CALIFORNIA ENERGY COMMISSION

Projected cross-shore changes in upwelling induced by offshore wind farm development along the California coast

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NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

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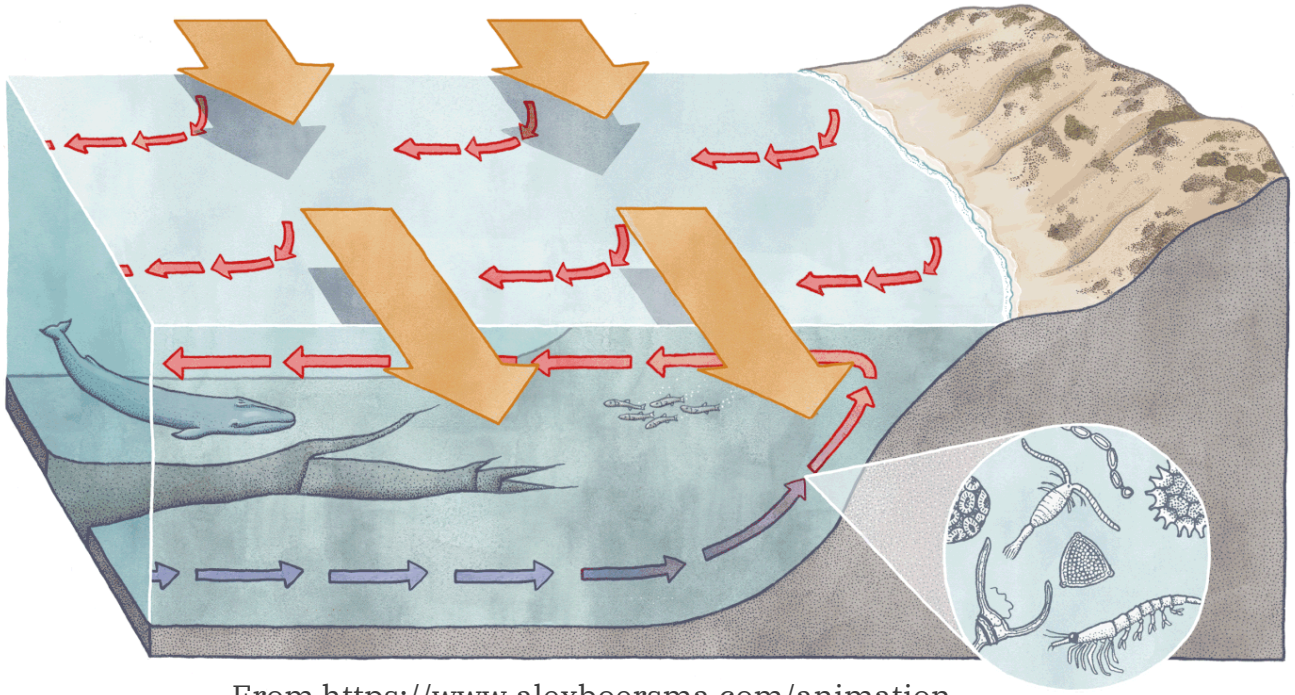
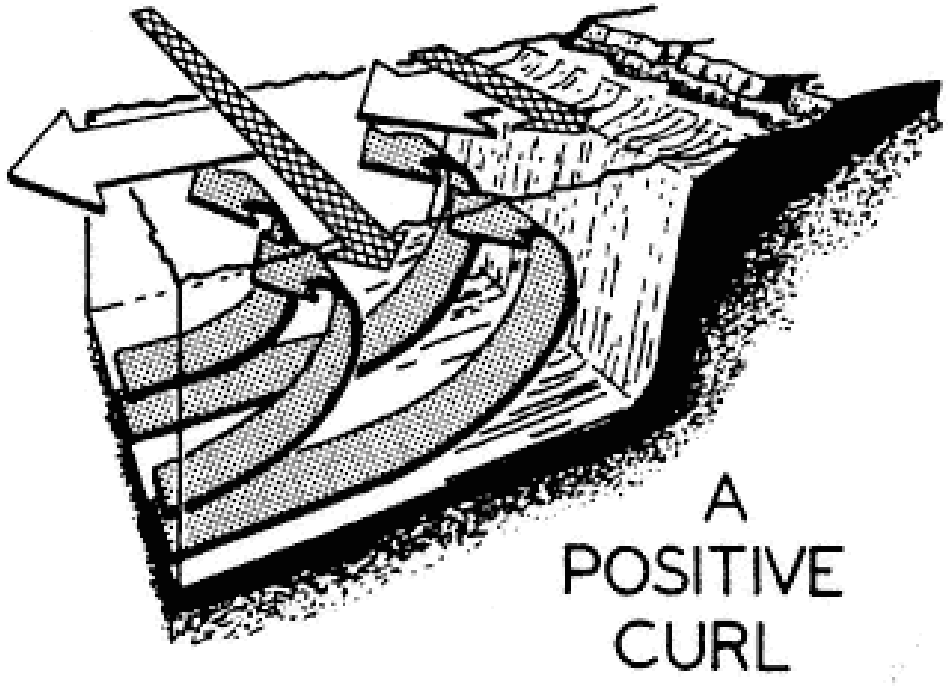
What is upwelling?



From https://www.alexboersma.com/animation

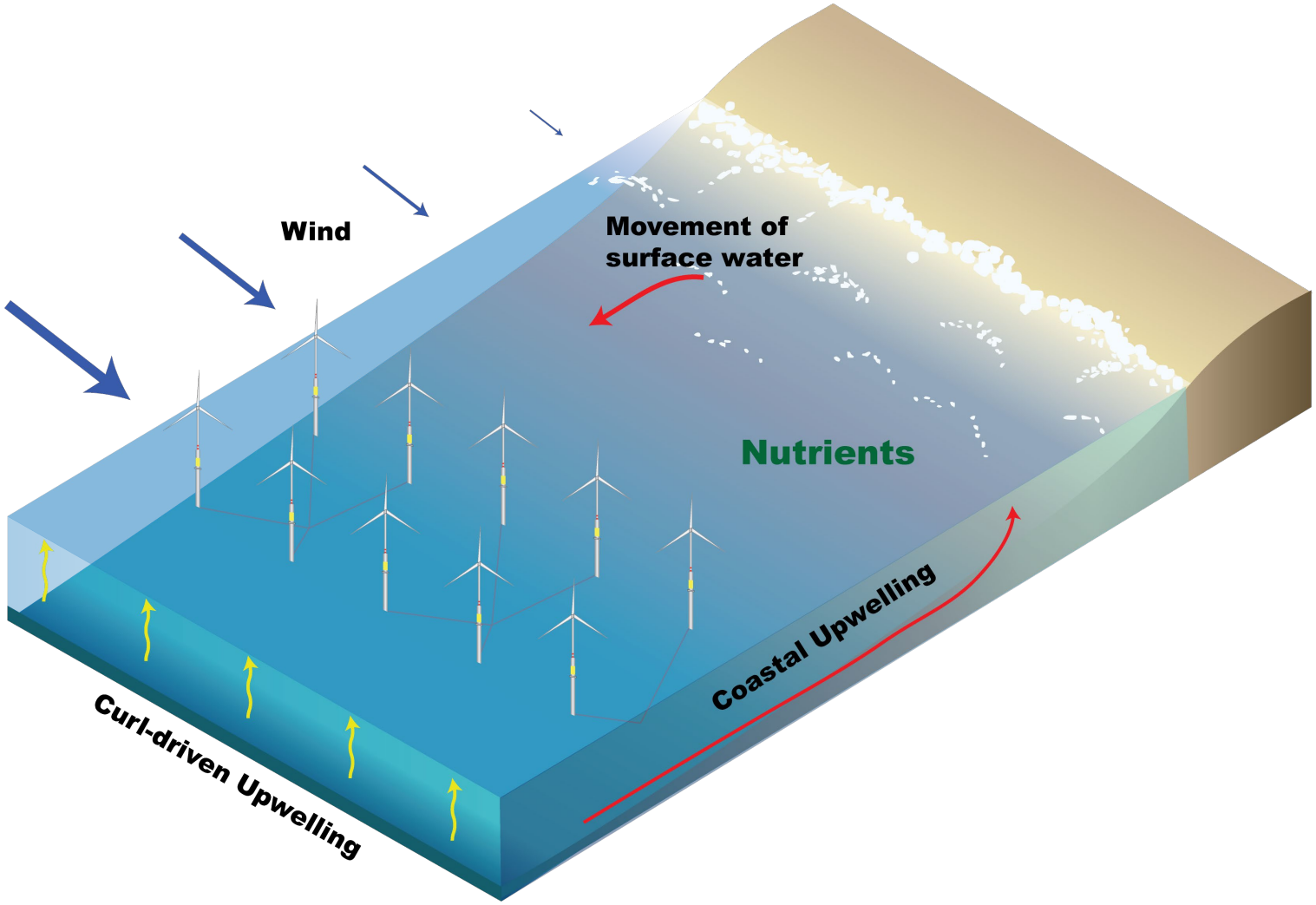


From https://nap.nationalacademies.org/read/1991/chapter/8

- **Coastal upwelling**
  - Driven by strong northwesterly winds on the U.S west coast
  - Generally occurs in a narrow band (~30 mi) along the coast

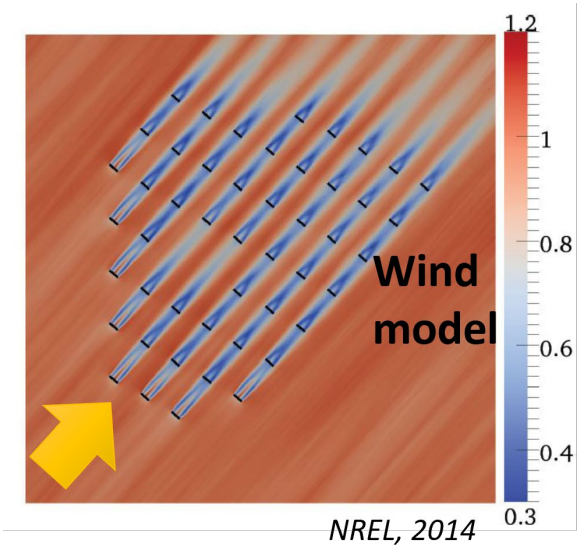
- **Curl-driven upwelling**
  - Driven by cross-shore gradients in wind speed
  - Can extend far offshore (100 – 200 mi)

Do offshore wind farms have the potential to affect coastal upwelling?



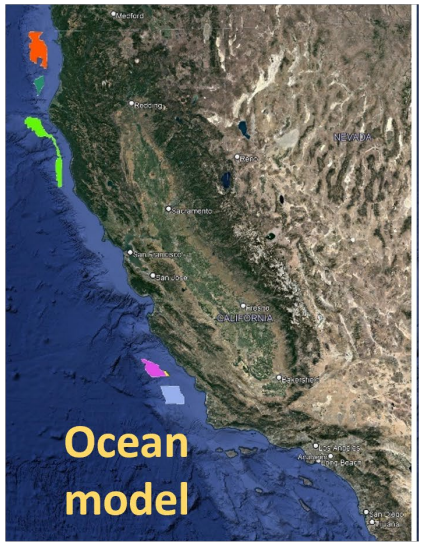
- Coastal upwelling – alongshore wind stress drives offshore transport of surface water
- Curl-driven upwelling- cross-shore gradient in wind speeds
- Maritime economy valued at ~$22 billion

Goals and Objectives



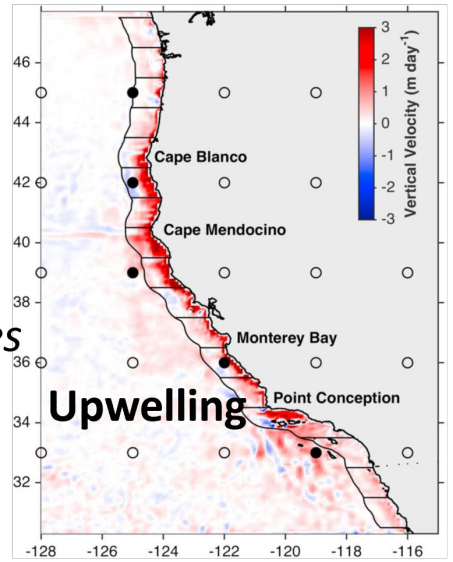
NREL, 2014

drives



Adapted from Raghukumar et al., 2023

computes



Jacox et al, 2018 (UCSC/NOAA)

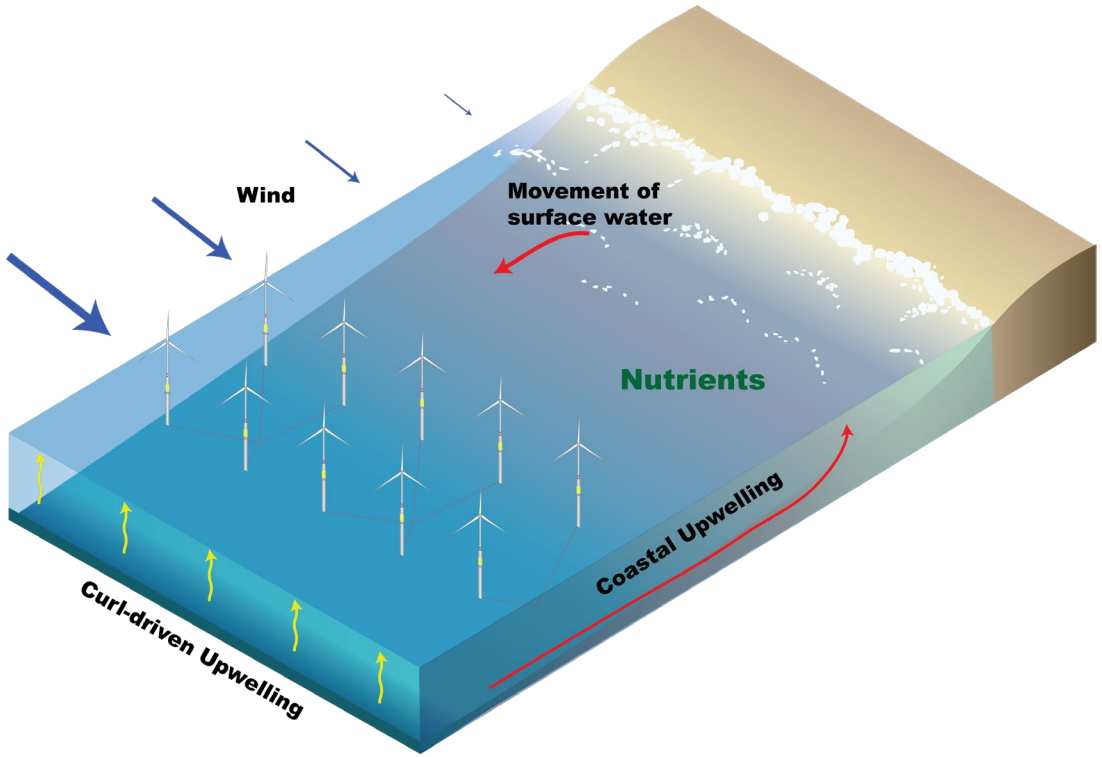
Goals

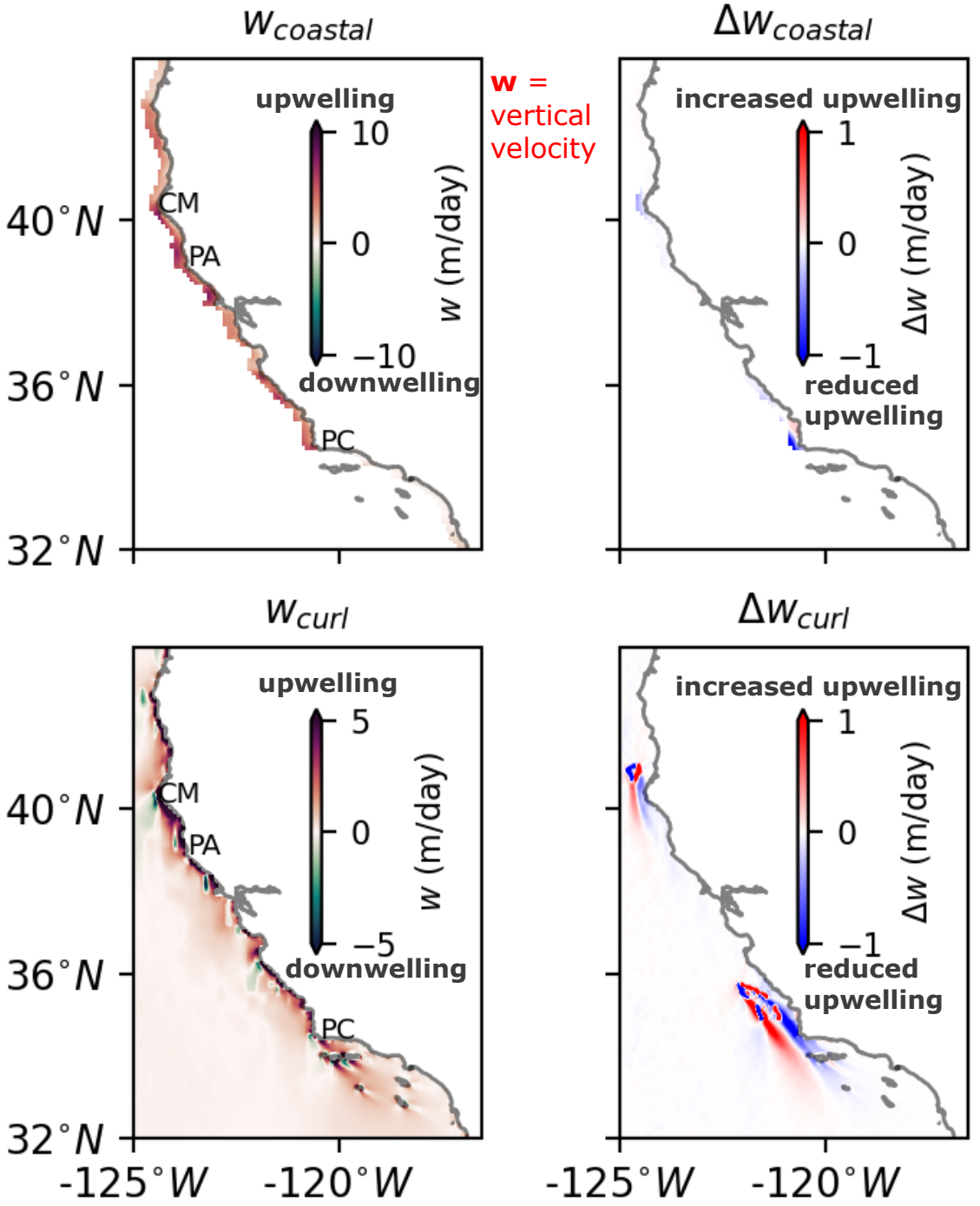
- Determine potential changes in California upwelling due to offshore wind project development

Objectives

- Numerical modeling of atmosphere and ocean circulation

Vertical Velocity from Wind Fields

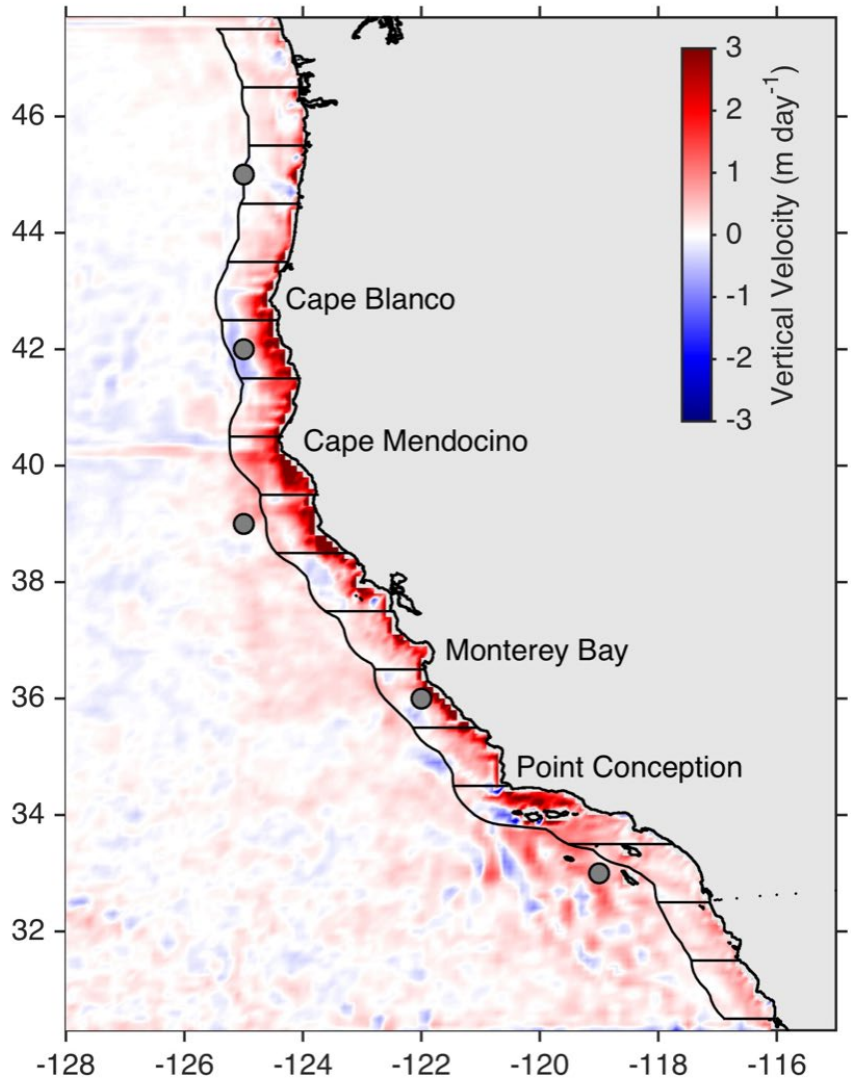




Upwelling Metrics

Operational NOAA upwelling metrics

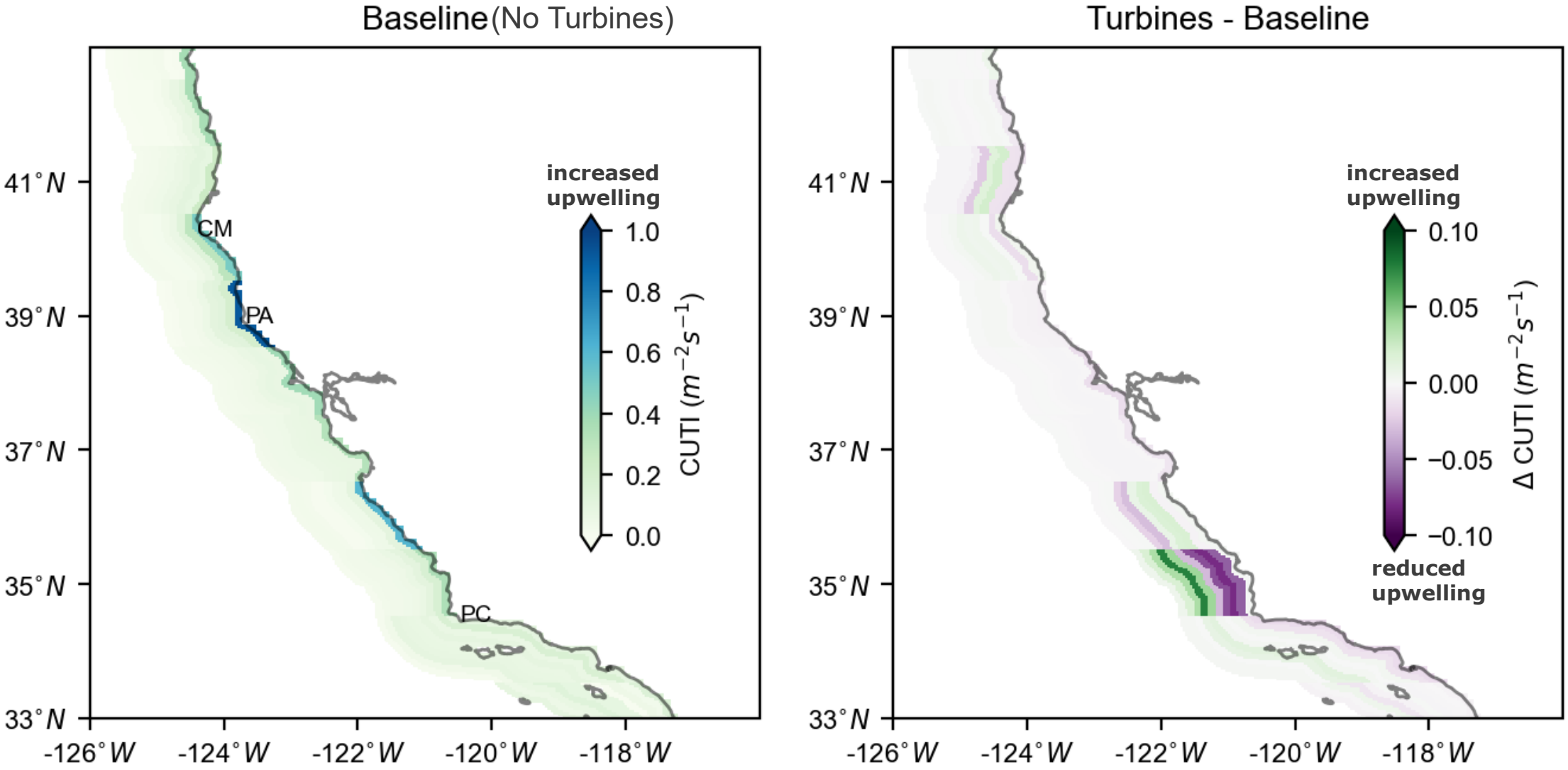
- https://oceanview.pfeg.noaa.gov/products/upwelling/cutibeuti
- Coastal Upwelling Transport Index
  - Volume transport
- Biologically Effective Upwelling Transport Index
  - Nitrate flux (nutrient transport)
  - Estimated by relating temperature to nitrate concentrations. ***Not from ecosystem model***



Mean spring/summer vertical velocity (upwelling in red, downwelling in blue). CUTI and BEUTI are calculated for 1˚ latitude bins, outlined in black. Gray dots are Bakun Index locations.

(Jacox et al. 2018)

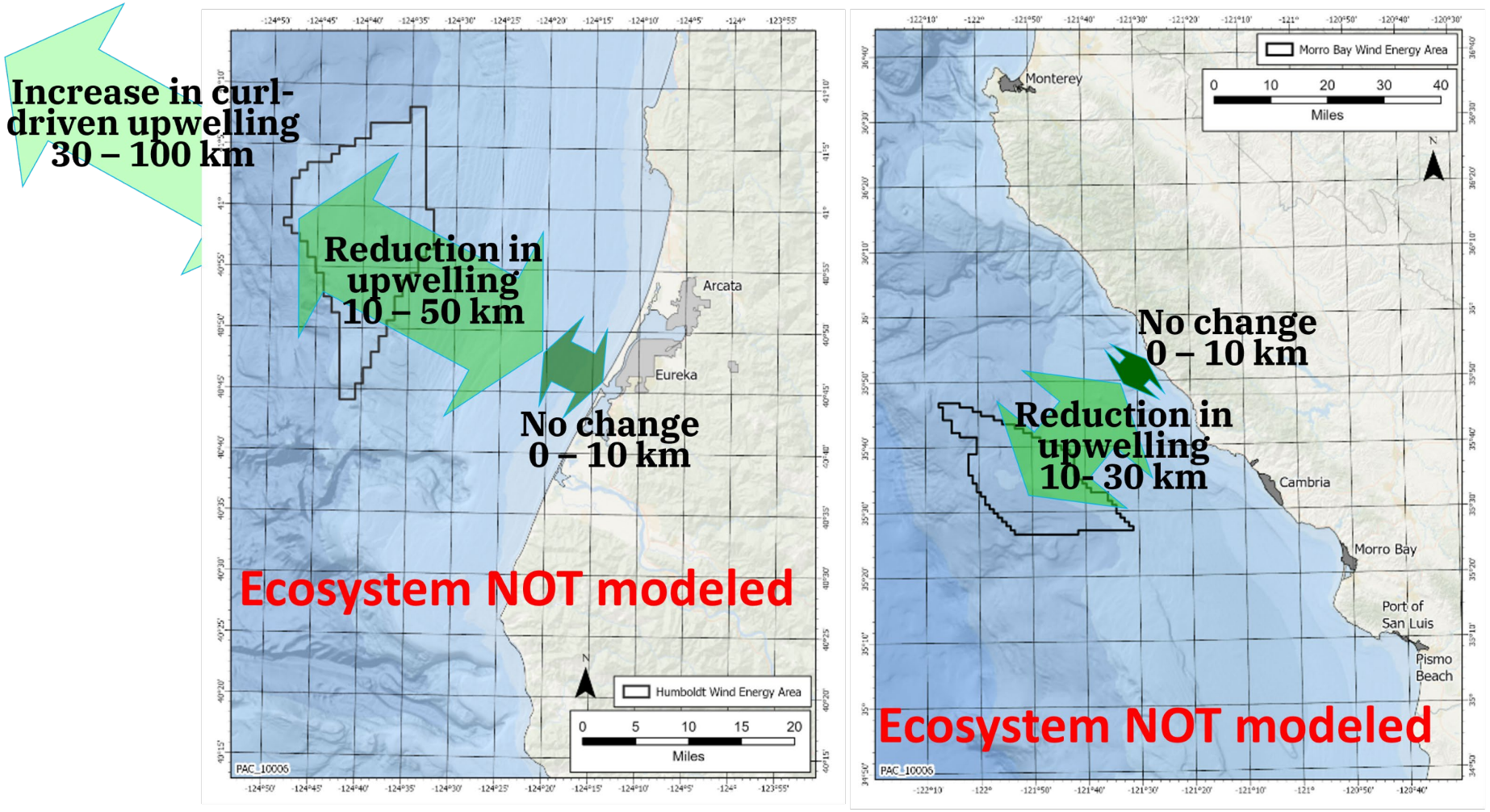
Upwelling Metrics – CUTI (upwelling strength)



Conclusions

Humboldt

Morro Bay



More Information

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Effect of Floating Offshore Wind Turbines on Atmospheric Circulation in California

https://www.frontiersin.org/articles/10.3389/fenrg.2022.863995/full

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https://www.nature.com/articles/s43247-023-00780-y