Crescent City Offshore Wind Preliminary Feasibility Assessment

Final Report
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About the Schatz Energy Research Center

The Schatz Energy Research Center at Humboldt State University advances clean and renewable energy. Our projects aim to reduce climate change and pollution while increasing energy access and resilience.

Our work is collaborative and multidisciplinary, and we are grateful to the many partners who together make our efforts possible.

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1. INTRODUCTION

This report has been prepared by the Schatz Energy Research Center (Schatz Center) for the Crescent City Harbor District. It is intended to provide preliminary information regarding the possibility of offshore wind development off the Del Norte County Coast.

This report draws heavily on previous work conducted by the Schatz Center and referred to as the California North Coast Offshore Wind Studies.[1] To evaluate the potential for offshore wind development in Del Norte County, it is recommended that a more robust and complete feasibility analysis be conducted.

This report is organized into twelve brief sections that discuss a range of relevant topics. Section 12 summarizes the findings, draws some overall conclusions, and makes recommendations for further research.

[1] The California North Coast Offshore Wind Studies (2020) is a compilation of reports that can be found here: http://schatzcenter.org/publications/.

2. WIND SPEED RESOURCE AND POWER GENERATION PROFILE

Strong wind speeds off of California's northern coast, from Mendocino County north to the Oregon border, offer substantial opportunity to generate renewable electricity using floating offshore wind turbines. In this report, we provide a summary comparison of the wind resource and power generation profile between potential wind farms for a notional area offshore from Crescent City, the Humboldt Call Area,[2] and a notional area offshore from Cape Mendocino. A more thorough analysis of the wind resource in these three locations is available in Younes, et al. (forthcoming).

The location of the notional area offshore Crescent City is based on the National Renewable Energy Laboratory's study of the region (Musial et al., 2016). The centroid for this notional area is at a latitude of 41.657° and longitude of -124.878°.

On average, the Cape Mendocino area, the most powerful location, provides 10-11% more energy than the centroid of the Humboldt Call Area, and 5% more than the Crescent City area (Table 1).

Table 1. Annual energy production for 48-MW wind farms. n = 20 years.

	Annual Energy Production, GWh per year	
Region	95% Confidence Interval[3] for Population Mean	95% Tolerance Interval[4]
Notional Cape Mendocino Area	242 +/- 5.39	210 - 273
Notional Crescent City Area	230 +/- 4.59	203 - 257
Humboldt Call Area	219 +/- 5.47	187 - 251

Figure 1 shows the number of hours each year that a 48-MW wind farm would produce at or above a given power level. While all three sites are expected to generate zero power for very similar numbers of hours each year, there is a steady decrease in time spent at full power moving from Cape Mendocino to Crescent City, to the Humboldt Call Area. Note that a 48-MW wind farm size was arbitrarily chosen for comparison purposes. The comparison would be very similar for wind farms of other sizes, as the curves would essentially be proportionally scaled. Wind farms involving a greater number of turbines would have larger wake losses, meaning that the proportional increase would not be exact. However, the wake loss effect should be small.

[2] The Humboldt Call Area was identified by the Bureau of Ocean Energy Management when they submitted a Call for Information and Nominations in this area in 2018 (Bureau of Ocean Energy Management, 2018a, 2018b).

[3] A confidence interval describes how confidently the value of a population parameter is known. For example, in the long run, 95 out of 100 calculated 95% confidence intervals of sample average annual energy production would contain the true population average annual energy production.

[4] A 95% tolerance interval describes the range over which 95% of future observations would be expected to fall.

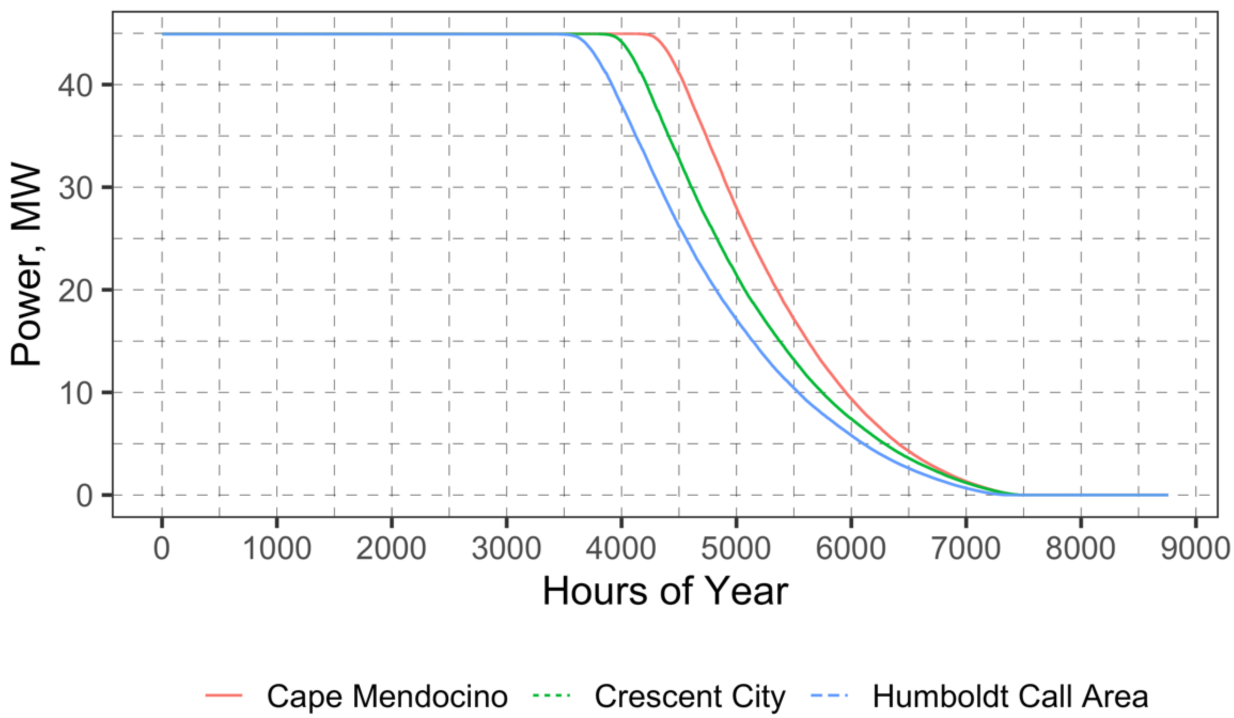

Figure 1. Generation duration curves for study locations at a scale of 48 MW.

3. OFFSHORE WIND AND REGIONAL LOAD COMPATIBILITY

A preliminary assessment of offshore wind power and its compatibility with the regional electrical load can be made based on the size and profile of the regional load. While this analysis did not assess the regional load profile, we can draw some broad conclusions based on the magnitude of the regional load. "The peak load in Crescent City is just under 40 MW in the summer and under 60 MW in the Winter[.] ... Light loads during the day and at night would typically be less than half of the peaks, probably down to about 20% of peak at times" (Anderson, 2021). Crescent City has no significant sources of local generation and has an estimated export limit of 98 MW (Anderson, 2021), assuming redundant lines (see Figure 2). In terms of electricity consumption, from 1990 to 2019 Del Norte County consumed between 190 and 255 GWh per year, and usage between 2015 and 2019 averaged 210 GWh per year (California Energy Commission, n.d.).

Drawing on work done by Younes et al. (2020) for Humboldt County, we think it is possible that a significant fraction of the energy from a 48-MW wind farm could be used within Del Norte County, but this warrants further analysis. At a scale of 144 MW in Del Norte County, we expect most of the generation would be exported, and a significant portion would be curtailed. Curtailment would likely occur during periods of light loads during the day and night, and essentially any time during summer when the farm operated at full capacity. At larger scales (e.g., 480 MW, 1,836 MW) most of the generation would be curtailed if relying on existing transmission infrastructure.

Based on correspondence with Pacific Power personnel, we were informed that reactive power support may be needed to maintain stability if a large generator were interconnected in the Crescent City area (Anderson, 2021). Literature suggests that some types of modern wind turbines can provide reactive support "consistent with other forms of generation" (Opila et al., 2010). This is another area where further research is warranted.

In summary, there is a scale of wind farm where the power generated could be used locally within Del Norte County, and a somewhat larger scale where power could be exported with little curtailment. These farms are likely in the range of 10 MW and 110 MW, respectively, but could well be smaller, meaning there could be times when even a single turbine might produce so much power that it could not all be consumed locally. If a larger scale wind farm is envisioned, this would necessitate the export of the majority of its production. Any scale of development will require further study to determine potential electrical system impacts and to characterize the need for electrical infrastructure upgrades.

4. INTERCONNECTION CONSTRAINTS AND PATHWAYS

The electrical transmission system is designed to reliably and safely deliver power from electricity generating facilities to serve regional electricity loads. "Transmission lines are built and expanded to ensure reliable and safe transfer of power. When new generation sources are proposed, for example offshore wind . . . , the existing transmission network must be evaluated to determine if the new generation source will exceed the capacity constraints of the system. Transmission improvements are then proposed as needed to allow safe and reliable interconnection of a new generation source ..." (Severy, et.al., 2021).

Del Norte County's main interconnection is provided by two 115-kV lines running northeast into Oregon (U.S. Department of Homeland Security, n.d.), as illustrated in Figure 2 and shown in Figure 3. These lines, part of the PacifiCorp transmission network, connect to 500-kV lines in Grants Pass. These lines are designed to serve the modest loads in Crescent City and the surrounding area. According to Pacific Power, "this is a fairly weak system with relatively light loads at the end of the radial transmission path, so significant generation interconnections at the transmission level could cause voltage stability issues. There are two 115 kV sources in the area. They are each thermally rated for continuous summer operation of 98 MVA. (Anderson, 2021). Assuming about 98 MW of export capacity from Crescent City, an interconnection at Crescent City might accommodate an offshore wind farm up to about 110 MW of peak capacity, as mentioned in Section 3, but further analysis is needed to confirm this.

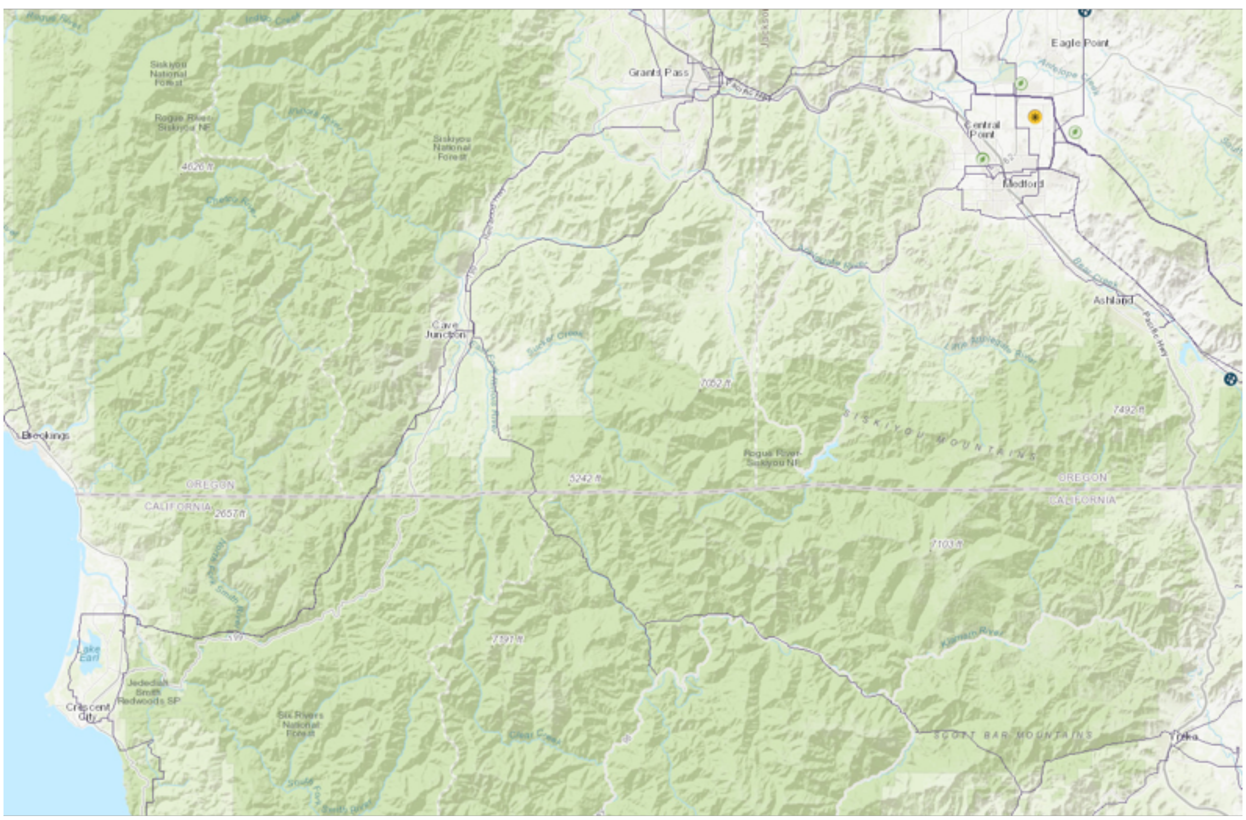

Figure 2. Transmission lines into and out of Crescent City. A 69-kV line runs south, while two parallel 115-kV lines run east then northeast. Source: U.S. Energy Information Admin. (n.d.).

Crescent City is not within the California Independent System Operator (CAISO) balancing area (California ISO, 2014), and utilizing any portion of Pacific Power transmission lines, even if solely within California, would prevent power generated offshore Del Norte from being delivered within the CAISO balancing area. As discussed below in Section 5, the geographic point of interconnection impacts the wholesale market opportunities. Wholesale market opportunities are currently more favorable in the CAISO balancing area. However, building transmission infrastructure to enable interconnection at a point in the CAISO balancing area would add substantial expense and would likely require an undersea cable like the one studied for offshore wind development in the Humboldt Call Area (Pacific Gas and Electric Company, 2020; Porter & Phillips, 2020a). Evaluating the feasibility of any interconnection option will require detailed cost and impact studies.

Figure 3. Two parallel 115-kV transmission lines run northeast from Crescent City toward Grants Pass where they connect to 500-kV lines.

The California North Coast Offshore Wind Studies examined the interconnection constraints and pathways for wind developments offshore of Humboldt Bay (Severy, et.al., 2021). It was determined that transmission constraints are a serious issue. For every size of wind farm examined, from 48 MW to 1,836 MW, significant transmission upgrade costs were estimated if full deliverability of the power is desired. The estimated upgrade costs ranged from a low of $365M for the low estimate for a 48 MW wind farm all the way up to an estimate of $5.8B for the high cost estimate for an 1,836 MW wind farm. It should be noted that all of these estimates assumed full deliverability interconnection status for the wind generators. That means that the system needed to accommodate the full output from the wind farm at any time. In fact, wind farms often choose to interconnect as energy-only facilities, which can substantially decrease the need for upgrades, but also can result in curtailment of the wind resource if there is congestion on the system and too much wind power is being generated. Alternatives to transmission upgrades such as curtailment, energy storage, or flexible loads that mitigate periods of overgeneration and resulting congestion could potentially help reduce interconnection costs for offshore wind development. Additional analysis would be needed to assess these alternatives.

It should also be noted that transmission upgrade costs, while they can be very substantial, are also generally reimbursed in full or in part. The Transmission Upgrades Report and Policy Analysis (Severy, et.al., 2021) discusses the pathways for transmission development in California and explains the cost allocation and reimbursement process. This report notes that in nearly any approach for transmission development, much of the upgrade cost is ultimately carried by ratepayers.

A transmission study needs to be completed for power generated offshore Del Norte County, and it should include assessment of both undersea cables and overland routes. It is also important to note that Attachment A: Modeling Assumptions for the 2021-2022 Transmission Planning Process, an attachment to the California Public Utilities Commission Decision 21-02-008, specifies that the resource portfolios included in the 2021-2022 Transmission Planning Process, to be carried out by the California Independent System Operator, will include a sensitivity analysis that models a total of 8.3 GW of offshore wind from the existing BOEM call areas (i.e. Humboldt, Diablo Canyon, and Morro Bay). In addition, a longer timeframe “outlook” assessment will include an evaluation of an additional 6.6 GW of offshore wind at Del Norte (California Public Utilities Commission, 2021).

5. ECONOMIC VIABILITY AND WHOLESALE MARKET OPPORTUNITIES

An economically viable offshore wind project will require access to wholesale electricity markets. In Section 3 we discuss regional load compatibility, and in Section 4 we discuss interconnection constraints and pathways. If a wind farm were sized to supply the regional load in Crescent City and Del Norte County, a wholesale buyer would be needed. One possible approach would be to establish a Community Choice Aggregation district, like has been done in Humboldt County under the Redwood Coast Energy Authority. Such an entity, referred to as a load serving entity (LSE), would have the ability to purchase the wholesale wind power and then provide it to its retail customers. However, a significant challenge would be that the LSE would need to purchase a portfolio of energy with various characteristics in order to effectively serve its load, and offshore wind power would only be able to satisfy a portion of the load. For that reason, it is very unlikely that a wind farm offshore of Crescent City would be viable without exporting power.

To export power, the wind farm would need to interconnect to the transmission system, likely either through Pacific Power's system or through PG&E's system. For an offshore wind project connecting in Pacific Power service territory, the options for participation in the CAISO wholesale markets would be significantly limited because Pacific Power is not part of the CAISO Balancing Authority Area (BAA). Generators that interconnect in the CAISO BAA have the opportunity to participate in several CAISO markets as described in Harris, et al. (2020); this includes day-ahead, real-time, and ancillary services. However, generators interconnecting through Pacific Power would be excluded from these markets. Note that it may be possible for a project in the Del Norte region to interconnect to the PG&E service territory, which does fall into the CAISO BAA. However, as noted above in Section 4, this would likely entail higher transmission system upgrade costs.

While Pacific Power is not part of the CAISO BAA, they do participate in the Western Energy Imbalance Market (EIM), which is a real-time electricity market extended through much of the western interconnect, and administered by CAISO. This differs from the Real Time Dispatch (RTD) markets within the CAISO BAA described in Harris et al., (2020), and poses a barrier for offshore wind. When participating in the RTD market with CAISO, a generator can act as a "price taker", simply sending electricity to the grid as it is produced, and accepting a settlement based on the market price at that time. However, when participating in the EIM the generator must be dispatched by CAISO in 5-minute intervals. Offshore wind generators are not dispatchable as they are dependent on the wind resource, and would need addition of storage to allow this type of market participation.

While this represents the current state of the EIM, there is an initiative in process between CAISO and PacifiCorp which may allow easier participation in the future. This initiative is planning for an Extended Day Ahead Market (EDAM) for the EIM, which would allow participation more similar to the current RTD of the CAISO BAA. While this was originally intended to be implemented at the end of 2022, there have been delays and there is currently no anticipated date of completion. This warrants further study for offshore wind development in Pacific Power territory.

The options described above are the only regulated wholesale markets available to generators in the Pacific Power service territory, but it is not necessary to participate in this way. Once generators go through the interconnection processes defined by the Open Access Transmission Tariff, they can be eligible to enter directly into a Power Purchase Agreement with Pacific Power.

6. PORT INFRASTRUCTURE OVERVIEW

A 2016 study assessed the infrastructure needs to support large-scale off-shore wind development on the Pacific West Coast. The assessment evaluated vessel requirements and characteristics, assessed port and harbor infrastructure needs to support offshore wind (OSW), and identified and characterized candidate port facilities in Washington, Oregon, California, and three Hawaiian Islands (Porter and Philips, 2016).

In the study, the existing or developed characteristics of the candidate ports were used to determine the functions the port could provide. The ports are classified depending on these potential functions and include: quick reaction port (QRP), fabrication and construction port (FCP), and assembly port (AP). The list of functions for each type of port are shown in Table 2 below (Porter and Philips, 2016).

Table 2. Port Classifications and Functions. Source: Porter and Philips (2016), Table 2-6.

Quick Reaction	Fabrication and Construction	Assembly
Crew Transfer Minor maintenance and repairs Operations homeport Homeport for pre-installation surveys (bathymetric, benthic)	Construction, staging, and pre-assembly of device components Transport hub for device components and materials Fabrication of nacelle, blade, foundation, cable, generator, hub	Final assembly of devices Provide staging and storage areas Marine tow out Potential cable-laying and mooring installation

A detailed evaluation of the Crescent City Harbor was not included in the study, but authors suggested that it may be suitable as a quick reaction port. A QRP serves as the homeport for operations and maintenance vessels and is in close proximity to the wind farm so that vessels are able to navigate to the project site within two hours. Other basic requirements for a QRP include the berthing specifications (depth and width), air draft, and the number of berths (approximately one vessel per 30-40 devices) for support vessels, and also potentially helipad infrastructure.

There are a significant number of criteria to be met for a port to serve as an AP or FCP. A few of the main requirements are sufficient depths and area for berthing, assembly, and wet staging of the wind turbine generators, and also a sufficient amount of available upland area for component staging and assembly operations (Porter and Philips, 2020b).

The current inner boat basin of the Crescent City Harbor was developed to serve commercial fishing and recreational uses. Therefore, the berth, staging area, and navigational channel depths are below the required depths needed for deep draft vessel port activities such as OSW wharfside assembly and ballasting, wet-staging, and device tow-out. Figure 4 shows the depths in Crescent City Harbor ranging from 9 ft. dockside to 14 ft. in the navigational channel. Minimum berthing depths for modern wind turbine generator assemblies are estimated to be 29 ft. MLLW (Porter and Philips, 2020b, Table 9), depending on technology.

Additional area outside the existing Crescent City Harbor could be considered for development. On March 4, 1963 the legislature of the state of California passed and the governor signed into law Chapter 1510 of the statutes of 1963 (California, 1963). This statute granted the Crescent City Harbor District 4,200 acres of land and water surface area (see Figure 5 and Figure 6). Detailed additional analysis would be needed to determine the feasibility of developing this area and adjacent upland regions to support activities related to offshore wind system deployment and maintenance.

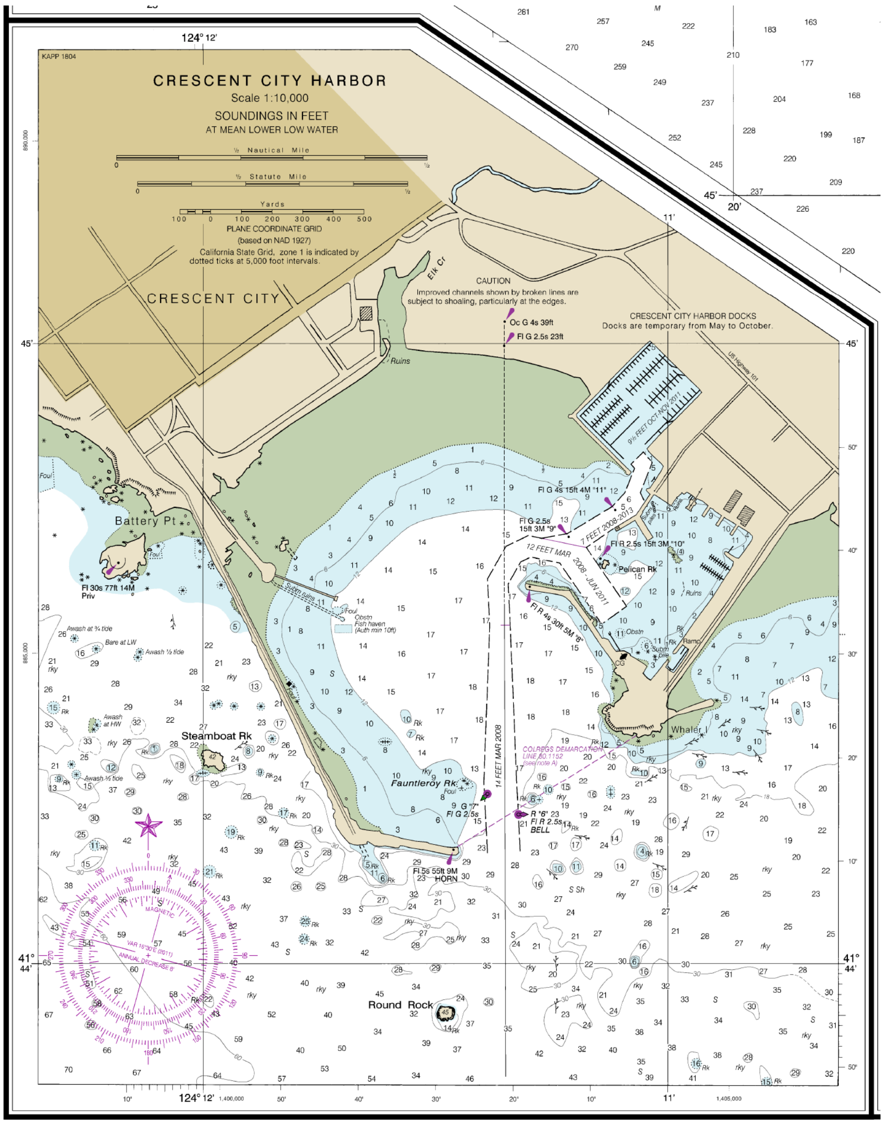

Figure 4. Nautical chart for Crescent City Harbor (soundings in feet). Source: St. George Reef and Crescent City Harbor, U. S Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service Coast Survey, Nautical Chart 18603.

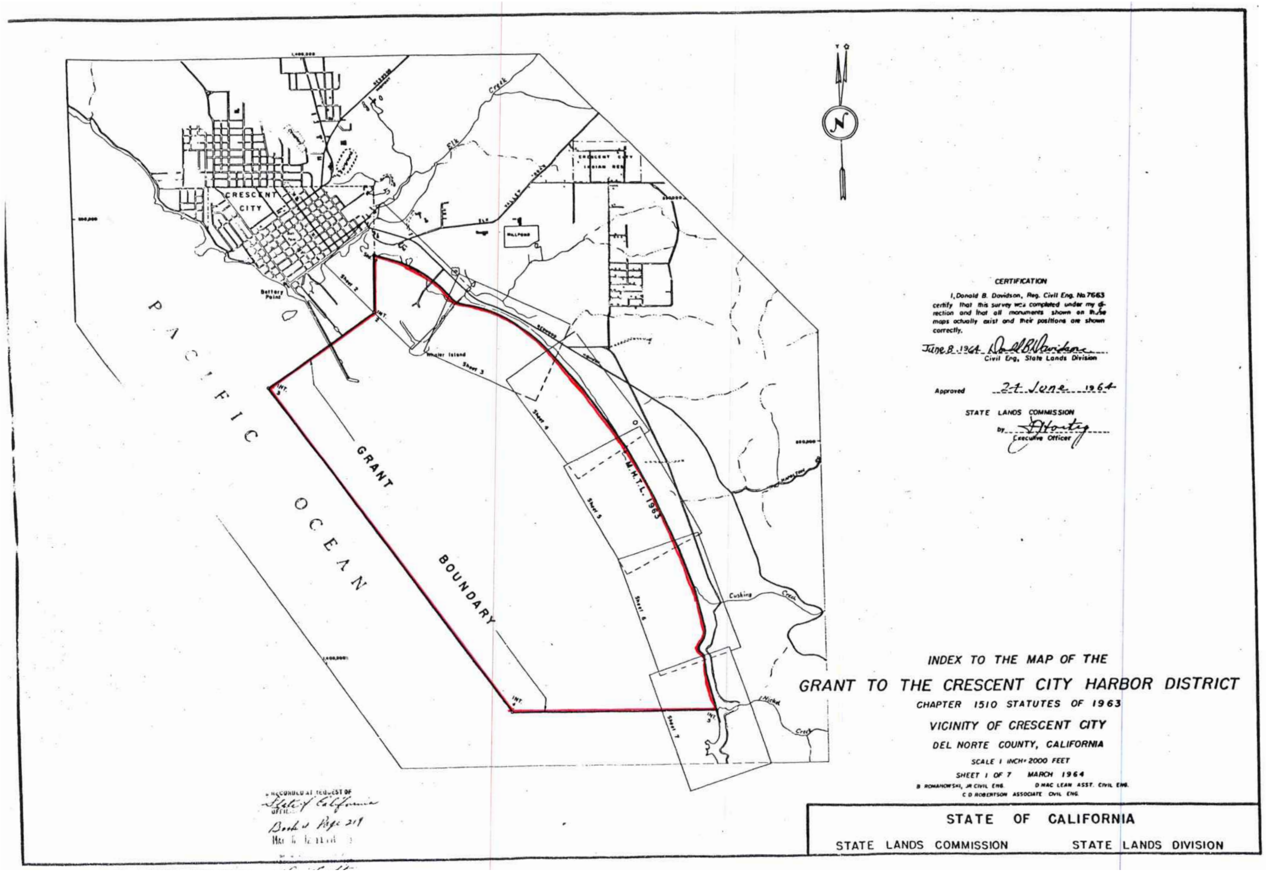

Figure 5. Map showing full extent of land and water surface granted to the Crescent City Harbor District. Source: *Report on Granted Lands Under the Jurisdiction of the Crescent City Harbor District - 1963-1974. (n.d.).*

Figure 6. Aerial photograph of Crescent City Harbor. Source: Crescent City Harbor District.

7. POTENTIAL ENVIRONMENTAL IMPACTS

Development of an OSW facility off the coast of Crescent City would entail construction, operations and maintenance, and decommissioning that would result in effects on the marine and terrestrial environments similar to those expected in a 2020 report authored by H. T. Harvey & Associates (H. T. Harvey & Associates, 2020). As would be true for other offshore areas and associated ports on the California coast, the effects could result in both short-term and long-term effects on the marine environments. It is likely that the short-term impacts from construction activities on the marine environments would include: "the disturbance of benthic habitat; changes in water quality from sedimentation or contaminants; an increase in ambient acoustic levels underwater; an increase in the risk for vessel collisions with wildlife; and wildlife disturbance from the use of artificial lighting, either on decks or underwater" (H. T. Harvey & Associates, 2020). While the potential longer-term effects that are expected from operations and maintenance activities on the marine environments would include: "operational noise of turbines and maintenance vessels; seabird and bat collision / avoidance with rotating turbine blades; marine mammal interactions with underwater structures; habitat changes associated with structures in the water column and on the seafloor; perching and haul-out effects; and electromagnetic field transmissions from the interarray cables, offshore substation, and export cable(s)" (H. T. Harvey & Associates, 2020). Notably, the largest single island murre colony south of Alaska is at Castle Rock, off Crescent City. Common murres that nest at Castle Rock need to forage to feed their young, and may forage as far as 100 km from the island colony. However, they typically fly closer to the water surface and therefore, it is unlikely that they fly as high as the rotor swept zone of an offshore wind turbine, but could be greatly affected by displacement and avoidance of offshore wind projects in proximity to their nesting habitat. A diversity of locally breeding species are concentrated in the nearshore environment, so the closer to shore offshore wind projects are, the more likely they are to affect bird and bat species.

Another area of concern for offshore wind development, including near Crescent City and elsewhere on the California coast, would come from transmission line upgrades. If these upgrades are needed, which is likely, the potential effects on the terrestrial environment would include the following: "disturbance of threatened or endangered wildlife species from the noise associated with horizontal directional drilling and transmission line improvements; removal of threatened or endangered plant species or sensitive natural communities during ground-disturbing activities; loss of wildlife habitat; hydrological interruption or the placement of fill in jurisdictional water bodies; increased long-term risk of bird collision with transmission lines improvements; and the introduction and spread of terrestrial invasive plant species" (H. T. Harvey & Associates, 2020).

It is expected that most of the potential effects from construction activities for both onshore and offshore components "may be short-term and localized", and there will likely be "opportunities for mitigation" of these effects (H. T. Harvey & Associates, 2020). However, major changes to existing habitat in or near the existing Crescent City Harbor such as creating larger docks and dredging to increase channel size/depth beyond the current channel configuration will likely pose permitting challenges. It is unknown what the effects of building a new deep water port would be, and further study would be required to address those questions. Because there are still many uncertainties about "interactions with seabirds and marine mammals" with offshore project operations and maintenance, the potential effects are difficult to estimate without additional analysis (H. T. Harvey & Associates, 2020).

Larger projects tend to have greater environmental uncertainties and potential risks given that they have a larger footprint, which is why "permitting challenges tend to be scaled to project size" (H. T. Harvey &

Associates, 2020). For example, larger scale projects will not only have a larger offshore footprint, but will also likely include “long terrestrial transmission line improvements that potentially affect a large number of threatened or endangered species and natural communities (e.g., wetlands and other waters)” (H. T. Harvey & Associates, 2020).

Construction, installation and operation of the subsea transmission cable is also another area that will likely have potential environmental effects. Currently, the anticipated environmental effects associated with a subsea transmission cable are not well defined and will likely require more information “to identify a potential cable route and improve the understanding of environmental risks and permitting challenges” (H. T. Harvey & Associates, 2020). When looking at a potential route pathway along the California coast, these pathways “should avoid marine geological features, protected marine areas, and if applicable to the area, rocky or hard substrates, to minimize the potential effects” (H. T. Harvey & Associates, 2020).

8. GEOLOGY

The Overview of Geologic Hazards Report for the California North Coast Offshore Wind Studies investigated the geological hazards associated with development of offshore wind and associated facilities in the seismically active north coast of California (Hemphill-Haley et al., 2020). The report reviewed the geologic and seismic hazards that could potentially impact the components of offshore wind facilities (including both offshore and onshore components) such as: "floating offshore wind farm, cable landfall on the coastline, interconnection with terrestrial electric transmission infrastructure, and port infrastructure located within Humboldt Bay" (Hemphill-Haley et al., 2020). This report concluded that there are seven geological hazards to take into consideration that can affect the onshore and offshore components of an offshore wind farm: strong motion (seismic shaking), surface fault rupture and deformation, gas hydrates, liquefaction, submarine landslides, tsunamis, and coseismic land level change (Hemphill-Haley et al., 2020).

Given that the geological hazard analysis in Hemphill-Haley, et al. (2020) was specific to the Humboldt Call Area, another study specific to possible wind area(s) near Crescent City should be conducted to gain a better understanding of the potential hazards within the region. Future work should include a study of geological hazards associated with tsunamis which would include: "assessing the seafloor, near coastal, and coastal conditions that may be conducive to increased impacts from tsunamis, including evaluation of bathymetry, coastal geometry and onshore terrain; assess available, and, if deemed necessary, newly-acquired onshore paleoseismic evidence for timing of and inundation extent for tsunamis; and incorporate geological and geotechnical design considerations to minimize impacts of tsunami inundation" (Hemphill-Haley et al., 2020).

Like other west coast ports, Crescent City also lies within a seismically active area of northwestern North America. While another study specific to Crescent City will be needed, most of the seismic sources capable of delivering strong motion to any component of an offshore wind facility would include those mentioned for the Humboldt Call Area which were: "(1) the Cascadia subduction zone, which is capable of producing earthquakes greater than M9; (2) the San Andreas fault, which has produced historical earthquakes as large as M7.9; (3) the Mendocino fault, which is capable of producing M7 earthquakes; (4) faults within the Gorda plate, which is the subducting oceanic plate along the southernmost Cascadia subduction zone; and (5) faults within the fold and thrust belt of the Cascadia subduction zone accretionary wedge that, although they have not ruptured during historical times, show ample geological evidence for producing M>7 earthquakes in the past hundreds to thousands of years (Figure 7, Hemphill-Haley et al., 2020). For northwestern California, the primary sources of historical seismicity have been active faults in the Gorda plate and activity along with the Mendocino fault, with recorded earthquakes as large as M7.2" (Hemphill-Haley et al., 2020).

Offshore and onshore components of the wind facilities could potentially be impacted either directly or indirectly by "the effects of strong ground motion which may include high ground accelerations, long-period and/or high frequency motion, and long-duration shaking" (Hemphill-Haley et al., 2020). It should be noted that the seismic sources referred to in the Hemphill-Haley et al., (2020) study are located differently with respect to Crescent City than for Humboldt Bay. For example, the San Andreas fault and Mendocino faults are located much farther to the south and are unlikely to produce significant strong motion at this location. Additionally, the Cascadia subduction megathrust is located further to the west which may affect strong motion for Crescent City. Finally, fewer faults within the fold and thrust belt occur onshore near Crescent City than to the south. Apart from components facing directs impacts due to the strong shaking event, the “strong ground motion can also trigger other adverse geological hazards including destabilizing gas hydrates beneath the seafloor, sediment liquefaction both on- and offshore, and submarine landslides” (Hemphill-Haley et al., 2020).

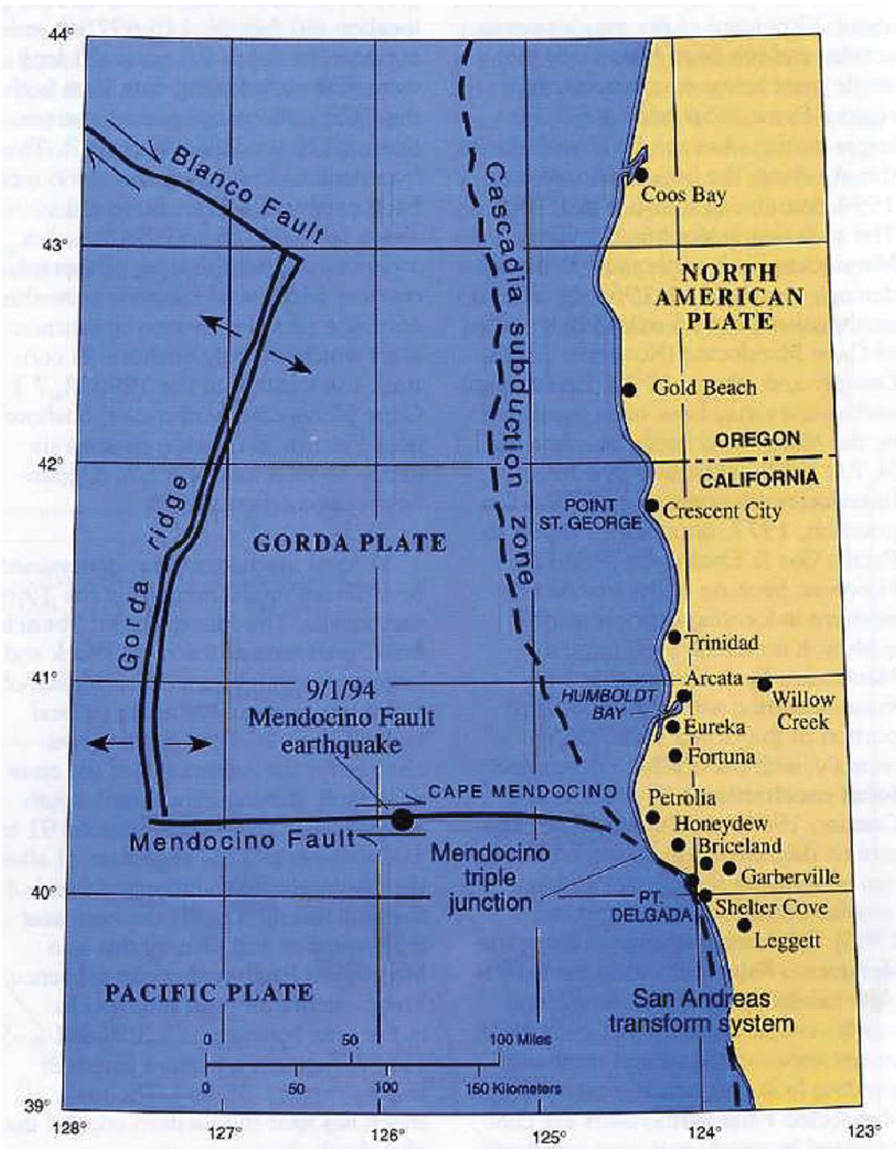

Figure 7. Map of the seismic sources off the coast of Crescent City, California. Source: The September 1, 1994 Mendocino fault earthquake by Dengler et al. (1995) as cited in the Overview of Geological Hazards Hemphill-Haley et al., their Figure 2 (2020).

9. ECONOMICS

The California North Coast Offshore Wind Studies assessed the economic impact to the State of California from an offshore wind farm and associated port and transmission infrastructure development on the California North Coast (Hackett and Anderson, 2020). Offshore wind development provides a potential opportunity for the creation of economic activity that could lead to a "ripple effect of new jobs and economic output" (Hackett and Anderson, 2020). These areas of economic activity would include "production of upstream supply-chain inputs, as well as induced spending as new employee households increase local spending (e.g., at grocery stores, auto dealerships, and restaurants)" (Hackett and Anderson, 2020).

The previous study analyzed various wind farm and transmission scenarios that included wind farm construction and operations, as well as port and transmission infrastructure investments. Overall, estimated job and economic output impacts from wind farm development were substantial:

- California economic output gained from construction of the offshore wind farm components "range from about $330 million for a small farm scale scenario (48MW) to over $2.5 billion for the largest wind farm scale analyzed (1,836 MW); this economic activity is associated with creating between about 1,600 (smallest farm scale) to over 13,000 (largest farm scale) new full-time equivalent (FTE)[5] construction jobs in California" (Hackett and Anderson, 2020).
- California economic output gained from annual operations of the facility "range from about $3.2 million to about $117 million, and the creation of roughly 26 to 960 new FTE jobs" (Hackett and Anderson, 2020).

Economies of scale can be defined as "a doubling of output results from less than a doubling of total cost" and in the wind farm development process economies of scale are usually seen when you have "relatively larger job and economic output impacts per MW of installed capacity for the smallest wind farm scenarios" (Hackett and Anderson, 2020).

Wind farm development offshore of Del Norte County would most certainly spur economic development in the County; however, the level of development and the associated impacts to other economic sectors would depend on many factors and would need to be studied in detail to determine expected impacts. Some characteristics that would impact economic development include: size of the wind farm, interconnection location, level of port development, level of training and development of local trades people, and level of wind farm services provided locally. Other aspects would include the corresponding level of regional offshore wind development, for example in the Humboldt Bay region, elsewhere along the North Coast of California, and/or in Southern Oregon, and the level of coordination throughout the region. For example, if Humboldt Bay, other California North Coast, and Southern Oregon areas were also involved in wind development projects, the way services were provided and shared across the region would have regional economic development impacts.

[5] One full-time equivalent (FTE) job is equivalent to one person working 40 hours per week for one full year.

10. MILITARY COMPATIBILITY

A significant portion of the area that may be considered for offshore wind development near Crescent City falls within a "Special Use Airspace" (SUA) area designated by the Department of Defense[6] (DOD) (Figure 8). Offshore wind development that encroaches on military use areas or could potentially affect military operations may be of concern to the DOD. DOD-specified SUA areas have been a major hurdle for offshore wind development on the California Central Coast. Each SUA along the California coast area likely has its own constraints, and, to identify what these are, early communication with DOD is advisable to determine if the existence of SUA areas may pose a barrier to future offshore wind development near Del Norte County.

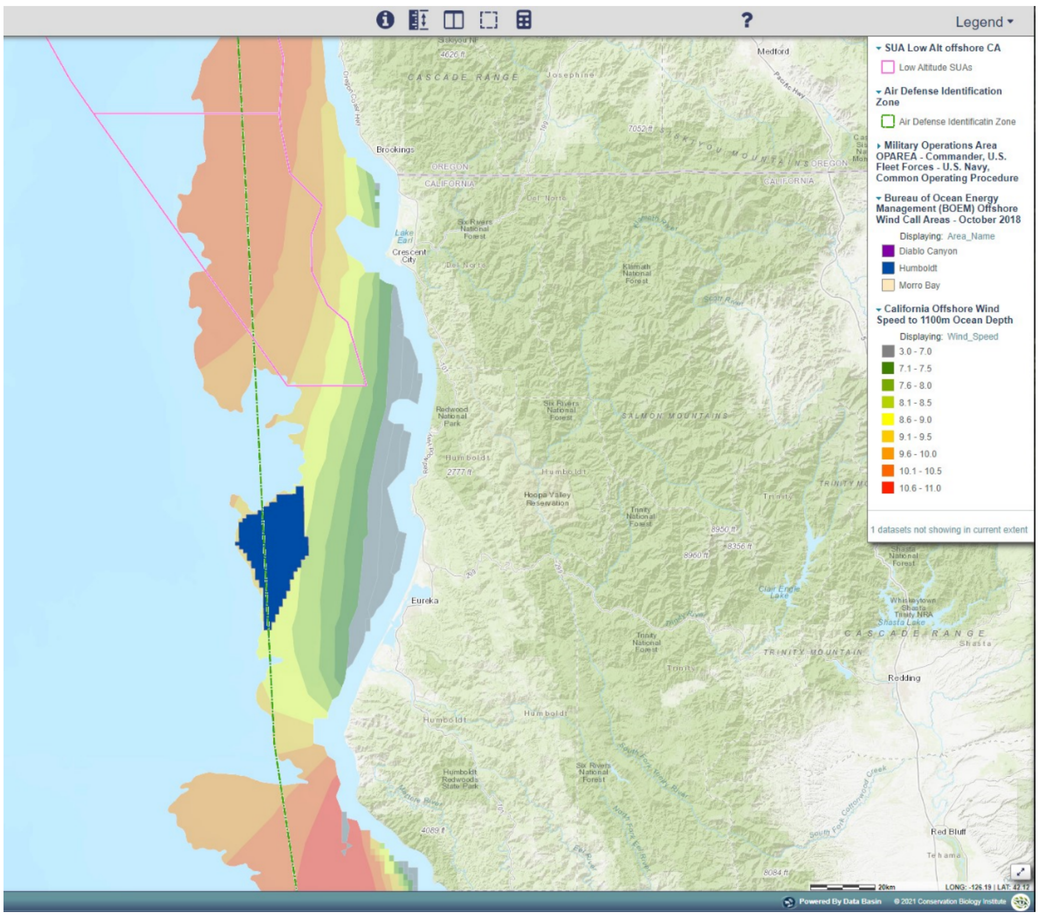

Figure 8. U.S. Department of Defense Special Use Airspace (SUA) areas offshore of Del Norte County along with the Humboldt Call Area (in blue) and offshore wind speeds along the coast. Map source: https://caoffshorewind.databasin.org/.

[6] For more information see DataBasin Special Use Airspace areas designated by the DOD along California coast: https://caoffshorewind.databasin.org/maps/88306cb855464783a12cae6aa6bd79af/active/

11. STAKEHOLDER BENEFITS AND CONCERNS

A successful offshore wind development project not only has to face economic and technology challenges, but also should actively engage with "local communities and government agencies to be able to address concerns, impacts, and potential community benefits" throughout the offshore wind development process (Emery et al., 2020). The following stakeholder perceptions are from the Stakeholder Benefit and Concerns Report for Humboldt County, California (Emery et al., 2020). It is possible that residents of Del Norte County will have similar stakeholder perceptions with respect to some issues, although there may also be significant differences. Stakeholder outreach and analysis should be conducted within Del Norte County to gain a better understanding of community perspectives regarding the potential for offshore wind development.

In the analysis focused on offshore wind development in the Humboldt Call Area, stakeholders were identified from the energy industry, local governments, environmental groups, fishermen, and labor/business (Emery et al., 2020). A majority of the stakeholders "cited emissions reductions or climate change as a direct benefit of proposed offshore wind energy generation in Humboldt County" and "the second most cited benefit of offshore wind energy generation was jobs and economic benefits" (Emery et al., 2020). Another commonly cited benefit related to the potential for "port infrastructure upgrades" (Emery et al., 2020). Finally, about half of the participants "cited energy independence and local control as a benefit" (Emery et al., 2020). Leaders and government staff members from Native American Tribes in the region expressed interest in further information about the feasibility of offshore wind development and "a desire for greater understanding regarding possible community benefits" (Emery et al., 2020). Some tribal government representatives also "expressed support for potential economic development associated with offshore wind, including the possibility of workforce development for tribal members" (Emery et al., 2020).

The main area of concern that was mentioned and expressed the most by stakeholders "were impacts to the environment and the local fishing industry" (Emery et al., 2020). A majority of stakeholders which included "all government and environmental group stakeholders along with fishermen and members of other interest groups, mentioned either impacts to the environment in general or specifically to birds, fish or mammals" (Emery et al., 2020). In addition, another common concern shared by many stakeholders were the "potential impacts of offshore wind to the local Humboldt County commercial fishing fleet" (Emery et al., 2020). The fishing fleet concerns that were mentioned by community members included: "possible loss of fishing grounds, disrupted access to the Humboldt Bay channel, and increased ocean hazards with the installation of floating offshore wind turbines" (Emery et al., 2020). The concerns associated with the potential impacts "to the local fishing industry came up in every fishing and wind industry interview" (Emery et al., 2020). In 2018, Eureka Area Ports gross revenue was close to $20.6 million, which was about $8 million less than the gross revenue for Crescent City Area Ports, which was $28.3 million. In Crescent City in 2018, the top two fisheries from a revenue perspective were Dungeness Crab trapping ($7.8 million) and Shrimp/Prawn trawling ($4.2 million)[7]. Concerns about impact to fishing may be even greater in Del Norte County than in Humboldt County given that the local economy depends more heavily on the fishing industry in the former case. Engagement with Tribal governments through

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[7] For more fishery revenue summaries of the Crescent City Port Area see the California Fisheries Data Explorer: https://mpahumanuses.com/data-viewer.html

both formal consultation and informal collaboration and communication is very important in the interagency consultation process of offshore wind development.

As mentioned before, the key to a "successful development process" requires transparent communication and an understanding of the benefits and concerns of local communities and government agencies in relation to offshore wind development (Emery et al., 2020). It is likely that local communities will have different concerns and benefits regarding offshore wind development. Therefore, an analysis of local community concerns and benefits is important as they can be used by "government agencies and developers to design a project and process that responds and adapts to community needs" (Emery et al., 2020). Further studies regarding potential stakeholder concerns and constraints associated with offshore wind development along the Del Norte County coast are needed to understand and consider community perspectives.

12. CONCLUSIONS AND RECOMMENDATIONS

This section provides a summary of the conclusions of this study and makes recommendations of further research related to offshore wind development off the Del Norte County coast. In general, there is a substantial wind resource located offshore of Del Norte County that could be developed. However, the viability of this development is uncertain. There are many issues that require further study. It is recommended that a more detailed feasibility analysis be conducted, similar to the California North Coast Offshore Wind Studies that were recently completed with a focus on Humboldt County.

Wind Speed Resource

The wind resource off shore of Del Norte County is substantial and provides significant opportunity for development. The resource located offshore Del Norte County is somewhat larger than the resource located offshore Humboldt Bay and is slightly smaller than the resource offshore Cape Mendocino. All of these locations have excellent offshore wind resources.

Load Compatibility and Interconnection Constraints

The regional electric load in the Crescent City area and Del Norte County is relatively small. If a windfarm were developed off the Del Norte Coast, it would very likely need to be able to export power out of the region. Del Norte County has minimal transmission capacity, and upgrades would likely be necessary to allow export. The cost of upgrades would depend on the size of the wind farm and other factors. Connecting a wind farm on an energy-only basis could help reduce transmission upgrade requirements, but this approach would entail curtailment penalties except in the case of a small commercial wind farm. More research is needed to understand the options and tradeoffs with regard to interconnection and transmission.

Economic Viability

An offshore wind project off the Del Norte coast would most likely connect into Pacific Power service territory. This may constrain available wholesale power market options, thereby impacting revenue potential. At this time the wholesale market opportunities are greater in the CAISO Balancing Authority Area, which is available for projects that connect in PG&E territory, but is not available for projects that connect in Pacific Power territory. Wholesale market options would need to be examined alongside transmission and interconnection options, and both of these deserve further study.

Port Infrastructure

Currently, the Crescent City Harbor is not suitable for wharfside assembly and ballasting, wet-staging, and offshore wind device tow-out. However, the Crescent City Harbor District owns an additional 4,200 surface acres of land and water that could be considered for development to support offshore wind. Detailed assessment of the harbor and surrounding upland areas would be necessary to determine what level of service could be provided from the Crescent City Harbor.

Environmental Impacts

Development of an OSW facility off the coast of Crescent City would entail construction, operations and maintenance, and decommissioning that would result in effects on the marine and terrestrial environments such as disturbance or loss of habitat and short-term and long-term behavioral effects from the introduction of offshore wind components in the area (both marine and terrestrial). There are many uncertainties regarding the effects of offshore wind components on marine and terrestrial habitats which have led to permitting challenges. Early communication, both informal and formal dialogue, with agencies is recommended to better understand the species and habitat constraints and also what permits, consultations, and mitigation measures will likely be expected for offshore wind development in the area.

Geology

Crescent City is located in an area that faces seismic sources capable of delivering strong motion to any component of an offshore wind facility. For northwestern California, the primary sources of historical seismicity have been the active faults in the Gorda Plate and activity along the Mendocino Fault. Historically, Crescent City has experienced damage from tsunamis. A report that investigates the geological hazards associated with development of offshore wind and associated facilities specific to Crescent City and the Del Norte County coast is recommended.

Economics

Wind farm development offshore Del Norte County would spur economic development; however, the level of development and the associated impacts to other economic sectors would depend on many factors and would need to be studied in detail to determine expected impacts.

Military Compatibility

Offshore of the Del Norte coast is a Special Use Airspace (SUA) area designated by the United States Department of Defense (DOD). Given that each SUA has its own constraints, it is recommended that early consultation with the DOD occur to determine if offshore wind development would be of concern within the area and if there are any constraints that must be addressed.

Stakeholder Engagement

It is recommended that a stakeholder assessment be conducted to identify potential benefits and concerns within the local community with regard to offshore wind development. Transparent communication and knowledge between local community members, agencies, and developers should occur throughout the offshore wind development process. One key stakeholder group that will need to be engaged is the commercial fishing industry, as they are a major part of Crescent City’s community and local economy.

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