricity by using the oscillating motion of water within a chamber as waves pass by. These WECs typically consist of a partially submerged chamber open to the sea.

Oscillating wave surge converters: Oscillating wave surge converters consist of a buoyant structure that moves back and forth (surges) in response to the passing waves to create energy.

Overtopping wave energy converters (WEC) generate electricity across a sloping structure or a seawall with a reservoir behind it. As waves approach the structure, they climb up and spill over the crest, filling the reservoir with water. Being impounded, the water accumulated in the reservoir is at a higher elevation than the surrounding ocean. The water collected in the reservoir is then released through turbines or sluice gates. This controlled release of water drives turbines or generators, converting the potential energy of the stored water into electricity.

Point absorbers typically involve a floating buoy or platform that moves up and down or back and forth in response to the motion of passing waves. This movement, relative to a fixed structure (like an anchor), is then converted into mechanical energy using a power take-off mechanism, such as hydraulic pistons or linear generators.

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64 NOAA. 2025. "About Our Agency." Accessed at https://www.noaa.gov/about-our-agency. January 16, 2025.

65 NLR. 2026. "About NLR." Accessed at https://www.nlr.gov/about.

Power matrix defines the expected energy output of a specific technology at varying resource levels.

Powering the Blue Economy involves using marine energy technologies to support and enhance various sectors and activities within California's rich ocean economy.

Pressure differential wave energy converter generates electricity by harnessing the difference in pressure between two points caused by the motion of ocean waves, the crest, and trough.

Project developer (or developer): A project developer is responsible for developing and managing the project, including activities required to secure financing and permits, determine the project design and engineering aspects, and engage with partners, agencies, and stakeholders. A developer may also be the owner and operator of the energy project.

Port: This term is used both for the harbor area where ships are docked and for the agency (port authority), which administers use of public wharves and port properties. Offshore wind will require ports and waterfront facilities to support a range of activities, including construction and staging of floating platform foundations, manufacturing and storage of components, final assembly, and long-term operations and maintenance.

Senate Bill 605 (SB 605): The law requires that the CEC evaluate the feasibility, costs, and benefits of using wave energy and tidal energy as forms of clean energy in California's state and federal coastal waters.

Substation connects two or more transmission lines and transforms voltage from higher to lower. Substations may contain high-voltage switches that allow lines to be connected or isolated for maintenance. Substations can have transformers to convert between two transmission voltages, or equipment such as phase angle regulators to control power flow between two adjacent power systems. A large transmission substation can cover 50 or 100 acres, including multiple voltage levels, and a large amount of protection and control equipment (capacitors, relays, switches, breakers, voltage, and current transformers).[66]

Tidal energy converters (TEC): Technologies that create electricity using tidal or current movement.

Transmission lines carry electricity over long distances, from the generating facility to areas of demand. The electricity in transmission lines is transported at voltages of more than 200 kV to maximize efficiency. Voltages of 220 kV to 500 kV are typical. Transmission lines are usually attached to large lattice steel towers or tubular steel poles.[67]

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66 CPUC. Electric Transmission Fact Sheet.

67 Ibid.

Volt (V): A unit of electromotive force. It is the amount of force required to drive a steady current of 1 ampere through a resistance of 1 ohm. Electrical systems of most homes and office have 120 volts.

Wave energy converter (WEC): Technologies that use wave movement to create electricity. These can be both onshore and offshore installations.

Workforce: All the workers needed to support a project or industry. The workforce for wave and tidal energy consists of workers needed to perform all types of jobs related to the wave and tidal energy ecosystem for all project phases.