Alternate Pathways to Productivity on the Washington Shelf

Nina Buzby – University of Washington School of Oceanography

PICES 2026



Alternate Pathways to Productivity on the Washington Shelf

Changing Ecosystems and Fisheries Initiative (CEFI)

Jens Nielsen | Eric Ward | Silvana Yanet Gonzalez | Steph Moore



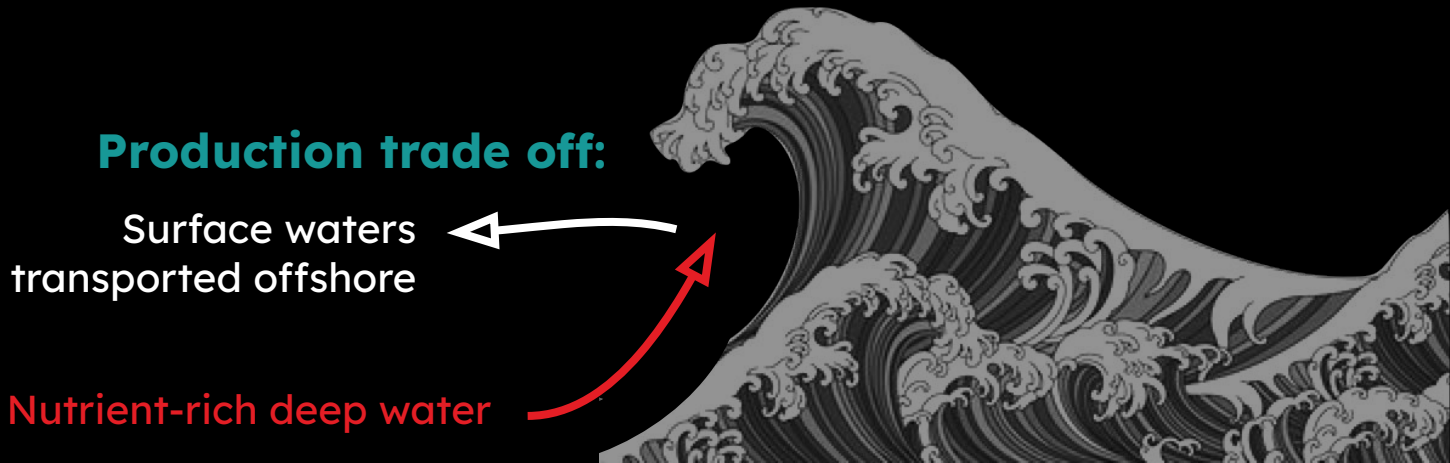
Alaska & Northwest Fishery Science Center(s)

Inflation Reduction Act Funding Profile ($ in Millions)	**Total**
Data Acquisition and Management	$141.8
Climate, Ecosystems, and Fisheries Initiative (CEFI)	$40.0
Regional Fishery Management Councils	$20.0
Red Snapper	$20.0
North Atlantic Right Whales	$82.0
Pacific Salmon	$42.0
Hatcheries and Tribal Support	$300.0
Habitat Restoration	$313.0
Fish Passage	$171.0
Arctic Research	$2.9
Permitting Efficiency	$15.5
Facilities Modernization	$95.0
Administrative Overhead	$21.6
Total NOAA Fisheries IRA Investments*	**$1,269.3**

*Total includes an additional $4.5 million for tribal support activities

Motivations tied to coastal fisheries

- PNW commercial fisheries generated more than $400 million in 2012 [NMFS, 2014] and are a **vital socioeconomic industry**
- **20% of global fisheries** catches come from eastern boundary upwelling systems (EBUS), despite covering < 1% of the ocean surface [FAO, 2022]
- Coastal seasonal **upwelling transports nutrients** to the surface, driving high production



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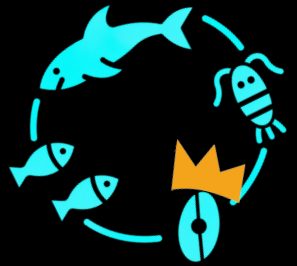
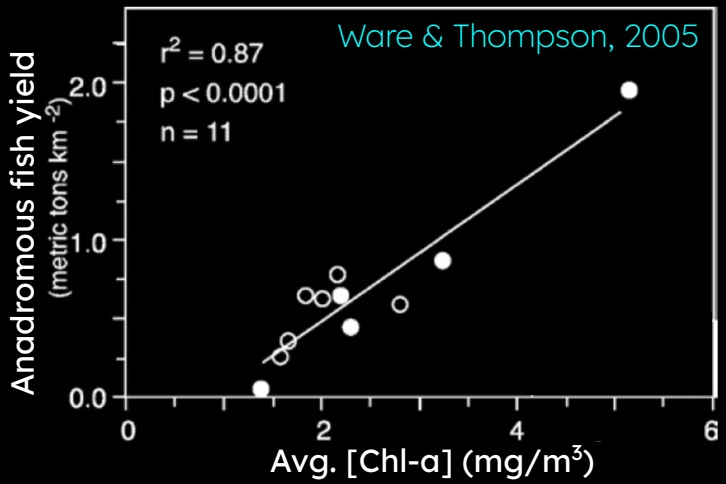
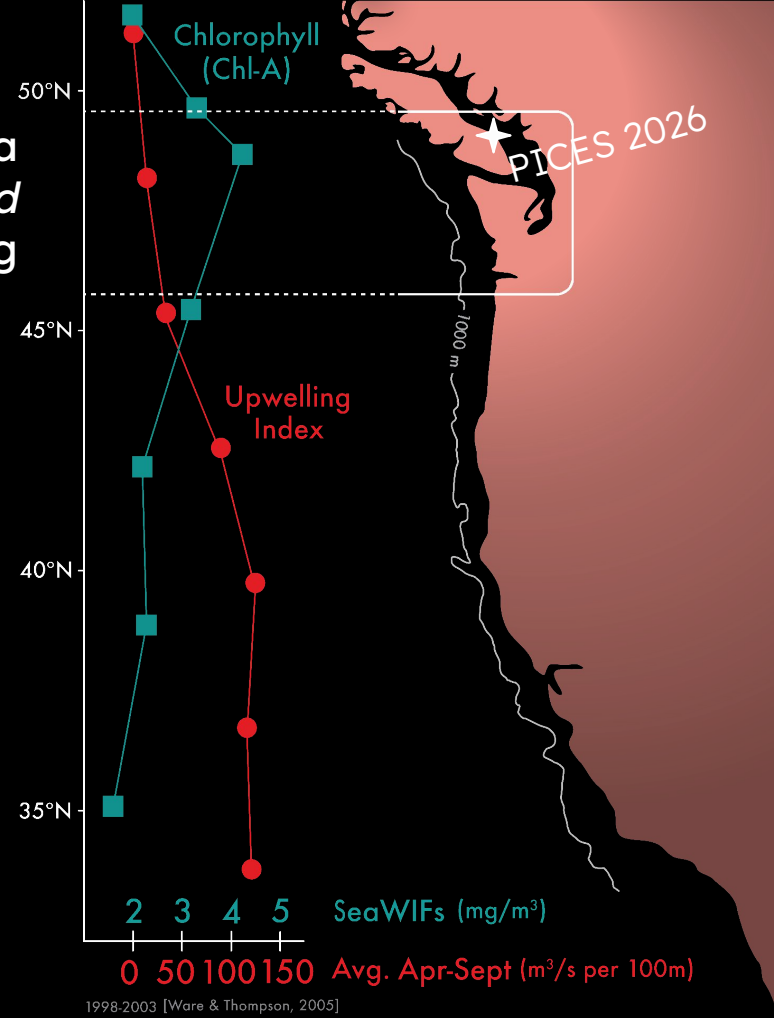
- Coastal seasonal **upwelling transports nutrients** to the surface, driving high production
- NE Pacific known for strong, large-scale **"bottom-up"** trophic linkage
  - Selection of supporting studies: *Ruzika et al., 2016; Miller et al., 2010; Field et al., 2006; Brodeur et al., 2005; Ware & McFarlane, 1989*





Compared to the rest of the California Current System (CCS), WA shows *elevated* production despite reduced upwelling



Why the Washington (WA) shelf?

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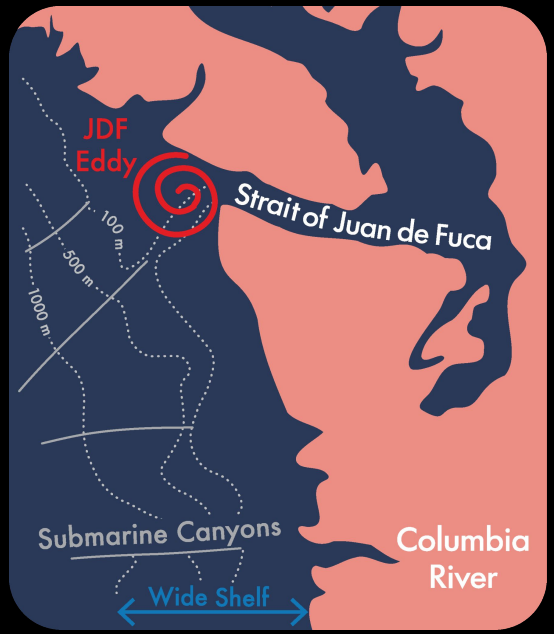
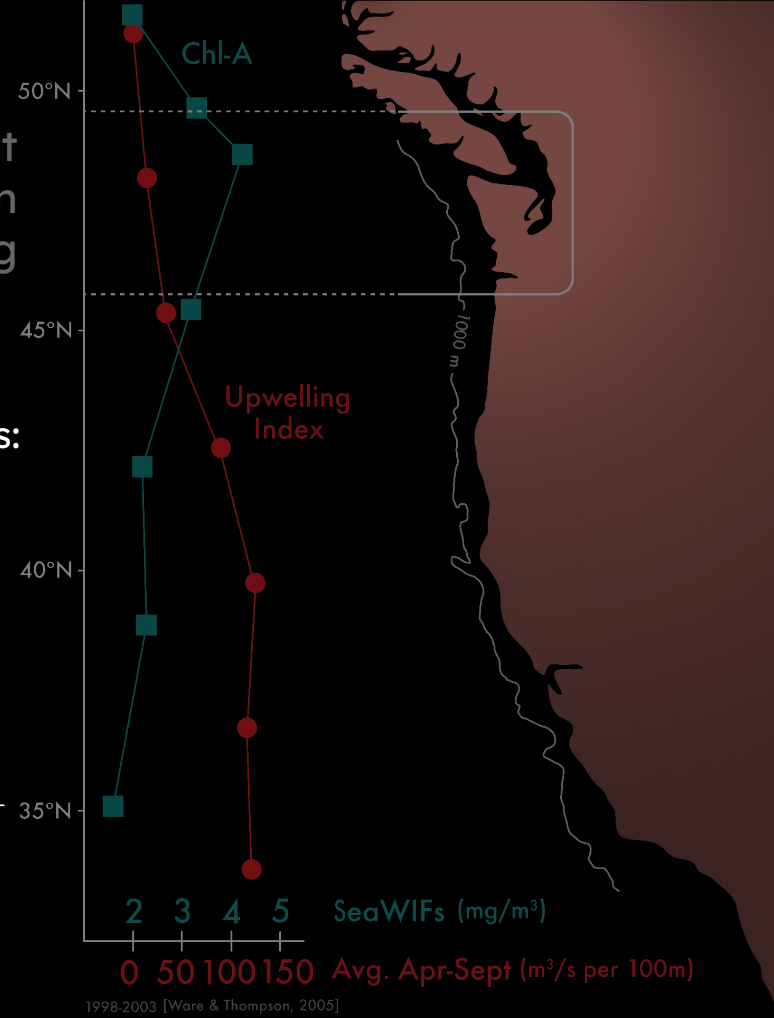


Prior modeling work proposed alternative physical & topographic production drivers:

- **Shelf width** - longer on-shelf residence times
- **Submarine canyons** - enhanced vertical mixing
- **River & estuarine nutrient inputs** - Salish Sea & Columbia
- **Juan de Fuca [JDF] Eddy** - highly retentive feature



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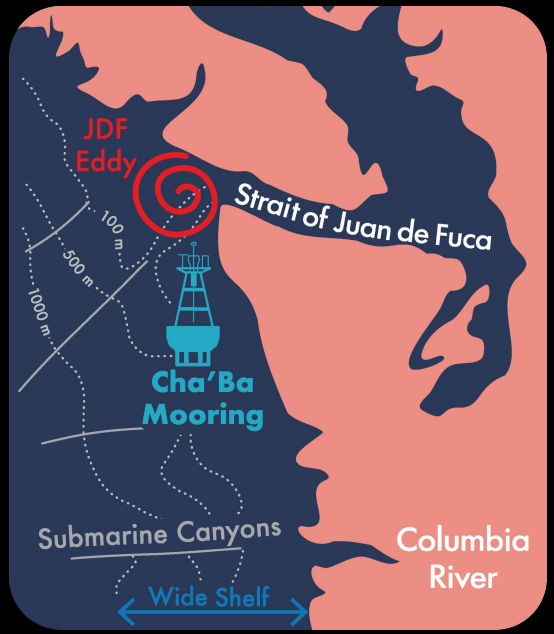
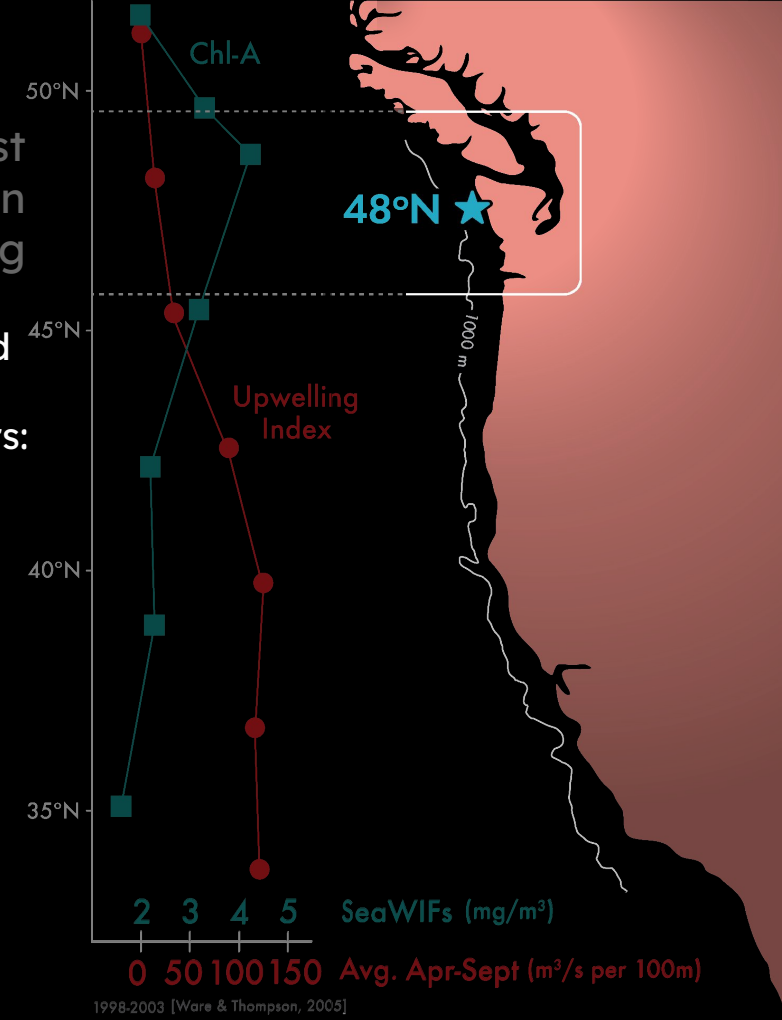


Prior ***modeling*** work proposed alternative physical & topographic production drivers:

NEMO (Northwest Enhanced Moored Observatory) moorings observe the WA shelf



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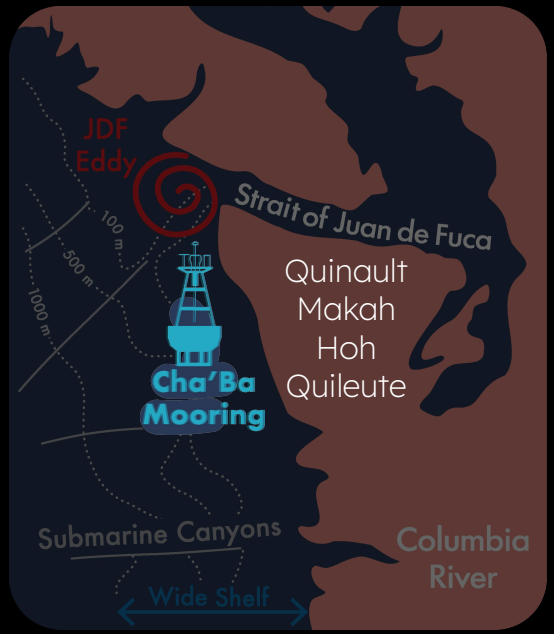


Ćhá?ba·

"Whale tail"

(Quileute)

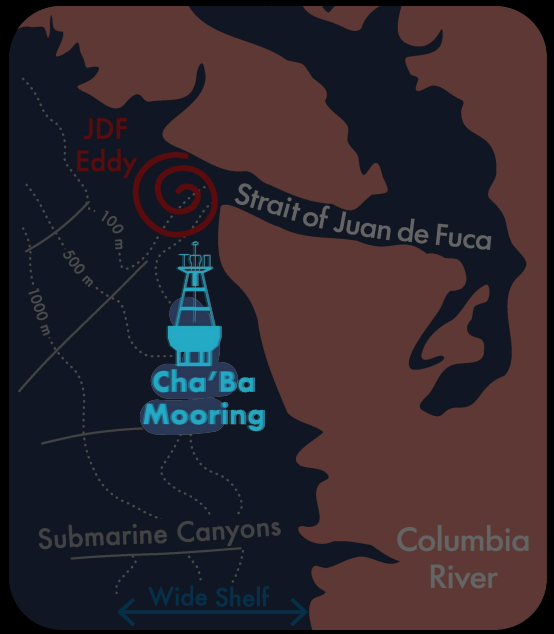


Credit: John Payne

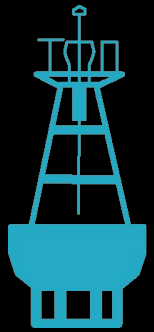
NANOOS

Northwest Association of Networked Ocean Observing Systems

Northwest Enhanced Moored Observatory (NEMO):



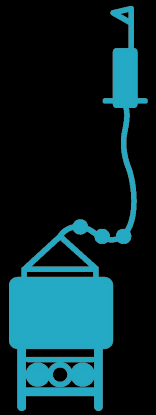
(~100m water)



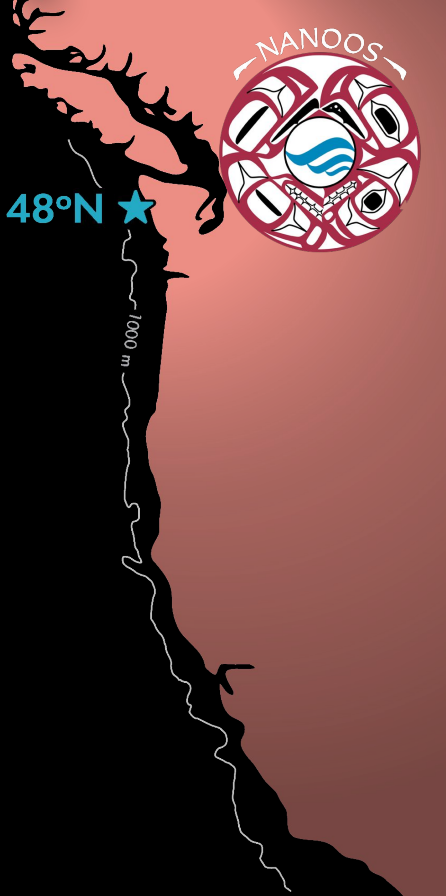
temp, salinity
ADCP
chlorophyll
dissolved oxygen
pCO2, pH

&

(~400m further offshore)

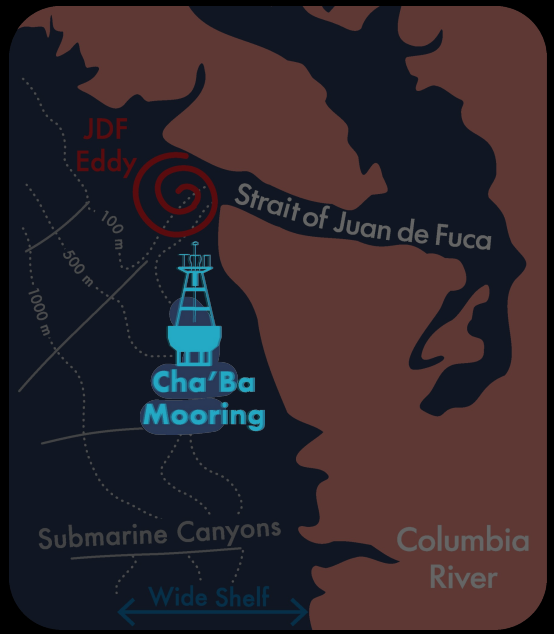


temp, salinity
ADCP
eDNA



To inform ecosystem-based fisheries management…

How and which, observed environmental conditions influence production dynamics in the WA shelf region?



2012 | 2013 | 2014 | 2017 | 2020 | 2021

> 15 years of observations **(6 of interest)**

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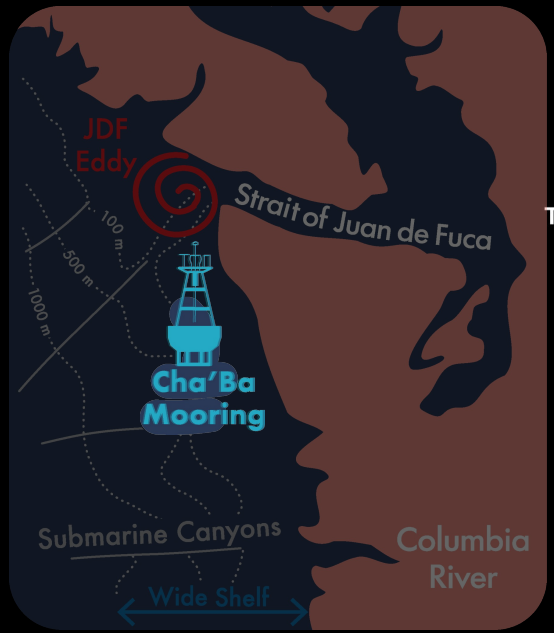

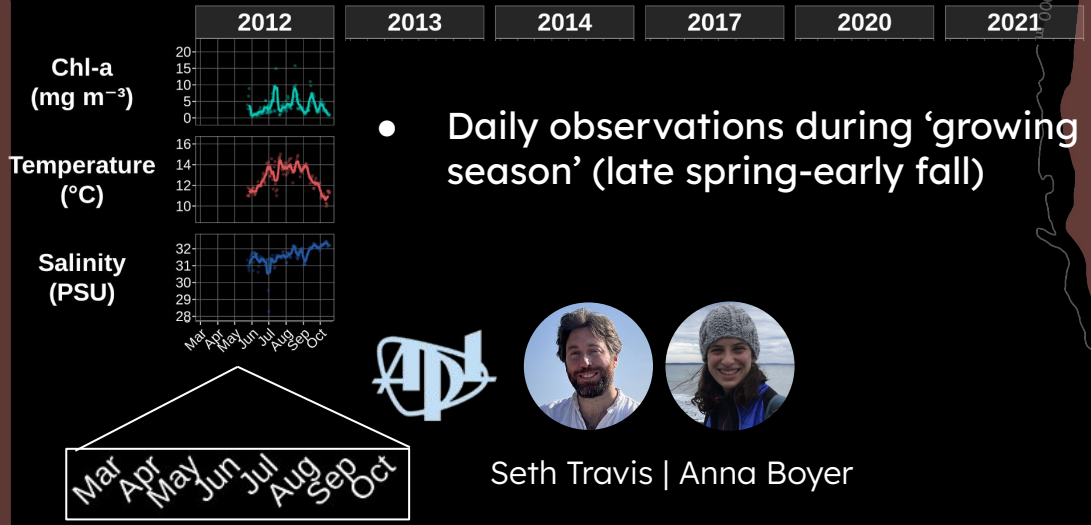

- Daily observations during 'growing season' (late spring-early fall)

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Seth Travis | Anna Boyer

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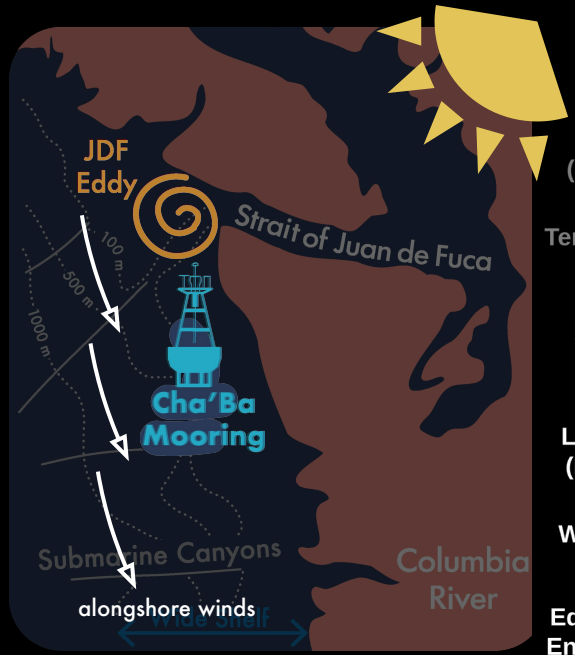
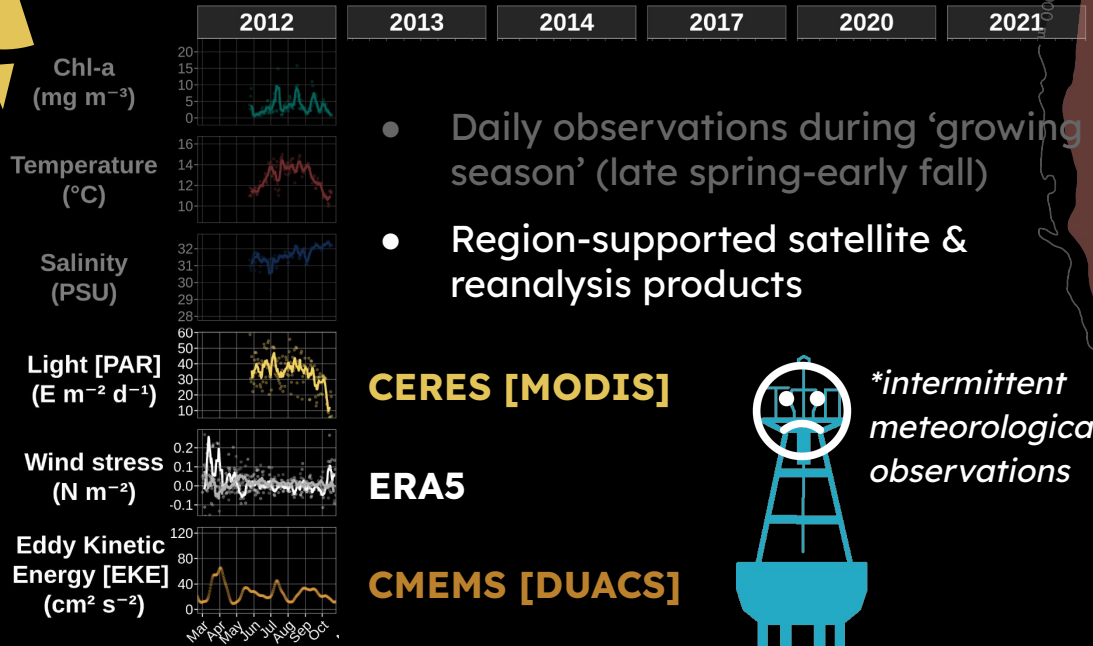




> 15 years of observations **(6 of interest)**

- Daily observations during 'growing season' (late spring-early fall)
- Region-supported satellite & reanalysis products

CERES [MODIS]

ERA5

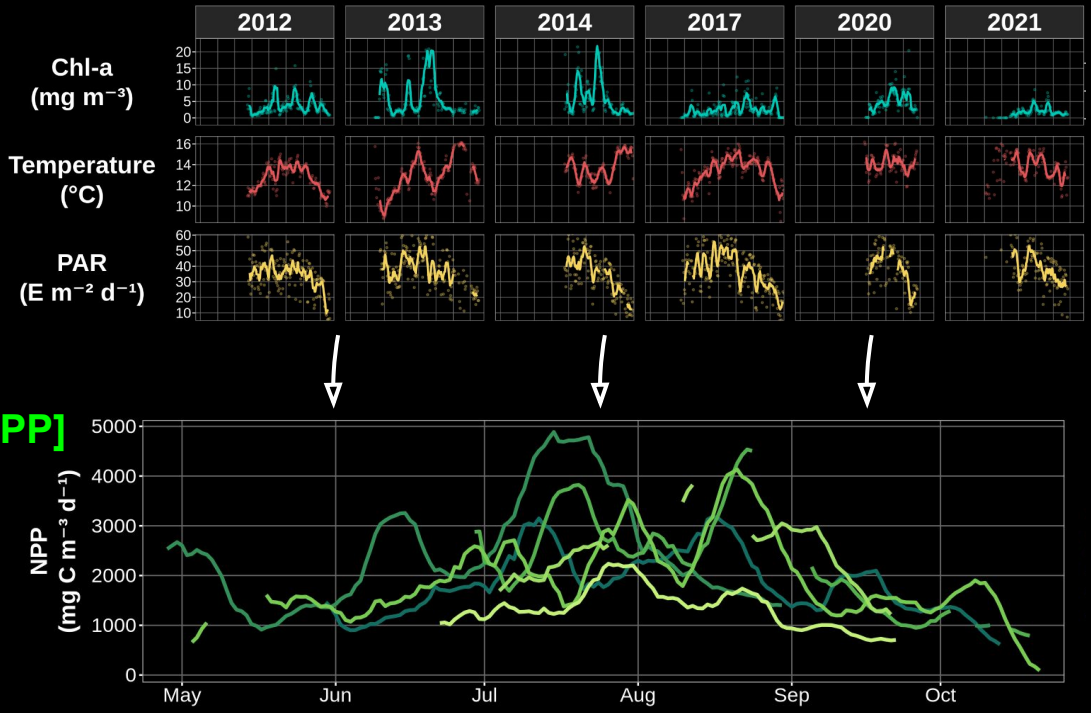
CMEMS [DUACS]

**intermittent meteorological observations*



To inform ecosystem-based fisheries management…

*How and which, observed environmental conditions influence **production** dynamics in the WA shelf region?*



Vertical General Productivity Model† (VGPM)

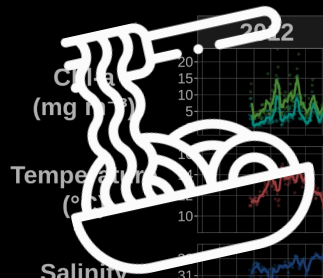
Net Primary Productivity [NPP] (Gross - Respiration) = *f* [chl-a*, temp, light]

†Eppley (1972) formulation
*NPQ & fluorescence corrected



To inform ecosystem-based fisheries management…

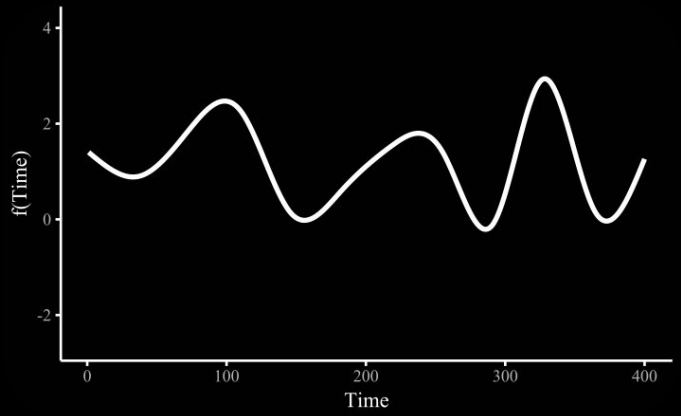
How and which, observed environmental conditions influence NPP dynamics in the WA shelf region?

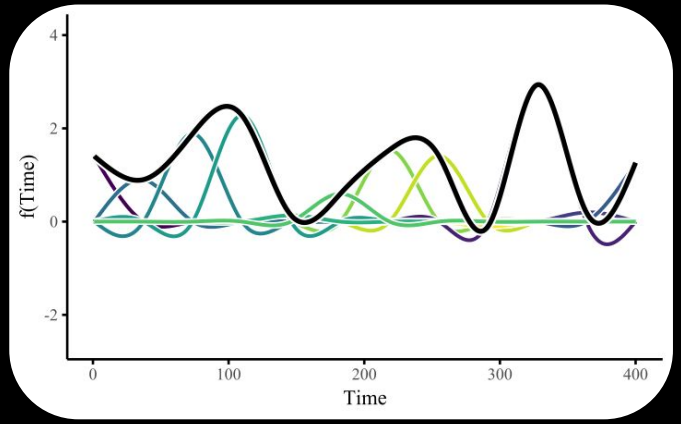


Drivers of Production?

How can concurrent observations inform production mechanisms?

General Additive Models (GAMs) relate predictors using a combination of non-linear relationships









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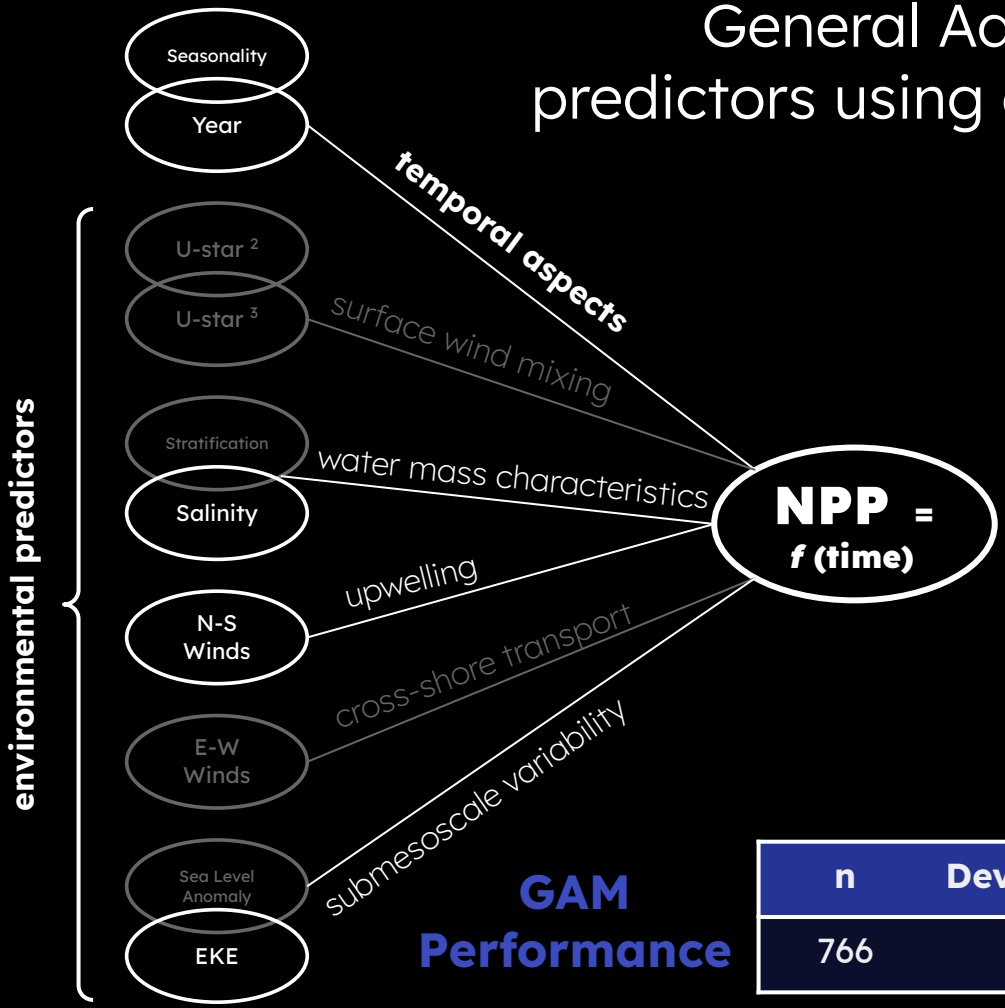
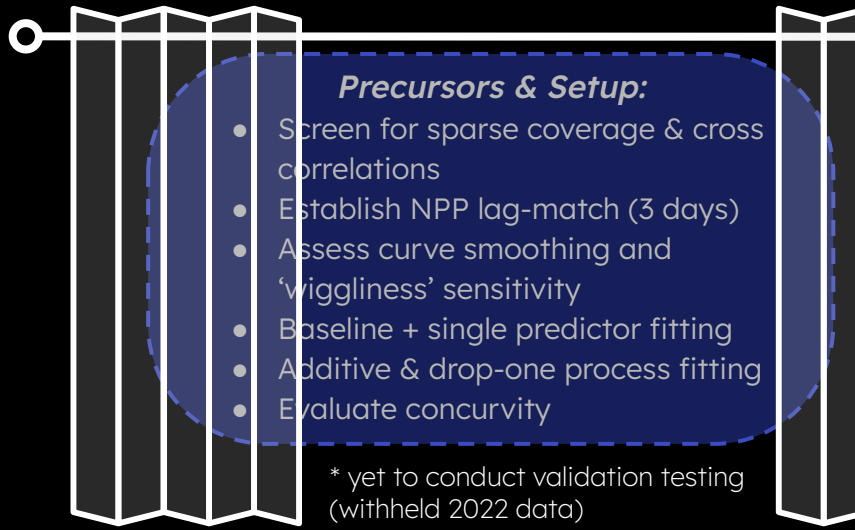




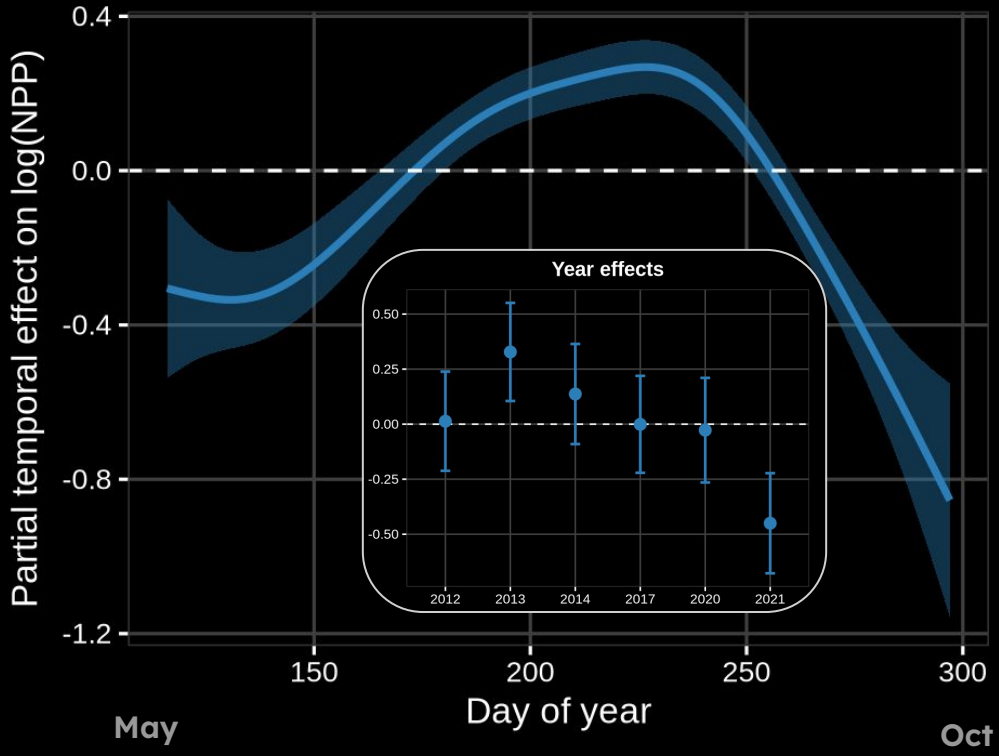
* yet to conduct validation testing (withheld 2022 data)

GAM Performance

n	Deviance explained	Adjusted R^2	RMSE (NPP)
766	64.7 %	0.629	839



What does the model say about the basic NPP pattern through time?



- **Best fit:** common seasonal curve that accounts for year as a ‘random effect’
- General increase in late spring/summer followed by a decrease later in growing season
- Some years depart from pattern more than others



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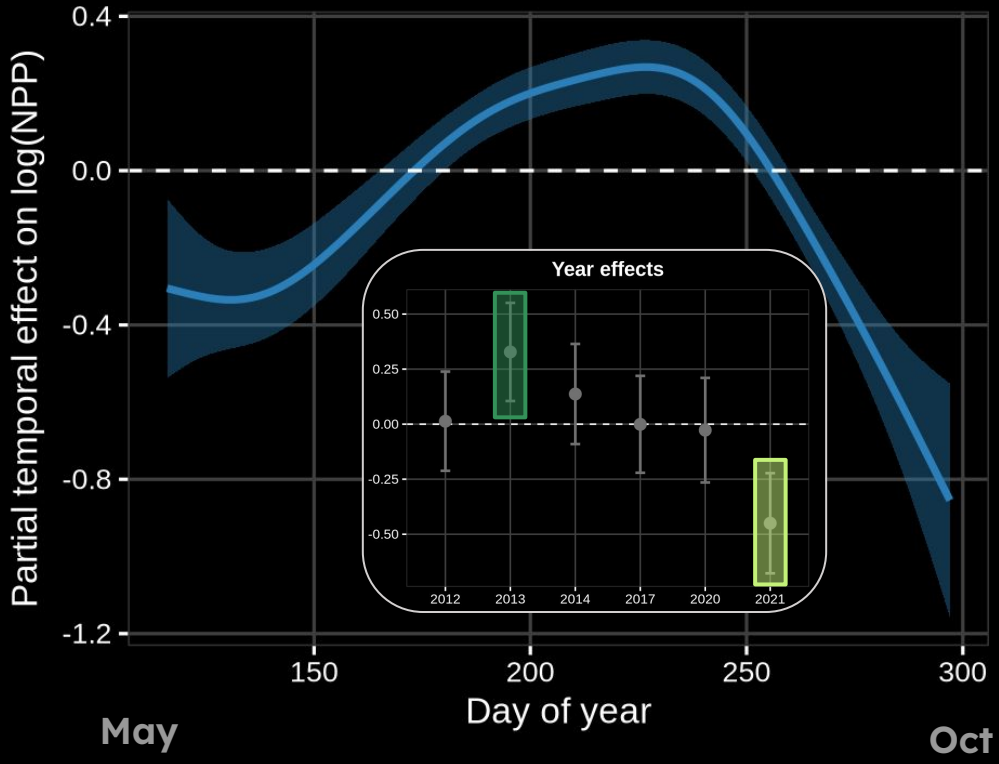

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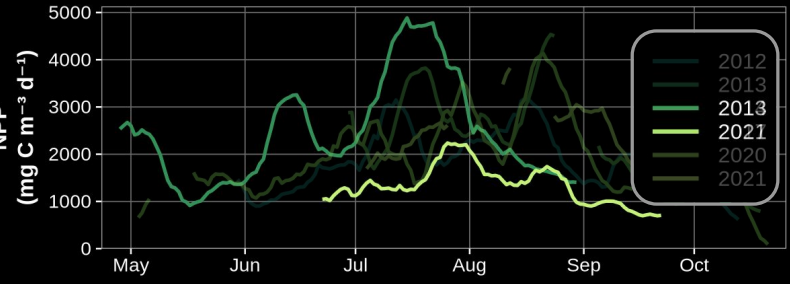
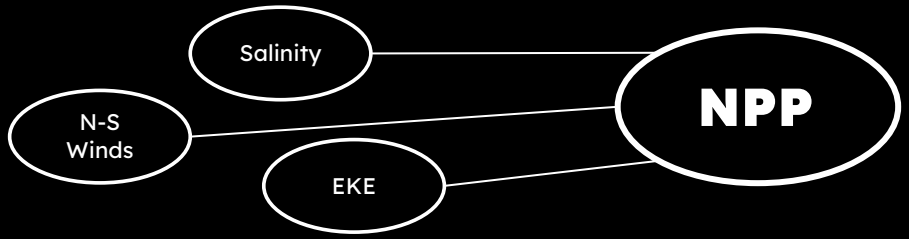
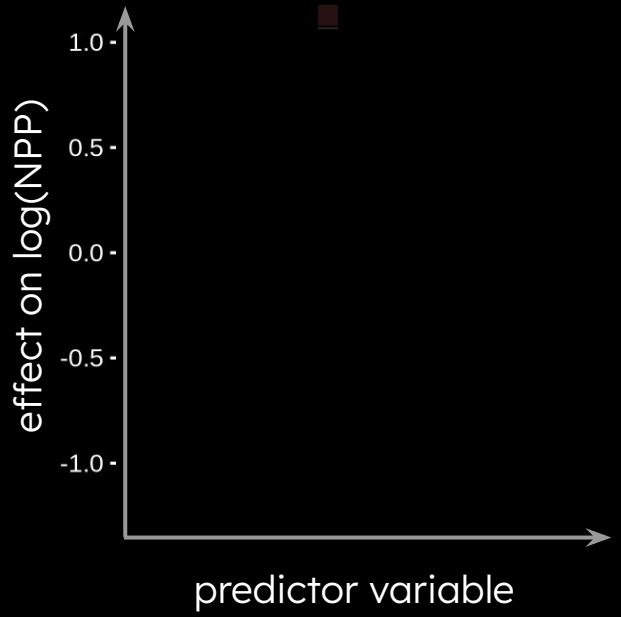


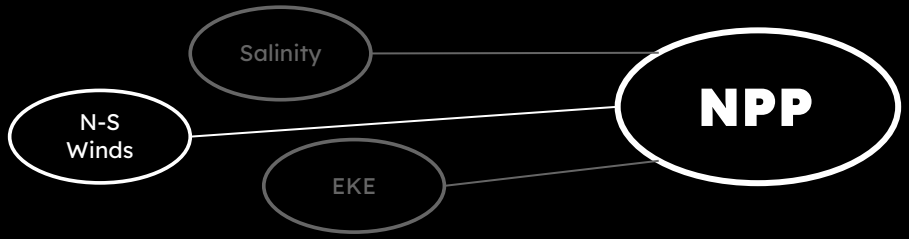


What are the basic relationships between NPP and each environmental driver?

GAM-estimated environmental relationships







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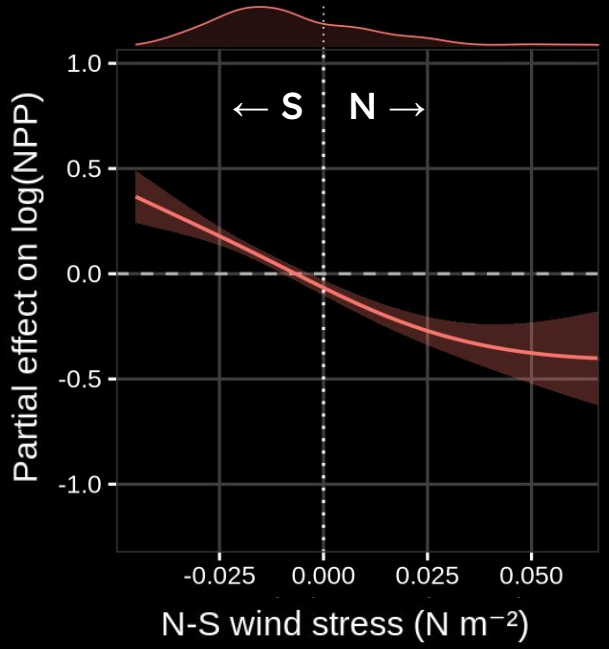



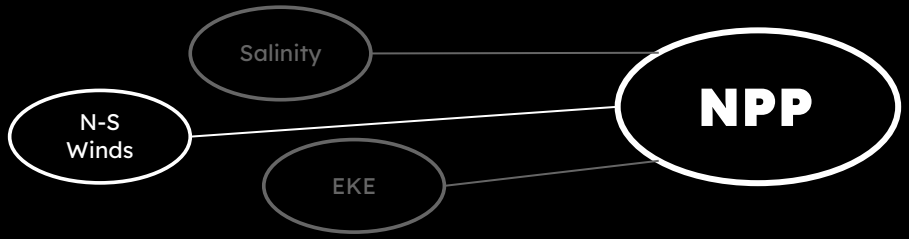

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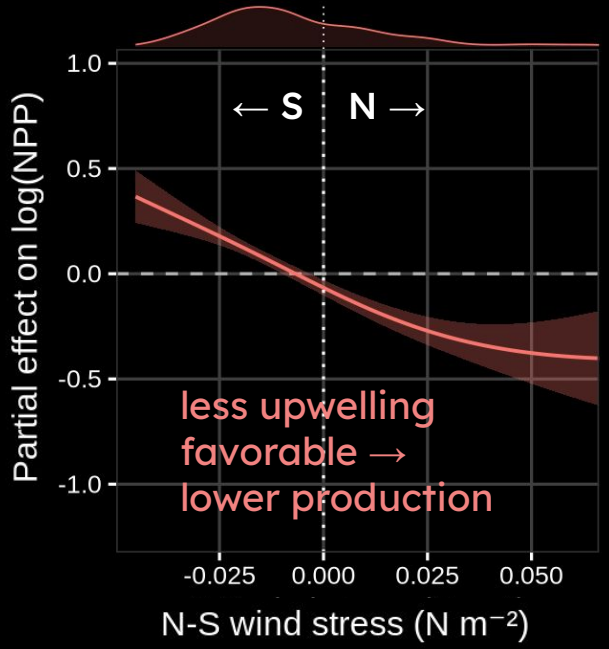

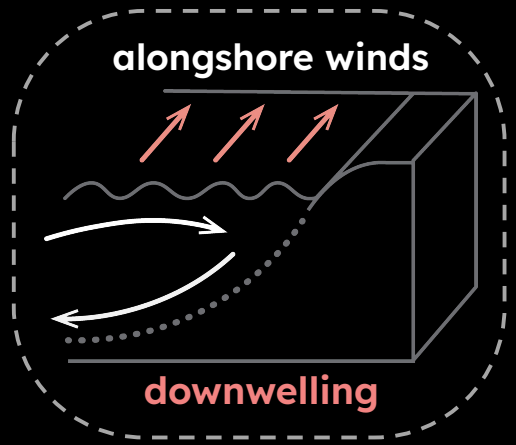

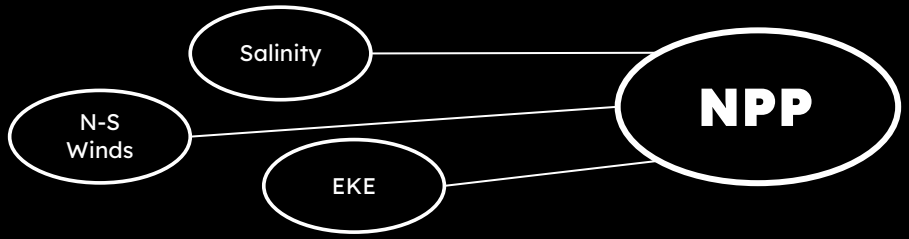

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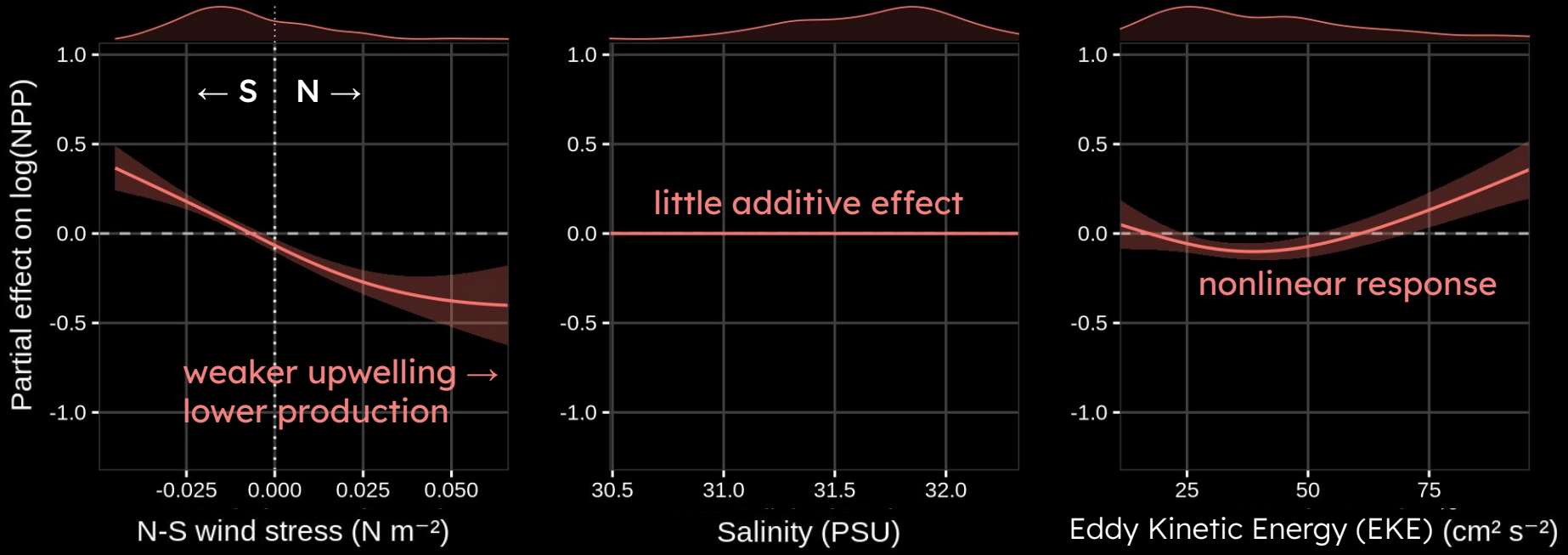
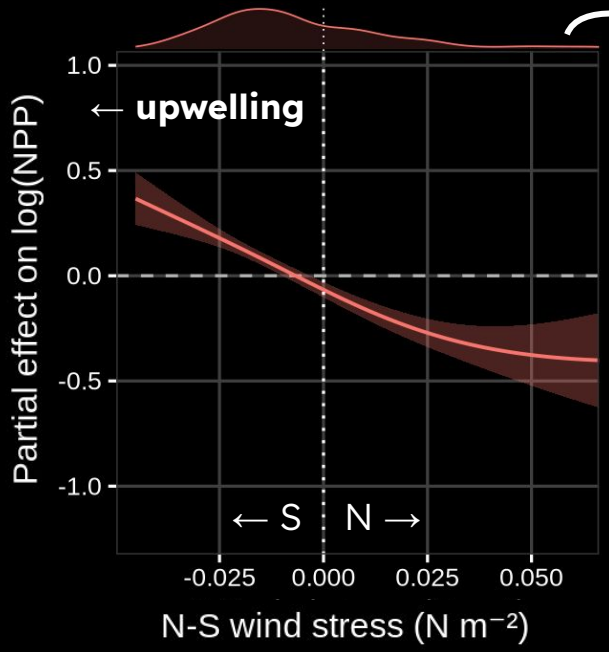
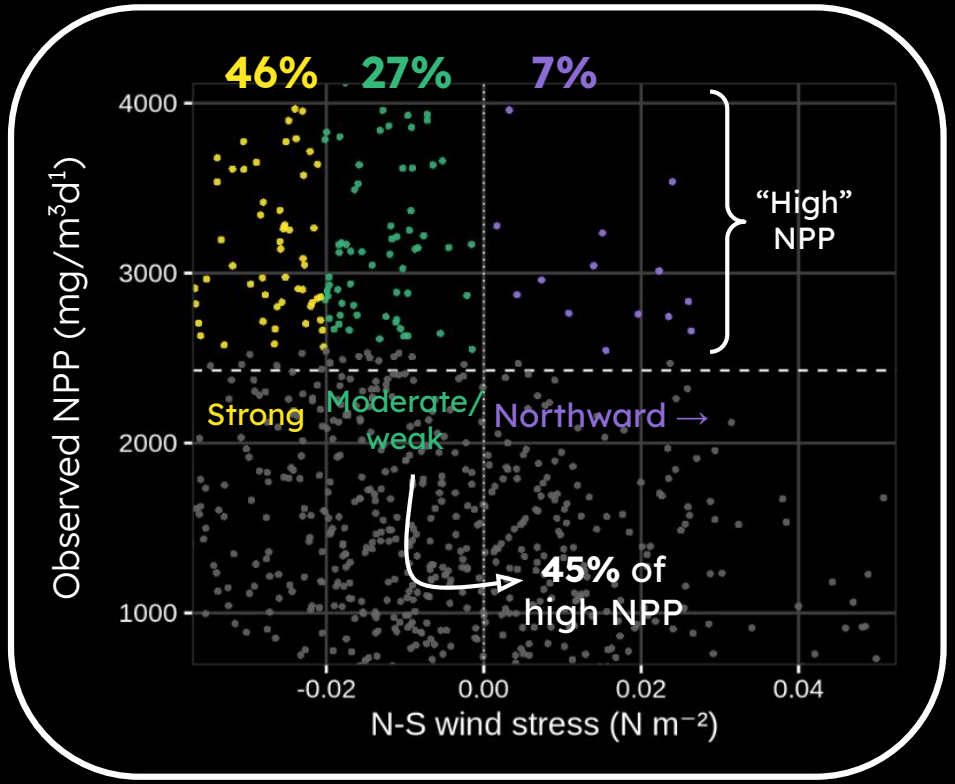
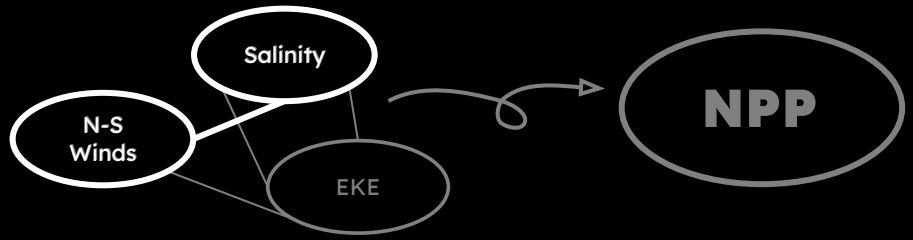


Observations show upwelling favorable conditions are not required for high productivity



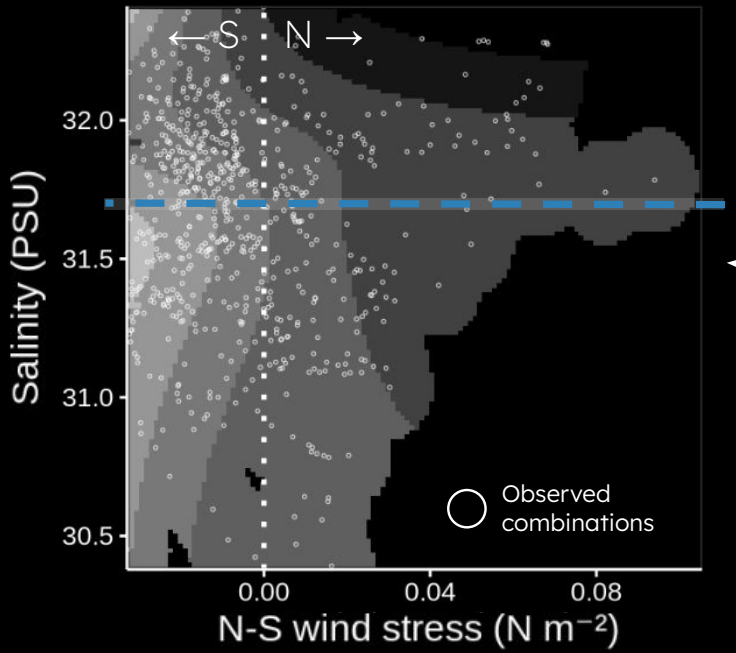


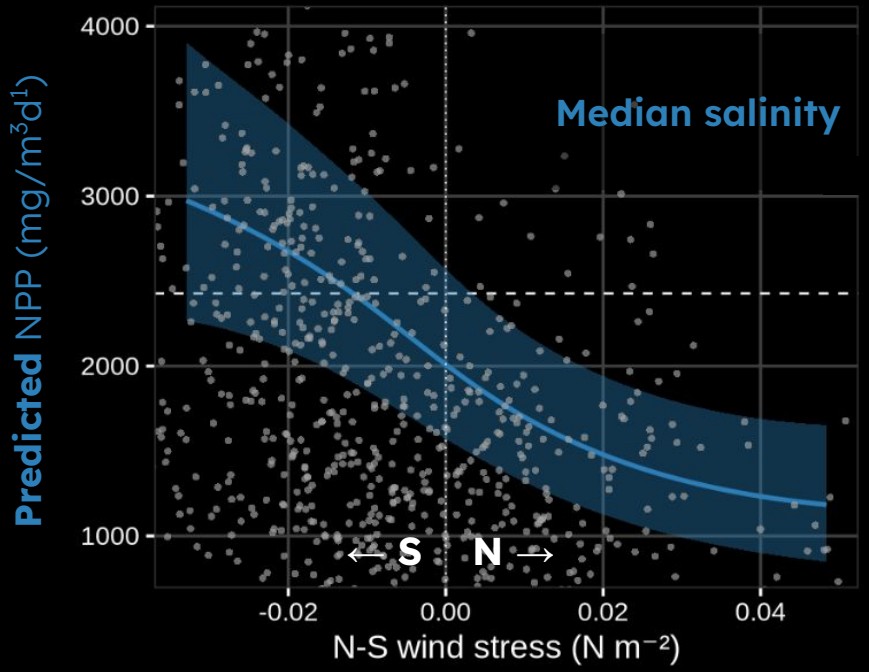


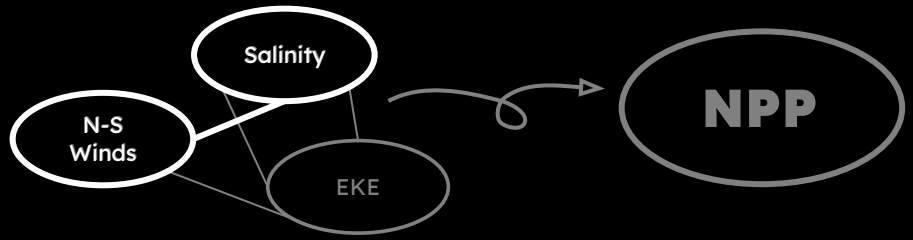
What if predictors interact?

Do environmental effects depend on one another?

Interaction Surface







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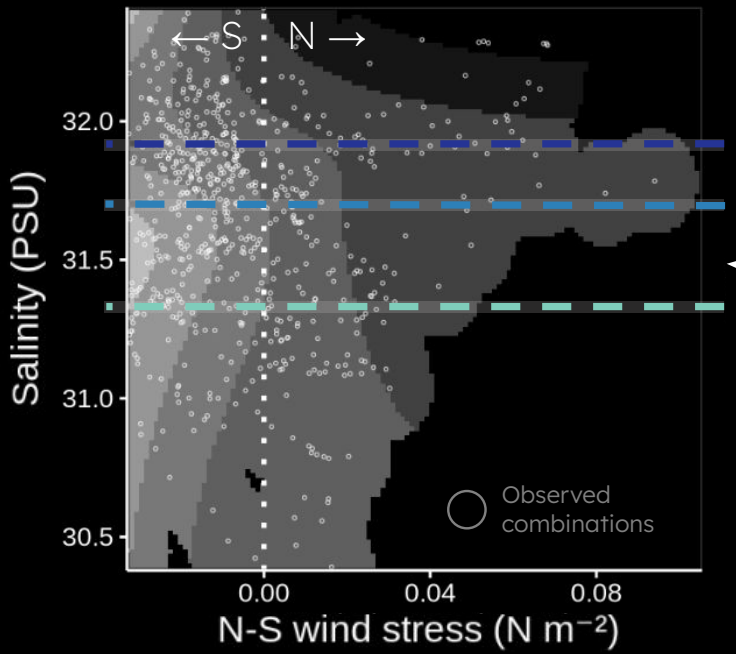

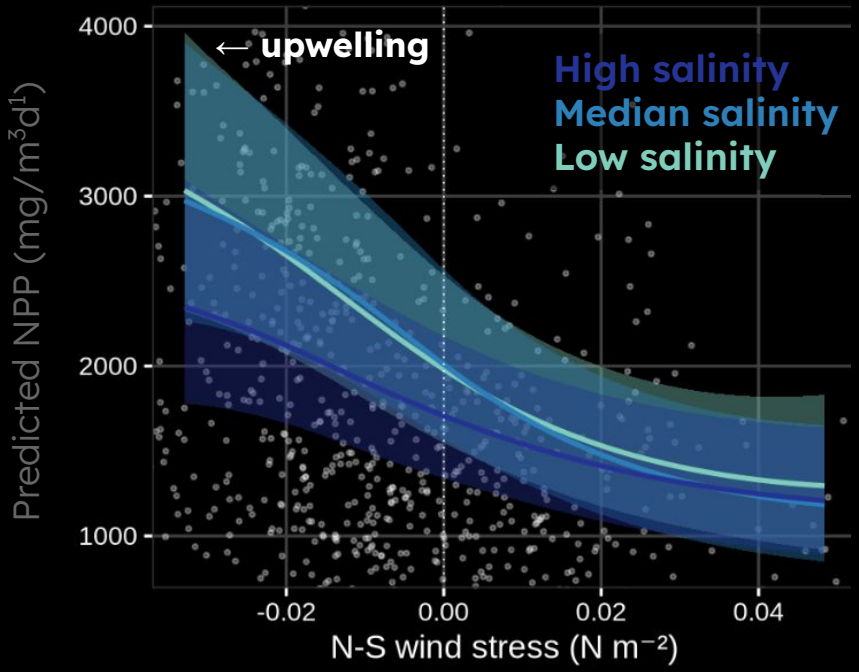

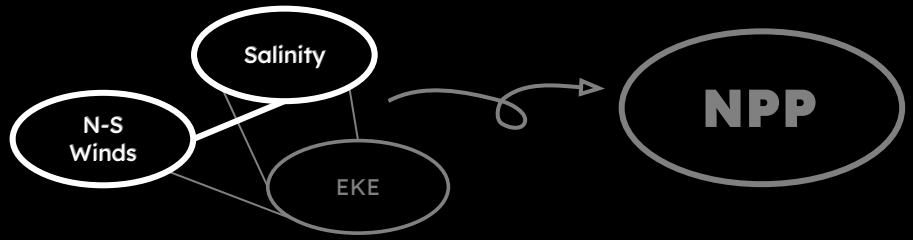

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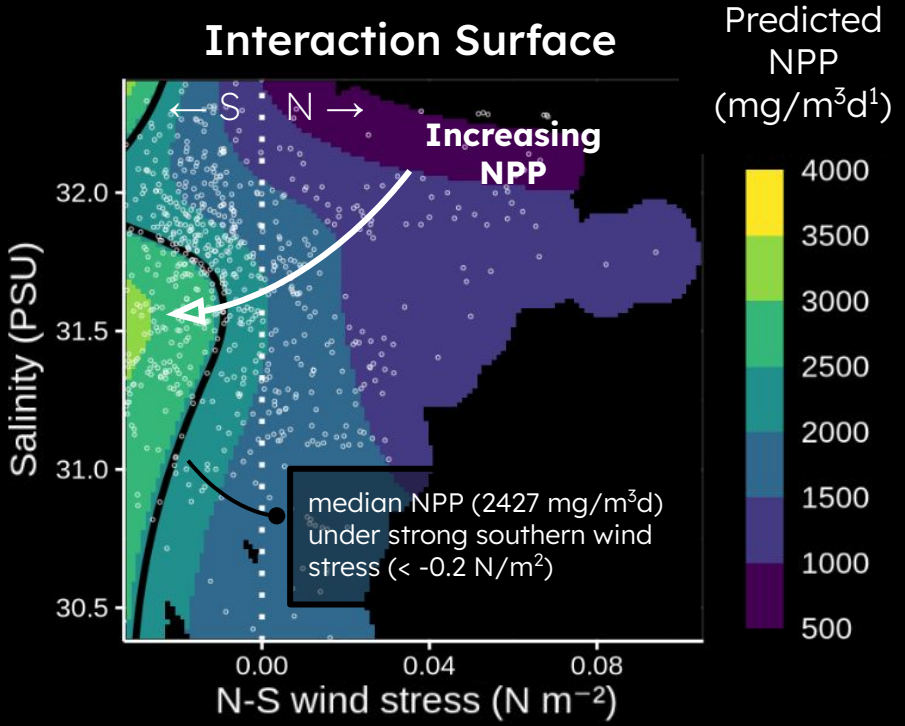
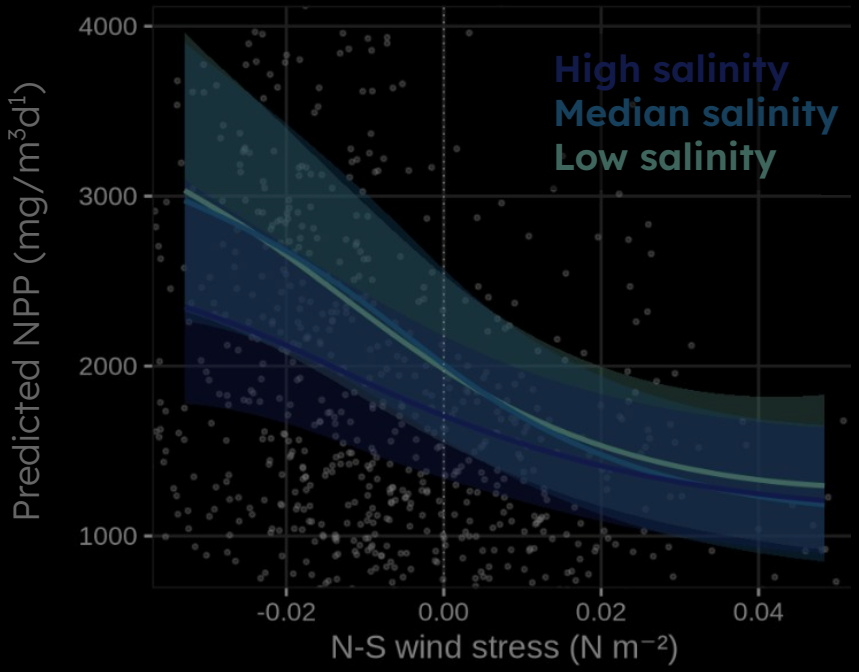
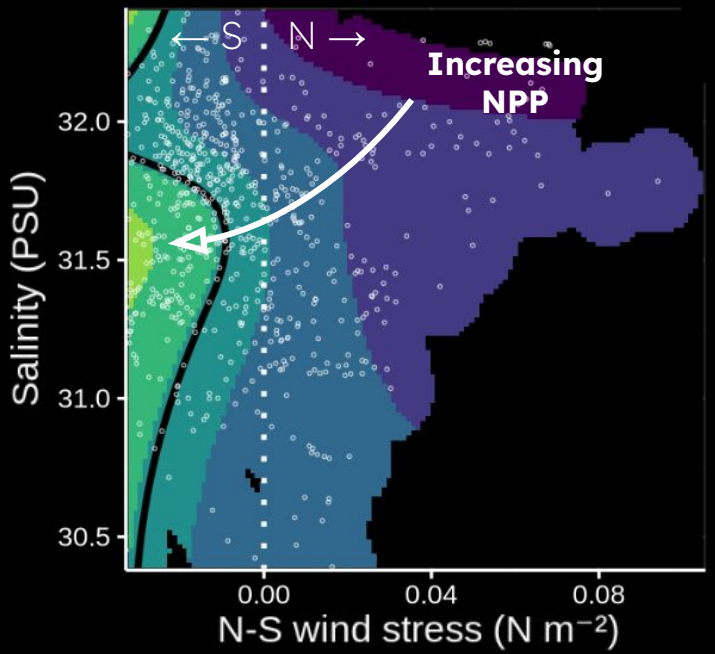
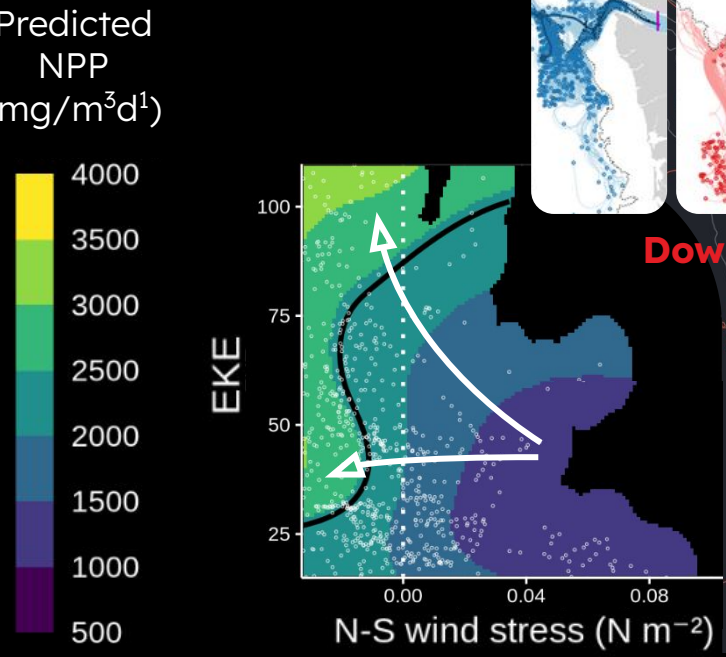
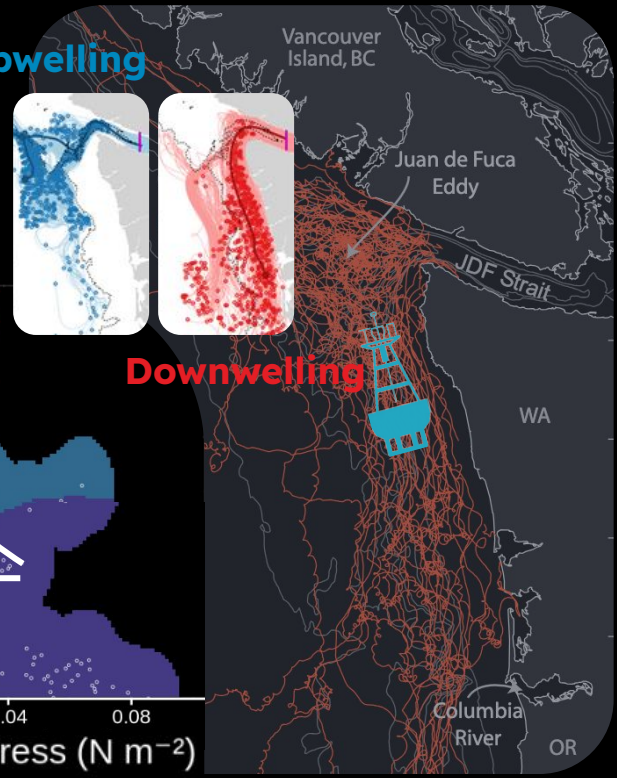




Production response to upwelling favorable wind forcing depends on a **broader physical context**







Surface drifters (summer 2003-2006) | Hickey & Banas, 2015

Particle tracking (2017) | Brasseale & MacCready, 2025

To inform ecosystem-based fisheries management…

How and which, observed environmental conditions influence NPP dynamics in the WA shelf region?

- Understanding production is powerful in a bottom-up system
- Washington shelf productivity reflects **combined influence of physical processes**, rather than responses to individual drivers in isolation.
- Knowledge of relationships between production and **varying oceanographic conditions** can inform fisheries management and ecosystem health

Next step: considering interannual mechanisms

- Marine heat waves (Blob & Blob 2.0)
- Harmful algal blooms
- ENSO dynamics (2026 El Niño)





Many thanks!



Jens Nielsen
Aarhus University









Eric Ward, Silvana Yanet Gonzalez, Steph Moore, Alison Gray, Seth Travis, Anna Boyer, Jodi Young

Questions?

nbuzby@uw.edu

