DOCKETED	
Docket Number:	24-SB-605
Project Title:	SB 605 Wave and Tidal Energy - Phase 2
TN #:	262568
Document Title:	Presentation - Sea Space Conflicts and Mitigation Measures
Description:	April 2 Workshop Presentation 3 - H. T. Harvey & Associates
Filer:	Danielle Mullany
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	4/2/2025 4:10:14 PM
Docketed Date:	4/2/2025

Potential Sea Space Conflicts, Protective Measures, and Monitoring & Adaptive Management Strategies

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Sea Space Analysis for SB 605 Wave and Tidal Energy Resource
CEC Workshop – April 2, 2025

Photo by L. Terrill

Chapter 3 Goals

Identify marine resources, ocean infrastructure, and other ocean uses along the California coast and determine how restrictive these resources and activities are to the development of wave and tidal energy projects.

Photo by S. Kramer

Potential Conflicts

How restrictive identified resources and activities are to marine energy development depends on several factors, including:

- Legal protections
- Permitting complexities
- Potential for controversy

Potential Sea Space Conflicts

"No-Go" Zones

Protected areas and other regions where commercial development is not permitted or where energy development would be dangerous/hazardous

Proceed with Caution

Development is likely allowed, however:

- Significant permitting challenges may be present;
- Collaboration and coordination with multiple groups and agencies on specific minimization and management measures is required; and/or
- Depends on device type

Marine Resources

Environmental Resources

Sensitive habitats and resources used by marine mammals, fish, seabirds, and sea turtles, such as:

- Migratory routes
- Feeding areas

Two humpbacks surfacing (Photo by L. Terrill)

Cultural Resources

Areas that are used by and/or are important to Native American groups

Chumash Tomol Crossing (Photo by R. Schwemmer/NOAA)

Historical Resources

Shipwrecks and other underwater archaeological sites/artifacts

Shipwreck of the *U.S.S. Chauncey*, 1923, Santa Barbara County (Wikipedia Commons)

Marine Resources

Environmental Resources

Sensitive habitats and resources used by marine mammals, fish, seabirds, and sea turtles, such as:

- Migratory routes
- Feeding areas

Two humpbacks surfacing, Photo by L. Terrill

1) National Marine Sanctuaries (NMS) and Marine Protected Areas (MPAs)

2) Critical habitat designated under the federal Endangered Species Act (ESA)

3) Biologically Important Areas (BIAs) for cetaceans

4) Essential fish habitat (EFH), EFH habitat areas of particular concern (HAPCs), and EFH conservation areas defined by the Magnuson-Stevens Fishery Conservation and Management Act

Marine Resources

1) National Marine Sanctuaries (NMS)

California has five NMS:

1. The Greater Farallones NMS (formerly Gulf of the Farallones)
2. Cordell Bank NMS
3. Monterey Bay NMS
4. Chumash Heritage NMS
5. Channel Islands NMS

NMS prohibit the take (harm, harassment, killing of) of all marine organisms and have restrictions on the construction or placement of any structures on the seabed, including anchors.

Permits are limited to a narrow range of purposes including research, education, salvage and recovery or to assist in managing the sanctuary.

Channel Islands (US National Park Service)

Marine Resources

1) California Marine Protected Areas (MPAs)

Three main types of MPAs in California:

1. State Marine Reserves
2. State Marine Parks
3. State Marine Conservation Areas

MPAs are a subset of state marine managed areas (MMAs), which are discrete geographic areas along the coast that protect, conserve, or otherwise manage a variety of resources.

Cable placement and the construction of infrastructure to support marine energy are not allowed within California's MMAs.

Salt Point State Park (Wikipedia Commons)

Marine Resources

National Marine Sanctuaries (NMS) and Marine Protected Areas (MPAs)

NMS & MPAs are "No Go" Zones

Commercial development is not allowed in NMS and permitting restrictions make development in MPAs difficult, therefore both areas should be avoided when siting projects.

Monterey Bay National Marine Sanctuary (Robert Schwemmer, CINMS, NOAA)

Marine Resources

2) ESA-listed Species & Designated Critical Habitat

When considering a project in an area where a protected species could occur, developers must ensure that project activities would not result in the take (harm, harassment, or death) of the protected species.

Critical habitat areas contain essential physical and biological features that are critical for conserving the species, therefore any commercial activities within these areas must avoid destroying or adversely modifying theses features.

Note that not all federally listed species that occur within California have designated critical habitat (e.g., blue and fin whales).

Blue whale (Photo by L. Terrill)

Marine Resources

2) ESA-listed Species & Designated Critical Habitat

ESA-listed species with critical habitats in CA waters where wave or tidal energy projects could occur:

1. **Western distinct population segment (DPS) of Steller sea lions**
2. Southern DPS of green sturgeon
3. Southern Resident Killer Whale DPS
4. Leatherback sea turtles
5. Central America DPS and the Mexico DPS of humpback whales
6. Black abalone
7. Sacramento River winter-run Evolutionary Significant Unit (ESU) of Chinook salmon

Steller sea lion (Photo by L. Terrill)

All Steller sea lion critical habitat areas in California fall within NMS/MPAs.

Marine Resources

2) ESA-listed Species & Designated Critical Habitat

ESA-listed species with critical habitats in CA waters where wave or tidal energy projects could occur:

1. Western distinct population segment (DPS) of Steller sea lions
2. **Southern DPS of green sturgeon**
3. **Southern Resident Killer Whale DPS**
4. **Leatherback sea turtles**
5. **Central America DPS and the Mexico DPS of humpback whales**
6. Black abalone
7. Sacramento River winter-run Evolutionary Significant Unit (ESU) of Chinook salmon

Critical habitat for these species cover large swaths of marine areas and therefore development in these areas would require more site-specific analysis.

Marine Resources

2) ESA-listed Species & Designated Critical Habitat

ESA-listed species with critical habitats in CA waters where wave or tidal energy projects could occur:

1. Western distinct population segment (DPS) of Steller sea lions
2. Southern DPS of green sturgeon
3. Southern Resident Killer Whale DPS
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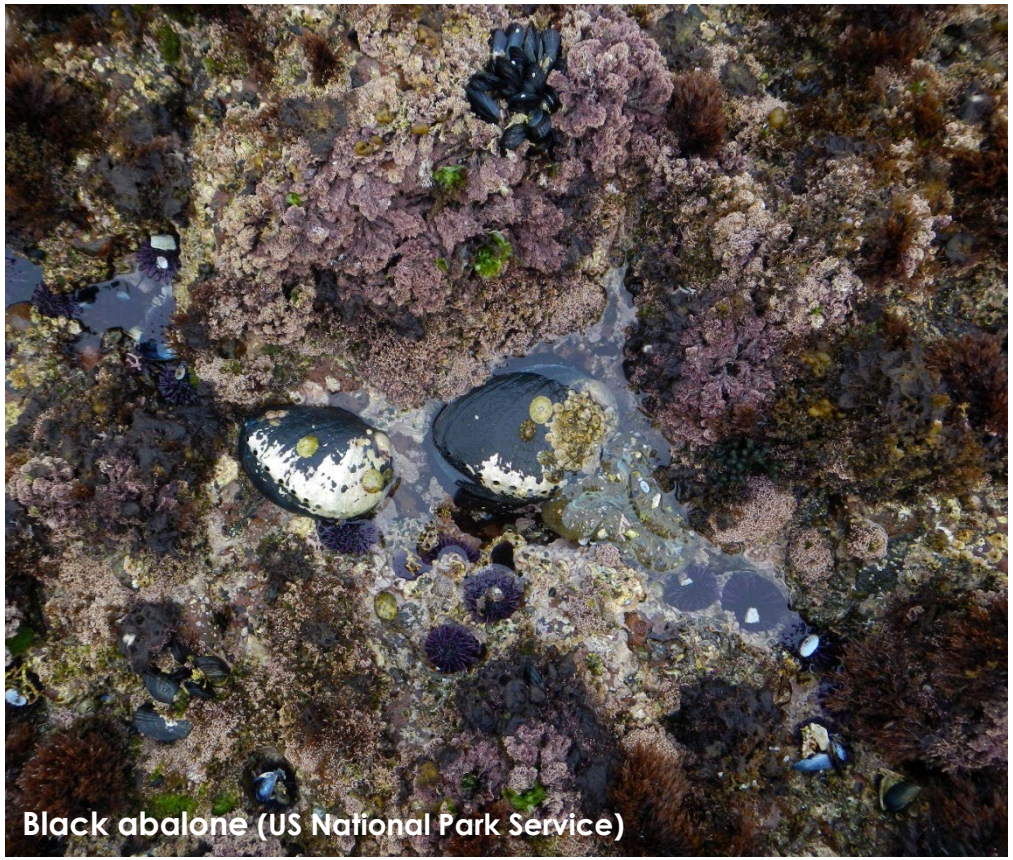
5. Central America DPS and the Mexico DPS of humpback whales
6. **Black abalone**
7. Sacramento River winter-run Evolutionary Significant Unit (ESU) of Chinook salmon



Black abalone (US National Park Service)

Designated critical habitat includes rocky intertidal areas that would be difficult/impossible to repair or replace if damaged or lost.

Careful routing of transmission cables through these areas may be possible.

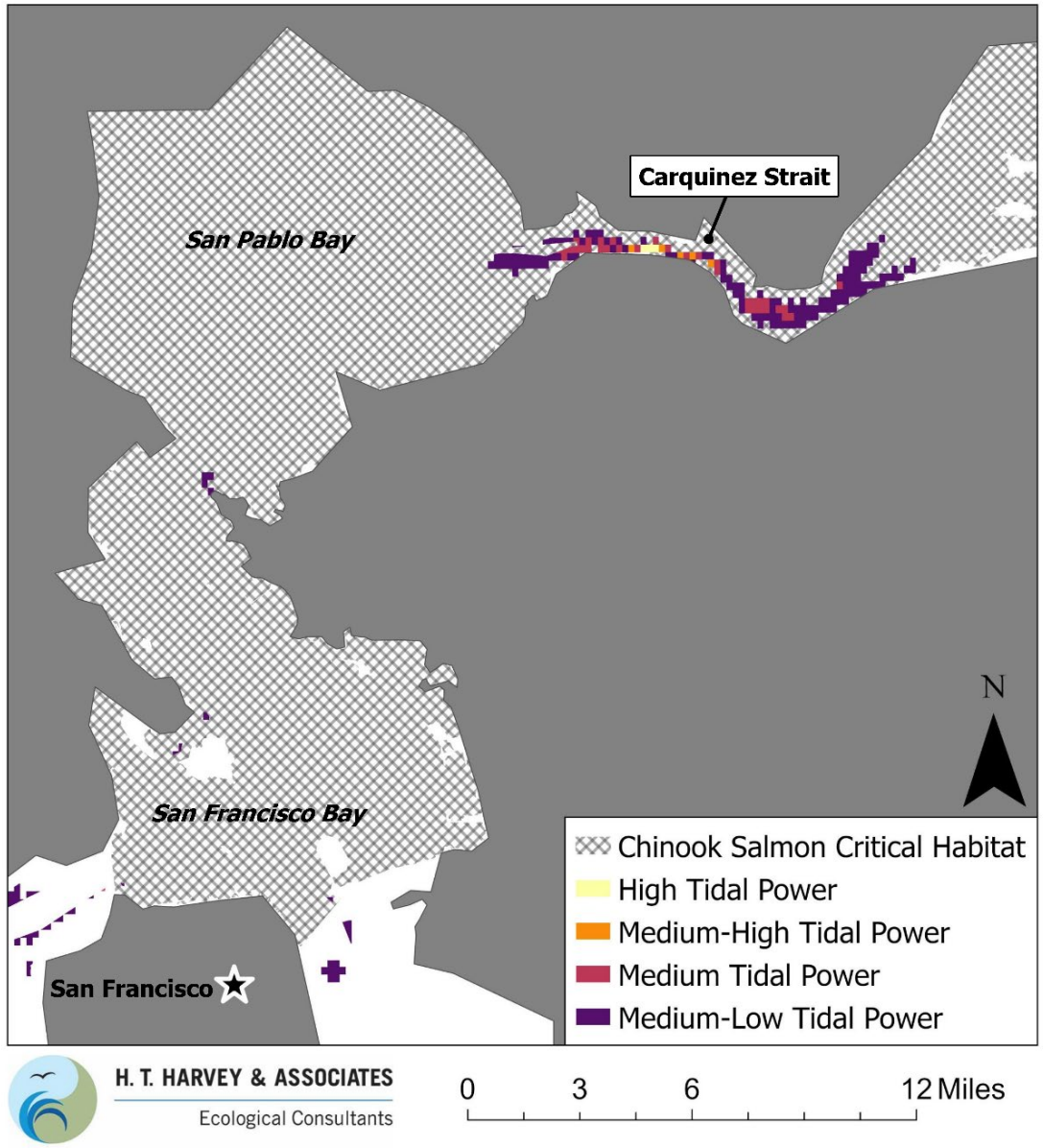
Marine Resources

2) ESA-listed Species & Designated Critical Habitat

ESA-listed species with critical habitats in CA waters where wave or tidal energy projects could occur:

1. Western distinct population segment (DPS) of Steller sea lions
2. Southern DPS of green sturgeon
3. Southern Resident Killer Whale (SRKW) DPS
4. Leatherback sea turtles
5. Central America DPS and the Mexico DPS of humpback whales
6. Black abalone
7. **Sacramento River winter-run Evolutionary Significant Unit (ESU) of Chinook salmon**

Critical habitat for the ESU is within Carquinez Strait, which has the highest potential tidal energy resource for Central California. Development in this area will be difficult since the strait is an important migration corridor.



Marine Resources

ESA Designated Critical Habitat

Proceed with Caution

Development within designated critical habitat areas may require ESA Section 7 consultation with NMFS and/or USFWS to ensure that project activities will not interfere with, adversely modify, or destroy the essential physical and biological features of that habitat.

Adverse effects must be avoided, minimized, or addressed, which could cause permitting delays and increase project costs.

Sacramento Winter-run Chinook salmon (USFWS)

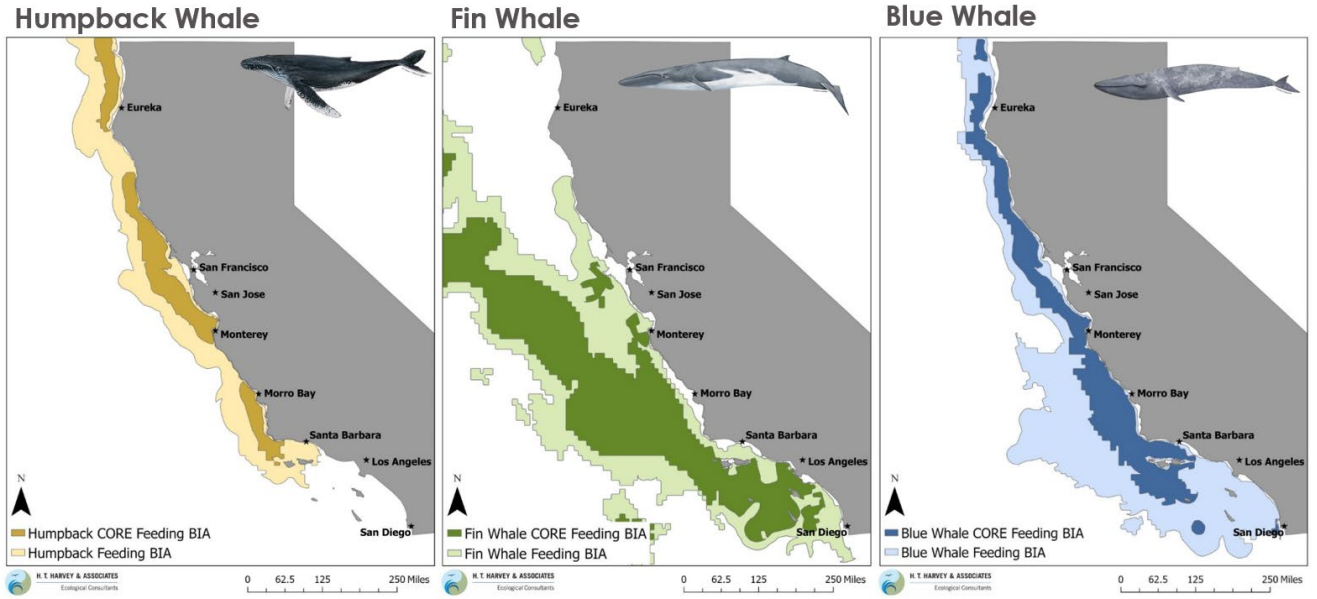
Marine Resources

3) Biologically Important Areas (BIAs) for cetaceans

Biologically important areas (BIAs) for cetaceans (baleen whales, toothed whales, dolphins, and porpoises) do not have any regulations associated with them but rather serve as a summation of the best available science on important feeding areas, migratory routes, and population boundaries for marine spatial planning.

California has several BIAs:

- Feeding BIAs for humpback whales, fin whales, and blue whales
- Migratory and reproductive BIAs for gray whales
- Small and resident population BIAs for Southern Resident killer whales (SRKW) and harbor porpoises



Whale Illustrations from NOAA

Marine Resources

Biologically Important Areas (BIAs) for cetaceans

Proceed with Caution

Cetacean BIAs cover large areas and are sometimes seasonal in nature (i.e., gray whale migration areas).

Potential conflicts with BIAs can be avoided through careful siting and construction windows, along with other mitigation measures.

Gray whale fluke (Photo by E. Escajeda)

Marine Resources

4) Essential fish habitat (EFH), EFH conservation areas, and EFH habitat areas of particular concern (HAPCs)

EFH: areas that are vital for every life stage of federally managed fish species.

EFH conservation areas: (subset of EFH) are closed to specific types of fishing.

HAPCs: Areas within EFH that are especially important or that contain habitat features that are rare, stressed due to development, or especially vulnerable to degradation or a combination thereof; considered high-priority areas for conservation, however, they do not have specific protections or restrictions. Adverse effects should be avoided.

Two HAPCs that could prove challenging for device deployment include kelp canopy and rocky reef HAPCs:

- Kelp stipes in kelp canopies could preclude the deployment of certain devices
- Devices could displace marine life that rely on rocky reefs
- Device anchor(s) could damage sensitive colonizing organisms on rocky substrate in rocky reefs

Marine Resources

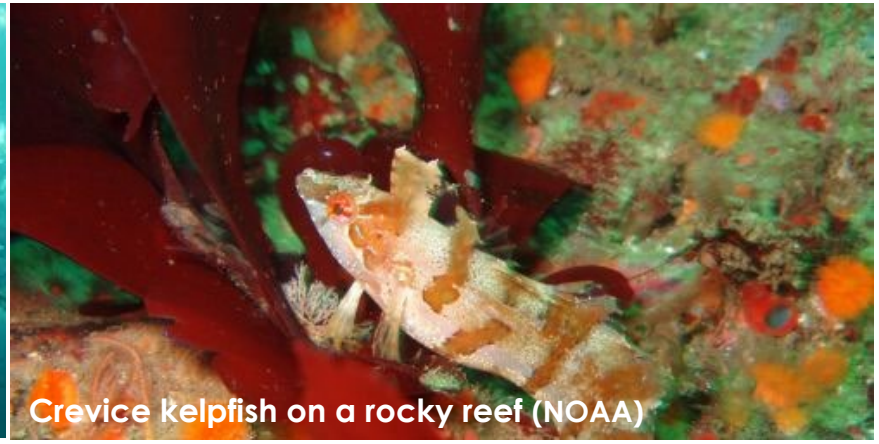
Essential fish habitat (EFH), EFH habitat areas of particular concern (HAPCs), and EFH conservation areas

EFH & EFH Conservation Areas: Proceed with Caution

HAPCs: Avoid

While impacts to EFH can be addressed through permitting and mitigation measures, it is recommended that developers avoid HAPCs when considering where to site wave and tidal energy projects.


Kelp canopy habitat (NOAA)


Crevice kelpfish on a rocky reef (NOAA)

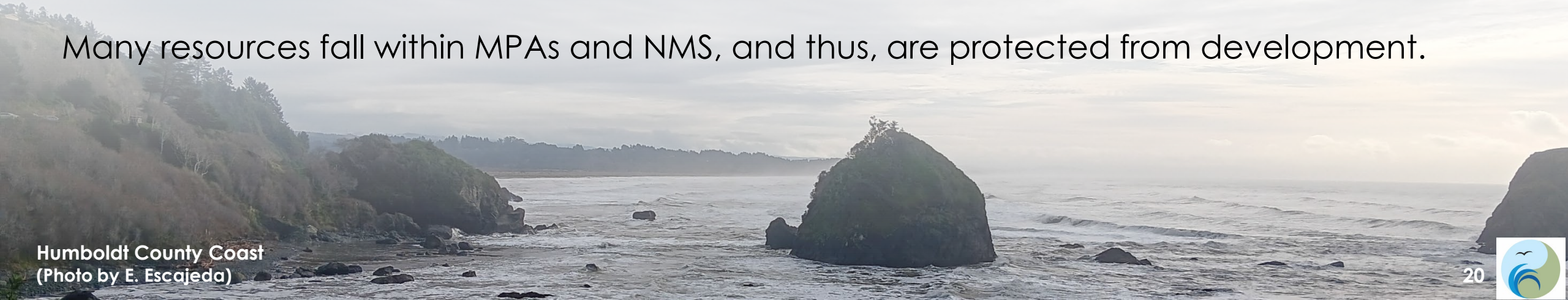
Marine Resources

Cultural Resources: Native American Cultural Sites, Resources, and Viewsheds

Before any siting for wave and tidal development, it will be important to identify areas of cultural importance to California Native American tribes and Indigenous people, including both federally and non-federally recognized Native American tribes within California.

Tribal cultural resources encompass full landscapes, plant and animal species, water, air, and the interconnection of tribal lifeways with the environment. Many cultural resources are not mapped for reasons such as confidentiality, resource constraints, and/or lack of documentation.

Many resources fall within MPAs and NMS, and thus, are protected from development.



Humboldt County Coast
(Photo by E. Escajeda)

Marine Resources

Cultural Resources: Native American Cultural Sites, Resources, and Viewsheds

Direct consultation and communication with tribal communities is required to ensure that deployment sites do not overlap with important areas and that project activities (including site surveys, installation, operations, and maintenance schedules) will not adversely affect resources or interfere with tribal uses.

Potential for deployment of marine renewable energy projects within tribal lands if the project will benefit the tribe.

Trinidad State Beach
(Photo by E. Escajeda)

Marine Resources

Historical Resources: Shipwrecks and Underwater Archaeological Sites

There are more than 1,500 shipwrecks along the California coast, some with exact mapped locations while others are known to have wrecked but their exact location is approximate or unknown.

Many shipwrecks and other archaeological sites are located within NMS and MPAs, and thus, are protected from marine energy development.

Collecting sonar data of the seafloor around a proposed site as well as along the transmission cable pathway is recommended to ensure that the area does not include any undocumented artifacts.

The steamship *Brother Jonathan* which wrecked near Crescent City, CA, in 1865 (Source: Wikipedia)

Marine Resources

Historical Resources: Shipwrecks and Underwater Archaeological Sites

Proceed with Caution

Projects located on submerged lands within 3 nautical miles of the shoreline (i.e., within state waters) would fall within the jurisdiction of the California State Lands Commission (SLC) and would require a tide and submerged lands lease.

The SLC would assess the potential for impacts to shipwrecks and other historical sites/artifacts.

A consultation with the Office of Historic Preservation is also required to ensure that the proposed deployment/installation area does not include a shipwreck or any other archaeological site.

Ocean Infrastructure

Subsea Cables & Pipelines

(dreamstime)

Offshore Oil Platforms

(AFP/Getty Images)

Navigational Buoys

(Getty Images/iStockphoto)

Proceed with Caution

Ocean infrastructure and their cumulative impacts need to be considered when siting marine renewable energy projects.

Offshore Wind Infrastructure

Floating offshore wind turbine and platform (rawpixel.com)

Metocean Buoys

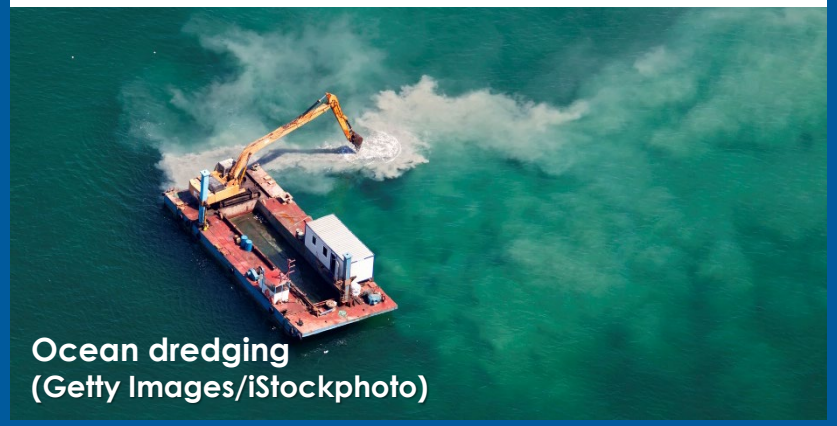
NOAA/NDBC buoy (NOAA)

Ocean Uses

Commercial & Recreational Fishing

Herring Fishing Boat
(H.T. Harvey & Associates)

Ocean Dredging & Disposal Sites



Ocean dredging
(Getty Images/iStockphoto)

Recreational Areas & Tourism

Surfer
(dreamstime)

Military Operations

US Naval Base in San Diego
(Getty Images)

Aquacultural Sites

Cultured Abalone, Goleta, California
(Getty Images)

Commercial Shipping Lanes

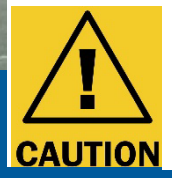
Cargo ships lining up for the Port of Long Beach
(LA Times)

Ocean Uses

Commercial & Recreational Fishing

(Photo by S. Kramer)

Avoid High-Conflict Areas
&



Proceed with Caution in Approved Areas

Commercial and recreational fishing is an important part of California's economy and its coastal communities.

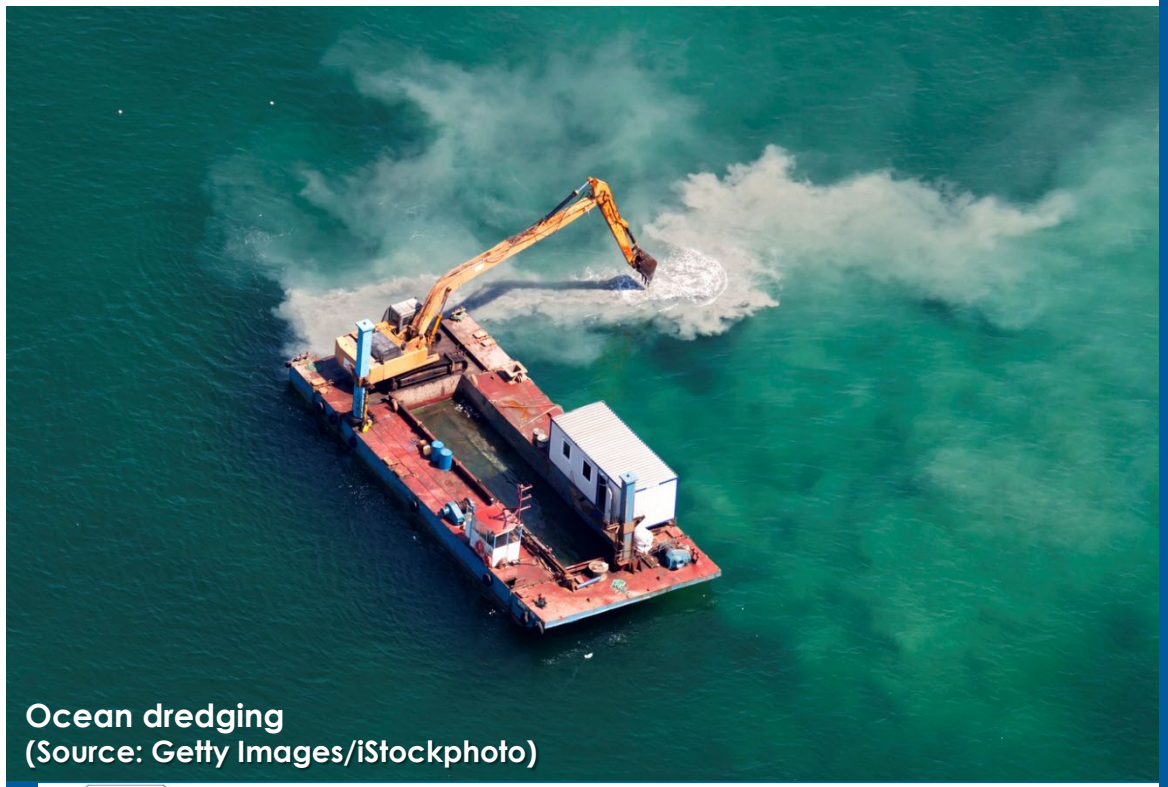
Any future projects should include early coordination with commercial and recreational fisheries to identify high-conflict areas and ways to minimize conflicts, including:

- Fishing exclusion areas around large arrays
- Collaborative agreements with fishers and tribal, state, and federal fisheries managers
- Compensation plans and communication protocols

With proper siting and mitigation measures, conflicts can be avoided or minimized.

Ocean Uses

Ocean Dredging & Disposal Sites



Ocean dredging
(Source: Getty Images/iStockphoto)

Avoid Regularly Dredged Areas & Active Borrow/Disposal Sites

Dredging operations could damage energy devices, making these areas unsafe for moored devices.

Routinely dredged areas — e.g., entrance and navigational channels — are "no go" zones for moored devices and transmission cables (although WECs built into existing structures such as jetties may be feasible).

Coordination with U.S. Army Corps of Engineers or local port authorities is recommended.

Offshore borrow sites dredged for sediment and designated ocean disposal sites are considered "no go" zones. Disposal/Borrow sites could be used in the future if they are retired (depending on the dumped material).

Ocean Uses

Commercial Shipping Lanes

Cargo ships lining up for the Port of Long Beach
(Source: LA Times)

Avoid Commercial Shipping Lanes and Safety Fairways

Anchoring or stalling a vessel within a shipping lane or ferry route is dangerous, making installation and maintenance of a device difficult.

Need to avoid creating any navigational hazards for ships traveling through the lane.

Ship safety fairways prohibit any fixed structures within their boundaries (no moored devices).

Any changes to shipping lanes or safety fairways require negotiations with the U.S. Coast Guard and could delay permitting.

Given these challenges, shipping lanes, safety fairways, and ferry routes are considered "no go" zones for most devices.

Ocean Uses

Military Operations

US Naval Base in San Diego
(Source: Getty Images)

Proceed with Caution

The Department of Defense (DoD) conducts training, testing, and other operations off the California coast, which could conflict with wave/tidal energy development.

However, marine renewable energy could be useful for the DoD since these systems could provide decentralized and sustainable power.

To determine if a project would be compatible with DoD military operations, developers would need to submit project information to the DoD Siting Clearinghouse for review, which would then identify any challenges and operational impacts.

Ocean Uses

Aquaculture

Cultured Abalone, Goleta, California
(Source: Getty Images)

Proceed with Caution

There is growing interest in using renewable energy for powering aquaculture.

The colocation of energy systems with aquaculture could provide developers with the opportunity to test their devices.

Given the potential for colocation of marine renewable energy, current and future aquaculture sites are considered technology-dependent constraints for energy development.

Ocean Uses

Recreational Areas & Tourism

Surfer
(Source: dreamstime)

Proceed with Caution

Devices, transmission cables, or both could be installed near any state beaches, county beaches, or recreational areas that do not fall within the California MPA system.

However, the device type(s) and array size of the project may be limited to avoid conflicts with recreational use of the areas, such as sailing, wind surfing, kayaking, swimming, and surfing.

Potential effects of the devices and array size on recreational areas will need to be evaluated before installing a project.


Photo by E. Escajeda

Sea Space Conflict Maps

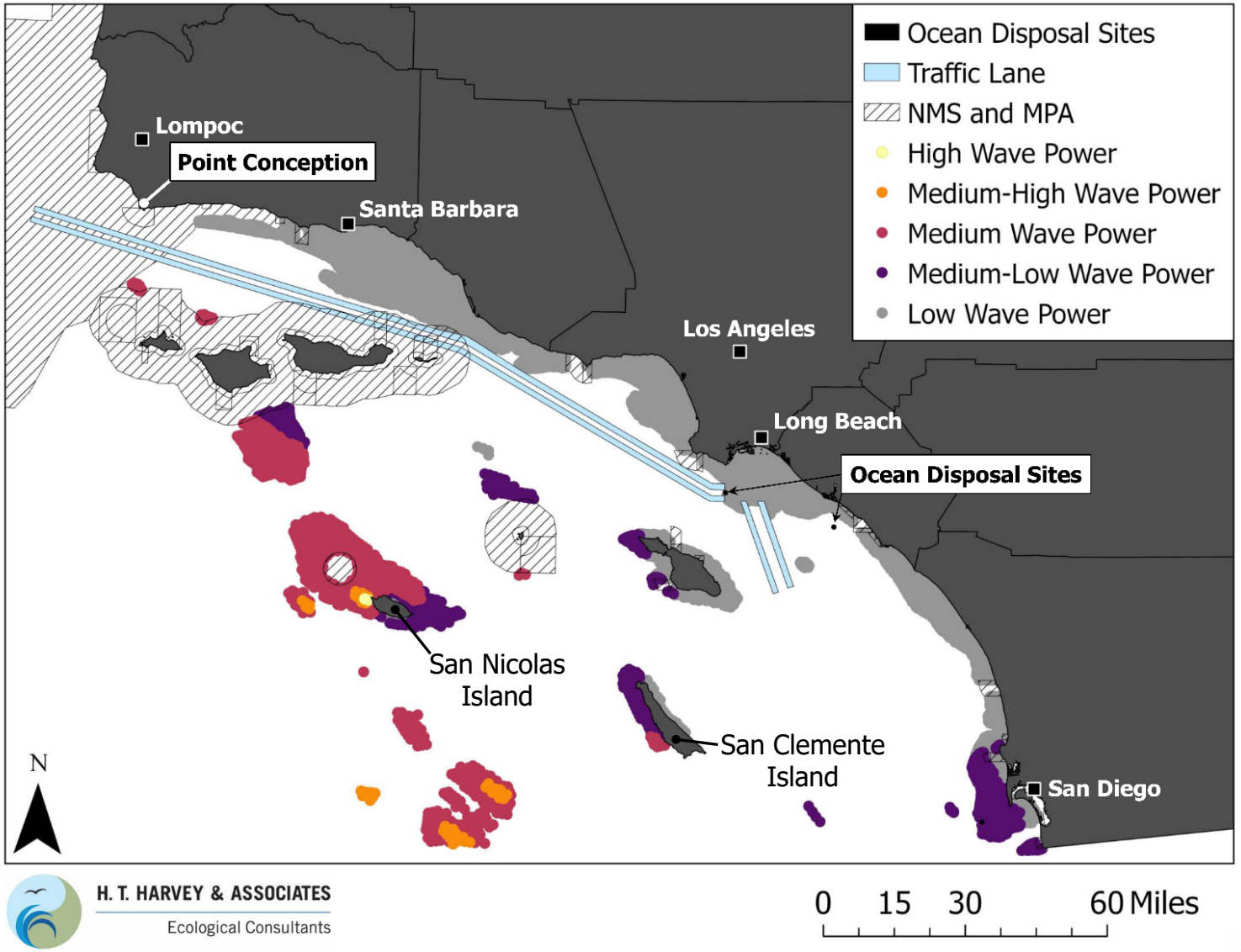
Potential deployment sites for wave and tidal energy projects identified in Chapter 1 were mapped along with the “no go” zones identified in the present chapter. Any potential deployment points/polygons for wave/tidal energy developments that fell within the “no go” zones were removed.

Wave Energy	Tidal Energy

Wave Energy: Southern California "No Go" Zones

The majority of the potential wave energy deployment sites in Southern California had low wave power (nearshore areas).

Some medium-low or higher power sites offshore near the Channel Islands (e.g., San Nicolas Island and San Clemente Island).

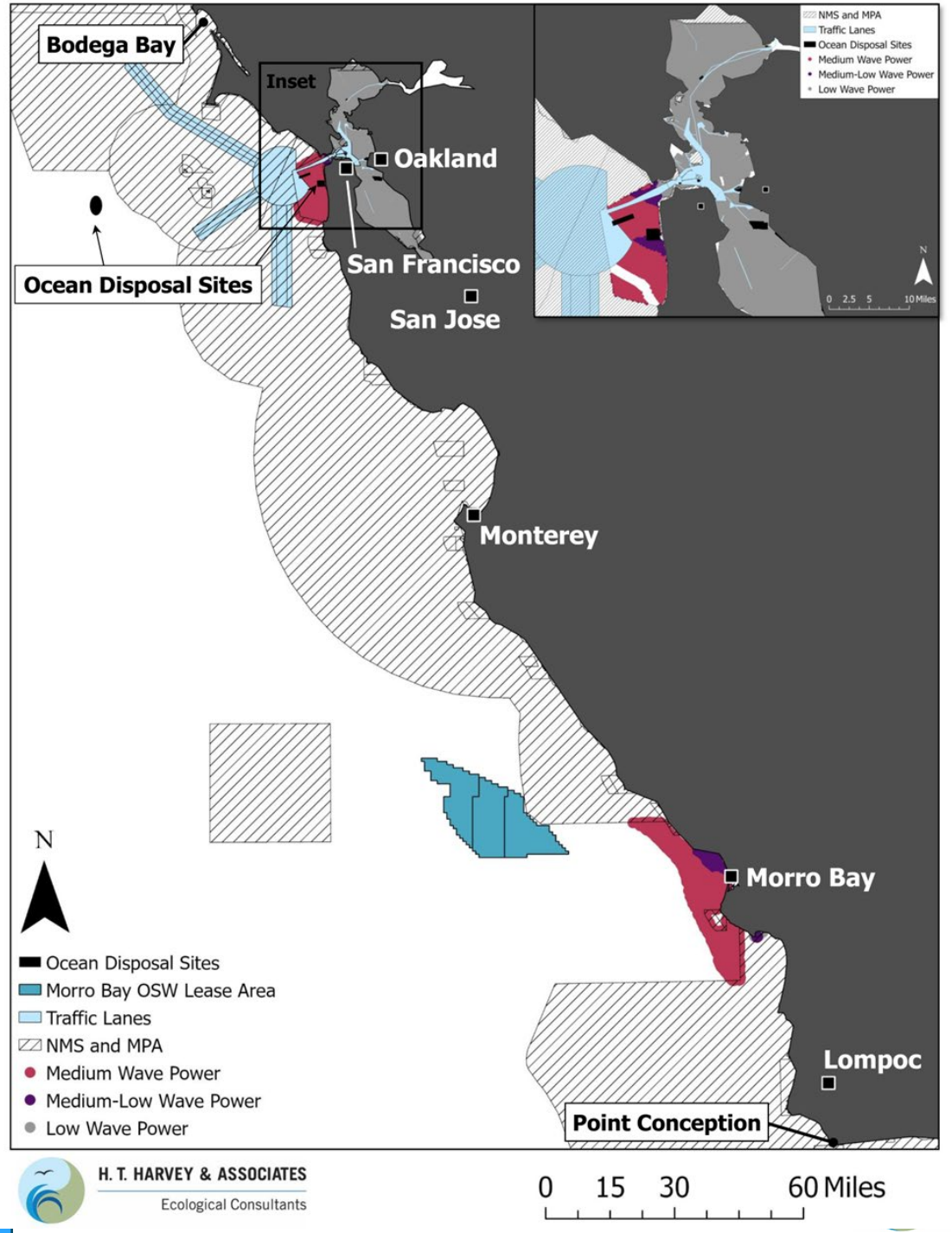


Wave Energy:
Central California "No Go" Zones

The Central California region only had sites with low to medium potential wave power.

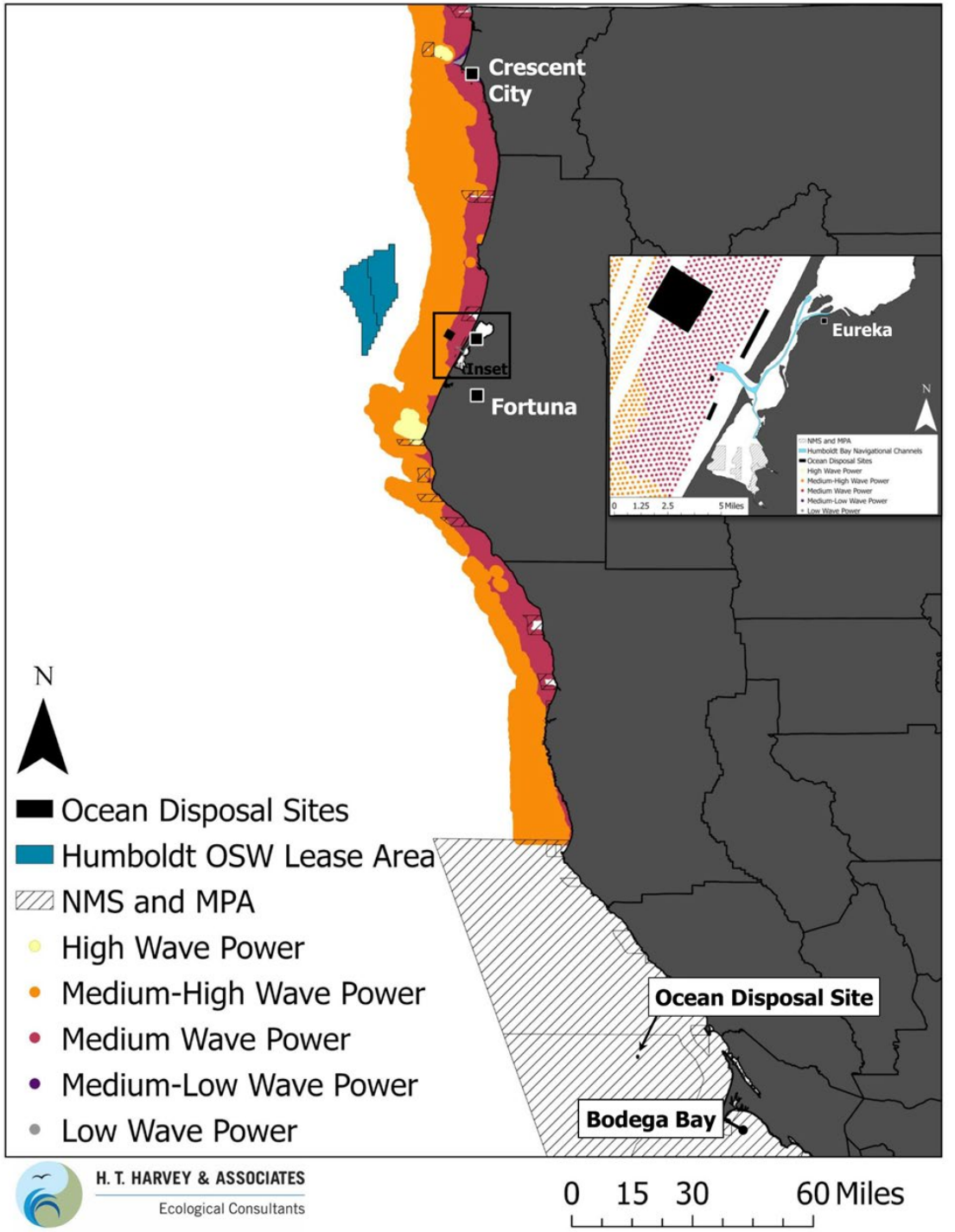
Few areas remaining after the NMS/MPA filter was applied:

- San Francisco Bay area
- Morro Bay area



Wave Energy:
Northern California "No Go" Zones

Good number of potential wave energy deployment sites available in the Northern California region, though more site-specific analysis is recommended.

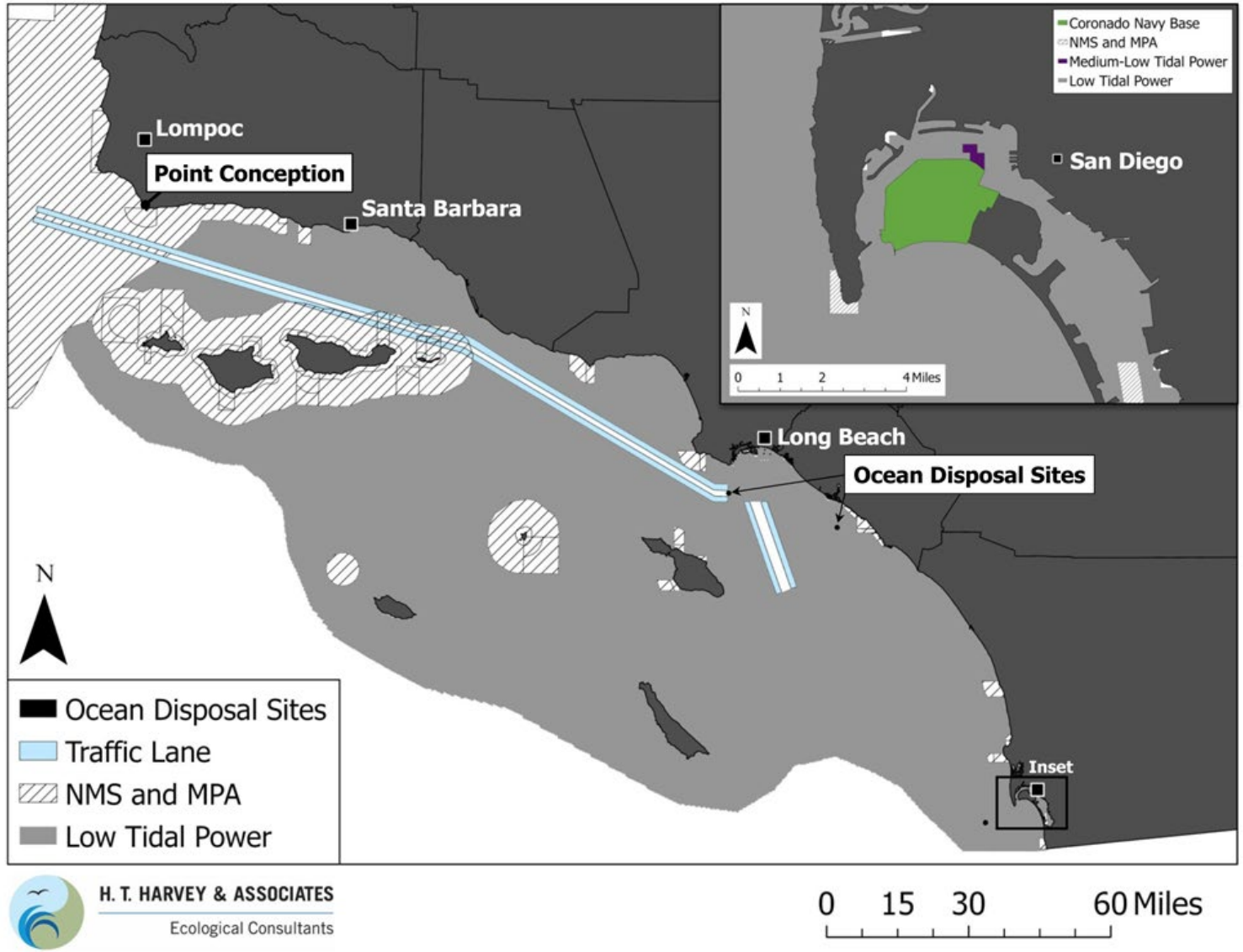


Tidal Energy: Southern California "No Go" Zones

Only one area with medium-low tidal power available.

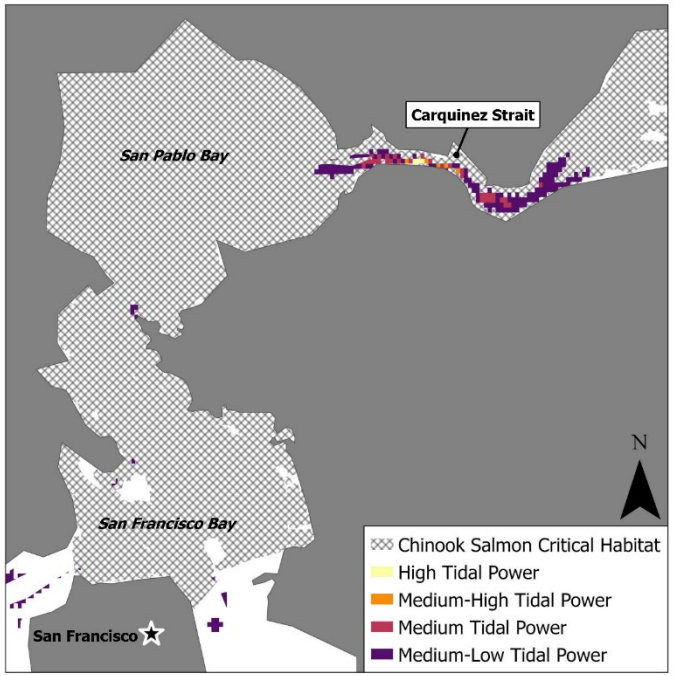
Area is offshore of the Coronado Naval Base (inset map).

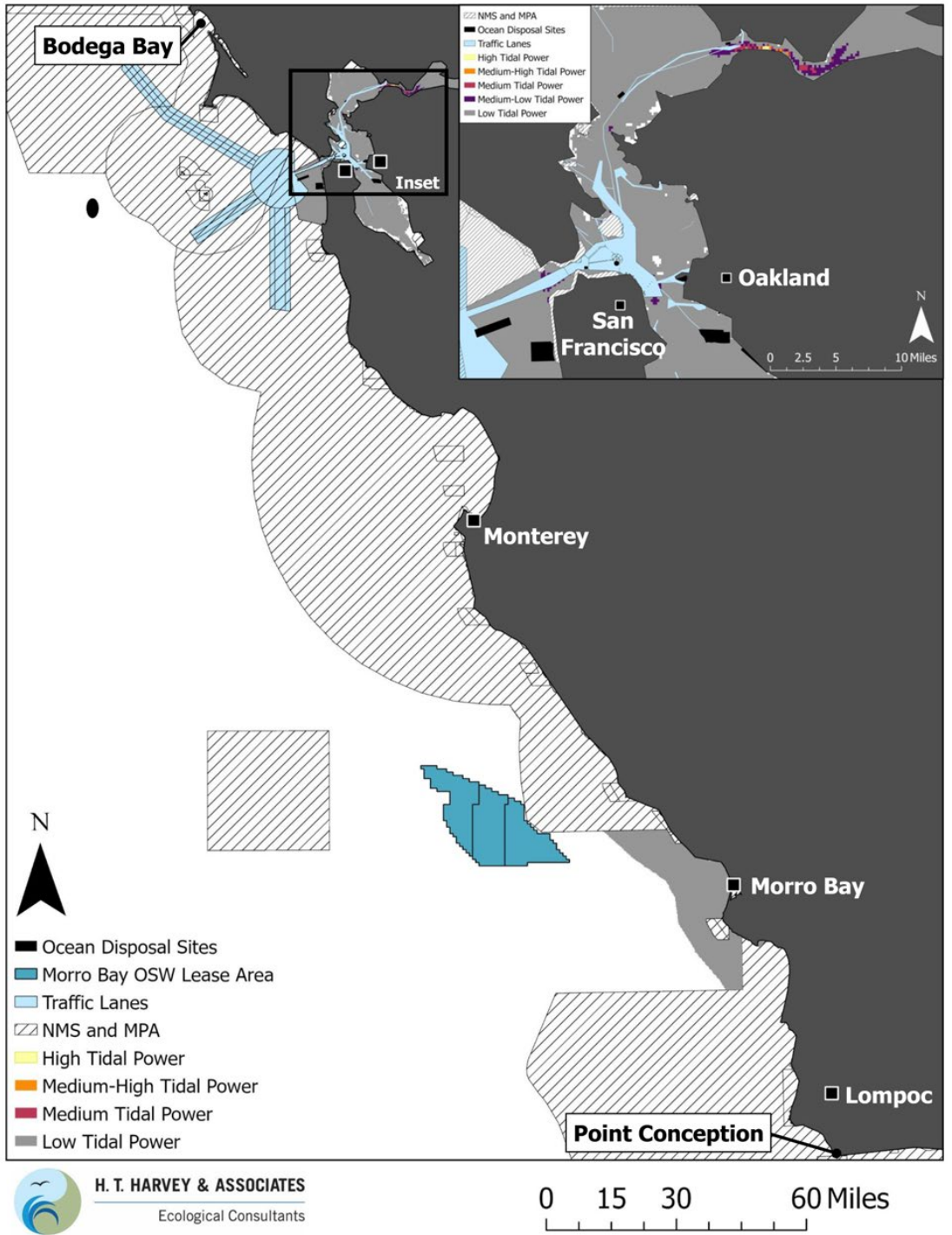
Coordination with the DoD is recommended for developments in this area.



Tidal Energy:
Central California "No Go" Zones

Only one area with medium-low to high tidal power (Carquinez Strait, within San Francisco Bay) and the area overlaps with critical habitat for endangered Chinook salmon.





Tidal Energy:
Northern California "No Go" Zones

Two areas with medium-low or higher tidal power: entrance channel to Humboldt Bay and the Eel River.

Routine dredging in the entrance channel to Humbolt Bay may preclude development of tidal energy in this area.

Fishing in Eel River may make development in this area difficult.

Energy resources are low elsewhere.

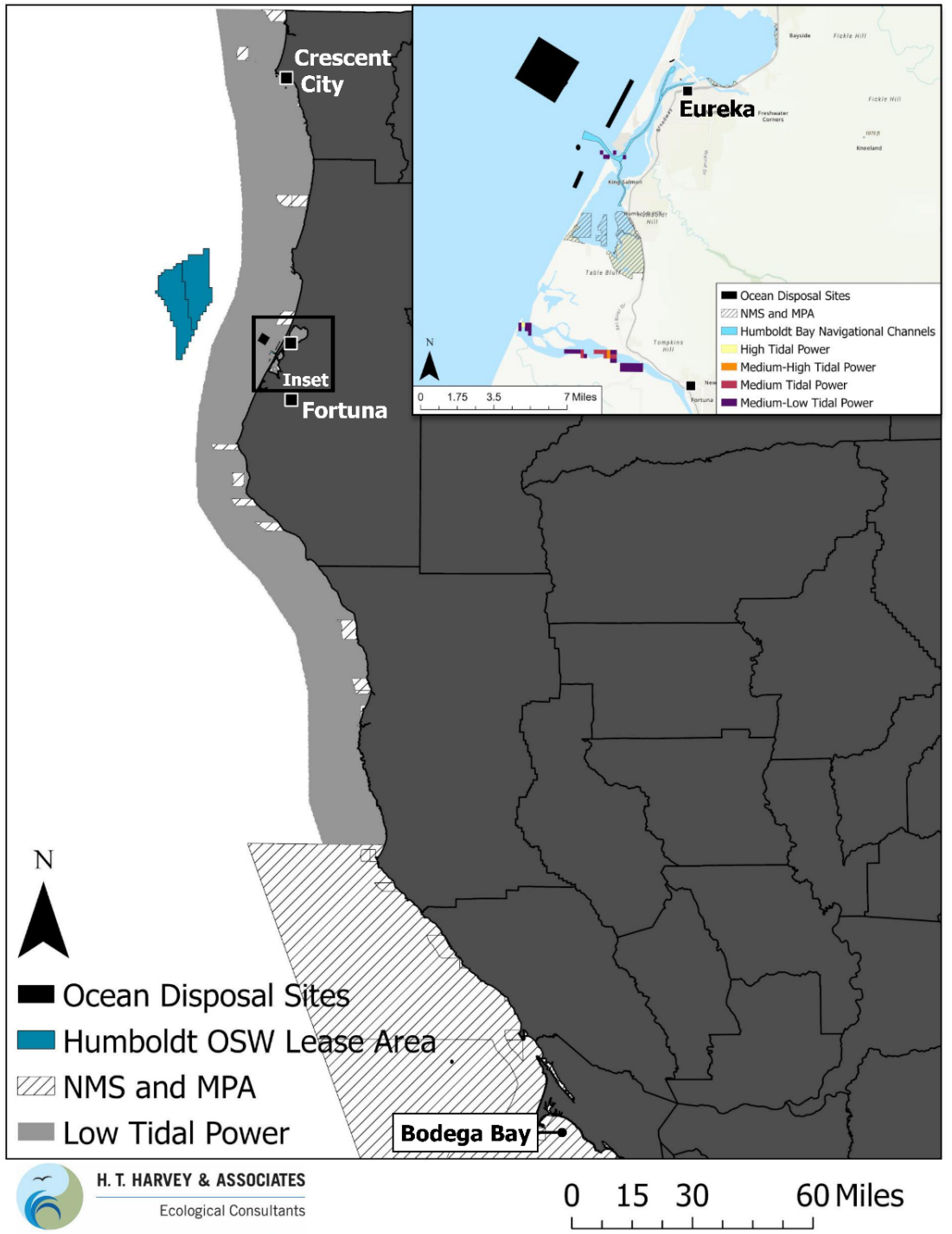


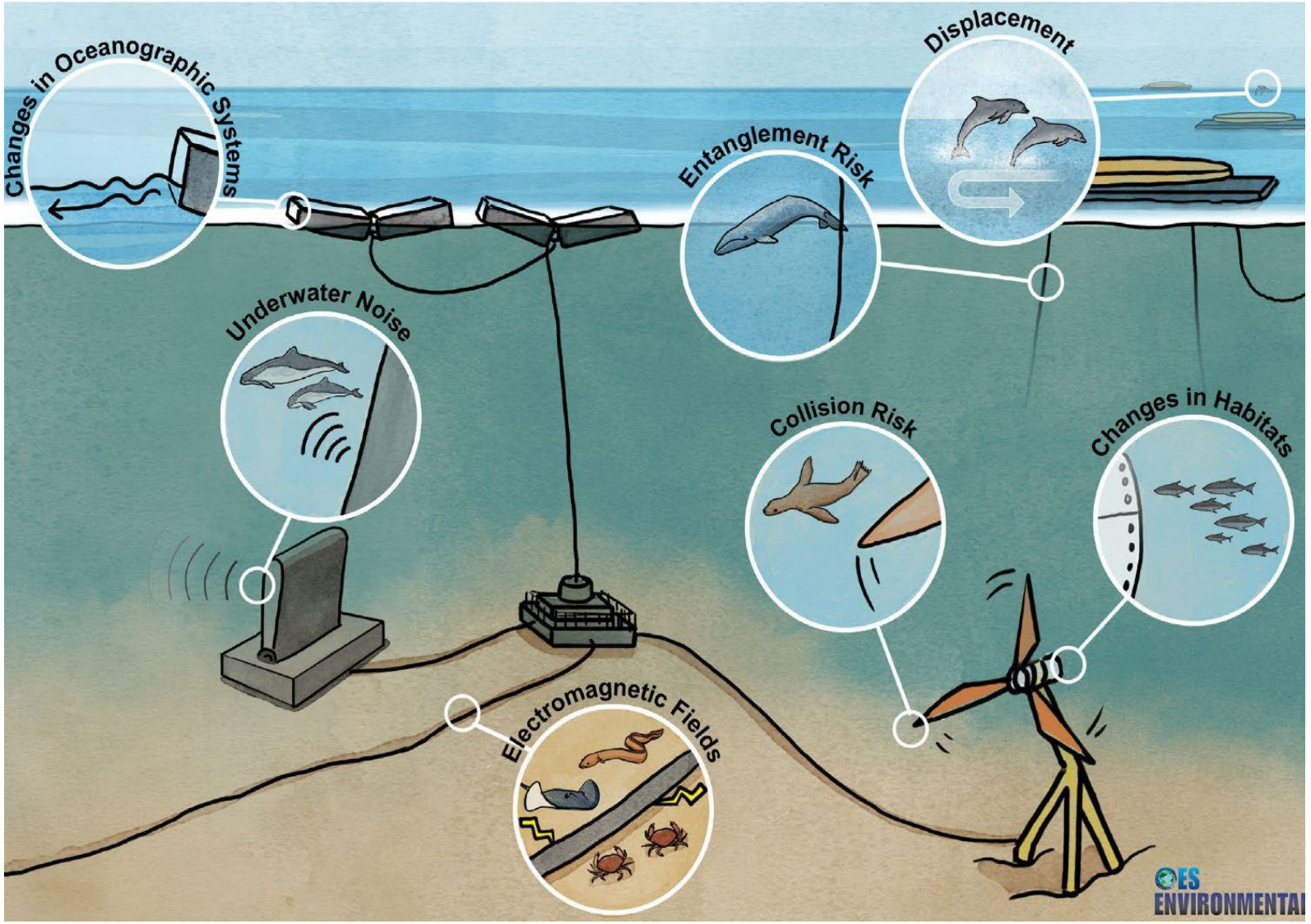
Photo by L. Terrill

Chapter 5 Goals

Identify protective measures that would avoid, minimize, and mitigate any potential adverse environmental impacts and conflicts with other ocean uses.

Environmental Interactions

1. Collision, entrainment, impingement, and entrapment
2. Underwater noise
3. Electromagnetic fields (EMFs)
4. Changes in habitats
5. Entanglement
6. Changes in oceanographic systems
7. Displacement
8. Water quality



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

Protective Measures

Sources:

1) OES-Environmental State of the Science 2024 report

   https://tethys.pnnl.gov/publications/state-of-the-science-2024

2) The Marine Energy Environmental Toolkit

   https://marineenergy.app/

3) The Management Measures Tool for Marine Energy

   https://tethys.pnnl.gov/management-measures

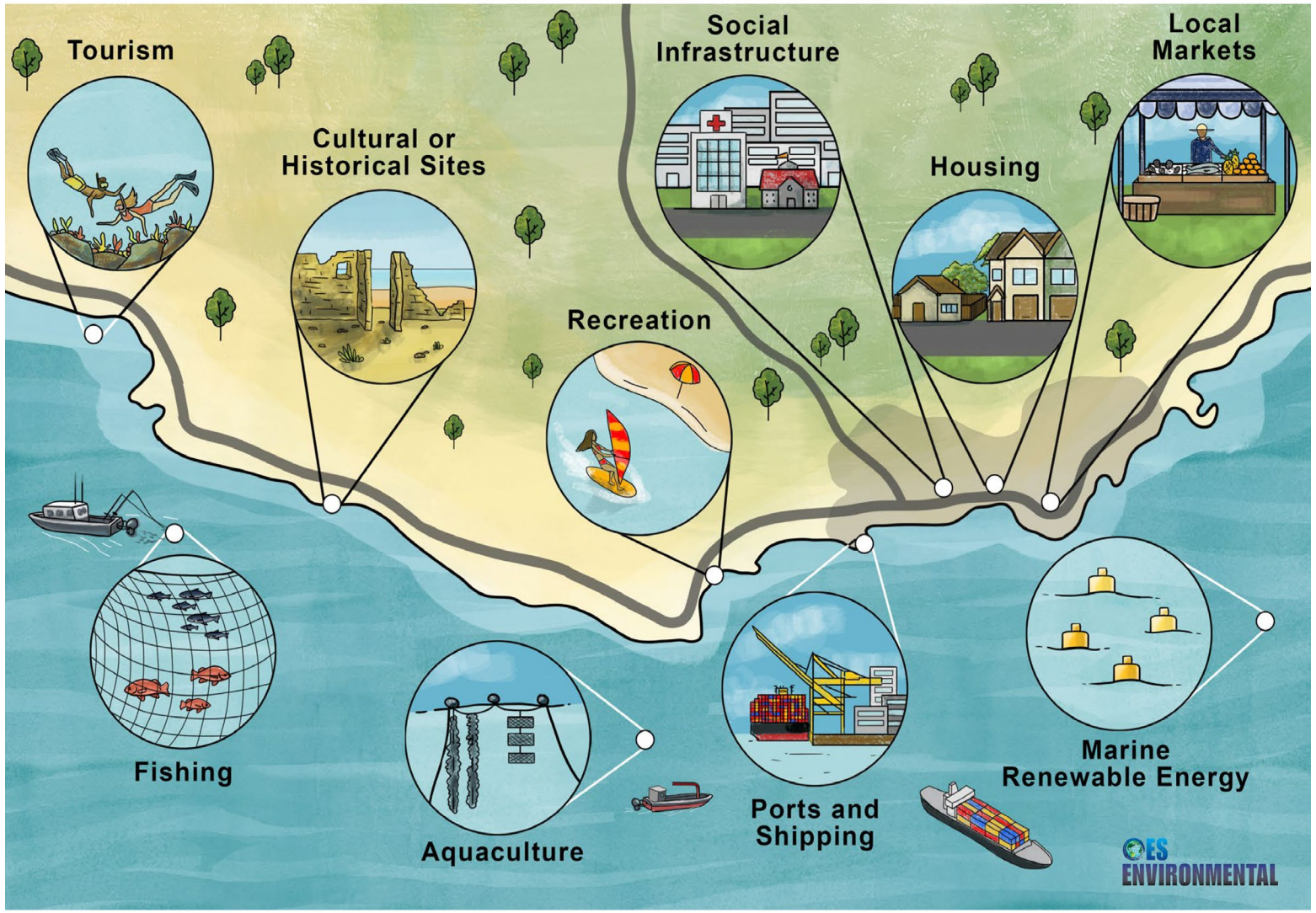
Project Phase	Stressor	Receptor	Management Measure	Advantages	Challenges	Project Documents
Operation & Maintenance	**Underwater noise** The potential effects from underwater noise generated by wave and tidal energy converters.	**Marine Mammals**	**Monitoring** Measure noise generated by device(s) during operation to better understand the potential effects on sensitive species.	Measured noise levels can be correlated with threshold values of relevant species and baseline noise levels of the site to determine impact and need for adaptive management measures.	Can be complex and costly to undertake this type of monitoring in high energy environments. Data and analysis have requirement for acoustic experts.	**SAE Renewables 2011, Aquamarine Power Ltd 2011, Orbital Marine Power 2014, Minesto 2016, Xodus AURORA 2010, European Marine Energy Centre (EMEC) 2019, ScottishPower Renewables 2010, Davison and Mallows 2005, McGrath 2013, Royal Haskoning 2012, Orbital Marine Power 2018, Atlantis Resources Corporation at EMEC, Oyster 800 at EMEC, Minesto Holyhead Deep - Non-grid connected DG500, HS1000 at EMEC, EMEC Billia Croo Grid-Connected Wave Test Site, Sound of Islay Demonstration Tidal Array, Strangford Lough - MCT (SeaGen), Fair Head Tidal Array, Oyster 800 at EMEC, Orbital Marine Power O2 at EMEC**

(OES-Environmental State of the Science 2024)

Ocean Uses

Impacts to:

- Viewsheds
- Recreation
- Aquaculture
- Commercial and recreational fishing
- Navigation
- Cultural resources
- Tribal cultural landscapes and uses



Freeman, M. C., and Rose, D. J. 2024. Social and Economic Effects of Marine Renewable Energy. 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. 104-142). doi:10.2172/2438591

Photo by L. Terrill

Chapter 6 Goals

Monitoring and adaptive management strategies can assist permitting by addressing potential interactions where uncertainty is high and risks to individuals, populations, or important/sensitive habitats are not well understood.

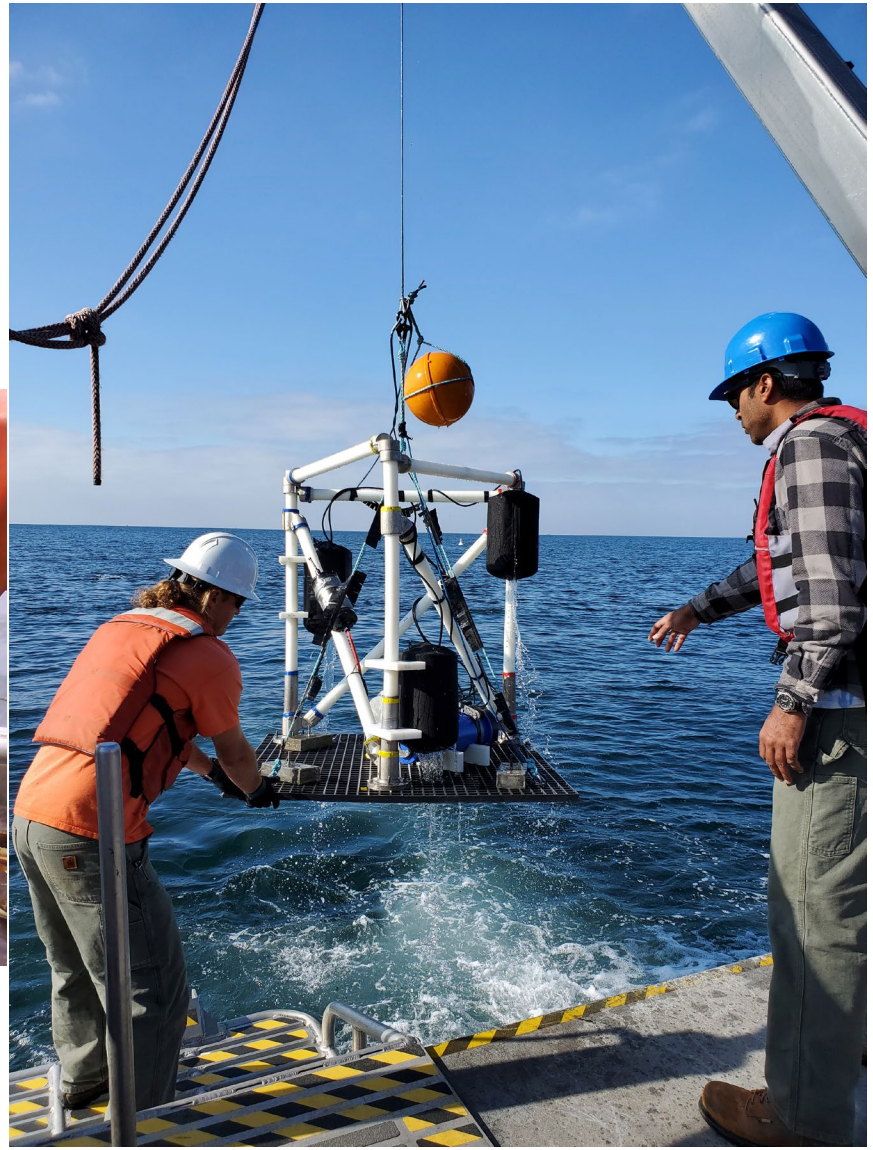
Identify knowledge gaps and studies

Evaluate baseline and identify high-risk, high-uncertainty interactions

Determine critical information gaps

Develop targeted studies to address data gaps and identify thresholds of concern

Dungeness crab movement study, Reedsport, OR



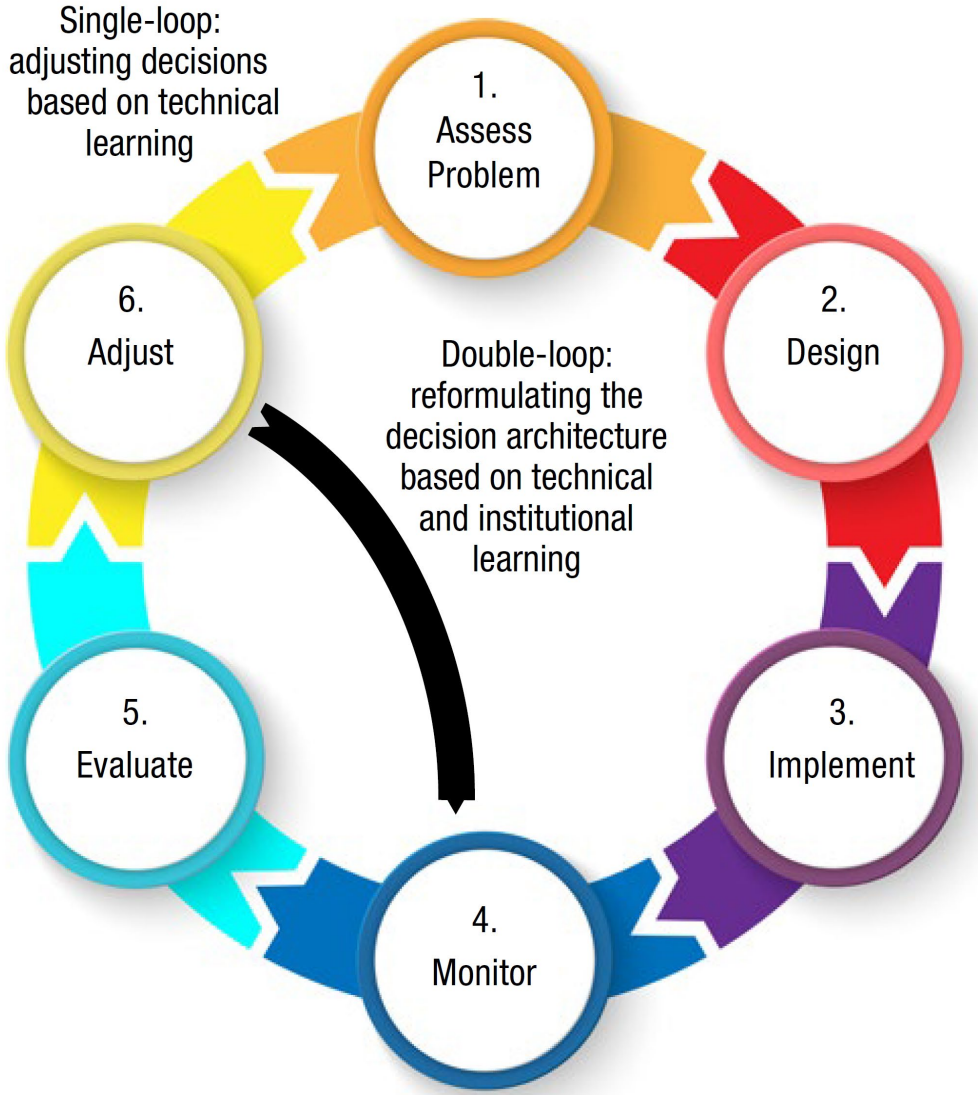
Integral Consulting NoiseSpotter Acoustic Study, CalWave, La Jolla CA

Decision-making

Develop communication protocols for providing study findings to adaptive management decision-makers in a timely manner

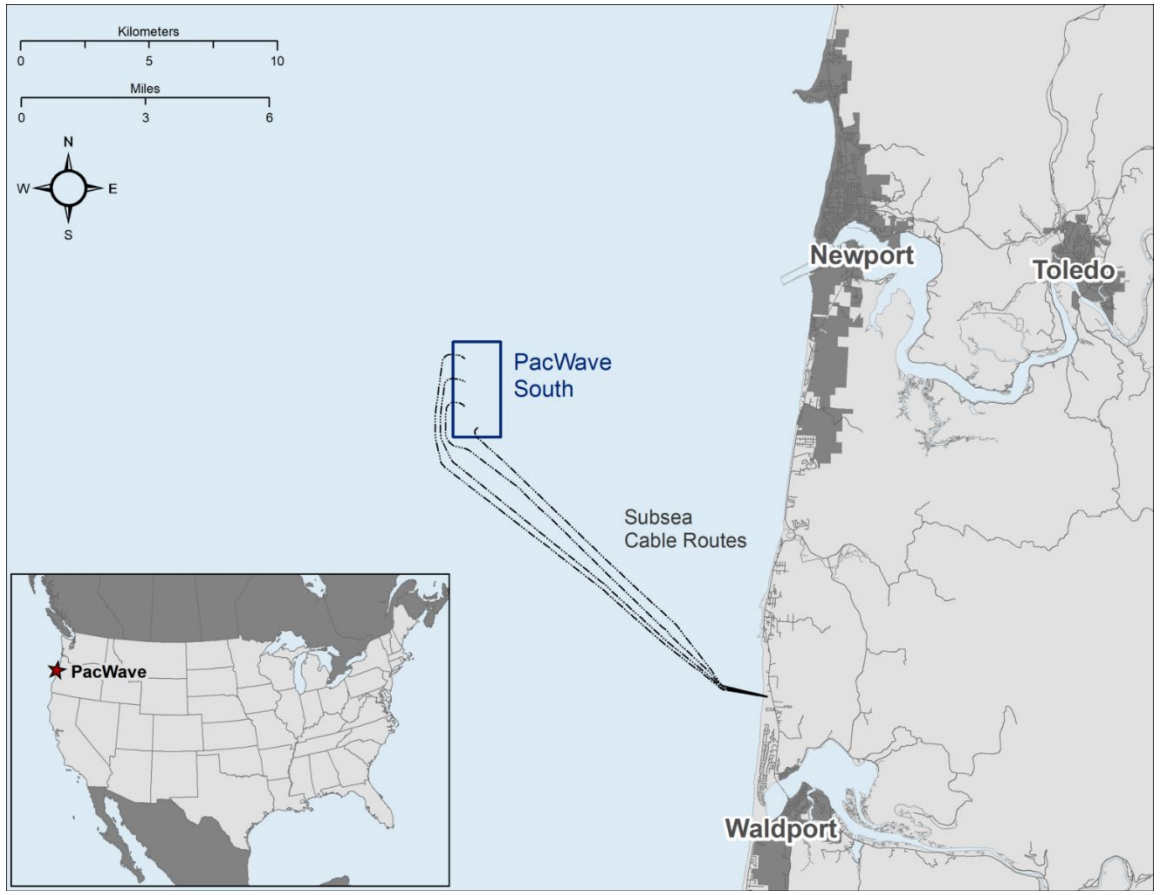
Identify protection, mitigation, and enhancement measures that provide a clear path for decision-making

Agree on monitoring timelines and mileposts (for example, monitor for one year and then re-evaluate)



Le Lièvre, C. 2020. Adaptive Management Related to Maritime Renewable Energy. In A.E. Copping and L.G. Hemery (Eds.), OES-Environmental 2020 State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World. Report for Ocean Energy Systems (OES). (pp. 242-261). doi:10.2172/1633206

Case Study: Oregon State University's PacWave South, Newport Oregon



Concern	Risk	Uncertainty	Outcome
EMFs	High	High	Monitoring Plans
Benthic habitat impacts	High	High	
Acoustic emissions	High	High	
Entanglement/ collision	High	Moderate	Specific mitigation
Dynamic positioning vessels	High	Low	
Pinniped haul-outs	Low	High	
Bird/Bat impacts	Low	High	
Other: Vessels, cable lay	Low	Low	Best management Practices

Freeman, M.C. R. O'Neil, L. Garavelli, D. Hellin, J. Klure. Case study on the novel permitting and authorization of PacWave South, a US grid-connected wave energy test facility: Development, challenges, and insights, Energy Policy, Volume 168, 2022, 113141, https://doi.org/10.1016/j.enpol.2022.113141.

Case Study: Ocean Power Technologies (OPT) Reedsport Wave Park, Oregon

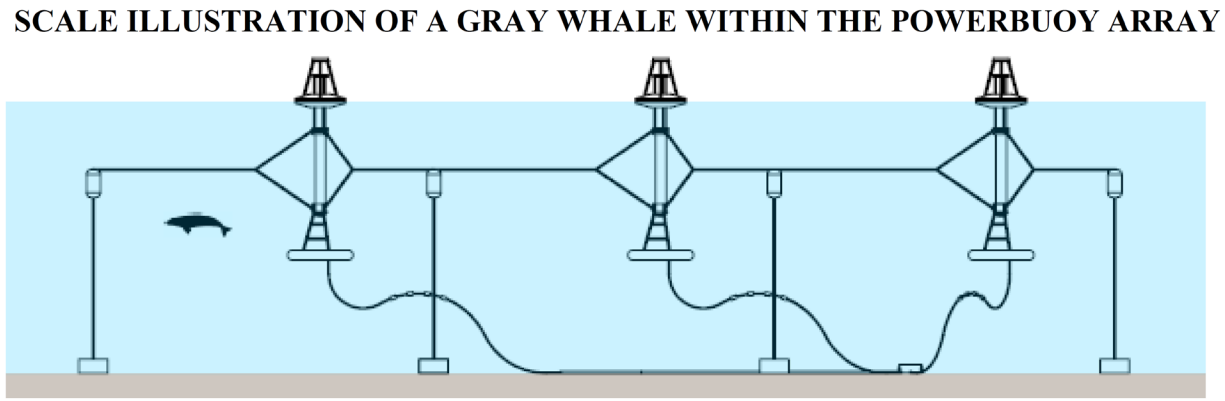
Project is the first of its kind on the west coast

Lack of understanding of potential impacts

Studies/Adaptive Management

- Pinnipeds and cetaceans
- EMFs
- Fish,
- Seabirds
- Changes in waves, currents, and sediment transport

Cetaceans



Scaled full size adult gray whale 45 feet (NMFS 2007)

Interactions:

- Collision/entanglement during operation
- Underwater noise/vibration
- Change in migration route within area of the project

Studies:

- Phase 1 Baseline Characterization: behavior
- Phase 2 Acoustic Emissions Characterization
- Phase 3 Post-Deployment Monitoring: behavior, derelict fishing gear

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Ecological Consultants

50 years of field notes, exploration, and excellence

Thank you!

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