Apr 30th, 3:30 PM - 5:00 PM

Is hypoxia's influence restricted to the deep? Evaluation of nearshore community composition in Hood Canal, Washington, a seasonally hypoxic estuary

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Is hypoxia restricted to the deep?

Spatial & temporal variation in nearshore community structure in a seasonally hypoxic estuary

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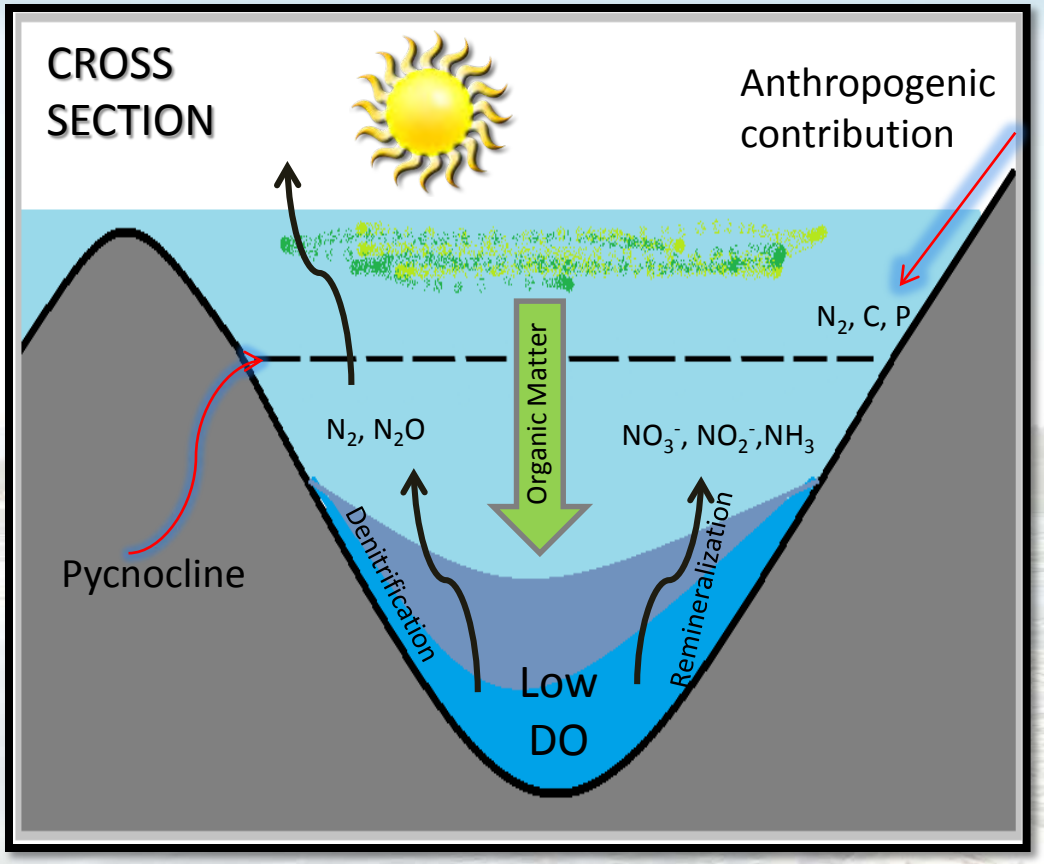
Salish Sea Ecosystem Conference 2014

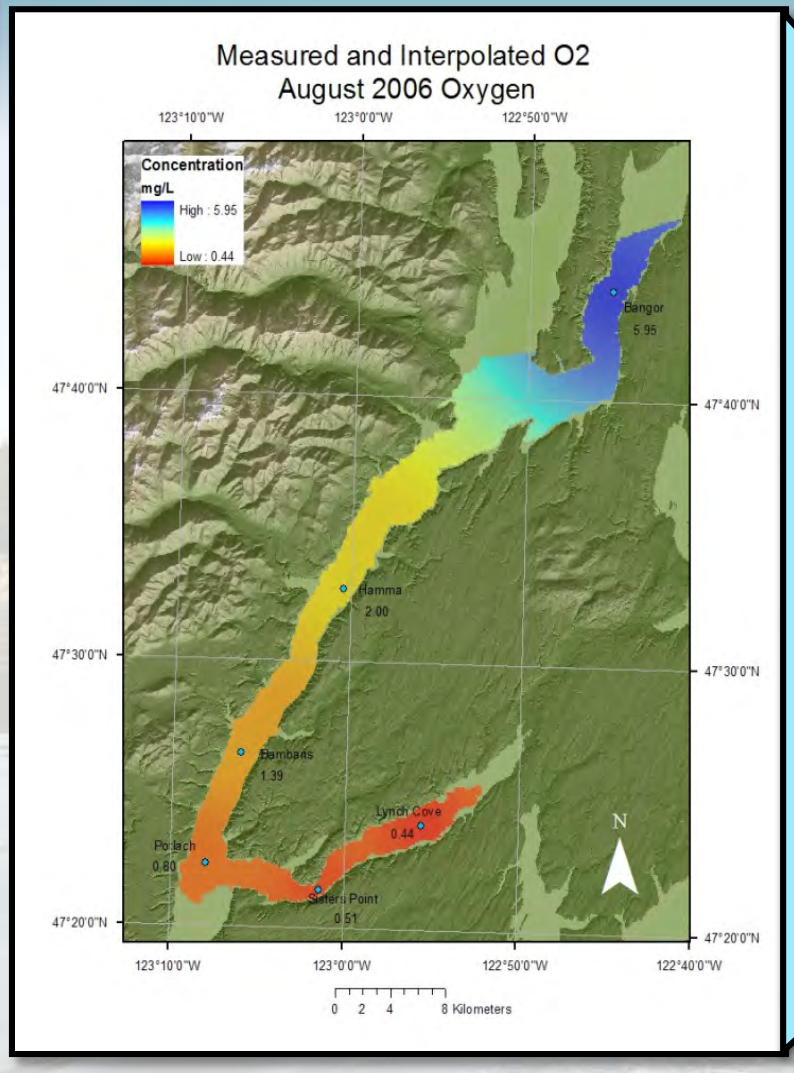
Hypoxia

- Dissolved oxygen concentration "<2mg L^{-1}"
- Worldwide
- Pulse disturbance
- Anthropogenic



Diaz (2001); Diaz and Rosenberg (2008)

Hood Canal, Washington

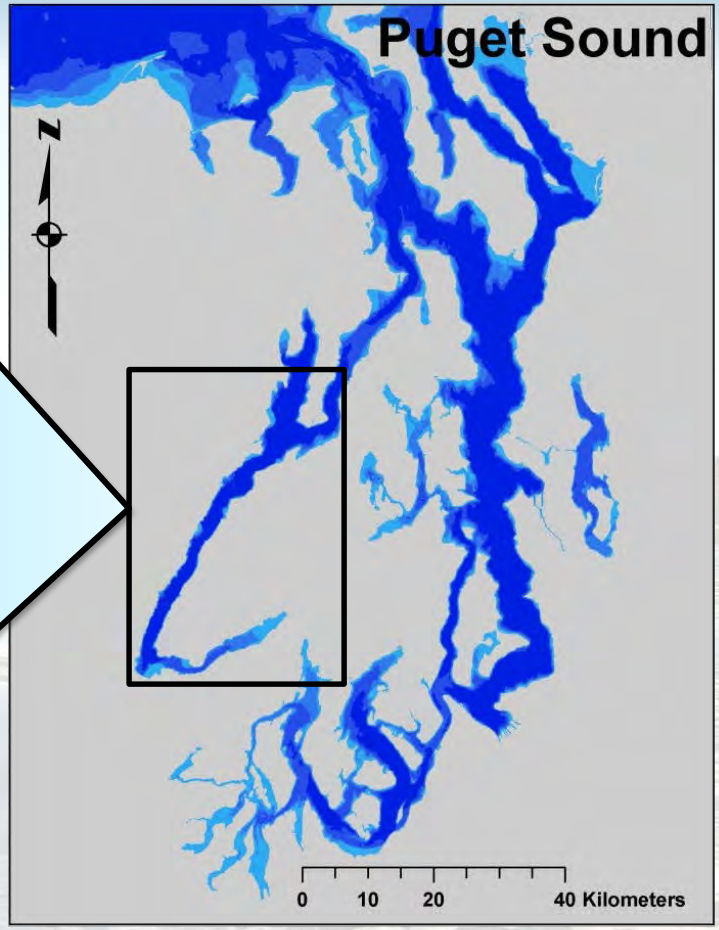


Seasonal hypoxia

High productivity

Slow turnover

Deep bathymetry



http://www.hoodcanal.washington.edu/documents/

Newton et al.(1995)

Biological Impacts

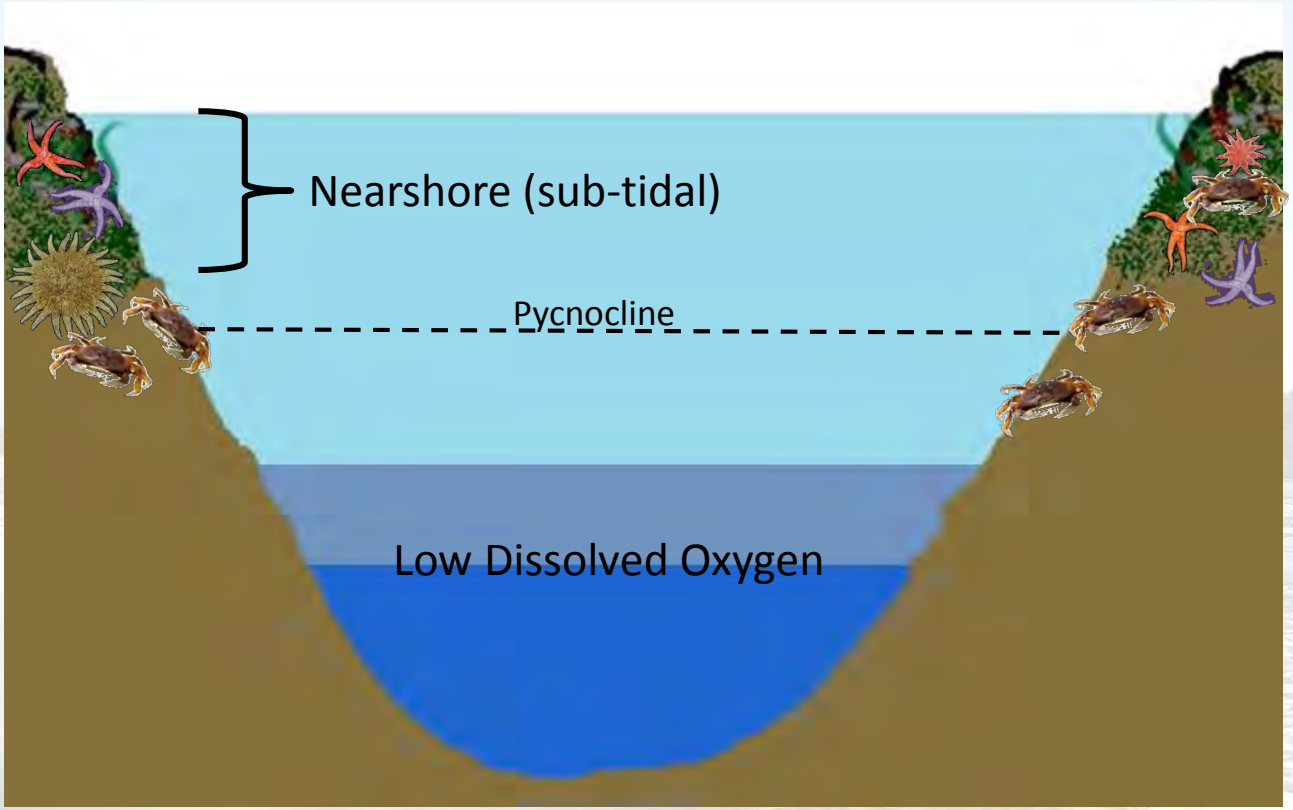
1. Mortality

2. **Sub-lethal effects**

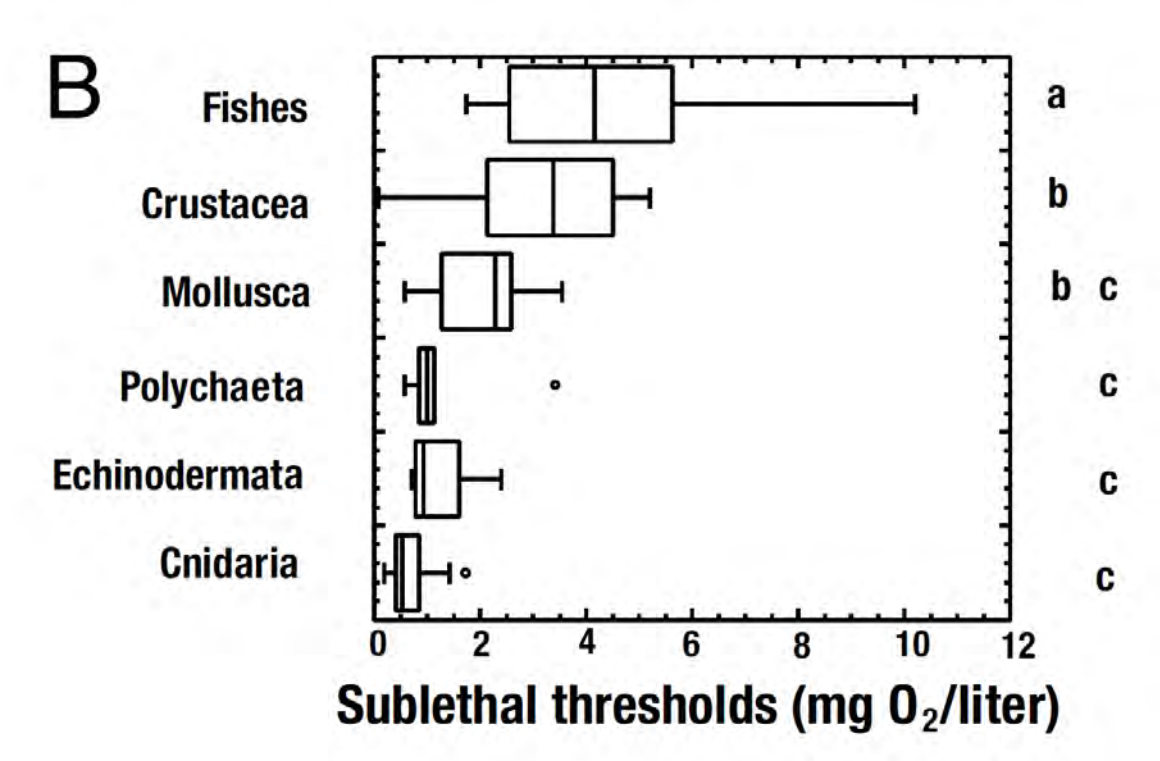
Hypoxic influence on the nearshore community?

Nearshore

- High productivity
- Nursery habitat
- Closer to human influence



Physiological driven patterns



Vaquer-sunyer and Duarte (2008)

Questions

1. Are there more hypoxia tolerant invertebrates and fewer fish species in the south?

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2. Does the southern community change temporally with the onset of hypoxia?

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3. Is dissolved oxygen (DO) a main predictor for species presence and absence?

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2. Does the southern community change temporally with the onset of hypoxia?

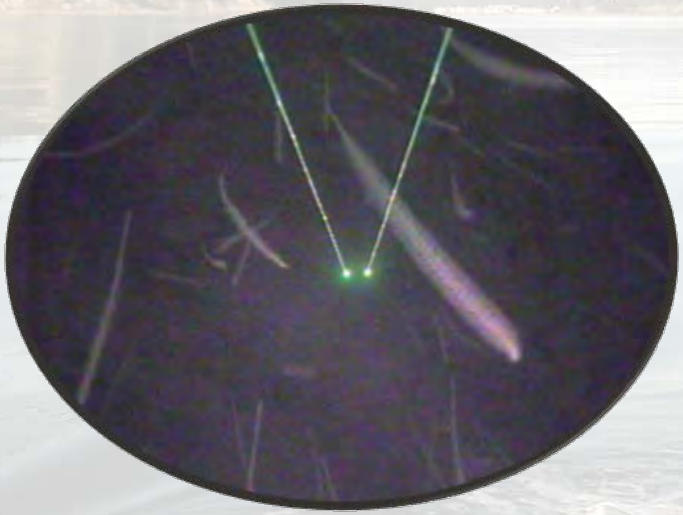
3. Is dissolved oxygen (DO) a main predictor for species presence and absence?

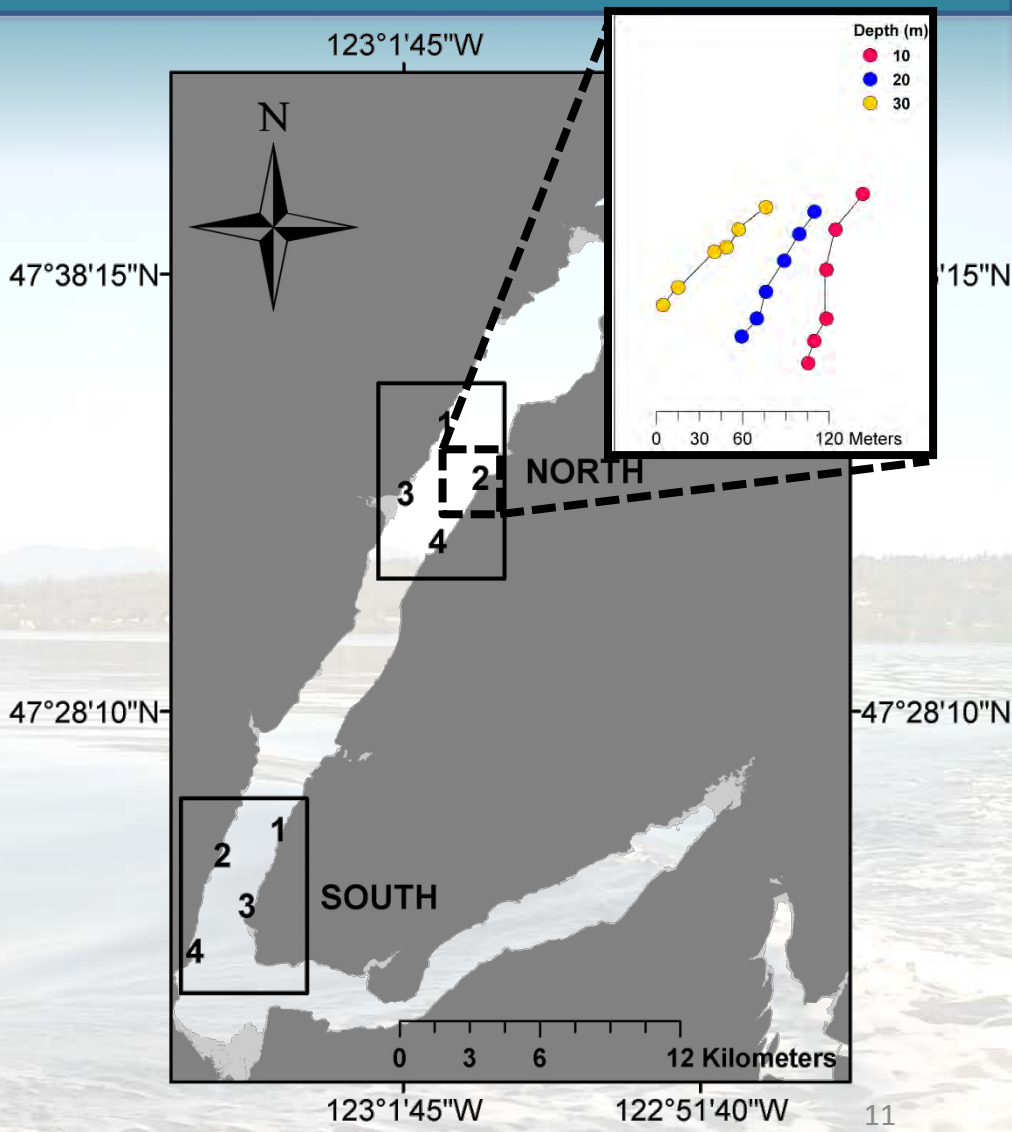
4. Do we detect distinct DO thresholds for ‘sensitive’ and ‘tolerant’ species?

Drop-camera

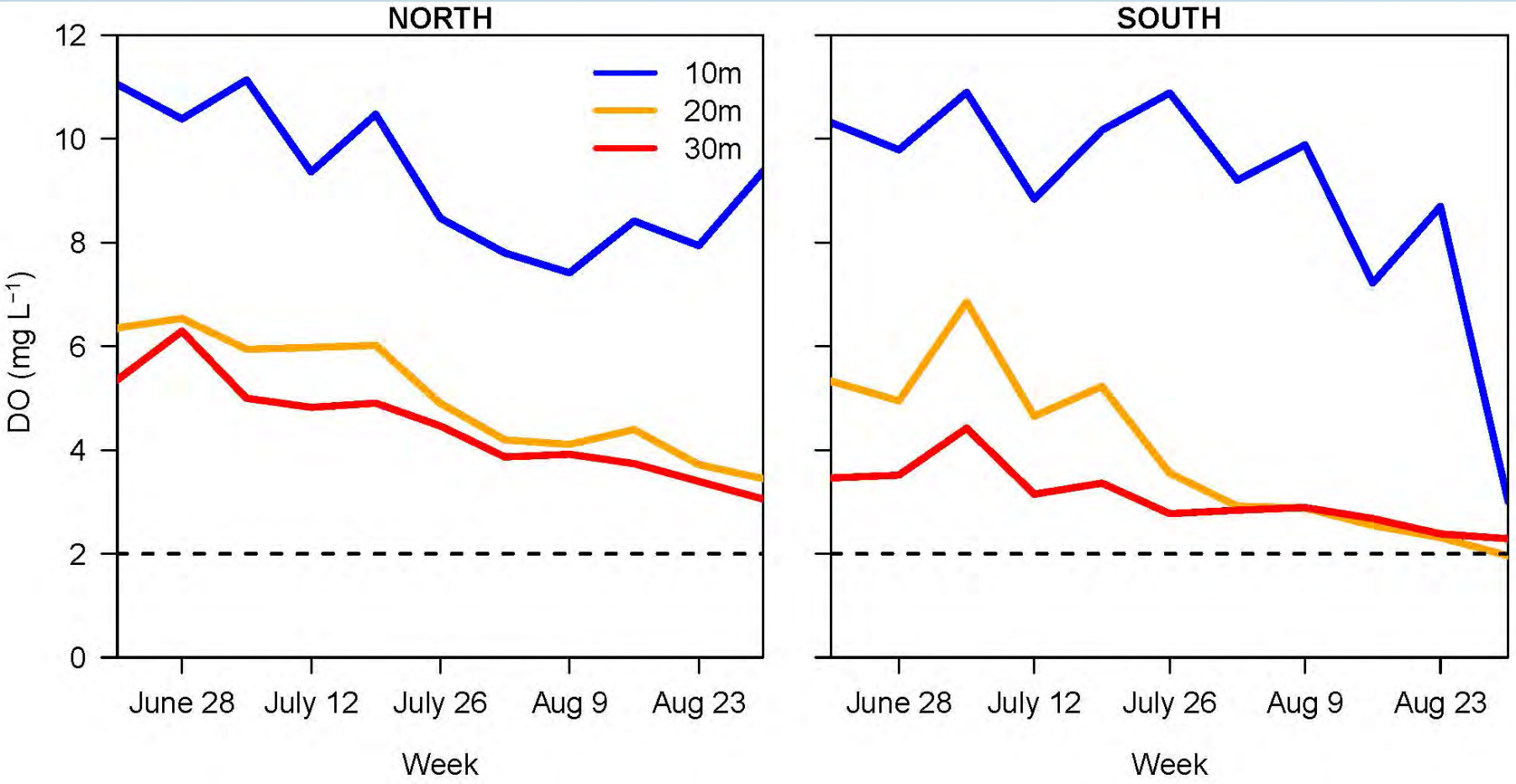
Paired study design

- June-Sept 2010
- Depths: 10, 20, 30m
- 5min transects
- Water quality data

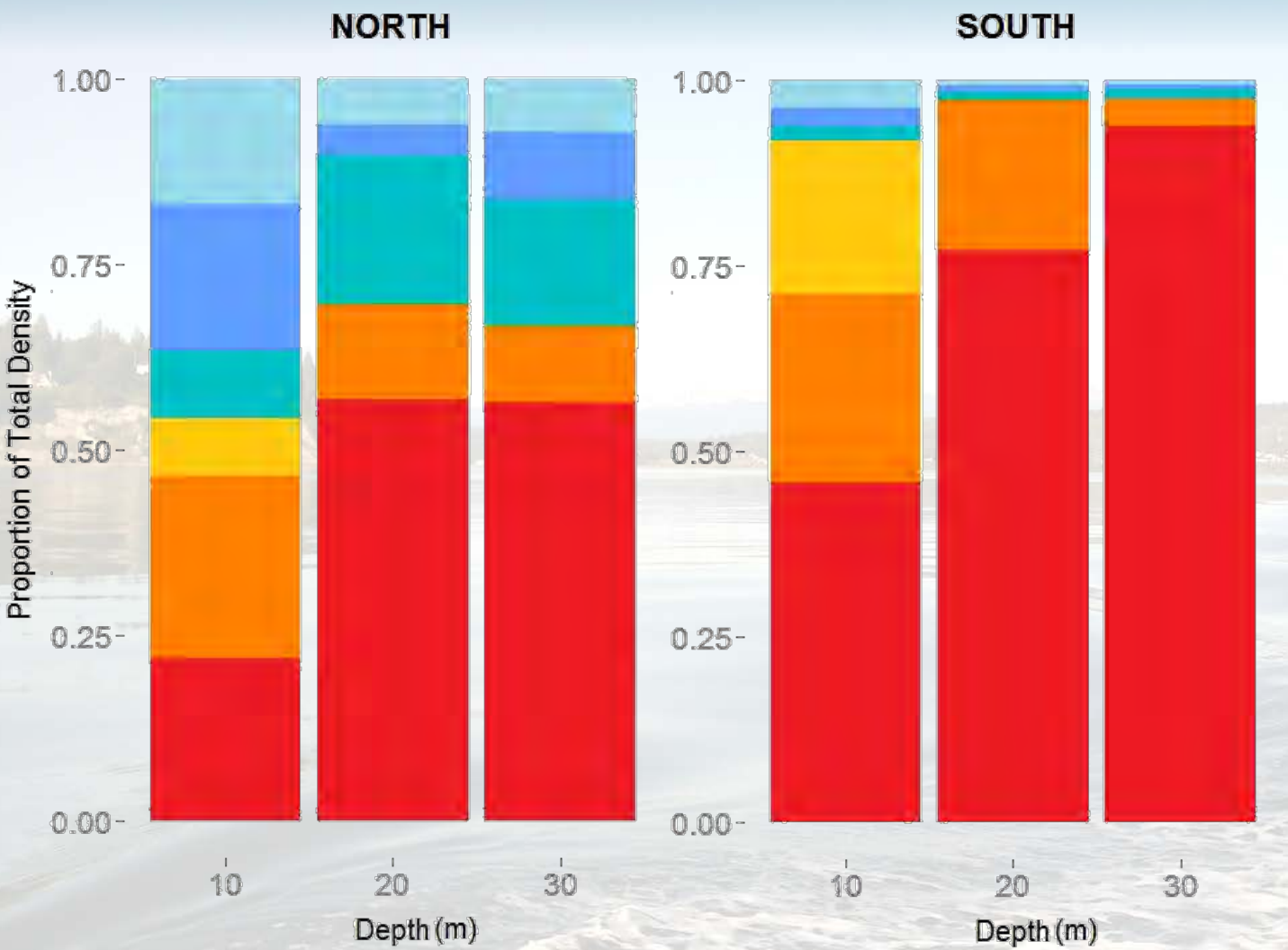




Water quality



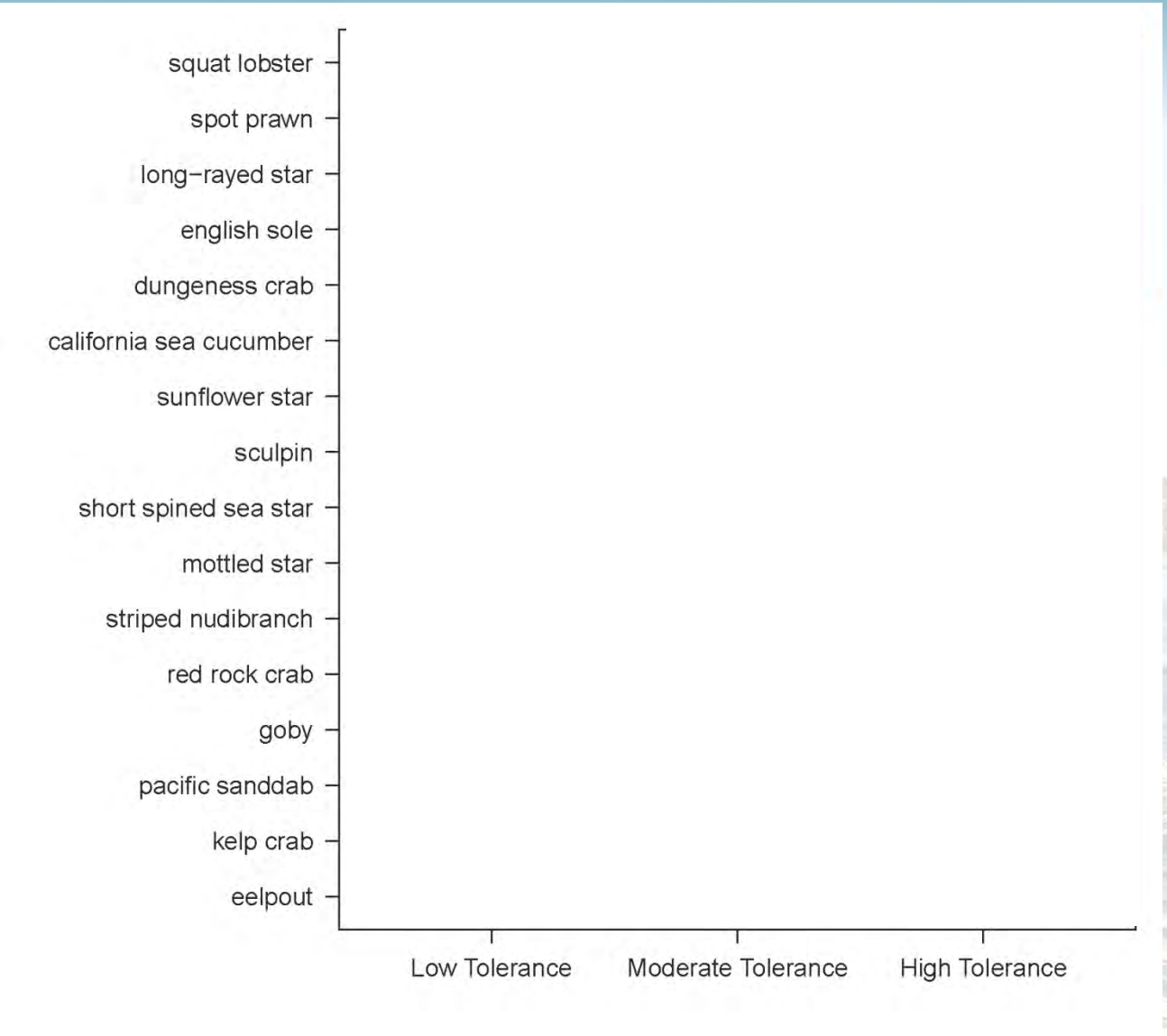
South composed of more hypoxia tolerant invertebrates and fewer fish species compared to the north?



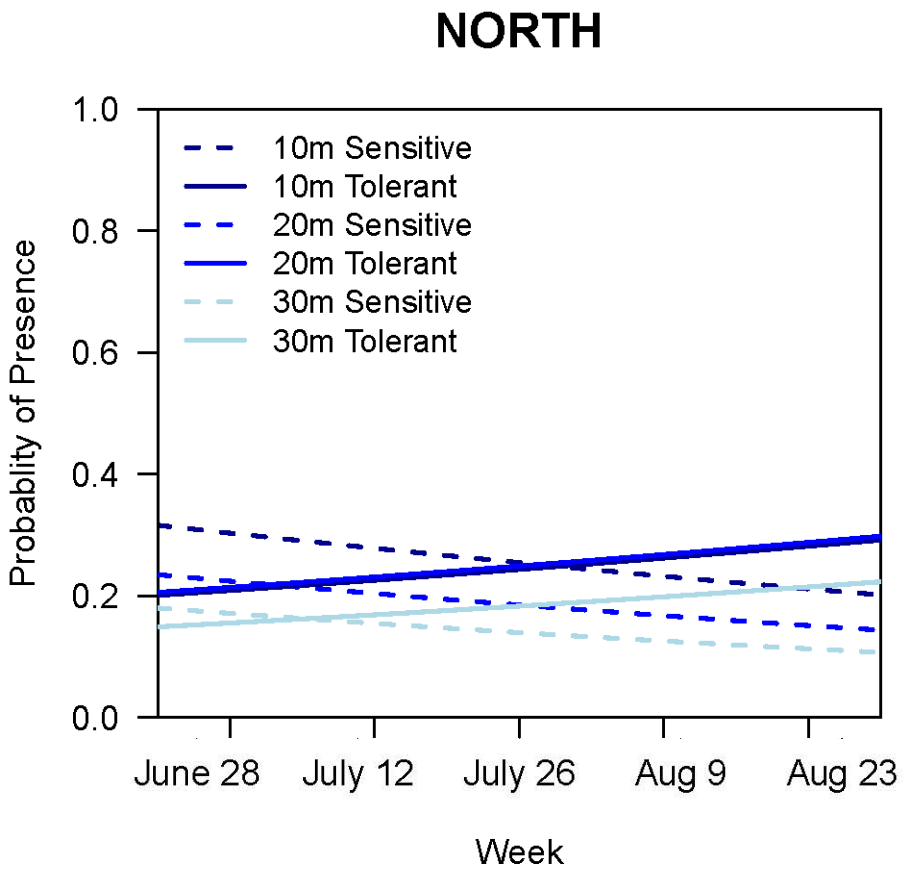
NMDS

- **Regions significantly different**
- **Fish associated with north**

South composed of more hypoxia tolerant invertebrates and fewer fish species compared to the north?



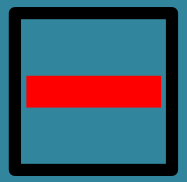
Southern community changes temporally with the onset of hypoxia?



DO a main predictor for species presence-absence?

Rank predictor importance for each species (N=16):

Predictor	No. of times rank 1	Mean rank	No. times within top 5
Depth			
Region			
Temp			
Sample site			
DO			
Habitat			
Salinity			
Week			
Slope			
Side			



DO a main predictor for species presence-absence?

Rank predictor importance for each species (N=16):

Predictor	No. of times rank 1	Mean rank	No. times within top 5
Depth	6	3.5	13
Region	3	3.8	11
Temp	2	3.8	13
Sample site	2	4.9	9
DO	2	5.1	9
Habitat	1	5.9	8
Salinity	0	5.6	8
Week	0	7.1	5
Slope	0	7.4	2
Side	0	8.0	2

Detect distinct DO thresholds for 'sensitive' and 'tolerant' species?

Broken-line analysis (GLM)

'Sensitive species' (n=7)

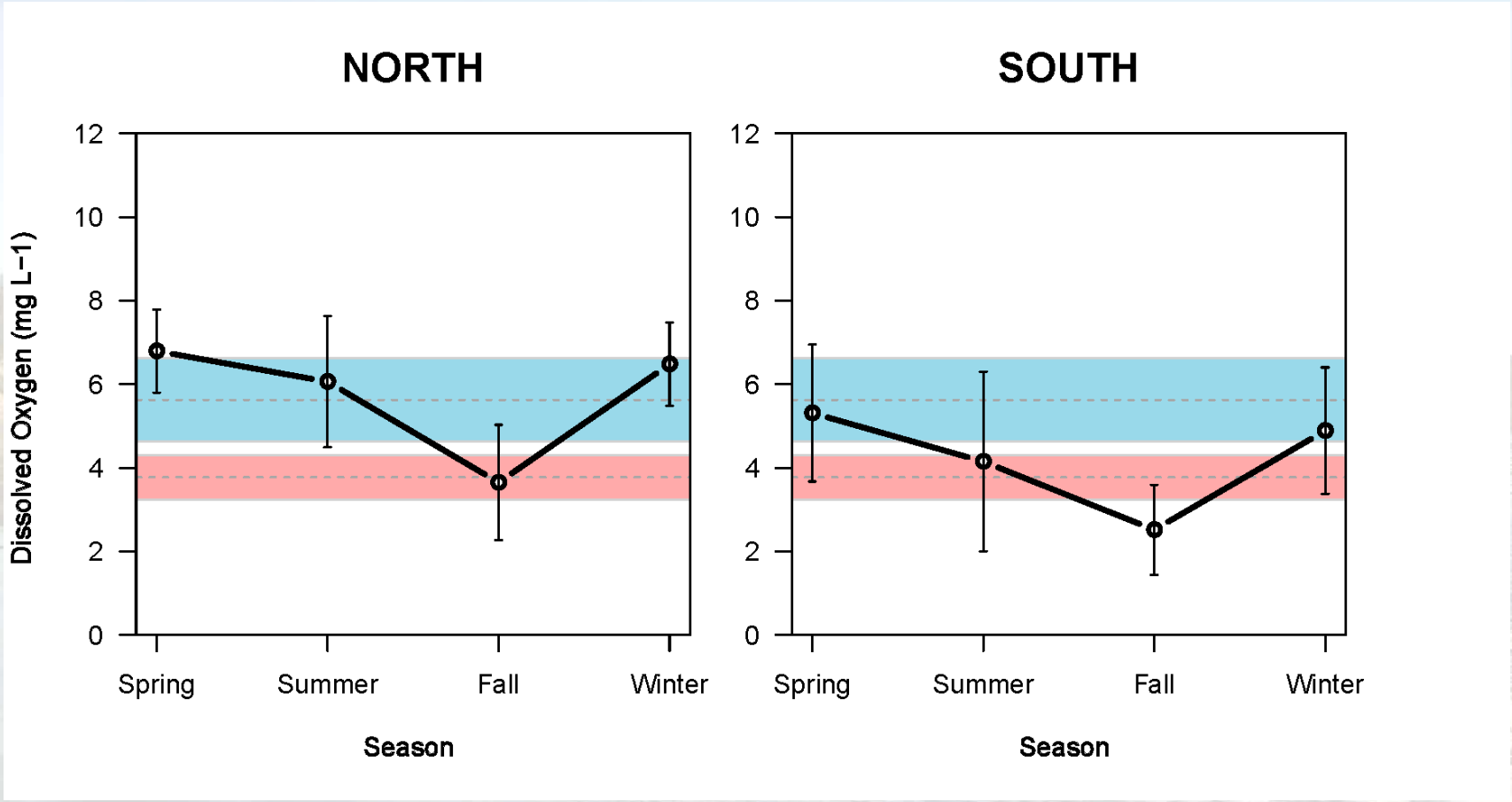
- **Breakpoint = 5.62mg L^{-1} (SE ± 0.51)**

'Tolerant species' (n=9)

- **Breakpoint = 3.77 mg L^{-1} (SE ± 0.27)**

Long-term implications?

6 years of shallow, cruise data



Northwest Association of the Networked Ocean Observing Systems (NANOOS)
Hood Canal Dissolved Oxygen Program (HCDOP; http://nvs.nanoos.org/CruiseHcdop)

Summary

I. **Hypoxia influencing the nearshore community**
   - Synergistic/additive effects?

II. **More 'universal' hypoxia response level (3-4 mg L^{-1})**

III. **More persistent low DO state in the south**
   - More vulnerable? Ecosystem function?

Acknowledgements

- **THANK YOU**:
  - P. Sean McDonald
  - Charles Simenstad
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  - NANOOS
  - Essington lab

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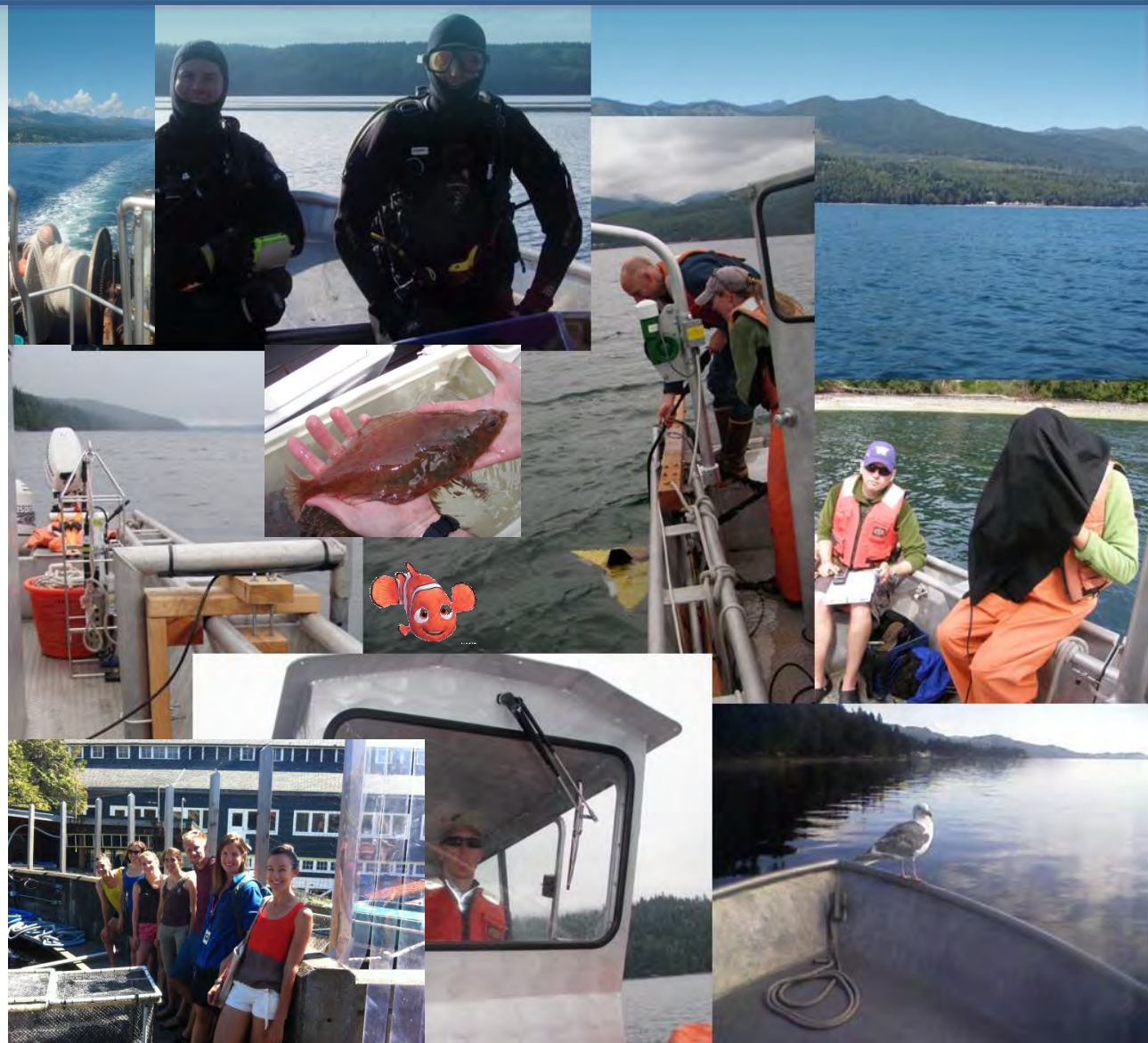
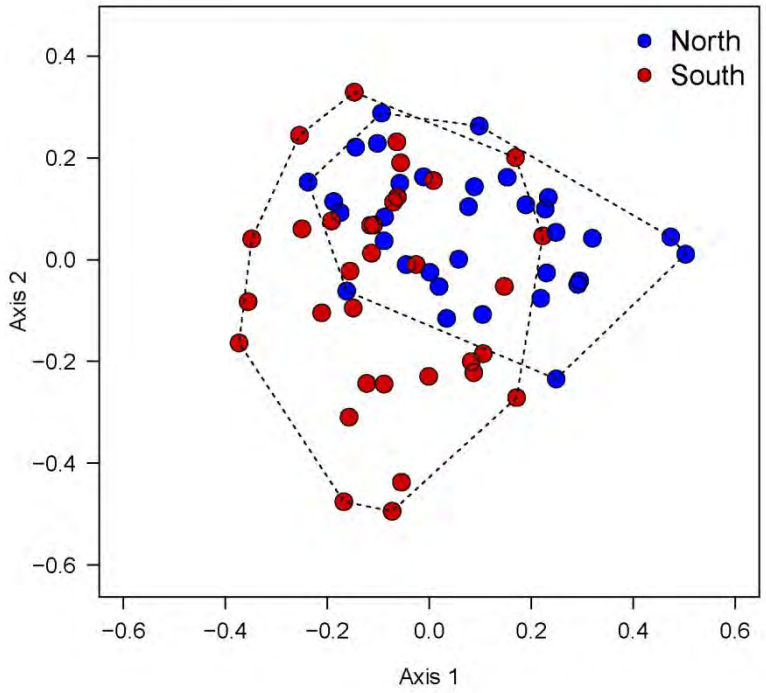
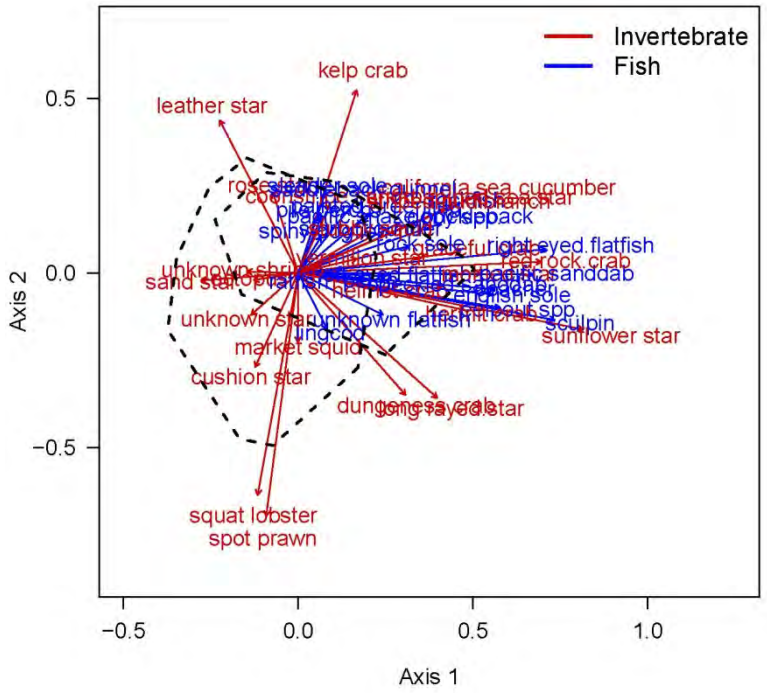
SAFS SCHOOL OF AQUATIC and FISHERY SCIENCES



Common name	Scientific name	DO Range	DO Tolerance	Overall Tolerance	Relative Abundance (north; south)	Ordination Correlation Significance
Long-rayed star	Stylasterias forreri	0.5-6.6 ml/L[12]	*more tolerant than fish & crustaceans[14]	High?	1.3%; 3.1%	$p < 0.01$
Spot prawn	Pandalus platyceros	0.9-6.9 ml/L[12]	minimum lethal ~1 ml/L[7]; 3.5 to 4.0 mg/l (below this metabolism declines)[15]	High	16.2%; 15%	$p < 0.001$
Squat lobster	Munida quadrispina	0.8-4.6 ml/L[12]	0.1 to 0.15 ml/L, well adapted to hypoxia[4]; exposed to < 0.5 mg/L[5]; no association between density & DO[10]	High	15%; 55.1%	$p < 0.001$
Dungeness crab	Metacarcinas /Cancer magister	4.9-6.6 mg/L[2];2.6-7.5 ml/L[12]	>3.3 mg/L[1]; 1.2 mg/L> DO > 0.6 mg/L[2]	Moderate to high	3.2%; 3.4%	$p < 0.01$
Giant California sea cucumber	Parastichopus californicus	0.32 - 6.7 ml/L[12]	*more tolerant than fish & crustaceans[14]; > 3.2 mg/L[15]; < 2.5 mg/L mortality[16]	Moderate to high	3.1%; 4.0%	$p < 0.001$
English sole	Parophrys vetulus	1.1-6.6 ml/L[12]	moderate degree of hypoxia tolerance (1.09 ml/L)[3]; condition not sig. different btw 0.4-1.0 ml/L[8]	Moderate to high	4.5%; 0.4%	$p < 0.01$
Sunflower star	Pycnopodia helianthoides	2.6-6.8 ml/L[12]	more abundant >1 ml/L[8] ; least abundant < 0.5 ml/L[8]; > 0.5 ml/L[13]; present in hypoxic conditions[13]	Moderate	9.8%; 5.3%	$p < 0.001$
Shortspined sea star	Pisaster brevispinus	3.9-6.6 ml/L[12]	present in hypoxic conditions[6]; *more tolerant than fish & crustaceans[14]	Moderate	1.6%; 0.9%	$p < 0.01$
Sculpin spp.	Malacocottus kincaidi; Enophrys bison	1.0-6.6 ml/L[12]	more abundant ≥1.3 ml/L[8]; absent 0.6 ml/L[8]	Low to moderate	4.5%; 0.6%	$p < 0.001$
Mottled star	Evasterias troschelii	3.0-7.3 ml/L[12]	*more tolerant than fish & crustaceans[14]	Low to moderate?	2.8%; 3.0%	$p < 0.01$
Striped nudibranch	Armina californica	2.4-6.5 ml/L[12]	absent ≤ 0.8 ml/L[8]	Low	3.6%; 0%	$p < 0.01$
Pacific sanddab	Citharichthys sordidus	2.6-5.5 ml/L[12]	condition sig. better in DO > 1ml/L[8]; can move off the bottom[9]	Low	3.9%; 0.2%	$p < 0.001$
Eelpout spp.	Lycodopsis pacifica	2.3-5.5 ml/L[12]		Low?	1.2%; 0.2%	$p < 0.001$
Goby spp.	Rhinogobiops nicholsii	3.3 - 6.4 ml/L[12]		Low?	3.1%; 0.4%	$p < 0.05$
Kelp crab	Pugettia producta; Pugettia richii	6.6 ml/L[12]		Low?	1.1%; 1.0%	$p < 0.001$
Red rock crab	Cancer productus	3.2-6.6 ml/L[12]	Emersion (<12hrs)[11]	Low?	8.2%; 1.7%	$p < 0.001$

Habitat Type
cobble/sand/algae
cobble/sand/algae/seapens
cobble/sand/rock/algae
cobble/sand/rock/seawhips
cobble/sand/seawhips
cobble/sand/seawhips/algae
cobble/sand/seawhips/some algae


North
South
Axis 1
Axis 2
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.6
−0.4
−0.2
0.0
0.2
0.4
0.6


Invertebrate
Fish
kelp crab
leather star
sea cucumber
right eyed flatfish
red rock crab
sanddab
sculpin
sunflower star
unknown flatfish
lingcod
market squid
cushion star
dungeness crab
squat lobster
spot prawn
Axis 1
Axis 2
0.5
0.0
−0.5
−0.5
0.0
0.5
1.0