

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



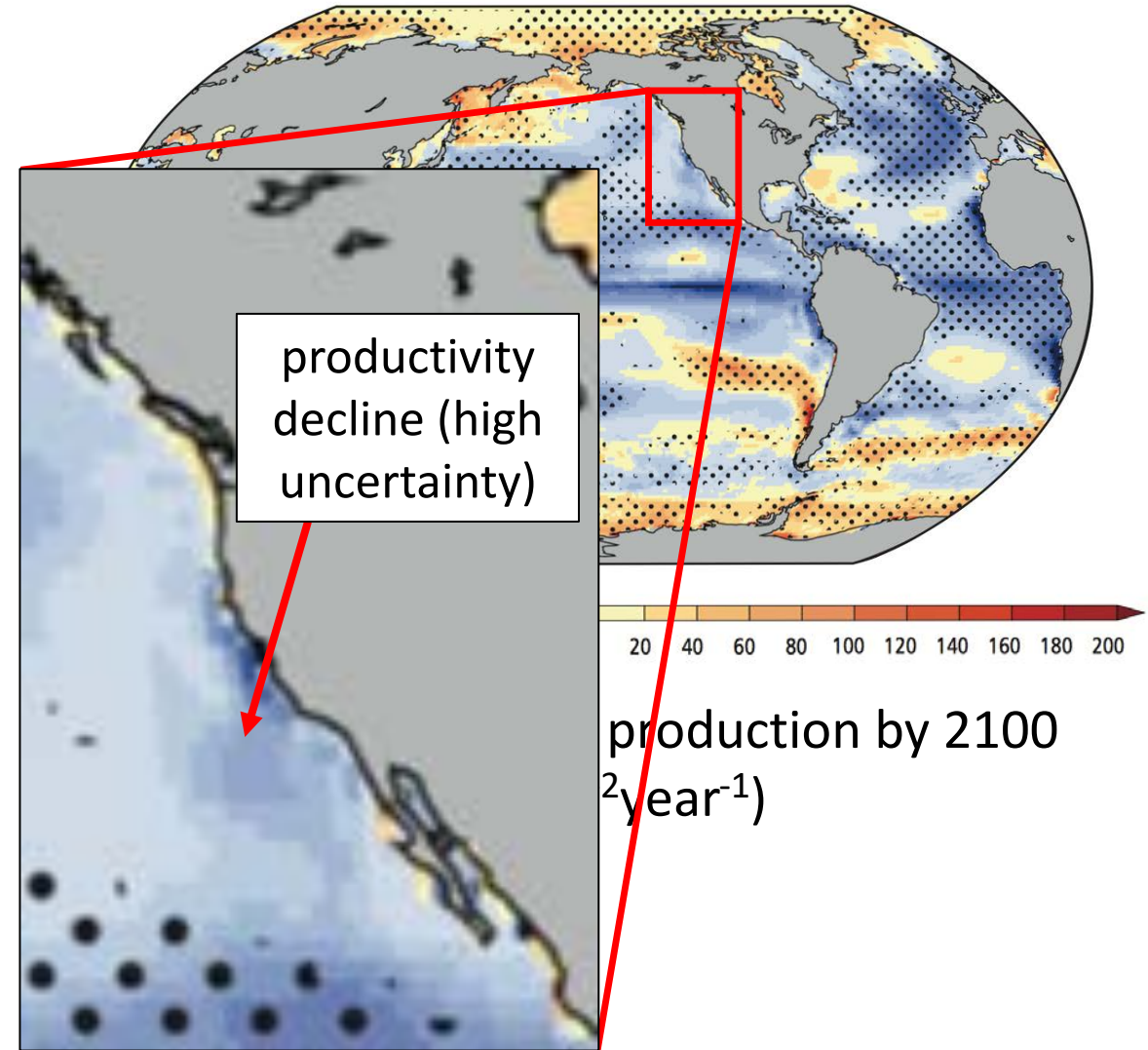
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University of California Los Angeles

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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

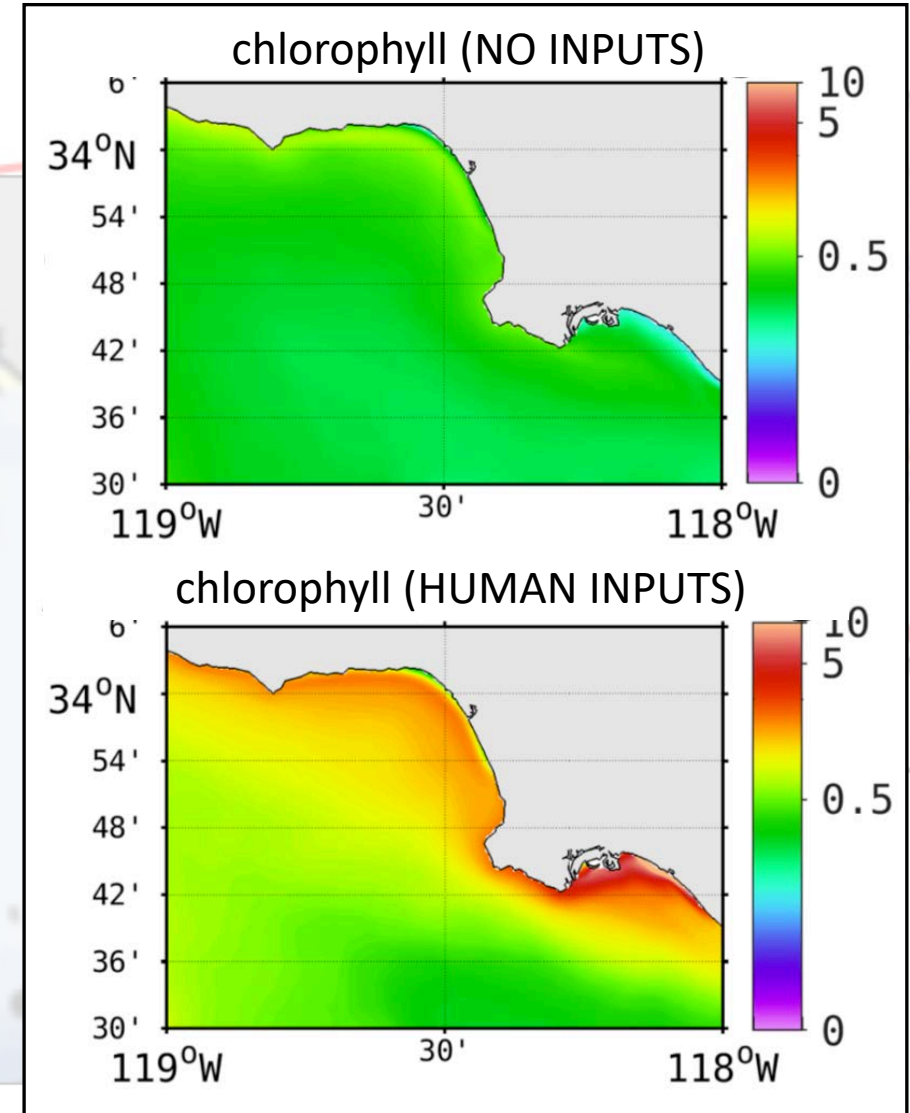


figure courtesy of Fayçal Kessouri, UCLA

Leveraging UCLA's regional model

1. Food-web and fishery productivity
2. Harmful algal blooms (HABs)
3. Nitrogen cycle and nitrous oxide (N₂O) emissions

Leveraged projects

1. Food-web and fishery productivity modeling



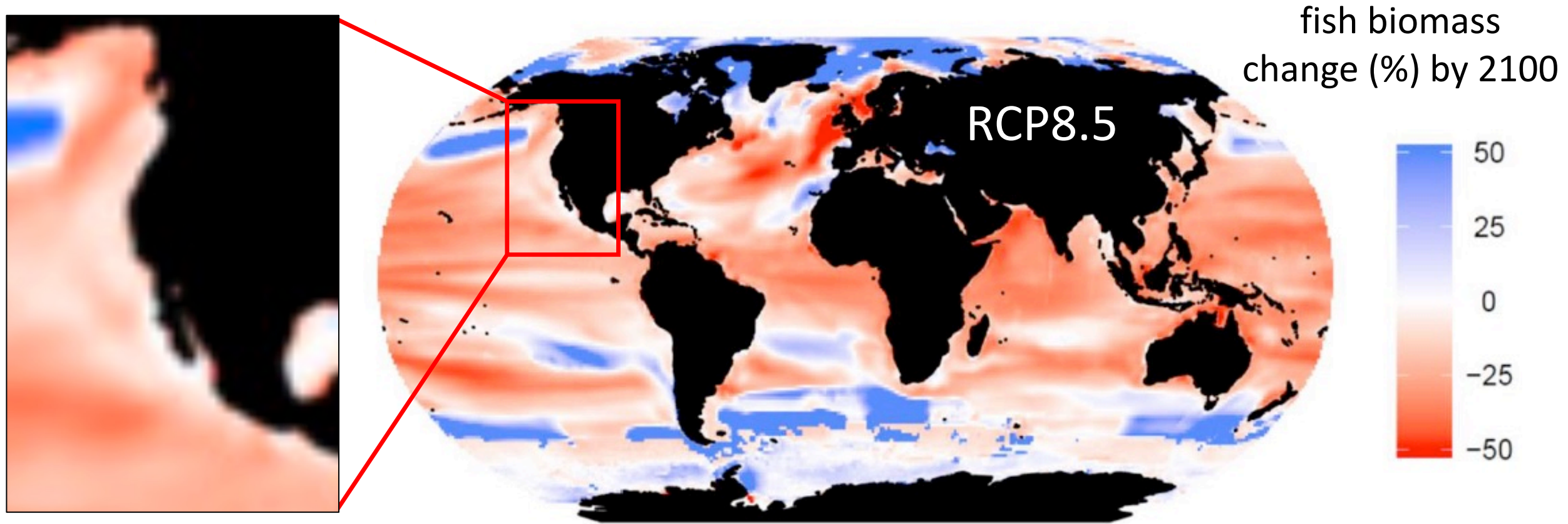
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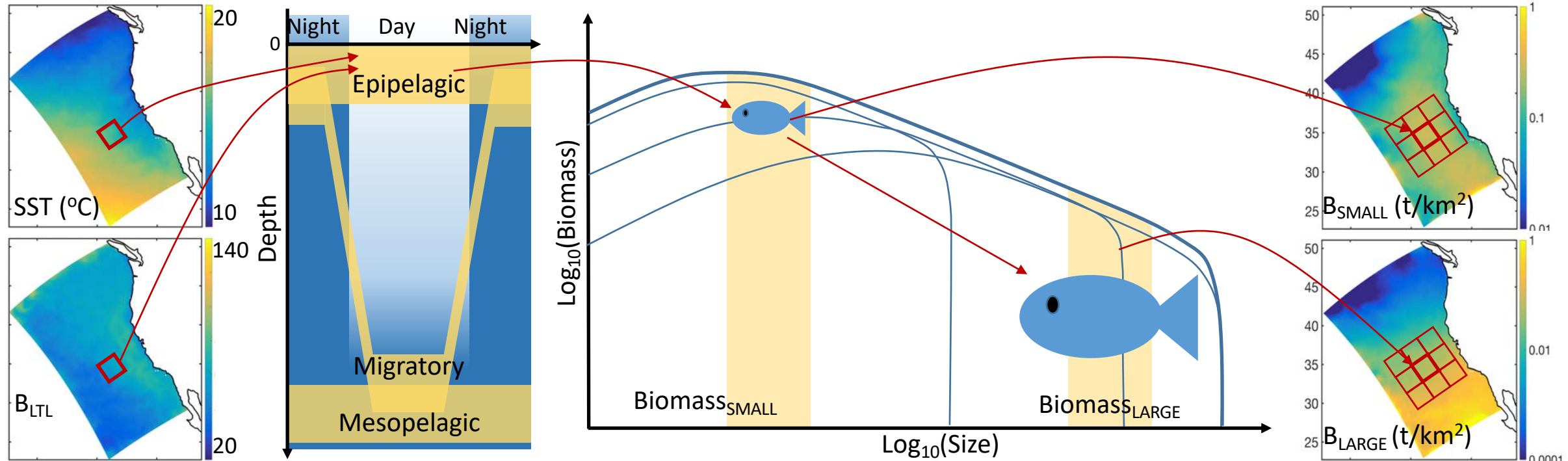
The future of marine ecosystems



- 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



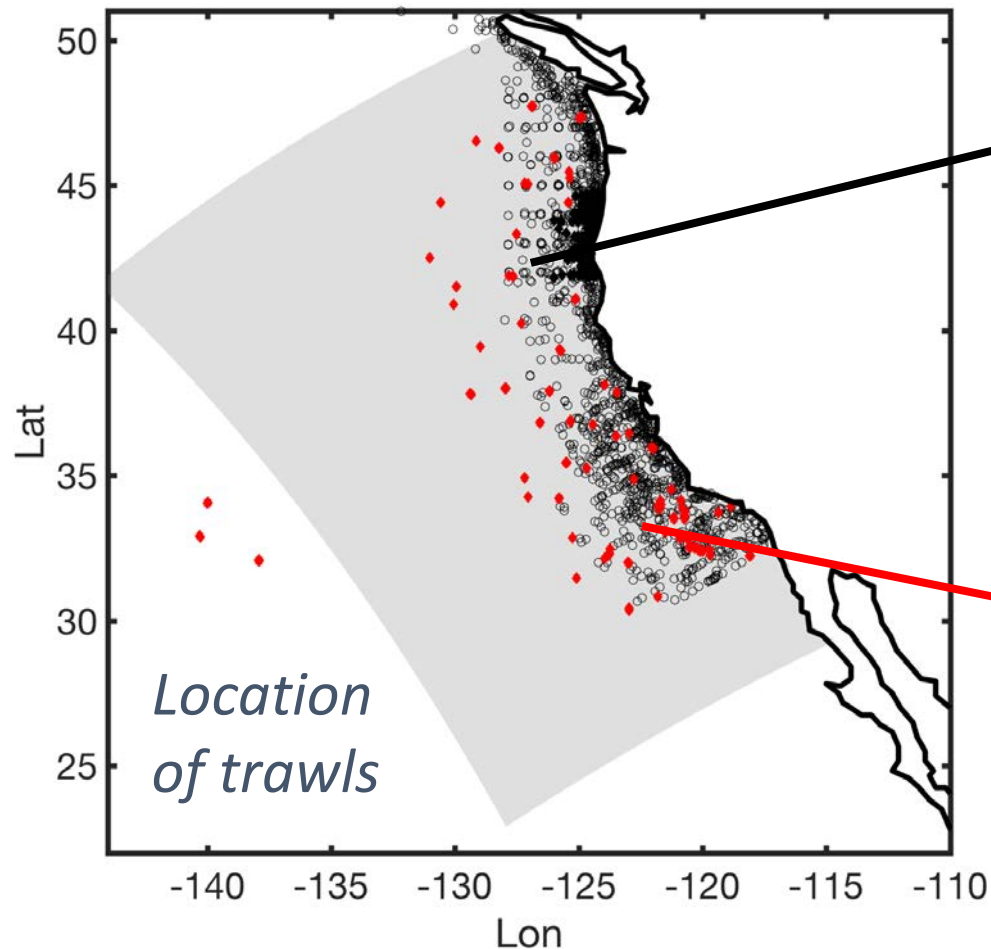
takes inputs from
UCLA's ocean model

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



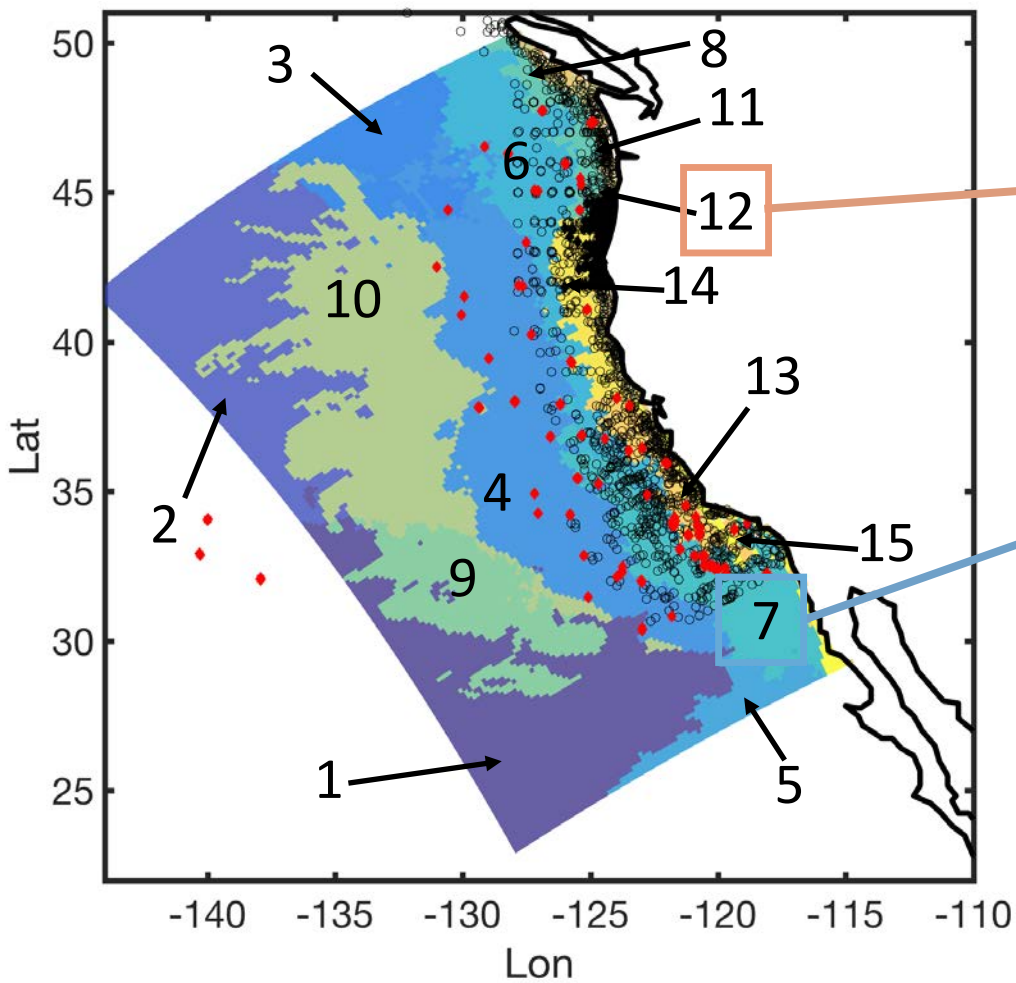
144 mid-water trawls from
CalCOFI:

sample mesopelagic
& migratory communities

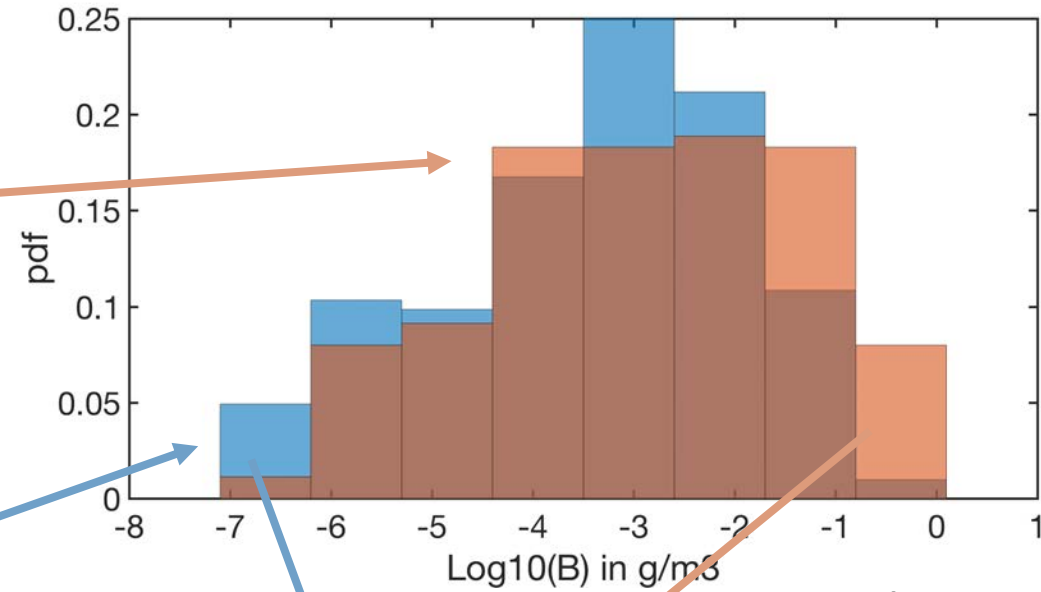


Data collected over 16 years – **sporadic** and sampling a **strong variability**

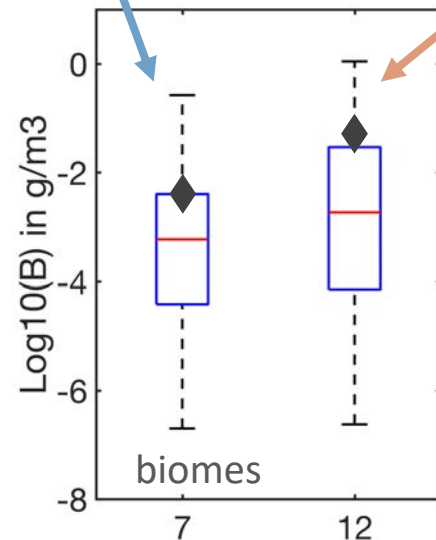
Constraining the model with observations



Trawl location on top of 15
biogeographically coherent biomes

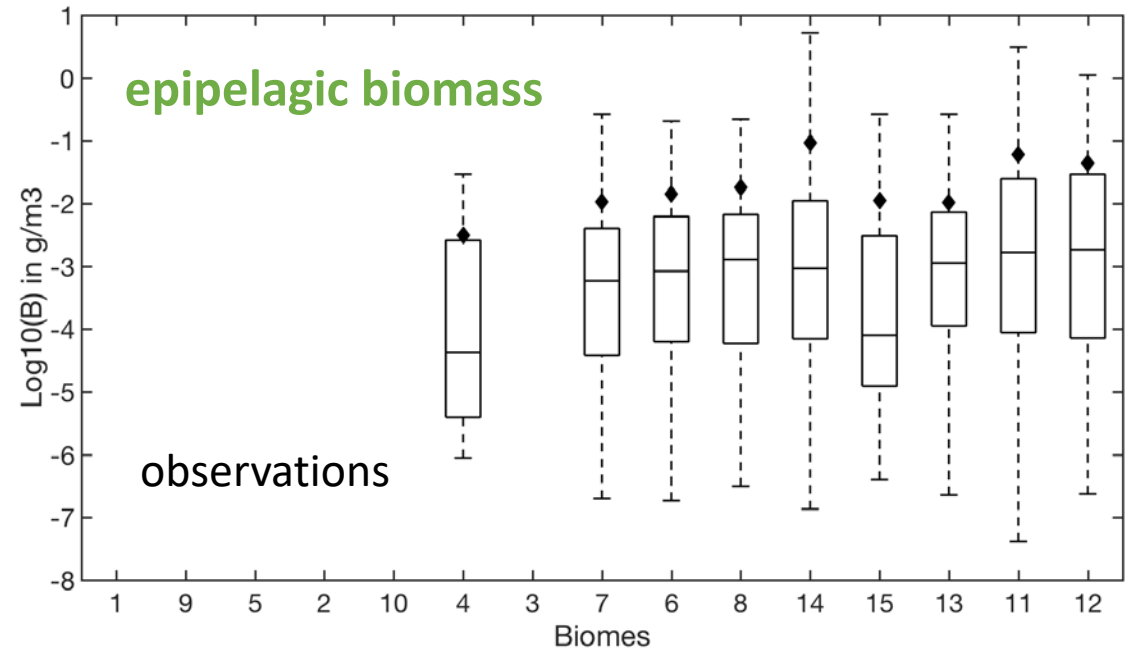
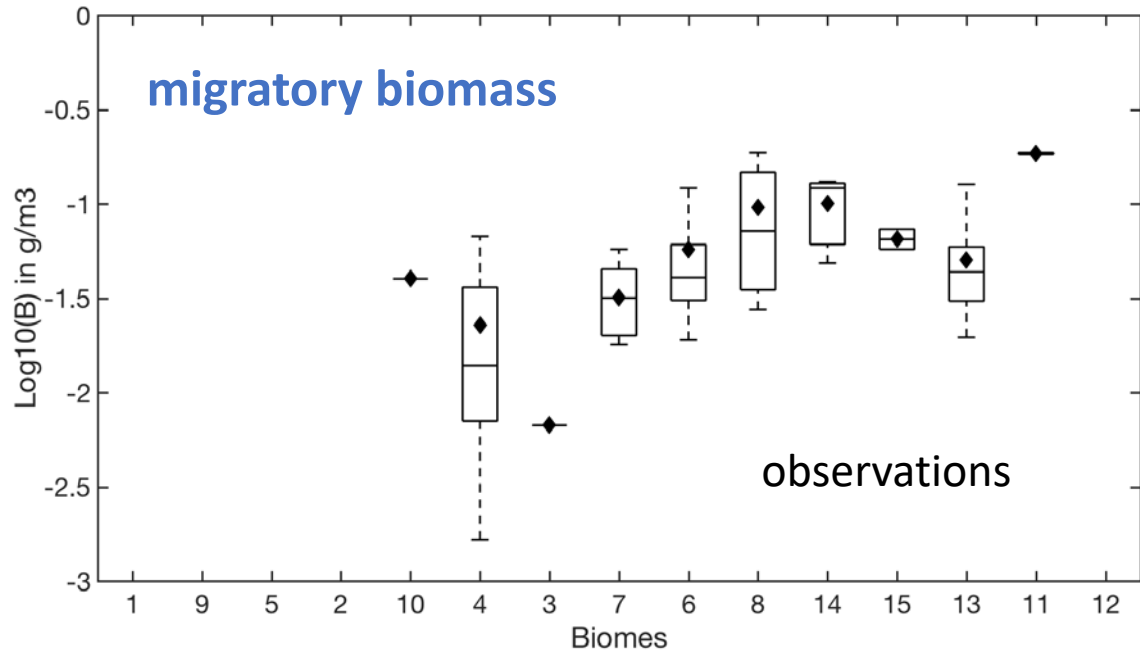


Observed epipelagic
biomass distributions in
different biomes



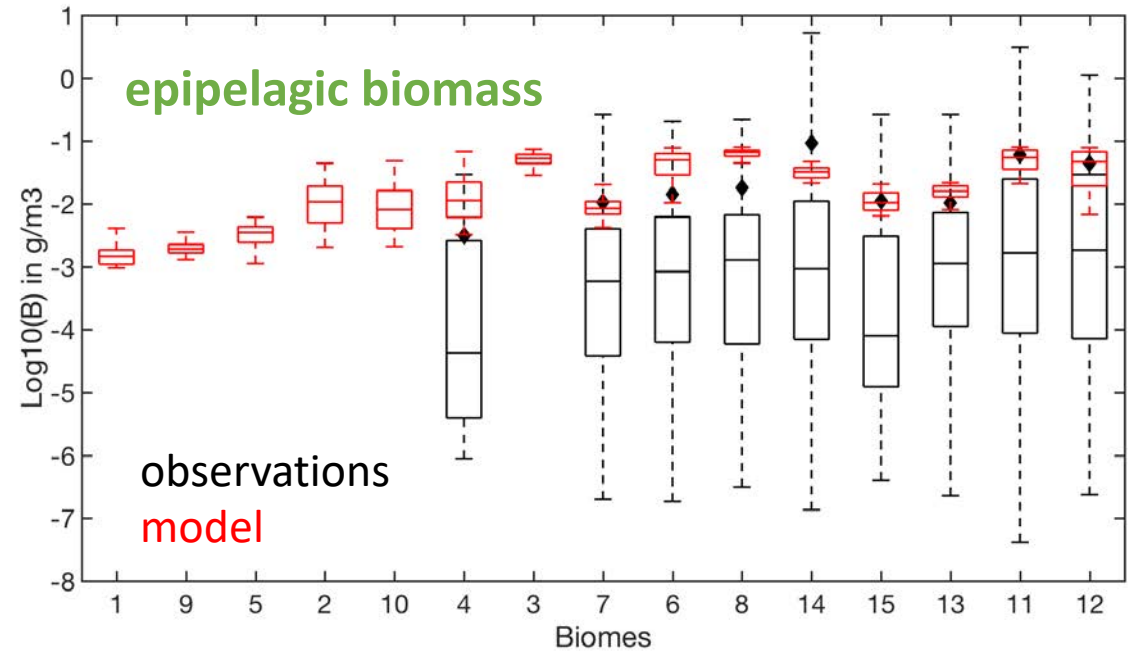
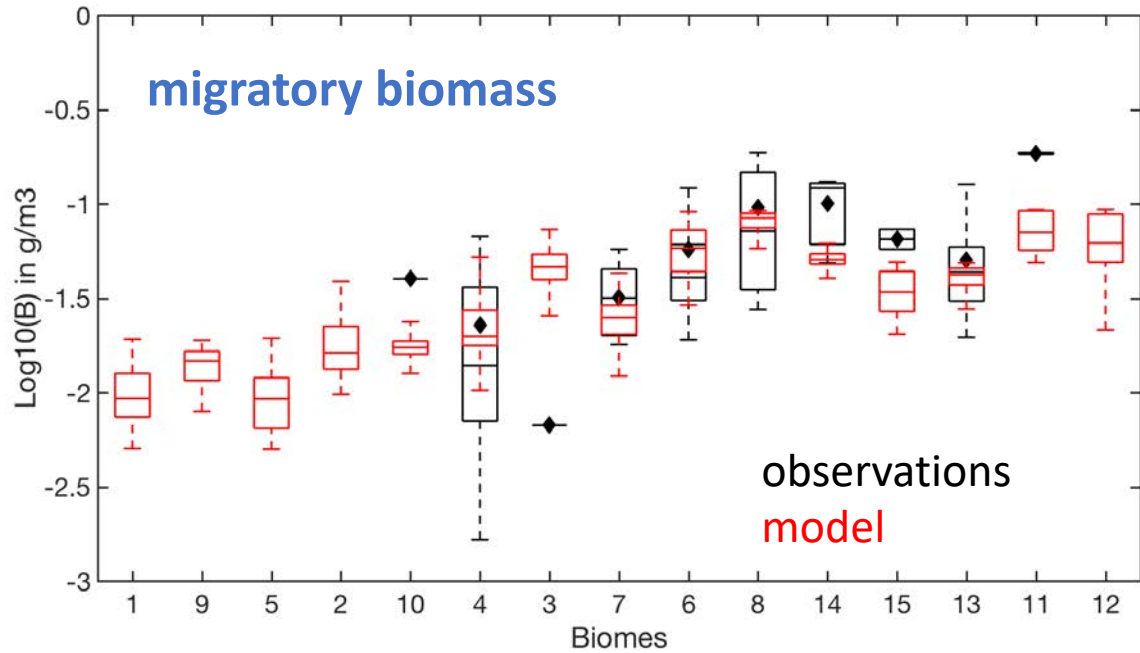
Summarized by
“box plots” (showing
median, range, mean)

Observed vs. modeled biomass



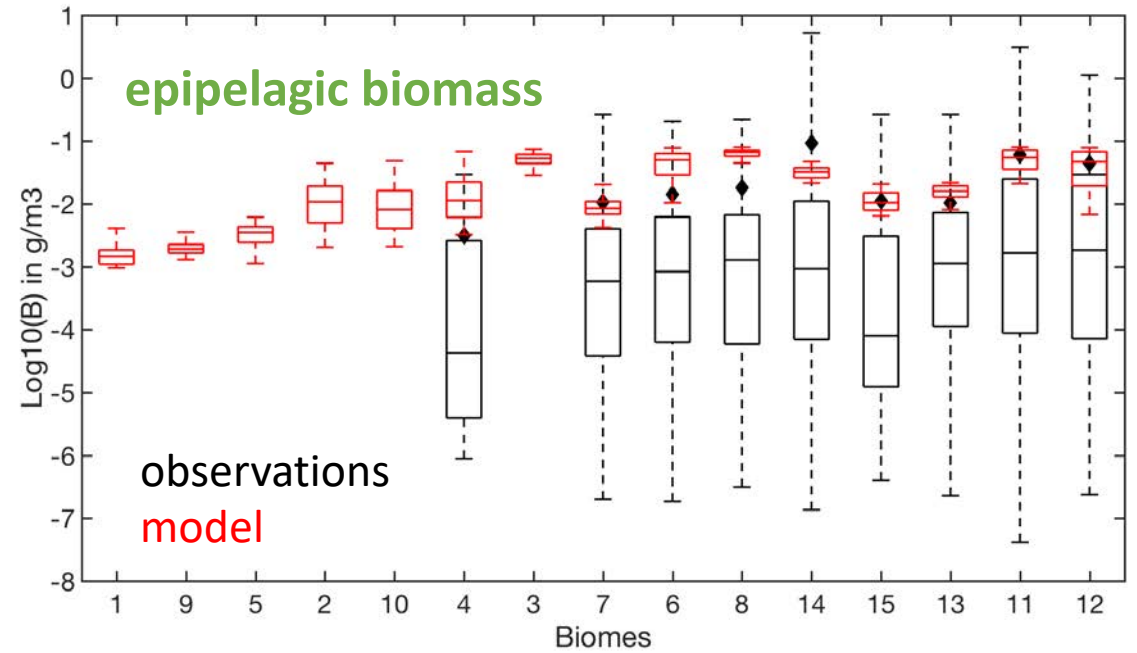
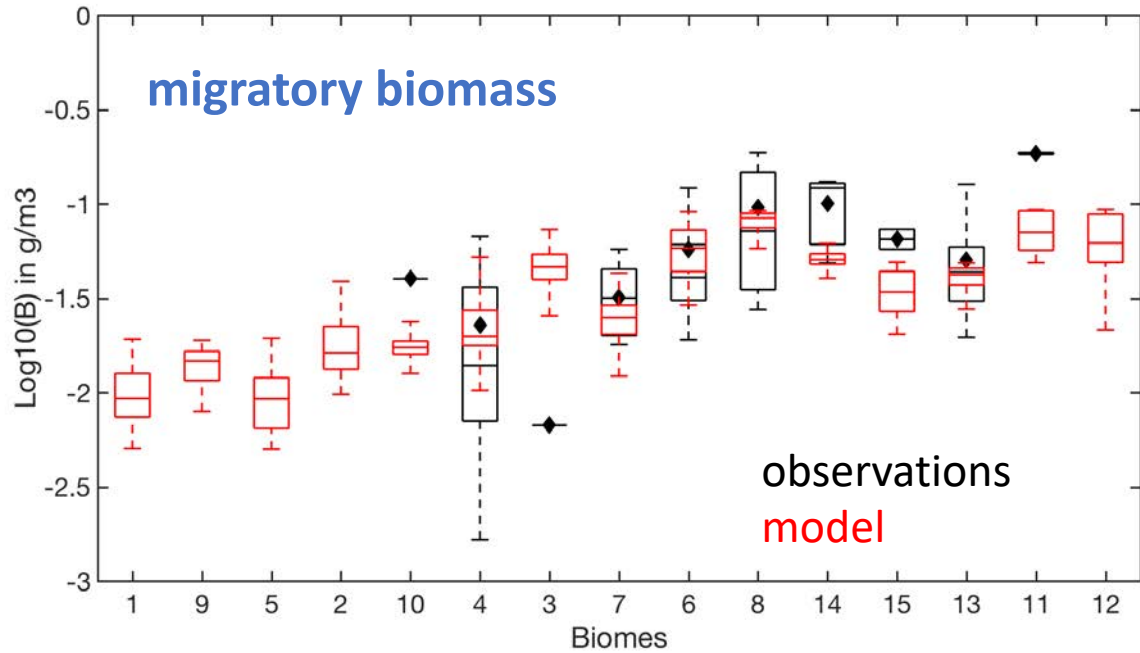
- Observations show **regional trends** across biomes, following the environment
- Note the large range in epipelagic biomass, caused by both sampling and ecosystem variability

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)

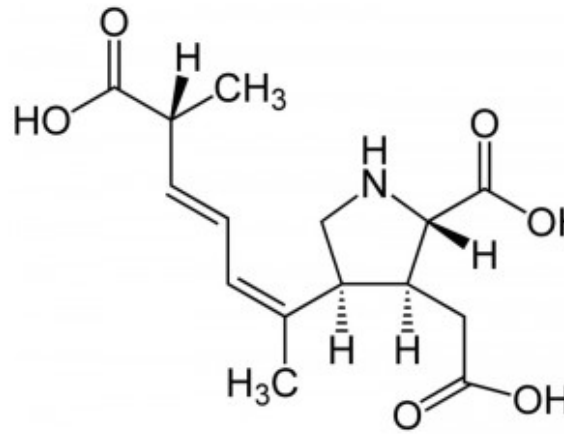
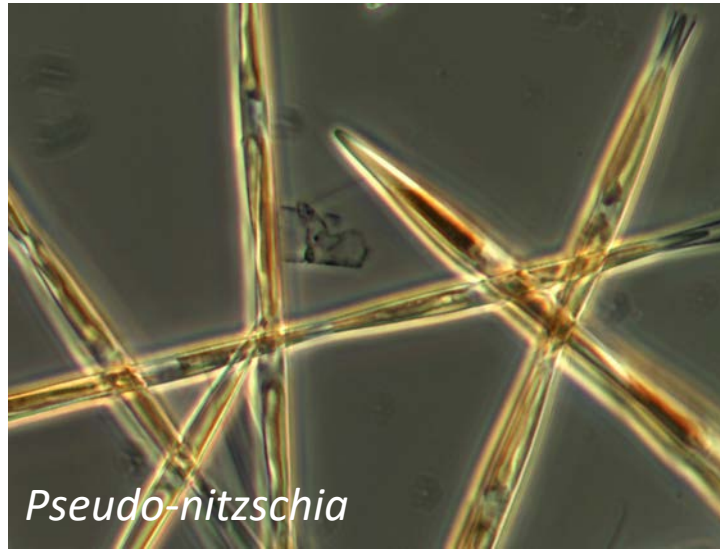
Clarissa Anderson (SCCOOS)

Martha Sutula (SCCWRP)

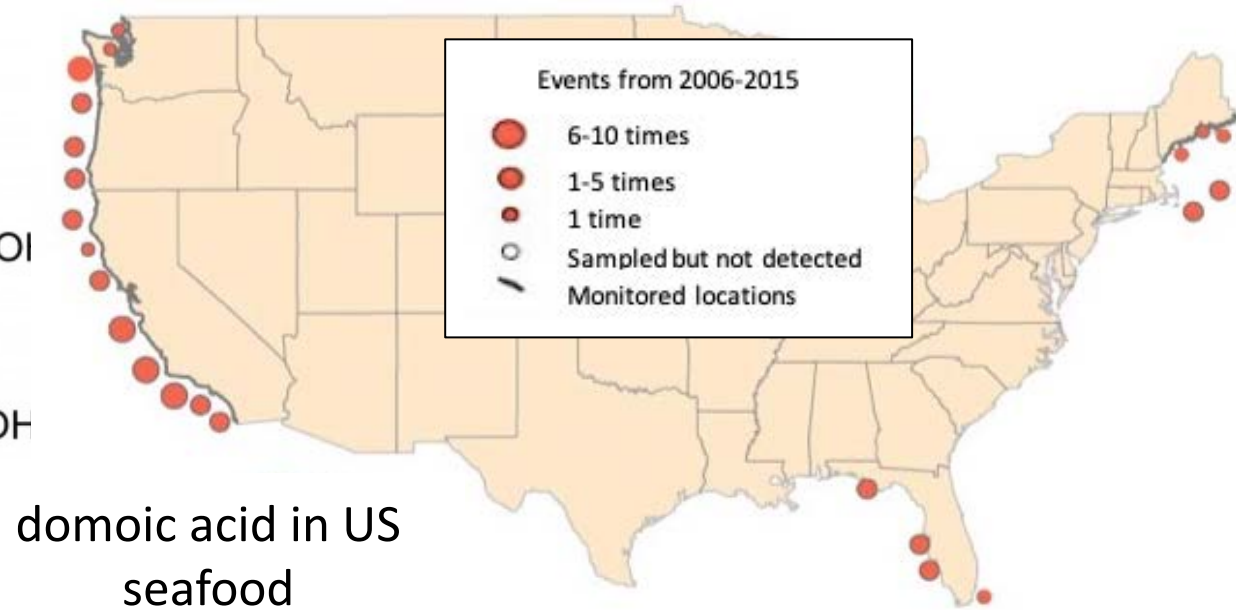
Fayçal Kessouri (UCLA, SCCWRP)

Jayme Smith (SCCWRP)

HABs in the California Current



domoic acid

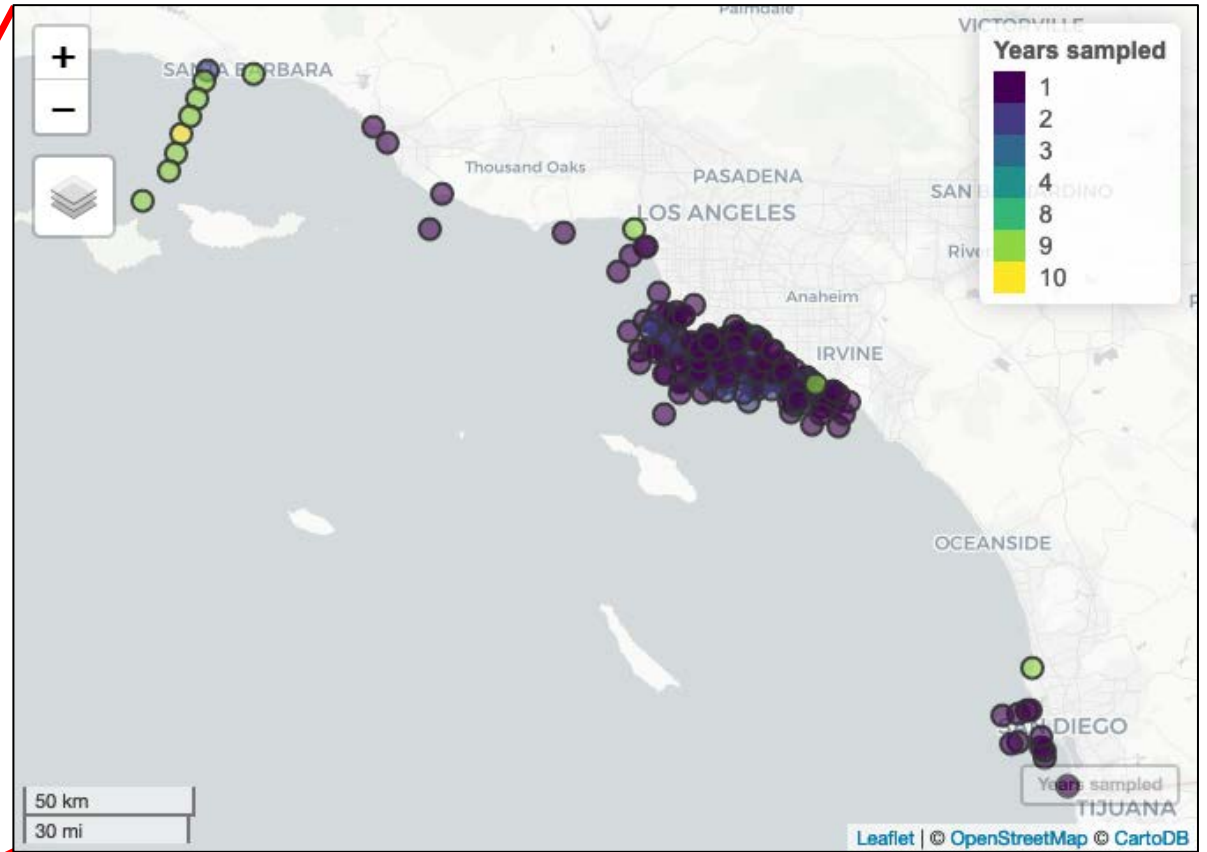
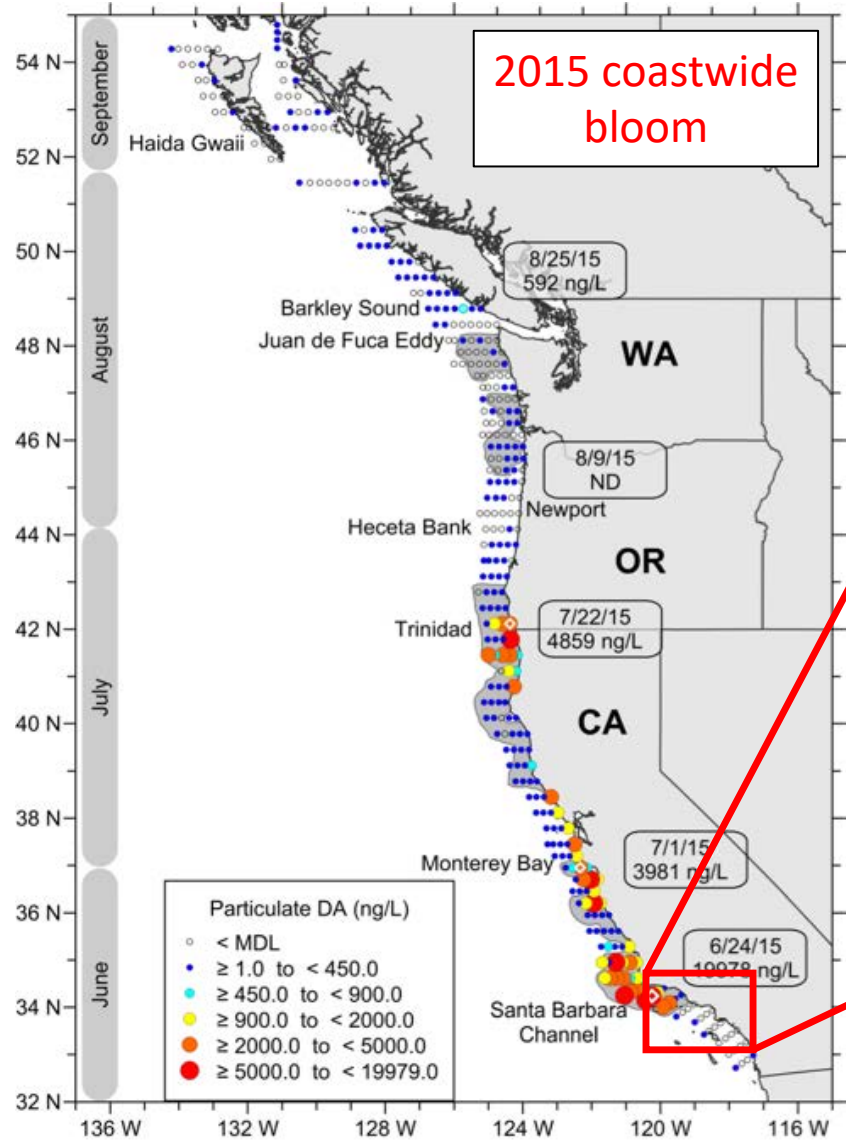


Pseudo-nitzschia spp. (a diatom genus)

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

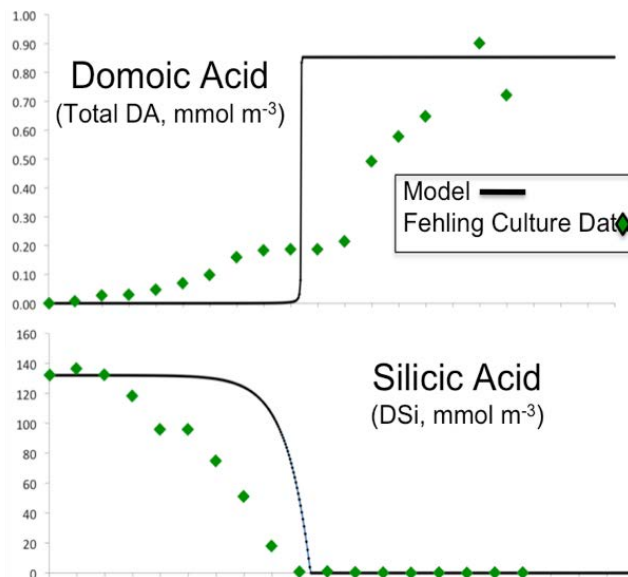
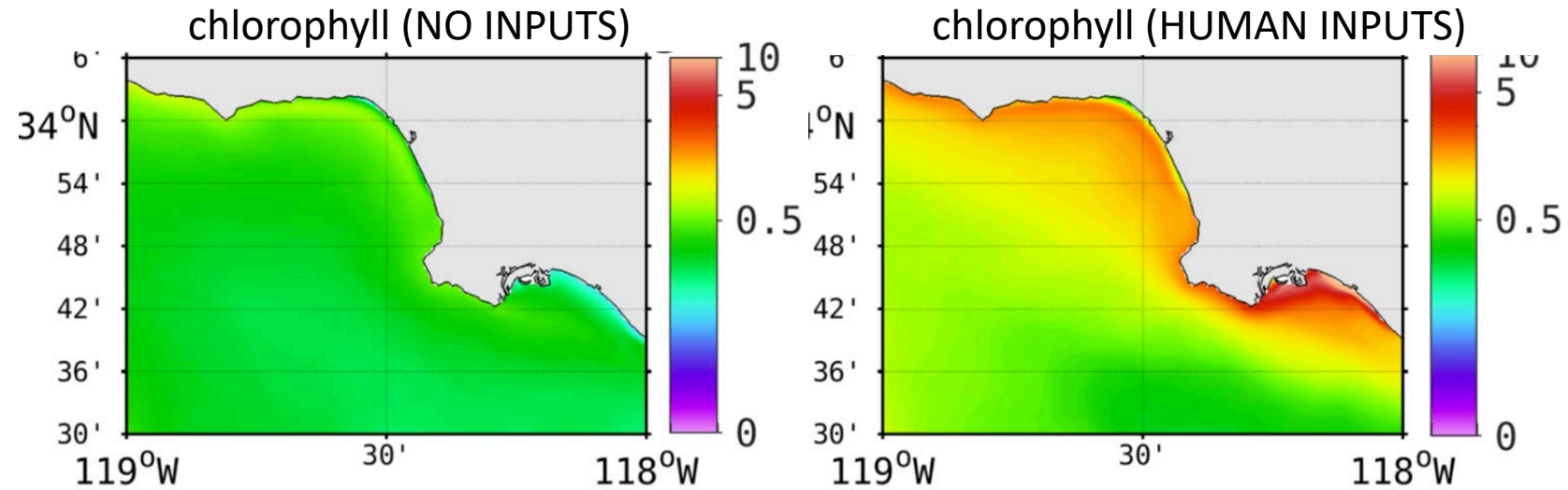
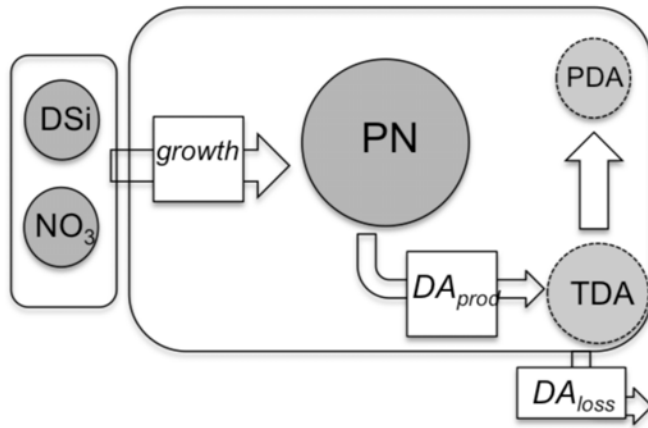
- A range of symptoms, from mild to life-threatening (nausea, dizziness, memory loss, seizures, coma, death)
- Impact marine mammals and birds, with 1000s strandings and deaths during past 10yrs
- Common in California. Unprecedented **2015 coastwide bloom** caused substantial **economic damage**

Observations of Domoic Acid in the CC



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

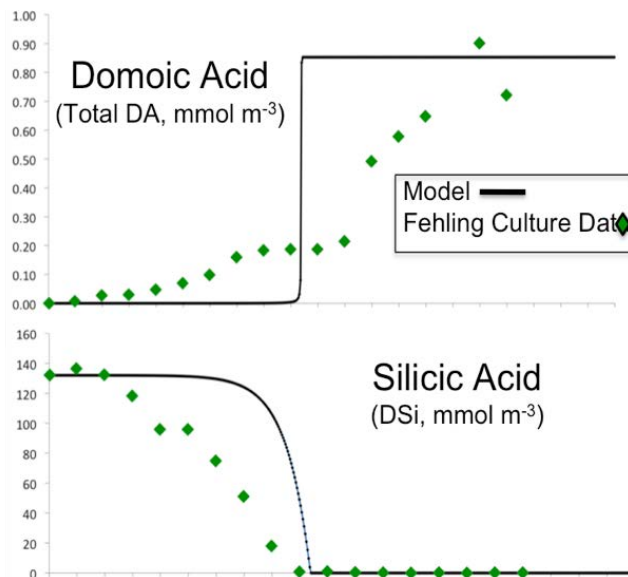
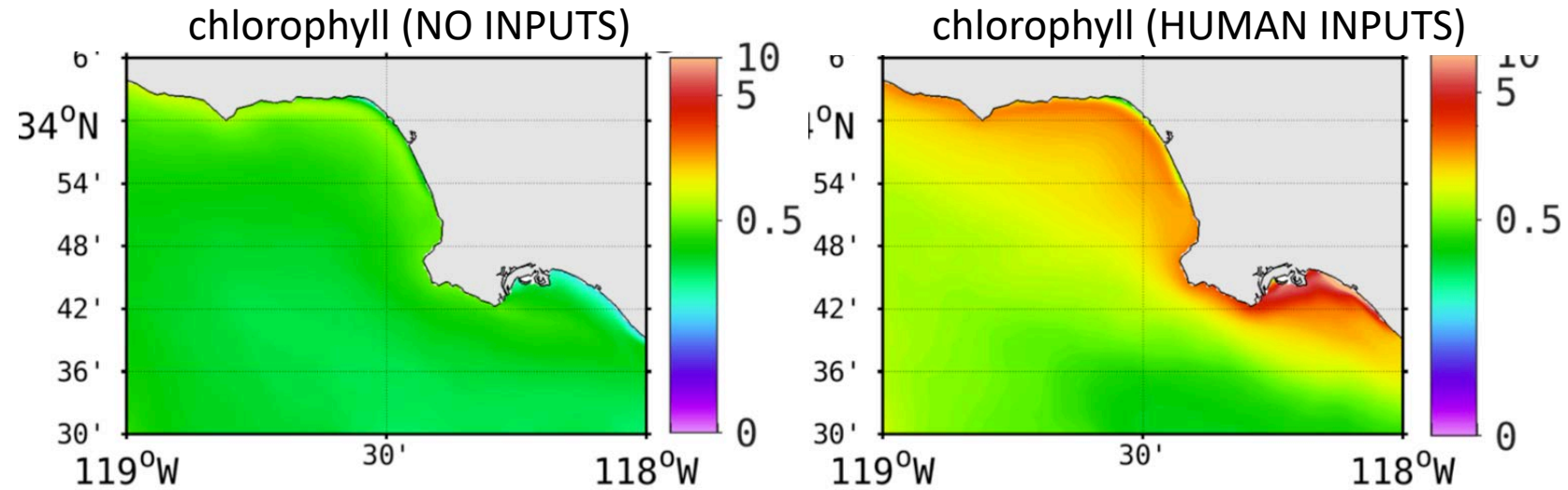
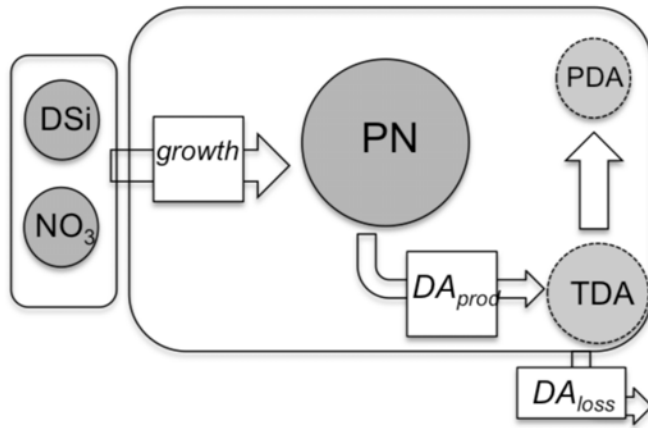
Developing a model of HABs in the CC



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 (N_2O) emissions



Simon Yang (UCLA)

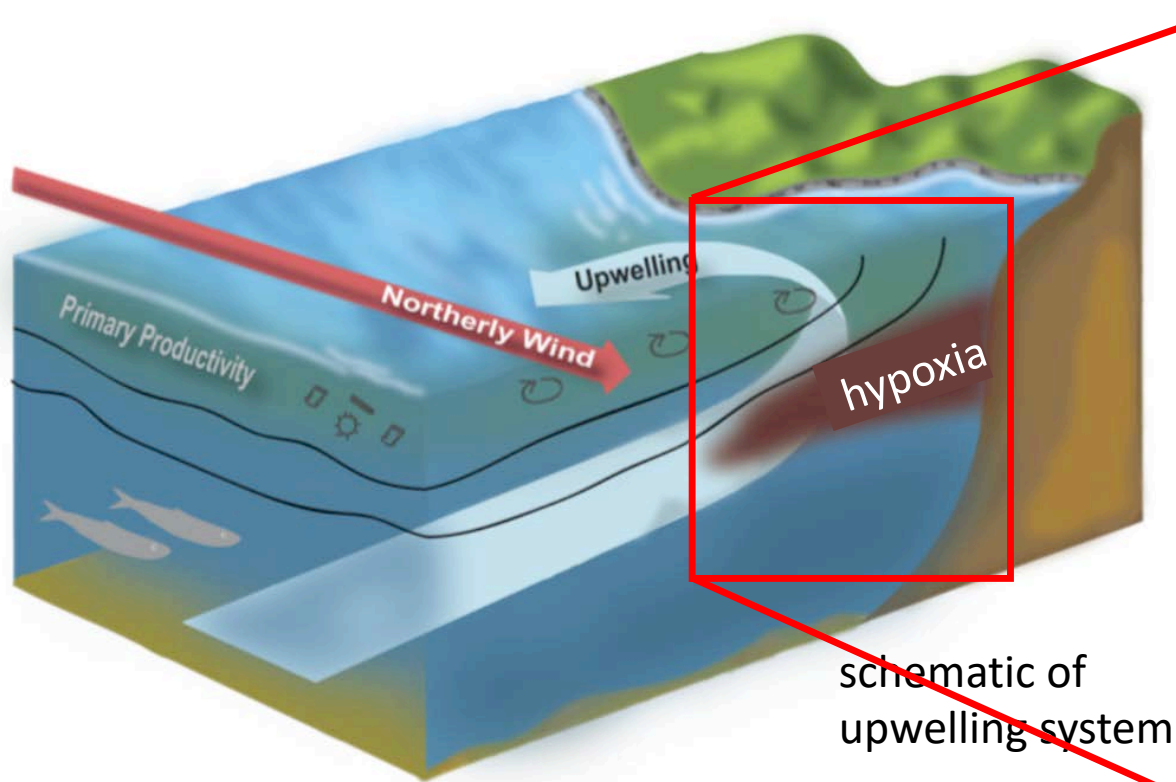
Fayçal Kessouri (UCLA, SCCWRP)

+ UCLA's modeling team:

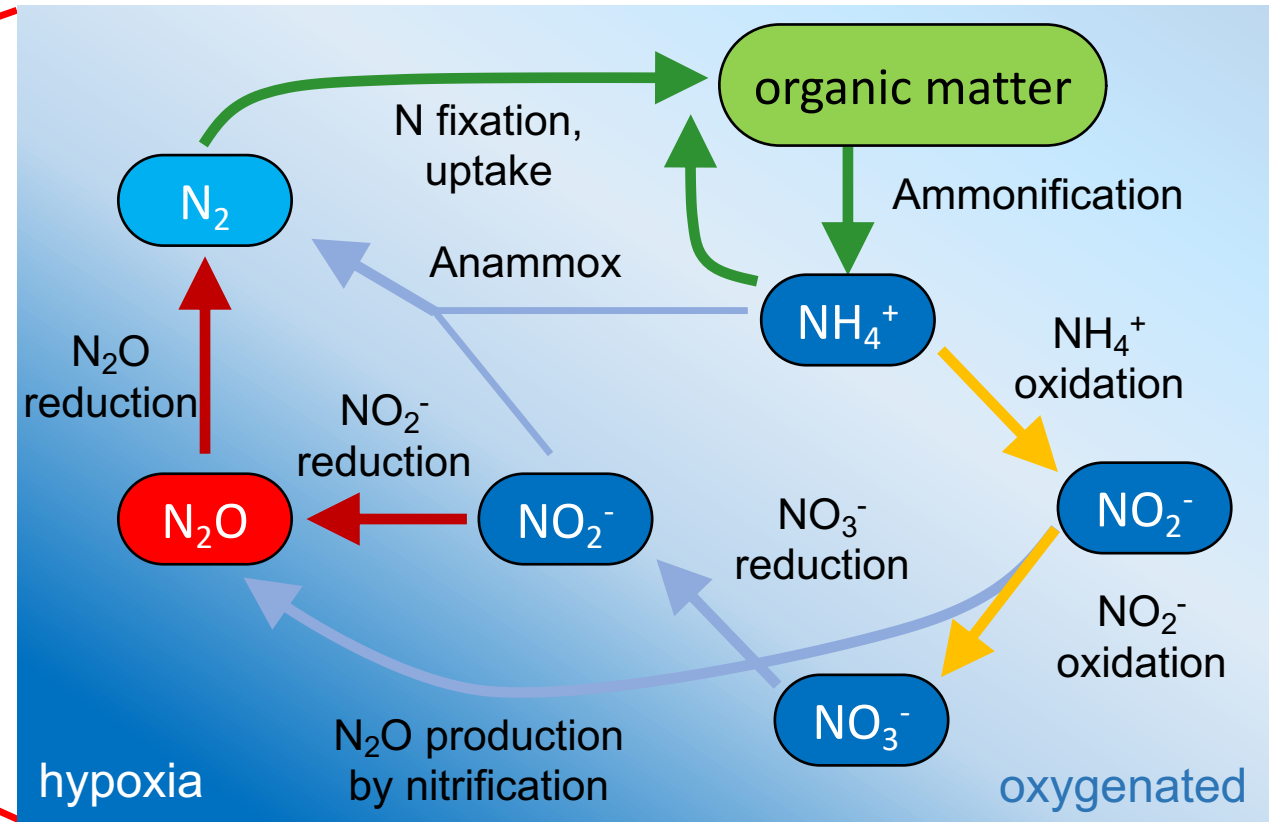
James McWilliams, Jeroen Molemaker,

Pierre Damien (UCLA)

1. Nitrogen cycle and N₂O emissions

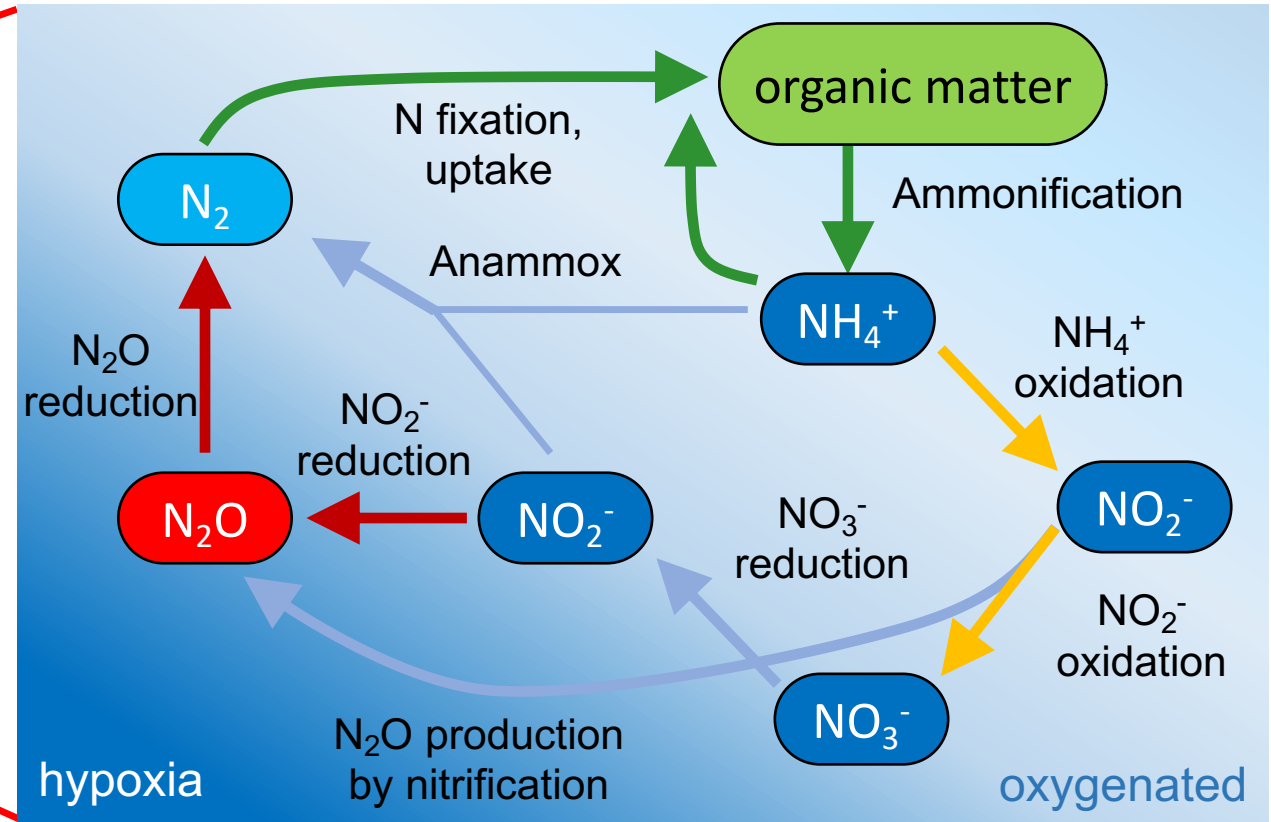
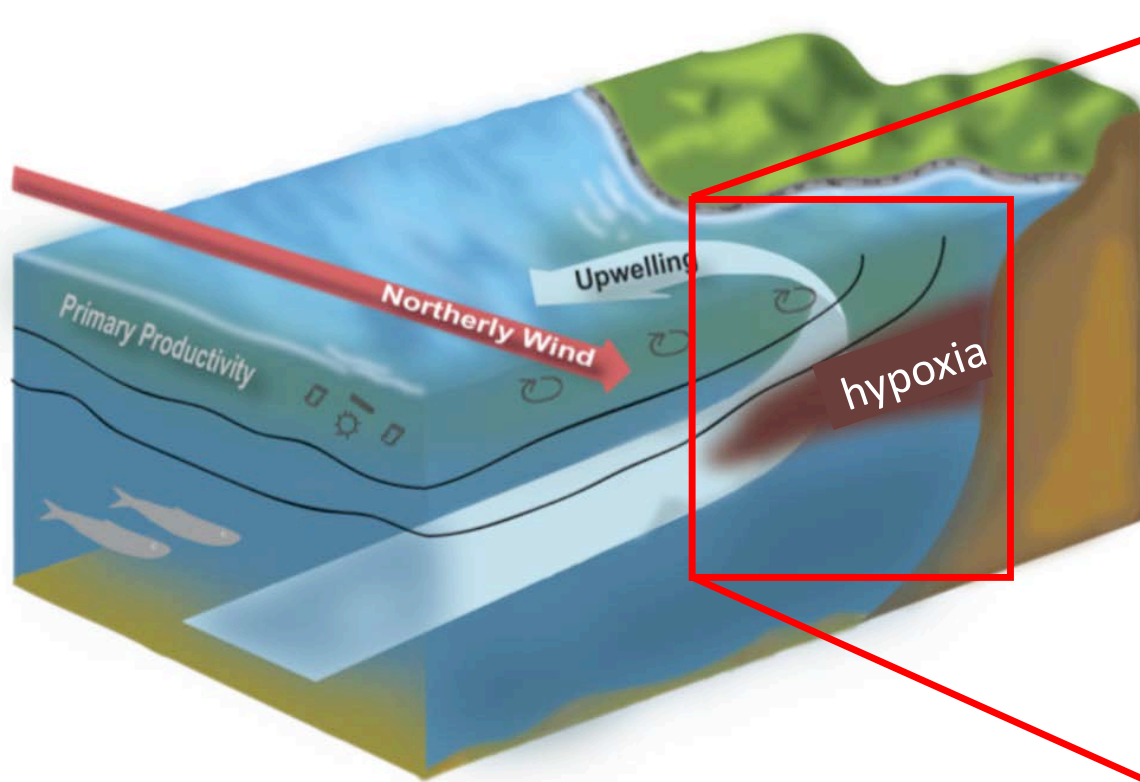


schematic of upwelling system



In upwelling systems, low oxygen conditions (**hypoxia**) promote removal of fixed nitrogen (**denitrification**) and **production of N₂O**, a powerful greenhouse gas

1. Nitrogen cycle and N₂O 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 N₂O production
- Magnitude and drivers of N₂O emissions
- Role of global and local anthropogenic impacts

As an example, we begun a regional assessment of N₂O sources in the CCS

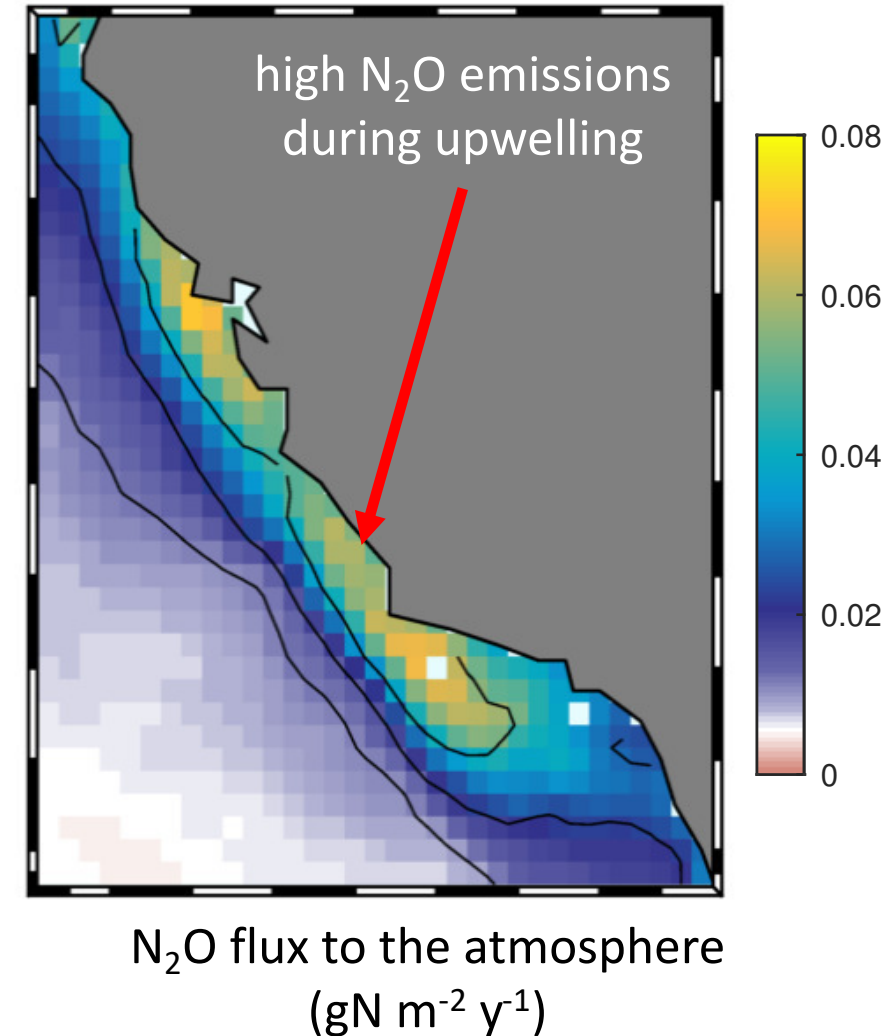
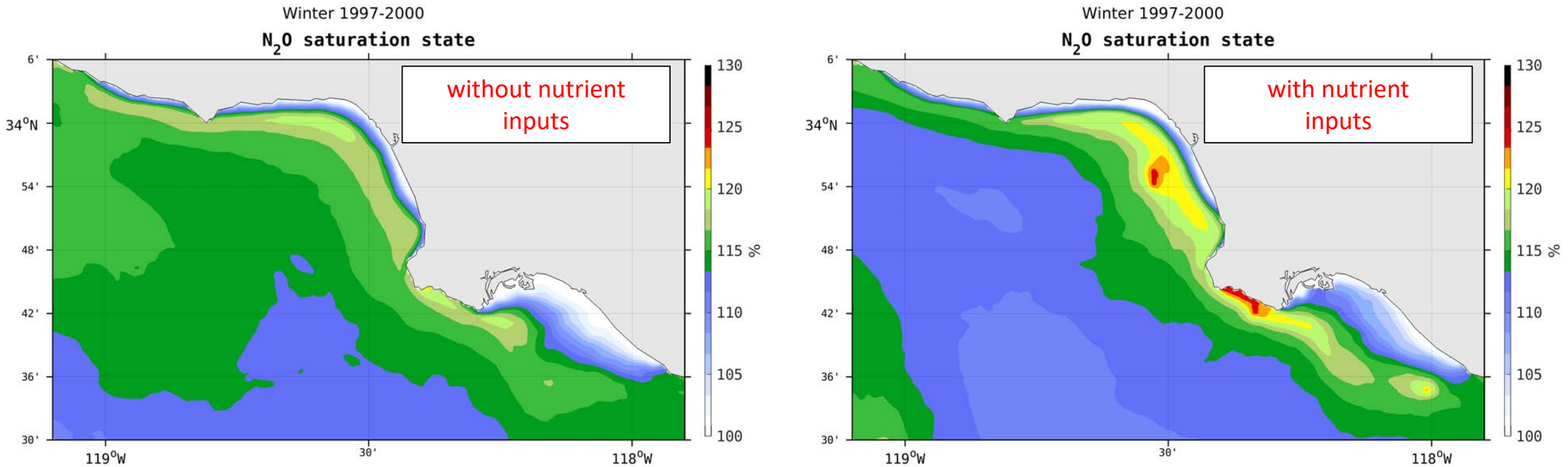


figure courtesy of Simon Yang, UCLA

Anthropogenic impacts on N₂O emission



Preliminary results suggest that anthropogenic nutrient inputs could enhance local N₂O emissions to the atmosphere

→ This may be important for constraining local N₂O 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 N₂O emissions & human impacts

Thank you!

