Investigations of effects of anthropogenic nutrients on acidification and hypoxia (OAH) in the Southern California Bight Progress Report

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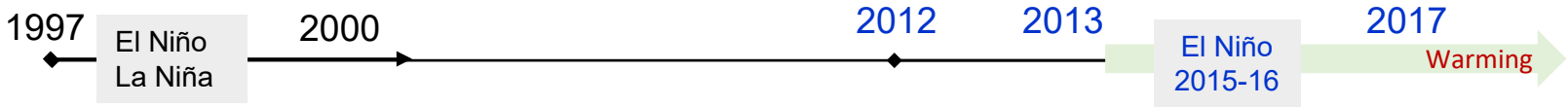
June 3, 2022 SCCWRP Commission Update

ANTHROPOGENIC EFFECTS ASSESSMENT: CONTEXT

- We developed and validated a coupled physical and biogeochemical model
- We assessed the effect of land-based nutrients on OAH in the SCB
  - We documented those nutrients have an important effect on OAH chemistry
- But that simulation was based on all "land-based" nutrient inputs from 20 years ago
  - And it didn't pull out specifically "anthropogenic" inputs
  - Nor did it speak to biological effects of those changes in OAH

So.. We've conducted new work to provide an improved understanding to inform ocean water quality management decisions



WE BEGIN TO PROVIDE ANSWERS TO TWO OF THREE MANAGEMENT QUESTIONS

1. **What is the effect of anthropogenic nutrient loads on OAH in the SCB?**

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

3. **What is the potential for nitrogen management and/or wastewater recycling to alter these effects?**

We consider our analyses ~70% complete

We anticipate refining these answers with your input from CTAG over the next 6 months

QUESTION 1. EFFECTS OF ANTHROPOGENIC NUTRIENTS ON OAH

Land-based nutrient inputs are causing an 150% increase in algal productivity in nearshore coastal waters

- Relative to an ocean only scenario

This leads to ~3% reduction in average oxygen (O_2) concentration and omega saturation state across the entire Bight

- But can be up to 20-30% during late summer in regions of the Bight

Magnitude of change is not isolated to areas in proximity to ocean discharges; these changes occur in equal magnitude onshore versus offshore habitats and in shallow versus deepwater habitats

Bightwide 98 % of these changes are caused by point sources alone

QUESTION 2: WHAT ARE THE BIOLOGICAL EFFECTS OF OAH LOSS FROM LAND-BASED NUTRIENTS IN THE BIGHT?

Inputs do not ever trigger lethal thresholds in upper surface waters for O_2 or pH, nor thresholds that represent "fitness-level" effects for 9 months out of the year

During late summer for ~3 months, land-based nutrients are causing pH related habitat loss for shelled organisms over 25% of the entire Bight in upper surface waters

- Answer is similar for aerobic habitat for northern anchovy (represents a median sensitivity for upper surface waters)

Very little habitat loss from nutrient inputs is occurring in the very nearshore (in state waters)

- It occurs most persistently offshore of San Diego, Orange, and LA Counties.

We only have the answer for upper surface waters so far (0-200 m)

- We will continue to look at effects in waters > 200 m deep and to the seafloor

OUR PRESENTATION BEGINS TO PROVIDE ANSWERS TO THREE MANAGEMENT QUESTIONS

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TO ANSWER THE THIRD QUESTION….
WE HAVE COMPLETED RUNNING THE NUTRIENT MANAGEMENT % WATER RECYCLING SCENARIOS BUT ARE STILL ANALYZING THE EFFECTS

We anticipate briefing you on the results of these scenarios at the next Commission meeting

Scenarios		Range of % effluent recycled for potable reuse*		
		0%	50%	90%
Nutrient Management Options	Current loading ~44 mg/L inorganic nitrogen	X		
	50% reduction in inorganic nitrogen	X	X	X
	85 % reduction in inorganic nitrogen	X	X	X

IN THE INTERIM, HOW WILL WE BE INTERACTING WITH CTAG ON THIS WORK?

Getting input on a consistent set of chemical and biological effect assessments methodologies

- Your staff already has begun to engage us on the details of these approaches

Identifying high priority actions to enhance understanding of uncertainty

- Update of model skill assessment metric for more recent period is a good example of what can be done relatively quickly

Offering lots of contact time with our project team, including

- Two special subcommittee meetings in July and August
- Offering “office hours” in June to give CTAG more opportunity to engage, answer questions, and provide us with feedback as we fine tune our methodologies

ROADMAP TO TODAY'S PRESENTATION, FOCUSED ON PRELIMINARY FINDINGS FOR THE FIRST TWO QUESTIONS

1. **What is the effect of anthropogenic nutrient loads on OAH in the SCB?**

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

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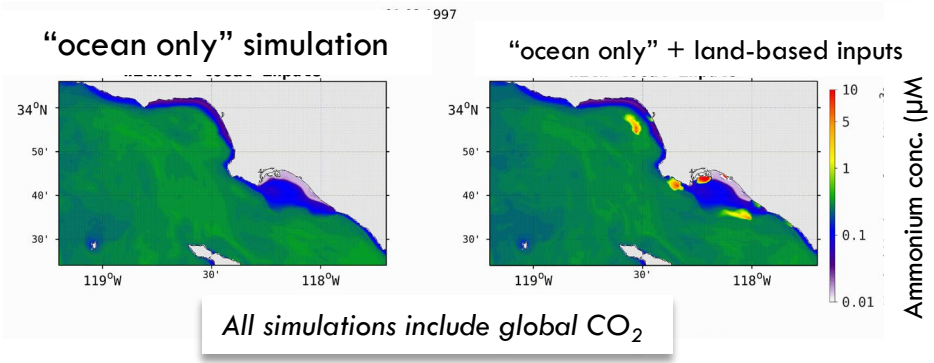
QUESTION 1 HAS TWO PARTS, EACH WITH ITS OWN APPROACH

1a. What is the effect of land-based nutrients on OAH in the SCB?

Calculate difference in two simulations:

1. Ocean + land-based inputs
2. Ocean only

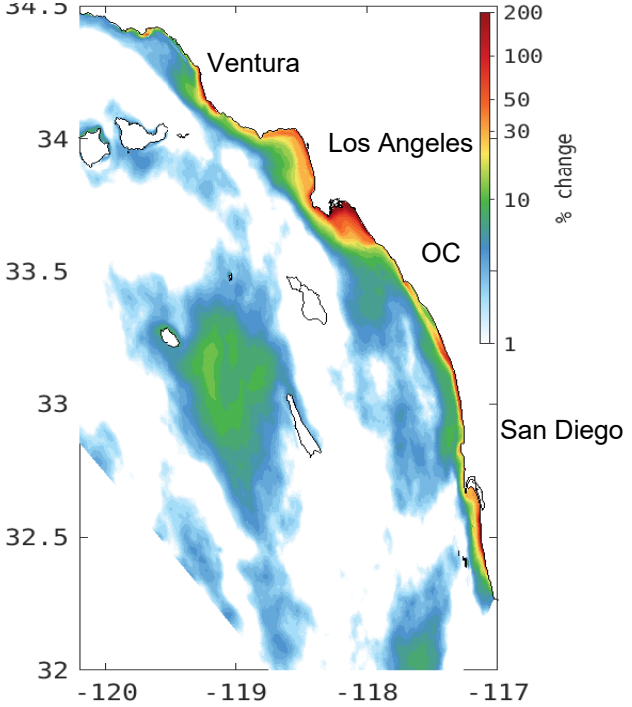


1b. How much of that effect is due to anthropogenic nutrients and which sources are driving that?

Multiple source attribution scenarios to pull apart point, non-point, and natural sources

LAND-BASED NUTRIENT INPUTS ARE CAUSING AN 150% INCREASE IN ALGAL PRODUCTIVITY, ON AVERAGE IN NEARSHORE COASTAL WATERS

Mean Change in Net Algal Productivity, 2014-17

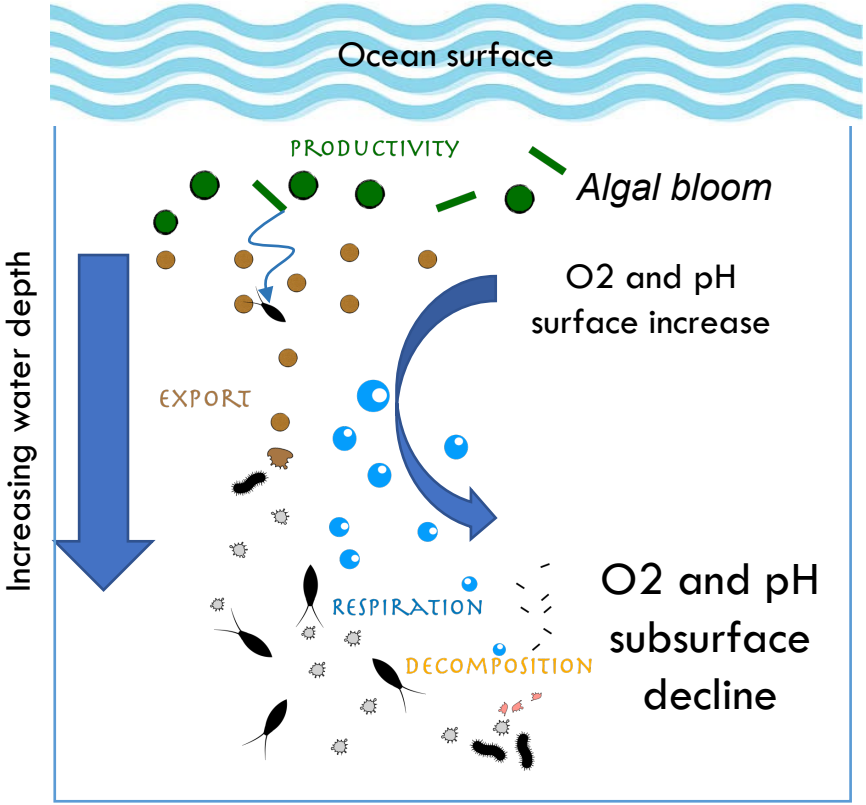


Based on change between two scenarios, 2013-2017:

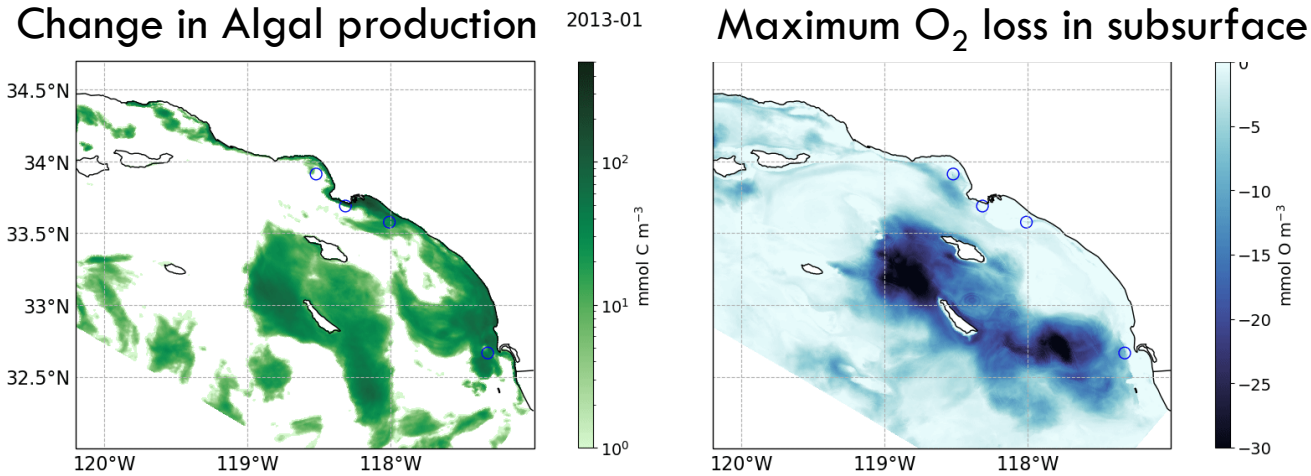
- Ocean only
- Ocean plus land-based nutrient inputs

THESE COASTAL ALGAL BLOOMS LEAD TO A LOSS IN SUBSURFACE OXYGEN (O_2) CONCENTRATION AND OMEGA SATURATION STATE ACROSS THE BIGHT

ON AVERAGE, THAT LOSS IS ~3% BIGHTWIDE

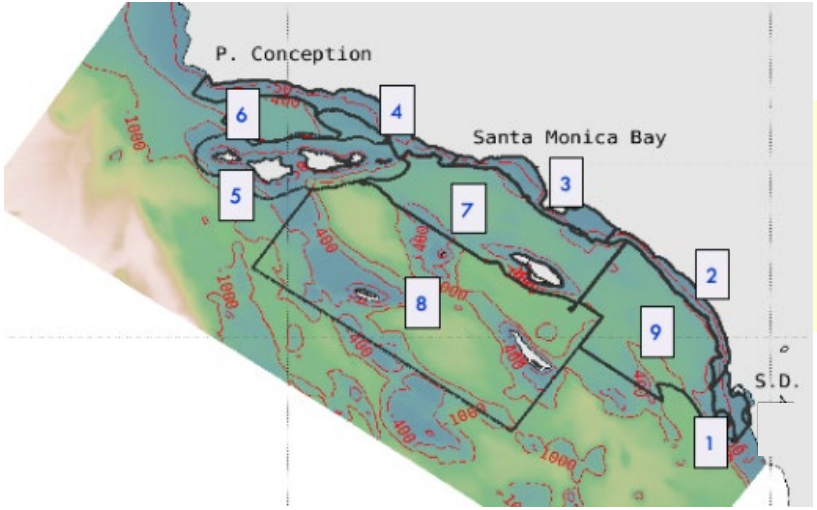


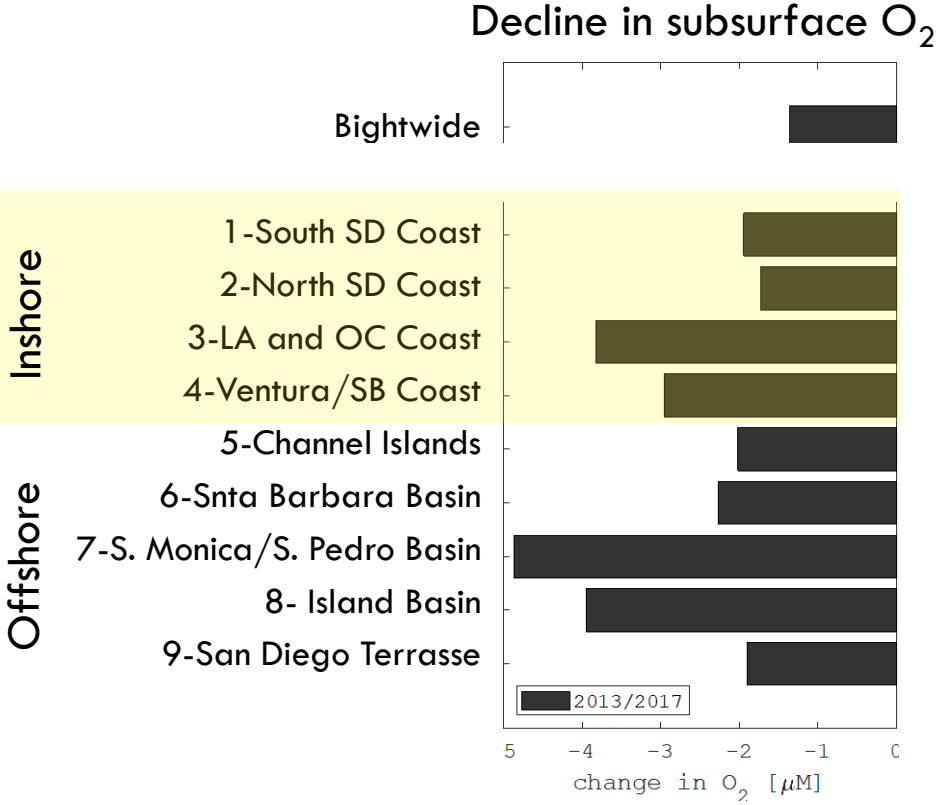
BUT RANGES UP TO 20% IN CERTAIN PLACES, MOSTLY DURING THE LATE SUMMER AND FALL



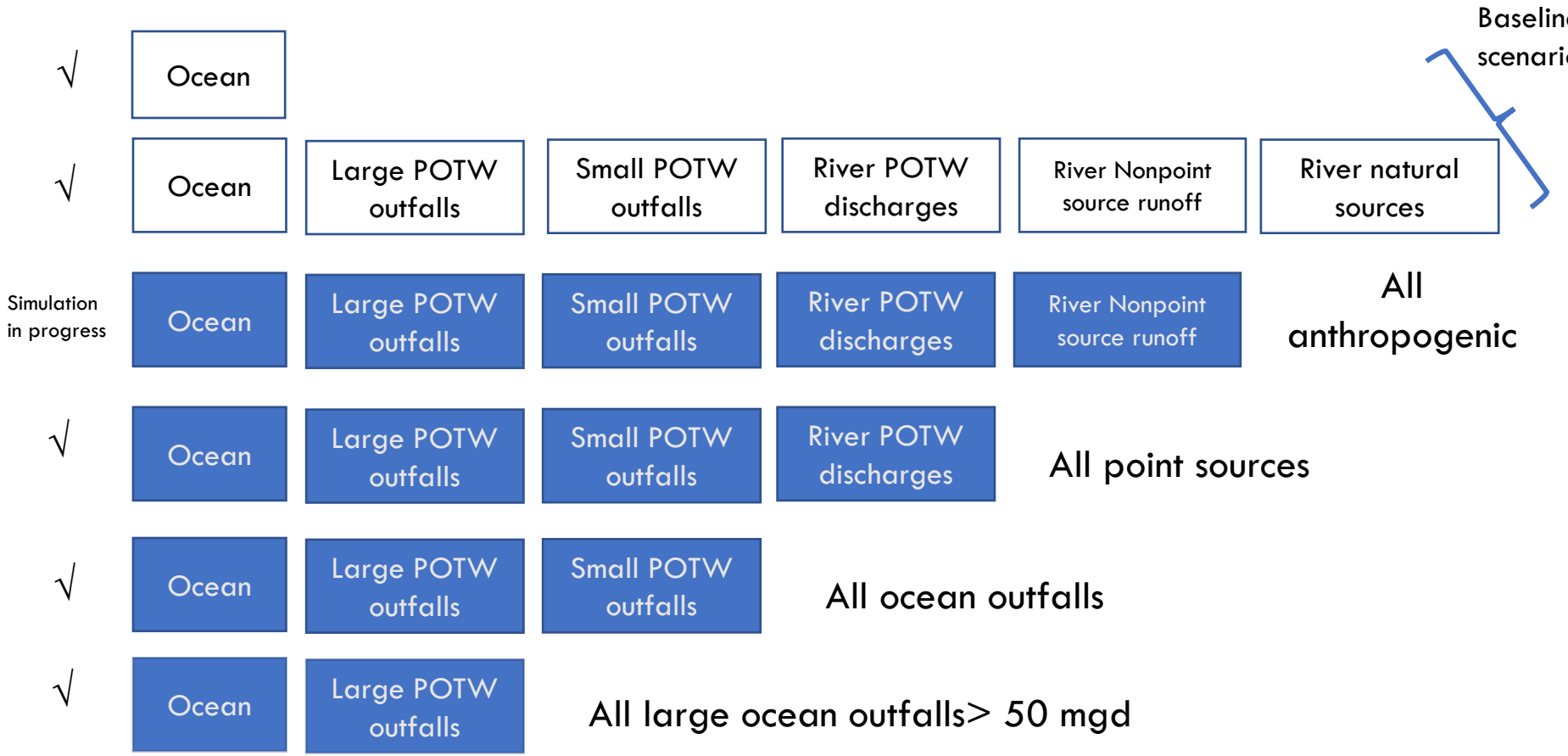
Monthly average net difference of (land based + ocean) – ocean only simulations, 2013-2017

DECLINES IN pH AND O_2 ARE OCCURRING BOTH INSHORE AND OFFSHORE, IN BOTH SHALLOW AND DEEPWATER HABITATS, IN EQUAL MAGNITUDE





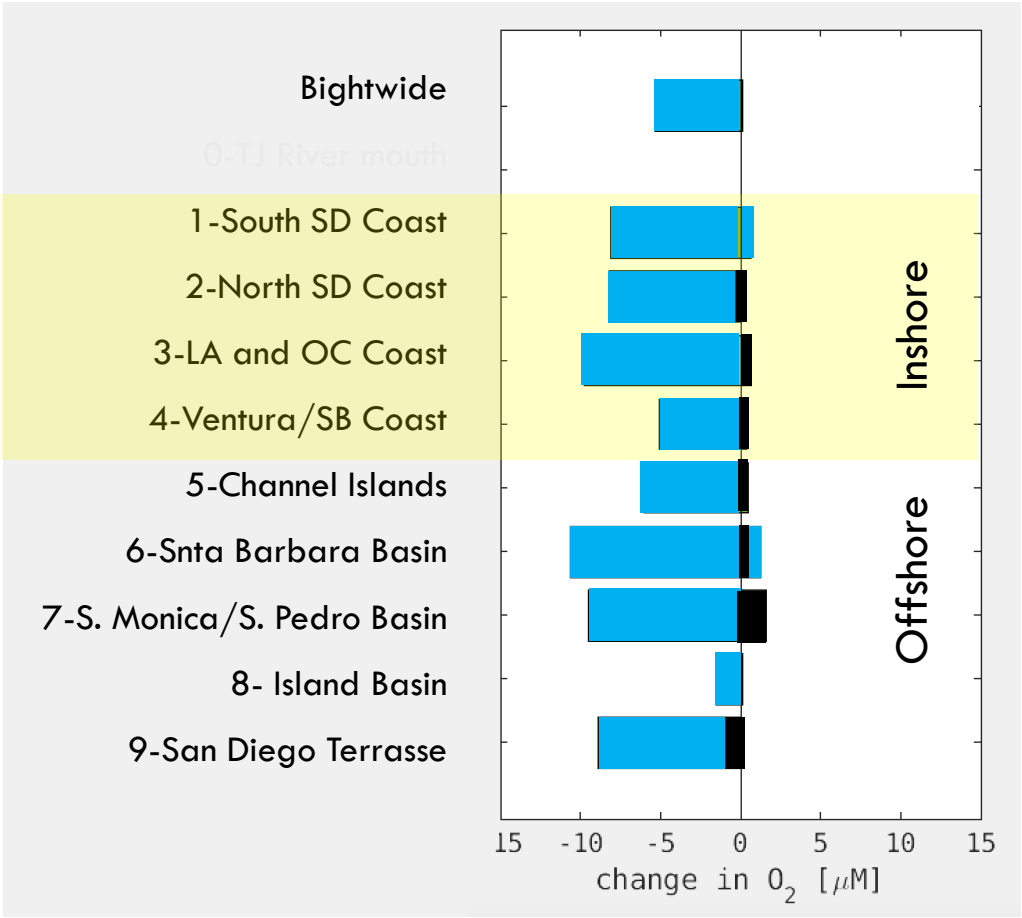
APPROACH TO ANSWER SECOND PART OF QUESTION 1
HOW MUCH OF THOSE EFFECTS ARE ANTHROPOGENIC, AND ATTRIBUTABLE TO SPECIFIC SOURCES?



ON AVERAGE, ACROSS THESE 9 SUBREGIONS, 98% OF THE pH AND O_2 LOSSES FROM LAND–BASED NUTRIENTS ARE ATTRIBUTABLE TO POINT SOURCES, BOTH INSHORE AND OFFSHORE

River NPS/Natural
Point sources

Change at subsurface = average 50-300m



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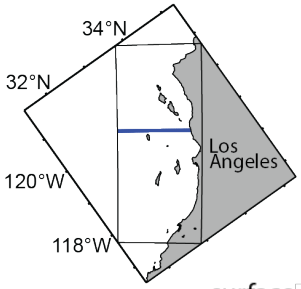
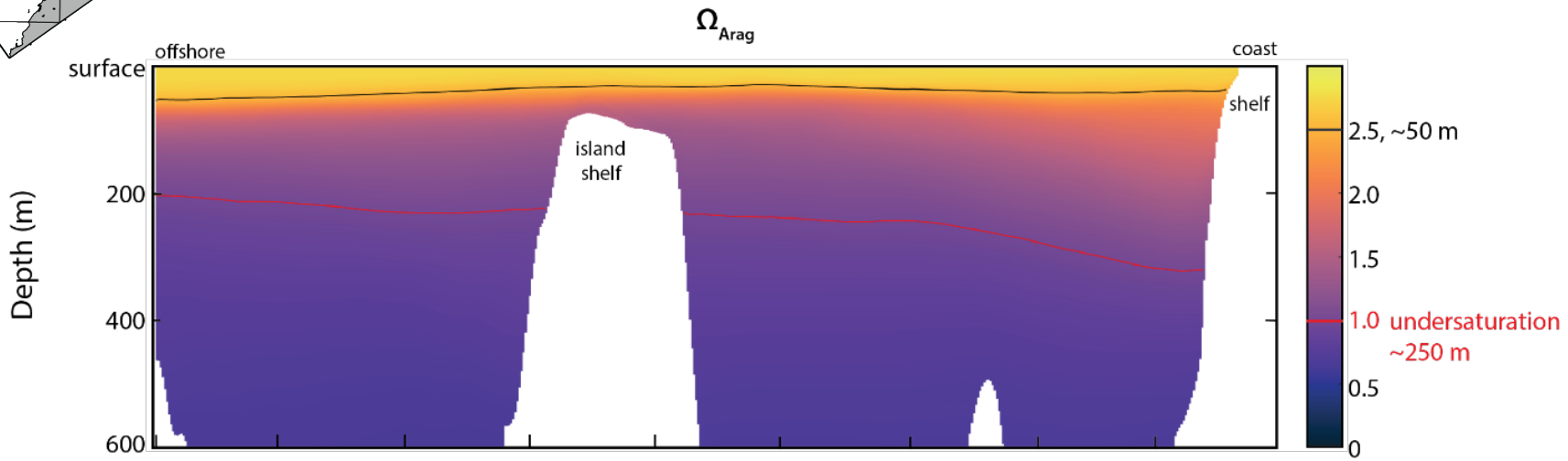
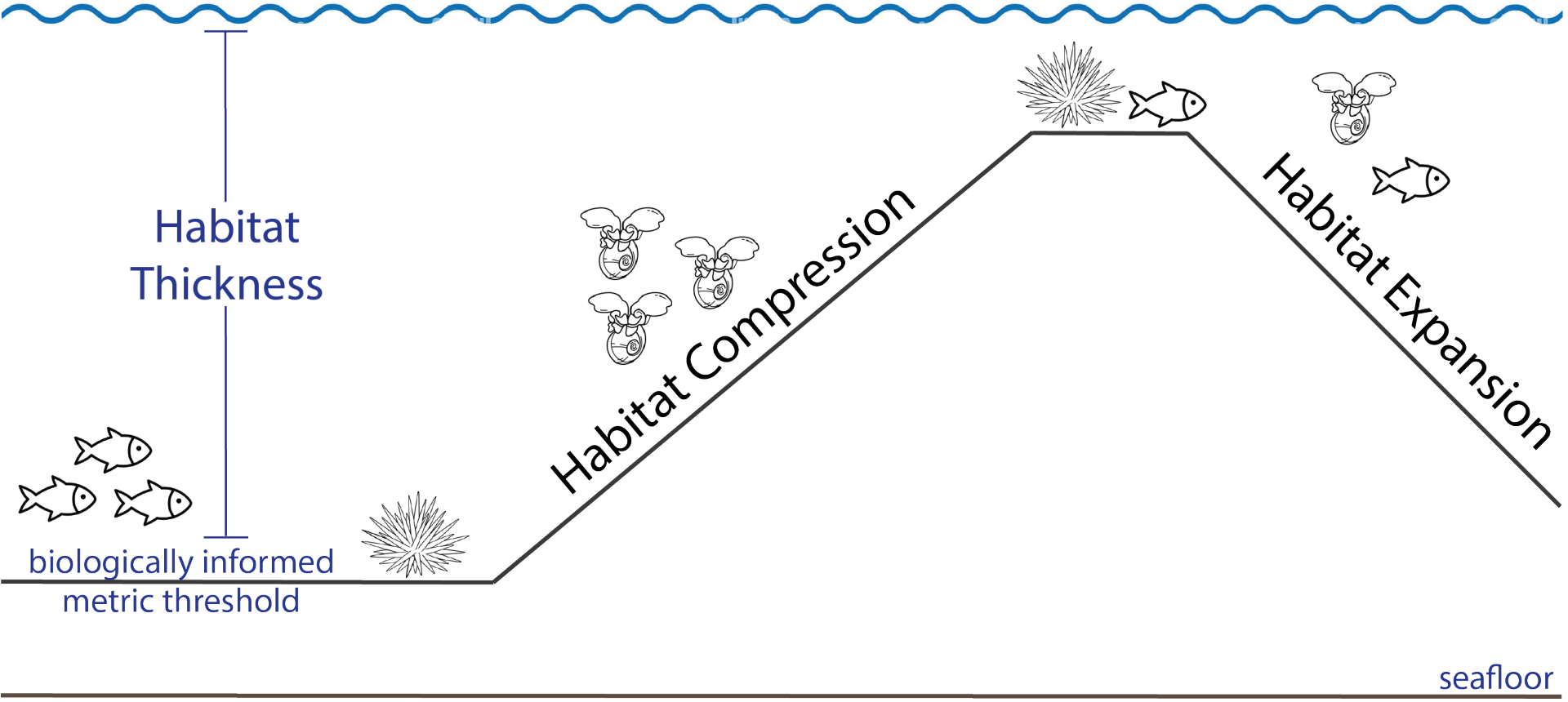
APPROACH NEEDS TO ACCOUNT FOR HOW OCEAN BECOMES LOW IN O_2 AND SATURATION STATE (Ω) WITH DEPTH

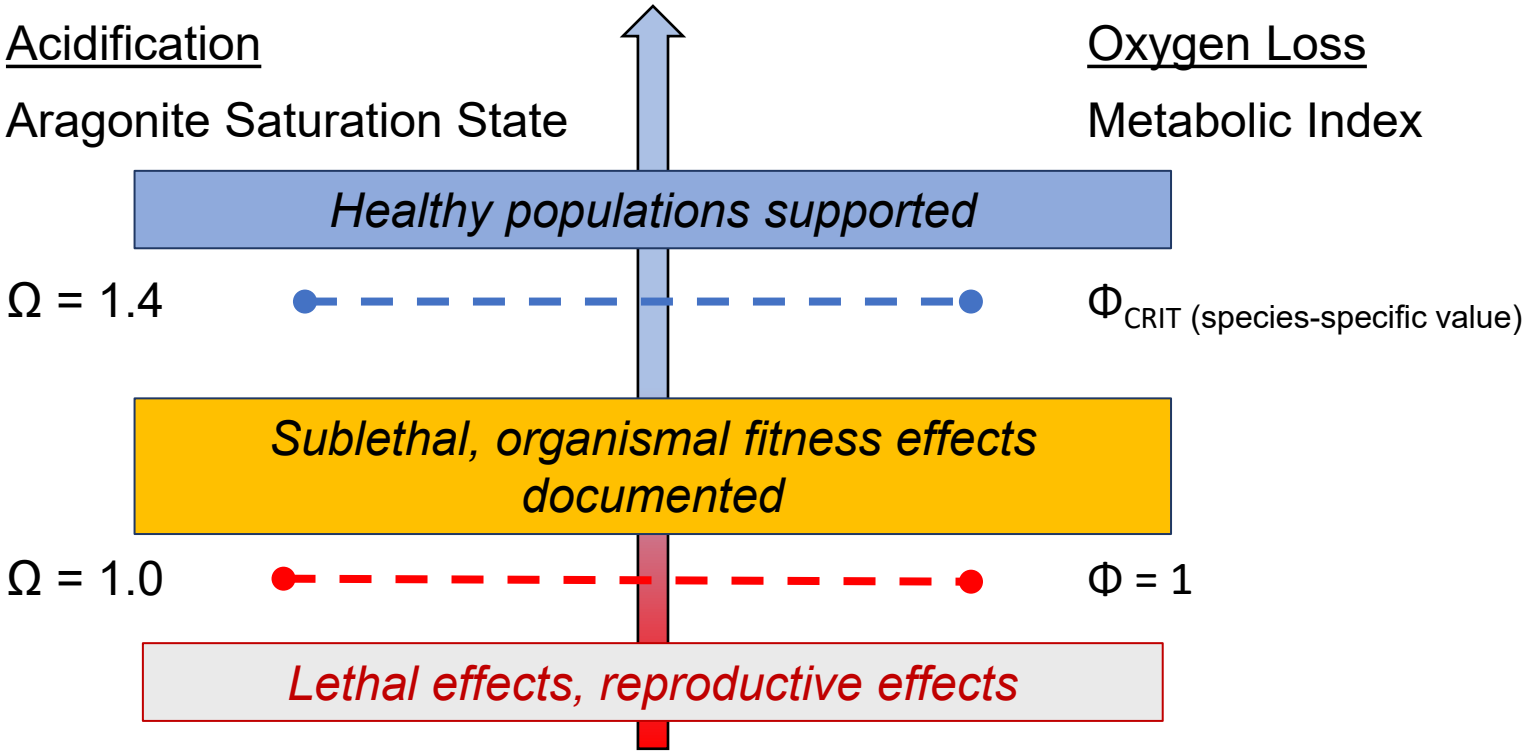




HOW DO WE ASSESS CHANGE IN HABITAT?



TO EVALUATE CHANGES IN HABITAT THICKNESS FOR PH AND O_2, WE USED TWO THRESHOLDS TO BRACKET EFFECTS



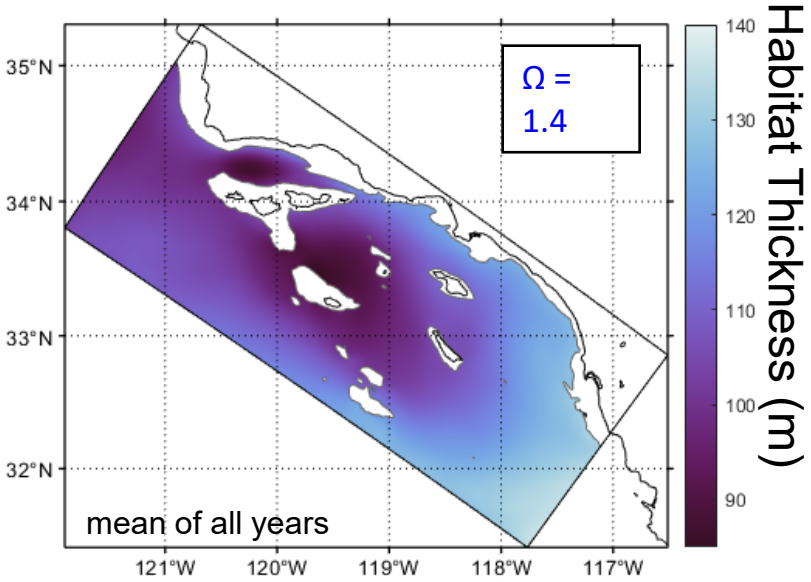
THE GOOD NEWS …

- Land-based nutrient inputs do not trigger lethal thresholds in upper surface waters of the Bight for O_2 or pH

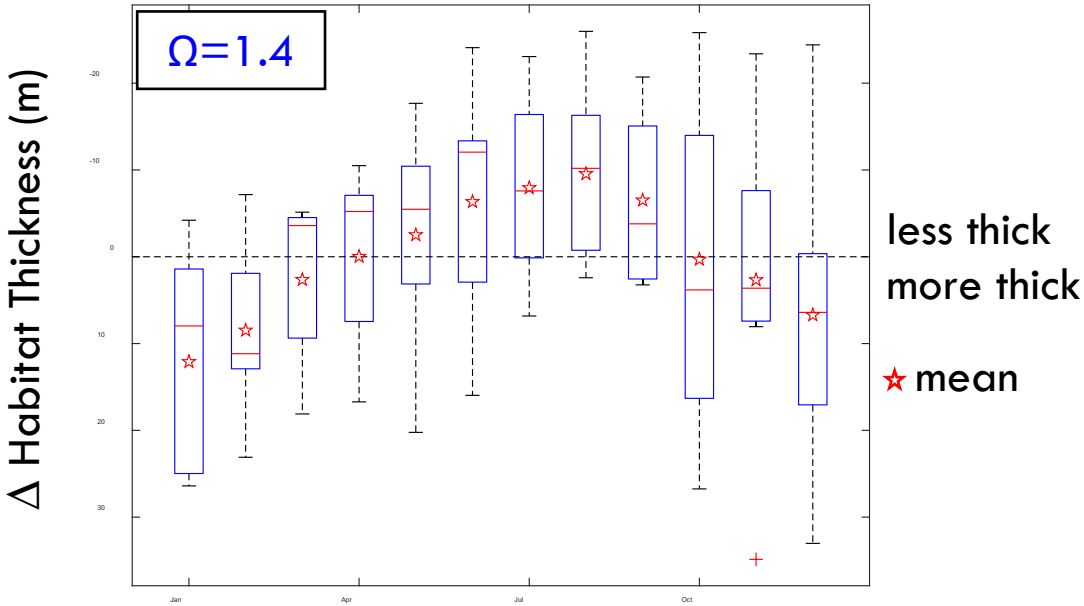
- Land-based nutrient inputs also do not cause “fitness-level” effects to habitat capacity for 9 months out of the year

ACROSS THE BIGHT, AVERAGE HABITAT THICKNESS IS 110 M FOR Ω = 1.4

- south-to-north gradient of ± 10 m (n = 602)
- coastal-to-offshore gradient of ± 5 m (n = 1412)
- interannual variability (n = 7 years)



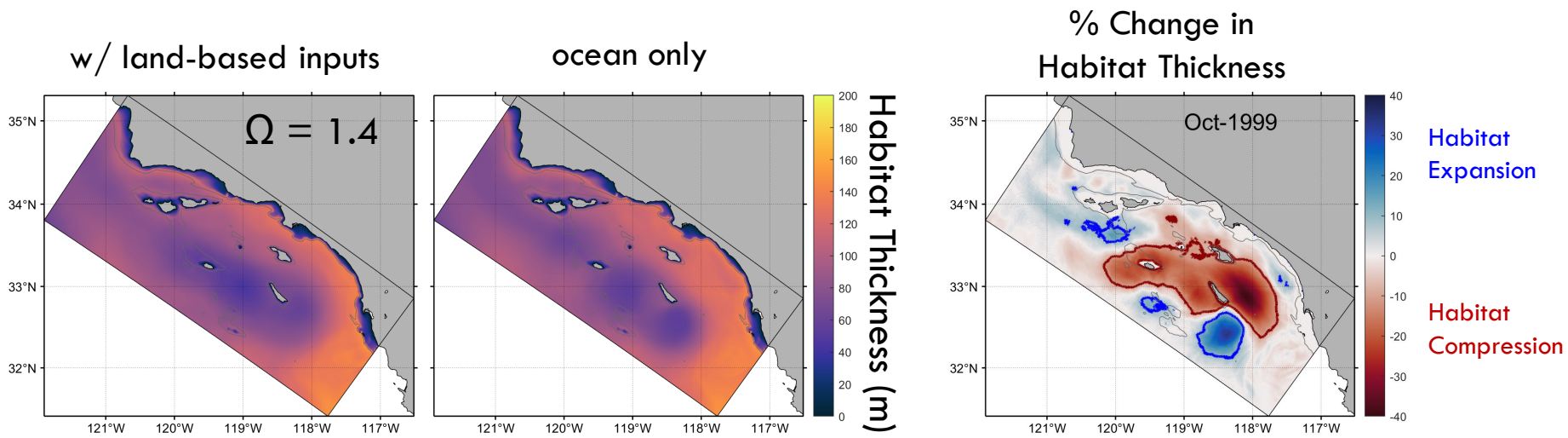
VERTICAL HABITAT THICKNESS VARIES SEASONALLY; LEAST THICK (MOST COMPRESSED) IN LATE SUMMER



Monthly values are detrended (annual mean removed).
Each boxplot represents 7 years of detrended monthly values.

DOES LAND-BASED NUTRIENT INPUTS EFFECT HABITAT THICKNESS?

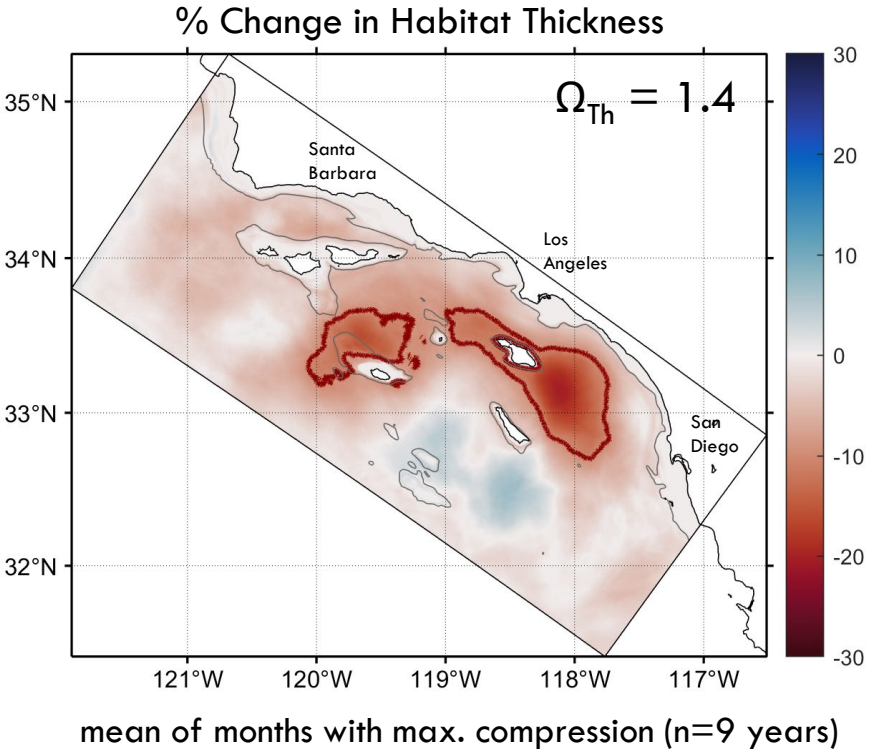
Approach: Assess areas with > ± 10% change in habitat thickness between simulation output with land-based nutrient inputs versus that without



9 years of output available to conduct this assessment

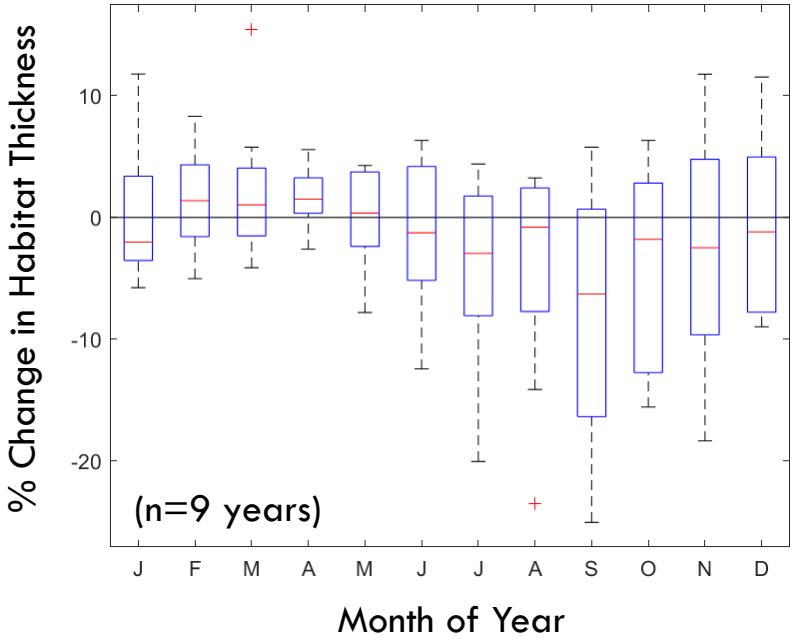
THE BAD NEWS…

- Habitat compression for shelled organisms extends across 25% of the Bight (19,000 km^2)
- Compression is recurrent in regions offshore of SD, OC, and LA Counties
- There's seasonality to compression events



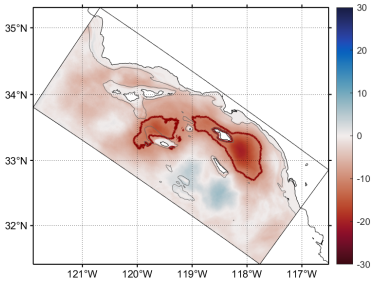
HABITAT COMPRESSION DRIVEN BY LAND-BASED NUTRIENTS LASTS ON THE ORDER OF 3 MONTHS

- Between late summer and winter
- Overlaps with seasonally least thick vertical habitat

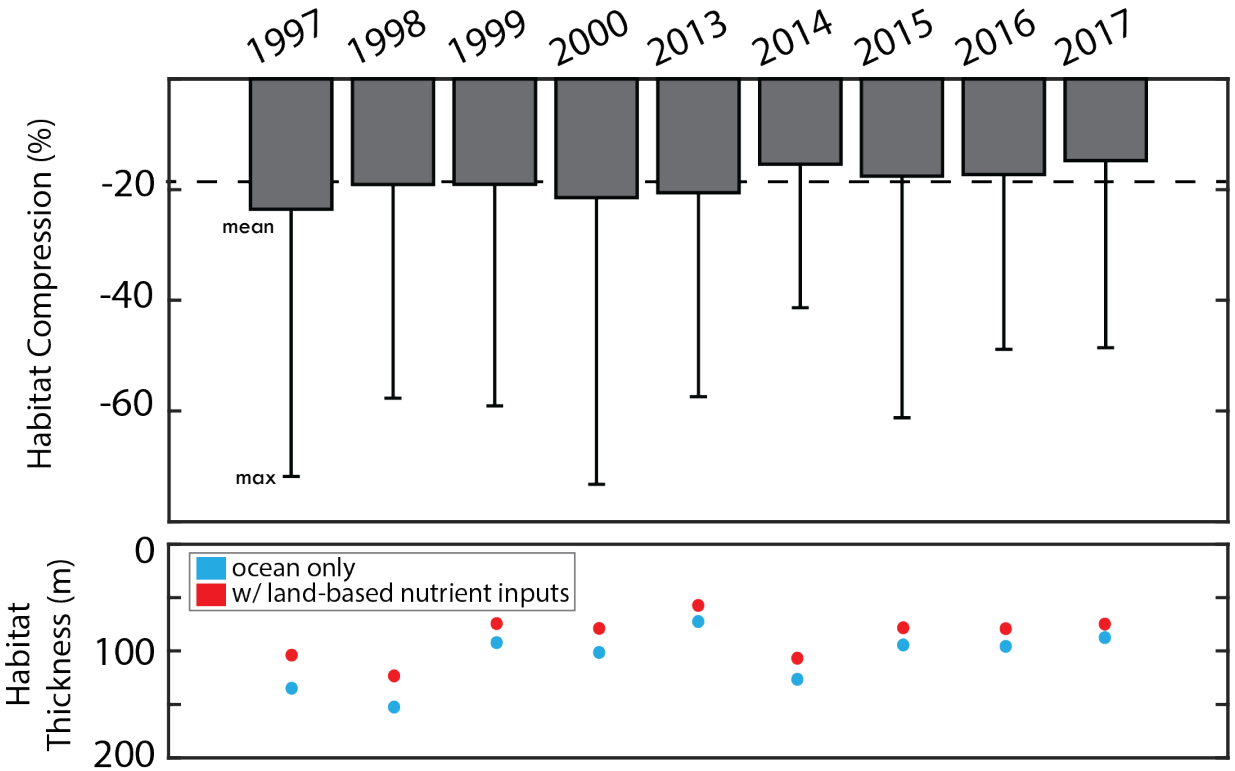


Habitat Expansion

Habitat Compression



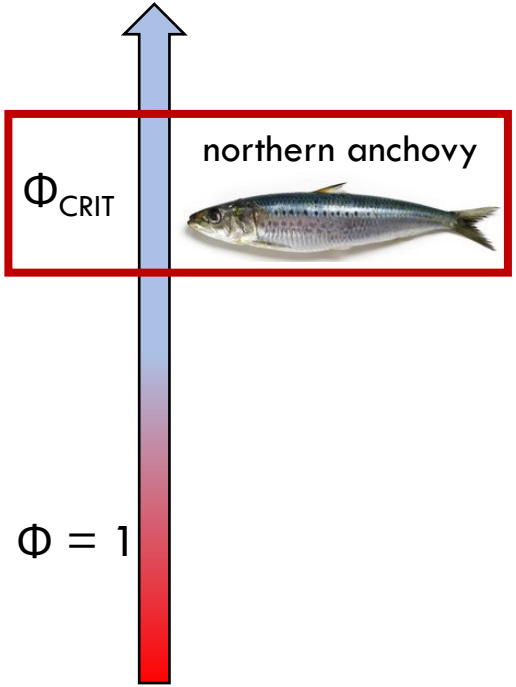
VERTICAL HABITAT COMPRESSION IS ON AVERAGE 20% (± 3%; 1 S.D.)

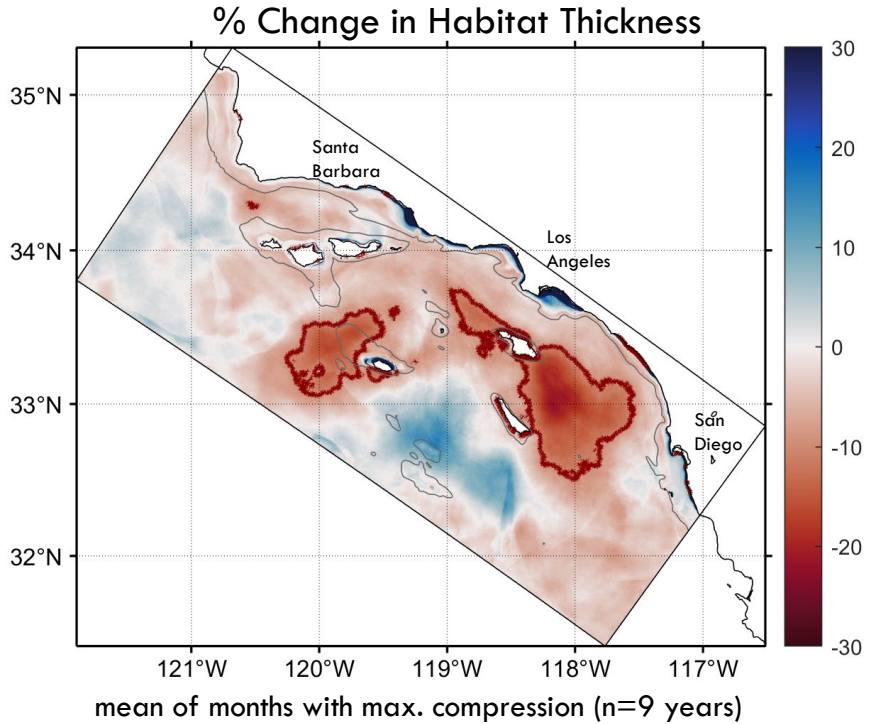


- Minimal variation among years

86 m
106 m

BAD NEWS CONTINUED …
VERY SIMILAR LEVEL OF HABITAT LOSS FOR NORTHERN ANCHOVY





- Habitat compression occurring in the same locales and at the same time of year

WHAT ARE THE BIOLOGICAL EFFECTS OF SUBSURFACE ACIDIFICATION AND OXYGEN LOSS FROM LAND-BASED NUTRIENTS IN THE BIGHT?

- Inputs do not trigger lethal thresholds in upper surface waters for O_2 or Ω, nor are there "fitness-level" effects to habitat thickness for 9 months out of the year
- During late summer for ~3 months, land-based nutrients are decreasing subsurface Ω and compressing vertical habitat across 25% of the Bight in upper surface waters
  - Answer is similar for aerobic habitat for Anchovy
- Very little habitat loss in the nearshore
  - It occurs recurrently offshore of San Diego, Orange, and LA Counties
- This assessment is for upper surface waters (0-200 m)
  - We will continue to look at effects in waters > 200-m deep and conditions at the seafloor