Biological threshold application for forecasting sustainability of estuarine calcifiers in the Salish Sea

Nina Bednaršek[1], Greg Pelletier[2], Richard Feely[3], Anise Ahmed[2]

[1]Southern California Coastal Water Resources Project

[2]Washington State Department of Ecology/ Pacific Northwest National Laboratory

[3]NOAA/Pacific Marine Environmental Lab

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Background: Need For Application of Biological OA Endpoints

- **Global climate change is rapidly changing in the highly productive and economically valuable coastal and estuarine ecosystems**
- **Managers are investing $$ in OA research and monitoring**
  - Predictive capacity of the ecologically and economically important species and biodiversity loss is currently limited
- **Regionally important anthropogenic factors require addressing economically implications at the *regional scales***
  - linkages with the local economies based on the marine resources, fisheries, etc.
- ***We need scientific consensus on approaches to interpretation that can provide a consistent basis for communication and coordinated actions.***

Ecologically and economically important calcifiers in the Salish Sea

We Have Criteria for Selection of Taxa

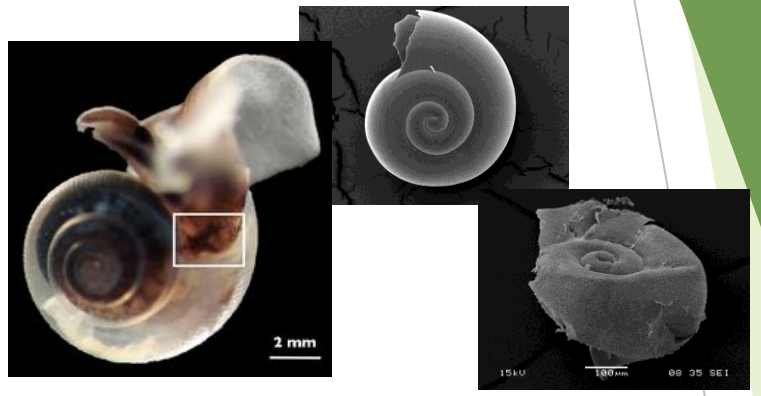
- Sensitivity to OA
- Ubiquitous distribution
- Representative Habitat, e.g.

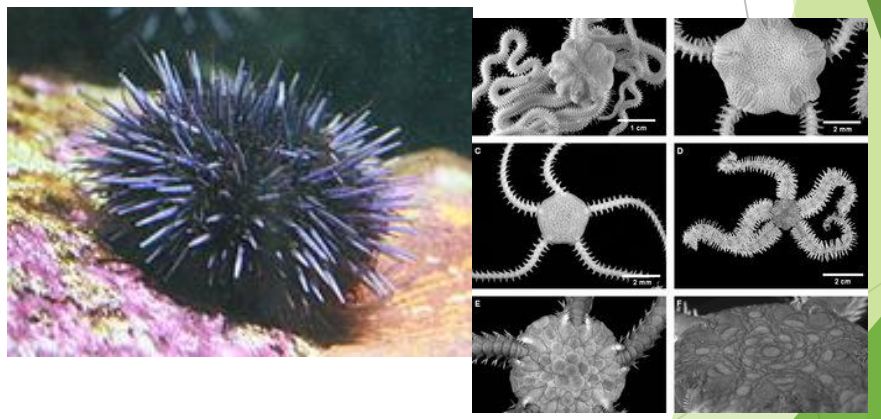
  Pelagic/Benthic
- Data availability
- Management endpoint: Valuable role in ecosystem or commercially important

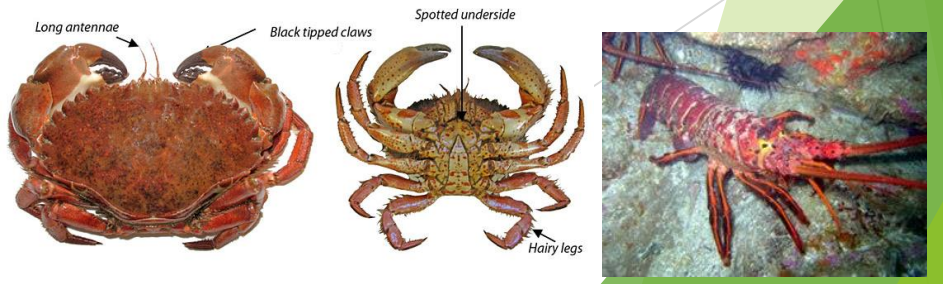
Pteropods, Echinoderms and Dungeness crabs

Basis for Selection of Three Focal OA Taxa

Taxa	Habitat/Sensitivity
Pteropods	Pelagic Calcifying Zooplankton Extreme sensitivity to OA
	Permanent distribution and ecosystem role in Salish Sea
Echinoderms	Shallow to deep-water pelagic and epibenthic
	Ecosystem role in Salish Sea
Dungeness crabs	Shallow to deep-water pelagic and epibenthic
	Economic role in Salish Sea







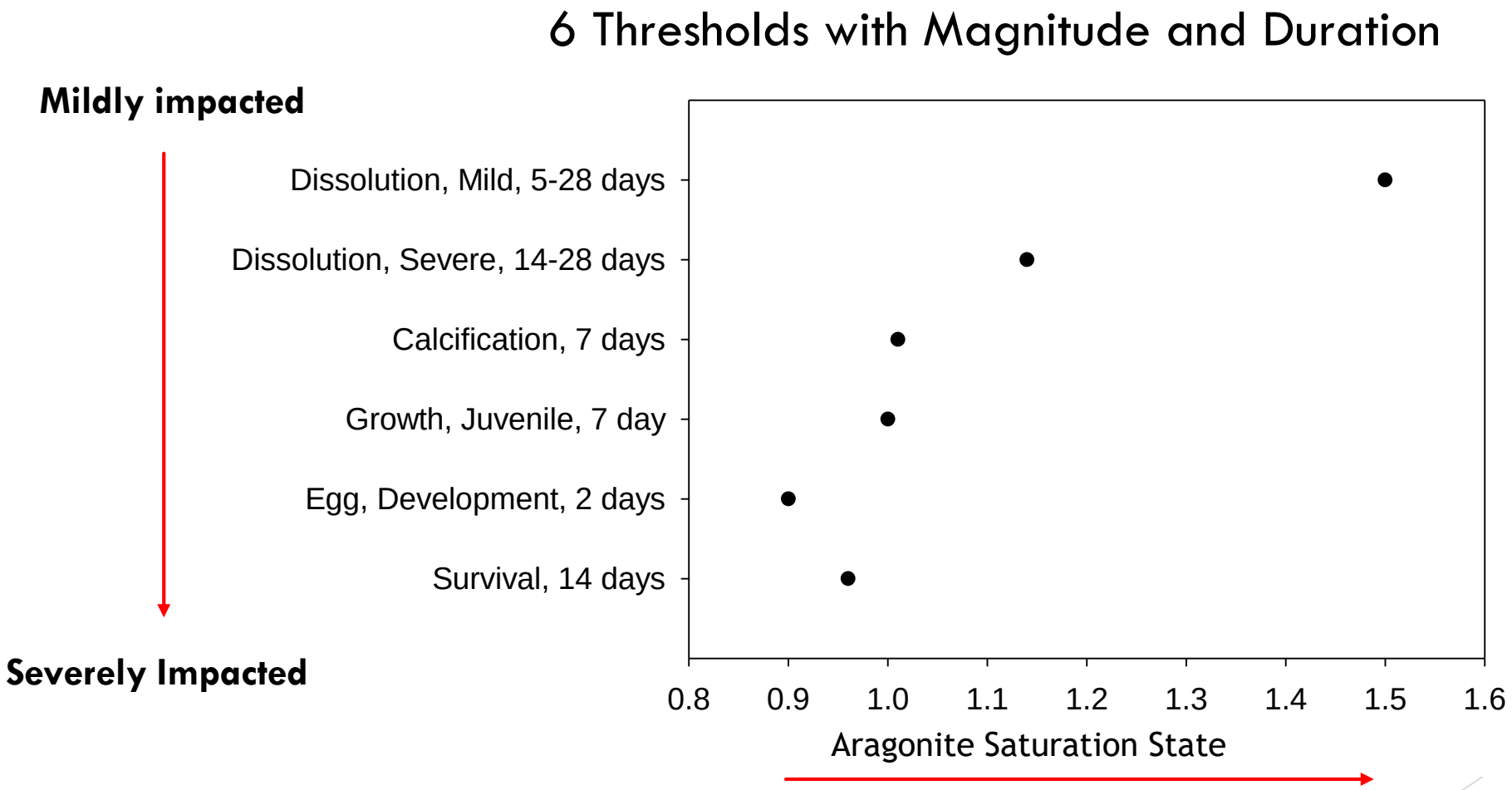
Thresholds Can Be Applied to Model Output to Visualize Potential Habitat At Risk AND the Impact of Nutrient Loading

We Have Undertaken a Synthesis of Thresholds With a 4-step Approach

Sequential steps:

- Data collection and literature review
- Meta-analyses
- Breakpoint analyses
- Expert consensus

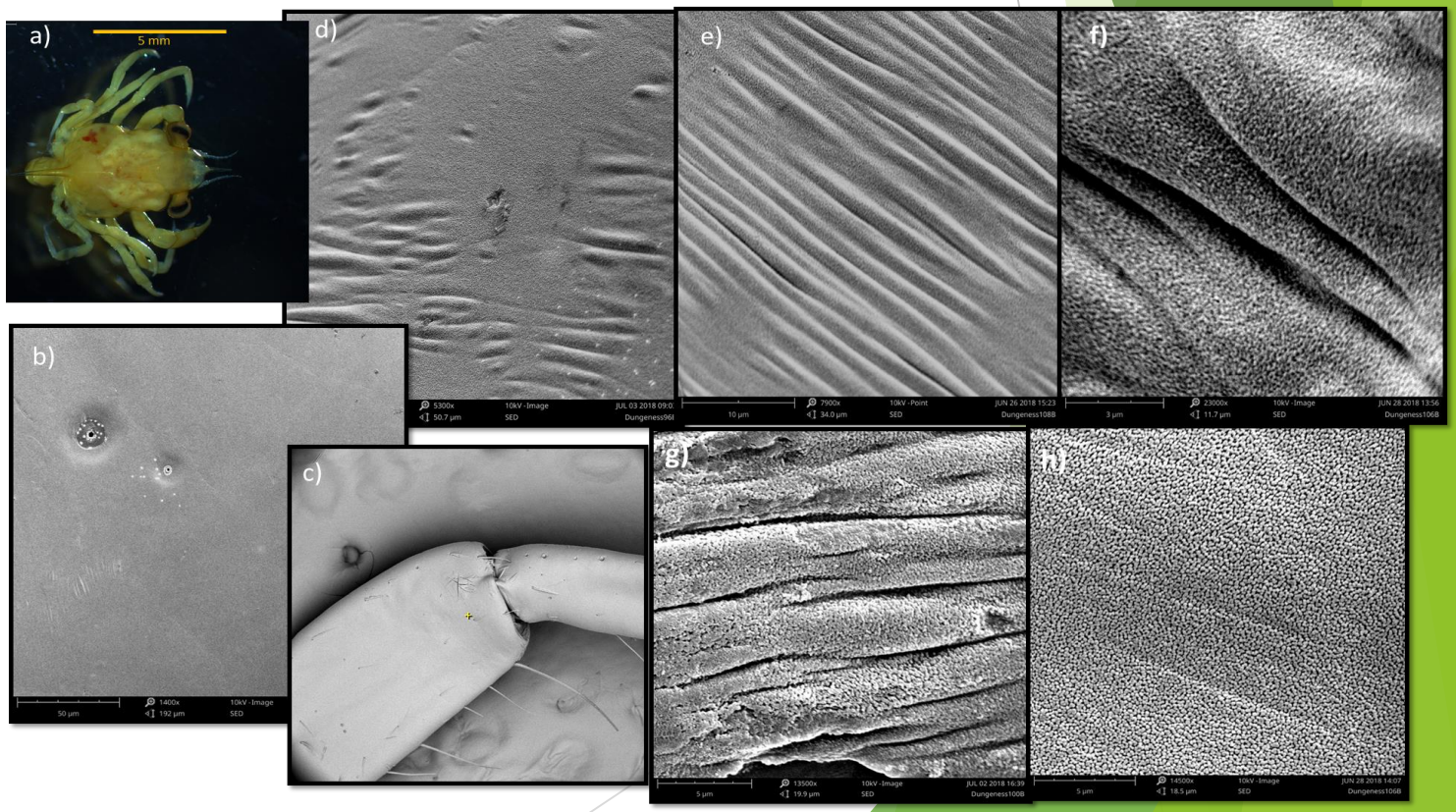
OA Thresholds for Pteropods



Bednarsek et al., 2019, Frontiers in Marine Science

Echinoderm and Dungeness crab thresholds

- The same set of threshold was selected for larger echinoderm groups
- For decapods, SCCWRP will host a workshop later this year.
  - For now, application of threshold based on the Dungeness crab dissolution (ΔpH = 7.8)

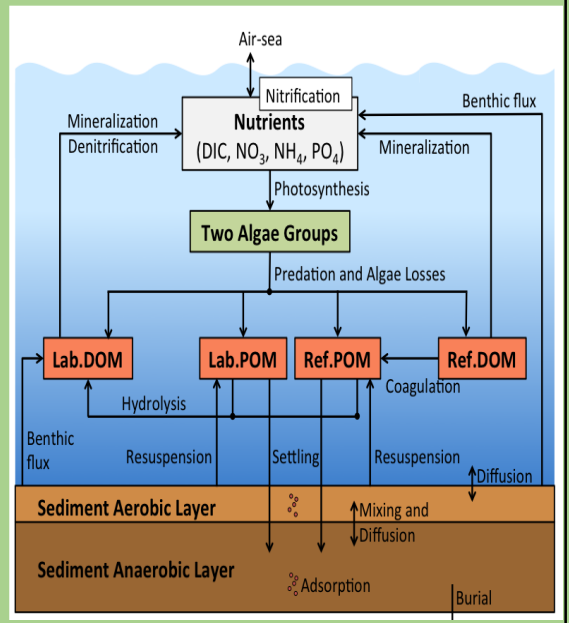


Salish Sea Model – PNNL / Ecology / EPA

Hydrodynamics and Water Quality - Y2008

Model Grid (PSM)

Biogeochemistry



Model Specifications

- **Hydrodynamic Model**
  - FVCOM (Chen et al 2003)
  - 3-D Baroclinic
  - 10-layers, sigma coordinates
  - Boundaries
    - Strait of Juan de Fuca
    - Strait of Georgia
    - S, T, and Elevation
  - Meteorology
    - UW – WRF Model
  - Hydrology
    - River flows
    - Watershed models
- **Water Quality Model**
  - CE-QUAL-ICM / USACE
  - FVCOM-ICM (Kim and Khangaonkar 2011)
  - Nutrients, phytoplankton/algae, carbon, DO, …. 19 variables
  - Benthic fluxes, pH
  - Boundary loads based on DFO monitoring data
  - Point source loads (99)…

Salish Sea Model – http://salish-sea.pnnl.gov/

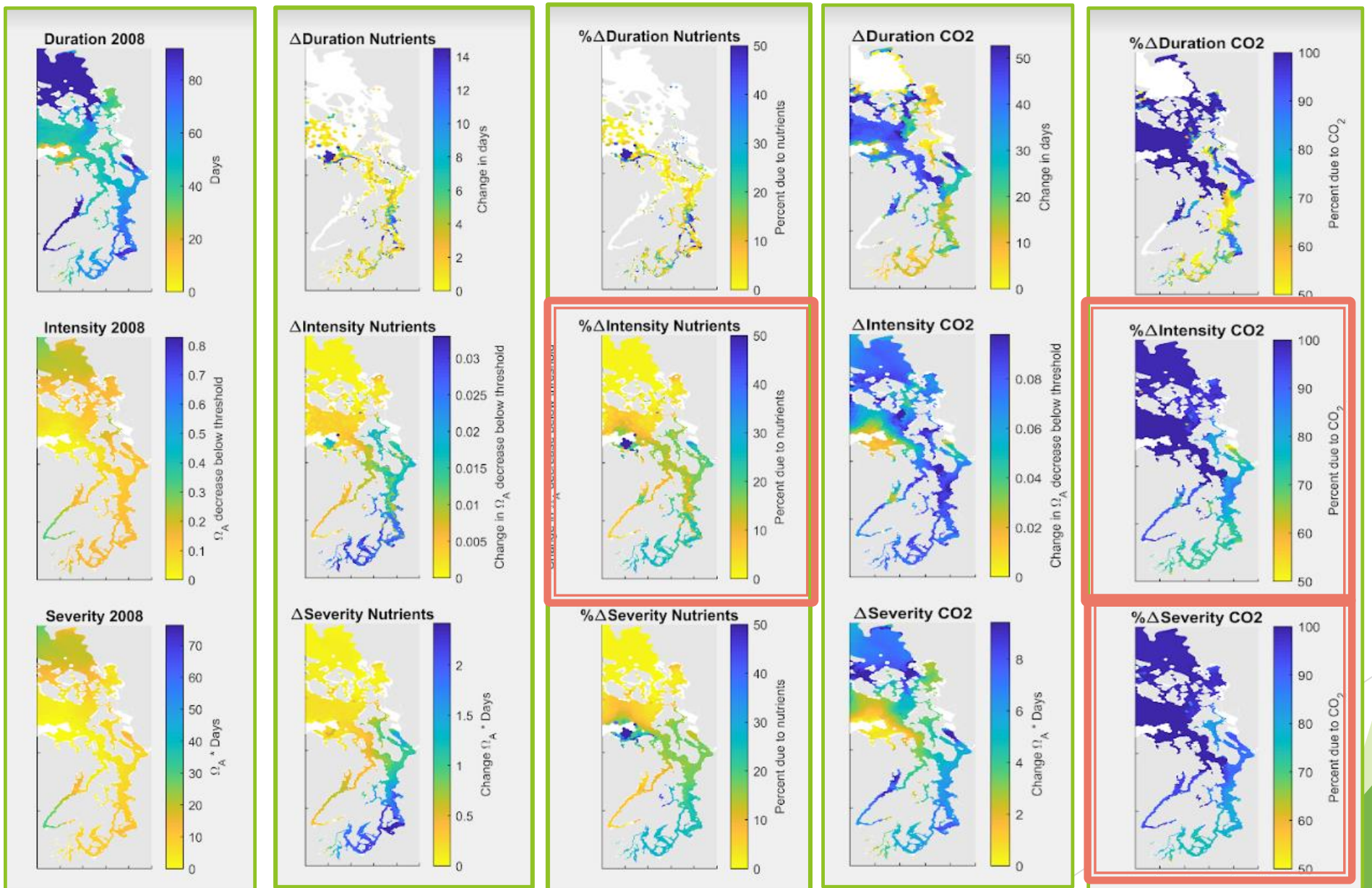
Khangaonkar et al. 2011 a,b, 2012, 2013, 2016, 2017]

Pelletier at al. 2017 a,b, Bianucci et al 2018, Khangaonkar et al 2018

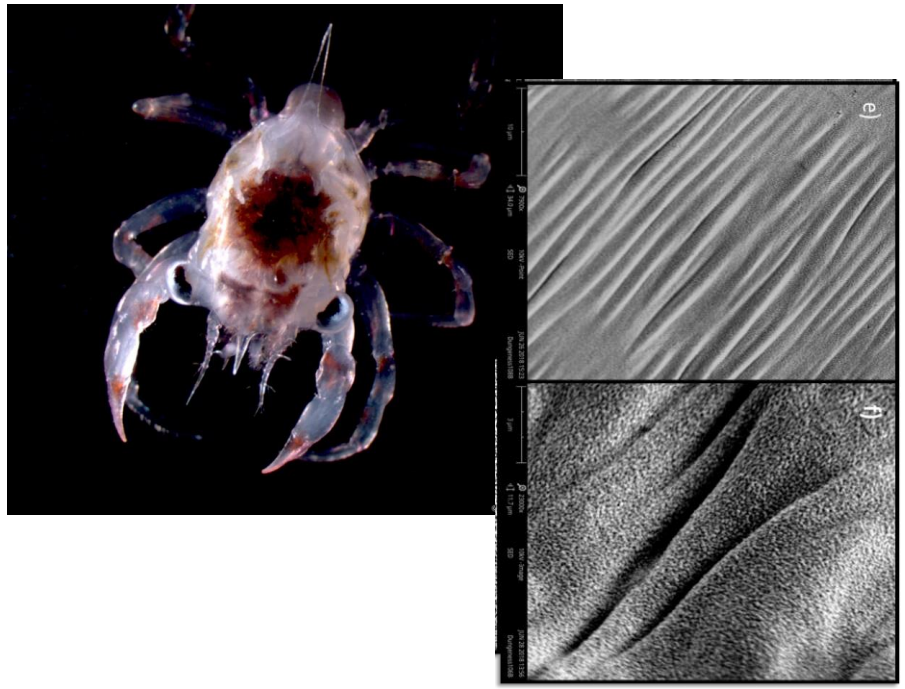
Model scenarios

1. Realistic conditions during 2008 (magnitude, duration and severity)
2. Explicit representation of human nutrient sources

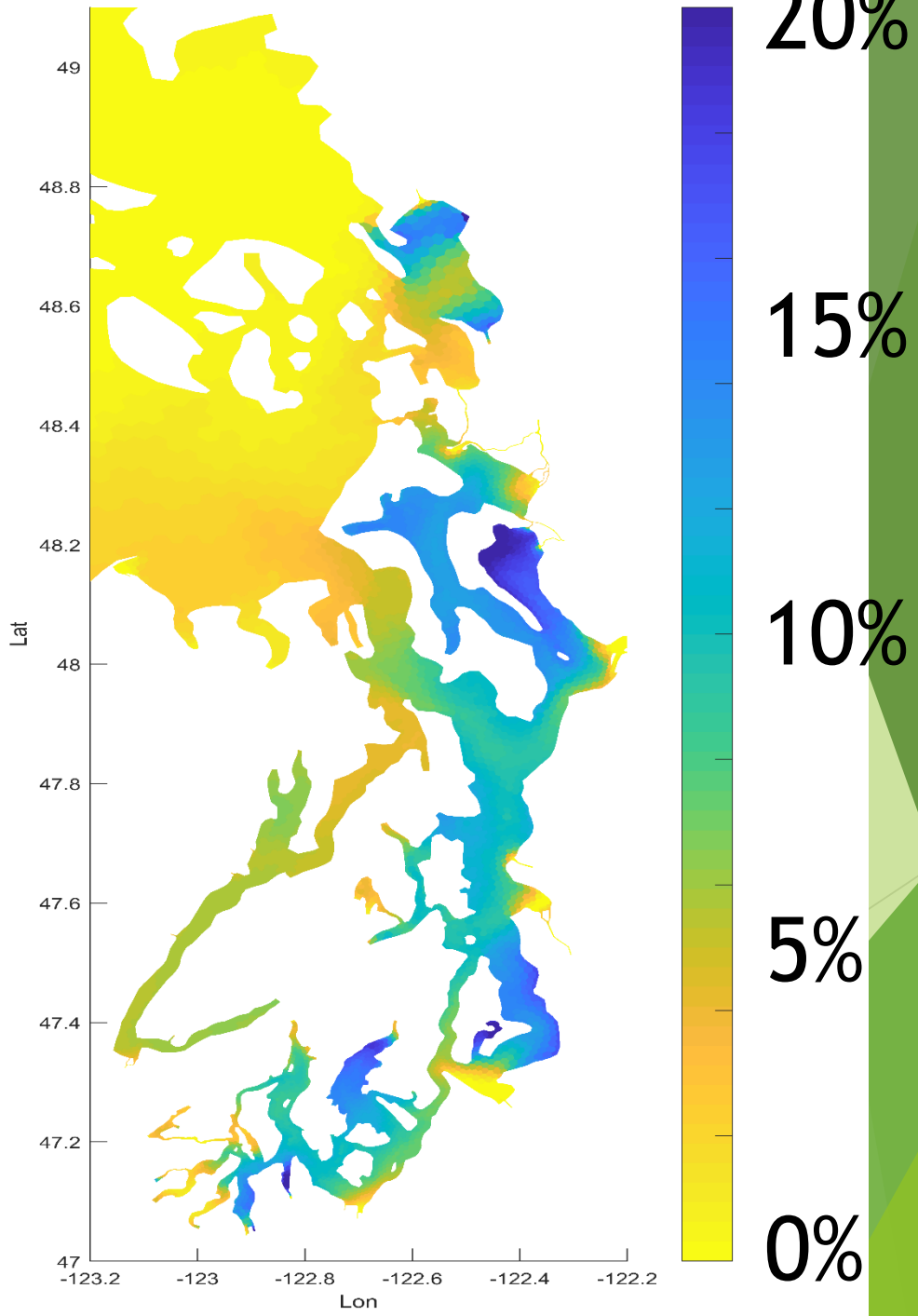
Application of pteropod threshold (survival, Ω=0.95 for 14 days)



Increase in crab dissolution during May-Jun due to human nutrients



Part of the Puget Sound has been closed to Dungeness crab fishing in due to collapse of the population!



Conclusions

- The conditions in the Puget Sound are below **ALL** the pteropod threshold **in the fall,** especially in the stratified embayments of the **Hood Canal, South Sound, and the Whidbey Basin** → this carries important population level effects.
- Echinoderm thresholds are crossed in the same regions but so far, only for the most sensitive, physiological impairments.
- Nutrients contribute up to **30-50%** towards **deterioration of the conditions below the thresholds** and might play a role in the population dynamics of the larval Dungeness crab.

Thank you!

- For additional questions, contact

ninab@sccwrp.org