Synthesis of Thresholds of Ocean Acidification Effects on Marine Calcifiers

Update for Commission

December, 2018

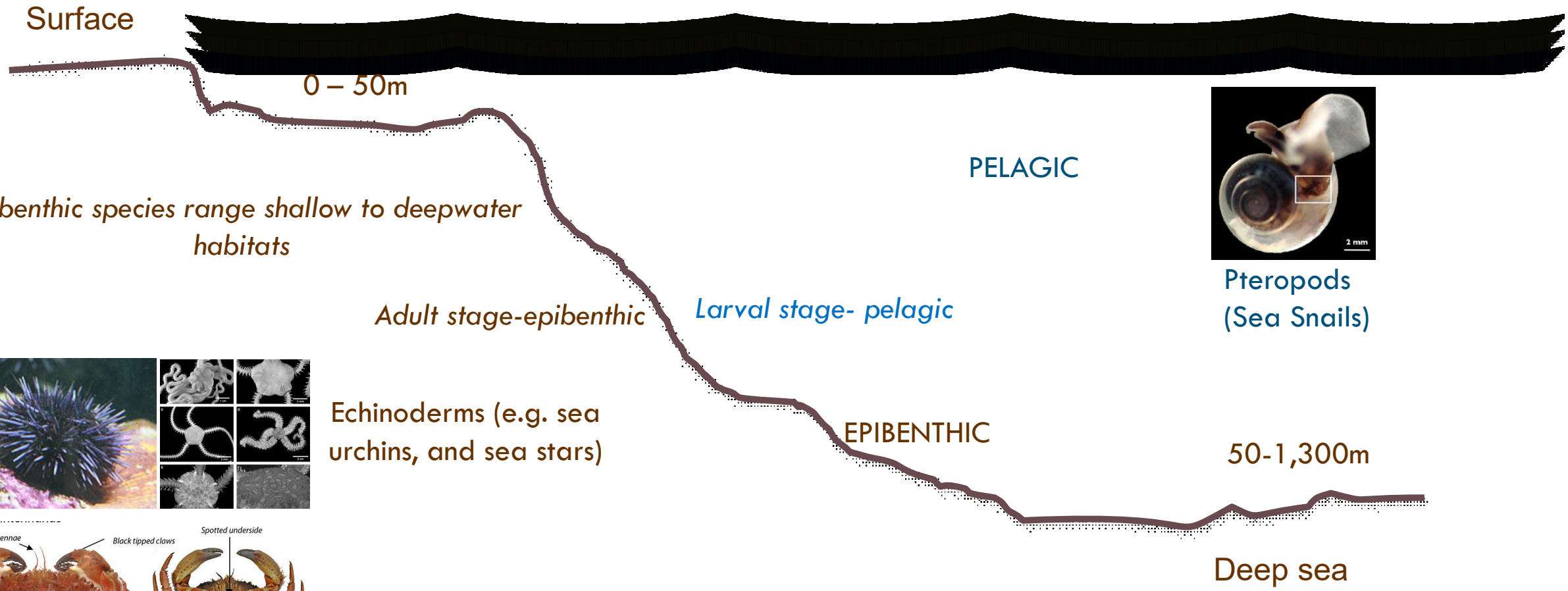
Biologically Relevant Thresholds Are Needed to Support All These OA Action Plan Recommendations

- OA water quality goals
- Assess impact of local pollution sources
- Preserve, support and enhance the resilience of fisheries
- Carbon sequestration through natural and constructed systems

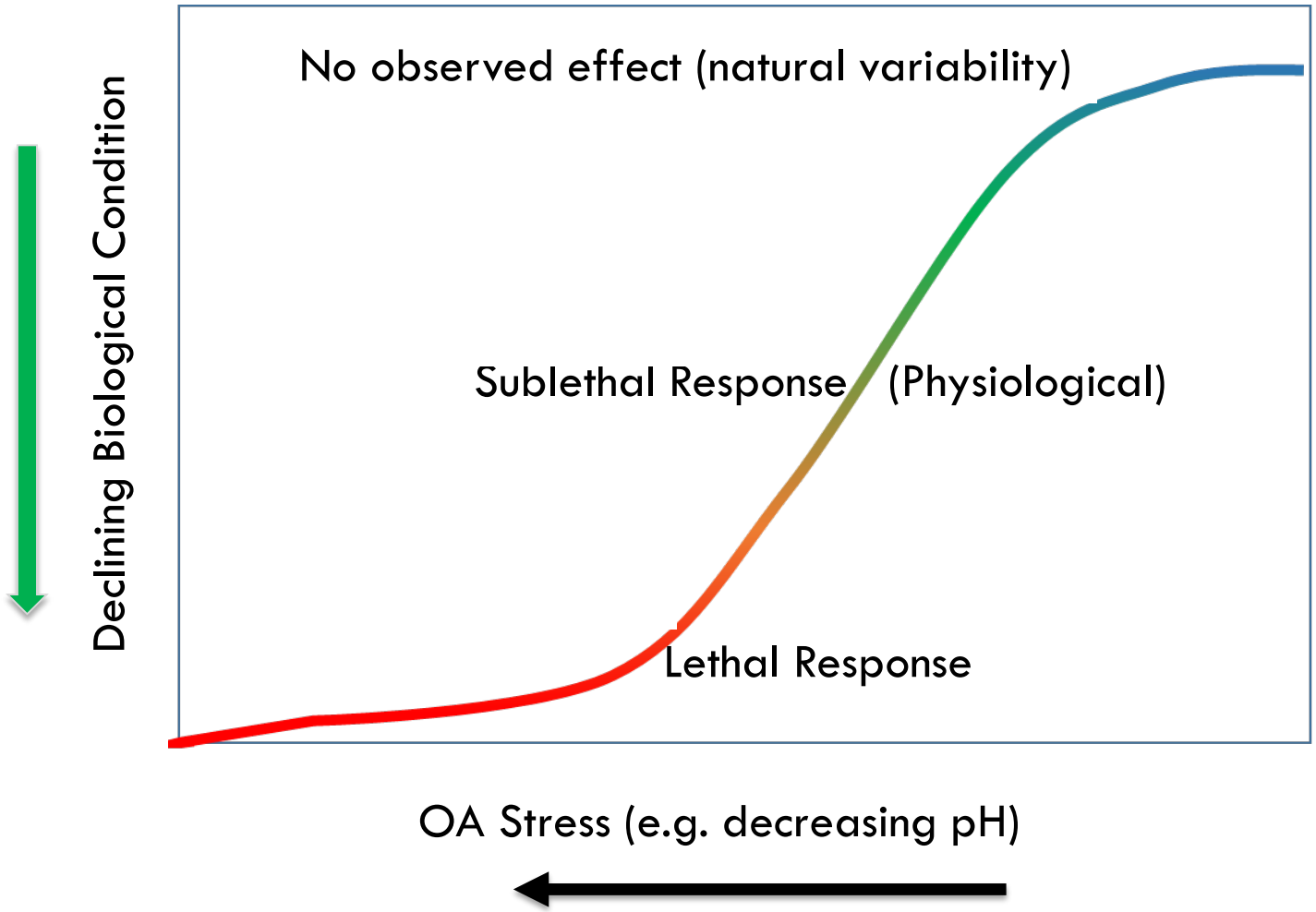
Use of Biologically–Relevant Endpoints As Approach Requires Answering Important Science Questions…

- Which taxa to select? What habitats do they represent?
- What is the scientific basis for thresholds, considering magnitude, duration, extent and frequency
- How do we deal with multiple stressors?

We Want OA Sentinel Taxa that Represent Different Habitats



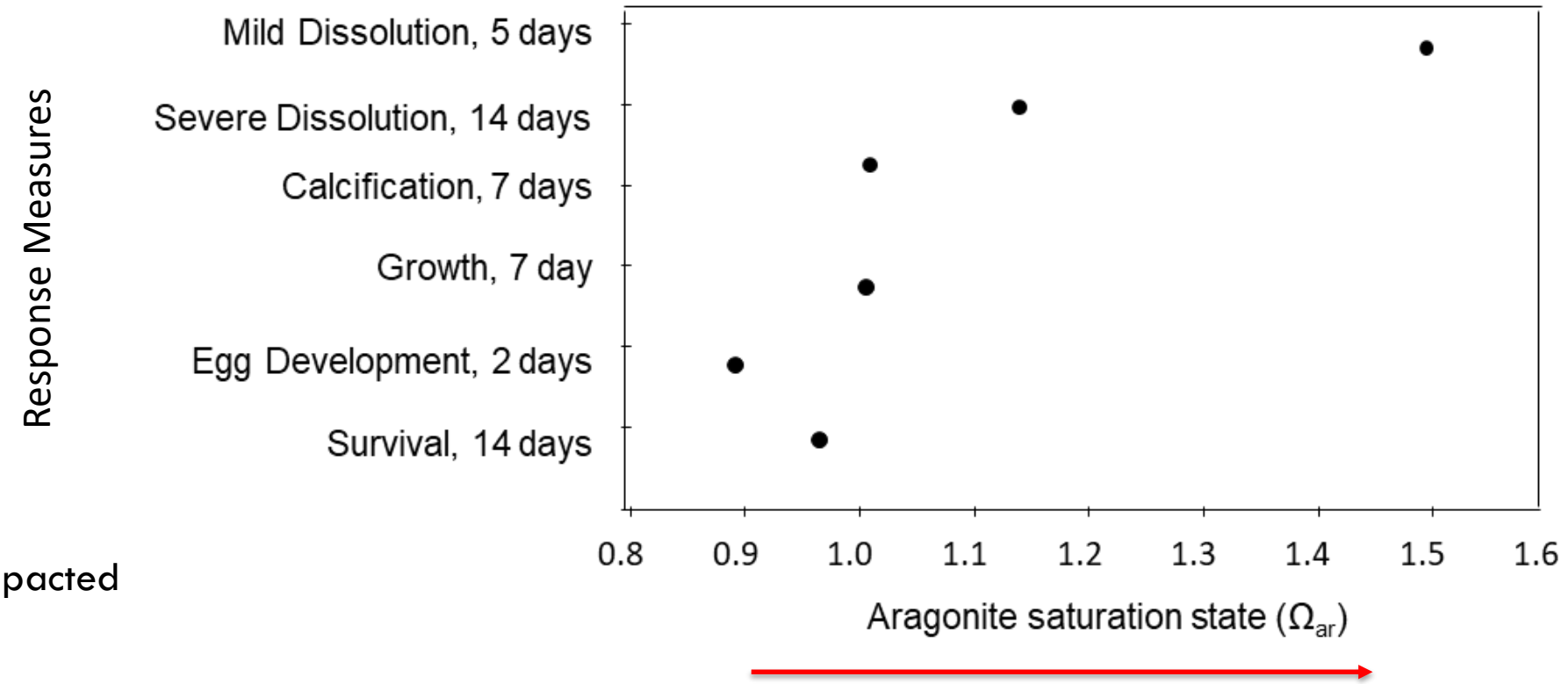
Need a Key Graphic, By Taxa, to Support Management Decisions



We Have This Key Graphic for Pteropods (and now, Echinoderms)!

Pteropod Synthesis Features 6 Thresholds with Magnitude and Duration

Unimpacted



Severely Impacted

We Convened Experts from Around the World to Help Us Get Consensus on Thresholds

Pablo Leon Diaz, Scottish Env. Agency, UK

Ella Howes, Nature Conservation, UK

Brian Hunt, UBC, Canada

Silke Lischka, GEOMAR, Germany

Amy Maas, Bermuda, USA

Clara Manno, BAS, UK

Brad Seibel, USF, USA

Rich Ambrose, UCLA, USA

Maria Byrne, University of Sydney, AU

Piero Calosi, Université du Québec, Canada

Karen Chan, Swarthmore College, USA

Sam Dupont, University of Gothenburg, Sweden

Jacqueline Padilla-Gamino, UW, USA

John Spice, University of Plymouth, UK

Nina Bednaršek, SCCWRP

Richard Feely, PMEL, NOAA

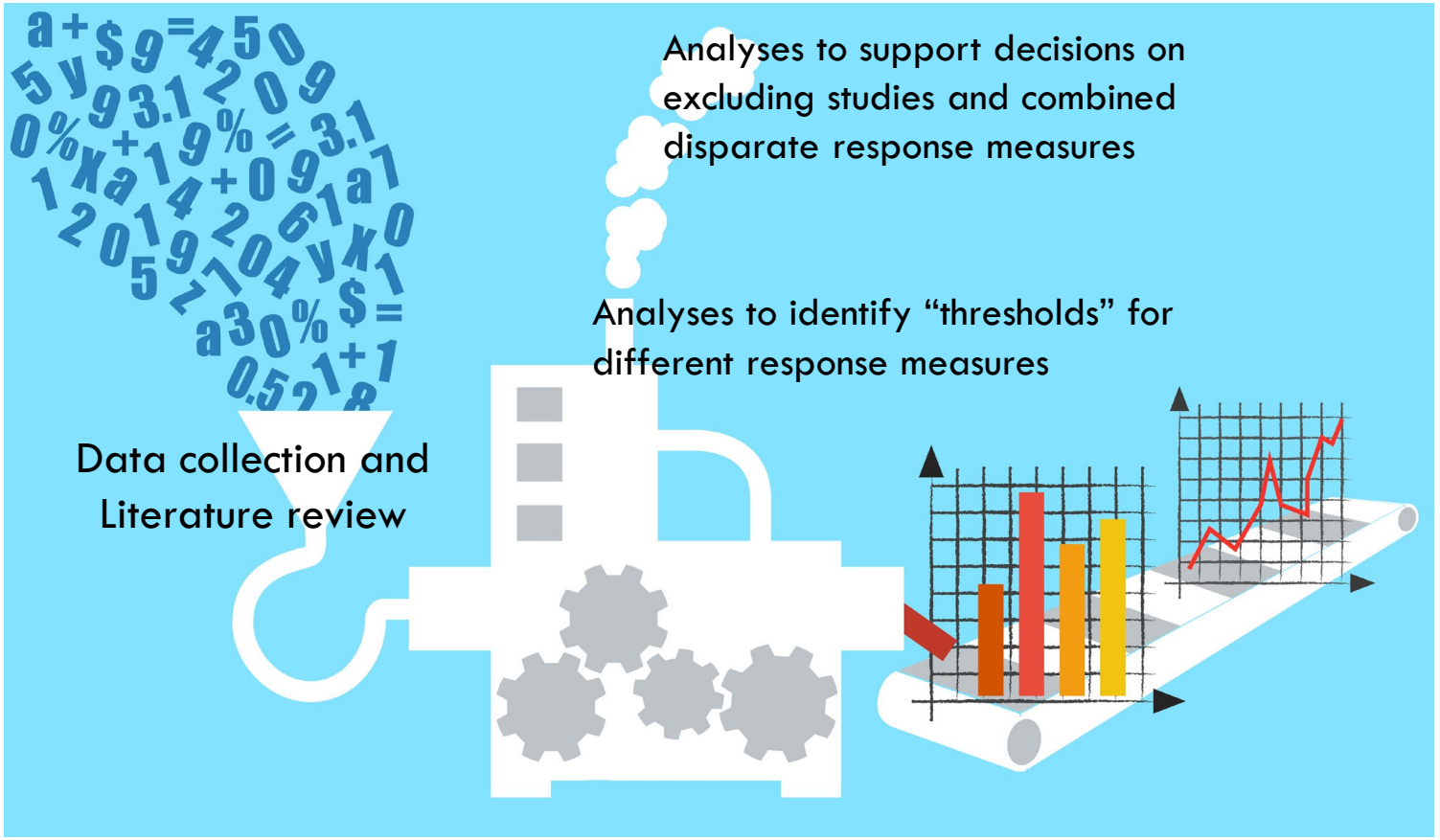
We Started With Comprehensive Data Compilation, Literature Review, and Data Analyses

Pteropod OA responses :

- *18 studies and 3k data points*
- *22 response measures!*
- *One taxon*

Echinoderm OA responses :

- *41 studies and 12k data points*
- *237 response measures!*
- *Three taxa (Sea urchins, brittle stars, Sea stars)*

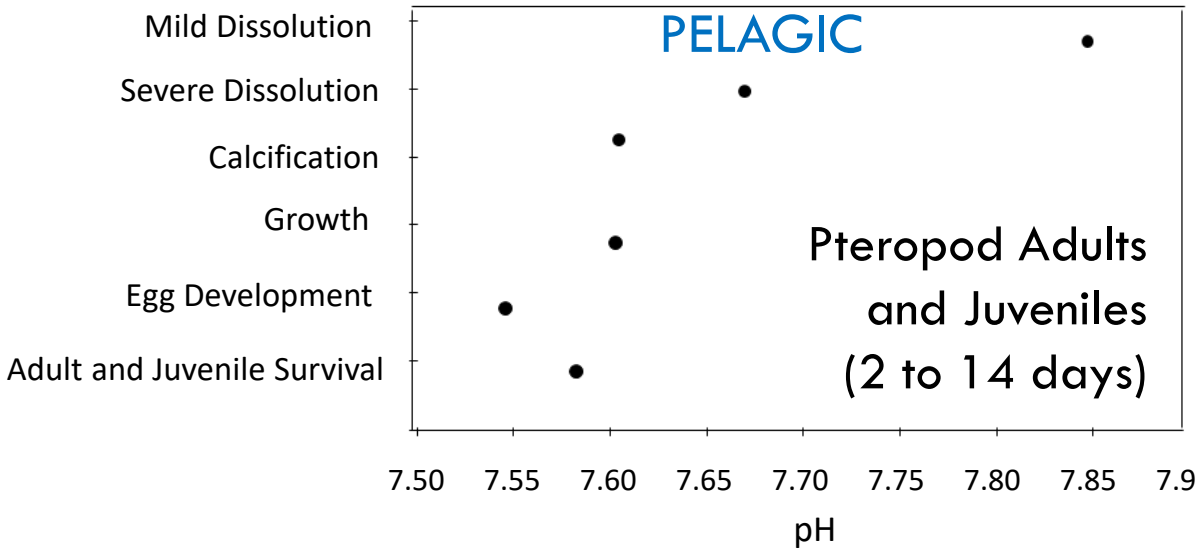


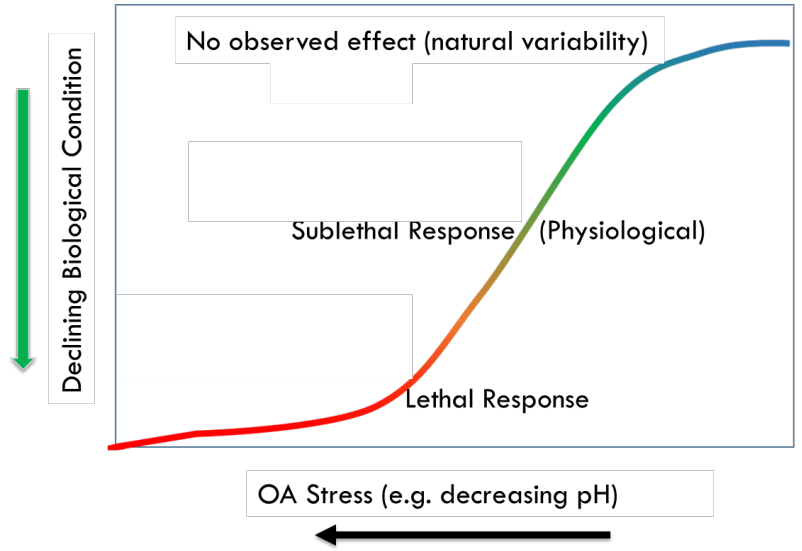
Best Measure of OA Stress Varies By Taxonomic Group

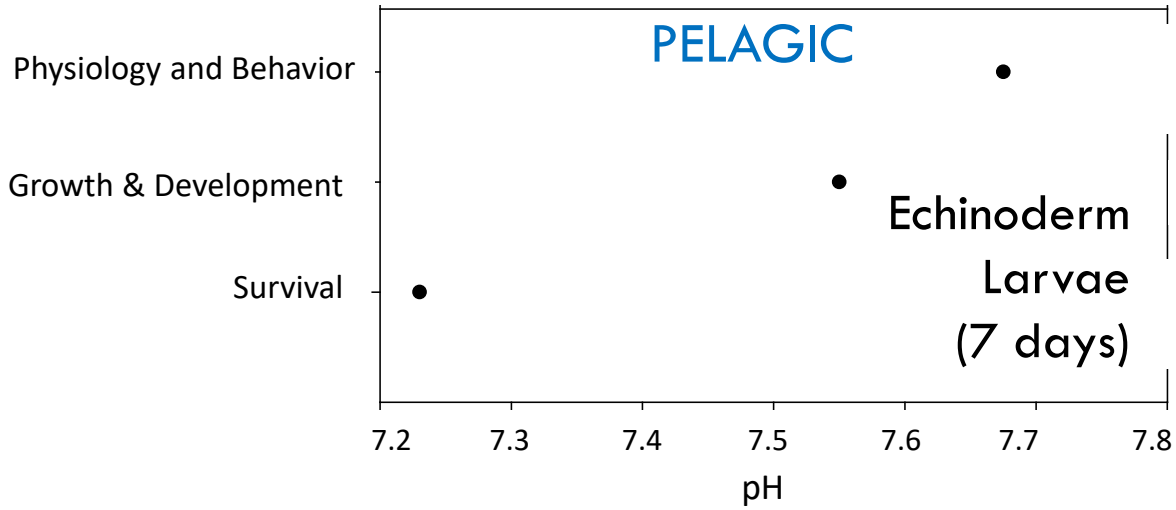
- Omega Saturation state (Ωar) recommended for pteropods
  - Measure that directly relates to saturation state required for calcification

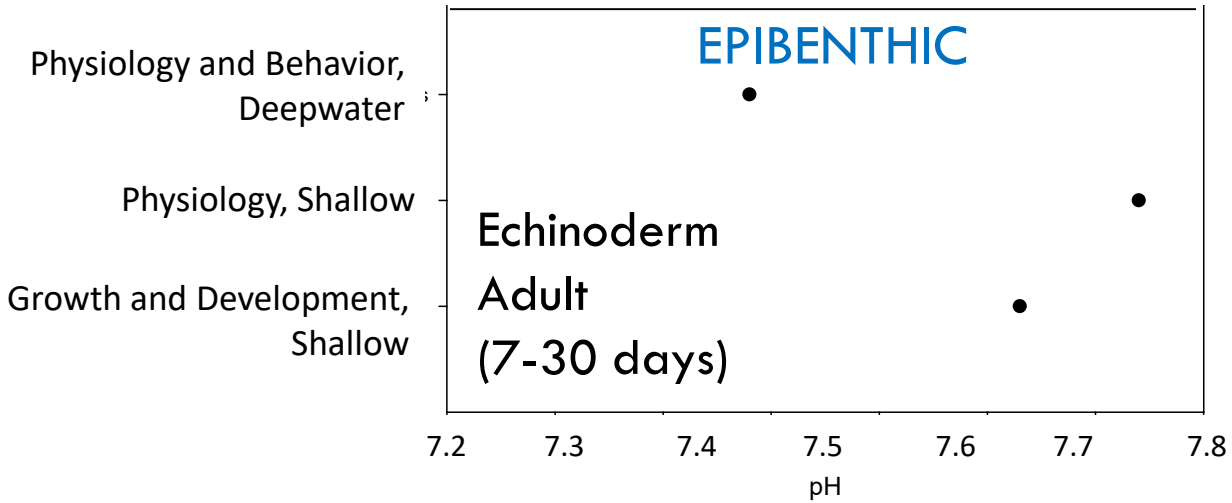
- Echinoderm experts leaning towards pH
  - More directly speaks to internal acid/base regulation
  - But we have some follow up analyses to see whether pCO2 is a better measure

Pteropod and Echinoderms Impacted over pH Ranges from 7.8 to 7.2 at Durations from 5 to 30 days







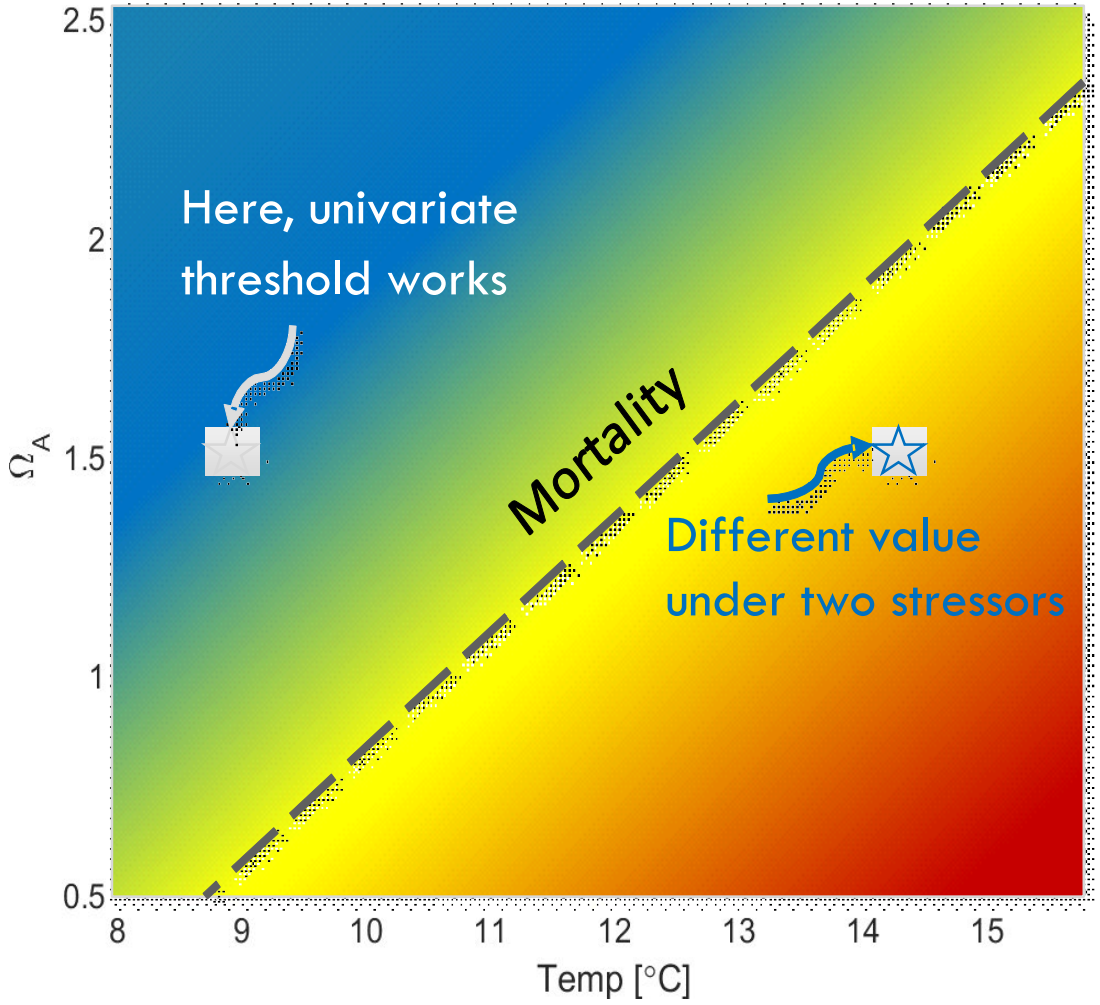


Application of Single Stressor Thresholds is Challenging in Our Dynamic Ocean Environment

- So we know we can get to **univariate thresholds** with a straightforward, consensus-based process…

- But, applying them in the ocean can be more complicated.
  - OA, temperature and DO co-vary, results can be additive, synergistic, or antagonistic
  - How do we account for multiple stressor effects on habitat?

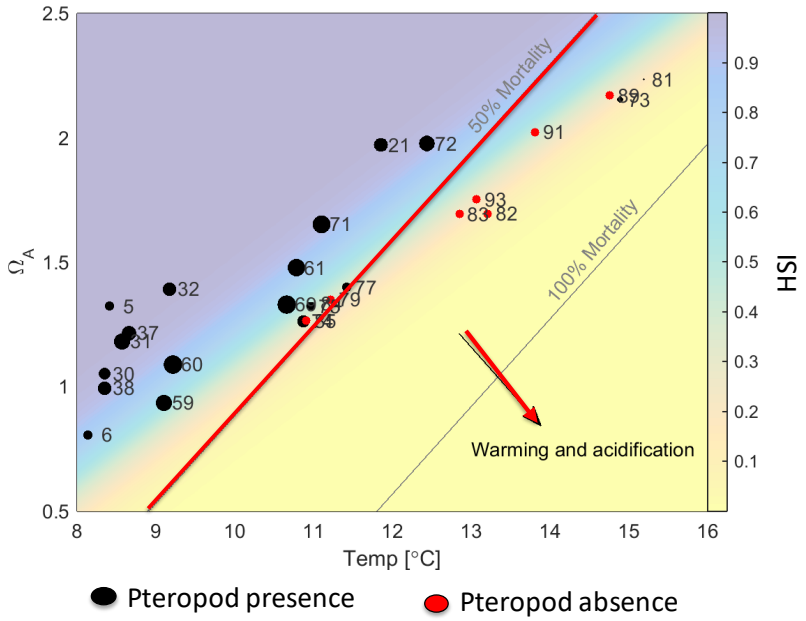
Take home message: We need additional **tools** to assist with interpretation of thresholds under multiple stressors.

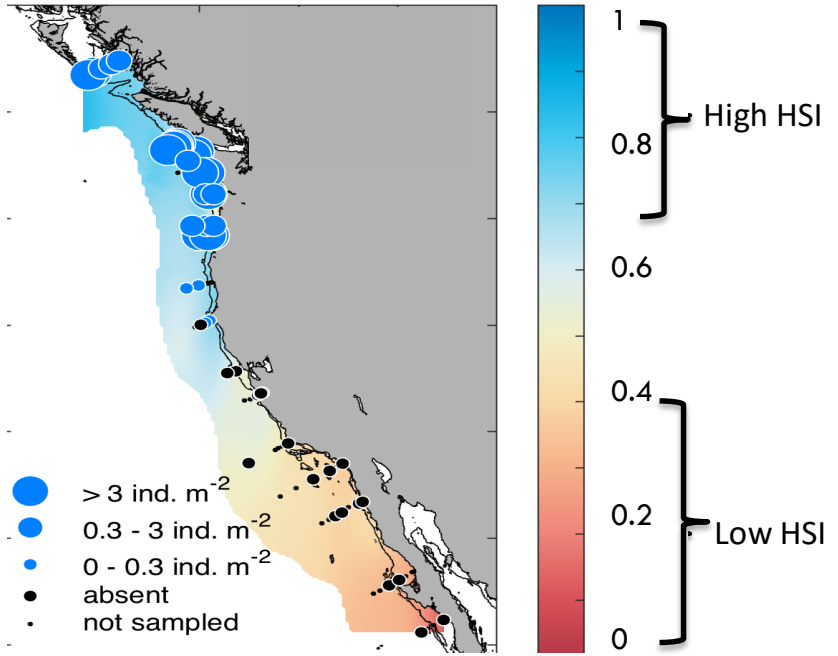


We are Working on Habitat Suitability Index (HSI) Models as a Solution to this Issue

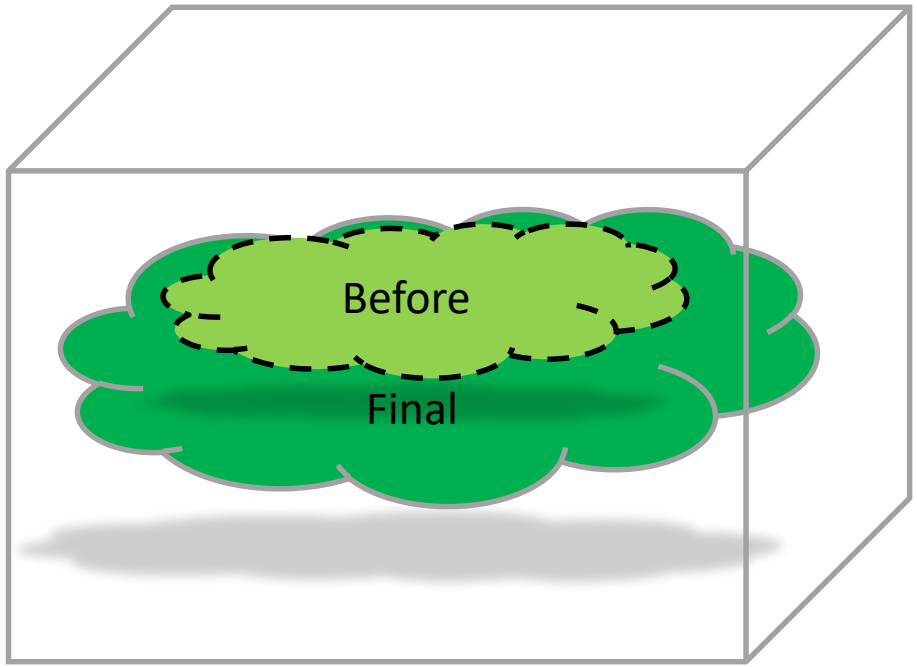
- HSIs are empirical, statistical models of relationship between environmental gradients and species abundance
  - Predict habitat suitability

- *We have an pteropod HSI now,* validated with experimental LC50 mortality data (redline), and independent observational dataset

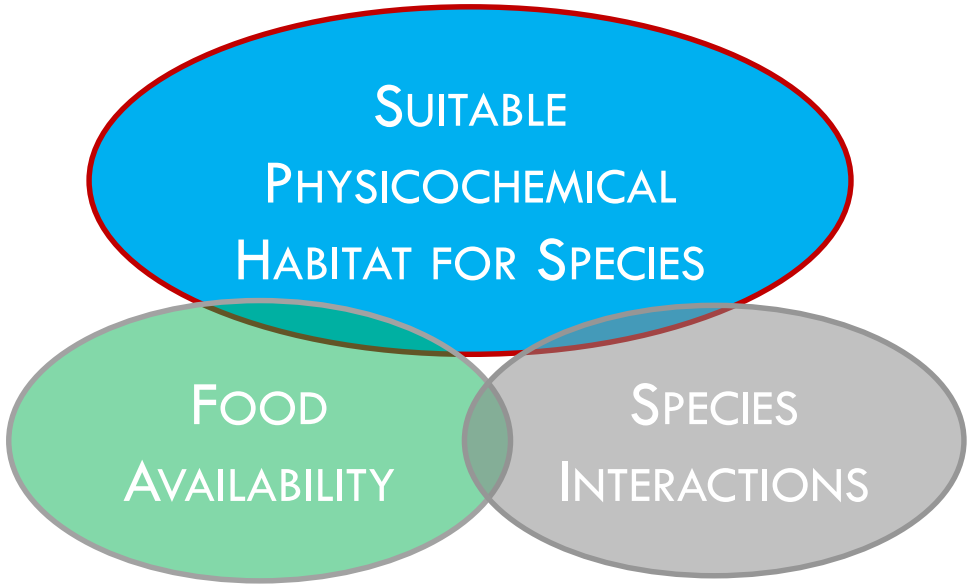




Basic Principles:
When When you Apply these Thresholds to Monitoring Data or Model Output, You are Estimating Habitat Compression



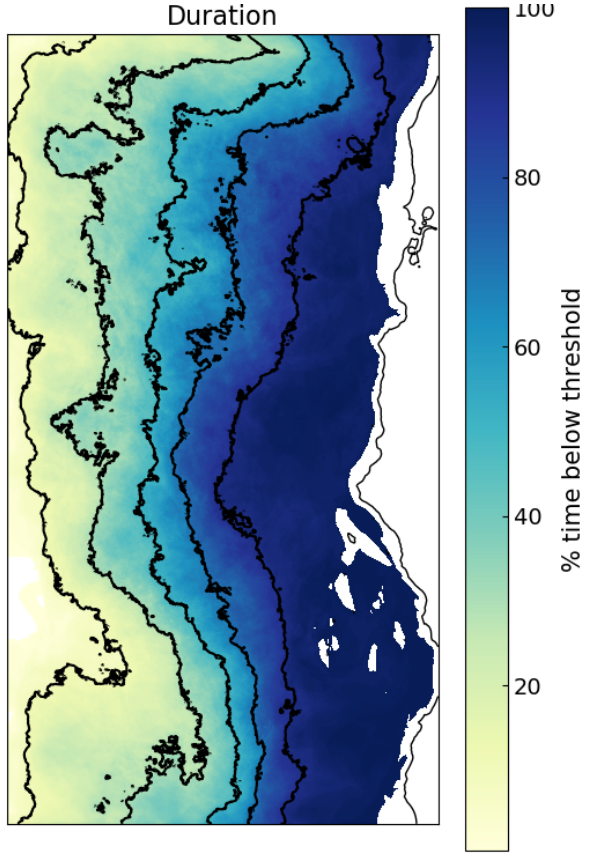
Habitat compression can be spatial or temporal



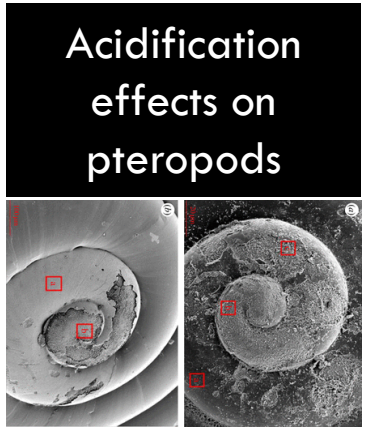
Our team is beginning to work towards predictions of population level (single taxa) and ecosystem effects (trophic interactions)

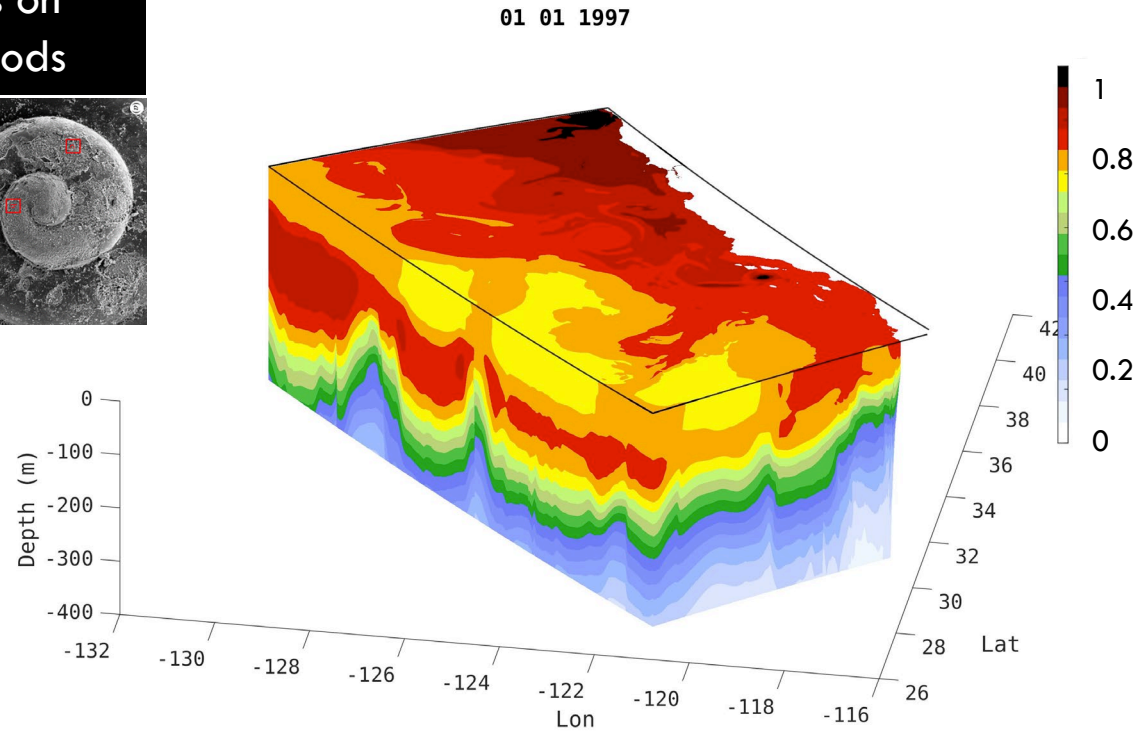
Apply OA Thresholds and HSI Tool to Model Output As Multiple Lines of Evidence to Assess Habitat Compression

Working on Ways to Visual Results to Best Communicate Findings



Adult Survival at 200 m depth, June to February
(Ω = 0.95, 14 days)





HSI Modeled Prediction of High Quality (red) versus Low Quality (blue) Habitat from Temperature Dependent OA Impacts

Next Steps

- Utilize expert derived thresholds and HSI (pteropods only) to conduct assess vulnerability
  - SCCWRP is hosting modeling forum--OPC Vulnerability Assessment Workshop--in late spring 2019

- Third expert workshop on decapods to be held in the late spring 2019

- We look forward to coming back to update you on progress and preliminary findings of next year