

# Leveraging a California Current System OAH Modeling for Future Applications: Fisheries Productivity, Harmful Algal Blooms, and Nitrogen Cycle



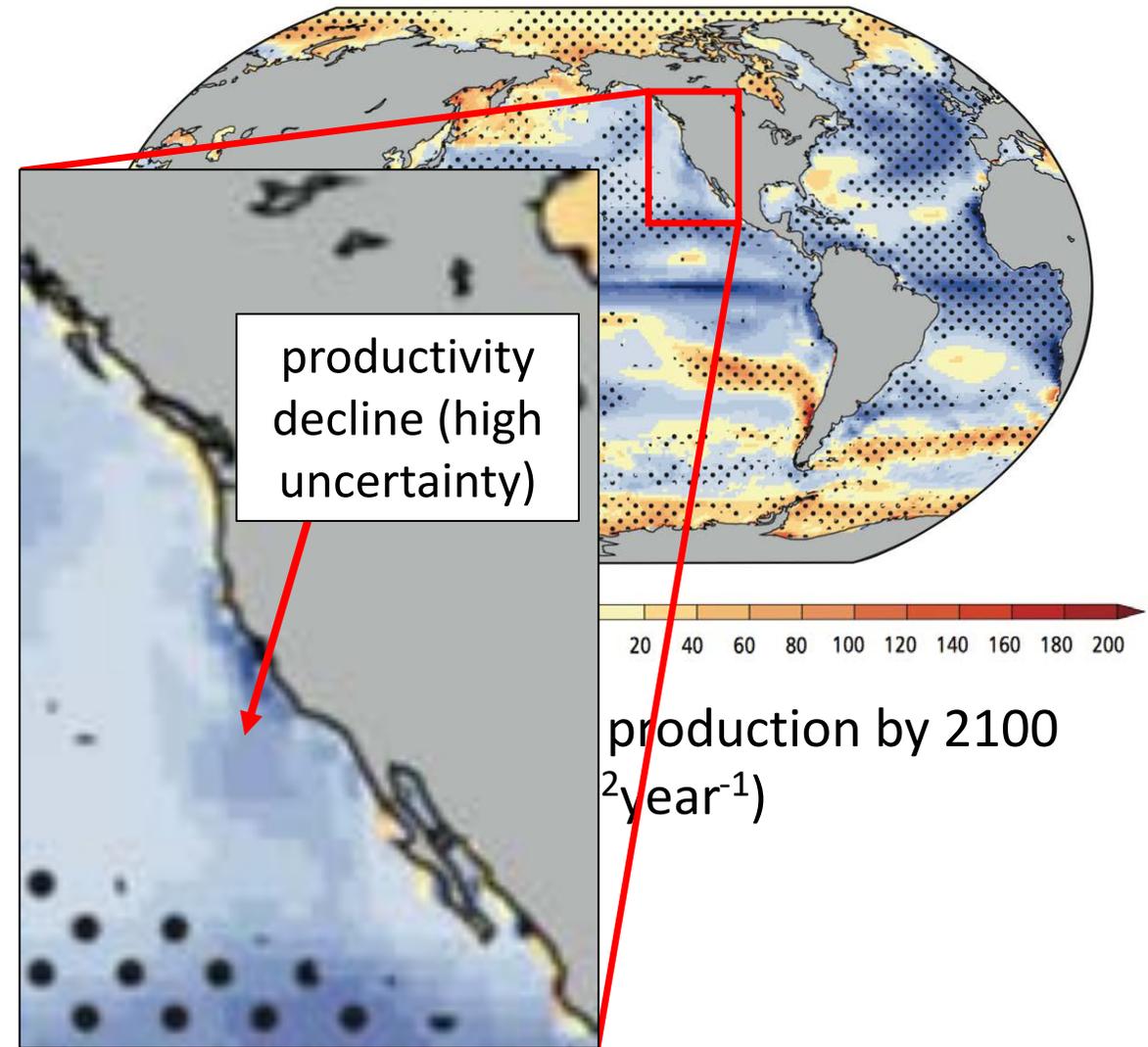
**Daniele Bianchi**  
*University of California Los Angeles*

**James McWilliams, Simon Yang,  
Jerome Guet, Pierre Damien (UCLA)  
Fayçal Kessouri, Martha Sutula, Jayme Smith  
(SCCWRP) Clarissa Anderson (SCOOS)  
Raphe Kudela (UCSC) & several others...**



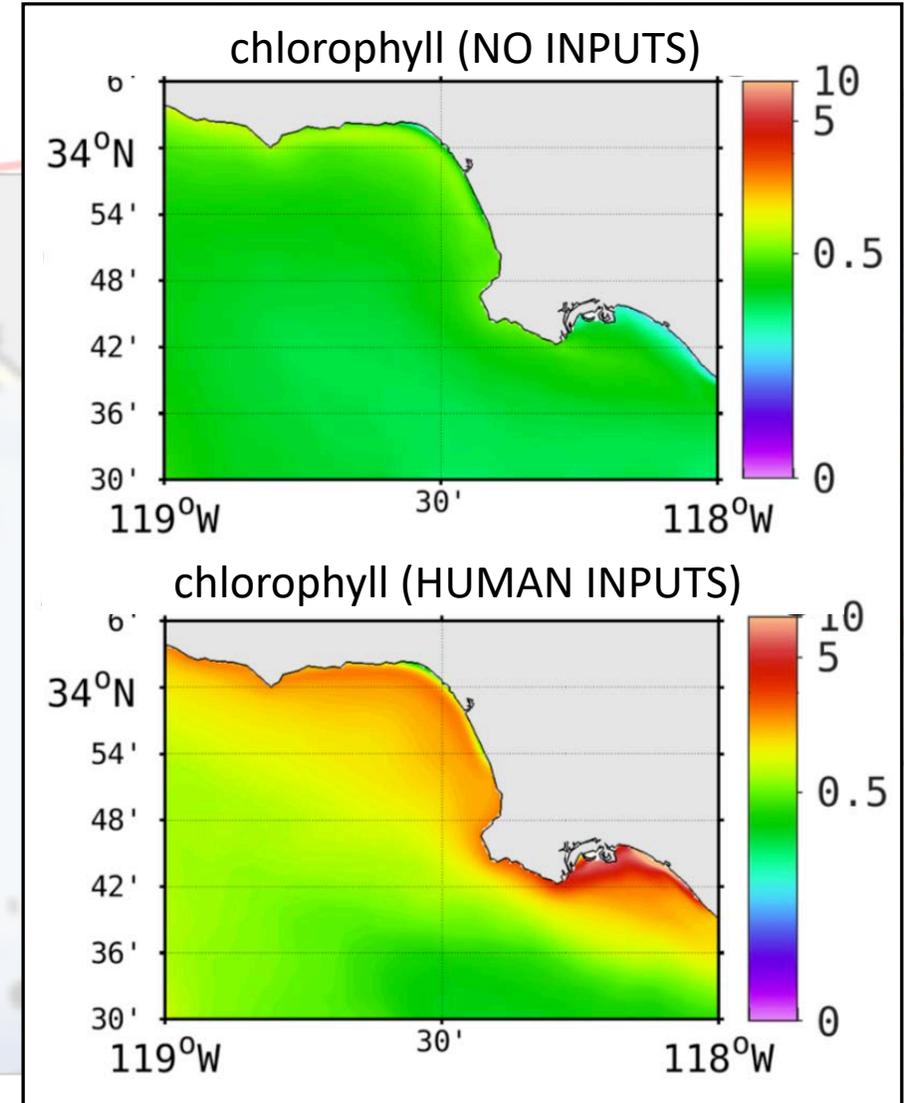
# Global change, regionally declined

- Global change will affect ocean ecosystems:
  - warming
  - acidification
  - deoxygenation
  - decline in primary production
- The **regional** manifestation of these global impacts is uncertain



# Global change, regionally declined

- Global change will affect ocean ecosystems:
  - warming
  - acidification
  - deoxygenation
  - decline in primary production
- The **regional** manifestation of these global impacts is uncertain
- **Local-scale human impacts** will also be important (not included in global models)
- UCLA's **Regional Earth System Model** can be used to project these impacts regionally



*figure courtesy of Fayçal Kessouri, UCLA*

# Leveraging UCLA's regional model

1. Food-web and fishery productivity
2. Harmful algal blooms (HABs)
3. Nitrogen cycle and nitrous oxide (N<sub>2</sub>O) emissions

# Leveraged projects

## 1. Food-web and fishery productivity modeling



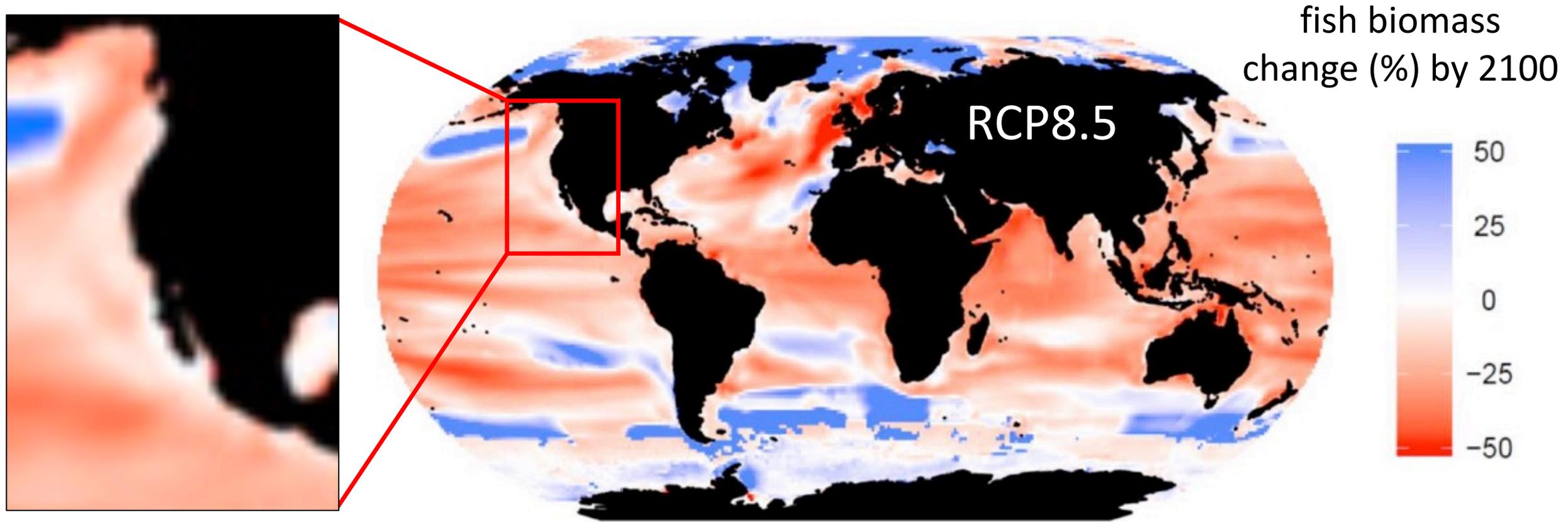
**Jerome Guiet (UCLA)**

**Fayçal Kessouri (UCLA, SCCWRP)**

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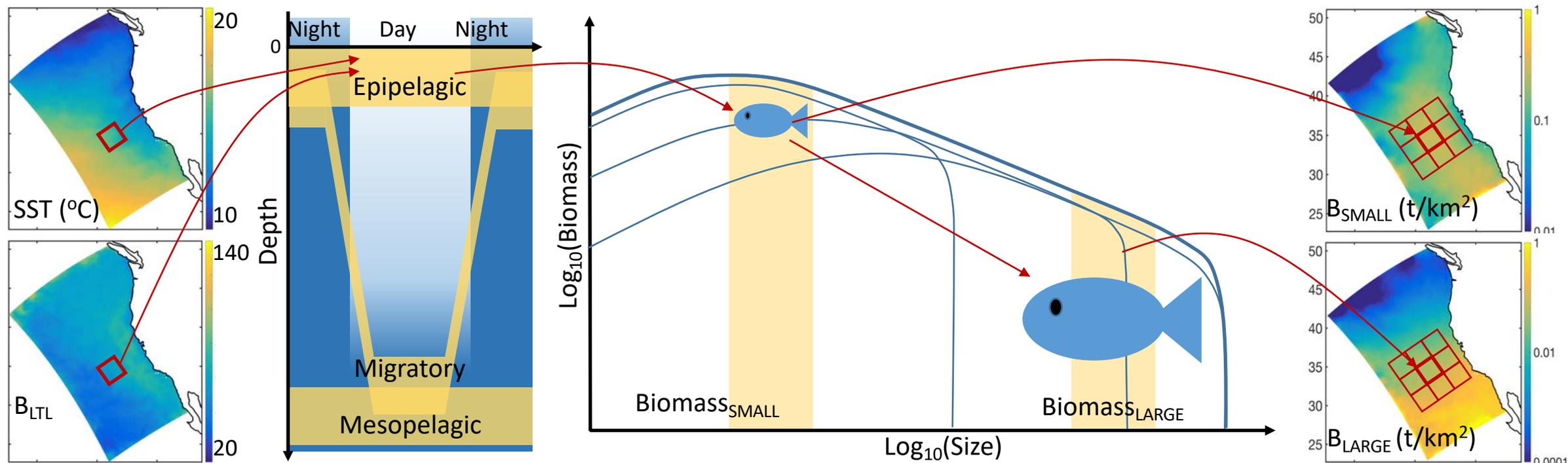
# The future of marine ecosystems



- Multi-model projections predict global fish biomass reduction
- Downscaling projections to the CCE requires **regional food-web models**

# A regional model of the CC food web

We are developing a regional model of the California Current food web coupled to UCLA's Regional Earth System Model



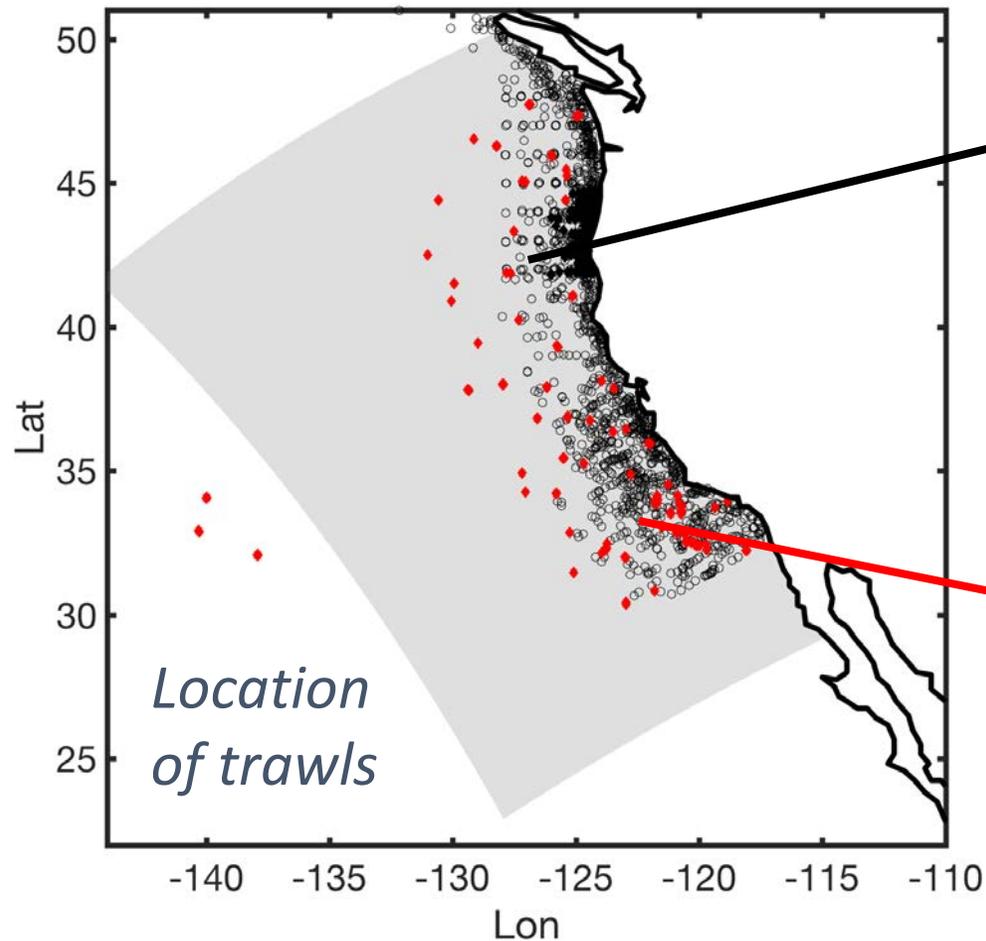
takes inputs from  
UCLA's ocean model

resolves the interactions  
of **3 communities**

solves for the evolution of **biomass size spectra**  
for **multiple species** in each community

represents food-web  
dynamics spatially

# Constraining the model with observations



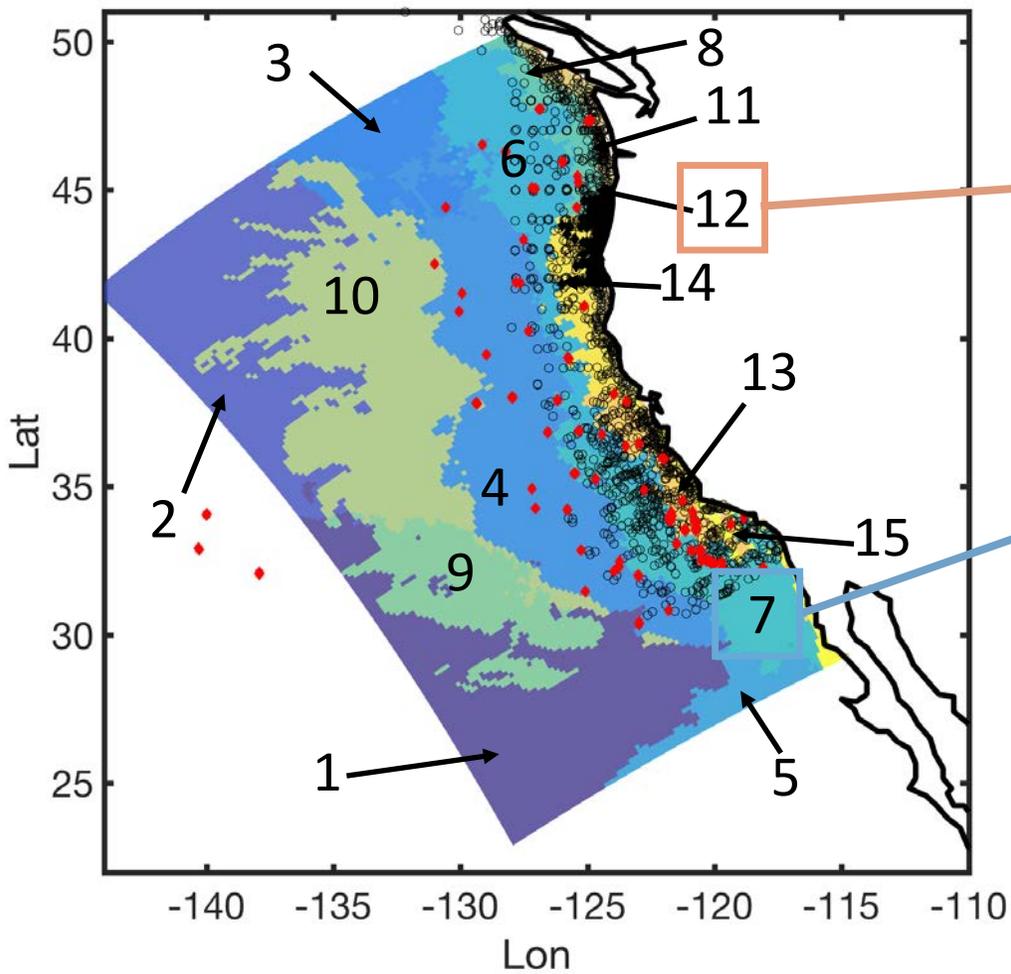
1852 surface trawls from  
NOAA surveys:  
sample epipelagic & migratory  
communities

144 mid-water trawls from  
CalCOFI:  
sample mesopelagic  
& migratory communities

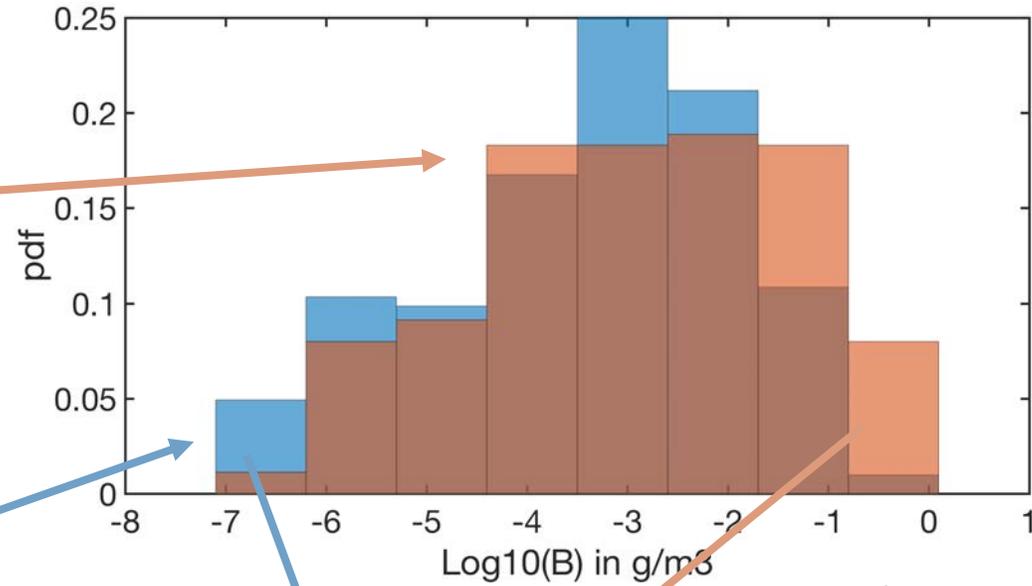


Data collected over 16 years – **sporadic** and sampling a **strong variability**

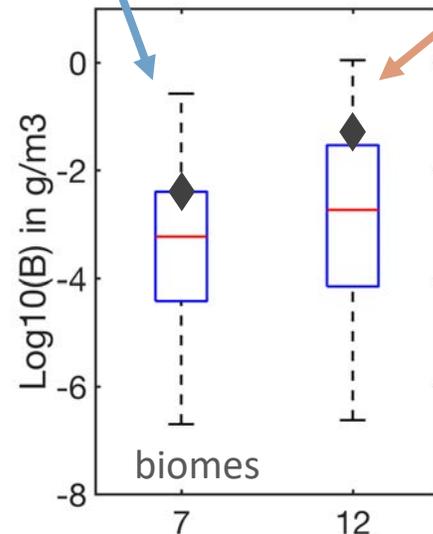
# Constraining the model with observations



Trawl location on top of 15  
*biogeographically coherent biomes*

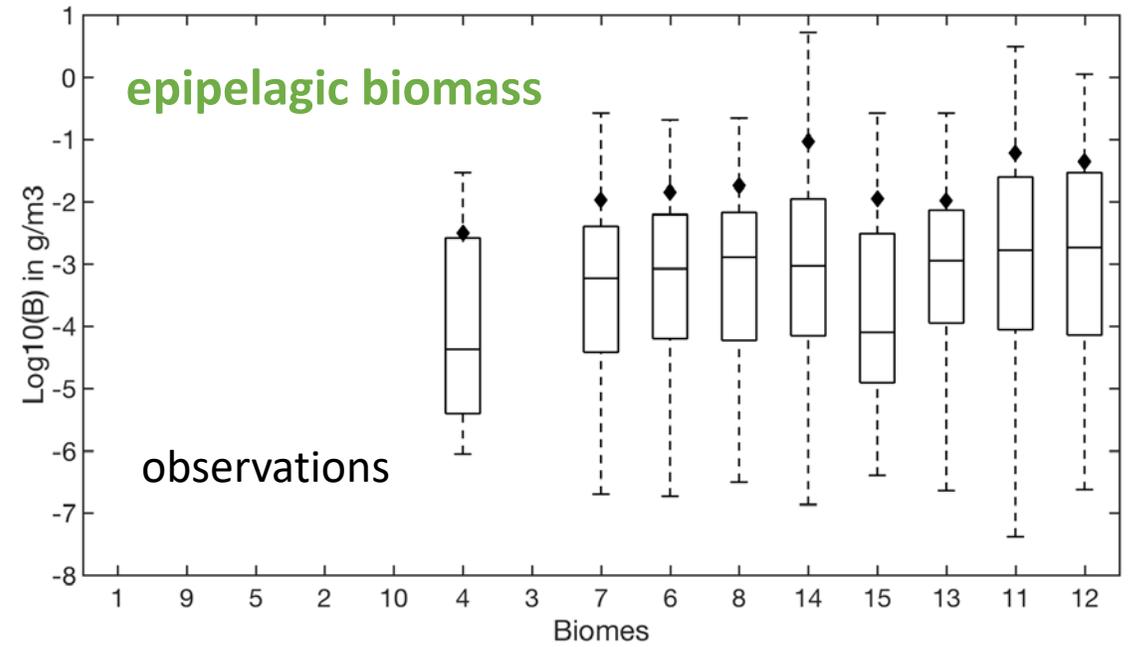
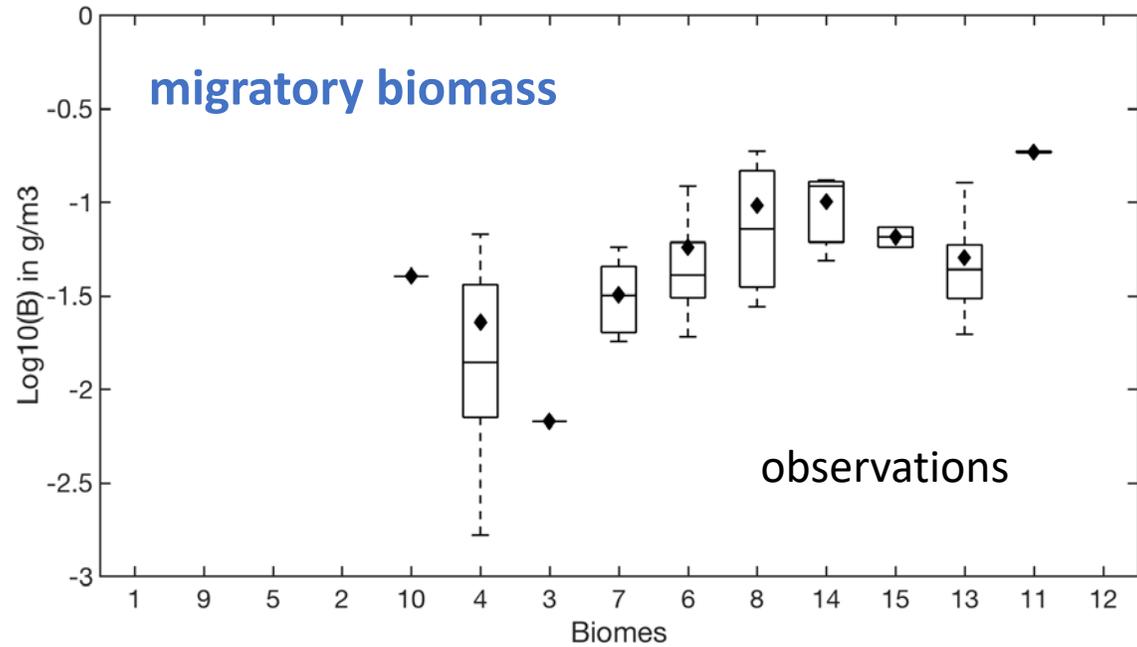


Observed epipelagic  
biomass distributions in  
different biomes



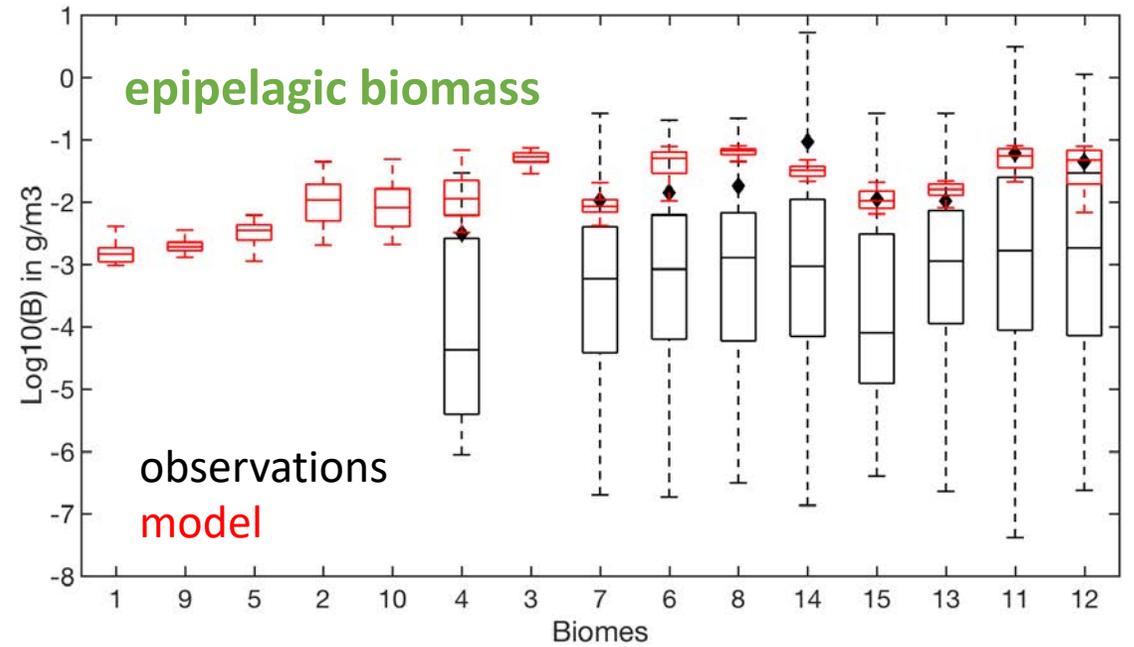
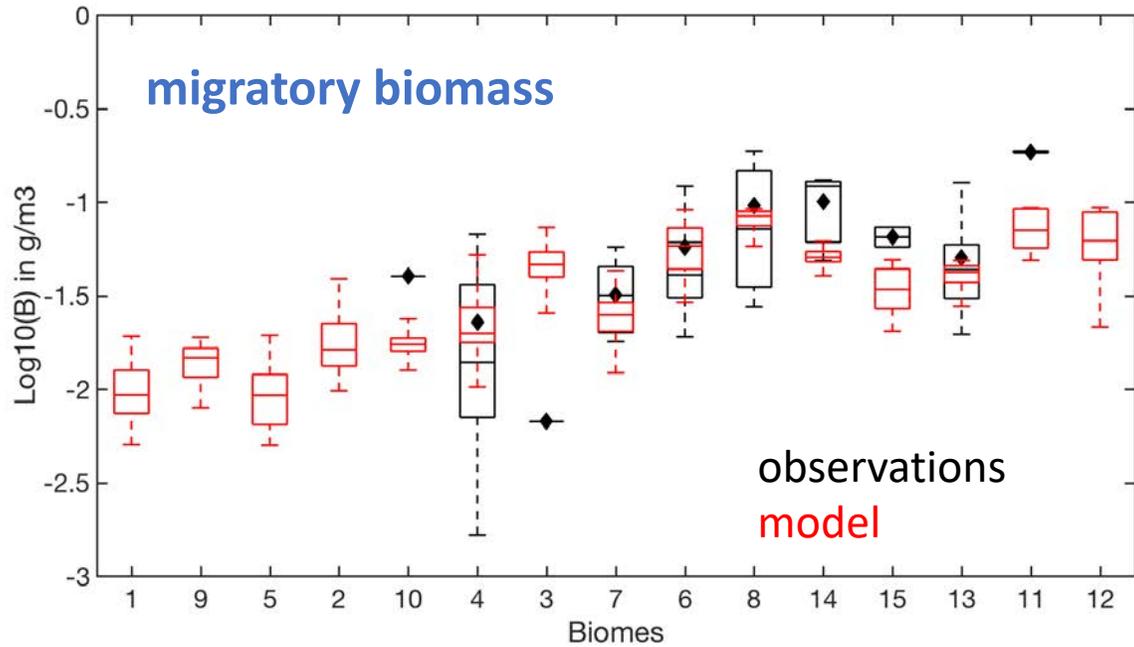
Summarized by  
"box plots" (showing  
median, range, mean)

# Observed vs. modeled biomass



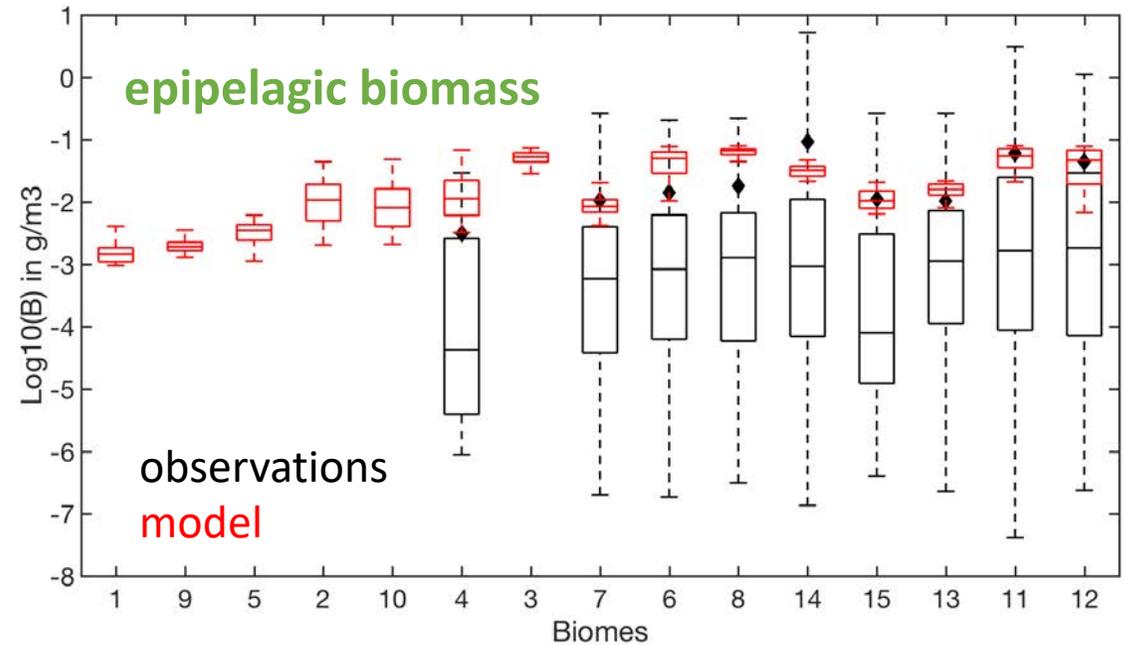
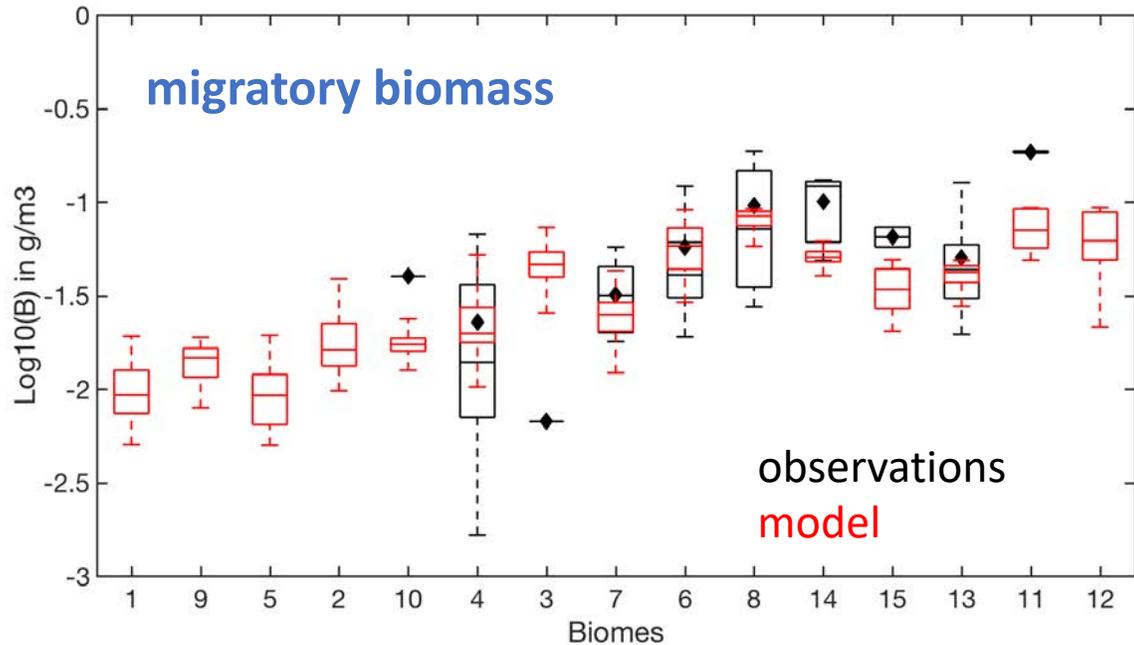
- Observations show **regional trends** across biomes, following the environment
- Note the large range in epipelagic biomass, caused by both sampling and ecosystem variability

# Observed vs. modeled biomass



- The model captures biomass magnitude and trends across biomes
- The model shows a rich dynamics, but biases still present (work in progress!)
- Once completed, will be coupled to UCLA's regional model simulations

# Observed vs. modeled biomass



- We plan to use the food-web model to quantify:
  - Spatial and temporal **variability** in food-web dynamics (seasonal, interannual scales)
  - The impacts of **global change**: warming, primary production decline, etc.
  - **Local human drivers**: nutrient inputs, fishing, marine protected areas

## 2. Harmful algal blooms (HABs) modeling



**Raphael Kudela (UCSC)**

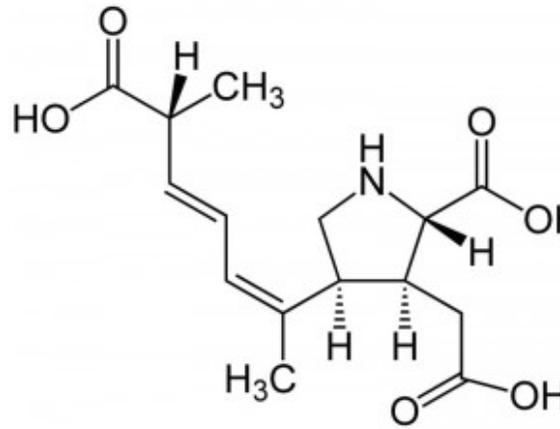
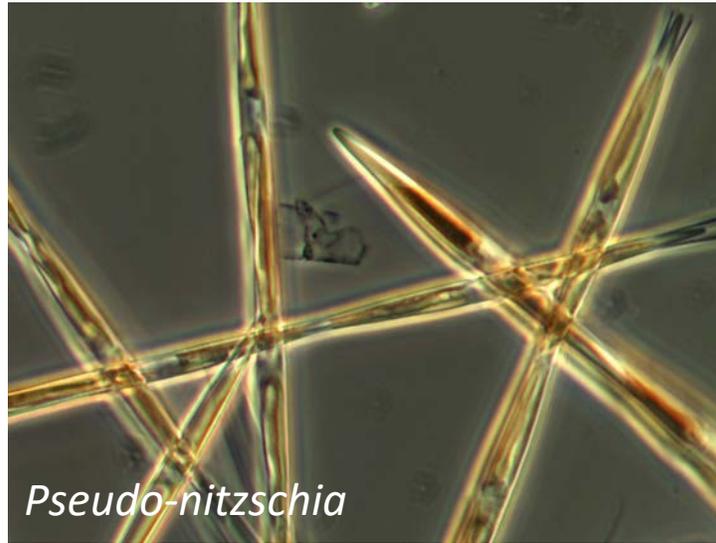
**Clarissa Anderson (SCCOOS)**

**Martha Sutula (SCCWRP)**

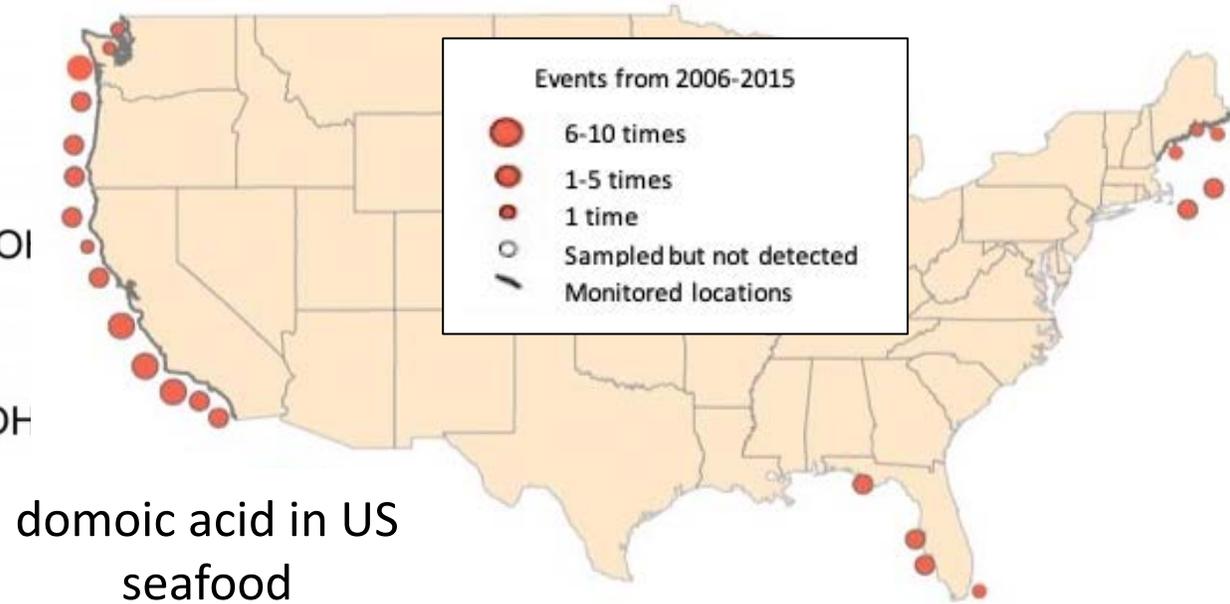
**Fayçal Kessouri (UCLA, SCCWRP)**

**Jayme Smith (SCCWRP)**

# HABs in the California Current



domoic acid

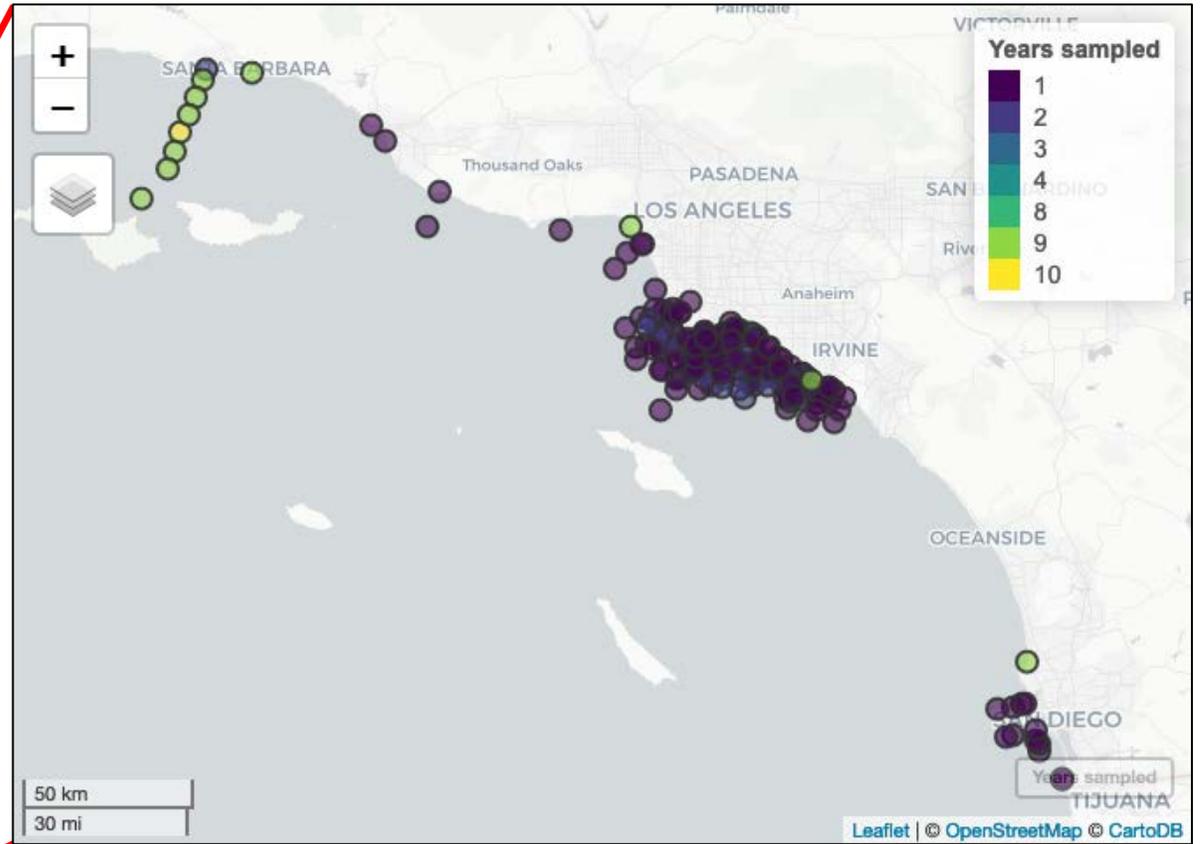
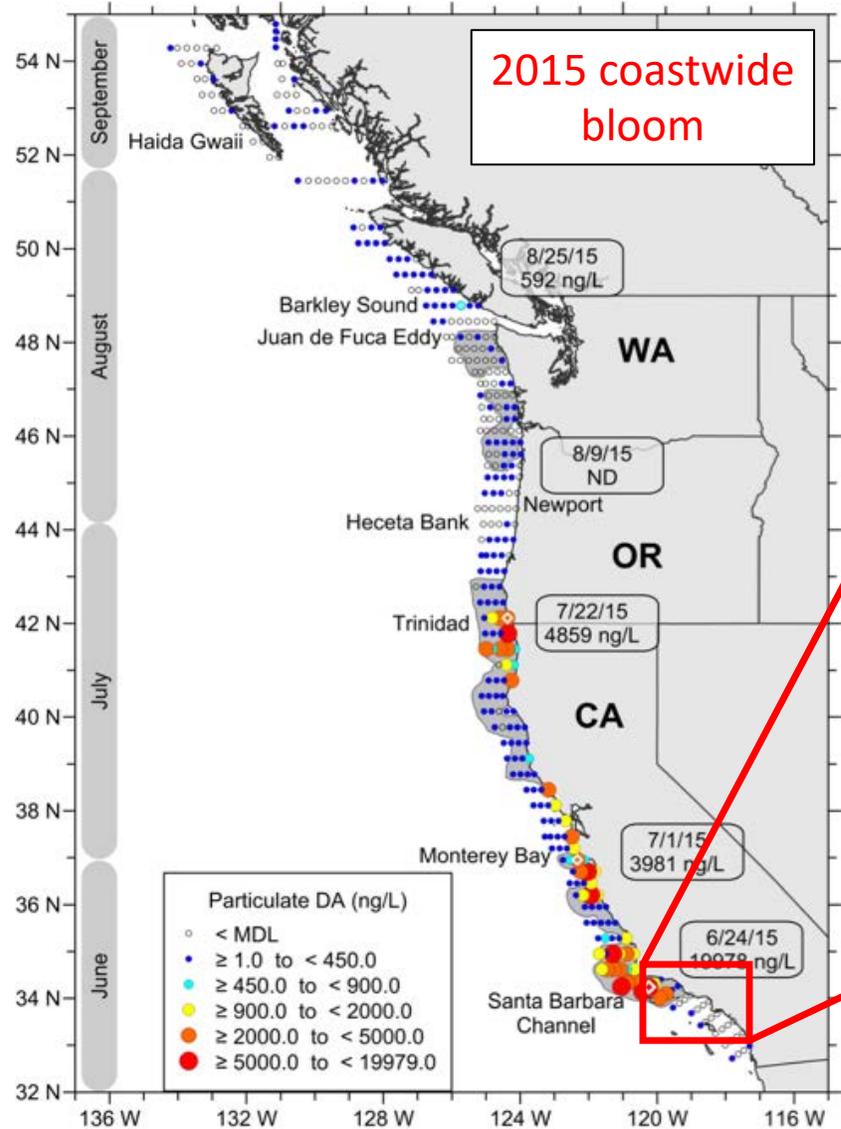


## *Pseudo-nitzschia spp.* (a diatom genus)

Produces **Domoic Acid** toxin, causing **Amnesic Shellfish Poisoning** syndrome

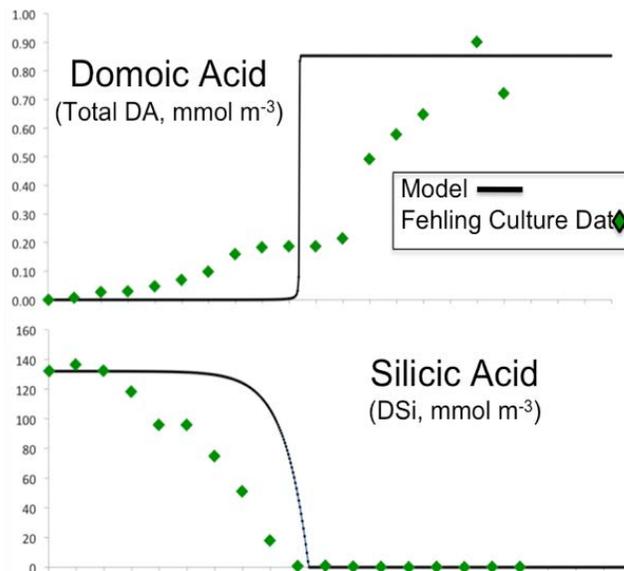
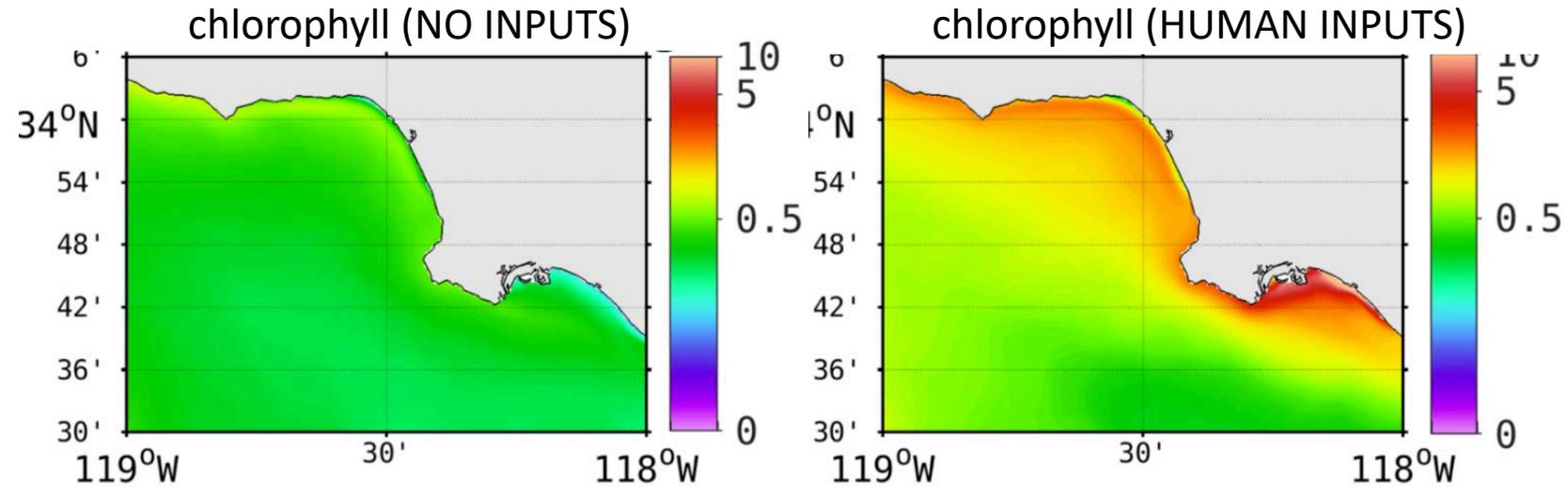
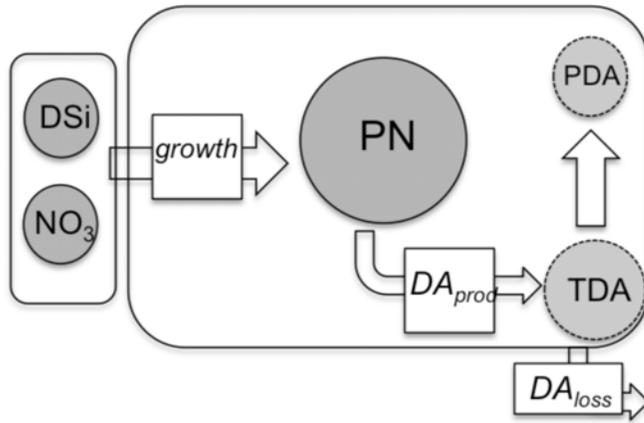
- A range of symptoms, from mild to life-threatening (nausea, dizziness, memory loss, seizures, coma, death)
- Impact marine mammals and birds, with 1000s strandings and deaths during past 10yrs
- Common in California. Unprecedented **2015 coastwide bloom** caused substantial **economic damage**

# Observations of Domoic Acid in the CC



The CC is home to a large database of PN and DA observations from multiple programs

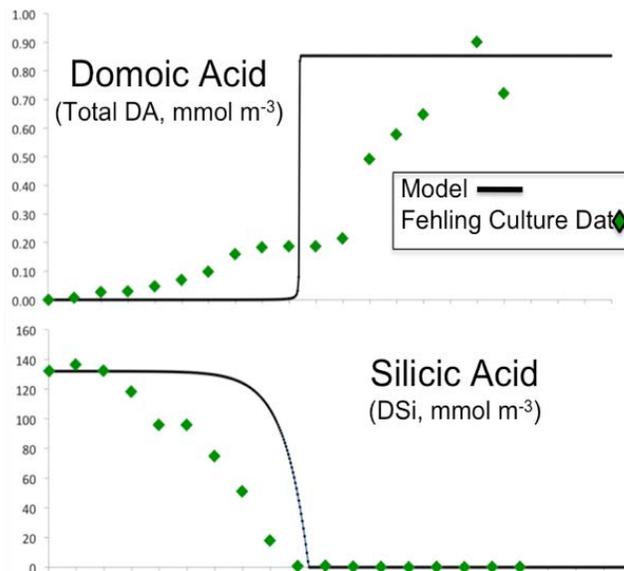
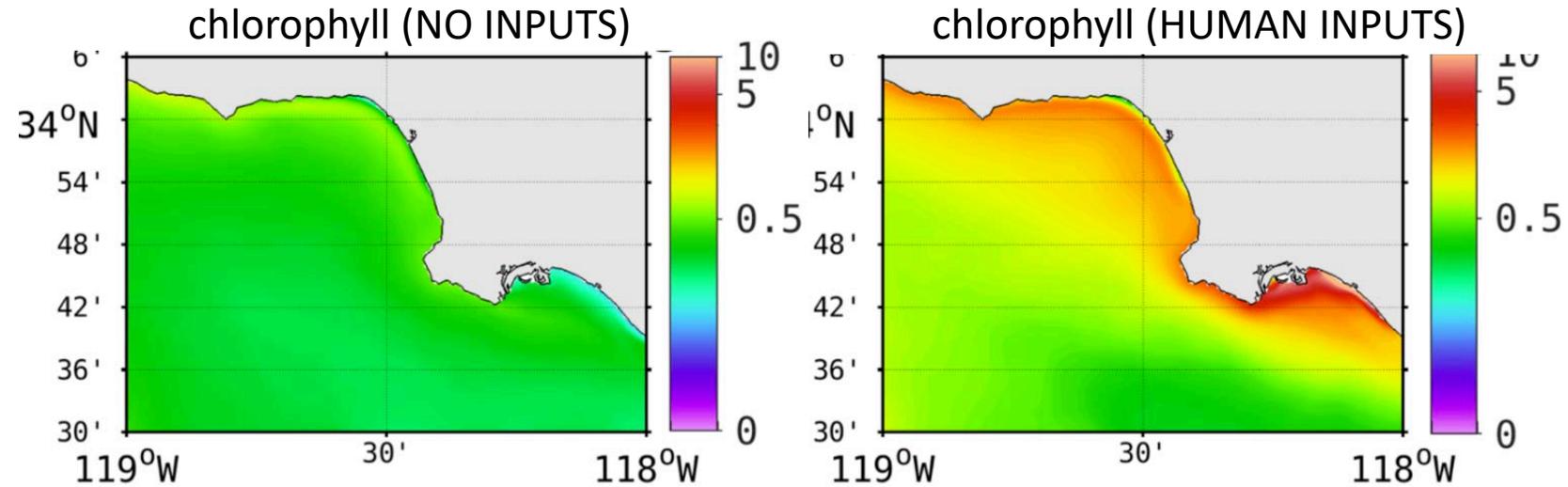
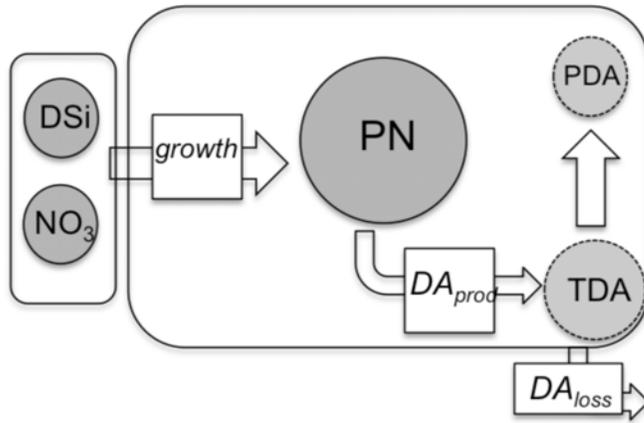
# Developing a model of HABs in the CC



With funding from NOAA, we started development of a model of *Pseudo nitzchia* and domoic acid:

- Constrained by laboratory experiments
- Designed to be coupled to UCLA's ocean model
- Constrained by the array of observations of *Pseudo nitzchia* and domoic acid in the California Current

# Developing a model of HABs in the CC



The purpose of the model is multifold:

- Investigate the **environmental drivers** of HABs in the California Current
- Investigate the role of local **nutrient inputs** on HABs
- Run projections under **different scenarios**, e.g. nutrient management strategies

# Leveraged projects

## 3. Nitrogen cycle and nitrous oxide ( $\text{N}_2\text{O}$ ) emissions



**Simon Yang (UCLA)**

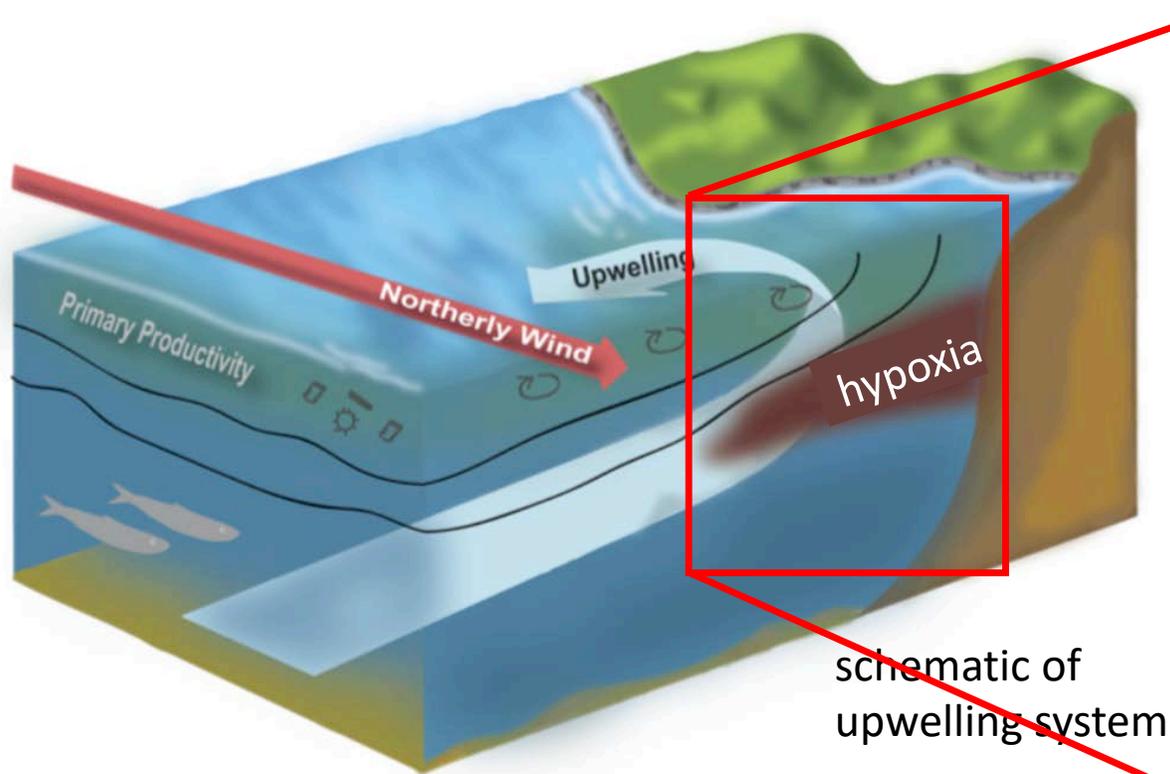
**Fayçal Kessouri (UCLA, SCCWRP)**

+ UCLA's modeling team:

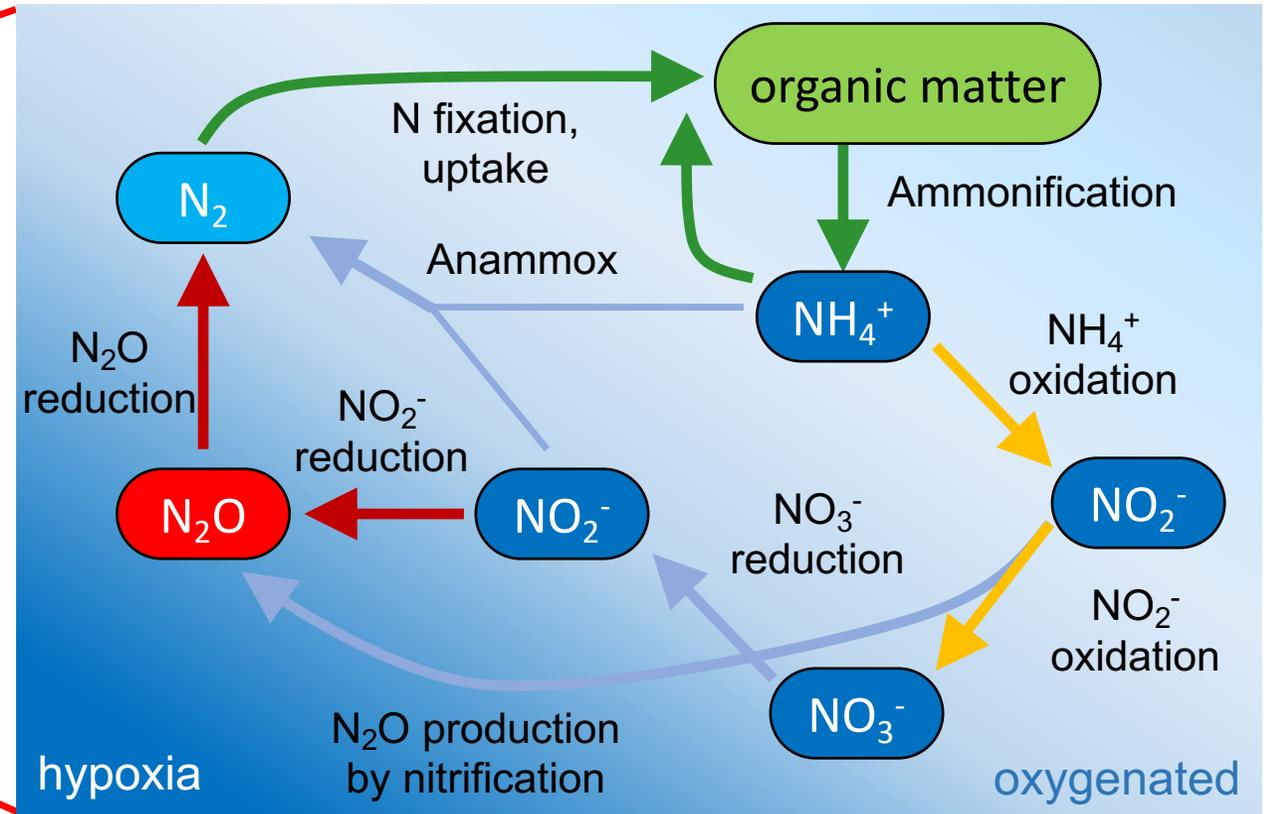
**James McWilliams, Jeroen Molemaker,**

**Pierre Damien (UCLA)**

# 1. Nitrogen cycle and N<sub>2</sub>O emissions

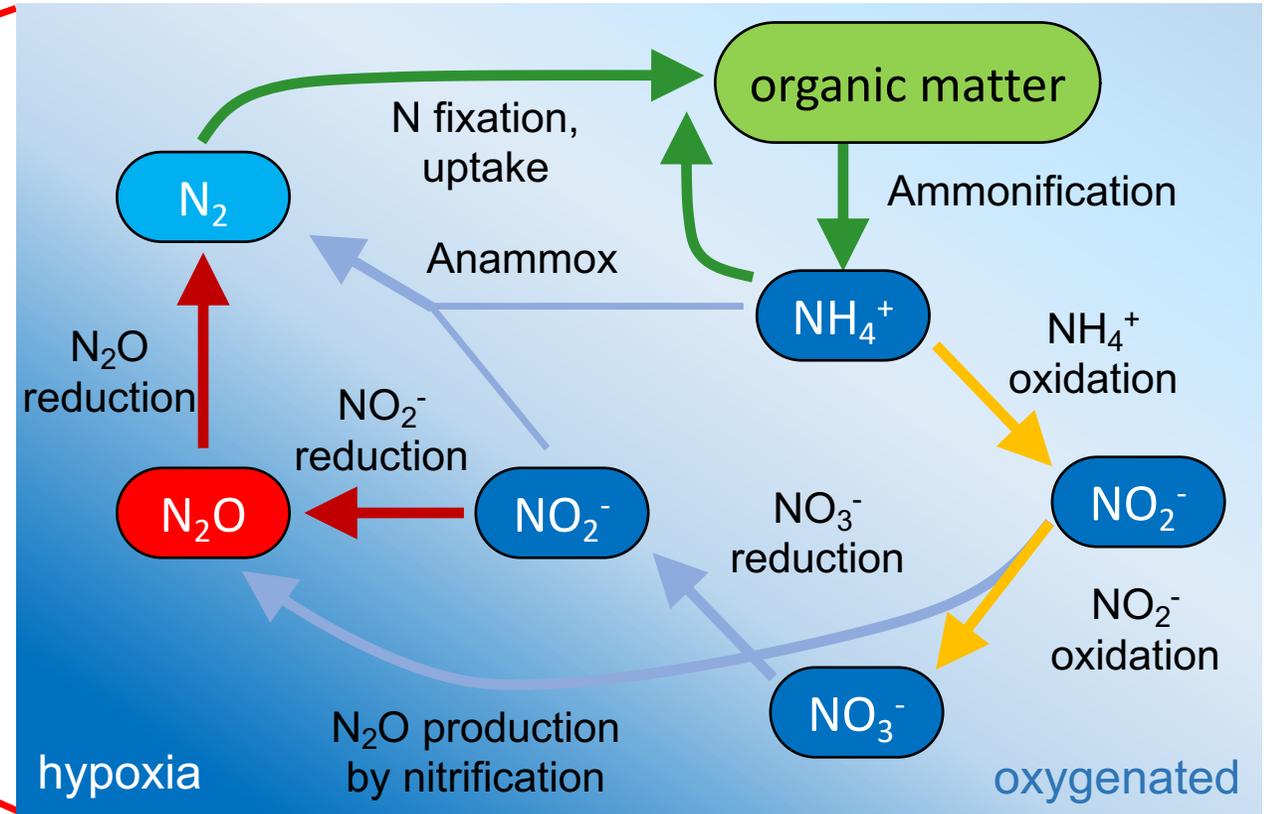
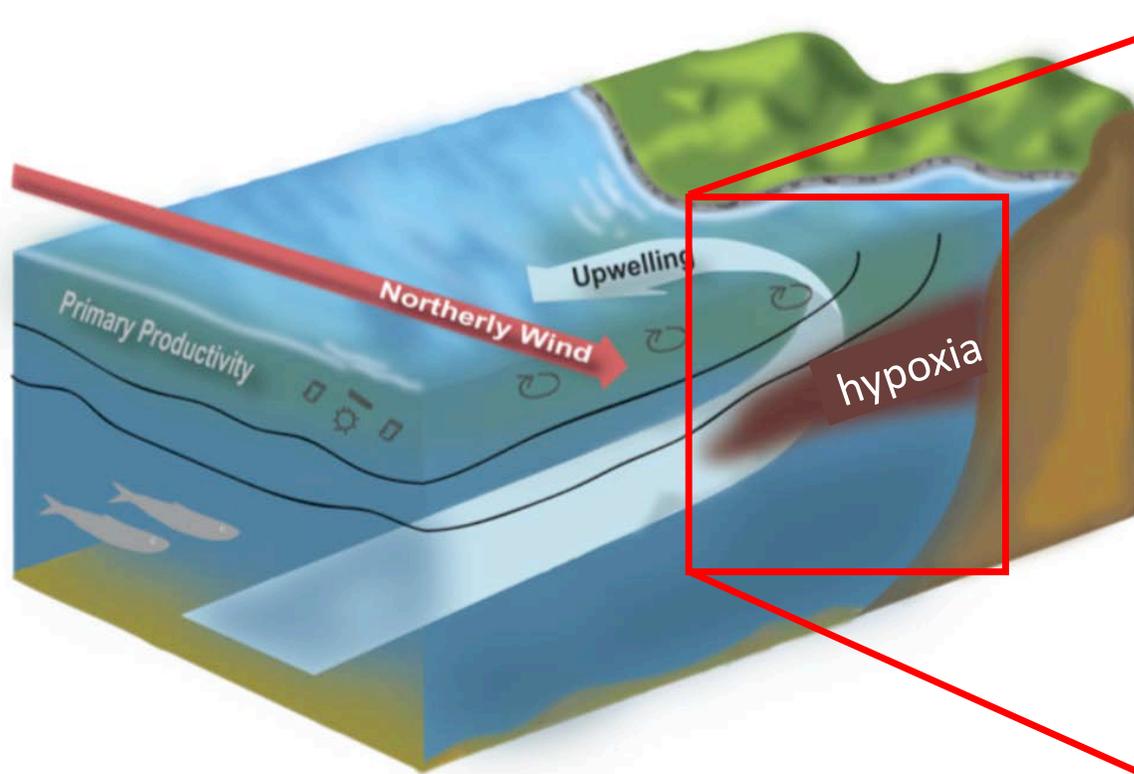


schematic of upwelling system



In upwelling systems, low oxygen conditions (**hypoxia**) promote removal of fixed nitrogen (**denitrification**) and **production of N<sub>2</sub>O**, a powerful greenhouse gas

# 1. Nitrogen cycle and N<sub>2</sub>O emissions



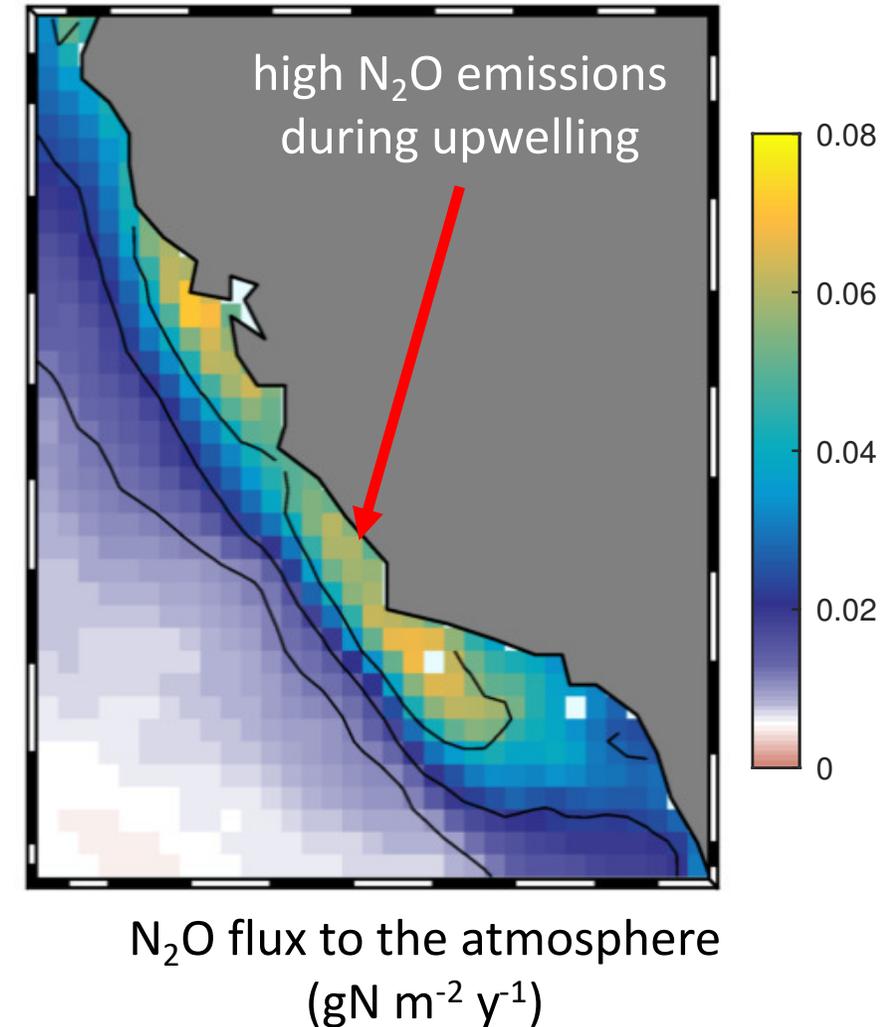
We included this dynamical nitrogen cycle in a revised version of UCLA's ocean biogeochemical model for regional studies

# Nitrogen Cycle in the CC

Research questions include:

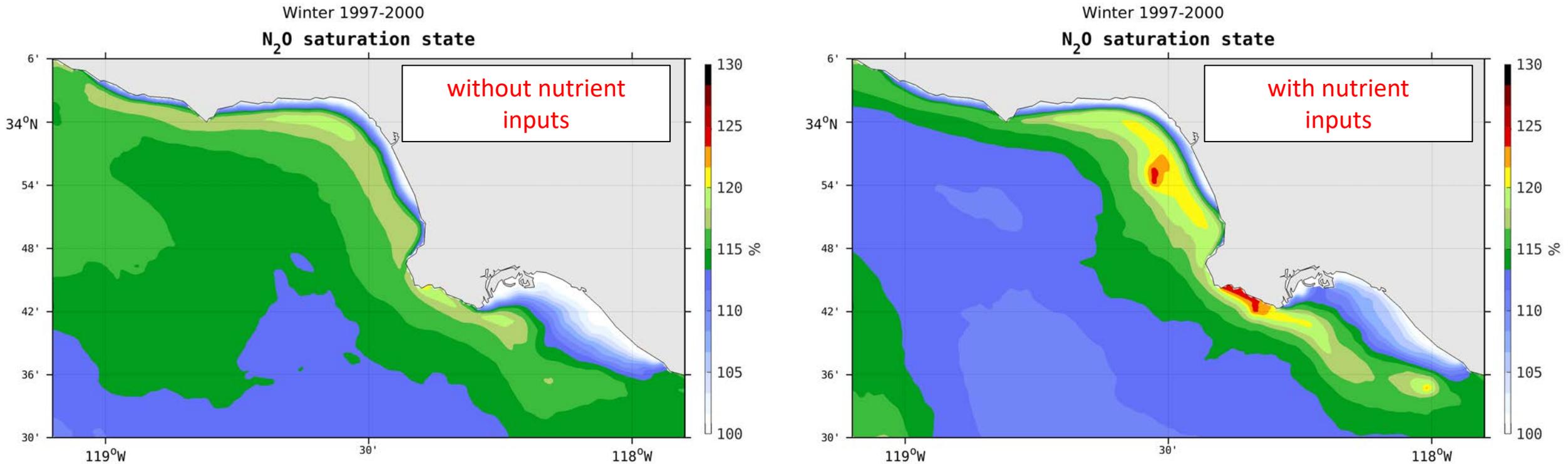
- Importance of regional hypoxia for denitrification and N<sub>2</sub>O production
- Magnitude and drivers of N<sub>2</sub>O emissions
- Role of global and local anthropogenic impacts

As an example, we begun a regional assessment of N<sub>2</sub>O sources in the CCS



*figure courtesy of Simon Yang, UCLA*

# Anthropogenic impacts on N<sub>2</sub>O emission



Preliminary results suggest that anthropogenic nutrient inputs could enhance local N<sub>2</sub>O emissions to the atmosphere

→ This may be important for constraining local N<sub>2</sub>O budgets

# Summary

UCLA's Regional Earth System Model is being leveraged for a series of modeling studies in the California Current:

## 1. Food-web and fishery productivity

- Realistic, coupled representation of circulation & food web dynamics
- Future application to scenarios: climate change, human impacts, etc.

## 2. Harmful algal blooms modeling (just started)

- HAB model development and data synthesis
- Application to study natural & human HAB drivers

## 3. Nitrogen cycle modeling

- Full representation of coupled oxygen and nitrogen cycles
- Allows assessment of N<sub>2</sub>O emissions & human impacts

# Thank you!

