Biological Indicators for Ocean Acidification

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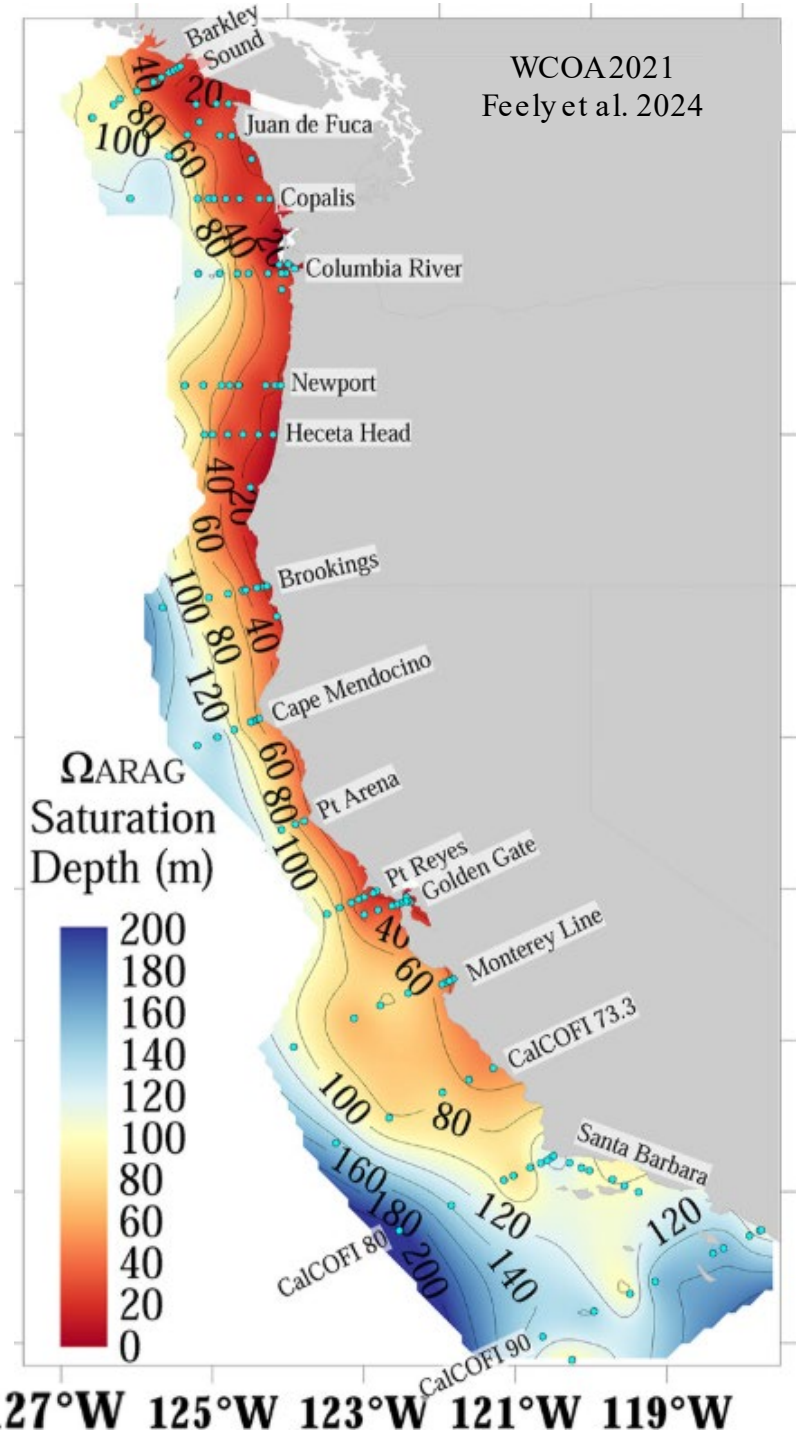
Presentation to Commission

Chemical data for Ocean Acidification are amassing; biological data are sparse

- Ocean acidification is shifting baselines in pH
- Monitoring programs along the West Coast are documenting these changes in space and time
- We lack the biological measures to detect when Ocean Acidification affects biology



Three steps to achieving a biological indicator

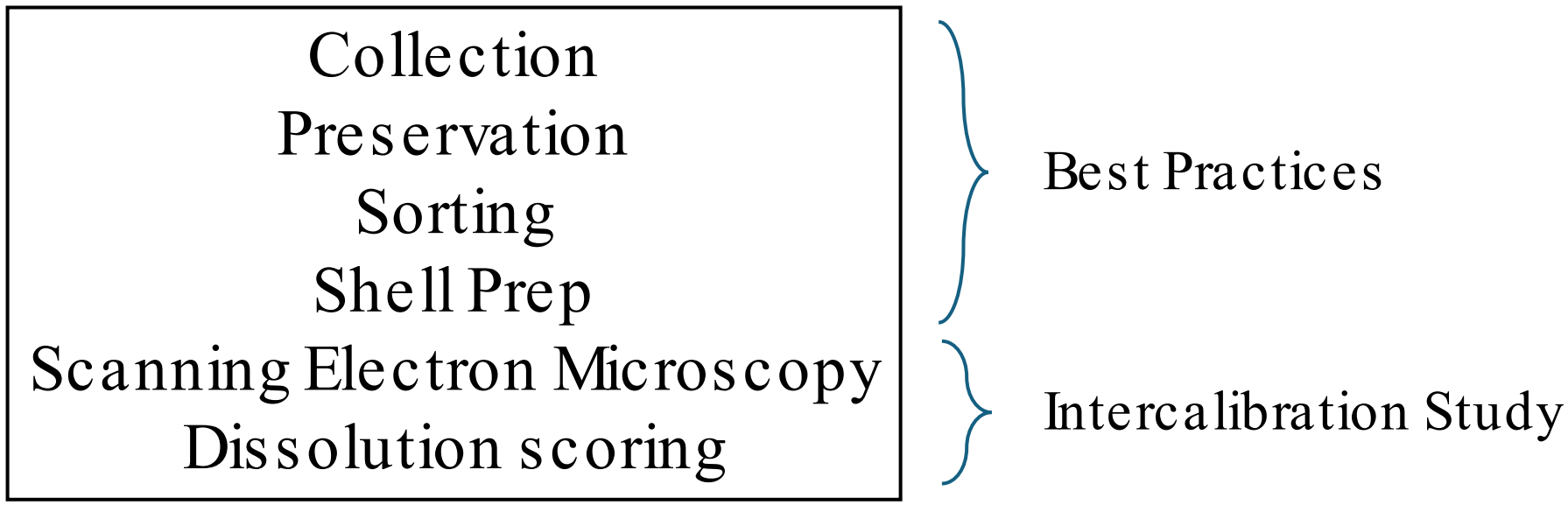
- Which biological endpoint?
- How to measure that endpoint so that it is standardized and repeatable?
- Which target species?

Shell dissolution emerged as leading biological endpoint

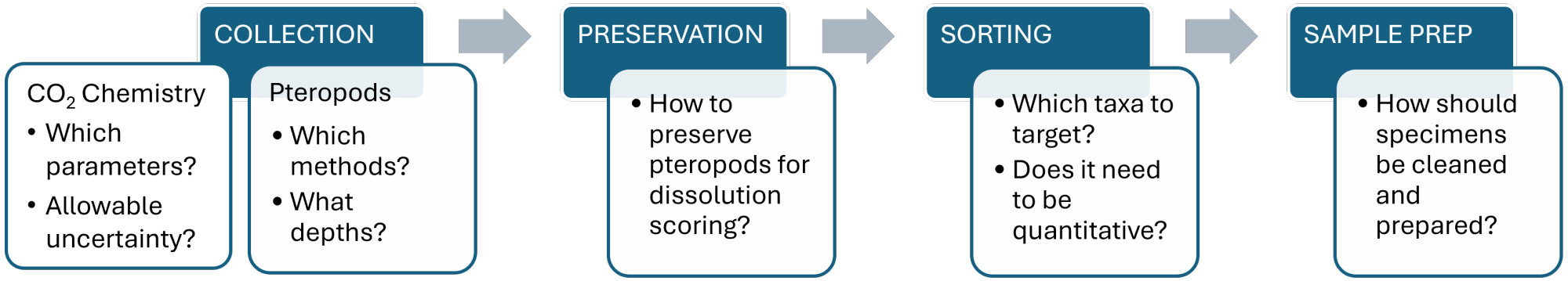
- Workshop identified three top candidates
  - Shell dissolution; Oxidative stress; Stable isotope analyses of oxygen in carbonate
- Bight ‘18 piloted these
- Expert consensus that shell dissolution has best attributes
  - Its use supported by laboratory and field studies
  - Specific to OA

How to measure that endpoint so that it is standardized and repeatable?

- Measuring shell dissolution has many steps



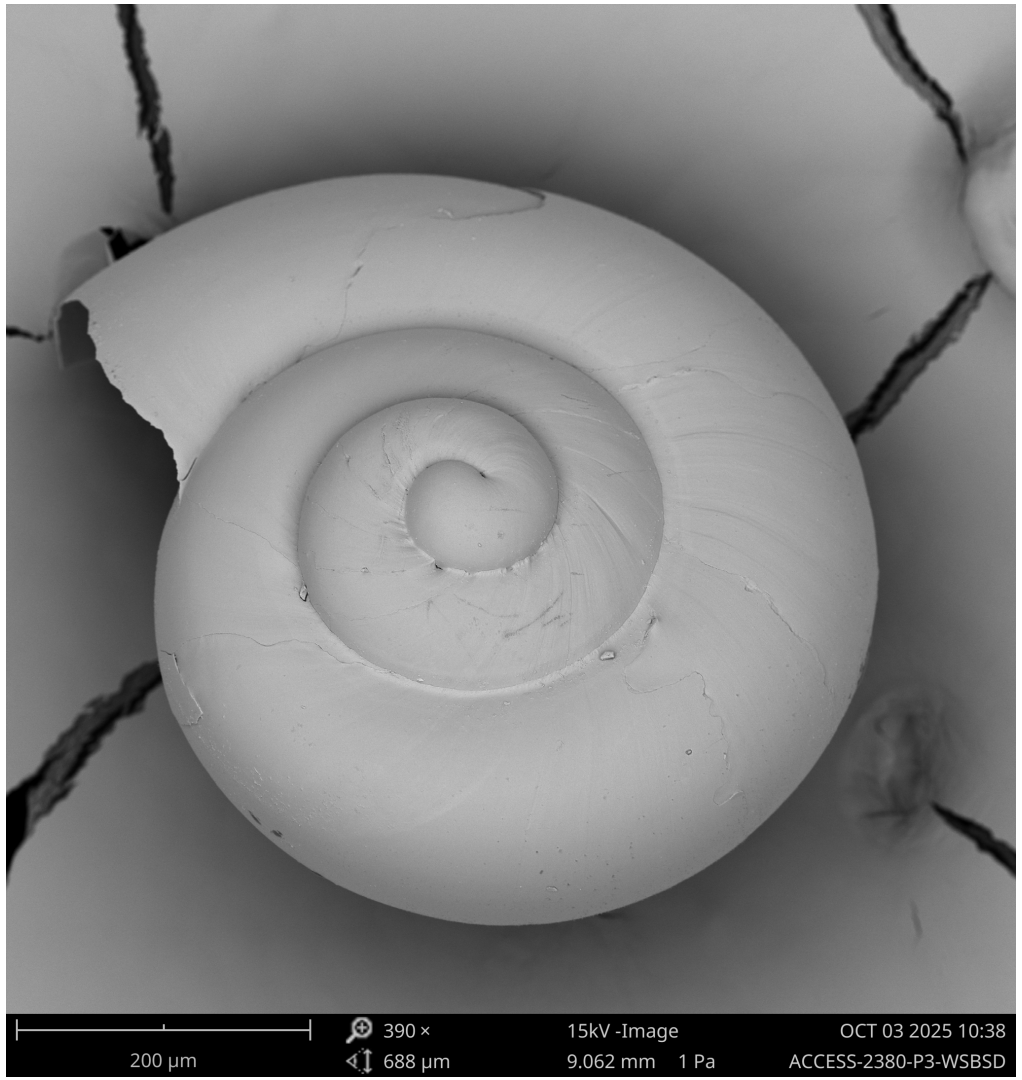
West Coast programs were collecting pteropods, but lacked coordination on how to do so



- An expert workshop with key monitoring partners and experts was held to discuss these issues
- Product: A "Best Practices" document

Intercalibration Study on shell dissolution identification is underway

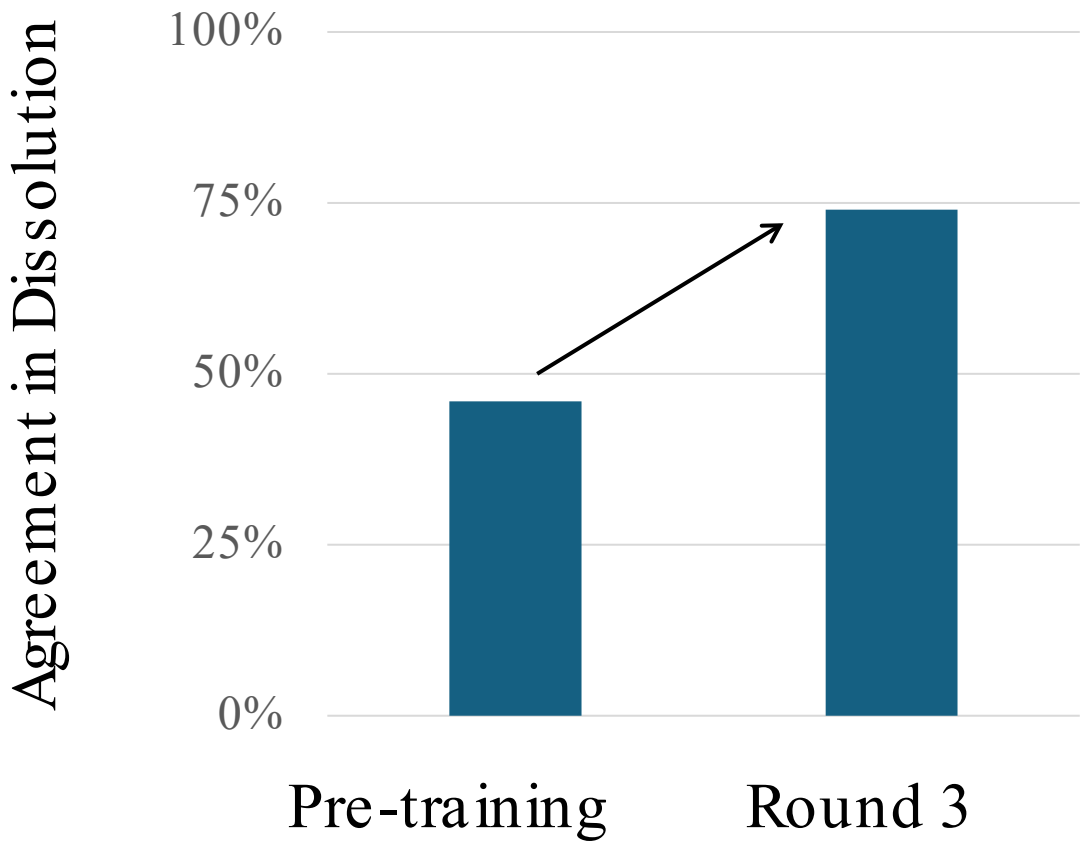
- Identifying dissolution requires visual interpretation
- Multiple sources of variability
  - Analyst experience/training
  - Instrument and Protocol
- Intercalibrate to improve confidence and comparability



Intercalibration Study Questions

1. How repeatable are existing methods at scoring shell dissolution?
    - Intensity of dissolution on the shell
    - Percent of shell covered by dissolution
2. What contributes most to error?
3. What improvements can we make to the protocols?

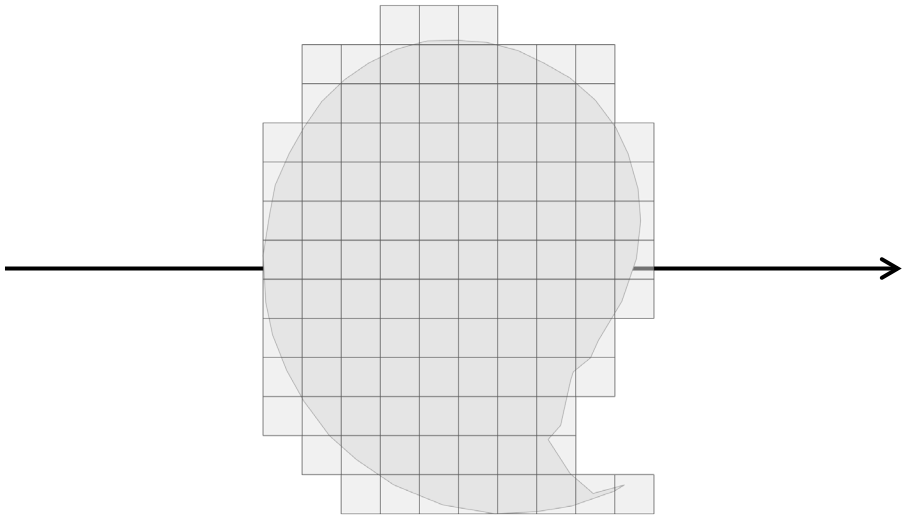
Existing protocols were insufficient for intensity and mapping dissolution; Training results in improvements

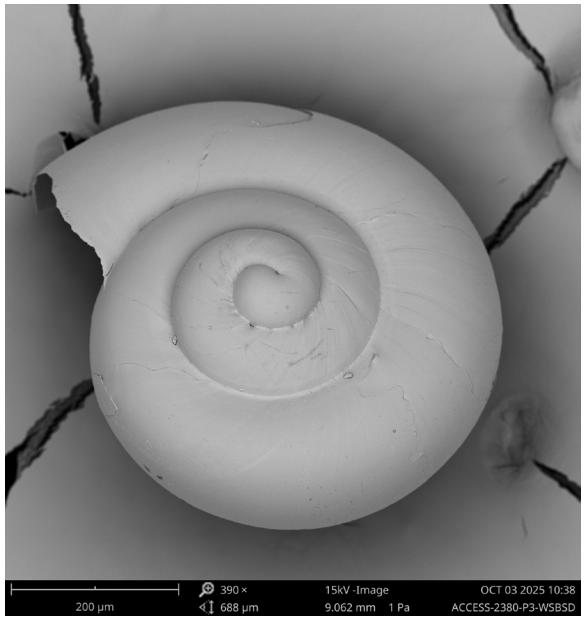


- 30% increase in agreement
- Early results; We have another round

What improvements can we make to existing protocols?

- Original protocol specified subsampling 20% of shell
- We are now censusing the entire shell
  - Improvements made possible by working with manufacturers





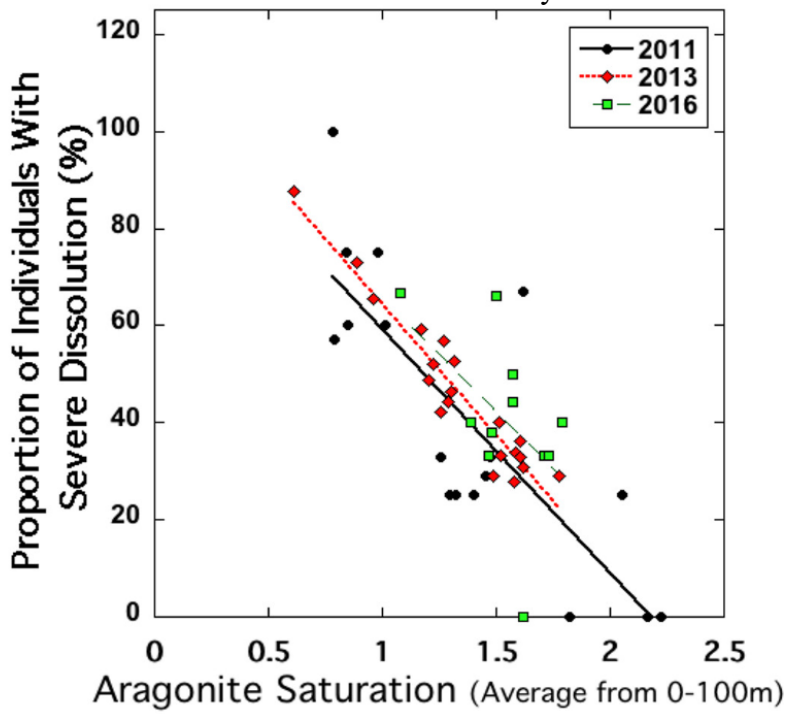
Three steps to achieving a biological indicator

- Which biological endpoint?
- How to measure that endpoint so that it is standardized and repeatable?
- Which target species?

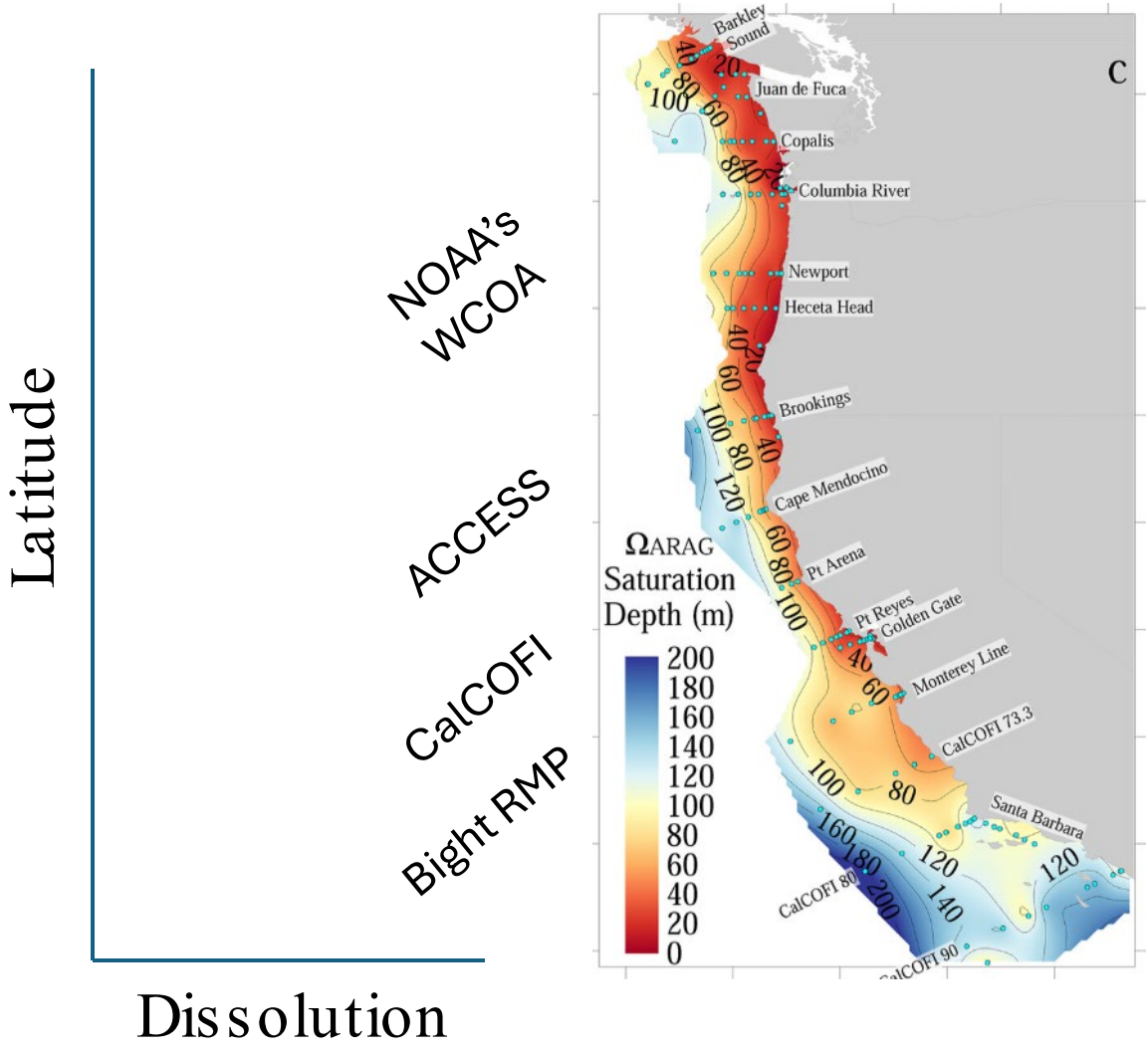
Choice of target taxa depends on the question

- How does shell dissolution compare with other geographies along the U.S. West Coast?
- How does shell dissolution correspond to a gradient in aragonite saturation state?

Feely et al. 2024



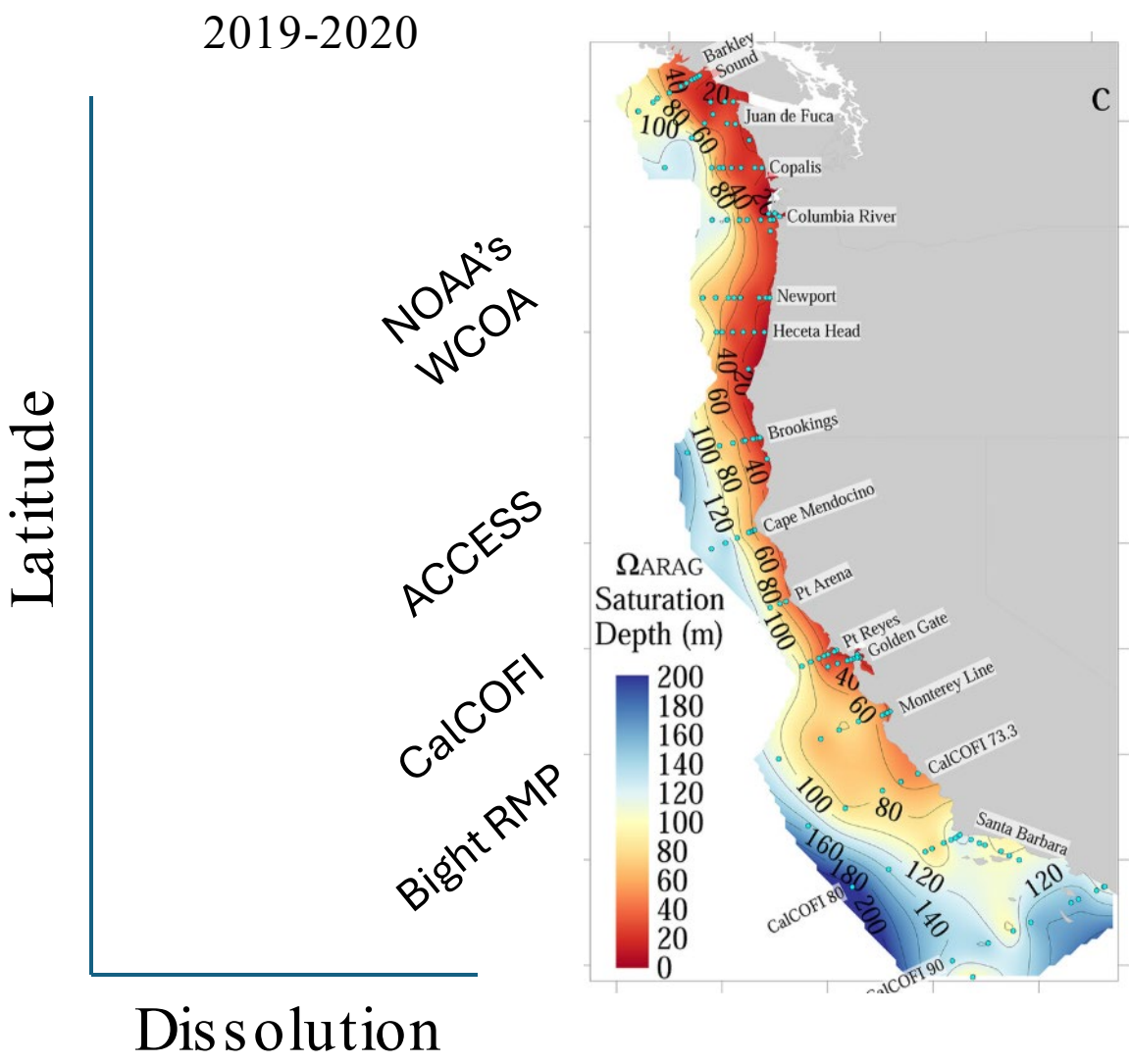
Key attributes to answer Question 1



- Coordinated monitoring across 18 degrees of latitude
- Target a species with…

- Demonstrated sensitivity
- Easy to catch
- Wide distribution

We are facing challenges to answer Question 1



- Limacina helicina is the species that NOAA cruises have previously focused on
- During Bight 18, not captured in southern California
- Currently, no obvious alternative

Activities to resolve Question 1 challenges

- Partners continue to sample for biological material
  - NOAA's coast-wide WCOA cruise – June 2026
  - CalCOFI cruise – July 2026
- OC San continues to sample
  - Is sampling Limacina in southern California contingent on oceanographic condition? Is there an alternative species?
- Conferring with Bight OAH Committee to participate in the 2026 summer sampling campaign

Answering Question 2 remains an important value to Bight Program

- Two candidate taxa
  - Larval shelled gastropods
  - Pteropod, Clio pyramidata
- Confer with Bight OAH Committee in April, identify path forward
- Rely on strong partnership with CalCOFI to support decision
  - We want to select something they support and can sample as well

We remain at the forefront of chemical-biological monitoring of OAH

- Unique in our multi-program coordination to OAH
- We have made necessary improvements so that protocols are standardized and repeatable
- While we face challenges, we have activities planned to address path forward