BOEM
BUREAU OF OCEAN ENERGY MANAGEMENT

November 2024

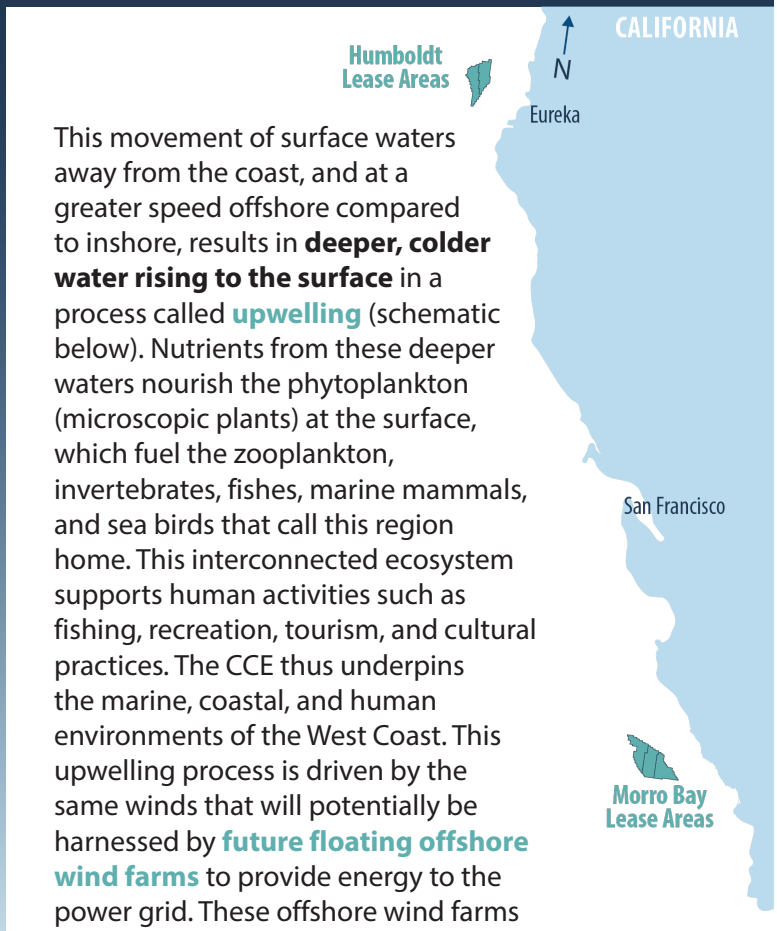
Upwelling and Offshore Wind: What We Know

An overview, investigations to date, and future directions.

The **California Current Ecosystem (CCE)** is one of the most diverse and productive marine ecosystems on the planet. Its productive nature can be attributed to the presence of rich upwelling zones.

What is upwelling?

Seasonal northwesterly winds create surface currents that move away from the coast due to the rotation of the earth. Due to greater wind speeds further offshore, these surface currents also travel at different speeds.

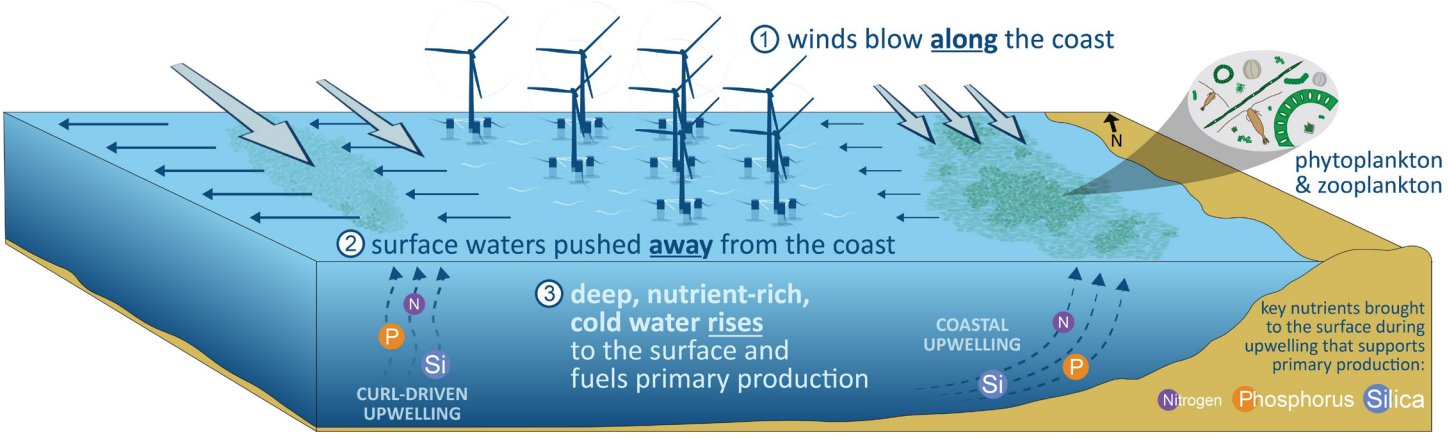


This movement of surface waters away from the coast, and at a greater speed offshore compared to inshore, results in **deeper, colder water rising to the surface** in a process called **upwelling** (schematic below). Nutrients from these deeper waters nourish the phytoplankton (microscopic plants) at the surface, which fuel the zooplankton, invertebrates, fishes, marine mammals, and sea birds that call this region home. This interconnected ecosystem supports human activities such as fishing, recreation, tourism, and cultural practices. The CCE thus underpins the marine, coastal, and human environments of the West Coast. This upwelling process is driven by the same winds that will potentially be harnessed by **future floating offshore wind farms** to provide energy to the power grid. These offshore wind farms will consist of 30 to 200 wind turbines per lease area that are up to 335 m tall. Due to the deep offshore environment, each turbine will be supported by a **floating base** (substructure) that will likely extend 20 to 30 m below the surface.

Scan this code to read about the latest specifications for California's future floating offshore wind farms.

A common question that BOEM receives:

Will these offshore wind farms influence upwelling behavior? ...If so, how will this affect the CCE?

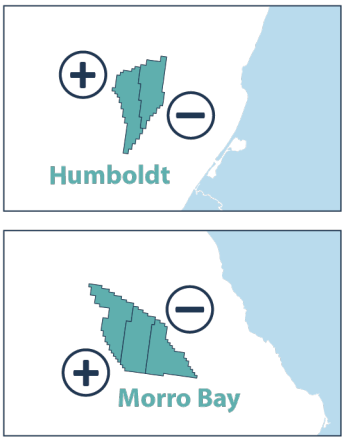


Investigations to Date & Future Directions

Follow the timeline below to learn about the studies recently completed, currently in progress, and planned for the future **that address concerns about offshore wind impacts on upwelling** and the CCE.

MAY 2020

Modeling Effort Takes First Look at Possible Impacts on Upwelling



Model results show that slight reductions in wind speed due to wind turbines lead to small changes in upwelling:

⊖ ***decrease in upwelling*** *between lease areas and shore*
⊕ ***increase in upwelling*** *offshore from lease areas*

Overall, there was minimal net change in upwelling.

This study did not model the ecosystem, and the focus was limited to offshore California.

...These are opportunities for further investigation.

Read the full report here:

And peer-reviewed papers here:

OCTOBER 2022

Follow-on Modeling Study in Progress

- **Add** a biogeochemical model to simulate changes in nutrient flux and primary productivity
- **Expand** the geographic scope to include the entire U.S. West Coast
- **Update** turbine capacity to include 15-20 MW turbines

Read more about the BOEM-funded study here:

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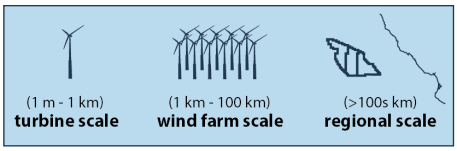
East Coast Study has Outcomes Relevant to West Coast



Observational and model validation studies should target processes relevant at **wind turbine, wind farm, and regional scales** to characterize upwelling.

Read the full National Academies report here:

MARCH 2024

BOEM and NOAA Hold a Workshop to Get Scientists Talking

Participants discussed **observational monitoring** and **modeling approaches** to understanding the potential impacts of offshore wind development on California Current upwelling.

Read the full workshop summary report here:

OCTOBER 2024

New Study Looks Below the Surface

BOEM funds an additional modeling study that will investigate an aspect not previously explored: how the **underwater infrastructure of floating wind farms** may influence local upwelling behavior, biogeochemistry and primary productivity.

For more information, visit BOEM's Environmental Studies in the Pacific

The Department of the Interior's Bureau of Ocean Energy Management (BOEM) manages development of U.S. Outer Continental Shelf (OCS) energy, mineral, and geological resources in an environmentally and economically responsible way.