Measuring Climate Variation at the Coast: Challenges and Opportunities for the Coming Decade

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Challenges

- Changing oceans, atmosphere and cryosphere, on a wide range of time and space scales

- Impacts to physical, biogeochemical, ecological and social systems

- The coupled system is (badly) under-sampled

- Systems of interest cross (many) disciplinary boundaries

- Systems of interest are increasingly nonstationary

- How best to identify extremes in the face of shifting baselines

 - Or will we be overwhelmed by catastrophic events, e.g. Bering Sea snow crab fisheries die-off?

Collapse of the eastern Bering Sea Snow Crab, Szuwalski et al., 2023, Science
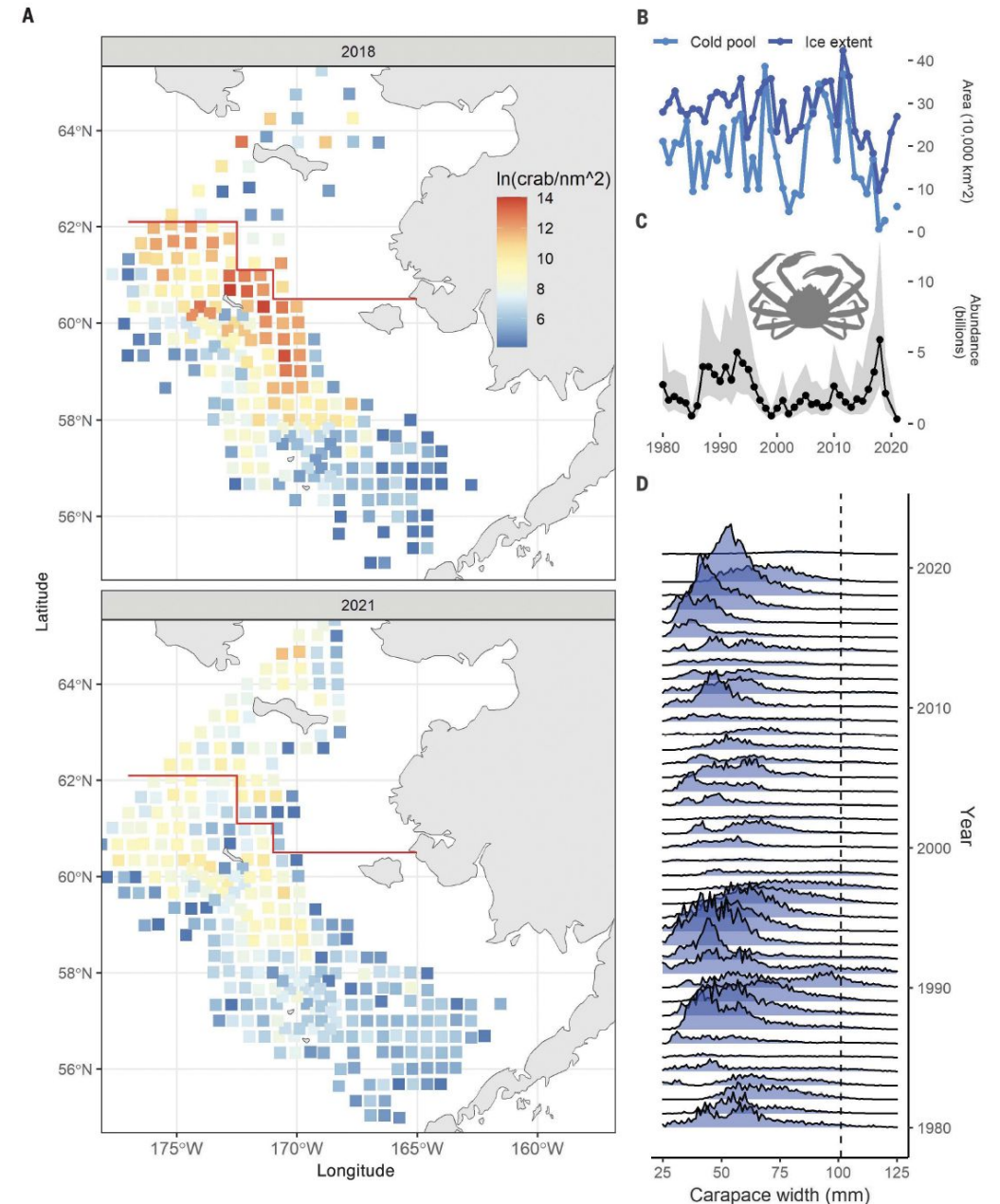
Given a footprint of the US EEZ, we must:

- utilize the breadth of observing assets at our disposal
  - Fixed (buoys, moorings)
  - mobile (ships, floats (surface and profiling), gliders, saildrones, wavegliders, animal tags,…)
  - remote sensing platforms (satellite [SWOT, PACE], coastal, offshore platforms to host acoustics, lidar…)
  - Coastline, coastal and benthic mapping (repeated)
  - monitoring (NOAA, IOOS, OOI, USGS, EPA…)
  - process studies (NSF, NASA, DOE,…)
  - human activity/use
- and observe physical, biogeochemical,
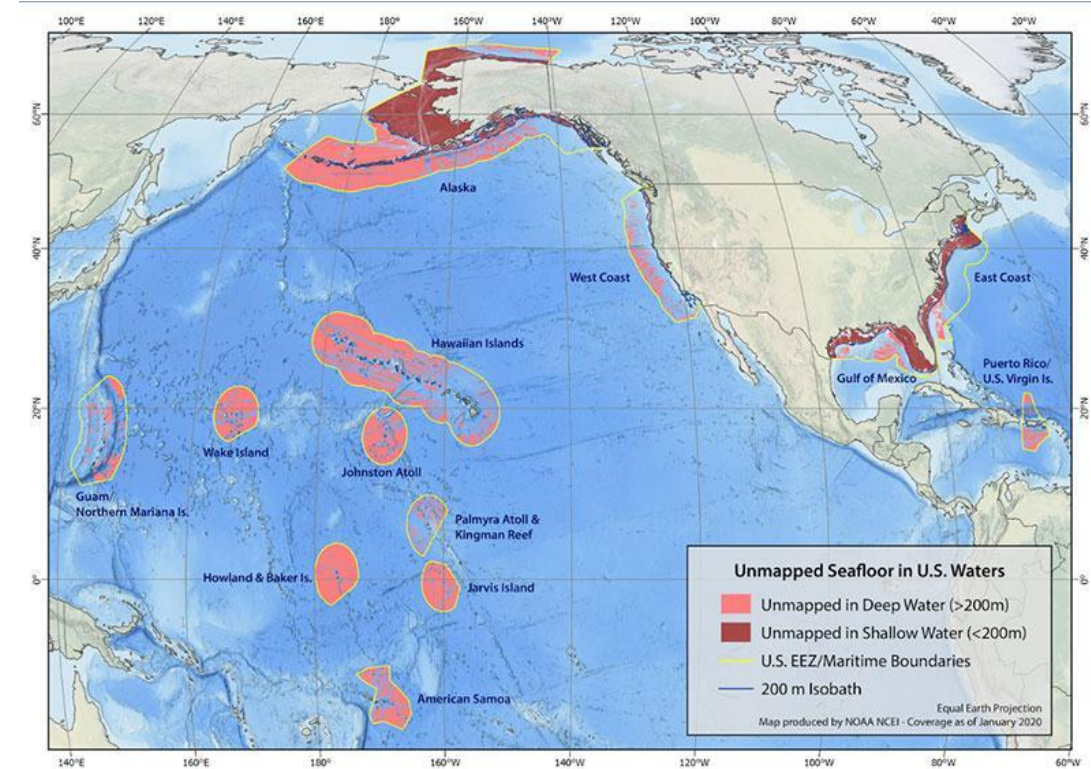
NOAA OE

# Modeling – a critical need given we are under-sampling

- Models of all types will be needed to interpolate information spatially and with time, but also to enable analyses of complex connections and sources of greatest uncertainty, e.g.
  - Nowcast/forecast systems – regional/nested/downscaled
  - Reanalysis – regional
  - Coupled NPZD
  - Ecosystem models
  - Correlative distribution models

- can evaluate impact of new observations, identify how new resources can be applied.

- And play a critical role in…

Impacts of MHWs on top predator distributions are variable but predictable, Welch et al., 2023. Nat. Comms
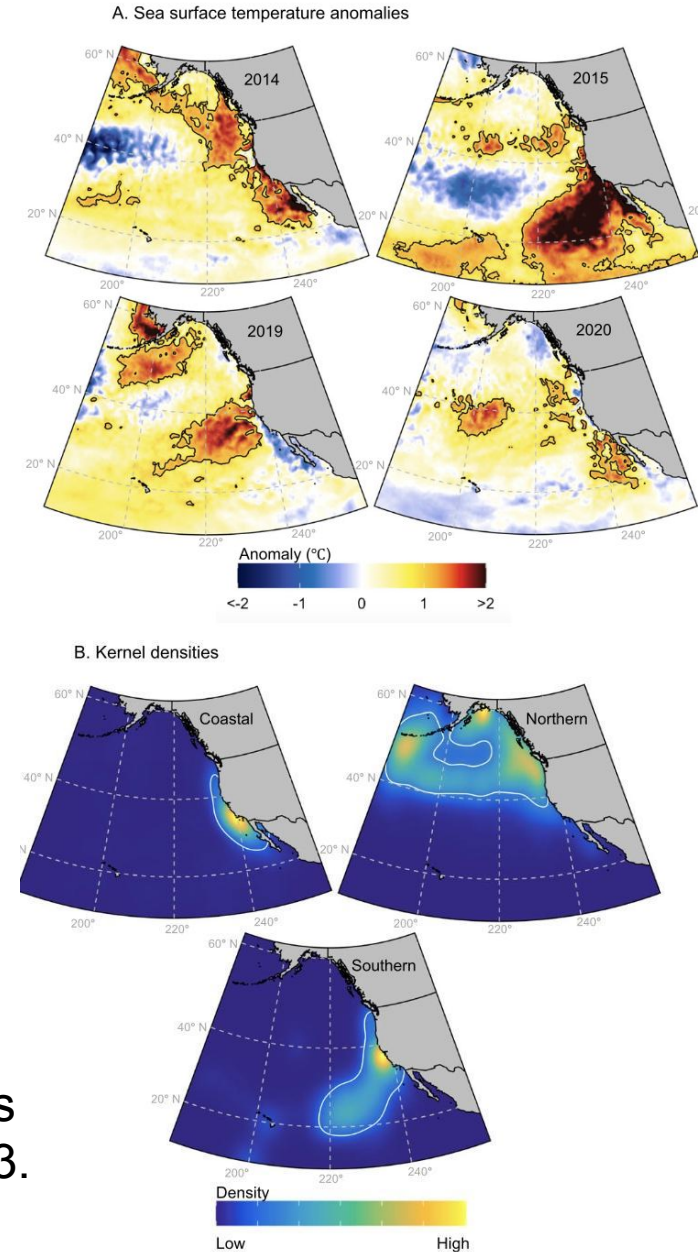
Attribution

- Can the cause of phenomena be identified?
- May be increasingly important, e.g. distinguishing larger-scale climate variations from more local effects, like offshore wind farms, fishing
- Spatial and temporal scales of 'variation' likely major clues
- Analyses and models of all types will be needed

Effects of warming and fishing on Atlantic sea

Z. Zhang et al., 2023, ICES JMS
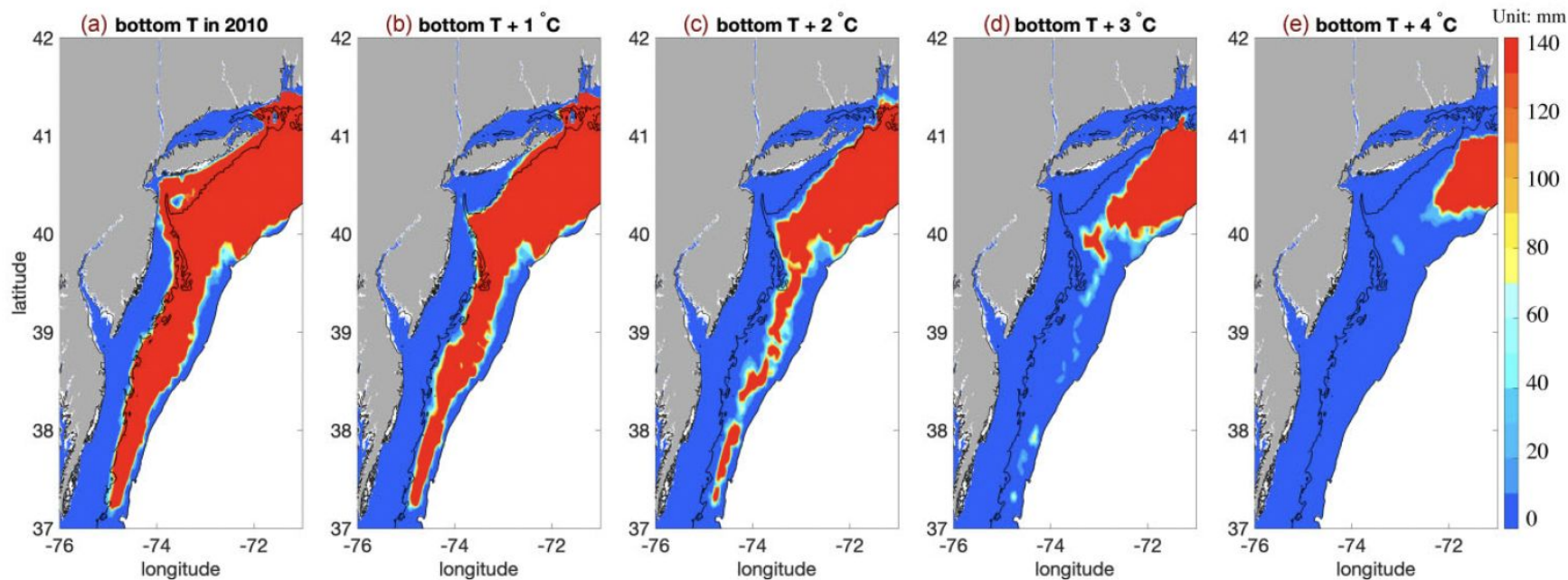
Leverage opportunities for more resources

- aligned interests:
  - coordination among funders of climate studies (e.g. NASA, Navy/DOD, DOE) – highlighted in the plans shared with us
  - partnerships with maritime industries (e.g. shipping, fishing)
  - renewable energy studies, operations and monitoring
  - vessels of opportunity
  - Citizen science
  - ?

Key actions

- streamline and incentivize data (writ large) sharing;

- reviewing existing observations, and existing observational plans – lots out there, wide variations geographically

- promote investment in essential variables that are under-reported and which are deemed critical indicators (geographically-tailored)

- Use existing knowledge and modeling systems to help optimize observing system design

Old idea whose time has come?

- Regional-scale ocean forecasters – analogous to NWS field office forecasters – but connected across organizations?
- Staff dedicated to analyzing and understanding ocean variability
  - Will require regular data examination, sharing
  - Will highlight where observing is lacking and uncertainties are large
  - Will enable tailoring to regional issues

Summary

- Coastal settings require geographically-tailored, transdisciplinary approaches to assessing climate variability (observing, modeling, application)

- Coordination is challenging given the wide range of organizational missions – what can be unifying activities?

- Application of understanding, for safety, health, resilience, etc. should be integrated across impacts, requires new level of synthesis