PNNL-36138

Preliminary Workforce Development and Environmental and Co-use Management Plans for a Floating Offshore Wind Platform

FLOWIN Prize Phase II Technical Assistance for PelaStar, LLC (CRADA #609)

June 2024

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Cooperative Research and Development Agreement (CRADA) Final Report

Report Date: July 2024

In accordance with Requirements set forth in the terms of the CRADA, this document is the CRADA Final Report, including a list of Subject Inventions, to be provided to PNNL Information Release who will forward to the DOE Office of Scientific and Technical Information as part of the commitment to the public to demonstrate results of federally funded research. **PNNL acknowledges that the CRADA parties have been involved in the preparation of the report or reviewed the report.**

Parties to the Agreement:

Battelle Memorial Institute, as Management and Operator Contractor for the Pacific Northwest National Laboratory, under its DOE M&O Contract No. DE-AC05-76RLO1830

AND

Glosten, Inc.

CRADA number: 609

CRADA Title: FLOWIN Prize Voucher – Glosten (Part 2)

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	Funding Amounts			
CRADA Parties	**DOE Funding**	**Funds-In**	***In-kind**	**Total**
Participant(s)			$10,000	$10,000
DOE Funding to PNNL	$75,000	N/A	N/A	$75,000
Total of all Contributions	$75,000		$10,000	$85,000

Provide a list of publications, conference papers, or other public releases of results, developed under this CRADA:

No public release of results or publications developed under this CRADA.

Provide a detailed list of all subject inventions, to include patent applications, copyrights, and trademarks:

No subject inventions were generated under this CRADA.

Contents

Executive Summary

Pacific Northwest National Laboratory (PNNL) provided technical assistance to Glosten, Inc. and its affiliate, PelaStar, LLC to advance the development of their floating offshore wind (FOSW) platform. PNNL provided guidance and assessment in two areas that are important to address in the development of FOSW platforms: (1) workforce development and (2) environmental impacts and ocean co-use considerations. This work was funded by the U.S. Department of Energy's (DOE) Wind Energy Technologies Office (WETO) through Phase 2 of the FLoating Offshore Wind ReadINess (FLOWIN) Prize. **It should be noted that the Plans presented in this report are specific to the PelaStar tension-leg platform (TLP) and may not be applicable to all FOSW platforms.**

Workforce development and environmental/co-use impacts are highly dependent on the geographical region in which activities take place. At the request of PelaStar, PNNL focused on two regions where development may take place: the Gulf of Maine and Northern California.

PNNL generated a preliminary Workforce Development Plan for PelaStar, which includes estimated job numbers and skillsets required to establish a workforce to manufacture, install, and operate their platform as part of FOSW projects. The Plan offers methods to increase diversity, equity, and inclusion practices when developing a new workforce and includes colleges and training centers for potential recruitment. Both positive and negative impacts to communities are evaluated, with potential mitigation strategies for reducing negative impacts. The structure of Community Benefit Agreements and Project Labor Agreements are discussed, noting the limitations of the role of a platform manufacturer versus the offshore wind developer.

PNNL also drafted a preliminary Environmental and Co-Use Management Plan that serves as a guide to preparing an environmental assessment related to the installation and operation of PelaStar's unique TLP design, including its potential ecological, socioeconomic, and emissions impacts. The Plan summarizes information on relevant regulatory requirements, potential impact producing factors, monitoring and mitigation measures, and physical and biological resources in the Gulf of Maine and Northern California. One of the primary perceived benefits of the PelaStar TLP is its reduced footprint due to its tensioned tendons versus catenary or taut moorings, but more research must be done as there are no studies on PelaStar's TLP system to-date. The section also highlights ocean co-use considerations for PelaStar's TLP system, specifically for fisheries, including existing perspectives, methods, examples, and limitations.

The PNNL team established through this preliminary work and review of available literature and resources that there is not yet much research or planning around FOSW. With FOSW being a new industry, many of the findings and planning are adapted from fixed bottom offshore wind, which itself is only just taking off in the United States. More research is needed to establish best practices for workforce development and to assess environmental and ocean co-use impacts and mitigation approaches.

1.0 Introduction

Pacific Northwest National Laboratory (PNNL) provided technical assistance to Glosten, Inc. and its affiliate, PelaStar, LLC for to advance the development of their floating offshore wind (FOSW) platform. PNNL provided guidance and assessment in two areas that are important to address in the development of FOSW platforms: (1) workforce development and (2) environmental impacts and ocean co-use considerations. This work was funded by the U.S. Department of Energy's (DOE) Wind Energy Technologies Office (WETO) through Phase 2 of the FLoating Offshore Wind ReadINess (FLOWIN) Prize.

This summary report compiles and summarizes the findings of the project, which were provided to PelaStar via separate targeted reports, resource and reference lists, and discussion in project meetings. This report excludes any information protected under the nondisclosure agreement between PNNL and PelaStar, including details and drawings of the PelaStar platform design.

The PelaStar floating platform is a tension leg platform (TLP) comprising of a central hull with ballast, tension legs, and tendons that are taught down to anchors on the seabed. The considerations in this report address the manufacture, installation, and operation of the floating platform and its associated components. At the request of PelaStar, PNNL focused on two regions where FOSW development is likely to take place: the Gulf of Maine and Northern California. **It should be noted that the Plans presented in this report are specific to the PelaStar TLP and may not be applicable to all FOSW platforms.**

Section 2 of the summary report addresses the topic area of workforce development. It provides information and strategies to inform a workforce development approach, including job types and skills, associated training needs, considerations for promoting diversity, and organizations and partners to engage; positive and negative community impacts of large energy projects and strategies to mitigate negative impacts; and outreach strategies for meeting workforce needs including identifying existing sills and developing new skills.

Section 3 provides a summary of the work PNNL performed in collaboration with PelaStar to develop a preliminary Environmental and Co-Use Management Plan. It serves as a guide to preparing an environmental assessment related to the installation and operation of PelaStar's unique TLP design, including its potential ecological, socioeconomic, and emissions impacts, and focuses on the Gulf of Maine and Northern California regions. The section also outlines an approach to establishing best practices for evaluating, avoiding, and mitigating these concerns. Only the potential impacts to the offshore environment are considered; impacts to the onshore environment and from manufacturing and distribution were out of scope. This section is not meant to serve as an environmental assessment, which should be performed as the technology matures, following the guidelines in this document and the associated resources. The section also highlights fisheries co-use considerations, including existing perspectives, methods, examples, and limitations.

This work was performed under PNNL CRADA #609, PNNL Project 82144.

2.0 Preliminary Workforce Development Plan

Floating offshore wind, as a new industry, will need to establish and recruit a workforce capable of performing the manufacture, installation, and operation of the floating platforms required for offshore wind (OSW) turbines. Parallels can be drawn from the way other industries, including fixed OSW, have performed this process, and lessons can be learned to improve the way it is done for future industries.

This section provides information and strategies to inform a workforce development approach, including job types and skills, associated training needs, considerations for promoting diversity, and organizations and partners to engage (Section 2.1); positive and negative community impacts of large energy projects and strategies to mitigate negative impacts (Section 2.2); and outreach strategies for meeting workforce needs including identifying existing sills and developing new skills (Section 2.3).

2.1 Labor Needs

2.1.1 Definitions

Below are definitions for various types of jobs including direct, indirect, and induced as described in (Collier et. al., 2019). The primary focus of this section will be on direct and indirect jobs, but induced jobs are also included as several of the referenced studies and reports include induced job forecasts. Jobs most relevant for project planners and developers include direct and indirect jobs.

Direct: Jobs including or related to construction, installation, operations, and maintenance

Indirect: Jobs including or related to manufacturing and fabrication supply chain

Induced: Jobs created by household spending of those in direct and indirect jobs

2.1.2 Number of Workers

The following section provides insight into current estimates regarding the number of jobs for different OSW development forecasts. Once the preliminary manufacturing site is decided, a comprehensive analysis to calculate job needs that considers needs and specifications of PelaStar's platforms should be conducted. Potential job types can be organized into five key industry segments including development, manufacturing and supply chain, ports and staging, maritime construction, and operations and maintenance. The largest workforce opportunity identified in the U.S. is in manufacturing components and the associated supply chain. Most workers in this segment are at the factory level. Identifying the number of new jobs will depend on several factors, including the region of the country and existing infrastructure, policy support, project size, timing, forecasting methodology, and more. To better estimate the number of jobs and economic impacts associated with power generation, the Jobs & Economic Development Impact (JEDI)[1] models may be used.

The National Renewable Energy Laboratory's (NREL's) U.S. Offshore Wind Workforce Assessment highlights estimated job numbers associated with the share of domestic content

[1] https://www.nrel.gov/analysis/jedi/

utilized in components. This assessment anticipated the workforce needs of the U.S. to meet its goal of 30GW of OSW energy by 2030. It predicts that 15,000 jobs will be created at 25% domestic content, and 58,000 jobs at 100% domestic content (Stefek et. al., 2022).

Table 1 compares two job forecasts for OSW wind projects in California. While the timing and sizing of the projects are different, the ratio of jobs to energy generated are relatively consistent.

Table 1. Number of jobs across construction and operation phases for various energy generation scenarios.

Energy Generation Target	NREL Totals include on-site and manufacturing supply chain jobs		BVG Totals include direct, indirect jobs	
5 GW by 2045		-	Construction Operation	3,202 2,095
10 GW by 2040-2050	Construction Operation	5,800 2,230		-
16 to 18 GW by 2045 to 2050	Construction Operation	13,620 4,330	Construction Operation	12,958 4,828
(Speer et. al., 2016, American Jobs Project 2019)				

2.1.3 Skills

There are several job types and required skills for workers employed in the trades supporting OSW development. Different project phases (e.g., planning, design, development, manufacturing, construction/installation, operations, and maintenance) may have different staffing needs. Aside from those directly involved in OSW development, workers will be needed at ports to ensure that the ports are operationally ready and/or sufficiently maintained to be able to support relevant OSW development activities. Figure 1 shows the relative proportion of workers by job type in the OSW industry in the UK.

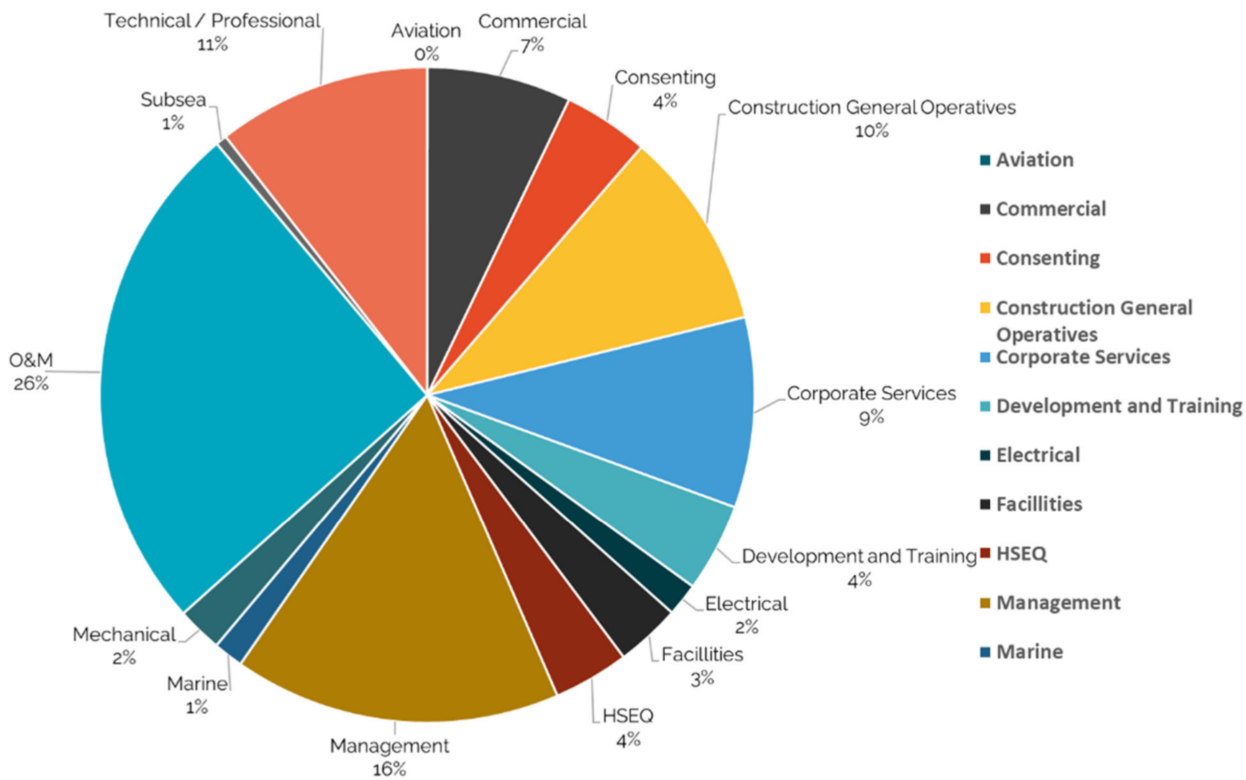

Figure 1. Breakdown of UK OSW workforce by job role (UK Offshore Wind Industry Council 2023).

Some of the most frequently mentioned skill requirements for occupations in the OSW sector include Microsoft Office, forklift operation, power tools, AutoDesk Auto CAD, and interpretation of blueprints (BW Research Partnership 2023). General skill and certification requirements in this realm may include Occupational Safety and Health Administration (OSHA) 10, OSHA 30, Global Wind Organization (GWO) certifications, Project Management Professional (PMP) certification, American Welder Society (AWS) Certified Welder, Class A CDL, National Commission for the Certification of Crane Operators (NCCCO) certification, Wind Industry Training Records Database (WINDA) registered, and Professional Engineering licensing (BW Research Partnership 2023). Additionally, factory workers that support manufacturing and supply chains typically have training in basic and skilled trades (e.g., welders, electricians). PelaStar components that require manufacturing include:

- Tendon cables [fabrication method: parallel wound cables]
- Tendon connectors [fabrication method: large specialty steel machining]
- Tendon porches [fabrication method: castings/forgings]
- Hull modules [fabrication method: large steel tubulars/stiffened plate steel]

Table 2 describes common occupations involved in OSW development and includes typical educational, experiential, and certification requirements for the associated positions.

Table 2. Certifications, experience, skills, and education standards for occupations employed in OSW manufacturing and construction.

Occupation Title	Minimum Educational Requirements	Skills	Certifications and Experience
Electricians	High school diploma or equivalent	Programable Logic Controllers (PLC), blueprints, installation, welding, repairing, or replacing complex electrical lines and equipment; electrical systems and tools needed to fix/maintain them; troubleshooting skills and diagnosing problems in complex electrical systems; ability to lift heavy tools, cables, and equipment.	GWO, OSHA 10, OSHA 30, Certified Welder Journey worker (industrial electrician): 4 yrs, >8000 hrs Journey worker (electrician): 5 yrs, >10000 hrs Supervising electrician: 5 years plus 4 years at Journey worker
Captains, Mates, and Pilots of Water Vessels	Postsecondary non-degree award	route navigation software, FURUNO navigational chart software, Jeppesen Marine Nobeltec Admiral, Maptech The CAPN, equipment operation, navigational skills, adherence to collision regulations, tug handling skills, communication skills, technological skills	Transportation Worker Identification Credential (TWIC), certification in cardiopulmonary resuscitation (CPR), First Aid certification, HAZMAT, lifeguard certification
Crane and Tower Operators	High school diploma or equivalent	operating mobile cranes, operating overhead cranes, human machine interface software, forklifts, equipment capacity, rigging, inspections, maintenance, equipment operation, reading & interpretation, writing reports, math skills, computing rate, drawing/interpreting graphs	Certified Crane Operator (NCCCO), Commercial Driver's License, Overhead Crane Operator 1 to 3 years' experience and/or training
Welders, Cutters, Solderers, and Brazers	High school diploma or equivalent	welding, metal inert gas welding (MIG), blueprints, forklifts, fabrication	GWO, Certified Welder, American Welding Society, ISO 3834, OSHA 10, HAZMAT 4 years' experience or completion of weldership apprenticeship
Structural Iron and Steel Workers	High school diploma or equivalent	Welding, Aerial Lifts, Metal Shears, Scissor Lifts, Operating Equipment.	OSHA 10, OSHA 30, Certified Welder, ISO 3834

(BW Research Partnership 2023, American Clean Power 2023)

Additional job positions may be created through necessary investments in port and maritime infrastructure upgrades to support the project. These upgrades may include:

- Widening and deepening existing port channel to accommodate floating foundations and large turbines. Requires specialized engineering and marine operators.
- Integration and fabrication yard. Requires specialized design, engineering, and construction.
- Marine terminal expansion or retrofitting. Requires engineering and construction.
- Potential component manufacturing facility. Requires specialized engineering and construction.
- Operations and management base to support project crew. Requires engineering and construction.

2.1.4 Training Needs

Many of the roles will need specialized training and/or experience in a skilled trade to meet the needs of the OSW industry. Labor unions have been integrating skills specific to this industry into existing training and apprenticeship programs as well as creating new training programs that meet requirements for the OSW industry. Apprenticeship programs are typically designed to train new workers; however, specialized courses and training for journey-level workers can be helpful for upskilling so that they may be appropriately trained to work in the OSW energy industry. Most apprenticeable occupations require 4-5 years of on-the-job training. Apprentice standards are defined at the state level, so safety and jobs performed under non-traditional OSW conditions must be addressed. OSHA dictates that the OSW energy industry must provide training on occupational hazards and risks and take action to mitigate those risks.

The Global Wind Organization delivers training portfolios for jobs specific to OSW conditions and partners with industry leaders. Partnering with the GWO can promote safety and awareness regarding potential hazards to reduce incidents/injuries, increase productivity, lower training costs, and provide standardization given that technicians from this program have verifiable certifications. GWO certification is designed to specify unique training for the risks of the OSW environment and is aligned with OSHA standards. Additional training gaps that have been identified are training workers to work at sea and standardized safety training (Stefek et. al., 2022). There is a lack of official industry training standard, making addressing these gaps challenging, but GWO standards have been widely adopted.

2.1.5 Methods for Promoting Workforce Diversity

As addressed further in Sections 2 and 4, job skill development must consider organized labor, local community, and diversity objectives. Local labor organizations and groups can assist in connecting to a variety of skilled workers. Ensuring that job postings and informational material are accessible and promoted to the local community, through traditional job marketing or local community-level groups, will promote a broader pool of potential hires. Organizations can benefit from directly marketing job positions to the local community through local labor groups, community groups, trade schools, high schools, community colleges, and more. Local government or developer-sponsored pre-apprenticeship programs can also increase diversity within trades by helping students fulfil educational requirements, increase awareness of industry-specific jobs and spark interest, and prepare students to succeed in apprenticeship programs.

Within the work environment, diversity can be maintained by promoting an environment of genuine inclusion. Implementing systems that facilitate accessibility to the workforce can increase employee well-being and job retention, such as providing stipends for childcare or transportation to workers who may benefit from it. It is important to note that once a particular site is identified, these strategies may not encapsulate all options to promote workforce diversity and must be reevaluated with a site-specific lens.

Organizations at all levels of the supply chain can design and implement a diversity, equity, inclusion, and accessibility (DEIA) plan to support equitable hiring and workforce practices. A DEIA plan demonstrates commitment from the organization to their immediate workforce and prospective employees to uphold these values and is something within the organization's direct scope of influence. Retention of existing staff and recruitment of a diverse workforce are both likely to improve with a thoughtful DEIA plan. While an organization can make recommendations for diversity in the workforce throughout the supply chain and the industry, and in some cases incorporate diversity requirements into contracting mechanisms, an internal DEIA plan is something that any organization has direct control over. A DEIA plan may incorporate strategies for hiring, training, promotion, and retention of a diverse workforce. Some examples may include flexible schedules, competitive and fair pay, accommodations, setting specific metrics and benchmarks, benefits packages, targeted outreach when hiring, training (such as unconscious bias or harassment), employee affinity groups, and more.

Diversity in the workforce can increase organization-wide innovation, employee retention, and community-business relationship building. Organizations with a more diverse workforce tend to benefit from increased creativity and range of thought, improved decision-making processes, and overall occupational wellness and synchronicity. Several strategies can be utilized to promote workforce diversity, both in the recruitment process and throughout employment. Hiring processes can be predesigned to achieve workforce diversity by setting hiring goals for traditionally marginalized groups including women, Black, Indigenous, and people of color (BIPOC), local residents underrepresented in union trades, and more. Implementing diversity-based recruitment strategies- hiring the best person for the job while structuring the hiring process in an equitable manner- can be particularly helpful in achieving diverse hiring goals.

Diversity metrics should be tracked and analyzed regularly to make improvements. Ensuring equity in wages, opportunities, and promotions is also a key part of maintaining a diverse workforce. Racial and gender wages gaps are most commonly found in inequitable workforces (Kochhar 2023). Strategies to overcome race and gender-based pay gaps include having a diverse array of hiring managers, increasing pay transparency in the recruitment process, and allowing paid family leave to support parents transitioning out and back into the workplace. Additionally, Project Labor Agreements (PLAs) can assist in achieving equitable pay and are discussed in detail in Section 4.

The criminal legal system disproportionately impacts the same populations DEIA programs seek to recruit for employment in the OSW industry. To mitigate the impacts of justice involvement, employers need to analyze whether justice involvement should be a consideration in hiring and eliminate those criteria when not essential.

Floating OSW will be manufactured, assembled, and deployed in lands and waters that have been part of the territory of native tribes since time immemorial. Workforce development and recruitment programs need to be designed in coordination with tribal nations since their training and education programs are often separate from other regional programs.

2.1.6 Labor Unions and Organizations to Engage

The labor unions and organizations included below may be beneficial to engage for workforce development and training purposes. North America's Building Trades Unions (NABTU) is a labor organization that represents more than 3 million skilled craft professionals across the U.S. and Canada. NABTU is composed of fourteen national and international unions and over 330 provincial, state, and local building and construction trades councils. Regional councils for the West Coast and Gulf of Maine are listed below.

Labor Unions

- North America's Building Trades Unions
  - Oregon State Building and Construction Trades Council
  - California State Building and Construction Trades Council
  - Building and Construction Trades Council of Humboldt and Del Norte Counties
  - Maine State Building and Construction Trades Council
  - Massachusetts State Building and Construction Trades Council
  - New Hampshire State Building and Construction Trades Council
- Northern California District Council of Laborers
- United Steelworkers
- Ironworkers
- SMART, the International Association of Sheet Metal, Air, Rail and Transportation Workers
- Sheet Metal Workers' International Association
- International Longshore and Warehouse Union
- International Brotherhood of Electrical Workers
- International Association of Machinists and Aerospace Workers
- United Brotherhood of Carpenters and Joiners (includes commercial divers)
- Laborers International Union of North America

Labor Organizations

- General
  - Blue Green Alliance
- Oregon
  - Southwestern Oregon Workforce Investment Board
  - Northwest Oregon Works
  - Lane Workforce Partnership
  - Rogue Workforce Partnership
- California
  - Humboldt Builders' Exchange

- Maine, New Hampshire, and Massachusetts
  - Massachusetts Office of Labor and Workforce Development

2.1.7 Community Colleges, Trade Schools, and Training Centers

While many working in the trades will go through apprenticeship programs offered in association with labor unions, community colleges, trade schools, and training centers also provide opportunities to learn skilled trades, including welding technology, construction technology, and engineering technology. Programs at community colleges may also be helpful for preparing students with more general educational requirements prior to apprenticeships. Examples of existing programs are listed in Table 3.

Table 3. Community colleges and relevant training programs in Washington, Oregon, northern California, Maine, New Hampshire, and Massachusetts.

Community College, Trade School, or Training Center	Location	Relevant Programs
Southwestern Oregon Community College	Coos Bay, OR Brookings, OR	Engineering, welding technology
Oregon Coast Community College	Newport, OR Lincoln City, OR Waldport, OR	Welding technology
College of the Redwoods	Eureka, CA	Truck driving, welding technology
Shasta College	Redding, CA	Engineering, industrial technology, heavy equipment operations, welding technology
Northern California Valley Sheet Metal Workers' Training Center	Mather, CA	Sheet metal, welding, manufacturer training
Renton Technical College	Renton, WA	Advanced manufacturing, transportation technology
Seattle Maritime Academy	Seattle, WA	Marine engineering technology, marine deck technology
Eastern Maine Community College	Bangor, Maine	Building construction, electricians technology, heavy equipment, welding technology
Southern Maine Community College	Brunswick, Maine	Construction technology, electrician technology, manufacturing, marine design, welding
Great Bay Community College	Portsmouth, New Hampshire	Engineering science, welding technologies
New Hampshire School of Mechanical Trades	Hampton, New Hampshire	Electrical
Bristol Community College **National Offshore Wind Institute located here**	Attleboro, MA Fall River, MA New Bedford, MA Taunton, MA	Engineering technology, machinist OSW power technician, OSW power technology, project management, supply chain management, welder technician

2.2 Potential Impacts on Communities

Large-scale project development inevitably impacts surrounding communities. These impacts can be beneficial to the community or harmful and will vary significantly depending on the identified site. Additional analysis could be conducted with a specific site and project plan to quantify the magnitude of expected impacts. For example, once a site is identified, an input/output model (for example, IMPLAN) can be built for the host region and anticipated project size. Model outputs would estimate direct, indirect, and induced effects of such a project on economic factors (e.g., number of jobs created, amount of revenue and wage growth, and tax revenue) across all industries in the region of study. This type of model could inform area impacts and be supplemented by targeted studies of natural resources, community socioeconomic factors, and infrastructure.

2.2.1 Community Benefits

Host communities may experience several community benefits from in-migration of workers and industry growth. These benefits may be tied to direct, indirect, and induced jobs, wages and earnings, increased tax revenue, improved infrastructure, and improved environmental and public health outcomes.

Any large development or manufacturing project would be expected to bring more job opportunities to the region. If filled by local residents, these new jobs could lower unemployment rates. In addition, skilled jobs and unionized jobs often offer higher pay and competitive benefits.

Local businesses may experience new growth opportunities and increased economic activity through indirect and induced effects. For example, suppliers would benefit from contracts with the project developer (indirect effects). Workers may spend their wages at area restaurants (induced effects).

Increased taxes from businesses, income, and property provide additional funding for public services (e.g., schools, libraries, public safety, etc.). This new tax revenue could be used to improve existing resources or create new ones, or even be re-invested to offset effects of growing population and increased utilization of public services (as discussed in Section 3.3).

Improved infrastructure such as roads and communications (e.g., broadband, cell service) are also benefits that may accrue to the community. Project developers may build out new infrastructure to meet project needs, which may also benefit the surrounding community, such as new roads, rail, and port capacity.

If clean energy projects supply power to the host community, there may be some benefit of offset carbon emissions and avoidance of fossil fuels. This is particularly true for communities with a fossil-fuel power plant that can reduce operations or shut down once the clean energy project is operational. A reduction in carbon emissions can improve health outcomes for downwind residents (Li and Jin 2024, Yang and Chou 2018).

2.2.2 Negative Externalities

In addition to community benefits such as new job opportunities, well-paying jobs, and lower unemployment rates, large-scale energy projects may have less desirable community impacts. These negative impacts can be attributed to the in-migration of workers and their families from outside the local area and project characteristics and impacts.

A growing population (from in-migration of workers and their families) will have a higher utilization of existing infrastructure. Utilities will face heavier demands on electric, water, and other services. Direct and indirect project use (such as manufacturing facilities) will also likely place a higher demand on utilities such as water and electricity. Communications channels will see more traffic and cellular and broadband connection may be slowed by increased usage.

Transportation will be affected with existing roads having longer travel times, increased congestion, and noise as a result of the increased number of workers and their families, materials transport, and construction.

Public services will experience increased utilization from the in-migration of workers and their families. The increased utilization of safety and first responder services (police, ambulance, fire), hospitals, and healthcare services could result in longer wait times. Public schools will have an increased student to teacher ratio.

An influx of new workers may cause housing shortages, lower vacancy rates, and drive costs up. Visual dis-amenities may result from project siting near residential, recreational, or commercial areas, and could negatively impact property values and recreational experiences. Projects with large in-migration of workers and their families relative to the size of the host community may experience cultural shifts.

Project lifecycle analysis should consider community impacts through decommissioning, which could result in a loss of jobs and revenue within the local community. Depending on project phases, there is the possibility of several boom-bust cycles in the local economy. The seasonality of work should be considered in areas where adverse weather conditions may impede offshore work. Seasonal workers may relocate during shoulder or off-season(s) which may have an effect of slowing economic activity in the area.

The fishing industry and existing job structures, including recreational fishing, may face changes. One study found impacts including increased fuel expenditures, increased insurance cost and potential for exclusions, reduced fishing industry revenues, loss of fishing areas and overcrowding of alternate areas, changes to income, livelihoods, and impacts on fishing support businesses (Chaji and Werner 2023).

It will be equally important to consider the implications of the project on local tribal governments and people. Tribes are sovereign entities; just as a state or municipality has its own laws and policies, so do tribes. Interactions with tribal governments and people should be considered in this context. The aforementioned impacts may be applicable to tribes, but also may vary based on different policies and community objectives. Once the project has been sited, a more comprehensive analysis should be conducted on the specific needs and goals of any affected tribal communities.

2.2.3 Strategies to Mitigate Negative Community Impacts

Large-scale energy generation projects, particularly large-scale projects like OSW, can have significant physical, cultural, and social impacts on surrounding communities. Several strategies exist to mitigate negative community impacts resulting from a quickly growing population and direct and indirect project effects.

The increased utilization of infrastructure, utilities, and public services could be addressed through a larger tax base. Several tax structures may feed into this (e.g., corporate, property, and/or income taxes). This tax revenue could be re-invested to offset effects of growing population and increased utilization. For example, tax revenue could pay for hiring additional school staff (teachers and administrators) to offset larger class sizes.

There may be a business reason for project developers to expand infrastructure and utilities that could also benefit residents. For example, a new road may need to be built from a port to a manufacturing facility. This road could alleviate some traffic related to direct business operations or provide an alternate route for commuters.

Existing businesses may grow (or new businesses may form) to meet increased demand. For example, new housing construction may increase to meet the demand of a growing population, which may create further jobs in the construction industry, reduce the risk of housing shortages, and create more affordable housing.

Project developers could partner with the host community to determine if there is interest in supporting a community project. One avenue to achieve this might be through a community benefits agreement (CBA) (see Section 4). There could be a specific agreement or activity designed to reduce fishing industry impacts, or it could be a project that is further removed from direct or indirect effects such as a park or recreation facility. Specific to the fishing industry and existing job structures, designated transit lanes, direct compensation, and retraining programs for displaced fishers are some mitigation strategies that could be employed (Chaji and Werner 2023).

Prioritizing training and hiring existing residents could reduce the number of positions filled by those outside the community and lower the impacts of in-migration. If these positions are filled by previously unemployed workers this could lower the unemployment rate. Training programs and outreach targeted at communities that are underserved and overburdened can provide a pathway to careers in clean energy.

Negative impacts may require collaboration or consulting with the impacted entities, especially when working with traditionally underserved communities. Tribes in particular have been historically underrepresented in decision-making processes and therefore benefit from extra care and consideration in outreach. One method of mitigating impacts on tribal communities is to create a training module for staff that will be interacting with tribal governments and people. Future projects impacting tribal lands or resources may benefit from conducting a training module on tribal rights, specific outreach and engagement strategies related to tribes, and best practices for navigating overlapping interests. Important considerations to include in a training module of this nature may include:

- Recognizing tribal governments as sovereign entities with their own rights and policies related to workforce development (may differ from non-tribal policies).
- Ensuring that development does not harm any physical or cultural resources of tribal governments/residents.
- Early, specific engagement and meaningful opportunities for participation.
- Recognizing the importance of cultural relativity.
- Promoting workforce diversity with special considerations for members of tribes.
- Local fisheries may be very important to tribal well-being and sustainment. Coordination with local fisheries, both tribal and non-tribal entities will be essential.

2.3 Outreach Plan for Meeting Specific Workforce Needs

The following section describes several general best practices and considerations for an outreach strategy to meet workforce needs. In future analysis, outreach strategies should take a regional approach that is specific to the location and collaborates with partners in the communities where projects will be built. Building consensus around specific role requirements, creating a plan for training and education, and considering existing labor standards and labor union offerings will be key pieces of developing a comprehensive outreach strategy.

The strategies for outreach discussed below focus on two broad categories: how to identify existing needed skills within a particular community and mobilize or attract those workers to join the workforce, and how to train and develop new needed skills within the existing workforce.

2.3.1 Identifying Existing Skills Within Community/Siting Location

The following recommendations serve as guidance for a generalized approach to identifying existing skills, but conducting a workforce analysis once a specific site is determined will be necessary. This future analysis should include demographics, distribution of skills in the region, best practices for outreach, and connecting with local institutions (e.g., unions, labor groups, community colleges, community-based organizations, schools, etc.).

A foundational hurdle to building a workforce using existing labor and skills is the fact that awareness of roles within the OSW workforce is low. Industry-wide efforts to raise awareness of the distinct roles needed in OSW will help with this gap. PelaStar can contribute to industry efforts to standardize the specific credentials and requirements for certain roles so that potential workers can understand how their skills can meet industry needs. In addition, PelaStar could develop platform-specific materials explaining the types of roles and skills needed, for example by creating career maps (certification and training requirements, career pathways, timelines, etc.) to raise awareness of specific career opportunities and skills needed to work on this technology.

To address the lack of awareness, industry and government need to begin outreach at the K-12 level, particularly for new or less well-known occupations. Career Connect WA identifies three levels of career connected learning for students to explore, prepare, and launch their career. Exploration begins as early as kindergarten[1]. By high school, students should have opportunities to visit and even intern in the industry worksites.

Once a location is identified, outreach efforts to local groups where skilled tradespeople congregate will support recruitment. Adjacent and related industries can then be assessed to determine if transferrable skills may exist within the workforce. Trade schools, community colleges, and universities can make good partners for outreach events such as job fairs, career days, and industry panels. To encourage a diverse group of participants, events could be hosted after normal work hours, on weekends, and have multiple options available to ensure accessibility. Finally, to make recruitment as easy as possible on potential workers, onsite interviews for open positions can be hosted at strategic locations like trade schools.

States, counties, and other local entities often create offices or bureaus focused on economic development, skills development, and training. Partnering with these entities will be a useful strategy for identifying existing skills in the workforce and tactics for recruitment. These entities

[1] https://careerconnectwa.org/

can also make good partners for development of new skills within the workforce. Several exist in Northern California and Maine, and a few examples are listed in Table 4.

Table 4. Examples of existing organizations in Northern California and Maine that may assist in the process of identifying workers with existing skills.

Organization	Description	Website
Humboldt County Office of Economic Development	Serves as a resource center for the county	https://www.gohumco.com/
Humboldt Bay Harbor, Recreation, and Conservation District	Developing the Humboldt Bay Offshore Wind Heavy Lift Multipurpose Marine Terminal. There may be skilled workers from this project who could be recruited to perform port- or marine-based roles for PelaStar's technology.	https://humboldtbay.org/humboldt-bay-offshore-wind-heavy-lift-marine-terminal-project-3
Maine Career Centers	Maine Career Centers provide a variety of employment and training services at no charge to Maine workers and businesses. Career Centers can aid in the recruitment process, provide support to candidates, and assists with employee retention during lean business time. It is administered through the Department of Labor.	https://www.mainecareercenter.gov/
New England Aqua Ventus project	Maine is the host of the New England Aqua Ventus project, a demonstration project of a floating semisubmersible OSW turbine through a partnership with Cianbro. Relevant skills likely exist in the communities from this project.	https://newenglandaquaventus.com/
Maine Office of Business Development	Produces several resources for businesses to attract, retain and train their workforce.	https://www.maine.gov/decd/business-development/workforce-resources

The process of investigating the availability of existing workforce and skills within host communities may identify gaps. There may be gaps in the breadth and level of skills present or in the quantity of employees available for work - this has been identified as a challenge for OSW on the North Coast (Collier et al, 2019). A comprehensive workforce development analysis will identify gaps between existing labor and skills and the available workforce and seek solutions to fill the gaps. In areas where there is moderate or high unemployment, there is an opportunity to develop the existing workforce and build training programs to promote community development (discussed further below). Where there is low unemployment, developers may need to consider outsourcing outside of the immediate community. Skilled labor is often employed from outside, especially for rural areas and in the earliest stages of a project when an endemic labor market does not exist. This includes for both initial construction and ongoing maintenance (Mauritzen

2018). IMPLAN input/output model results could be utilized to identify where gaps may exist in supply chain industries at a high level.

2.3.2 Developing New Skills Within the Community

Once skills gaps have been identified within the host or neighboring communities, project proponents and developers can invest in development of the existing workforce. This will include developing skills specific to OSW technology, training for proprietary technologies, and training staff to meet increased need for capacity in the supply chain. Developing strategic community-level partnerships should be central to any strategy to develop new skills within a community. CBAs and PLAs are potential vehicles for crafting strategies and commitments for workforce development and local hiring.

2.3.2.1 Strategies for Effective Localized Skill Development

Technology and project developers will need to identify the skills and roles that are of the greatest need and what it will take for those skills to be developed (e.g., a certification process or apprenticeship). Offering sample career maps can help eliminate some uncertainty potential workers may face when considering whether to join the OSW workforce.

One approach to utilizing existing local skills is to train workers from adjacent industries (e.g., maritime, oil and gas) to develop the offshore-wind-specific knowledge and skills (BW Research Partnership 2023, American Jobs Project 2019). Community colleges and other local institutions are ideal partners for developing such upskilling programs. Such a strategy requires understanding what types of industries exist in the proposed development locations and working with unions, economic development agencies and other partners to develop a recruitment strategy.

Basic and skilled tradespeople who support manufacturing, port terminal crews, and vessel crews will be in high demand for OSW and for other industries. These roles require multiple years of experience, which apprenticeship programs can provide. Expanding the capacity of apprenticeship programs together locationally with the planned facilities is a strategy to ensure a local workforce is available when needed. For example, Maine offers the Maine Apprenticeship Program which sets up structured yet flexible training programs to meet the needs of employers with on-the-job learning. The sponsoring organization must provide incremental wage increases as the apprentice gains proficiency and completes course requirements. Sponsors receive assistance developing their program and are reimbursed for up to 50% of cost of classroom instruction.

There are several benefits in building key partnerships with relevant local groups such as community colleges, labor unions, manufacturers, tribes (governments, communities, and affiliated groups), economic development organizations, local industry organizations, community-based organizations, school groups/educators, and more. Project proponents can benefit from the existing network and outreach infrastructure that exists within these partners, potentially receive assistance with running or funding apprenticeships and other programs and utilize the physical spaces that already exist to host recruiting events and training programs. Table 5 presents an example list of such partners and resources.

Table 5. Examples of existing organizations and resources that may assist in the process of identifying and developing local skilled workers in Northern California and Maine.

Organization	Description	Website
Gulf of Maine and Northeast		
Maine Maritime Academy	Center for Professional Mariner Development offers online, hybrid, and in-person courses to meet International Convention of Training, Certification and Watchkeeping (STCW) and maritime training needs. MMA also has the Harold Alfond School of Engineering that provides training and hands-on learning opportunities that prepare students for a career in maritime or power engineering.	https://mainemaritime.edu/
Maine Quality Centers Program	Offers customized workforce training that is delivered through one of Maine's seven community colleges. The program works with the business to put together a program that will provide workers the skills they need. Can include elaborate education on heavy machinery operation.	https://www.mccs.me.edu/workforce-training/maine-quality-centers/
West Coast		
Northwest Renewable Energy Institute	Focused on providing education and training programs for the renewable energy industry, including the OSW industry. The institution offers comprehensive training programs for individuals interested in pursuing a career in the OSW industry.	https://www.nw-rei.com/
Humboldt State Schatz Energy Research Center	Conducting research on OSW energy topics. Among these topics, researchers delve into energy generation and transmission, economic and job development, port and coastal infrastructure, environmental and geological systems, and community needs and goals for shared ocean resources.	https://schatzcenter.org/
Affiliated Tribes of Northwest Indians (ATNI)	May be able to assist in connecting to several tribes at once if the coverage area necessitates it.	https://atnitribes.org/
General Resources		
Vestas AME Technical and Safety Training	Offers education and training programs for individuals in the OSW sector.	https://us.vestas.com/en-us/careers/technician-readiness-program
NYSERDA Offshore Wind Training Opportunities Map	To help job seekers access the skills, training, and education necessary to thrive in the OSW industry.	https://www.offshorewindtraining.ny.gov/training/opportunity-map

2.3.2.2 Community Benefits and Project Labor Agreements

Given that CBAs are developed between project developers and communities and PLAs are developed between developers and labor organizations, the direct role of platform manufacturers and suppliers in the development and/or negotiation of such agreements is limited. Instead, they would have more of an indirect role in shaping where potential benefits may be realized. For example, the siting of manufacturing facilities and suppliers would influence the level of economic benefits seen by communities if such infrastructure is sited within their community. The Energy Justice Mapping Tool[1] may be used to explore information on census tracts that the U.S. Department of Energy has categorized as disadvantaged communities pursuant to Executive Order 14008 – Tackling the Climate Crisis at Home and Abroad. This tool may be considered during selection of suppliers and manufacturing facilities or during the siting of future facilities to assess impacts and potential benefits to disadvantaged communities.

Additional investments in infrastructure may be necessary if construction of new manufacturing facilities occurs, and this local investment could benefit communities. Similarly, if there is a greater share of domestically produced components, this will increase the number of workers needed. Projects with a greater share of domestic content could therefore employ more people, and this could inform content developed within a PLA if there's an increased demand for local workforce. As suppliers and manufacturers are selected by the platform developer, potential impacts to communities resulting from the siting of facilities and local hiring practices should inform decision making.

Community Benefits Agreements

CBAs are an effective way to engage with a host community, generate support for a project and address local concerns. The process of discussing and negotiating a CBA is a form of outreach to the local community that can raise awareness of potential employment opportunities and the skills required. Developing a CBA that includes investments in workforce development will directly benefit the project outcomes.

A CBA is legally binding and enforceable and signed by project developers and a representative of the community. CBAs should reflect the unique circumstances of the host community and be negotiated on a case-by-case basis. CBAs typically include multiple types of benefits designed to accrue to the community, including:

- Funding community programs or payments to residents.
- Opportunities for communities to access tax benefits. For example, the Inflation Reduction Act incentivizes investments in low-income communities and those dependent on fossil fuel industry for jobs.
- Fair or living wage guarantees, which are sometimes negotiated in a PLA (see below).
- Targeted workforce development and hiring programs.
- Education and training.
- Affordable housing.
- Environmental protections.
- Infrastructure or priority project upgrades, such as construction of new local facilities.

CBAs can directly benefit developers as well, primarily through generating good local community relationships. In addition, having a CBA in place can assist a developer in getting permits or winning leases. The state of New York requires host community benefits in order for developers to access a more streamlined state permitting process. The federal government

[1] https://energyjustice.egs.anl.gov/

used a bidding credit in the California OSW energy sale in 2023 to incentivize developers to form CBAs. Direct benefits to communities can also be favorable to developers: through the Inflation Reduction Act, tax credits are available for project developers that pay prevailing wages and employ people in apprenticeship programs.

Project Labor Agreements

PLAs are pre-hire collective bargaining agreements between a developer and labor organizations that determine economic and employment terms and conditions for a project. Common elements include agreements around work schedules, overtime hours, holidays, paydays, safety rules, drug testing, dispute resolution, management rights and union rights. Many states that have requirements for local and unionized labor and provisions for training and recruitment are considering PLAs (depending on whether a state has right-to-work laws).

Training and recruitment are simplified with a PLA. Building trades unions may establish skills training programs that recruit from underserved communities. This can help ensure a strong, safe, and skilled workforce and encourage all construction stage contractors, union or non-union, to adhere to collectively bargained terms and conditions (BW Research Partnership 2022).

Local union representatives may then participate in public permitting processes to advocate for the project. Dispute resolution procedures within PLAs can facilitate a more coordinated workforce and the timely completion of projects. Projects with PLAs will be more competitive than those without (BW Research Partnership 2022).

3.0 Preliminary Environmental and Co-Use Management Plan

This section summarizes the Preliminary Environmental and Co-Use Management Plan that PNNL developed in collaboration with PelaStar for their Phase II submission to the FLOWIN Prize. It is not comprehensive of the Technical Report PNNL delivered to PelaStar due to the suitability of public release, but it provides the background information, guide, and resources needed to conduct an environmental assessment of the developed technology.

This section provides a guide to preparing an environmental assessment related to the installation and operation of PelaStar's unique TLP design, including its potential ecological, socioeconomic, and emissions impacts, and focuses on the Gulf of Maine and Northern California regions. The section also outlines an approach to establishing best practices for evaluating, avoiding, and mitigating these concerns. Only the potential impacts to the offshore environment are considered; impacts to the onshore environment and from manufacturing and distribution were out of scope. This section is not meant to serve as an environmental assessment, which should be performed as the technology matures, following the guidelines in this document and the associated resources. The section also highlights fisheries co-use considerations, including existing perspectives, methods, examples, and limitations.

Section 3.1 provides a regulatory overview of relevant existing documents used to organize and assess the potential environmental effects of offshore energy development and a summary of environmental regulations relevant to development in the Gulf of Maine and Northern California.

Section 3.2 reviews the impact producing factors that may be involved in the development of floating offshore wind energy in the Gulf of Maine and along Northern California. Additional information and resources are highlighted (where available) to better understand the potential environmental effects/benefits associated with PelaStar's unique TLP system design.

Section 3.3 compiles information and references on the biological, socioeconomic, and physical resources that may be affected by development of offshore wind energy in the Gulf of Maine and along Northern California. These references and the summary table could be used to inform a future environmental assessment by PelaStar or an OSW developer or regulator.

Section 3.4 discusses fisheries co-use consideration, including existing perspectives, methods, examples, and limitations.

Section 3.5 provides links to additional resources. Appendix A provides tables of protected and enlisted species and Appendix B provides bathymetry maps and maps of vessel tracks and fishing vessel tracks in the Gulf of Maine and California.

3.1 Regulatory Overview

Any OSW project will be required to fulfill all federal, state, and local regulatory requirements. These activity areas include offshore wind lease areas as well as cable route and grid interconnection points and the ports of operation. This Plan only addresses offshore activities off the coast of Northern California and in the Gulf of Maine, two areas that have been identified as potential development areas for FOSW.

3.1.1 Relevant Existing Documents

The U.S. Bureau of Ocean Energy Management (BOEM) has previously prepared the following National Environmental Policy Act (NEPA) documents, which it uses to inform preparation of offshore projects' Environmental Assessments and Final Environmental Impact Statements. These documents are heavily referenced in this Plan and should be considered when performing any additional environmental assessment on the PelaStar TLP or any other FOSW platform.

- Final Programmatic Environmental Impact Statement for Alternative Energy Development and Production and Alternate Use of Facilities on the Outer Continental Shelf (BOEM 2007). This Programmatic Environmental Impact Statement (PEIS) examined the potential environmental consequences of implementing the Alternative Energy and Alternate Use Program on the Outer Continental Shelf (OCS) and established initial measures to mitigate environmental consequences. As the program evolves and more is learned, the mitigation measures may be modified, or new measures developed.
- Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore New York Revised Environmental Assessment (BOEM 2016). BOEM prepared this Environmental Assessment (EA) to determine whether issuance of a lease and approval of a Site Assessment Plan within the Wind Energy Area (WEA) offshore New York would lead to reasonably foreseeable significant impacts on the environment and, thus, whether an EIS should be prepared before a lease is issued.
- Commercial Wind Lease and Grant Issuance and Site Assessment Activities on the Pacific Outer Continental Shelf Humboldt Wind Energy Area, California (BOEM 2022). BOEM prepared this EA to determine whether the issuance of a lease within the Humboldt WEA would lead to reasonably foreseeable significant impacts on the environment and, thus, whether an EIS should be prepared prior to issuing a renewable energy lease. Additional resources are available on BOEM's CA State Activities page.
    - Appendix D. Typical Environmental Protection Mitigation Measures and Best Management Practices
    - Finding of No Significant Impact
- Offshore Wind Lease Issuance, Site Characterization, and Site Assessment: Central and Northern California - Biological Assessment of Endangered and Threatened Species And Essential Fish Habitat Assessment (Reeb & Schroeder 2022). BOEM prepared this Biological Assessment for the National Marine Fisheries Service and U.S. Fish and Wildlife Service in Accordance with Section 7(c) of the Endangered Species Act of 1973, and the Magnuson-Stevens Fishery Conservation and Management Act as Amended.
- Wind Energy Research Lease on the Atlantic Outer Continental Shelf Offshore Maine – Environmental Assessment (BOEM 2023). BOEM prepared this EA in accordance with NEPA to consider the reasonably foreseeable environmental consequences associated with the issuance of a wind energy research lease to the State of Maine.
- New York Bight Draft Programmatic Environmental Impact Statement (PEIS) (BOEM 2024). This draft PEIS assess the potential biological, socioeconomic, physical, and cultural impacts that could result from development activities for six commercial wind energy leases in an area offshore New Jersey and New York as the New York Bight, as well as the change in those impacts that could result from adopting related programmatic avoidance, minimization, mitigation, and monitoring (AMMM) measures.
    - Appendix C: Tiering Guidance
    - Appendix G: Mitigation and Monitoring

3.1.2 Regulatory Overview

This section provides a list and short description of some of the federal regulations that may be applicable to the installation and operation of a floating platform for the offshore wind industry. Note that some regulations are more broadly applicable to all OSW projects, and not specific only to the PelaStar TLP. Generally, the windfarm developer, and not the manufacturer of one component, is responsible for complying with regulatory requirements; however, being cognizant of the governing regulations can provide insight into the design of platforms to reduce impacts as much as possible and ease the permitting process.

3.1.2.1 Relevant Federal Regulations

- Endangered Species Act (ESA)
    - Section 7(a)(2) of the ESA requires each Federal agency to ensure that any action that they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species or result in the adverse modification of designated critical habitat. To satisfy its ESA obligations, BOEM consults with the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) regarding potential impacts to listed species and designated critical habitat under the jurisdiction of the services.
- Marine Mammal Protection Act (MMPA)
    - To ensure compliance with the MMPA, per BOEM regulation 30 CFR§ 585.801(b), BOEM lease requirements will stipulate that lease holders must not conduct any activity under their lease that may result in an incidental taking of marine mammals until the appropriate authorization has been issued under the MMPA of 1972 as amended (16 USC 1361 et seq.).
- Magnuson-Stevens Fishery Conservation and Management Act
    - The Magnuson-Stevens Fishery Conservation and Management Act (as amended) requires Federal agencies to consult with NMFS regarding actions that may adversely affect designated Essential Fish Habitat (EFH).
- Migratory Bird Treaty Act (MBTA) and Migratory Bird Treaty Reform Act (MBTRA)
    - The MBTA and MBTRA "prohibits the take (including capturing, killing, selling, trading, or transport) of protected migratory bird species" native to the U.S. and its territories without prior authorization by the U.S. Fish and Wildlife Service
- Coastal Zone Management Act
    - The Coastal Zone Management Act "assure[s] that all Federal agency activities including development projects affecting any coastal use or resource will be undertaken in a manner consistent to the maximum extent practicable with the enforceable policies of approved management programs" (15 CFR 930 Subpart C).
- National Historic Preservation Act (NHPA)
    - Section 106 of the NHPA (54 U.S.C. § 306108) and its implementing regulations (36 CFR § 800) require Federal agencies to consider the effects of their undertakings on historic properties and afford the Advisory Council on Historic Preservation an opportunity to comment.
- Clean Water Act (Section 404) and Rivers and Harbors Act (Section 10)
    - Section 404 of The Clean Water Act regulates the discharge of dredged or fill material into navigable waters and wetlands, while Section 10 of the Rivers and Harbors Act prohibits the obstruction or alteration of navigable waters without a permit. Both are managed by the U.S. Army Corps of Engineers.

3.1.2.2 Specific Regulatory Needs for Gulf of Maine

Development of FOSW in the Gulf of Maine, including the installation and operation of platforms such as PelaStar's TLP, must comply with federal regulations as well as state or local regulations in the areas that may be relevant. The states of Maine, New Hampshire and Massachusetts all have coastlines on the Gulf of Maine, and thus are included in Table 6.

Table 6: Key federal, state, and local regulations needed for permitting in Gulf of Maine

Jurisdiction	Regulation	Cognizant Agency	Receptor of Concern (where applicable)/ Notes
Federal	Endangered Species Act, Magnuson Stevens Conservation Act, Fish and Wildlife Coordination Act, Federal Power Act, Marine Mammal Protection Act	National Oceanic and Atmospheric Administration-National Marine Fisheries Service (NOAA - NMFS)	Marine mammals, marine and most anadromous fish
Federal	Endangered Species Act, Fish and Wildlife Coordination Act, Federal Power Act, Bald & Golden Eagle Protection Act, Migratory Bird Treaty Act	U.S. Fish and Wildlife Service (USFWS)	Seabirds, certain species of anadromous fish, migratory birds
Federal	Rivers and Harbors Act (Section 10), Clean Water Act (Section 404), Marine Protection and Sanctuaries Act (Section 103)	U.S. Army Corps of Engineers	Navigation
Federal	Federal Power Act, Public Utility Regulatory Policies Act, Energy Policy Act, Electric Consumers Protection Act, National Environmental Policy Act	FERC Federal Energy Regulatory Commission	National Environmental Policy Act process
Federal	PATON (Private Aid to Navigation)	U.S. Coast Guard	Navigation lighting and notice to mariners
State	Natural Resources Protection Act, Clean Water Act (Section 401 (d), Maine Waterway Development and Conservation Act	Maine Department of Environmental Protection	Significant wildlife habitat, water quality
State	Maine Endangered Species Act	Maine Department of Marine Resources	Fish, marine mammals, sea turtles
State	Fish and Wildlife Coordination Act	Maine Department of Inland Fisheries and Wildlife	Fish, marine mammals, sea turtles, seabirds

Jurisdiction	Regulation	Cognizant Agency	Receptor of Concern (where applicable)/ Notes
State	Submerged Lands Leasing Program	Maine Department of Conservation	Lands lease
State	Coastal Zone Management Act	Maine State Planning Office Massachusetts Office of Coastal Zone Management	
State	National Historic Preservation Act	Maine Historic Preservation Commission	Tribes with usual and accustomed fishing grounds in the area must be consulted to fulfill these requirements.
State	Massachusetts Environmental Policy Act (MEPA)	Massachusetts Environmental Policy Act Unit	Environmental impacts of proposed projects
State	Massachusetts Endangered Species Act (MESA)	Massachusetts Division of Fish and Wildlife	Endangered or threatened species or habitats of concern
State	Massachusetts Public Waterfront Act	Department of Environmental Protection	Waterways and tidelands
State	Massachusetts Clean Water Act	Department of Environmental Protection	Water quality
State	New Hampshire Endangered Species Conservation Act	New Hampshire Fish and Game	Endangered or threatened species

3.1.2.3 Specific Regulatory Needs for California

Table 7 lists the relevant regulations and cognizant agencies for development and operations off the coast of Northern California (Humboldt Bay lease areas).

Table 7: Key federal, state, and local regulations needed for permitting in Northern California

Jurisdiction	Regulation	Cognizant Agency	Receptor of Concern (where applicable)/ Notes
Federal	Endangered Species Act, Magnuson Stevens Conservation Act, Fish and Wildlife Coordination Act, Federal Power Act, Marine Mammal Protection Act	National Oceanic and Atmospheric Administration-National Marine Fisheries Service (NOAA - NMFS)	Marine mammals, marine and most anadromous fish

Jurisdiction	Regulation	Cognizant Agency	Receptor of Concern (where applicable)/ Notes
Federal	Endangered Species Act, Fish and Wildlife Coordination Act, Federal Power Act, Bald & Golden Eagle Protection Act, Migratory Bird Treaty Act	U.S. Fish and Wildlife Service (USFWS)	Seabirds, certain species of anadromous fish, sea otters, migratory birds
Federal	Rivers and Harbors Act (Section 10), Clean Water Act (Section 404), Marine Protection and Sanctuaries Act (Section 103)	U.S. Army Corps of Engineers	Navigation
Federal	Federal Power Act, Public Utility Regulatory Policies Act, Energy Policy Act, Electric Consumers Protection Act, National Environmental Policy Act	FERC Federal Energy Regulatory Commission	National Environmental Policy Act process
Federal	PATON (Private Aid to Navigation)	U.S. Coast Guard	Navigation lighting and notice to mariners
State	California Endangered Species Act (CESA)	California Department of Fish and Wildlife	Native species of fish, birds, mammals, invertebrates, and plants that are (or might be) threatened or endangered
State	California Coastal Act and Coastal Development Permit	California Coastal Commission	Developments in the coastal zone
State	California Environmental Quality Act (CEQA)	Governor's Office of Planning and Research	Environmental impacts of proposed projects
State	State Lands Lease	California State Lands Commission	Installations in offshore locations
Local	Humboldt Bay Ordinances	Humboldt Bay Harbor, Recreation, and Conservation District	Waterways and tidelands within Humboldt Bay

3.1.3 Tribal Considerations

Gaining the approval of local tribes is necessary to assure their way of life and harvests are not harmed by the proposed project. Tribal nations are sovereign; they must be consulted as one would another nation and are not considered as merely a stakeholder group. In general, U.S. federal agencies will carry out formal consultations with local tribal governments. However, to assure a successful outcome gaining the trust and agreement of local tribes, (as well as tribes that have usual and accustomed fishing grounds in or around the project) is necessary and can be achieved by engaging tribes early in the process and not relying on the formal government to government consultation.

3.2 Impact Producing Factors

This section provides an overview of the impact producing factors (IPFs) that may be involved in the development of floating offshore wind energy in the Gulf of Maine and along Northern California. Additional information and resources are highlighted (where available) to better understand the potential environmental effects/benefits associated with PelaStar's unique TLP system design.

3.2.1 Air Emissions

Background
Air quality is measured by the concentration of pollutants in the air, including criteria pollutants (such as CO, lead, ozone, particulate matter, NO2, and SO2), hazardous air pollutants (HAPs), and greenhouse gases (GHGs like CO2, methane, and nitrous oxide). Offshore wind energy development impacts air quality depending on factors like location, project scope, equipment type, and project phase schedule (BOEM 2022).

Most emissions come from manufacturing, with life-cycle assessments indicating 50%-75% of a project's carbon emissions are from manufacturing (de Paula & Carmo 2022; Tsai et al., 2016; Bang et al., 2019), particularly from raw materials like steel and concrete (Ferreira et al., 2023). Turbine design and substructure type significantly influence emissions, with one study finding that monopile and jacket substructures emit more GHGs in manufacturing due to higher steel usage compared to gravity-based substructures (Reimers et al., 2014). A more recent study including floating foundations found that the floating foundations release less carbon than gravity-based but more than monopile foundations (Tsai et al., 2016).

Other key parameters affecting overall carbon emissions include operational capacity, operational life, water depth, and distance from shore. Operational life, especially over 20 years, significantly impacts global warming potential (GWP), as most emissions occur during manufacturing (Tsai et al., 2016, Bang et al., 2019, Reimers et al., 2014). Increasing operational capacity can also significantly reduce GWP (Bang et al., 2019), while distance from shore and water depth mainly affect installation and operational phases and have less impact (Reimers et al., 2014).

For projects in California, a full environmental analysis under the California Environmental Quality Act (CEQA) would consider air and GHG emissions for all project phases, including manufacture onshore and operations offshore. Public comments on the Vandenberg Offshore Wind Energy Project emphasized evaluating air quality impacts, and provided the resource Our Air to aid in evaluating potential impacts to air quality (CSLC 2021).

For the Gulf of Maine, an Air Quality Emissions Calculations document would be submitted as part of the project's Construction and Operations Plan (COP). Third party analysts have used the BOEM Offshore Wind Energy Facilities Emission Estimating Tool, Version 2.0, for calculating emissions potential. This tool excludes manufacturing emissions and includes offshore emissions from construction, operation, and decommissioning (Maryland Offshore Wind COP 2022).

Considerations for PelaStar Design

- Tendons are designed with a bio-based Dyneema® synthetic fiber that reduces carbon emissions by 70% compared to equivalent petroleum-based fiber. The tendons are also far lighter and easier to handle than steel cable, which will reduce installation times and minimize vessel emissions. End-of-life fiber recycling is on a technical track to be available well before the first installations are decommissioned.
- Installation methods enable smaller, more efficient and locally available support vessels, reducing overall carbon emissions. This is achieved through the patent-pending hull installation methods.
- Redundant designs allow losing a tendon or anchor without losing platform stability and without the need for operations at sea to replace or repair.
- Overall design enables significant reductions in O&M emissions by eliminating the need for ballast system(s) maintenance and minimizing heavy turbine maintenance resulting from turbine component fatigue due to excessive platform motions present in other designs.
- Passive/permanent ballast and minimized platform motions: enables significant reductions in O&M-related emissions by reducing heavy maintenance resulting from turbine wear and tear.

Additional Resources

- Example calculations of air emissions, including vessel trip scenarios
    - Appendices A and B of the Wind Energy Research Lease on the Atlantic Outer Continental Shelf Offshore Maine – Environmental Assessment (BOEM 2023).
- Life cycle assessment (LCA) of a 15 MW reference wind turbine on floating platforms around the Scotland wind energy areas
    - Struthers et al. 2023
- Tool to assess the economic and environmental impacts of floating offshore wind farms through their project life cycle
    - Ferreira et al. 2023
- Evaluation of environmental impacts of a floating wind farm with 100 – 6.7 MW turbines
    - Yuan et al. 2023
- Environmental assessment and LCA for floating offshore wind turbine on a semi-submersible platform on the continental shelf of Brazil
    - de Paula & Carmo 2022

3.2.2 Attraction, Avoidance, & Artificial Reef Effects

Background

Offshore wind components create hard substructures that larvae can settle on, potentially increasing fish presence and forming artificial reefs. Floating wind farms, despite lacking monopiles, also offer surfaces for larval settlement and potential artificial reef formation (OSC 2022). Although floating offshore wind (OSW) farms are a newer technology with less known about their effects on fish and shellfish, they may have less impact on fish species and habitats due to their smaller vertical profile and footprint (SEER 2022).

Jacket foundations with large surface areas provide the most habitat for species colonization, versus monopiles, tripod, or gravity foundations. Floating foundation habitat creation could fall between these types, offering habitat 50-80 m from the surface, with little at the sea bed where less structure is present (Horwath et al. 2020).

Effective monitoring of fish community changes at OSW farms includes methods like BACI (before-after/control-impact) and BAG (before-after gradient) approaches, along with trawl, trap, and habitat surveys, and fish tagging. Best management practices recommend siting projects away from sensitive habitats and minimizing seafloor disturbance. Structures can be beneficial if designed to meet specific habitat needs. (SEER 2022).

Environmental assessments from Hywind Scotland, Dounreay, and Hywind Tampen suggest that FOSW enhances marine mammal habitats by increasing fish populations due to artificial reef effects (ABS 2021).

There is concern that floating wind farms could act as physical barriers for marine animals. The impact scale depends on how animals detect and respond to the farms. However, no barrier effect is anticipated for fish, elasmobranchs, or invertebrates, as they have been observed at similar offshore structures (OSC 2022). Visual disturbance avoidance effects are not expected to vary much across foundation types, with floating foundations causing less seabed disturbance due to their cables and anchors (Horwath et al. 2020).

Considerations for PelaStar Design

- PelaStar's hull's baseline draft is expected to be at ~45-50m depth and the tubular arm design similarly offers unquantified lattice-like benefits.
- Minimal structural elements above the water line: the single column minimizes avian habitation compared to other, larger, foundation designs.

Additional Resources

- Performance assessment of the use of eDNA for pelagic community characterization at the Hywind Pilot Park in the UK
    - Hestetun et al. (2023)
- Investigation of the potential reef-effect of Hywind Scotland floating wind farm, including the successful use of remotely operated glider technology to monitor fish
    - Ramasco (2022)

3.2.3 Changes in Benthic Habitats

Background
Foundations, anchors, and cables from offshore wind (OSW) energy projects can change the benthic environment during and after construction. This can lead to habitat alteration, displacing some invertebrate species while creating new habitats that may increase invertebrate abundance and biodiversity. Physical and chemical changes to sediment structure can also occur. However, disturbances from sediment displacement and suspension during construction are usually temporary, with seafloor conditions typically recovering within a few years (SEER 2022).

The tendon-anchor system used in TLPs, which utilize piles or suction caissons versus drag anchors, impart negligible disturbance to the seabed after installation (Horwath et al. 2020). More traditional catenary moorings can lead to repeated disturbance of the seabed as the mooring chain sweeps the seabed according to changes in currents, waves, and/or wind conditions (SEER 2022). The installation of tendon anchors can utilize designated or directed anchoring, in which a submersible or similar device is used to guide the anchor during the anchor fall, to reduce impact on the seabed (Maxwell et al. 2022).

The U.S. Offshore Wind Synthesis for Environmental Effects Research project's 2022 report describes some benthic monitoring techniques (SEER 2022):

- Seabed disturbance and recovery can be monitored using high-resolution acoustic sonar surveys (such as multibeam or sidescan sonar) that identify small changes in depth and surface characteristics of the seafloor.
- During construction, water quality samples and other techniques such as optical sensors are used to identify sediment plumes and suspended solids.
- For soft substrates, biological samples can be obtained from bottom grab samples or cores to assess benthic infauna community structure, including species composition, abundance, and diversity. Bottom trawls can also be used to obtain epifaunal samples from soft sediments.
- Sediment samples can be obtained from grab samples or cores to assess particle size distribution, total organic content, and contaminant concentrations.
- Video and photographic surveys can be used to characterize the habitat and identify organisms. Imaging surveys can also be used to monitor changes over larger spatial scales, provide a more holistic view of the study area, and verify measurements from sonar surveys.

Considerations for PelaStar Design

- Negligible seabed disturbance: no tendon contact during installation or operation.
    - Develop anchor installation plan to demonstrate minimal seabed disturbance expected from installation and plan for any additional mitigations necessary.
- Minimal footprint: TLP anchors and tendons installed directly below each hull arm minimizes its spatial footprint by 30–50% compared to taut and semi-taut designs, maximizing potential navigation and fisheries routes.

Additional Resources

- Metabarcoding of sediment eDNA communities at the Hywind Scotland OWF – A pilot study
    - Hestetun & Dahlgren 2023
- Environmental benthos survey, Hywind Scotland
    - DNV 2023
- Development of a semiautomated seafloor survey method, including multibeam echosounder and sediment profile and plan view imagery
    - Rebuck et al. 2024

3.2.4 Entanglement

Background

Entanglement risk in offshore wind (OSW) energy development involves primary entanglement, where animals get caught in mooring lines or cables, and secondary entanglement, where fishing gear becomes entangled and subsequently ensnares animals. Studies suggest the risk of entanglement in renewable energy devices is modest, particularly when compared to fisheries entanglements (Benjamins et al. 2014). Taut mooring configurations have the lowest risk, while slack or float lines pose higher risks. Despite these risks, the absolute entanglement risk is low (Harnois et al. 2015).

Large marine mammals, particularly whales, face the highest primary entanglement risk, but it remains low due to the taut and large-diameter lines. No primary entanglements have been reported since the largest floating offshore wind turbine (FOWT) array began operation in Scotland in 2017 (Maxwell et al. 2022).

There is limited knowledge about secondary entanglement risks due to the industry's infancy. Many marine species, including whales, sharks, sea turtles, seals, and seabirds, could interact with marine debris on OSW systems (SEER 2022). Developers or regulatory agencies can conduct a biological risk assessment similar to Benjamins et al. (2014) to establish the species with the highest chance of entanglement.

Mitigation strategies should aim to prevent fishing gear from becoming entangled. These include establishing fishing exclusion zones, regular inspections and removal of derelict gear, and ensuring mooring lines sink if disconnected (ABS 2021). Monitoring approaches could include aerial and drone surveys, remote sensing, passive acoustics, underwater cameras, and animal tagging (SEER 2022).

Considerations for PelaStar Design

- Minimal water column footprint: the 5-arm hull creates inherent redundancy, allowing for a single tendon per arm instead of closely paired tendons. This reduces entanglement risk for aquatic wildlife and fishing gear.
- Redundant designs allow losing a tendon or anchor without losing platform stability and without the need for operations at sea to replace or repair. However, loss or breakage of a tendon should be immediately addressed to avoid entanglement and additional disturbance concerns.

Additional Resources

- Bulletin describing the background of entanglement and the framework for performing a risk assessment around entanglement of floating offshore wind components
    - France Energies Marine COME3T Bulletin on Entanglement
- BOEM 2022 describes the deployment of metocean buoys in and around wind energy lease areas and notes the lack of entanglement occurring on those projects. It also describes the best practices for mooring design to minimize entanglement risk
- ABS 2021discusses the study of entanglement and monitoring methods in the Gulf of Maine for the Aqua Ventus scaled FOWT. The results of the project included no reported entanglements, and potential video monitoring methods.
- BOEM and NOAA North Atlantic Right Whale and Offshore Wind Strategy (BOEM 2024)

3.2.5 Underwater Noise

Background
The primary sources of underwater noise in OSW projects is that of vessels, in all phases of the project, and the installation of foundations or mooring systems.

Vessel sound in OSW projects is low frequency (below 1,000 Hz, peaking at 10-50 Hz) and continuous, varying by vessel type. Large vessels and barges emit noise levels between 177 to 200 dB re 1 μPa at 1 meter, while smaller crew vessels range from 150 to 180 dB re 1 μPa at 1 meter (BOEM 2023). This noise can mask communication signals of marine mammals and fish, causing stress and impairing foraging and predator responses. Noise reduction for support vessels can be achieved through retrofits, maintenance, and design changes, such as speed reduction and hull modifications. (SEER 2022).

The noise floating foundations can produce is dependent on the anchoring mechanism. Pile driving, albeit with smaller piles than fixed-bottom turbine monopiles, produce considerable more noise than suction bucket foundations or those that use suction caissons, drag, dead-weight, or embedded anchors (Horwath et al. 2020).

Environmental assessments for projects like Kincardine and Hywind Scotland found minor noise impacts on fish and marine mammals from FOWTs. The main noise concern comes from work vessels, as FOWTs lack solid foundations and monopiles (ABS 2021).

Considerations for PelaStar Design

- Quieter anchor installation options compatible with PelaStar system.
- The tendons are lighter and easier to handle than steel cable, which will reduce installation times and minimize noise emissions from vessels.

Additional Resources

- Acoustic study comparing porpoise detections near FOSW in Scotland, at both Kincardine and Hywind Scotland
    - Risch et al. 2023

3.2.6 Vessel Activity

Background

Vessel activity impacts the offshore environment primarily by introducing a potential for animal strikes and spills of oils or fuels. Impacts of vessel emissions on air quality is discussed in Section 3.2.1.

To mitigate potential impacts on whales, it's important to understand the overlap of transit routes with whale habitats, limit the number of vessels, and reduce vessel speeds. Reduced speeds lower collision-related whale mortality and trained marine mammal lookouts on vessels further reduce risks. Dynamic management tools like Whale Alert, WhaleWatch, and EcoCast help minimize impacts on sensitive species and could be adapted for the offshore wind sector (Maxwell et al. 2022).

Routine offshore wind development activities can affect water and sediment quality through vessel discharges and accidental oil spills, typically resulting in localized, short-term impacts (BOEM 2022).

Considerations for PelaStar Design

- PelaStar platforms can be transported to offshore wind farms using conventional U.S. ocean tugs.
- Construction-class multi-purpose support vessels will be used to deploy tendons and recover tooling.
- All necessary vessel types are currently available in the Jones Act fleet.
- Reduced installation times of tendons will minimize vessels use.

Additional Resources

- BOEM 2023 discusses the US Coast Guard Approaches of Maine, New Hampshire, and Massachusetts Port Access Route Study, which concluded that OSW may be one of several contributing factors in larger vessel classes, higher density of traffic, and displacement of some transit routes. It offers recommendations for additional shipping safety fairways
- BOEM and NOAA North Atlantic Right Whale and Offshore Wind Strategy (BOEM 2024)
    - Discusses vessel-based approaches for reducing the potential of marine mammal strikes, such as use of protected species observers, and vessel noise reduction

3.2.7 Wake Effects and Scour

Background

Offshore wind farms affect ocean hydrodynamics primarily in two ways: reducing wind speeds behind turbines (atmospheric wake effect) and inducing subsurface mixing via turbine substructures. These impacts are influenced by oceanic and atmospheric processes such as tides, stratification, and turbulence, and vary naturally (ACP 2023).

Changes in surface currents and sea surface temperatures from turbines are generally minor and have been hard to distinguish from natural variability in studies of European windfarms. Hydrodynamic impacts depend on factors like wind farm layout, turbine size, foundation type, and turbine spacing. Larger, more spaced-out turbines planned for U.S. wind farms are expected to have less hydrodynamic impact than smaller, closely spaced European turbines (ACP 2023).

Offshore wind farm development along the California coast may have an impact on the spatial distribution of coastal upwelling, due to the decreased wind stress on the sea surface caused by typical turbine layouts. Wind-driven upwelling, which transports nutrients from the deeper waters to the surface, leads to much of the primary productivity in the region (Raghukumat et al. 2023).

Wind farm foundations obstruct water flow from currents, tides, and waves, with the magnitude of wake effects proportional to foundation size. Spar floating foundations cause larger wake effects in surface water layers than semi-submersibles or TLPs; however, the multiple hulls may even out effects to be similar across types. Mooring lines of floating foundations create minimal wake effects in the water column (Horwath et al. 2020).

Embedded anchors for floating foundations have smaller profiles above the seabed compared to deadweight anchors, resulting in minimal wake effects, especially in deep waters with weak currents. Floating foundations, being in deep water, present minimal scour concerns, though anchor rodes can cause sediment disturbance similar to monopile foundations (Horwath et al. 2020).

Considerations for PelaStar Design

- PelaStar is compatible with several traditional and innovative high vertical load anchor designs. Anchors selected for a project will depend on the seabed conditions.

3.3 Affected Environment

Using BOEM's New York Bight Draft PEIS as a guide, this section compiles information and resources on the biological, socioeconomic, and physical resources that may be affected by development of offshore wind energy in the Gulf of Maine and along Northern California. These resources and the framework outlined can serve as a guide to prepare an environmental assessment, as needed, as the technology is advanced. An assessment will typically give a description of the local environment that could be affected, the potential impacts, and potential avoidance, minimization, mitigation, and monitoring (AMMM) measures that could be applied.

Table 8 follows the format of the Draft Tiering Guidance to list resources for describing the local affected environment in each of the focus regions, the potential impact producing factors (IPFs), and the potential AMMM measures in the context of the PelaStar platform and/or the larger FOSW project.

For background, BOEM’s New York Bight Draft PEIS is intended to be incorporated by reference into project-specific environmental analyses for individual COPs in that region and its Draft Tiering Guidance identifies additional analyses anticipated. BOEM is currently developing a Draft PEIS for central and northern California but has not announced similar plans for the Gulf of Maine yet. Although the New York Bight Draft PEIS is primarily focused on the development of fixed-bottom development, it provides useful information, resources, and insight into BOEM’s potential requirements for offshore wind development elsewhere in the United States.

Table 8: Guide for developing assessment of affected resources

Resource	Resources for Describing Affected Environment: *Gulf of Maine*	Resources for Describing Affected Environment: *Northern California*	Potential Impact Producing Factors	Potential Avoidance, Minimization, Mitigation, & Monitoring Measures
Physical Resources				
Air Quality & Greenhouse Gas Emissions	BOEM 2023	BOEM 2022	Emissions of criteria pollutants and greenhouse gases.	• Comply with EPA emission standards. • Use alternative fuels, or low or zero emission technology.
Water Quality	BOEM 2023	BOEM 2022	Sedimentation, sediment movement, changes to stratification or mixing patterns, or release of contaminants.	• Reduce potential for release of contaminants or spills. • Employ methods to minimize sediment disturbance.
Biological Resources				
Bats	Solick & Newman 2021	BOEM 2022 HT Harvey & Associates 2020	Habitat loss/modification, disturbance/displacement, collision/injury, prey impacts.	• Use best available technology. • Measures to adjust project design to minimize impacts on bat habitat.
Benthic Resources	BOEM 2023 Maine Coastal Mapping Initiative	BOEM 2022 Allen et al. 2006 Kaplan et al. 2010 HT Harvey & Associates 2020	Underwater noise and vibration, seabed and water column disturbance, and water quality impacts.	• Employ installation methods to minimize disturbance. • Develop anchor install plan. • Environmental monitoring.
Birds	BOEM 2023	BOEM 2022	Habitat loss/modification, disturbance/displacement, collision/injury, prey impacts, potential entanglement.	• Use bird perching deterrents. • Measures to adjust project design to minimize impacts on bird habitat.

Resource	Resources for Describing Affected Environment: Gulf of Maine	Resources for Describing Affected Environment: Northern California	Potential Impact Producing Factors	Potential Avoidance, Minimization, Mitigation, & Monitoring Measures
Coastal Habitat & Fauna	BOEM 2023 Kritzer et al. 2016 Stevenson et al. 2014	BOEM 2022 Jenkinson and Craig 2017 Lauermann and Rosen 2017 Mulligan et al. 2017 Shaughnessy et al. 2017	Habitat loss/modification, disturbance/displacement, and collision/injury.	• Use technology to minimize noise and other impacts. • Environmental monitoring.
Finfish, Invertebrates, & Essential Fish Habitat	BOEM 2023	BOEM 2022 Reeb & Schoeder 2022	Underwater noise and vibration, seabed and water column disturbance, water quality impacts.	• Implement measures to reduce noise during installation. • Incorporate ecological design elements where practical. • Employ methods to minimize sediment disturbance.
Marine Mammals	BOEM 2023 LaBrecque et al. 2015 Mapping Tool for BIA	BOEM 2022 Reeb & Schoeder 2022	Underwater noise, vessel collisions, entanglement risk, water quality impacts, prey impacts, habitat alterations.	• Implement best practices to reduce vessel collision risk. • Implement measures to reduce noise during installation. • Real- or near-real time monitoring to inform adaptive management. • Measures to reduce marine debris and entanglement.

Resource	Resources for Describing Affected Environment: Gulf of Maine	Resources for Describing Affected Environment: Northern California	Potential Impact Producing Factors	Potential Avoidance, Minimization, Mitigation, & Monitoring Measures
Sea Turtles	BOEM 2023	BOEM 2022	Underwater noise, vessel collisions, water quality impacts, seabed and water column disturbance/alteration, habitat alteration, prey impacts, and potential entanglement risk.	• Implement best practices to reduce vessel collision risk. • Implement measures to reduce noise. • Real- or near-real time monitoring to inform adaptive management. • Measures to reduce marine debris and entanglement.
Social Resources				
Commercial Fisheries & For-Hire Recreational Fisheries	BOEM 2023 Map of Aquaculture Leases	BOEM 2022 California Department of Fisheries and Wildlife 2020	Port and fishing access, loss of or damage to fishing gear, change in distribution of catch, social and cultural impacts, and shoreside business impacts.	• Implement a gear loss and damage compensation plan. • Implement fisheries mitigation to minimize risk of gear snags and plan to minimize space use conflicts with fisheries. • Contribute to a compensatory mitigation fund.
Cultural Resources	BOEM 2023	BOEM 2022 California Tribal List	Offshore seabed disturbance, onshore ground disturbance, viewshed disturbance and lighting.	• Establish and comply with marine cultural resource buffers. • Contribute to a compensatory mitigation fund.

Resource	Resources for Describing Affected Environment: Gulf of Maine	Resources for Describing Affected Environment: Northern California	Potential Impact Producing Factors	Potential Avoidance, Minimization, Mitigation, & Monitoring Measures
Demographics, Employment, & Economics	The Island Institute (2016) *American Community Survey Five-Year Estimates* (NOAA data)	BOEM 2022	Impacts on particular demographic and employment sectors.	• No specific measures.
Environmental Justice	The Island Institute (2016)	BOEM 2022	Public health and safety impacts, changes in economy, job or income losses, access to public spaces, impacts on culture and identity.	• Contribute to an environmental justice communications plan. • Contribute to an environmental justice mitigation resources plan. • Contribute to a compensatory mitigation fund.
Navigation & Vessel Traffic	BOEM 2023	BOEM 2022	Vessel damage due to incident, navigation risk, port expansion and congestion, and increased traffic.	• Use AIS transponder signals to mark structures for navigators. • Use avoidance measures that minimize navigation hazards. • Increasing spacing between structures. • Communicating effectively with affected entities
Other Uses (Marine Minerals, Military Use, Aviation, Surveys)	BOEM 2023	California State Lands Commission, 2024	Changes in access and use of ocean spaces by other users.	• Operational modifications, coordination, and/or mitigation agreements.

Resource	Resources for Describing Affected Environment: *Gulf of Maine*	Resources for Describing Affected Environment: *Northern California*	Potential Impact Producing Factors	Potential Avoidance, Minimization, Mitigation, & Monitoring Measures
Recreation & Tourism	BOEM 2023 Northeast Regional Planning Body, 2016	BOEM 2022	Changes to recreation and tourism access and opportunity.	• Schedule installation activities to avoid tourist seasons. • Use of equipment and best practices to reduce noise.

3.4 Fisheries Co-Use Considerations

The growth of offshore wind development is anticipated to alter access to fishing areas, lead to space-use conflicts, and cause the displacement and redistribution of fisheries. The displacement of fishing efforts and spatial competition may affect commercial and recreational fisheries to varying extents. Additionally, offshore wind projects will impact ongoing scientific surveys essential for managing commercial fisheries, increasing uncertainty in stock assessments and negatively affecting U.S. fisheries stakeholders. (NOAA 2023).

Co-use (also known as co-location or co-existence) refers to the concept that two activities, such as fisheries and offshore wind, can simultaneously and/or cohabit the same space. These activities are actively managed together to share maritime space effectively (Stelzenmüller et al. 2020). In Europe, research has investigated the potential for co-locating offshore wind farms and fishing activities. For instance, the coexistence of crab and lobster fishing with offshore wind development might be feasible, though it is crucial to consider site-specific attitudes and issues. (Hooper et al. 2015; Haggett et al. 2020; NOAA 2023).

As new activities are introduced into an area, if they cannot coexist, one will be displaced. Consequently, fisheries unable to coexist in the same spatial-temporal context will experience effort displacement. Similarly, the construction of wind turbines could temporarily displace fishing activities. Various fisheries already coexist (e.g., fixed and mobile gear), with different gear types generally adhering to established spatial and seasonal restrictions to minimize interactions with other gear types, marine mammals, and essential fish habitats. Offshore wind represents a new static use that may disrupt these patterns and heighten conflicts between fisheries. (NOAA 2023).

Onshore co-use

Fisheries and offshore wind development will need to coexist not only offshore but also onshore, particularly within ports, where they will share or compete for coastal space and infrastructure. The business ecosystem in New England fishing ports includes a range of businesses that support commercial and recreational fisheries. Many of these businesses depend on or are enhanced by their waterfront locations, which are now under pressure due to high demand and rising property values. Increased competition for these properties from the offshore wind industry could jeopardize the ability of these support businesses and services to maintain their critical presence. These indirect effects will also threaten the viability of fishing businesses in these ports, especially in small fishing ports and among owner-operator fishing operations. (NOAA 2023).

Perspectives of fishing communities

Fishermen have collaborated with the offshore wind industry to understand operational needs, such as appropriate cable burial depths for the scallop and clam industries. However, fishermen, particularly those from mobile gear fisheries like trawlers, have conveyed through public meetings, research interviews, and collaborative efforts that they will not be able to operate safely within wind farm areas, especially under varying sea state conditions. Maintaining the viability of fishing businesses and their support infrastructure, particularly small owner-operator fishing operations, is a significant concern for the industry. All the research needs outlined in this section would greatly benefit from collaborating with fishermen and utilizing their knowledge to address data gaps. (NOAA 2023).

Mitigation measures

To reduce mooring system footprints and address challenges related to fishing coexistence, the University of Maine has focused on taut and semi-taut mooring configurations for its VolturnUS platform design. An analysis by the National Renewable Energy Laboratory (NREL) of the University of Maine's semi-taut configurations indicates that these mooring systems can reduce the mooring system footprint diameter by approximately 50% compared to catenary configurations, with negligible changes to the overall system cost. Discussions with commercial fisheries participants and organizations suggest that the footprint reduction modestly increases the perceived accessibility and acceptability of a floating wind farm in the Gulf of Maine. However, many questions and concerns about these interactions remain, potentially providing topics for future research at NEAV and MeRA (Green et al. 2023).

Table 9: Methods to enhance fisheries co-use

Methods	References
Marine Spatial Planning and Adaptive Management: Marine spatial planning is the process of managing multiple ocean uses and promotes collaborative planning among multiple ocean users. Marine spatial plans are not one size fits all, and will require an adaptive management approach as motivations, goals, and outcomes shift.	Schupp et al. 2019 Spijkerboer et al. 2020 Dupont et al. 2020
Co-location: The successful co-location of fisheries and offshore wind farms requires ecological and feasibility research, safety and insurance clarity and cooperation between all parties to identify balanced tradeoffs.	Bonsu et al. 2024 Stelzenmüller et al. 2021
Co-design: Collaboration with fisheries to co-design wind structures and/or configurations of wind farms that allow for coexistence with fisheries. Requires information gathering through fishery interviews.	NREL 2023
Stakeholder Discussion and Working Group: Stakeholders are shown presentations including project background and then walked through a series of discussion questions to gather feedback. Stakeholders included commercial fishers, fisheries regulators, and other marine users. Working groups can be made with diverse set of stakeholders to avoid, minimize, and mitigate potential impacts of wind projects.	Green et al. 2023 Musial et al. 2023 Wever et al. 2015
Fishing Trials: Fishing trials were completed in Hywind Scotland floating wind farm to determine fishing success and gear operation within a wind farm area. This trial can be completed at other wind farms and will inform which types of fisheries can coexist with offshore wind.	Wright et al. 2023
Socioeconomic and Sociocultural Indicators: Using data gathered through communication with fishery stakeholders, important fishery indicators in OWF areas can be identified. These indicators should be monitored both pre- and post-construction to determine impact. Examples of indicators include total catch, time at sea, and catch quality. Prioritizing critical indicators allows for identification of	Willis-Norton et al. 2024

mitigation measures and shows stakeholders an understanding for their concerns.	
Survey Mitigation: Address adverse impacts caused by wind energy development on core recurring scientific surveys. Evaluate existing survey designs and identify and develop new survey approaches. Leverage wind energy monitoring to fill regional scientific survey data needs.	NOAA 2022 NOAA 2023

Table 10: Examples of fisheries co-use, from Bonsu et al. 2024

Table 3

Current co-locations practices in the Greater North Sea, including safety distances and restrictions, environmental assessments, fisheries compensations and insurances, as well as cases of co-location implementation.

Country	Operational Safety Distances and Permissions	Assessments related to fisheries and sector participation	Fisheries compensations	Fisheries Examples
UK	1. No mandatory safety zones during operation 2. Developer may apply for 50 m permanent safety zone around each structure 3. Conditional fishing over export cables (based on individual agreements with offshore developers)	1. SEA with fishing and changes to fish community, damage to benthic species, fish /marine mammal sensitivity to disturbances and contamination 2. Considerations for fisheries sector overlaps, impacts and conflicts (SEA) 3. EIA includes sustainability appraisal and formal consultations with fishers for data and identification of mitigation measures	1. Compensations after all residual impacts have not been avoided 2. Compensations related to offshore fouling that may impact fisheries	Dredging and Demersal Otter Trawl of Scallops at East (Moray Firth OWD) European lobster fisheries in Westermost Rough
Sweden	1. No mandatory safety zones 2. Developer may apply for a 50 m exclusion zone around each wind farm (current practice)	1. SEA and Sustainability assessment based on MSP and Swedish Environmental Code 2. EIA on environmental impacts including feedback/recommendations on impact mitigation on fisheries through non-statutory contacts between fisheries originations and developers	1. Negotiated compensations for fisheries in areas of assumed loss of income	
Denmark	1. No mandatory safety zones 2. 'Cable protection zones' covering entire wind farm area and 200 m buffer along each side of export cable 3. Conditional bottom trawling along cable lines based on defined agreements	1. SEA as defined within MSP 2. EIA of predetermined sites including worst-case scenarios and cumulative impacts including on commercial fisheries	1. Monetary and non-monetary compensations 2. Negotiated compensations for documented permanent or temporal losses at different OW life cycle	1. Bottom trawling over export cables connecting Horns Rev 2 offshore and Danish Westcoast
Belgium	1. No defined safety zones 2. Conditional passive gears may be permitted	1. SEA as described in the MSFD 2. EIS submitted by application to MUMM and further EIA on sectors and ecology, including fisheries	1. No compensations apply	1. Passive gear fisheries in Noordhinder North & South
Germany	1. 150 m from the outer buffer during operation to allow for passive fisheries 2. Transit of smaller fishing vessels, subject to weather conditions and restricted top speed	1. SEA as defined within MSP 2. EIA according to BSH and based on SEA to include likely significant impacts on fish and measures to avoid, mitigate and compensate	1. No direct compensations apply 2. Wind Energy Act allocates 5% of funds from offshore bids to support environmentally friendly fishing	1. 2cases of passive fisheries within OWF near Helgoland
Norway	1. No defined safety zones 2. May be up to 500 m (decided by the Norwegian Coastal Association (NCA) 3. Fishing allowed in cable areas with close cooperation between cable owners and fishers.	1. SEA and SIA on all planned activities as defined by MSP and offshore energy act 2. Specific assessment on fisheries impact (SIA) (exemption for pilot projects) 3. EIA on fisheries impact mitigation measures during construction and operation	1. Compensations for economic losses due to seizure of grounds 2. Compensations for lost fishing time due to longer distances or damage to objects if recorded and brought ashore	1. Trawling by Shrimp fisheries along cable lines
Netherlands	1. 'Passport areas' (500 m around each wind farm area for 2nd generations of wind farms) 2. 250 m fisheries multi use safety zone around monopiles and both sides of infield cables and export cables 3. Experimental passive gear fisheries in spaces between safety zones 4. Transit of vessels allowed when bottom-disturbing gear is visible above waterline	1. SEA based on MSP and National Environmental Management Act 2. SEA includes considerations for fishery ground preservation & impact on fish 3. EIA including environmental impact on fish and marine mammals (noise mitigation) during development phase 4. EIA includes socio-economic and safety impact on fisheries during construction and operationalization	1. Conditional compensations based on appeal related to experienced adverse effects from another lawful use if losses extend beyond normal risk	1. Opening of OWEZ, Amalia and Luchterduinen wind farms for transit for vessels up to 24 m and for sport hand line fisheries and (experimental) pot fisheries. 2. Experimental pot fisheries in OWF plot Borsselle II (Rozemeijer et al., 2023 in prep)

Limitations to Co-Use

The following excerpt from ABS 2021 describes their findings on the limitations to co-use practices

> *ABS (2021) reviewed available fishing impact information from existing floating offshore wind projects to determine how a floating offshore wind site in the OCS would potentially impact U.S. fishing activities. The review included EAs from four existing European farms and published information on the Fukushima FORWARD project in Japan. Three of the European projects, Kincardine (2015), Hywind Scotland (Statoil, 2015), and Dounreay (2016), are in the United Kingdom, while the fourth, Hywind Tampen, is in Norway (Equinor, 2019).*
>
> *The common fishing impacts found in the floating offshore wind project assessments are that certain fishing activities would need to be excluded from the vicinity of the floating wind farm site due to FOWTs posing a collision/allision risk to fishing vessels, fishing gear snagging on mooring lines and dynamic power cables floating in the water, and distances between turbines prohibiting larger vessels from entering and certain fishing techniques from being performed.*
>
> *The Kincardine EA (Kincardine, 2016) recommends a fishing exclusion zone of 500 meters around the FOWT site during the O&M phase, finding that fishing activities, particularly those involving towing gear, cannot operate safely in the area of the turbines.*
>
> *The Hywind Scotland EA (Statoil, 2015) found, as the Kincardine assessment did, that the primary risks during the O&M phase of the FOWT lifecycle are mid-water mooring lines and inter-array cables posing a snagging risk. The Hywind Scotland EA recommended a fishing exclusion zone of 500 meters around the FOWT vicinity, judging snagging risks is sufficiently high that fishing activities cannot be conducted safely. During O&M, however, fishing vessels are expected to be able to operate in the export cable corridor, particularly if those cables are buried and made to be over-trawlable.*
>
> *The Dounreay EA (Dounreay, 2016) supported the findings found in the Kincardine and Hywind Scotland assessments that mooring lines and inter-array cables pose a serious snagging risk to fishing gear. Fishing activity is recommended to be excluded from the immediate 500 meters around the FOWT site with no exclusion in the export cable corridor.*
>
> *The Hywind Tampen (Equinor, 2019) impact assessment recommended during the O&M phase, fishing in and around the FOWT site using bottom trawl, purse seine, and other bottom-dragging fishing gear to be excluded with a 500-meter safety zone around the site. The developer will design the anchors around the outside of the FOWT site to be over trawlable as they will be located beyond 500 meters from the FOWTs.*
>
> *The Fukushima FORWARD project information (Fukushima Offshore Wind Consortium, n.d.) does not address current fishing practices but provides mitigation strategies for fishing in FOWT sites. The project organized a committee of government and fishermen's union members to study the impact on the sea and fishery operations around the project after the installation of FOWT and investigate new fishing methods for future collaboration between the FOWT industry and fishing industry. The research included using remote operated vehicles to observe fish around FOWT structures and moorings. The new methods include marine farming, marine fertilization and culture raft, artificial reefs, and providing real-time information from equipment on FOWT to the fishing industry.*

4.0 Bibliography

ABS. 2021. “Floating Offshore Wind Turbine Development Assessment.” Final Report and Technical Summary. Report for the Bureau of Ocean Energy Management. https://www.boem.gov/sites/default/files/documents/renewable-energy/studies/Study-Number-Deliverable-4-Final-Report-Technical-Summary.pdf.

Aldieri, Luigi, Jonas Grafström, Kristoffer Sundström, and Concetto Paolo Vinci. 2019. "Wind Power and Job Creation." Sustainability 12 (1): 45. https://dx.doi.org/10.3390/su12010045.

Alem, Mariel, Timo Herberz, Vishnu Sankar Karanayil, and Ahmed Ashfaque Hamid Fardin. 2020. "Qualitative meta-analysis of the socioeconomic impacts of offshore wind farms." Sustinere: Journal of Environment and Sustainability 4 (3): 155-171. https://dx.doi.org/10.22515/sustinere.jes.v4i3.121.

Allan, Grant, David Comerford, Kevin Connolly, Peter McGregor, and Andrew G Ross. 2020. "The economic and environmental impacts of UK offshore wind development: The importance of local content." Energy 199: 117436. https://doi.org/10.1016/j.energy.2020.117436.

American Clean Power (ACP). 2023. “Clean Energy Career Pathways Catalog.” https://cleanpower.org/resources/clean-energy-career-pathways-catalog/.

American Clean Power (ACP). 2023. “Guidelines for Entry-Level Wind Technician Training.” https://cleanpower.org/wp-content/uploads/2023/05/ACP-Guidelines-for-Entry-Level-Wind-Technician-Training_Final.pdf.

American Clean Power (ACP). 2023. “Oceanographic Effects of Offshore Wind Structures and Their Potential Impacts on the North Atlantic Right Whale and Their Prey.” https://cleanpower.org/wp-content/uploads/gateway/2023/10/ACP_OSW-Hydrodynamics-and-NARW_Whitepaper_2023.pdf.

Bacchiocchi, Eana, Ingrid Sant, and Alison Bates. 2022. "Energy justice and the co-opting of indigenous narratives in U.S. offshore wind development." Renewable Energy Focus 41: 133-142. https://doi.org/https://doi.org/10.1016/j.ref.2022.02.008.

Bang, J.; Ma, C.; Tarantino, E.; Vela, A.; Yamane, D. (2019). Life Cycle Assessment of Greenhouse Gas Emissions for Floating Offshore Wind Energy in California. Report by University of California Santa Barbara. https://tethys.pnnl.gov/sites/default/files/publications/Bang-2019-Floating-Wind-LCA.pdf.

Benjamins, S.; Harnois, V.; Smith, H.; Johanning, L.; Greenhill, L.; Carter, C.; Wilson, B. 2014. “Understanding the Potential for Marine Megafauna Entanglement Risk from Marine Renewable Energy Developments.” Report by Scottish Natural Heritage. (Report No. 791). https://tethys.pnnl.gov/sites/default/files/publications/SNH-2014-Report791.pdf.

Bureau of Ocean Energy Management (BOEM). 2022. “Final Environmental Assessment: Commercial Wind Lease and Grant Issuance and Site Assessment Activities on the Pacific Outer Continental Shelf Humboldt Wind Energy Area, California.” https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/Humboldt-EA.pdf.

Bureau of Ocean Energy Management (BOEM). 2023. “Wind Energy Research Lease on the Atlantic Outer Continental Shelf.” Environmental Assessment. https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/GoME-RL-EA.pdf.

California State Lands Commission. 2021. “Draft Preliminary Environmental Assessment: Vandenberg Offshore Wind Energy Projects.” Report by California State Lands Commission. https://tethys.pnnl.gov/sites/default/files/publications/Vandenberg-Offshore-Wind-Draft-PEA.pdf

Castello Branco Livi, Bruna, Rachel Wilczek Rodrigues, Fabio Batista, and Paula Macaira. 2022. "Economic Analysis of Offshore Wind Farms: a Brazilian Case Study." IEEE Latin America Transactions 20 (1): 32-40. https://dx.doi.org/10.1109/tla.2022.9662171.

Columbia Law School. n.d. “Community Benefits Agreement Database.” Accessed February 16, 2024. https://climate.law.columbia.edu/content/community-benefits-agreements-database.

de Groot, Jiska, Maria Campbell, Matthew Ashley, and Lynda Rodwell. 2014. "Investigating the co-existence of fisheries and offshore renewable energy in the UK: Identification of a mitigation agenda for fishing effort displacement." Ocean & Coastal Management 102: 7-18. https://doi.org/10.1016/j.ocecoaman.2014.08.013.

Ferraz de Paula, L.; Carmo, B.S. Environmental Impact Assessment and Life Cycle Assessment for a Deep Water Floating Offshore Wind Turbine on the Brazilian Continental Shelf. Wind 2022, 2, 495–512. https://doi.org/10.3390/wind2030027.

Ferreira, Victor J., Gabriela Benveniste, José I. Rapha, Cristina Corchero, Jose Luis Domínguez-García. 2023. “A holistic tool to assess the cost and environmental performance of floating offshore wind farms.” Renewable Energy. 216:119079. https://doi.org/10.1016/j.renene.2023.119079.

Fine, Cordelia, Victor Sojo, and Holly Lawford-Smith. 2020. "Why Does Workplace Gender Diversity Matter? Justice, Organizational Benefits, and Policy." Social Issues and Policy Review 14 (1): 36-72. https://dx.doi.org/10.1111/sipr.12064.

Glasson, John, Bridget Durning, Kellie Welch, and Tokunbo Olorundami. 2022. "The local socio-economic impacts of offshore wind farms." Environmental Impact Assessment Review 95: 106783. https://dx.doi.org/10.1016/j.eiar.2022.106783.

Hall, Damon M., and Eli D. Lazarus. 2015. "Deep waters: Lessons from community meetings about offshore wind resource development in the U.S." Marine Policy 57: 9-17. https://www.sciencedirect.com/science/article/pii/S0308597X15000536.

Harnois, Violette, Helen C.M. Smith, Steven Benjamins, Lars Johanning. 2015. “Assessment of entanglement risk to marine megafauna due to offshore renewable energy mooring systems.” International Journal of Marine Energy. 11:27-49. https://doi.org/10.1016/j.ijome.2015.04.001.

Hoff, Katherine and Katie Segal. 2023. “Offshore Wind and Community Benefits Agreements in California.” June 2023. https://www.law.berkeley.edu/wp-content/uploads/2023/06/CBA-Policy-Paper.pdf.

Horwath, S.; Hassrick, J.; Grismala, R.; Diller, E. 2020. "Comparison of Environmental Effects from Different Offshore Wind Turbine Foundations" (Report No. OCS Study BOEM 2020-041). Report by ICF International. Report for US Department of the Interior (DOI). https://tethys.pnnl.gov/sites/default/files/publications/Wind-Turbine-Foundations-White-Paper-Final-White-Paper.pdf

Kochhar, Rakesh. 2023. "The Enduring Grip of the Gender Pay Gap." Pew Research Center. Published March 1, 2023. https://www.pewresearch.org/social-trends/2023/03/01/the-enduring-grip-of-the-gender-pay-gap/.

Ladenburg, Jacob, and Alex Dubgaard. 2007. "Willingness to pay for reduced visual disamenities from offshore wind farms in Denmark." Energy Policy 35 (8): 4059-4071. https://doi.org/10.1016/j.enpol.2007.01.023.

Ladenburg, Jacob, and Sanja Lutzeyer. 2012. "The economics of visual disamenity reductions of offshore wind farms—Review and suggestions from an emerging field." Renewable and Sustainable Energy Reviews 16 (9): 6793-6802. https://doi.org/10.1016/j.rser.2012.08.017.

Mackinson, S, H Curtis, R Brown, K McTaggart, N Taylor, S Neville, and S Rogers. 2006. "A report on the perceptions of the fishing industry into the potential socio-economic impacts of offshore wind energy developments on their work patterns and income." Science Series Technical Report-Centre for Environment Fisheries and Aquaculture Science 133. https://www.cefas.co.uk/publications/techrep/tech133.pdf.

Maxwell, Sarah M, Francine Kershaw, Cameron C. Locke, Melinda G. Conners, Cyndi Dawson, Sandy Aylesworth, Rebecca Loomis, Andrew F. Johnson. 2022. "Potential impacts of floating wind turbine technology for marine species and habitats." Journal of Environmental Management. 307:114577. https://doi.org/10.1016/j.jenvman.2022.114577

National Renewable Energy Laboratory. Jobs and Economic Development Impact Modeling Tool. https://www.nrel.gov/analysis/jedi/.

New Jersey Economic Development Authority. 2022." New Jersey's Offshore Wind Workforce Assessment Through 2035." https://www.njeda.gov/wp-content/uploads/2022/09/2022-NewJersey-OSW-Workforce-Assessment-Report.pdf.

Okkonen, Lasse, and Olli Lehtonen. 2016. "Socio-economic impacts of community wind power projects in Northern Scotland." Renewable Energy 85: 826-833. https://doi.org/10.1016/j.renene.2015.07.047.

Ortega-Izquierdo, Margarita, and Pablo del Río. 2020. "An analysis of the socioeconomic and environmental benefits of wind energy deployment in Europe." Renewable Energy 160: 1067-1080. https://doi.org/10.1016/j.renene.2020.06.133.

OSC. 2022. "Literature review on barrier effects, ghost fishing, and electromagnetic field for floating windfarms." Literature Review No. 1 for Equinor ASA. https://cdn.equinor.com/files/h61q9gi9/global/434c3452ed651ae8ac9d256794981145ce942334.pdf?osc-study-floating-windfarms-2022-equinor.pdf

Raghukumar, K., Nelson, T., Jacox, M., Chartrand, C., Fiechter, J., Chang, G., Cheung, L., Roberts, J. 2023. "Projected cross-shore changes in upwelling induced by offshore wind farm development along the California coast.” Communications Earth & Environment. 4:116. https://doi.org/10.1038/s43247-023-00780-y.

Reilly, Kieran, Anne Marie O’Hagan, and Gordon Dalton. 2015. "Attitudes and perceptions of fishermen on the island of Ireland towards the development of marine renewable energy projects." Marine Policy 58: 88-97. https://doi.org/https://doi.org/10.1016/j.marpol.2015.04.001.

Reimers, Britta, Burcu Özdirik, Martin Kaltschmitt. 2014. “Greenhouse gas emissions from electricity generated by offshore wind farms.” Renewable Energy. 72:428-438. https://doi.org/10.1016/j.renene.2014.07.023

Schallenberg-Rodriguez, J, and F Inchausti-Sintes. 2021. "Socio-economic impact of a 200 MW floating wind farm in Gran Canaria." Renewable and Sustainable Energy Reviews 148: 111242. https://doi.org/10.1016/j.rser.2021.111242.

SEER (U.S. Offshore Wind Synthesis of Environmental Effects Research). 2022. “Environmental Effects of U.S. Offshore Wind Energy Development: Compilation of Educational Research Briefs [Booklet].” Report by National Renewable Energy Laboratory and Pacific Northwest National Laboratory for the U.S. Department of Energy, Wind Energy Technologies Office. https://tethys.pnnl.gov/sites/default/files/summaries/SEER-Booklet.pdf

Stefek, Jeremy, Corrie Christol, Tony R. Smith, Matthew Kotarbinski, Brinn McDowell. 2022. “Defining the Wind Energy Workforce Gap.” National Renewable Energy Laboratory. NREL/TP-5000-82907. https://www.nrel.gov/docs/fy23osti/82907.pdf.

Stelzenmüller, Vanessa, Antje Gimpel, Holger Haslob, Jonas Letschert, Jörg Berkenhagen, and Simone Brüning. 2021. "Sustainable co-location solutions for offshore wind farms and fisheries need to account for socio-ecological trade-offs." Science of The Total Environment 776: 145918. https://doi.org/10.1016/j.scitotenv.2021.145918.

TRC. 2023. “Maryland Offshore Wind Construction and Operations Plan. Appendix C: Air Quality Emissions Calculations.” Report for US Wind. https://tethys.pnnl.gov/sites/default/files/publications/USWIND-COP-Vol-1.pdf

Tsai, Liang, Jarod C. Kelly, Bretty S. Simon, Rachel M. Chalat, and Gregory A. Keoleaian. 2016. “Life Cycle Assessment of Offshore Wind Farm Siting: Effects of Locational Factors, Lake Depth, and Distance from Shore.” Journal of Industrial Ecology. 20 (6): 1370-1383. https://doi.org/10.1111/jiec.12400

U.S. Department of Energy. 2023. "Offshore Wind Energy Workforce Development Best Practices Resource." Office of Energy Efficiency and Renewable Energy Wind Energy Technologies Office: WINDExchange. https://windexchange.energy.gov/offshore-workforce-best-practices.

U.S. Department of Energy. 2023. "Offshore Wind Workforce Safety Standards & Training Resource" Office of Energy Efficiency and Renewable Energy Wind Energy Technologies Office: WINDExchange. https://windexchange.energy.gov/offshore-workforce-safety-training.

U.S. Department of Energy. n.d. "Wind Energy Education and Training Programs" Office of Energy Efficiency and Renewable Energy Wind Energy Technologies Office: WINDExchange. https://windexchange.energy.gov/training-programs.

U.S. Department of Energy. n.d. "Education and Training Database." Last updated December 11, 2023. https://openei.org/wiki/Offshore_Wind_Workforce/Education_and_Training_Database.

UK Offshore Wind Industry Council. 2023. "Offshore Wind Skills Intelligence Report." https://www.owic.org.uk/_files/ugd/1c0521_94c1d5e74ec14b59afc44cebe2960f62.pdf.

UN Women. 2016. "Tackling the Gender Pay Gap from Individual Choices to Institutional Change." https://www.unwomen.org/sites/default/files/Headquarters/Attachments/Sections/Library/Publications/2016/UN-Women-Policy-brief-06-Tackling-the-gender-pay-gap-en.pdf.

Appendix A – Additional Resources

Workforce Development

- General Resources
  - American Clean Power - Clean Energy Career Pathways Catalog: Offshore Wind Energy
  - BW Research Partnership - New York State Offshore Wind Workforce Skills Analysis, 2022
  - National Renewable Energy Laboratory - U.S. Offshore Wind Workforce Assessment
  - Fisheries Impacts
    - Chaji, Marina, and Samantha Werner. 2023. "Economic Impacts of Offshore Wind Farms on Fishing Industries: Perspectives, Methods, and Knowledge Gaps." Marine and Coastal Fisheries 15 (3). https://dx.doi.org/10.1002/mcf2.10237
  - Human Health Impacts
    - Li, Zheng, and Bohan Jin. 2024. "A breath of fresh air: Coal power plant closures and health in China." Energy Economics 129: 107235. https://dx.doi.org/10.1016/j.eneco.2023.107235.
    - Yang, Muzhe, and Shin-Yi Chou. 2018. "The impact of environmental regulation on fetal health: Evidence from the shutdown of a coal-fired power plant located upwind of New Jersey." Journal of Environmental Economics and Management 90: 269-293. https://dx.doi.org/10.1016/j.jeem.2018.05.005
  - Mauritzen, J. 2018. "The effect of wind power investments on rural labor markets." BI Norwegian Business School. January 15, 2018. https://jmaurit.github.io/research/wind_dev.pdf.
- California Resources
  - American Jobs Project - The California Offshore Wind Project: A Vision for Industry Growth
  - Center for Labor Research and Education, University of California, Berkeley - California Offshore Wind: Workforce Impacts and Grid Integration
  - National Renewable Energy Laboratory - Floating Offshore Wind in California: Gross Potential for Jobs and Economic Impacts from Two Future Scenarios
- Maine Resources

- BW Research Partnership - Maine Offshore Wind Talent Analysis

Environmental and Co-Use

- BOEM Resources
  - Gulf of Maine Environmental Studies Overview
  - Environmental Studies for Protected Species and Offshore Wind
  - Northeast Ocean Data Portal
  - Atlantic Marine Assessment Program for Protected Species (AMAPPS)
  - Gulf of Maine Data Inventory
  - Information Needed for Issuance of a Notice of Intent (NOI) Under the National Environmental Policy Act (NEPA) for a Construction and Operations Plan (COP)
  - Vulnerability Index to Scale Effects of Offshore Renewable Energy on Marine Mammals and Sea Turtles Off the U.S. West Coast (VIMMS)
  - A Wind Energy Area Siting Analysis for the Gulf of Maine Call Area (Randall et al. 2023)
- Other Federal Resources
  - Congressional Research Service (CRS): Potential Impacts of Offshore Wind on the Marine Ecosystem and Associated Species: Background and Issues for Congress
  - United States Coast Guard Pacific Coast Port Access Route Study
- Tethys/SEER Resources
  - Pacific Coast Offshore Wind Environmental Research Project Finder
  - Pacific & Atlantic Coast Offshore Wind Environmental Research Recommendations
  - Environmental Effects of U.S. Offshore Wind Energy Development: Compilation of Educational Research Briefs (SEER 2022)
- Data Portals
  - NOAA IOOS Regional Data Portals
    - California Ocean Observing Systems Data Portal
    - Northeast Atlantic (NERACOOS)
  - Data Basin
    - California Offshore Wind Energy Gateway
    - Ocean Uses in California
    - NOAA New Hampshire/Southern Maine Ocean Uses Atlas
  - Gulf of Maine Ocean Data Products
- California Regulatory Resources
  - California Coastal Commission
  - California Natural Resources Agency
  - State Water Resources Control Board
  - California Department of Fish and Wildlife
    - Scientific Collection Permit
  - California State Lands Commission
  - Humboldt Bay Harbor, Recreation, and Conservation Ordinances
- Misc. Documents
  - Vandenberg Offshore Wind Projects PEA (CSLC 2021)
  - Final Technical Report: New England Aqua Ventus I Hull Design (University of Maine 2023)
  - Kitty Hawk Wind: Construction and Operations Plan – Appendix FF – Summary of Applicant-Proposed Avoidance, Minimization, and Mitigation Measures

Appendix B – Protected & Enlisted Species

See BOEM 2022 for an overview of species, including endangered and threatened species, present in the Humboldt region, and BOEM 2023 for an overview of species in the Gulf of Maine. These and other resources include summary tables including the following tables.

Table 3-3: Protected Marine Mammal and Sea Turtle Species Expected to Occur in the Project Area

Baleen Whales

Common Name	Scientific Name	Stock	ESA/MMPA Status	Occurrence
Blue whale[1]	*Balaenoptera musculus*	Eastern North Pacific	Endangered/Depleted	Late summer and fall
Fin whale[1]	*Balaenoptera physalus*	California, Oregon, and Washington	Endangered/Depleted	Year round
Sei whale[1]	*Balaenoptera borealis*	Eastern North Pacific	Endangered/Depleted	Uncommon
Minke whale[1]	*Balaenoptera acutorostrata*	California, Oregon, and Washington	-	Occasional
North Pacific right whale	*Eubalaena japonica*	-	Endangered	Uncommon
Humpback whale	*Megaptera novaeangliae*	Central America DPS	Endangered	Spring to fall
Humpback whale	*Megaptera novaeangliae*	Mexico DPS	Threatened	Spring to fall
Gray whale[1]	*Eschrichtius robustus*	Eastern North Pacific	-	Oct–Jan and March–May
Gray whale[1]	*Eschrichtius robustus*	Western North Pacific	Endangered	Uncommon

Toothed and Beaked Whales

Common Name	Scientific Name	Stock	ESA/MMPA Status	Occurrence
Sperm whale[1]	*Physeter macrocephalus*	California, Oregon, and Washington	Endangered/Depleted	Year round
Killer whale	*Orcinus orca*	Eastern North Pacific Offshore	-	Sporadic
Killer whale – southern resident	*Orcinus orca*	Southern Resident	Endangered	Uncommon
Baird's beaked whale	*Berardius bairdii*	California, Oregon, and Washington	-	
Cuvier's beaked whale	*Ziphius cavirostris*	California, Oregon, and Washington	-	Uncommon
Mesoplodont beaked whale	*Mesoplodon spp.*	California, Oregon, and Washington	-	Sporadic
Risso's dolphin	*Grampus griseus*	California, Oregon, and Washington	-	Year round
Northern right whale dolphin	*Lissodelphis borealis*	California, Oregon, and Washington	-	Year round
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	California, Oregon, and Washington	-	Year round

Bottlenose dolphin	*Tursiops truncatus*	CA coastal	-	Year round
Short-beaked common dolphin	*Delphinus delphis*	California, Oregon, and Washington	-	Year round
Long-beaked common dolphin	*Delphinus capensis*	California	-	Year round
Dall's porpoise	*Phocoenoides dalli*	California, Oregon, and Washington	-	Year round
Harbor porpoise	*Phocoena phocoena*	Northern California/Southern Oregon		Late spring to early fall

Sea Lions and Seals

Common Name	Scientific Name	Stock	ESA/MMPA Status	Occurrence
Steller sea lion	*Eumetopias jubatus*	Eastern DPS	Delisted with critical habitat	Year round
California sea lion	*Zalophus californianus*	U.S. Stock	-	Year round
Northern elephant seal	*Mirounga angustirostris*	California	-	Year round
Harbor seal	*Phoca vitulina richardsi*	California	-	Year round
Guadalupe fur seal[1]	*Arctocephalus townsendi*	Throughout its range	Threatened	Spring/summer, seasonal low numbers

Table 3-5. Marine mammals that may occur within the Gulf of Maine and in the vicinity of the Proposed Action Activity Area

Common Name	Scientific Name	ESA/MMPA Status[1]	Relative Occurrence in the Proposed Action Activity Area[2]	Seasonal Occurrence in the Proposed Action Activity Area[3]	Critical Habitat in Area of Direct Effects	Stock (NMFS)	Population (Abundance) Estimate[4]	Population Trend[5]	Total Annual Human-Caused Mortality/ Serious Injury (M/SI)[6]	Reference
Mysticetes										
Blue whale	*Balaenoptera musculus*	E/D	Rare	Rare	N/A	Western North Atlantic	402[7]	Unknown	Unknown	Hayes et al. (2020)
Fin whale	*Balaenoptera physalus*	E/D	Common	Year-round (highest abundances mid-spring through mid-fall)	N/A	Western North Atlantic	6,802	Unknown	1.85	Hayes et al. (2022)
Humpback whale	*Megaptera novaeangliae*	None/N	Common	Year-round (highest abundances mid-spring through fall)	N/A	Gulf of Maine	1,396	+2.8% per year (2000 through 2016)	12.15	Hayes et al. (2020)
Minke whale	*Balaenoptera acutorostrata*	None/N	Common	Year-round (highest abundances mid-spring through mid-fall)	N/A	Canadian East Coast	21,968	Unknown	10.55	Hayes et al. (2022)
North Atlantic right whale	*Eubalaena glacialis*	E/D	Common	Year-round (highest abundances late fall through spring)	Yes[8]	Western North Atlantic	338	−29.7% overall (2011 through 2020)	8.1	NMFS 2023a
Sei whale	*Balaenoptera borealis*	E/D	Regular	Year-round (highest abundances late spring and mid-fall)	N/A	Nova Scotia	6,292	Unknown	0.80	Hayes et al. (2022)
Odontocetes										
Atlantic spotted dolphin	*Stenella frontalis*	None/N	Rare	Rare	N/A	Western North Atlantic	39,921	Decreasing	Presumed 0	Hayes et al. (2022)
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	None/N	Common	Year-round	N/A	Western North Atlantic	93,233	Unknown	27.2	Hayes et al. (2022)
Blainville's beaked whale	*Mesoplodon densirostris*	None/N	Rare	Rare	N/A	Western North Atlantic	10,107[9]	Unknown	0.2	Hayes et al. (2020)
Common bottlenose dolphin (offshore)	*Tursiops truncatus*	None/N	Uncommon	Summer	N/A	Western North Atlantic, Offshore	62,851	Unknown	28	Hayes et al. (2020)
Common dolphin	*Delphinius delphis*	None/N	Common	Summer through winter (highest abundances fall)	N/A	Western North Atlantic	172,974	Unknown	390.4	Hayes et al. (2022)
Cuvier's beaked whale	*Ziphius cavirostris*	None/N	Rare	Rare	N/A	Western North Atlantic	5,744	Unknown	0.2	Hayes et al. (2020)
Dwarf sperm whale	*Kogia sima*	None/N	Rare	Rare	N/A	Western North Atlantic	7,750[10]	Unknown	Presumed 0	Hayes et al. (2020)
Gervais' beaked whale	*Mesoplodon europaeus*	None/N	Rare	Rare	N/A	Western North Atlantic	10,107[9]	Unknown	0	Hayes et al. (2020)

Harbor porpoise	*Phocoena phocoena*	None/N	Common	Year-round	N/A	Gulf of Maine, Bay of Fundy	95,543	Unknown	163	Hayes et al. (2022)
Killer whale	*Orcinus orca*	None/N	Rare	Rare	N/A	Western North Atlantic	Unknown	Unknown	Unknown	Waring et al. (2015)
Long-finned pilot whale	*Globicephala melas*	None/N	Regular	Late spring through fall	N/A	Western North Atlantic	39,215	Unknown	9	Hayes et al. (2022)
Northern bottlenose whale	*Hyperodon ampullatus*	None/N	Rare	Rare	N/A	Western North Atlantic	Unknown	Unknown	Presumed 0	Waring et al. (2015)
Pygmy sperm whale	*Kogia breviceps*	None/N	Rare	Rare	N/A	Western North Atlantic	7,750[10]	Unknown	Presumed 0	Hayes et al. (2020)
Risso's dolphin	*Grampus griseus*	None/N	Rare	Late fall through early winter	N/A	Western North Atlantic	35,215	Unknown	34	Hayes et al. (2022)
Short-finned pilot whale	*Globicephala macrorhynchus*	None/N	Rare	Rare	N/A	Western North Atlantic	28,924	Unknown	136	Hayes et al. (2022)
Sowerby's beaked whale	*Mesoplodon bidens*	None/N	Rare	Rare	N/A	Western North Atlantic	10,107[9]	Unknown	0	Hayes et al. (2020)
Sperm whale	*Physeter macrocephalus*	E/D	Uncommon	Year-round (highest abundances summer through early fall)	N/A	North Atlantic	4,349	Unknown	0	Hayes et al. (2020)
Striped dolphin	*Stenella coeruleoalba*	None/N	Rare	Rare	N/A	Western North Atlantic	67,036	Unknown	0	Hayes et al. (2020)
True's beaked whale	*Mesoplodon mirus*	None/N	Rare	Rare	N/A	Western North Atlantic	10,107[9]	Unknown	0.2	Hayes et al. (2020)
White-beaked dolphin	*Lagenorhynchus albirostris*	None/N	Rare	Rare	N/A	Western North Atlantic	536,016	Unknown	0	Hayes et al. (2020)
Pinnipeds										
Gray seal	*Halichoerus grypus*	None/N	Common	Year-round (highest abundances summer through mid-fall)	N/A	Western North Atlantic	27,300	Increasing	4,452	Hayes et al. (2022)
Harbor seal	*Phoca vitulina*	None/N	Common	Year-round (highest abundances summer through mid-fall)	N/A	Western North Atlantic	61,336	Unknown	339	Hayes et al. (2022)
Harp seal	*Pagophilus groenlandicus*	None/N	Uncommon	Late winter, early spring	N/A	Western North Atlantic	Unknown[11]	Increasing	178,573	Hayes et al. (2022)
Hooded seal	*Cystophora cristata*	None/N	Rare	Rare	N/A	Western North Atlantic	593,500	Increasing	1,680	Hayes et al. (2019)

[1] This denotes the highest federal regulatory classification (16 U.S. Code 1531 et seq. and 16 U.S. Code 1361 et seq.). A strategic stock is defined as any marine mammal stock:
a. for which the level of direct human-caused mortality exceeds the PBR level;
b. that is declining and likely to be listed as threatened under the ESA; or
c. that is listed as threatened or endangered under the ESA or as depleted under the MMPA.

[2] Relative occurrence in the Proposed Action Activity Area is defined as:
Common: occurring consistently in moderate to large numbers

Appendix C – Maps

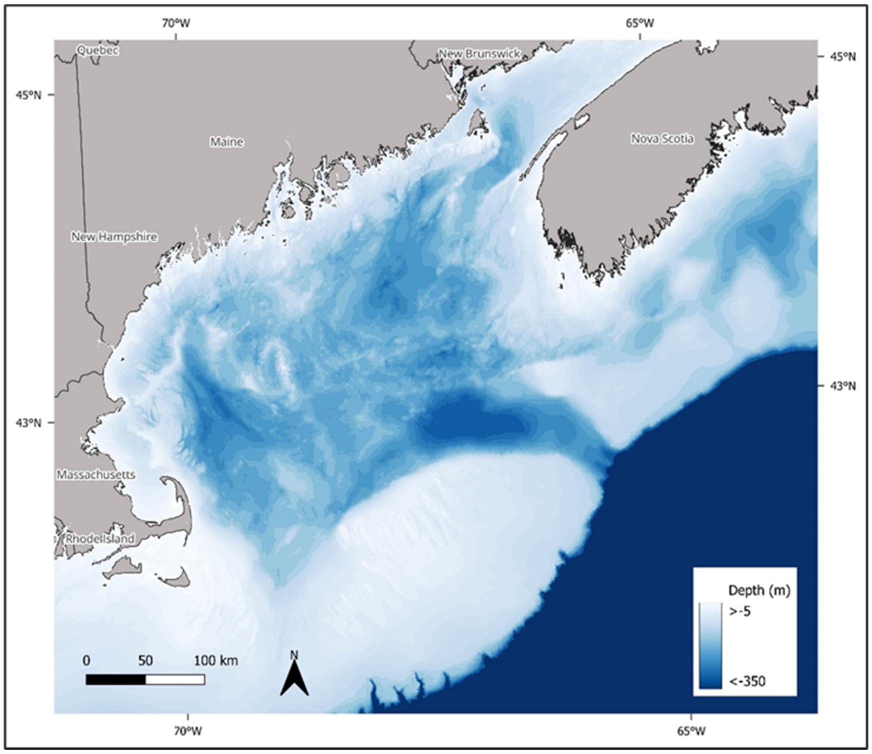

Figure 1. Bathymetry of the Gulf of Maine

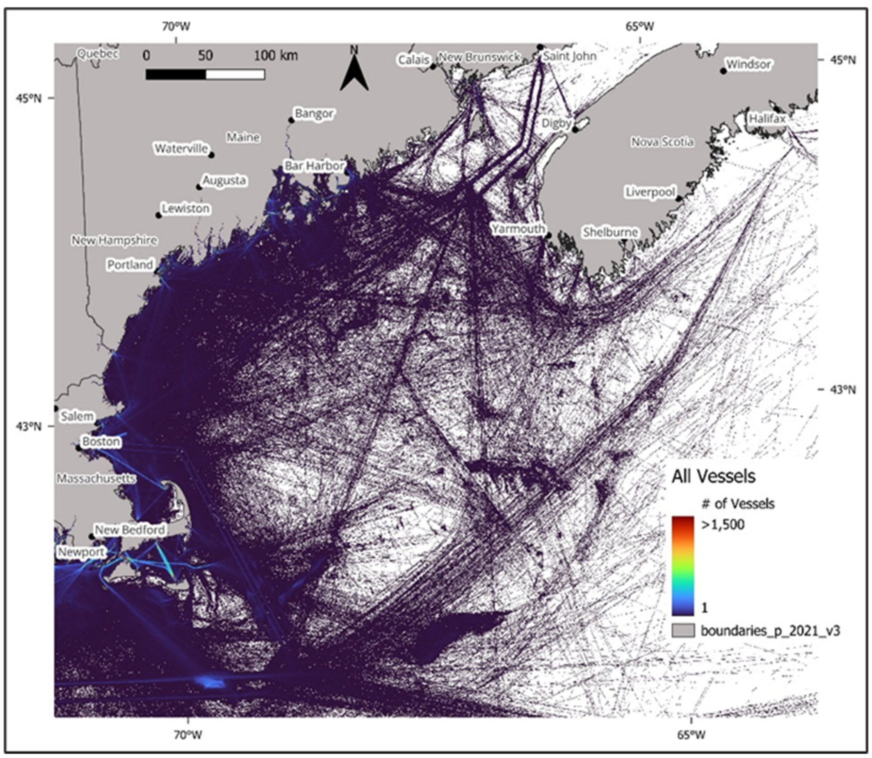

Figure 2. Vessels tracks in the Gulf of Maine (data from 2019).

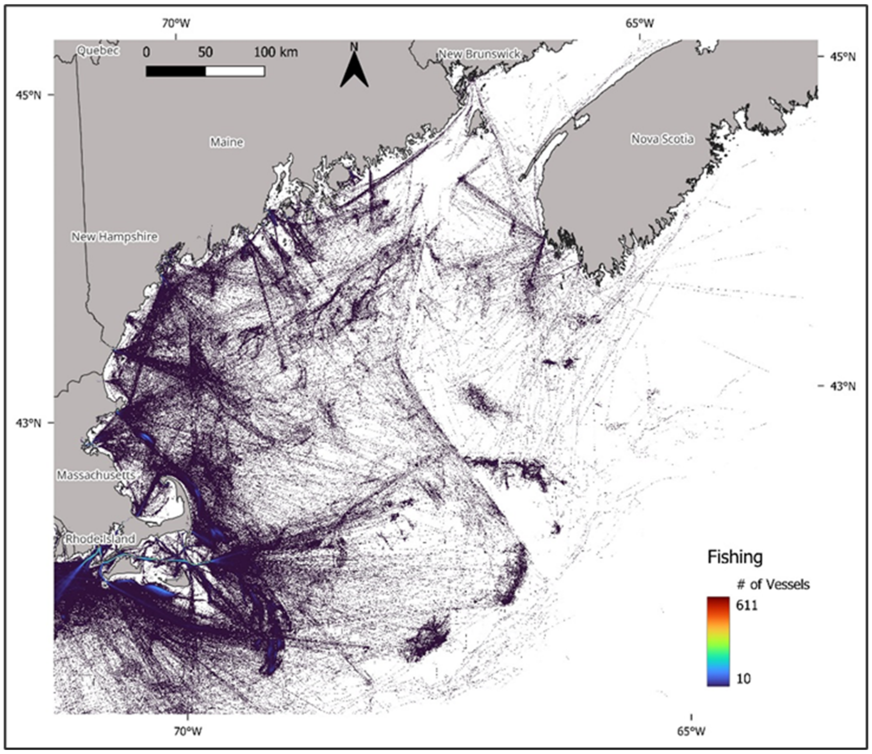

Figure 3. Fishing vessel tracks in the Gulf of Maine (data from 2019).

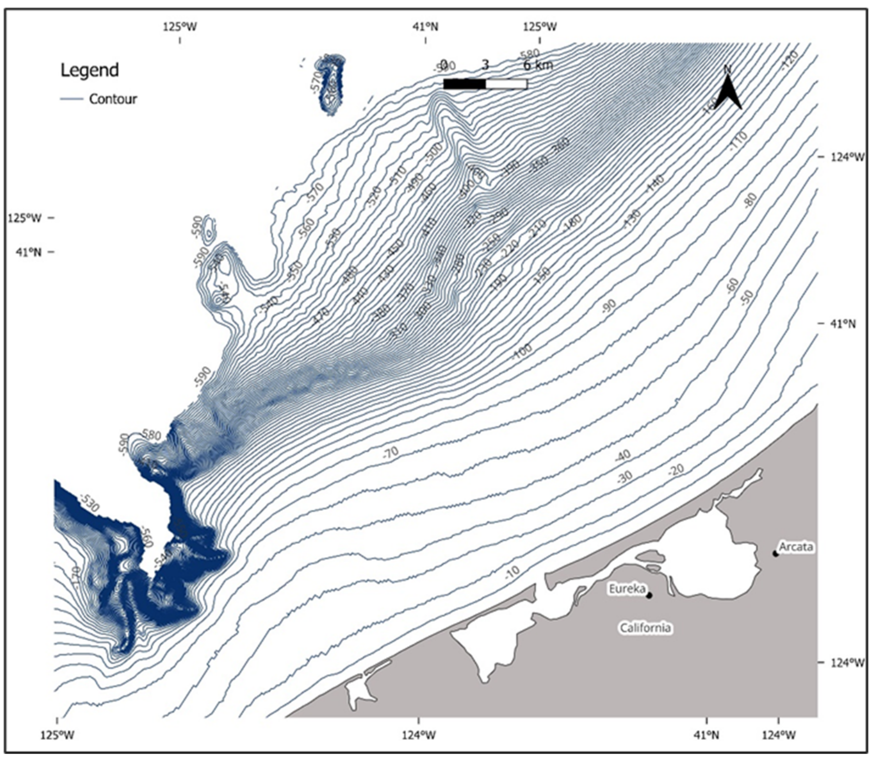

Figure 4. Bathymetry contour of Humboldt Bay.

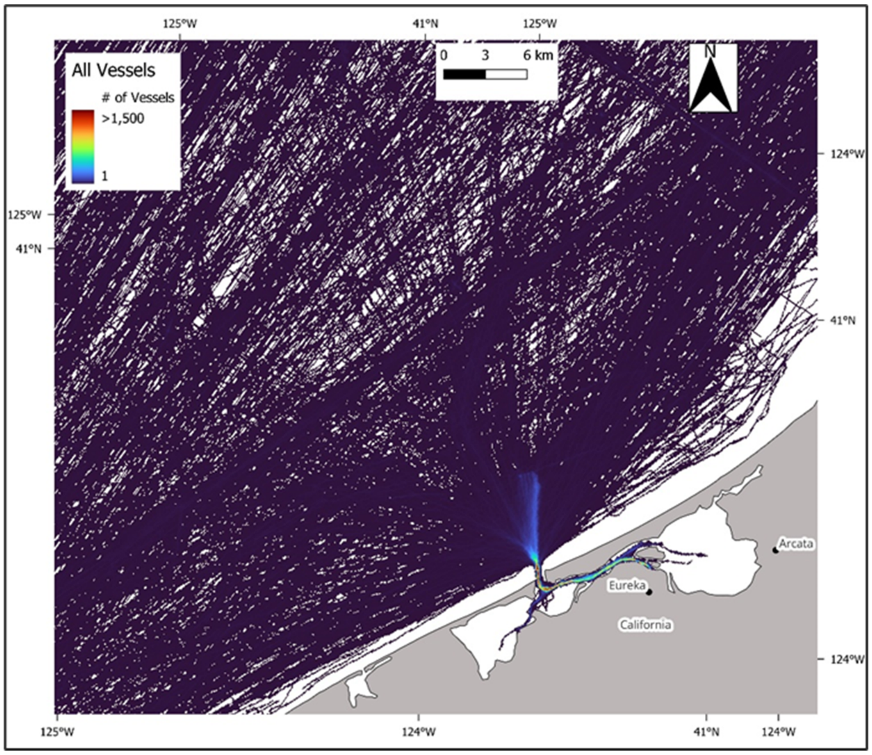

Figure 5. Vessel tracks in Humboldt Bay in 2019.

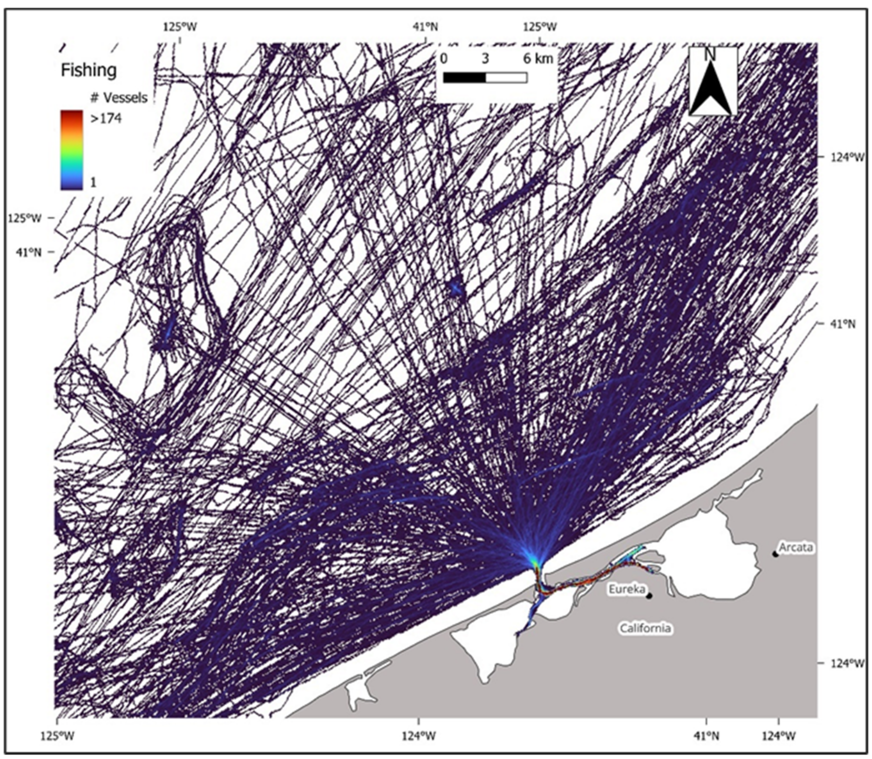

Figure 6. Fishing vessel tracks in Humboldt Bay in 2019.

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