

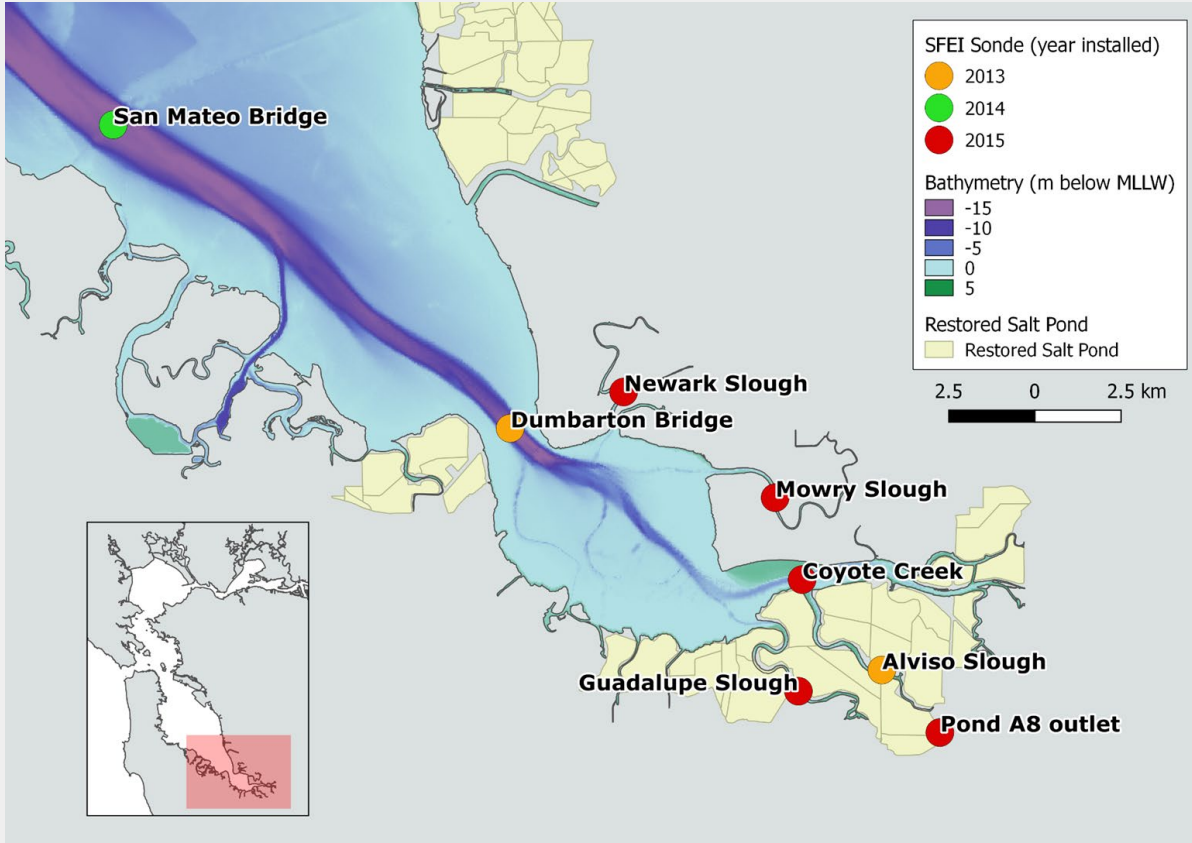
Determining protective dissolved oxygen levels in SF Bay sloughs

A scenic view of the Golden Gate Bridge in San Francisco, California, spanning across the water. In the foreground, a wooden pier extends into the blue water. The sky is clear and blue, and the bridge's iconic red towers and suspension cables are prominent.

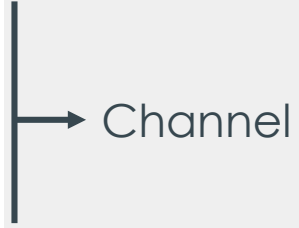
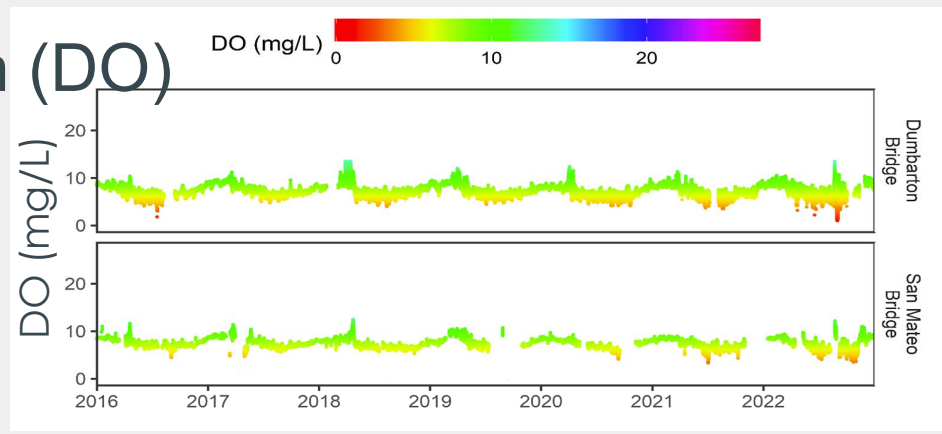
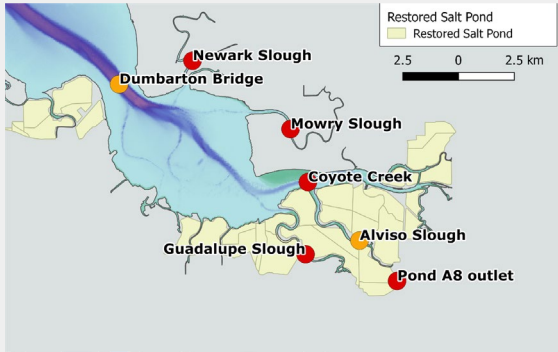
**Ariella Chelsky, Evan Howard, Levi Lewis,
Martha Sultula, Dan Killam, David Senn**

RMP Annual Meeting, October 2023

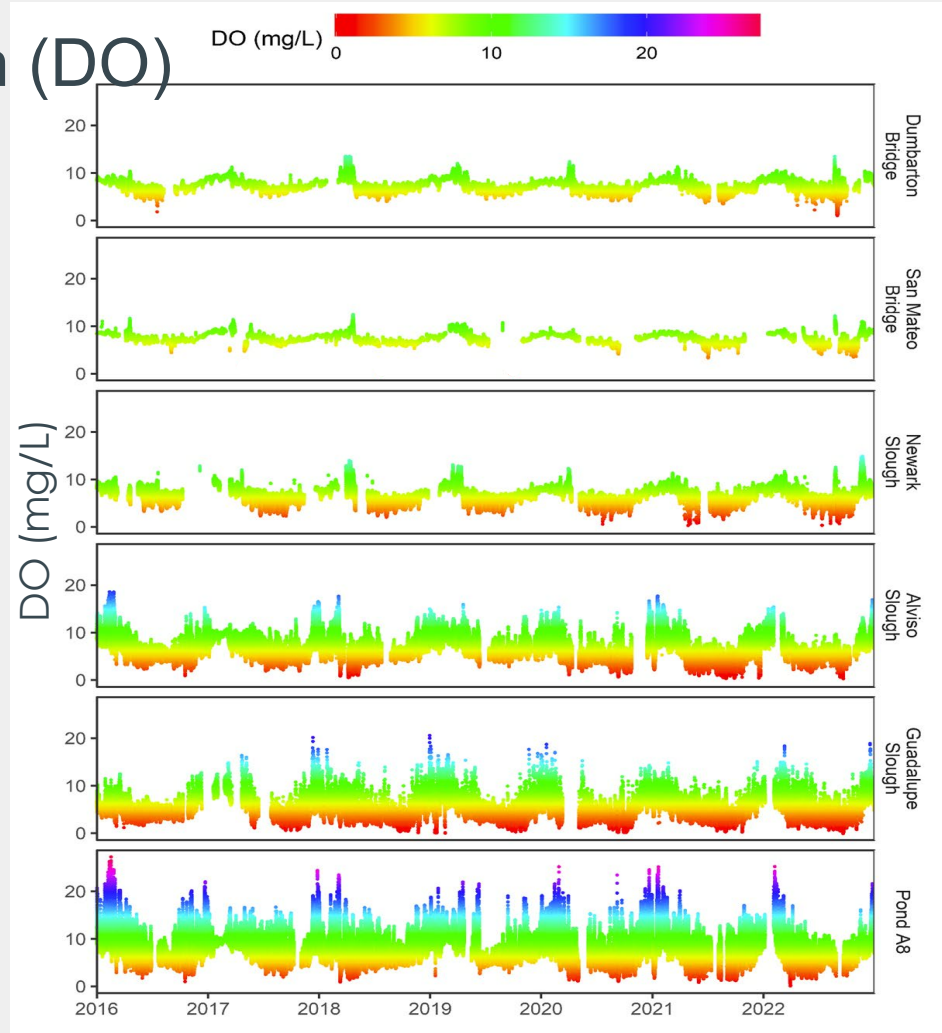
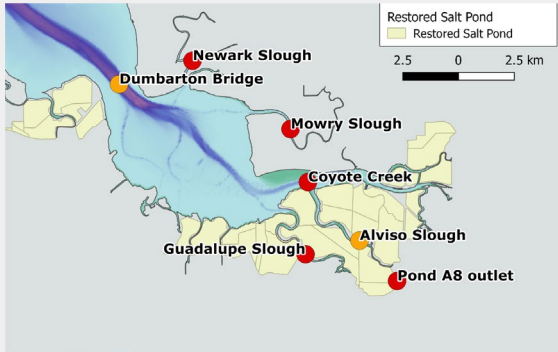
Lower South Bay Monitoring



Low dissolved oxygen (DO) in Slough Habitats



Low dissolved oxygen (DO) in Slough Habitats



Channel

Sloughs

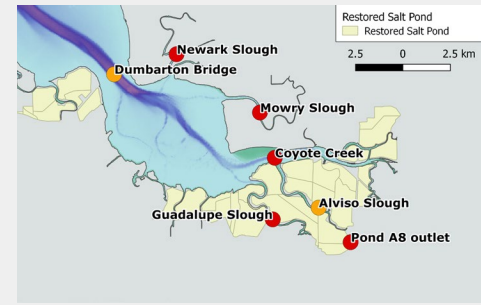
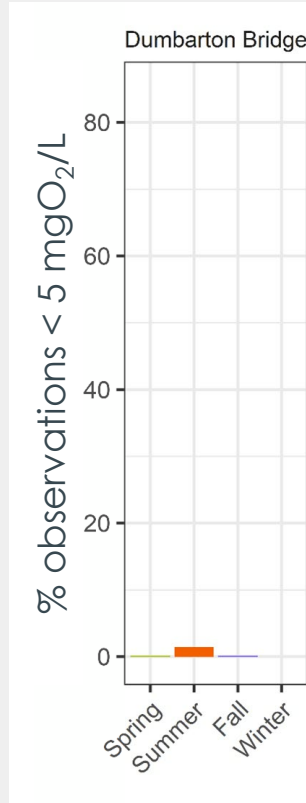


Dissolved Oxygen Objectives for SF Bay

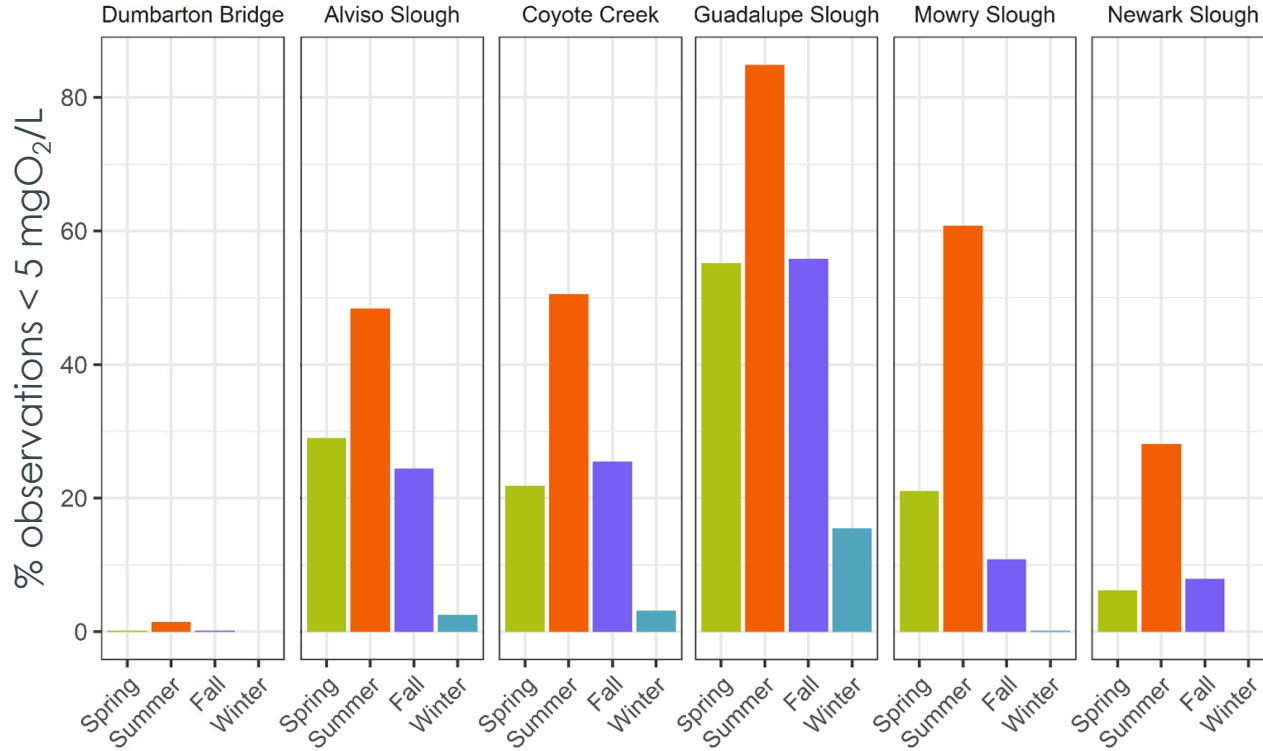
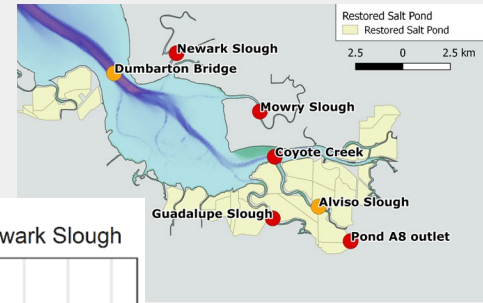
Indicator	Temporal Integration Method	Threshold by Region			
		North of Carquinez Br.	North/Central Bay	South Bay	Lower South Bay
DO (mg L ⁻¹)	none	7.0	5.0	5.0	5.0
DO (%sat)	3-month rolling median	80%	80%	80%	80%



Low DO in Slough Habitats



Low DO in Slough Habitats



Assessment Framework in LSB Sloughs and Tidal Creeks

- Develop thresholds/tools/models that delimit oxygen conditions that are protective of aquatic life in LSB sloughs and tidal creeks.
- Assess protective dissolved oxygen thresholds under future conditions.



Virginia Province
Approach

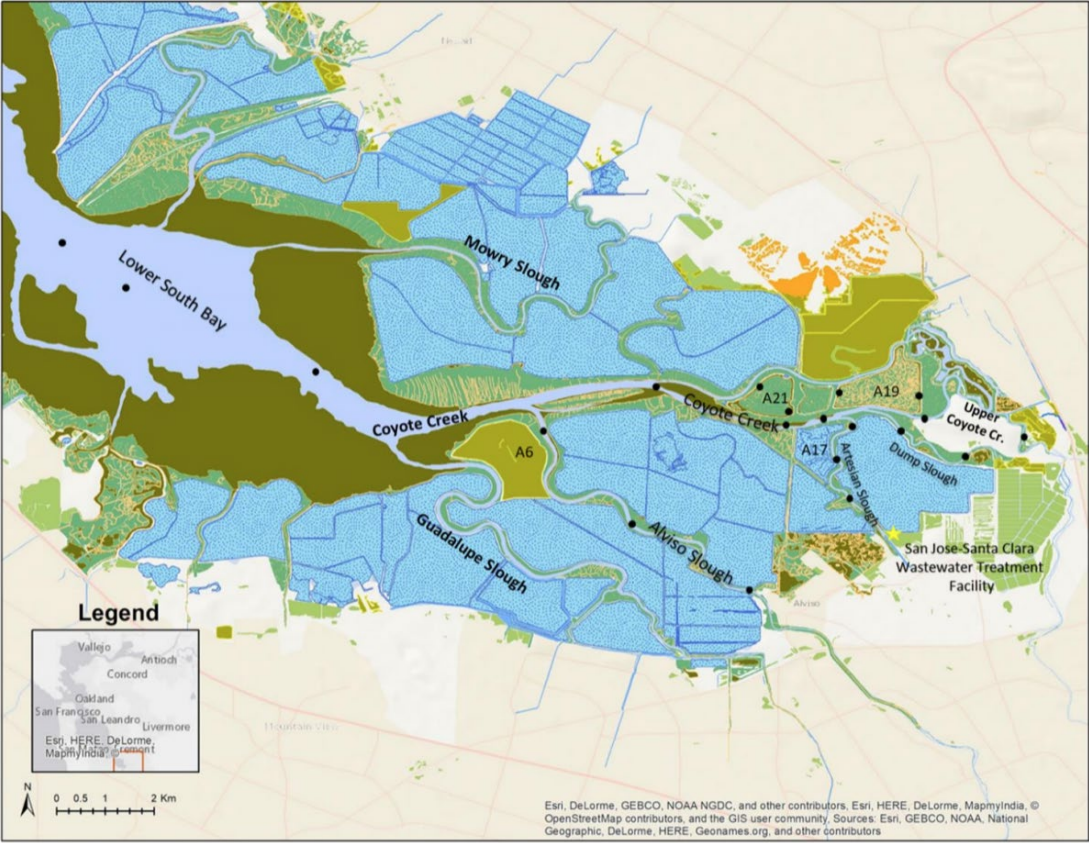
Protective DO

Metabolic Index

Fish Community
Models



Fish Community Sampling



Virginia Province Approach

Determine relevant
species



Virginia Province Approach

Determine relevant species



Compile existing data on tolerance to low DO



Virginia Province Approach

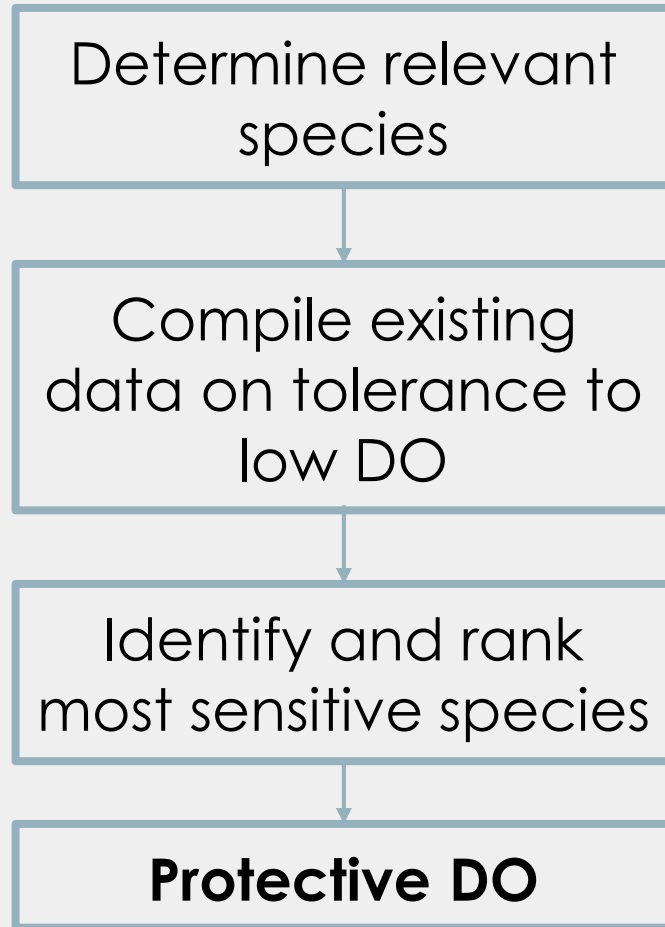
Determine relevant species

Compile existing data on tolerance to low DO

Identify and rank most sensitive species



Virginia Province Approach



Acute Thresholds

Genera with most sensitive acute values		Value (DO mg/L)
With Sturgeon	<i>Clupea (herring)</i>	3.7
	<i>Poecilia (mosquito fish)</i>	
	<i>Fundulus (killifish)</i>	
	<i>Acipenser (sturgeon)</i>	
Without Sturgeon	<i>Clupea (herring)</i>	3.8
	<i>Poecilia (mosquito fish)</i>	
	<i>Fundulus (killifish)</i>	
	<i>Harengula (sardine)</i>	

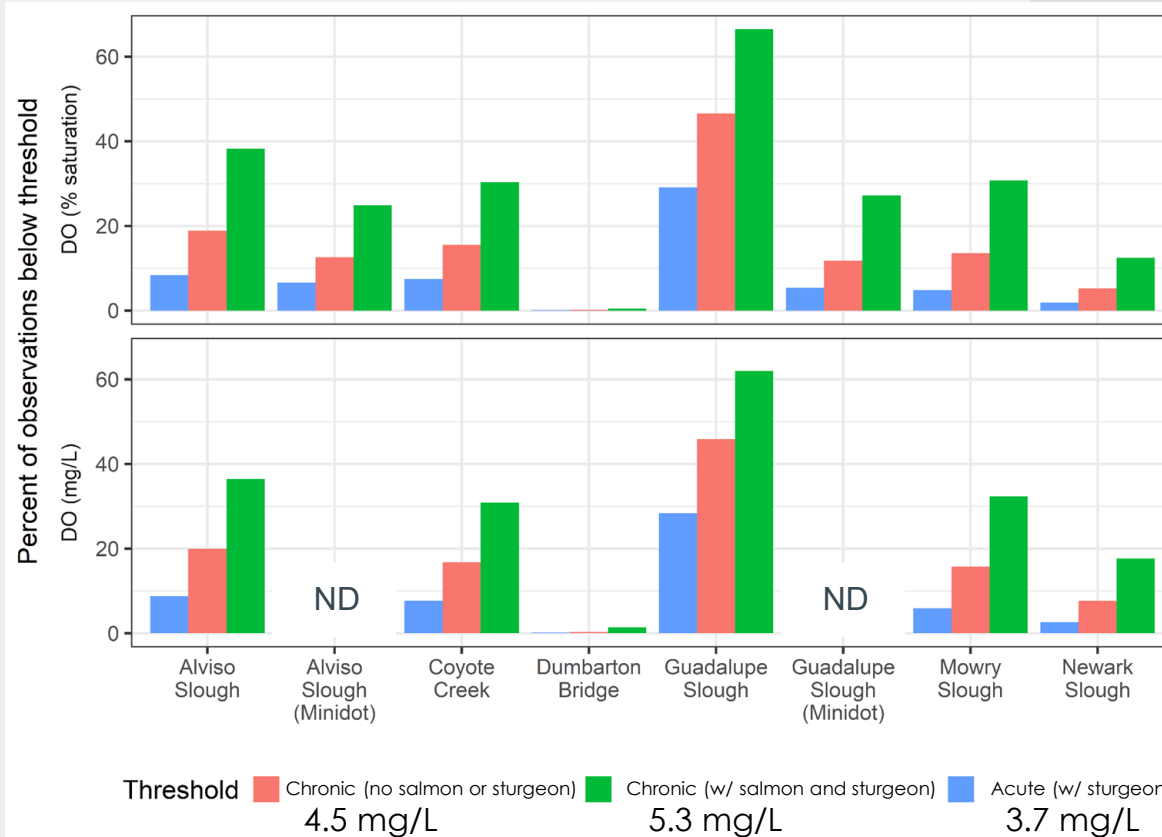
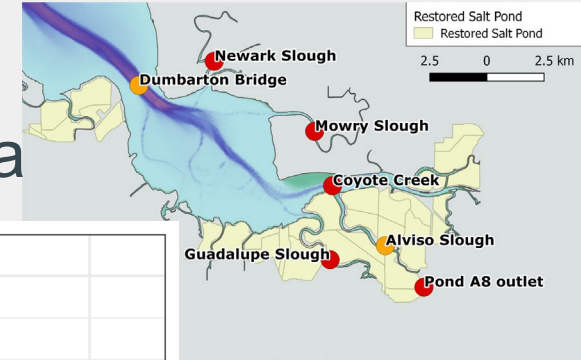


Chronic Thresholds

Genera with most sensitive chronic values		Value (DO mg/L)
With Sturgeon and Salmonids	<i>Oncorhynchus (salmonids)</i>	5.3
	<i>Libinia (spider crab)</i>	
	<i>Acipenser (sturgeon)</i>	
	<i>Paralichthys (flounder)</i>	
Without Sturgeon and Salmonids	<i>Libinia (spider crab)</i>	4.5
	<i>Paralichthys (flounder)</i>	
	<i>Menidia (silverside)</i>	
	<i>Mercenaria (clams)</i>	



Frequency of Exceedances of VPA Criteria



Metabolic Index

Compile experimental data of tolerance to low DO or field abundance & environmental data



Metabolic Index

Compile experimental data of tolerance to low DO or field abundance & environmental data

Determine temp dependence of species' oxygen supply and metabolic demand



Metabolic Index

Compile experimental data of tolerance to low DO or field abundance & environmental data

Determine temp dependence of species' oxygen supply and metabolic demand

DO required to support ecological activity at in situ temps



Metabolic Index

Compile experimental data of tolerance to low DO or field abundance & environmental data

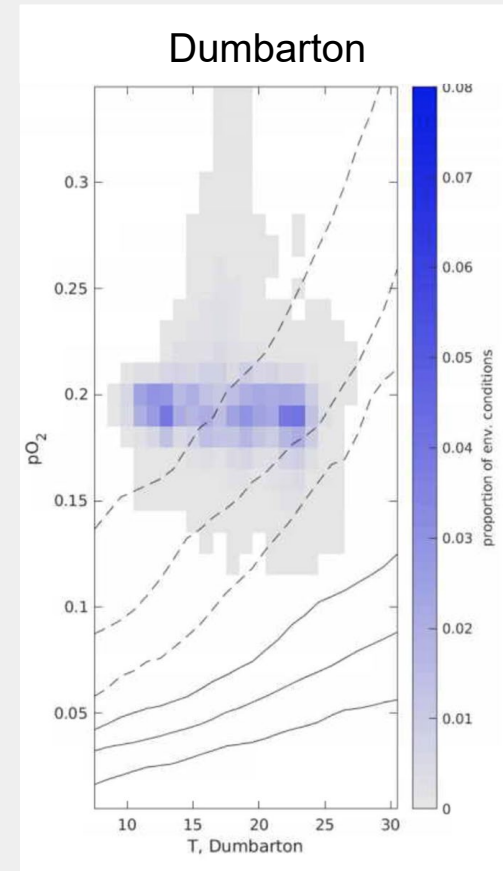
Determine temp dependence of species' oxygen supply and metabolic demand

DO required to support ecological activity at in situ temps

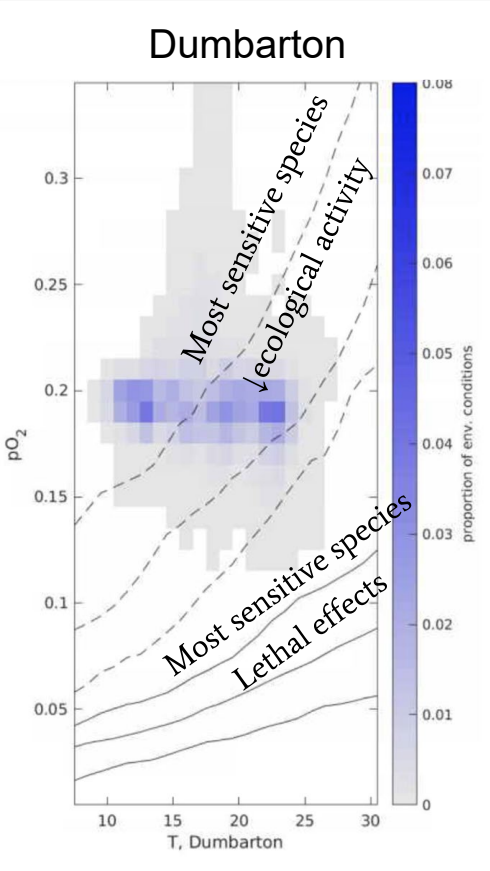
Protective DO



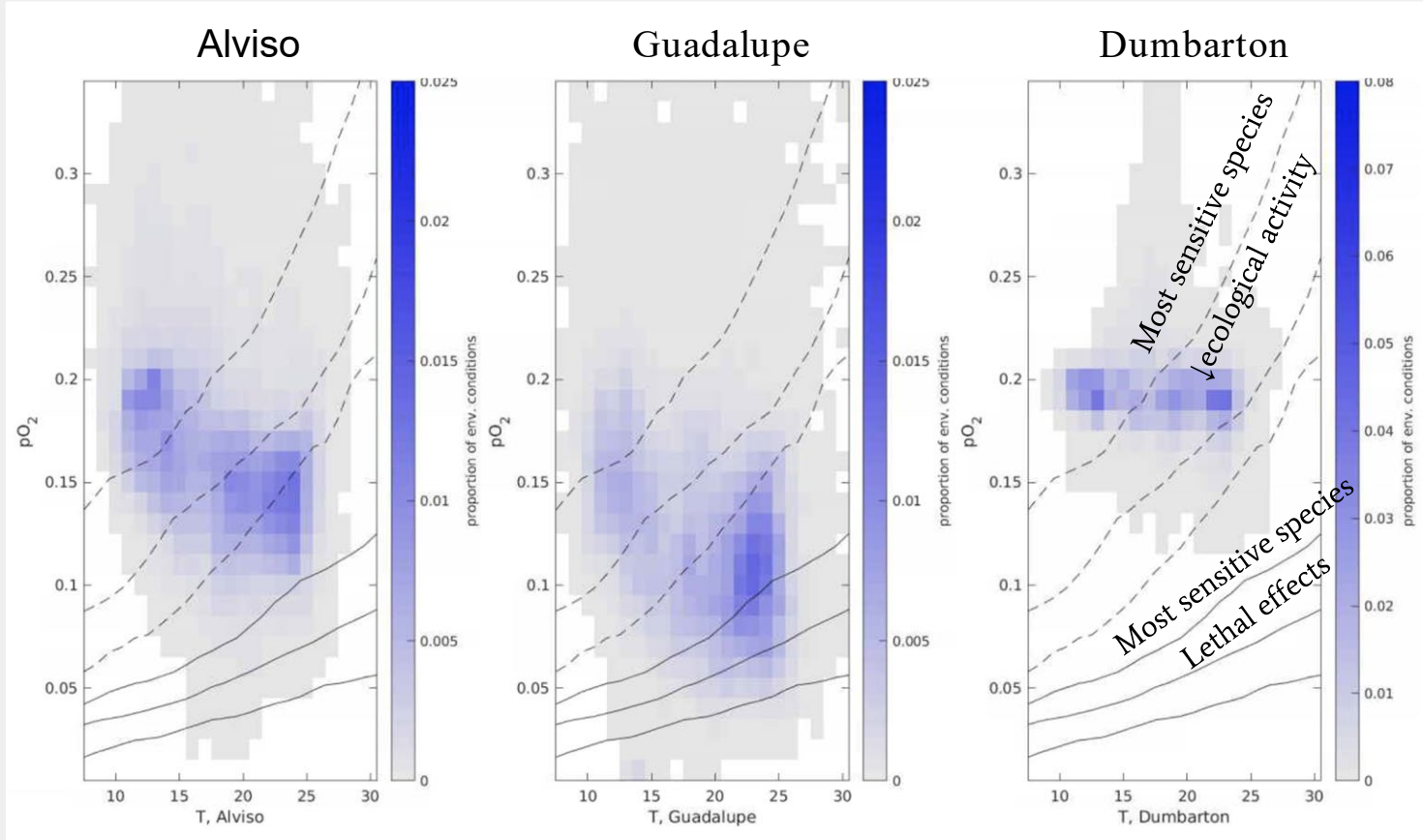
Metabolic Index Conditions in Lower South Bay



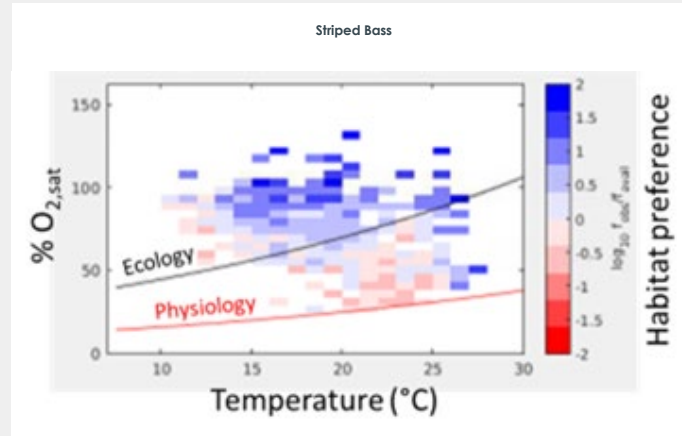
Metabolic Index Conditions in Lower South Bay



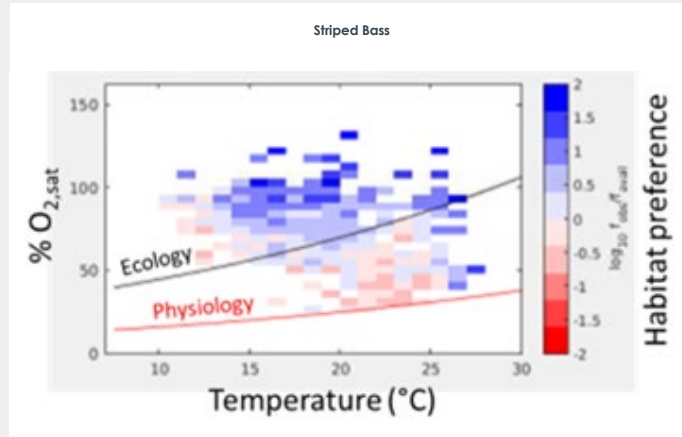
Metabolic Index Conditions in Lower South Bay



Metabolic Index Oxygen and Temperature Preference



Metabolic Index Oxygen and Temperature Preference



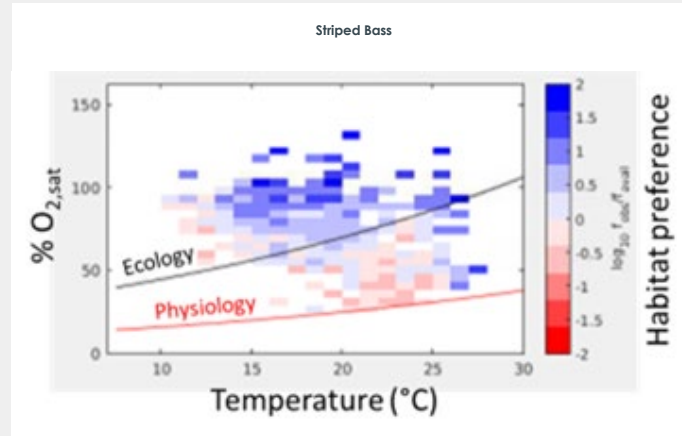
Fish distributions are consistent with oxygen sensitivity

→ Animals are disproportionately present in higher O₂ conditions

→ In general, a 'preference' for >50% O₂ sat (~4-5 mg O₂/L)

Some patterns consistent with temperature dependence of O₂ threshold

Metabolic Index Oxygen and Temperature Preference



Fish distributions are consistent with oxygen sensitivity

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Some patterns consistent with temperature dependence of O₂ threshold

Metabolic Index Findings To-Date

- DO concentrations occasionally dip below published lethal thresholds in LSB sloughs and often go below ecological thresholds
- Fish distributions in LSB are consistent with oxygen sensitivity, and oxygen thresholds appear to be temperature dependent
- Difficult to determine species-specific temperature-dependent hypoxia traits from LSB biogeography data
- Patterns in temperature-dependent hypoxia thresholds are relatively consistent across marine species and could be used to support the analysis



Fish Community
Models

Existing biota data and
targeted surveys



Fish Community Models

Existing biota data and targeted surveys

Analysis with generalized additive models (GAMs)



Fish Community Models

Existing biota data and targeted surveys

Analysis with generalized additive models (GAMs)

Model biota responses to environmental variation



Fish Community Models

Existing biota data and targeted surveys

Analysis with generalized additive models (GAMs)

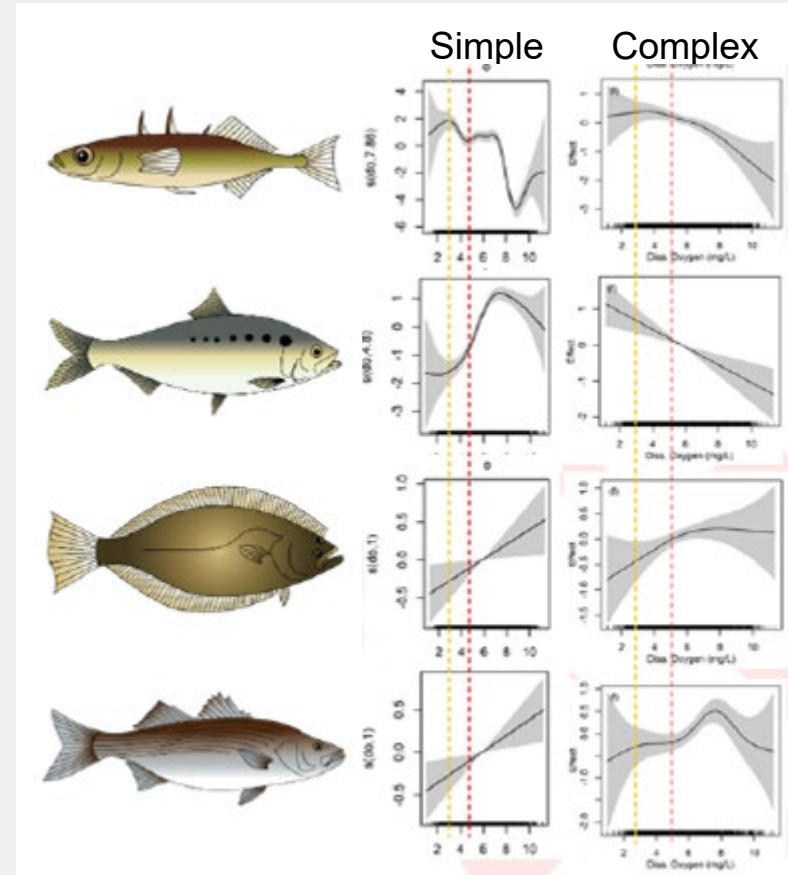
Model biota responses to environmental variation

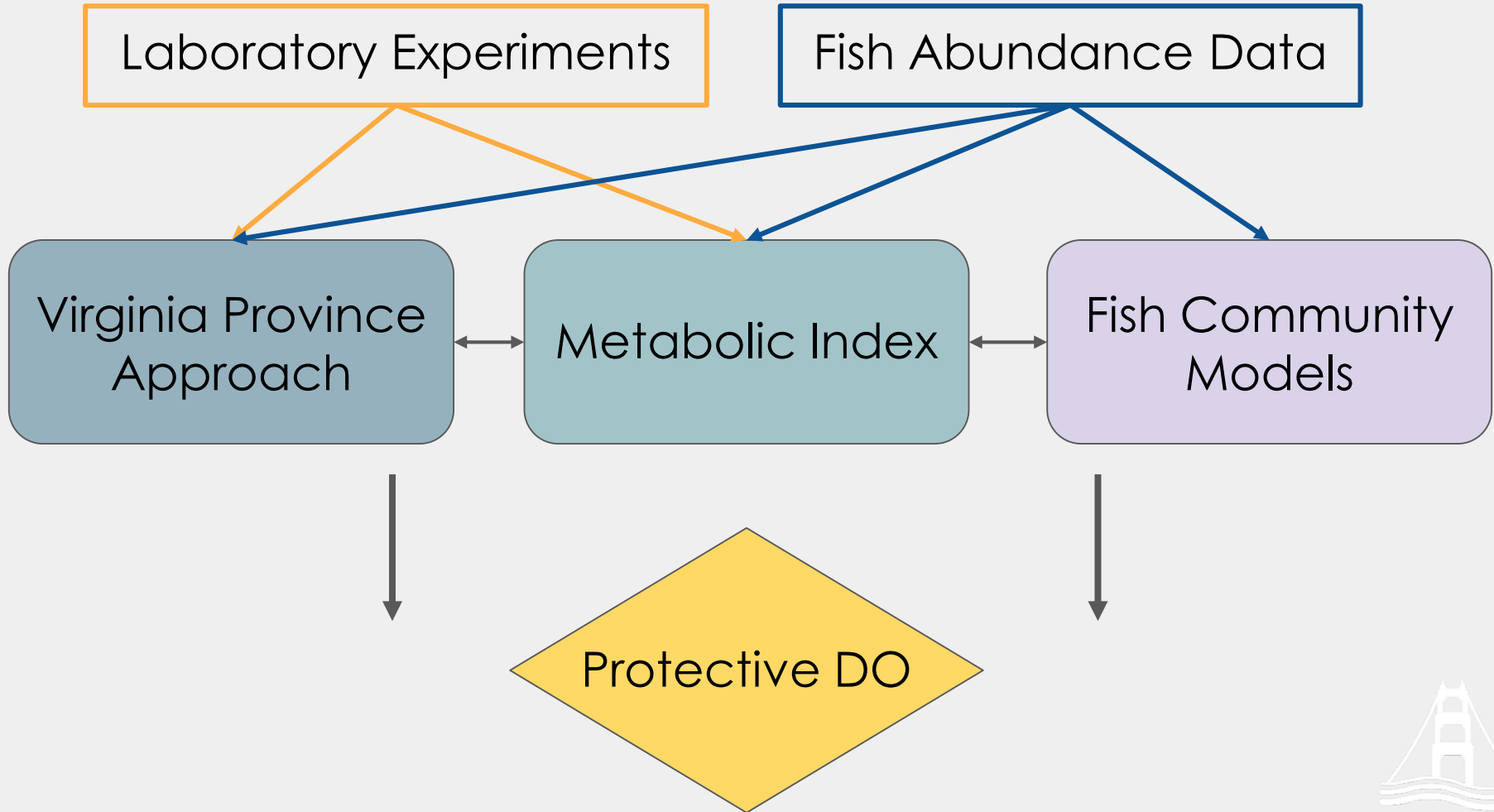
Protective DO



Fish Community Models

- Models accounted for 60-70% of deviance in abundance patterns of each species
- Variation in fish abundance occurred in space and time (regions, seasons, and years) and with environmental conditions
- Model performance increases with more complex models, however, simple vs. complex models exhibited different responses for some species





Key Takeaways

- Dissolved oxygen levels in Lower South Bay sloughs frequently fall below the 5 mg/L Basin Plan objectives
- Study goal is to investigate what constitutes protective DO levels using multiple lines of evidence
- Draft chronic and acute criteria were developed using the Virginia Province Approach
- Other mechanistic and empirical analyses could be powerful for validating and informing the VPA



Collaborators/Experts

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Martha Sutula, SCCWRP

Sujoy Roy, Tetra Tech

Jerry Diamond, Tetra Tech

Alexis Walls, Tetra Tech

Perry de Valpine, UC Berkeley

Jim Hagy, EPA

Peter Tango, USGS

Christina Frieder, SCCWRP



More Information

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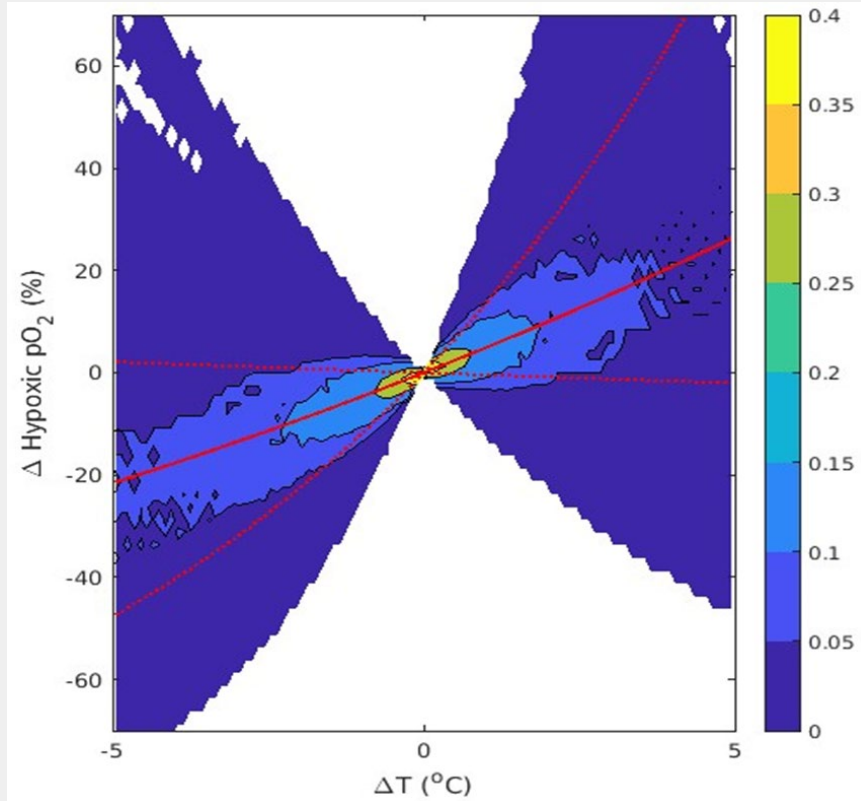
Explore data using Shiny app: sfeinms.shinyapps.io/LSB_AF

→ Created by Dan Killam, SFEI

View past reports at: sfbaynutrients.sfei.org



Metabolic Index Global Hypoxia Thresholds with Temperature



Takeaway: patterns in temperature dependent hypoxia thresholds are relatively consistent across marine species