Shifts in habitat and demography of American lobster in coastal Maine over the past quarter century

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Outline

Patterns & Demography

Paradigm Shift

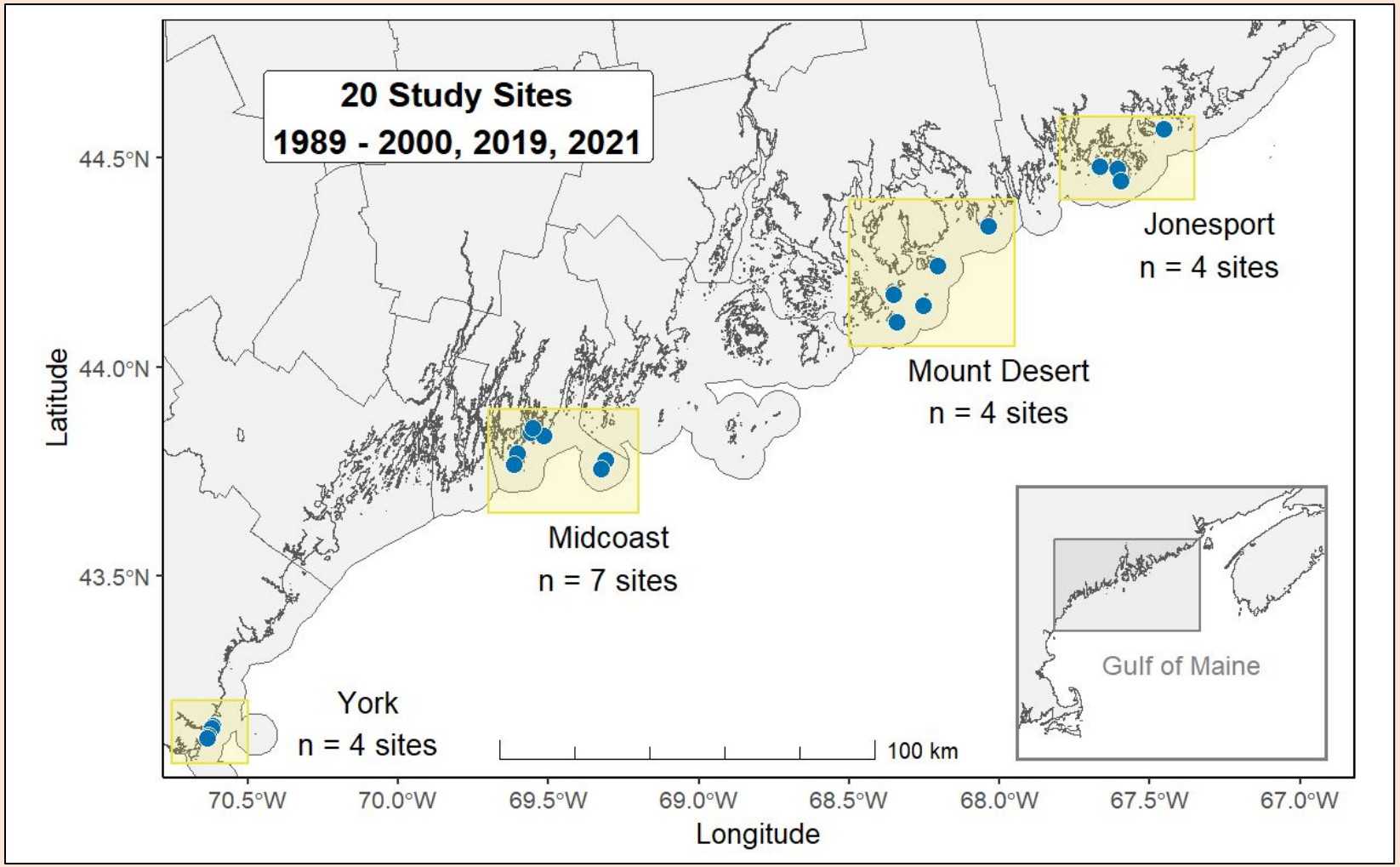
Driving Processes

Changing Habitat

Implications

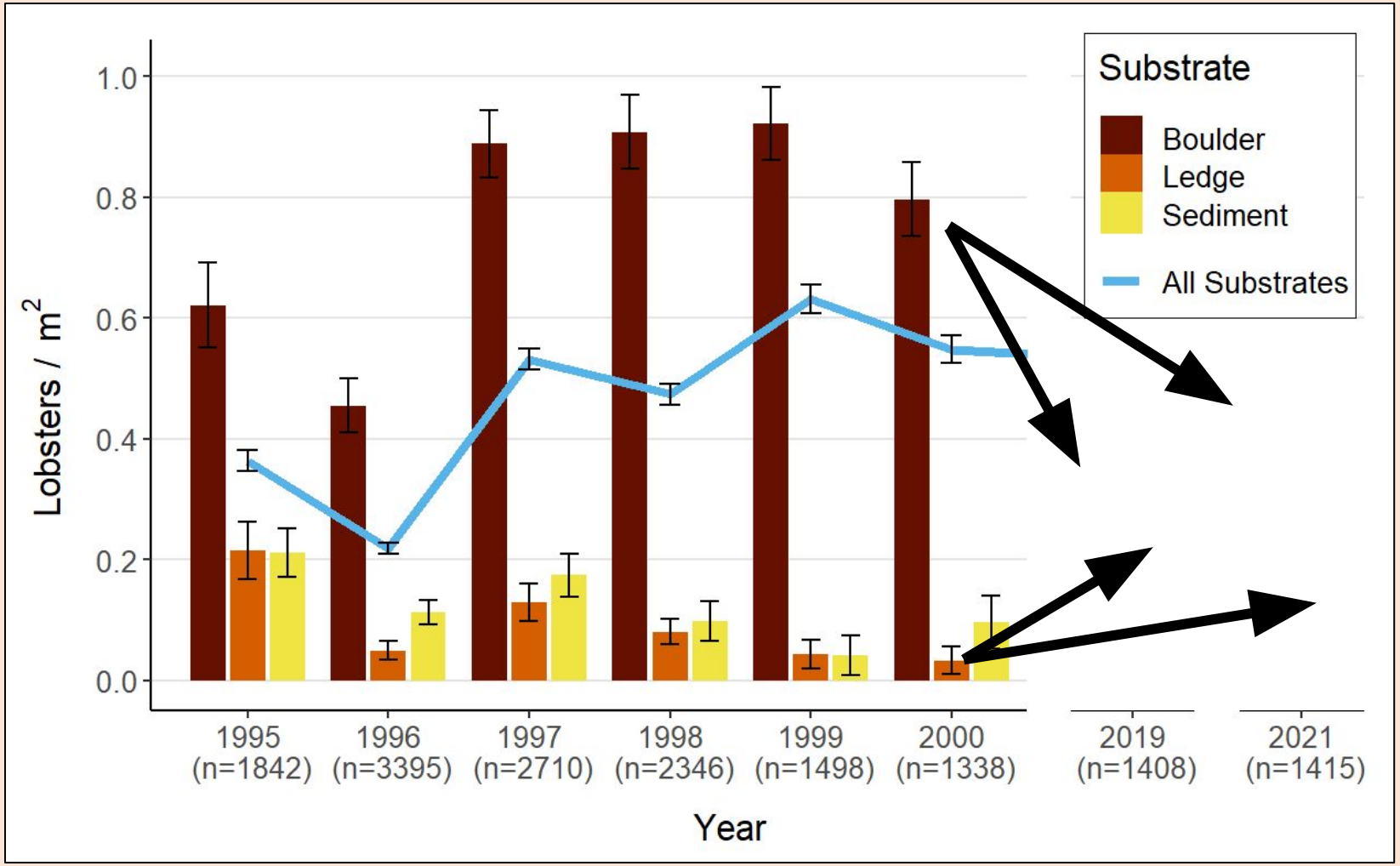
Quadrat Sampling

- Revisit Steneck & Wilson 2001
- Same methodology & sites
- 10 m depth
- Target boulder, ledge, & sediment habitats



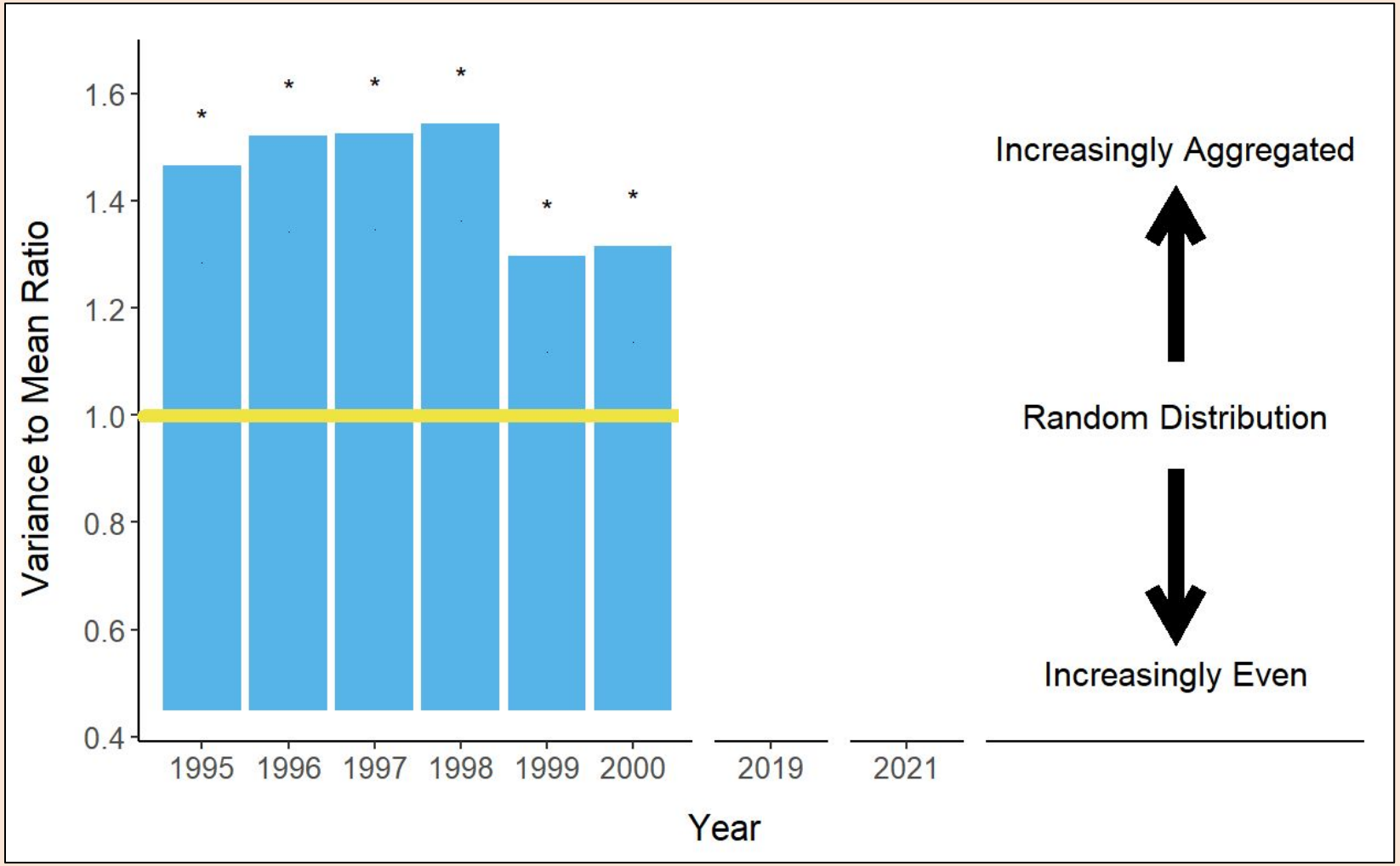
Population Densities

- Historically, lobsters almost exclusively used boulder habitats
- Overall decline from 2000 to 2019
- 60% decrease in complex boulder substrate
- Featureless ledge and sediment substrates increased 633% and 280%



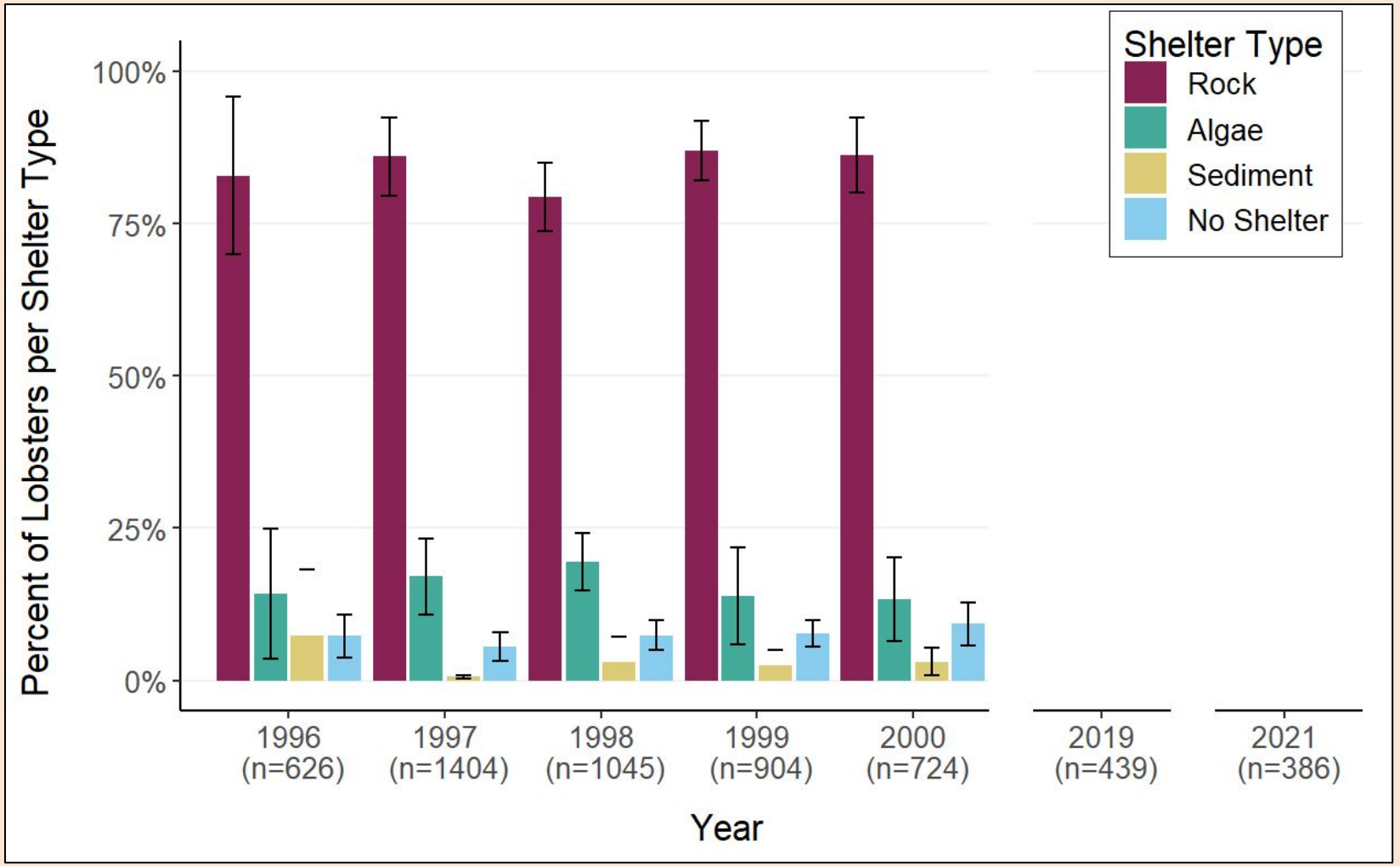
Distribution Shift

- Historically, lobsters were aggregated in boulder substrate
- Lobsters are now more randomly distributed across substrates



Shelter Use

- Rock shelters are most frequently occupied but declining 34% from 2000-2019
- Lobsters observed beneath algae or not using a shelter increased 161% and 168%



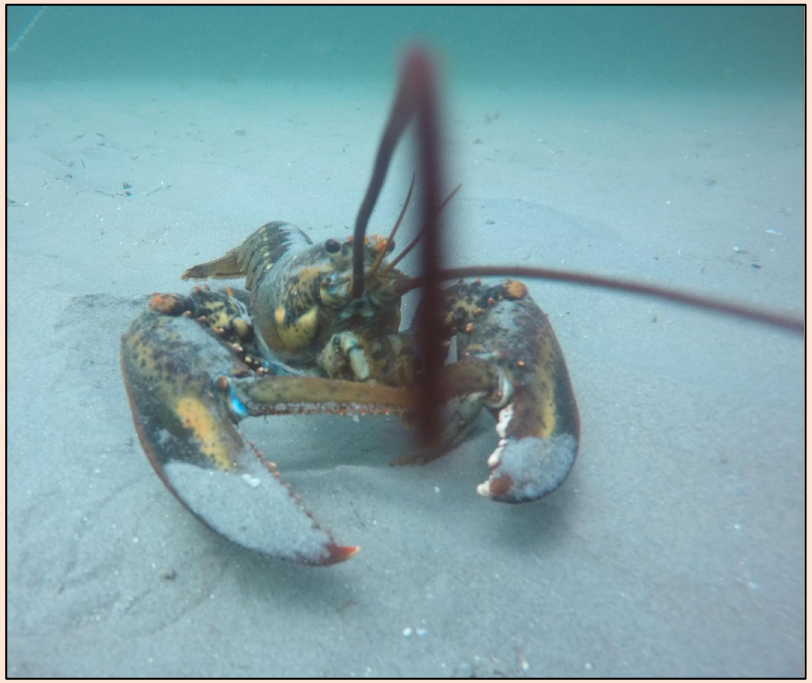
Historic Paradigm

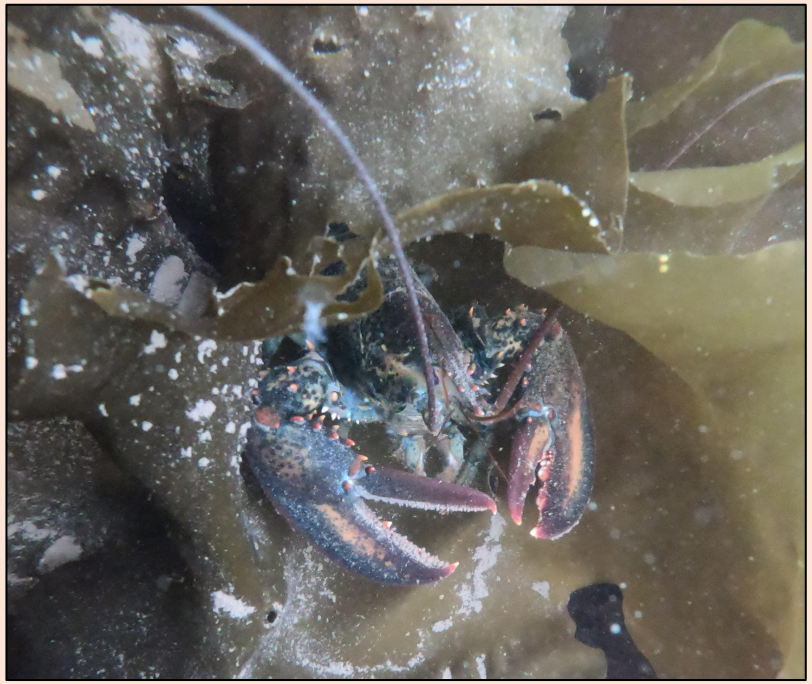
Lobsters concentrated in boulder habitats, using rocky shelters

New Paradigm

Lobsters using boulder, ledge, and sediment habitats
Many still using rocky shelters, but more lobsters are out in the open and moving around

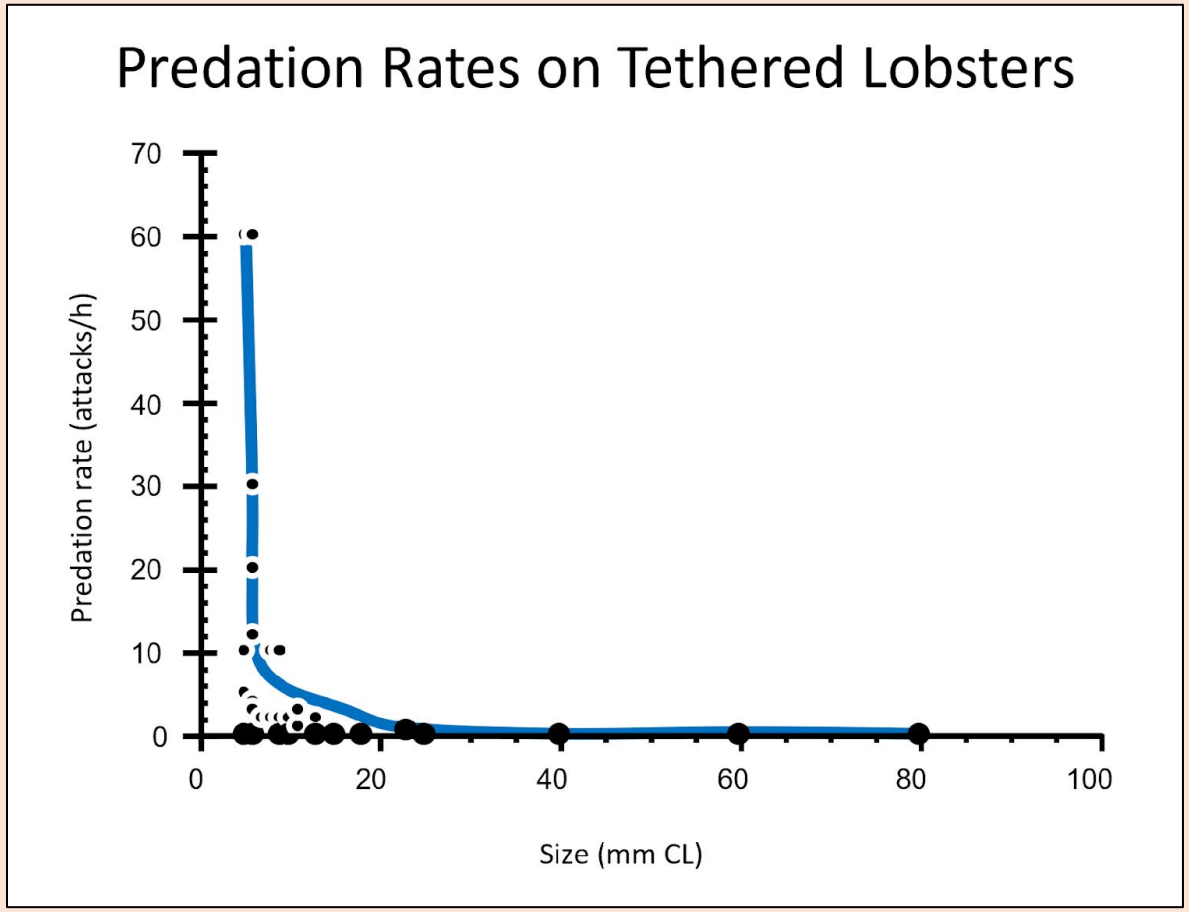
Why has lobster sheltering behavior declined?





Low Predation Risk

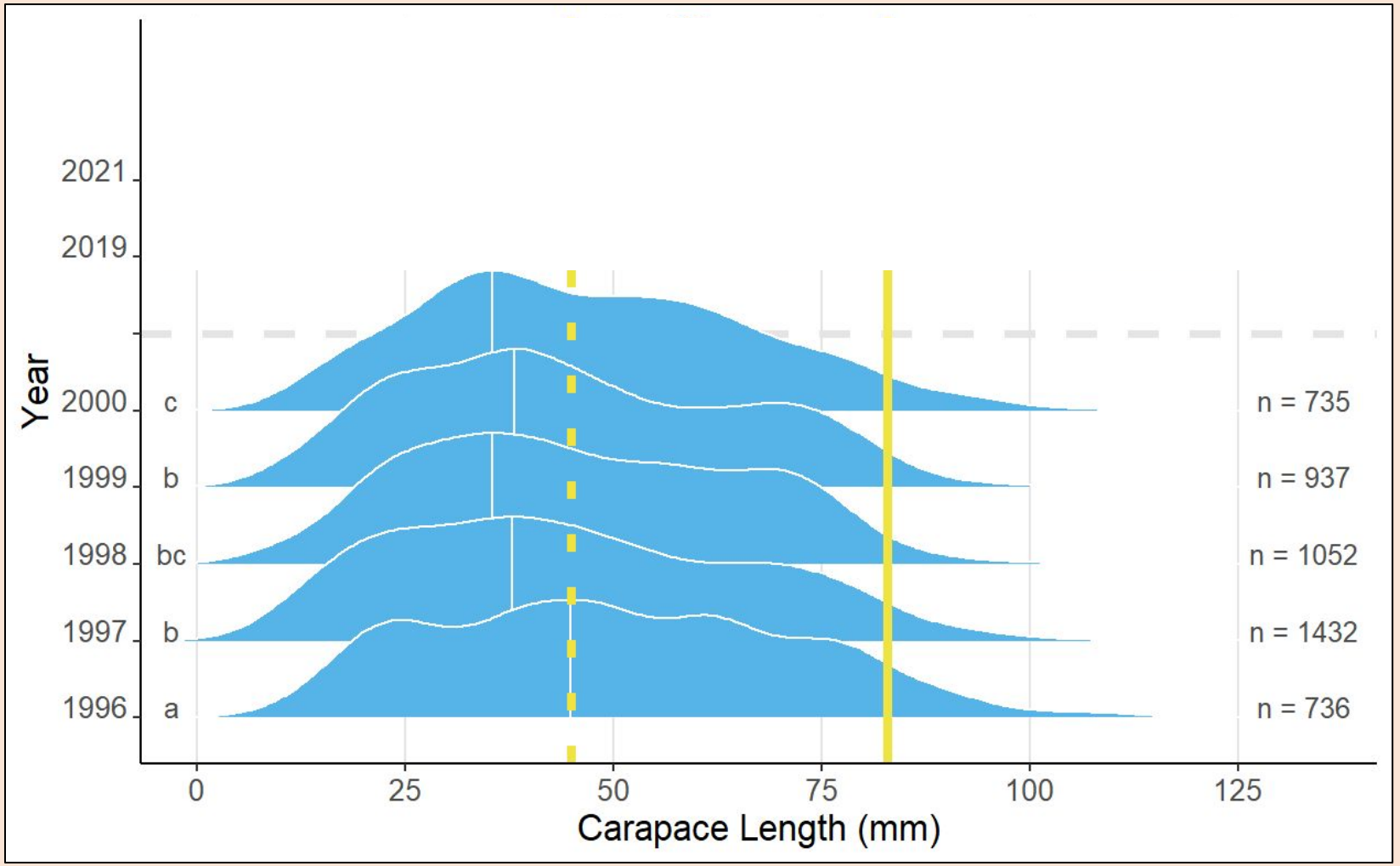
- Large predators functionally extinct by the 1990s in shallow coastal Maine
- Most risk is for newly settled lobsters, shelter is not necessary beyond early benthic phase
- But lobsters are still thigmotactic and seek shelter despite a lack of predators
- Enables subsequent change in ecological processes



(Wahle and Steneck 1992)

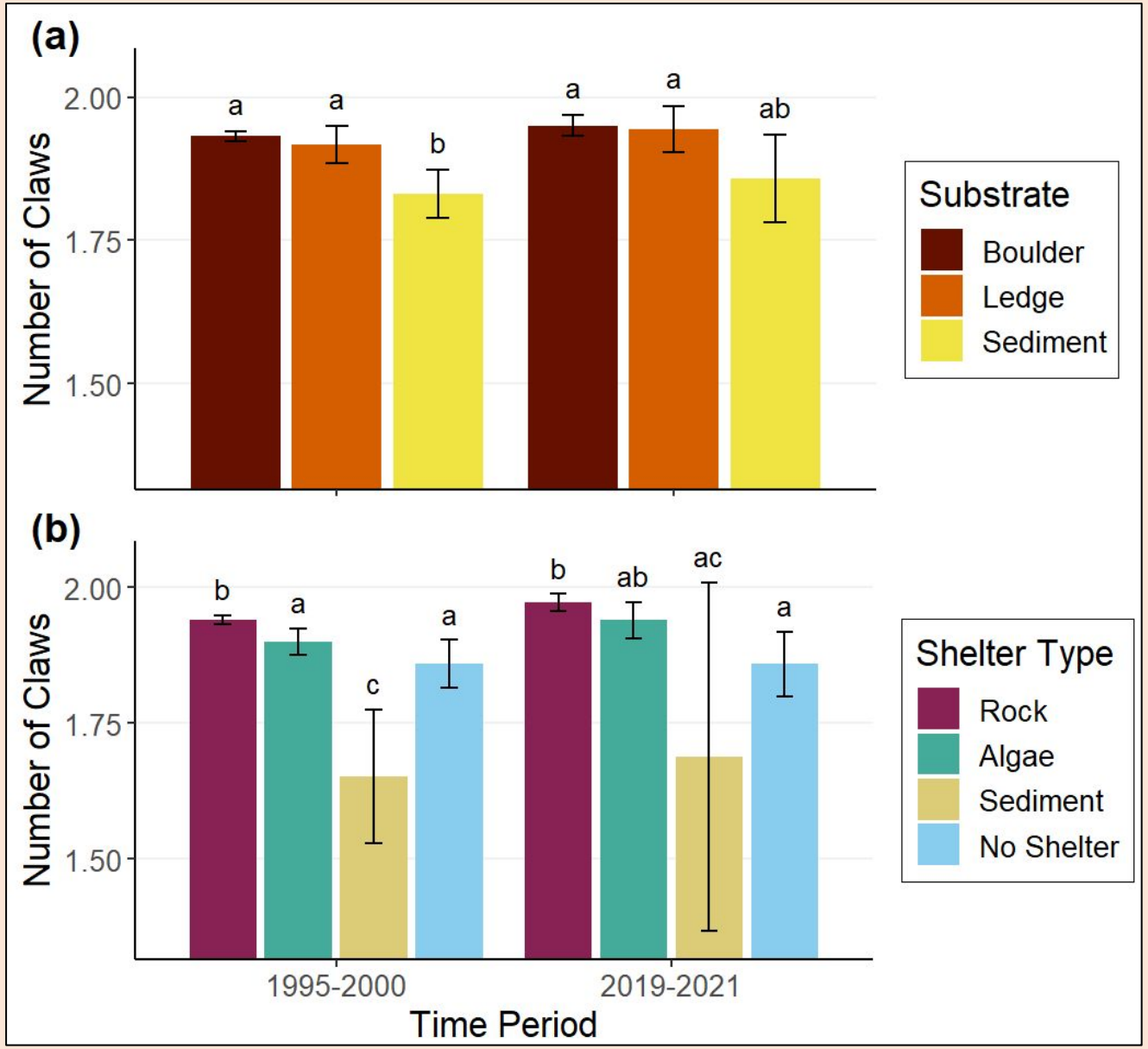
Size Distribution

- Dominated by early benthic phase pre-2000, switch to adolescent phase dominance 2019/2021
- Likely driven by the documented decline in lobster settlement at 10 m depths



Habitat Preference

- Number of claws determines competitive dominance
- For each substrate type & shelter type, no significant difference between time periods
- Sediment substrate and sediment pit shelters are less preferred, while boulder substrate and rocky shelters are most preferred
- Indicates habitat preferences have not changed but competition has

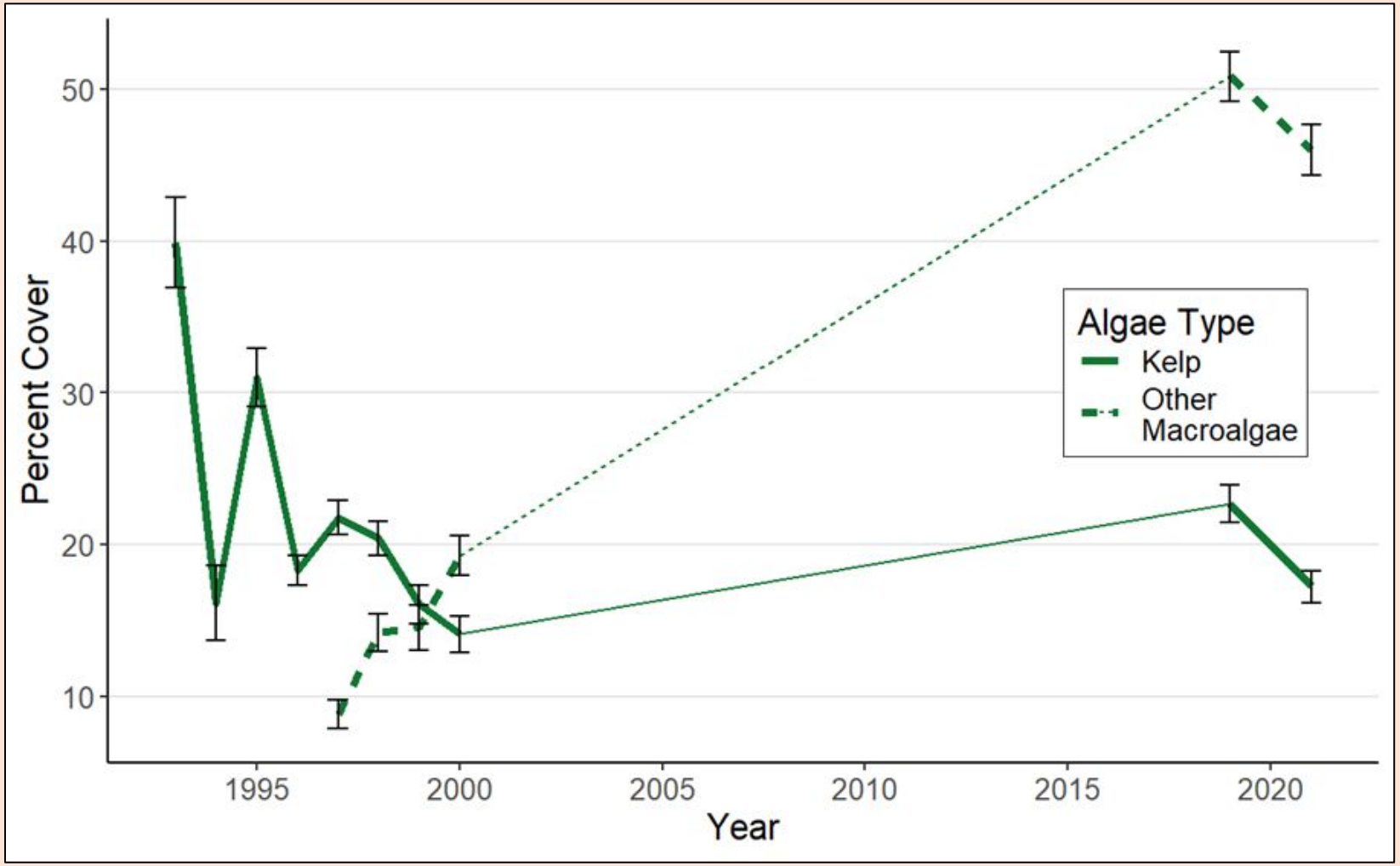


Intraspecific Competition

- *Demographic Diffusion* – experimental studies showed that larger lobsters would leave habitats having high population densities, though they are competitively dominate, often going to deeper habitats where population densities were lower (Steneck 2006)
- Decline in overall population density and the decline in smaller early benthic phase lobsters may have relaxed competition
- Suggesting demographic diffusion is no longer the dominant paradigm shaping size and distribution
- Larger adolescent and adult lobsters may now be retained in the shallow habitats and as they compete for space the losers may have spilled over into the less preferred habitats

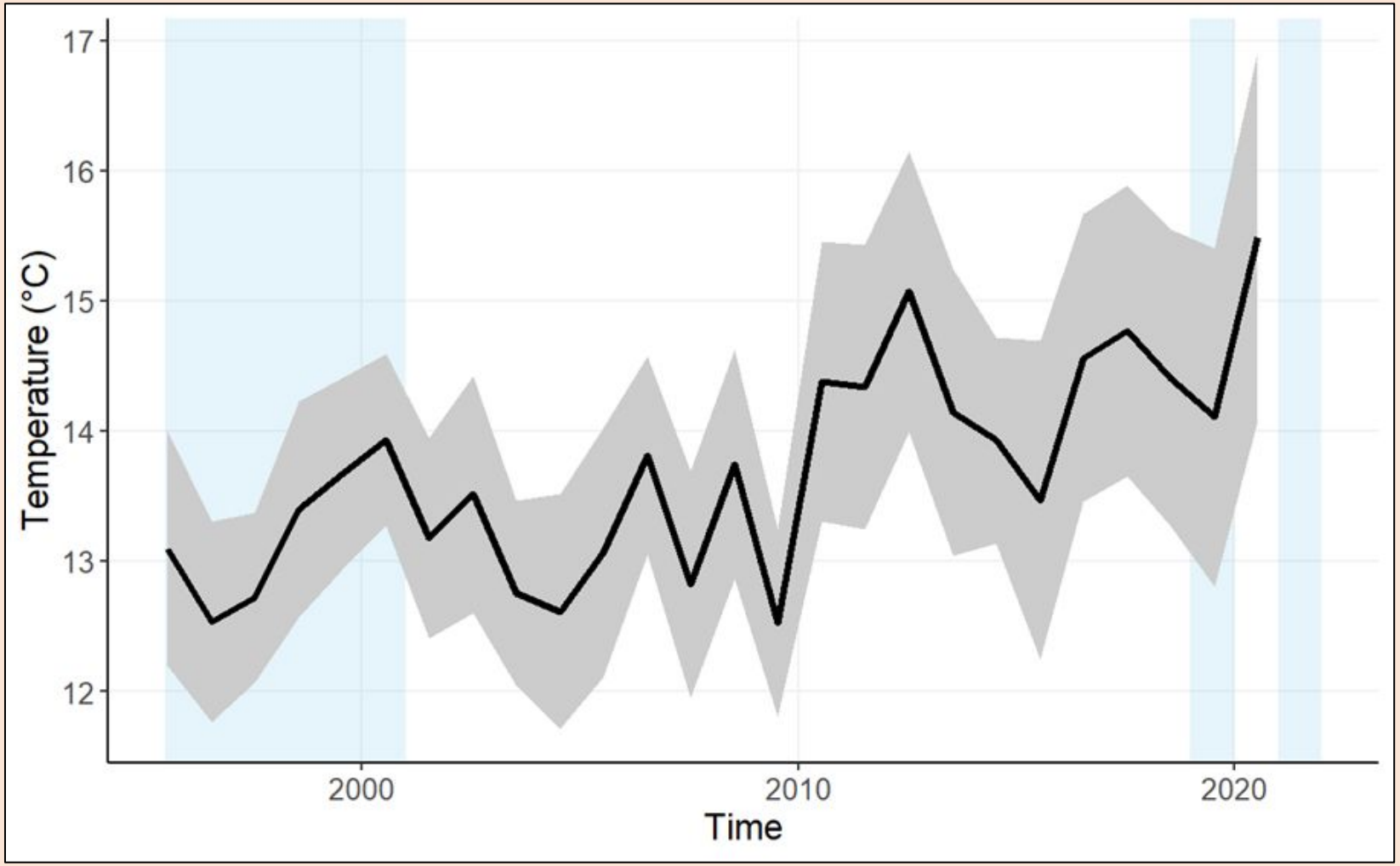
Algal Community

- Decline in kelp during the 1990s
- Increases in other macroalgae, filamentous species dominating in 2019, 2021
- Lobsters moving around beneath the higher canopy algae, account for increases in algae sheltering



Rising Temperatures

- NECOFS modeled bottom water temperature was averaged across study sites
- ~3°C increase in the mean from the start of our study and a rapid shift of increased temperature in 2010
- Lobsters spend more time out of their shelter to forage with increased temperatures



Implications

Trap Catchability

- Hydrodynamic difference in habitat affect scent plume of bait
  - Catchability increases in more featureless, ledge and sediment
  - Catchability declines with higher algae cover (hard bottom, boulder and ledge)
- Impacts both fishers and the Ventless Trap Survey

Trawl Catchability

- Complex boulder substrate is less well sampled and than featureless sediment habitat
- Increases in population densities on sediment habitats may compensate for overall decline in abundance
- Should be considered when interpreting MENH Inshore Trawl Survey and likely other trawls

Implications

- Rapid environmental change in the Gulf of Maine, warrants the revisiting of the previous ecological paradigms that we may now be using to draw conclusions on current research
- Understanding changes in fine-scale demographic patterns provides crucial context for the broad scale dynamics captured in fisheries-independent surveys for the assessment and management of the stock
- Habitat-specific monitoring within a finer spatial scale are necessary to incorporate these continued ecological changes into decision-making processes

Summary

Shifted Paradigm

- Lobsters are now more randomly distributed across different substrates
- Rocky shelter use has declined, while more lobsters are observed out of shelter

Driving Processes

- Large predators functionally extinct even before 1990s
- Adolescent phase lobsters dominate shallows due to low settlement
- Lower population density reduces competition, demographic diffusion relaxes

Implications

- Catchability changes for trap and trawl surveys with featureless habitat use
- Habitat-specific, fine scale surveys needed to provide context for fisheries independent surveys

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ABSTRACT: Some species are so linked to specific environments that their habitat association almost becomes a species-defining character and is used by managers and policymakers to direct their conservation. The American lobster *Homarus americanus* is among the most valuable fisheries species in North America and among the best studied benthic marine invertebrates in the world. Its

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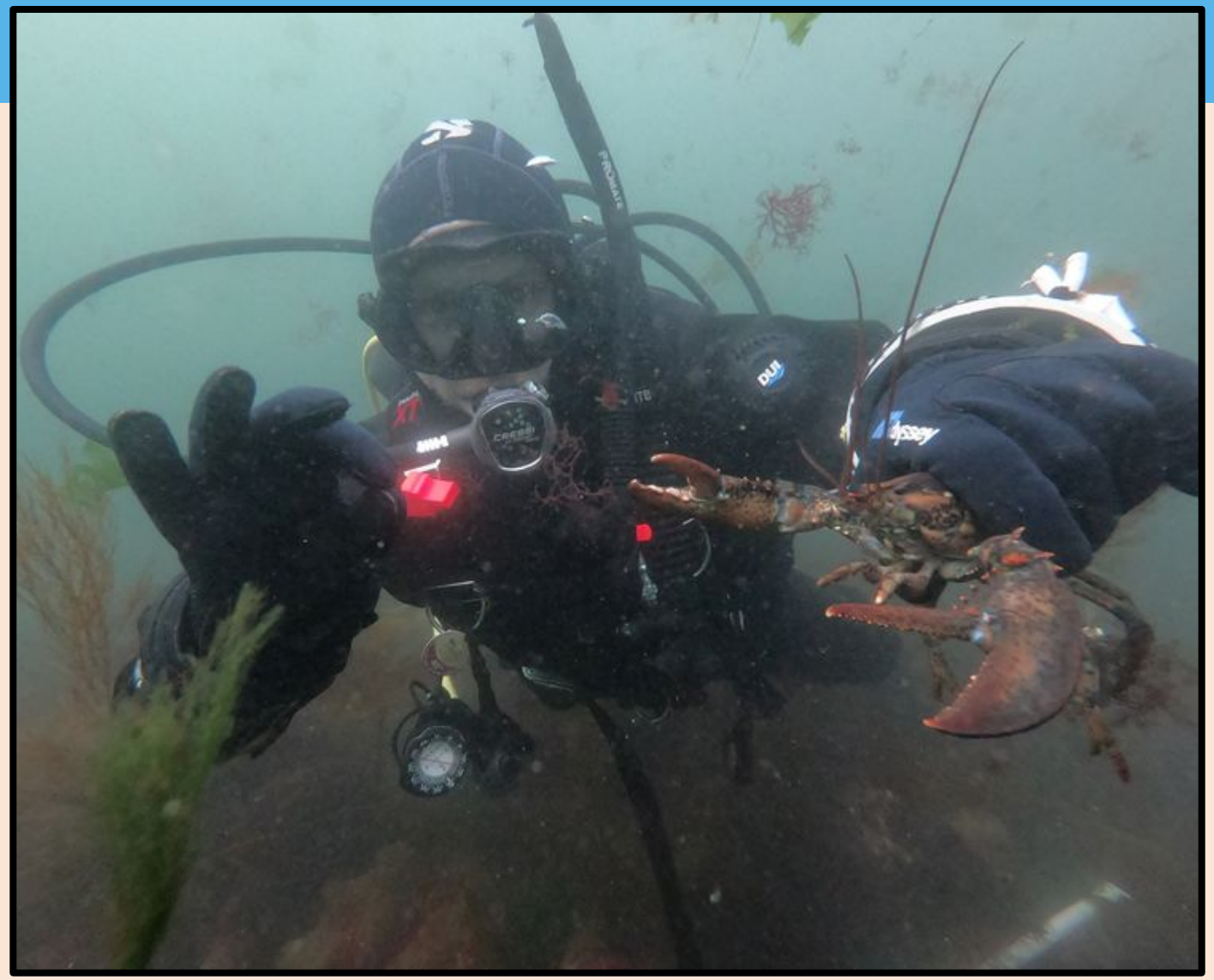

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