Northern California Offshore Wind Study: Overview of Geological Hazards

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NCOW areas of consideration

Call Area

1. Turbine assembly area
2. Transmission cable landfall
3. Humboldt Bay Generating Plant
4. Approximate area of transmission cable corridor
Hazards to be considered

- Strong motion
- Surface rupture
- Gas hydrates
- Liquefaction
- Submarine landslides
- Tsunamis
- Coseismic sea level change

- This study based on literature review of available data. No new data collection conducted during this period.
- No attempt to serve as proponent or opponent of potential wind farm - informational
Strong motion

Earthquake shaking caused by multiple sources

- Cascadia Subduction zone
- San Andreas fault
- Gorda plate
- Mendocino fault
- Numerous faults onshore and offshore

Potential impacts:
- Damaging shaking
- Can induce most of the other hazards under consideration
Earthquake shaking caused by multiple sources

- Cascadia Subduction zone
- San Andreas fault
- Gorda plate
- Mendocino fault
- Numerous faults onshore and offshore

- Extends from Vancouver, CA to Cape Mendocino
- Capable of M 9+ earthquakes
- Last event was in 1700 AD
- Native American oral history describes event
- Time between earthquakes approximately 245-720 years
Earthquake shaking caused by multiple sources

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- **San Andreas fault**
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**Strong motion**

Figure 4. USGS base map of the San Andreas fault in California. The 1906 rupture extended from San Juan Bautista in the south to Cape Mendocino in the north (Accessed June 2020 from: https://pubs.usgs.gov/gip/earthq/where.html)
• 1906 - most recent event on Northern SAF
• M 7.8 with large displacements near Shelter Cove
• Arguably largest shaking event in Humboldt area in modern history
Earthquake shaking caused by multiple sources

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Earthquake shaking caused by multiple sources

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- **Mendocino fault**
- Numerous faults onshore and offshore

- More than 400 earthquakes greater than M 4.5 since 1960
- Greatest impact to onland facilities from earthquakes on eastern end of fault
Earthquake shaking caused by multiple sources

- Cascadia Subduction zone
- San Andreas fault
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- Numerous faults onshore and offshore
Surface rupture

Active faults capable of significant displacements occur on- and offshore

Figure 25. Map showing the bathymetry and topography of the southernmost Cascadia subduction zone in and near the Humboldt Call Area (in center of map with pale-yellow shading and black outline). Quaternary active faults in the onshore and offshore area primarily from USGS Quaternary fault and fold database (USGS, 2020k) and McCroty (2003). Onshore faults extend offshore in the accretionary prism. Yellow solid line is approximate location of seismic profile from Burger et al. (2002) shown in Figure 27.

Figure 27. Uninterpreted and interpreted seismic profile from transect approximately parallel to coastline (see Figure 25 for location). Near vertical lines are interpreted faults. Of note are faults within the Little Salmon fault zone (LSFZ) and Table Bluff anticline (TBA). Note that some fault structures extend through the youngest sediments to the seafloor. Also, faults here are depleted as near vertical while the onshore projections of these structures are mapped as low angle thrust faults. (From Burger et al., 2002, their Figure 3.)

Potential impacts to infrastructure:
- ground or ocean bottom displacement
- distortion and folding
Gas Hydrates

Frozen methane formed within sediments due to appropriate temperature and pressure conditions

Methane formed by decay of biogenic material

Can become destabilized by
- strong shaking
- landsliding
- surface rupture
- climate change

Potential impacts
- liquefaction
- gas blowouts (pockmarks)
- landslides
Liquefaction

When water- or gas-saturated sediments temporarily lose strength and volume due to sudden shaking. Can occur onshore and offshore.

Liquefaction-induced collapse of buildings in Niigata, Japan during 1964 M7.6 event (Wikipedia)

Liquefaction-induced lateral spread at Port Kenyon, lower Eel River, formed during 1906 earthquake (From Dengler, 2008)

Potential impacts to infrastructure:
- loss of foundation support
- displacement
Landslides

Greatest hazard from offshore landslides

High-resolution bathymetry of Trinidad Canyon and Eel Plateau portions of the southern Cascadia subduction zone, modified from Hill et al. (2020, their Figures 10 and 12). The NCOWS callout area is shown in the center as a pale-yellow polygon.

Potential Impacts

- Displacements of ocean sediments and attached infrastructure
- Liquefaction
- Tsunami generation
Tsunamis

“Triggered by earthquakes, volcanic eruptions, submarine landslides, and by onshore landslides in which large volumes of debris fall into the water... [They] typically consists of multiple waves that rush ashore like a fast-rising tide with powerful currents” USGS, 2020

Potential impacts to infrastructure:

- flooding
- scouring
- deposition of debris and scoured sediments

Newly released maps for Humboldt County at https://maps.conservation.ca.gov/cgs/informationwarehouse/ts_evacuation/
Coseismic and interseismic sea-level change

**Coseismic** change - during the earthquake - abrupt change in land level due to earthquake-related displacement, especially during subduction zone earthquakes.

**Interseismic** change - between earthquakes - gradual change in relative sea level due to loading along a fault or climate induced sea level change.

1992 M 7.2 Cape Mendocino earthquake (uplifted sea floor ~ 2 m)

2004 M 9 Sumatra earthquake (subsided sea floor ~ 2 m)

**Potential Impacts**
- sudden emergence or submergence of near coastal infrastructure
Conclusion

There are significant potential geological hazards within the region that will need to be investigated and addressed for possible development of an offshore wind farm.