Ocean Acidification and Hypoxia (OAH) Modeling Progress Report for SCCWRP Commission

September 9, 2022

CONTEXT FOR TODAY'S DISCUSSION

We developed a coupled physical-biogeochemical model of Southern California Bight

We applied the model to simulate algal blooms, acidification and hypoxia (OAH)

- Including contributions from land-based nutrients.

And, working with CTAG, we conducted a model skill assessment, comparing predictions with observations.

We then pivoted toward model applications…

WE APPLIED THE MODEL TO ANSWER THREE MANAGEMENT QUESTIONS

1. What is the effect of anthropogenic nutrient loads on algal blooms, oxygen and pH in the SCB?

2. What are the biological effects of these changes in chemistry?

3. What is the effect of reducing inorganic nitrogen in outfall wastewater, alone, or combined with potable water recycling?

We briefed you on preliminary answers to the first two during the June 2022 Commission meeting

PRELIMINARY FINDINGS: QUESTIONS 1 AND 2

Q1: We documented that anthropogenic nutrients are increasing algal productivity

…that leads to decreases in oxygen and pH.

Q2: These oxygen and pH changes result in habitat compression for surface-dwelling shelled organisms and fish

...Though this compression is limited to three months around late summer.

ROAD MAP FOR TODAY'S PRESENTATION

- **Preliminary findings from nitrogen management and water recycling scenarios**

  Q3 What is the effect of nitrogen management, alone or in combination with potable water recycling?

- **Future directions**

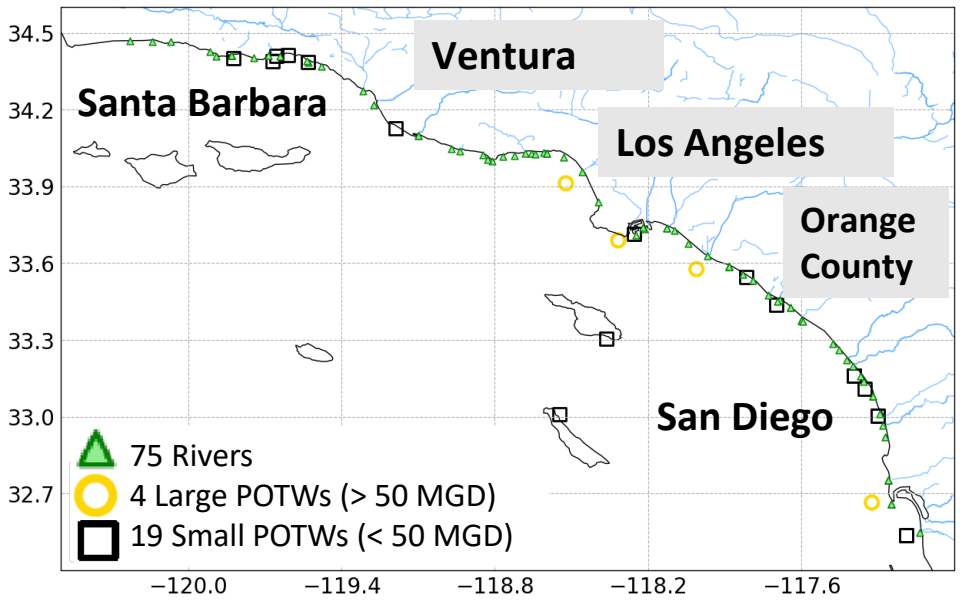
MODEL SCENARIO EXPERIMENTAL DESIGN

Scenarios		Range of % effluent recycled for potable reuse*		
		0%	50%	90%
Nutrient Management Options	Current loading ~40 mg/L inorganic nitrogen	X		
	50% reduction in inorganic nitrogen loading	X	X	X
	85% reduction in inorganic nitrogen loading	X	X	X

SCENARIO DETAILS

- Modern land-based nutrients (2016-2017) that includes all ocean outfalls + rivers
  - But we simulated changes to ocean outfalls only

- To investigate the influence of ocean state, we simulated four ocean years
  - Aug 1997 – Nov 1999
  - Aug 2015 – Nov 2017



TODAY WE ARE PRESENTING ANALYSES OF SCENARIOS BASED ON THREE TYPES OF CHANGE METRICS

Algal productivity

Chemical changes in oxygen and pH

Change in the volume of habitat for surface dwelling marine organisms

- pH effects on shelled organisms
- oxygen effects on aerobic habitat for fish and invertebrates

QUESTION 3: WHAT ARE THE EFFECTS OF NITROGEN MANAGEMENT, ALONE OR IN COMBINATION WITH WATER RECYCLING OF OUTFALL EFFLUENT?

Nitrogen reduction reduces algal production, reversing decreases in oxygen and pH

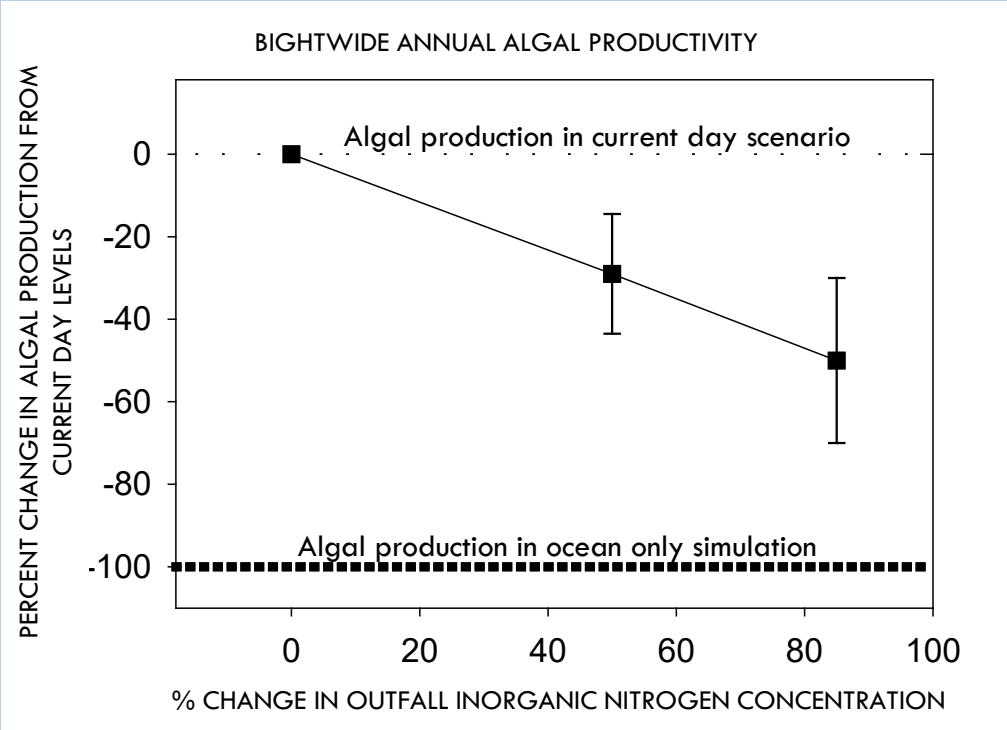
- This translates to a reduction in simulated habitat compression

Water recycling has no effect on total algal production in the Bight

- but it shifts and intensifies algal blooms, oxygen and pH loss within a smaller footprint towards the coast

WHAT ARE THE EFFECTS OF INORGANIC NITROGEN REDUCTIONS ALONE?

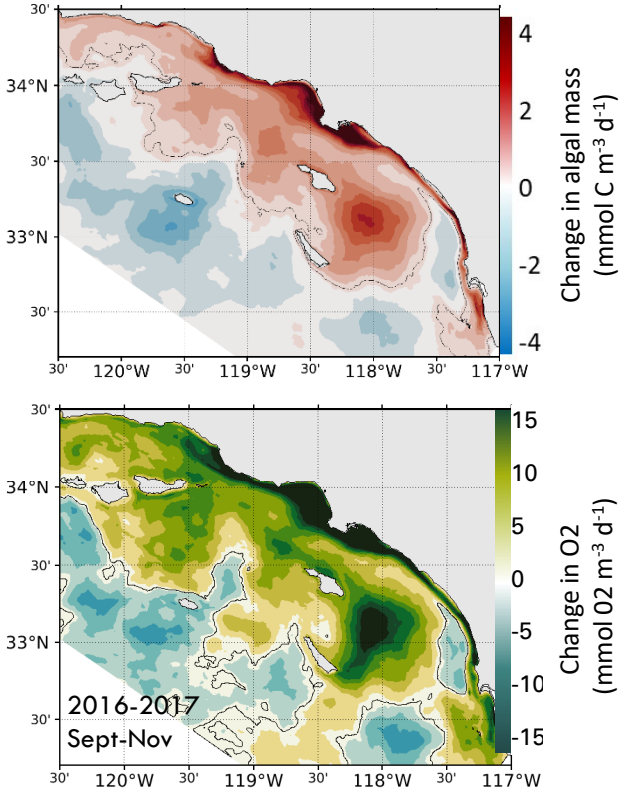
NEW SCENARIOS SHOW NITROGEN REDUCTIONS CONSISTENTLY REDUCE ALGAL PRODUCTIVITY



Error bars represent interannual standard error (N = 4 years)

NITROGEN REDUCTION EFFECTS ON ALGAL PRODUCTION TRANSLATE TO IMPROVEMENT IN OXYGEN AND PH LOSS

0% Nitrogen Reduction



Algal Production

red = increase

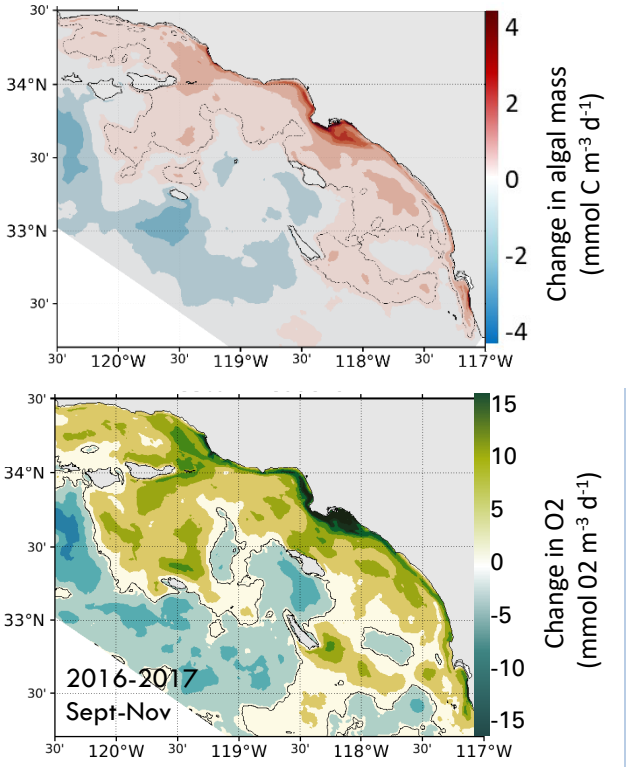
blue = decrease

Oxygen

green = loss

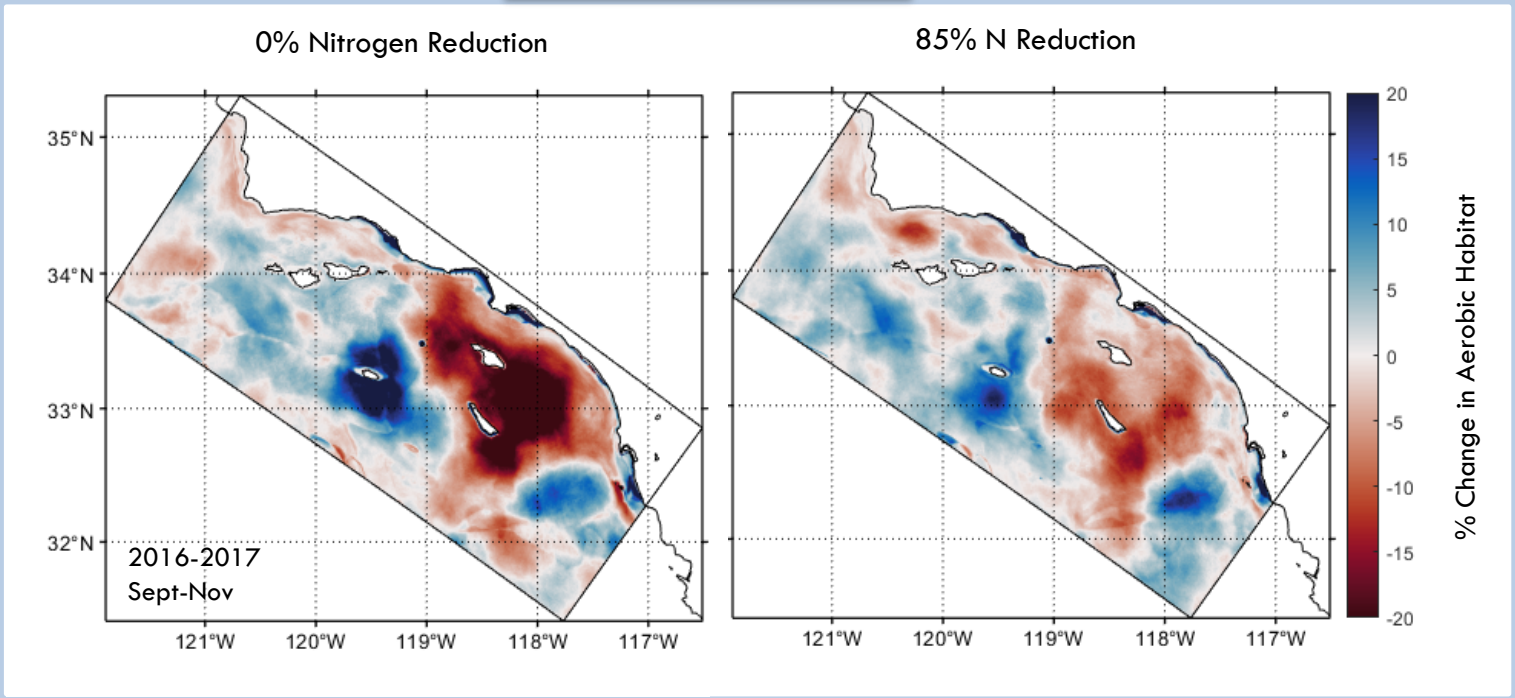
blue = gain

85% Nitrogen Reduction



OFFSHORE, NITROGEN REDUCTION TRANSLATES TO GAIN OF UP 75% OF HABITAT COMPRESSION DUE TO ANTHROPOGENIC INPUTS

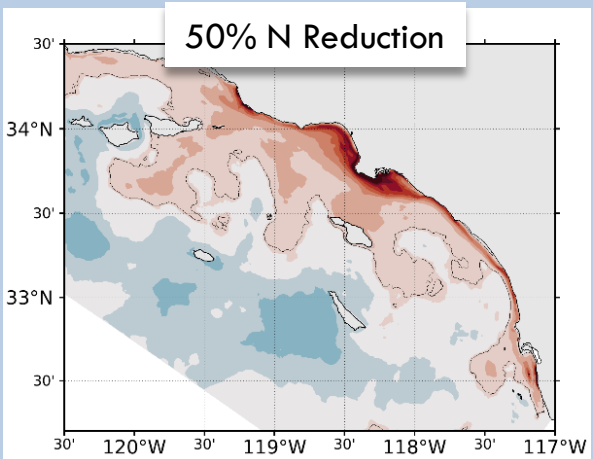
Aerobic Habitat Change
red = compression
blue = expansion

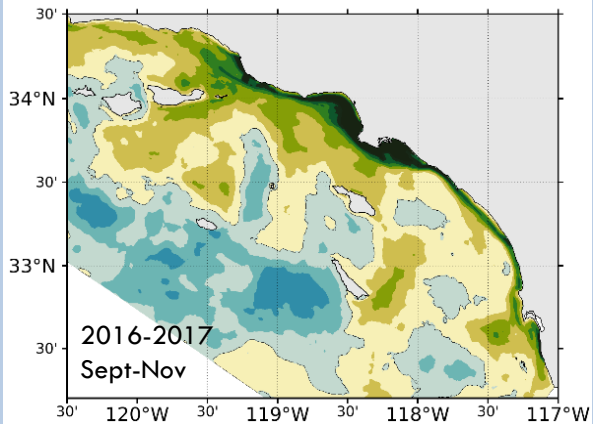


HOW DOES WASTEWATER RECYCLING MODIFY THE EFFECTS OF NITROGEN MANAGEMENT?

On average annual basis, Bightwide, water recycling doesn't consistently change total algal carbon production

WATER RECYCLING CAUSED MORE INTENSE LOCALIZED BLOOMS, AND OXYGEN AND PH LOSS, WITHIN A SMALLER FOOTPRINT OF EFFECT





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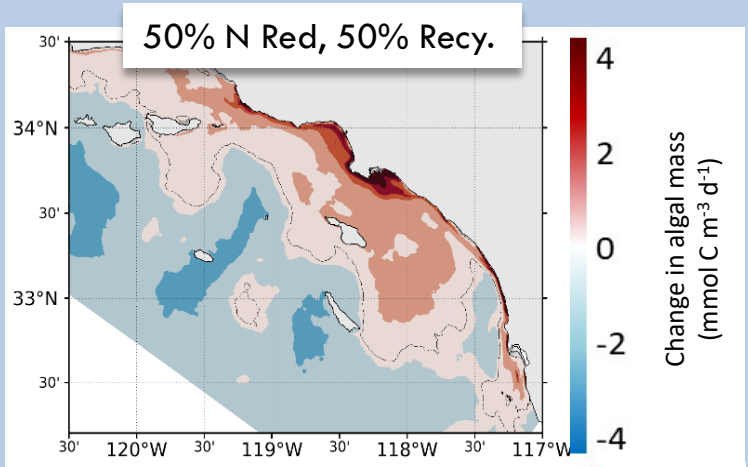

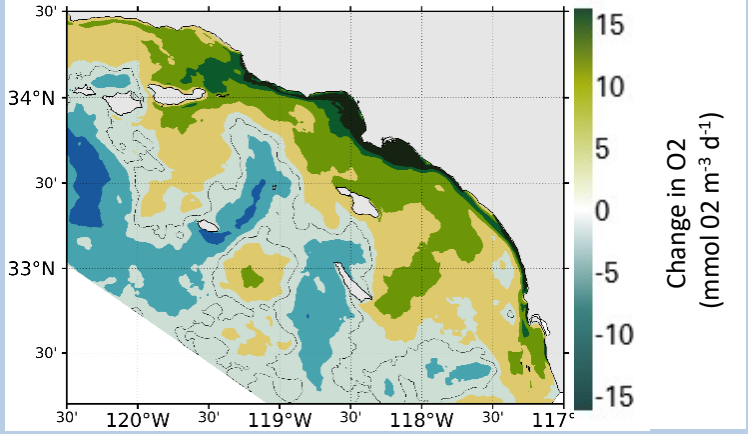

ON SOME YEARS, BENEFITS OF NITROGEN REDUCTION TO ALLEVIATE HABITAT COMPRESSION ARE PARTLY REVERSED BY WATER RECYCLING

Aerobic Habitat Change
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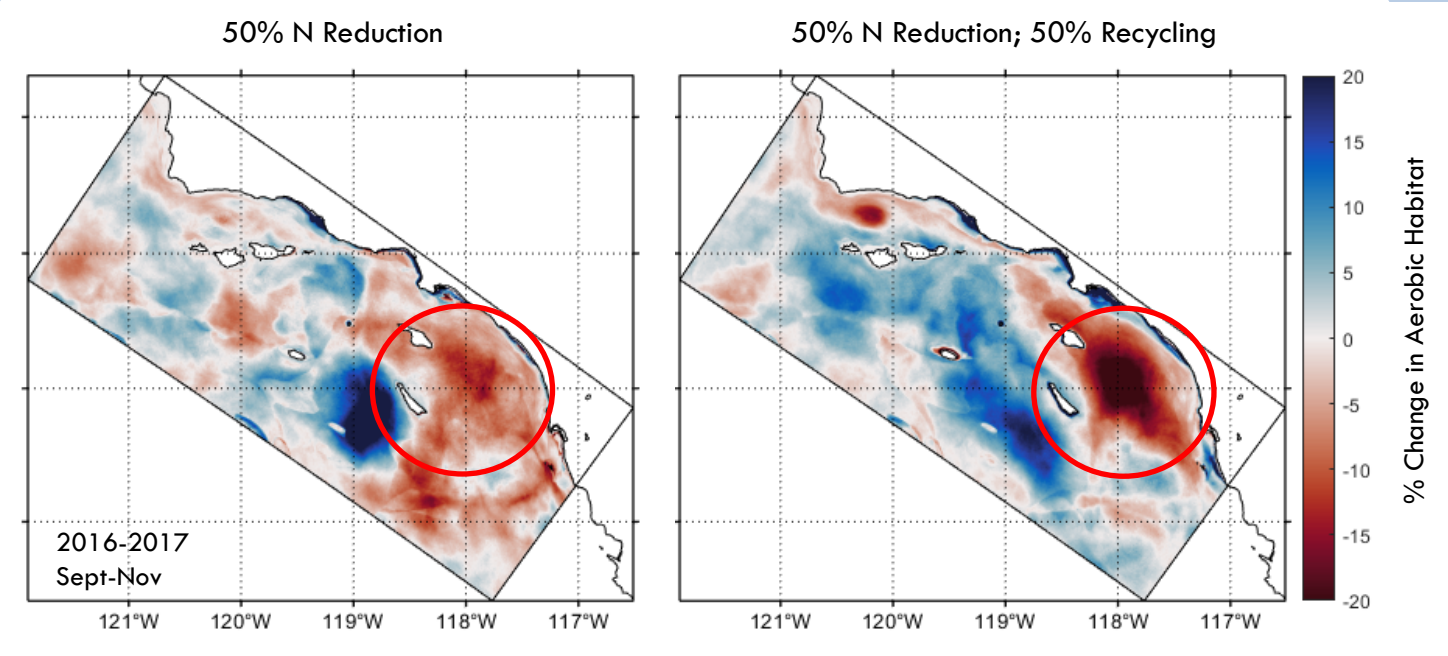
blue = expansion



HOW CONFIDENT ARE WE IN THESE FINDINGS?

Q1 What is the effect of anthropogenic nutrients on algal blooms, oxygen and pH?

High confidence that anthropogenic nutrients produce persistent algal blooms, subsurface pH & oxygen loss

Q2: What are biological effects of these changes?

High confidence that during late summer/fall, these inputs cause OAH habitat compression but **lower confidence** in how this translates to population-level effects

HOW CONFIDENT ARE WE IN THESE FINDINGS?

Q3: What are the effects of nitrogen management alone or in combination with potable water recycling

High confidence that nitrogen reduction causes up to 1:1 decrease in algal production, reversing loss of oxygen and pH

High confidence that nitrogen reductions can reverse extent of offshore oxygen and pH related habitat compression

Moderate confidence that water recycling at any level of N management can cause algal blooms, O2 and pH loss to intensify near the coast

The optimum nitrogen reductions vis-a-vis water recycling needed are **untested**.

FUTURE DIRECTIONS

1. Provide context for findings

- Compare local anthropogenic load with effects of natural (climate) variability and climate change

2. Work with CTAG to improve confidence in ROMS-BEC as a decision support tools

3. Build confidence in biological interpretation tools

4. Alternative solutions to nutrient management

- How can kelp and bivalve aquaculture offset effects?

QUESTIONS?

THANK YOU!