Using long term research on sea otters and kelp forests to study effects of climate change on coastal ecosystems

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Climate Change and Coastal Oceans

- Near-shore marine ecosystems particularly vulnerable to combined impacts of climate change and anthropogenic influences
- What ecosystem processes or functions are most sensitive to change?

Some coastal biotic processes affected by climate change

- Changes in species distribution and abundance
- **Ocean chemistry: pH changes (BIG affects)**
- Timing/intensity of upwelling → productivity
- Recruitment variation → demographic effects
- Emergent infectious diseases (land-sea)
- Frequency of algal/diatom toxic blooms
- Impacts of wildfires (sedimentation, run-off)
- **INTERACTIONS among all of the above**

Predicting Community Responses

- Much progress in forecasting climate-change effects on physically-driven processes
- Predicting impacts to entire communities is a much bigger head-ache:
  - interactions among main effects
  - abiotic effects mediated by species interactions
  - impacts often non-linear

- How to approach such a complex problem?

What we propose…

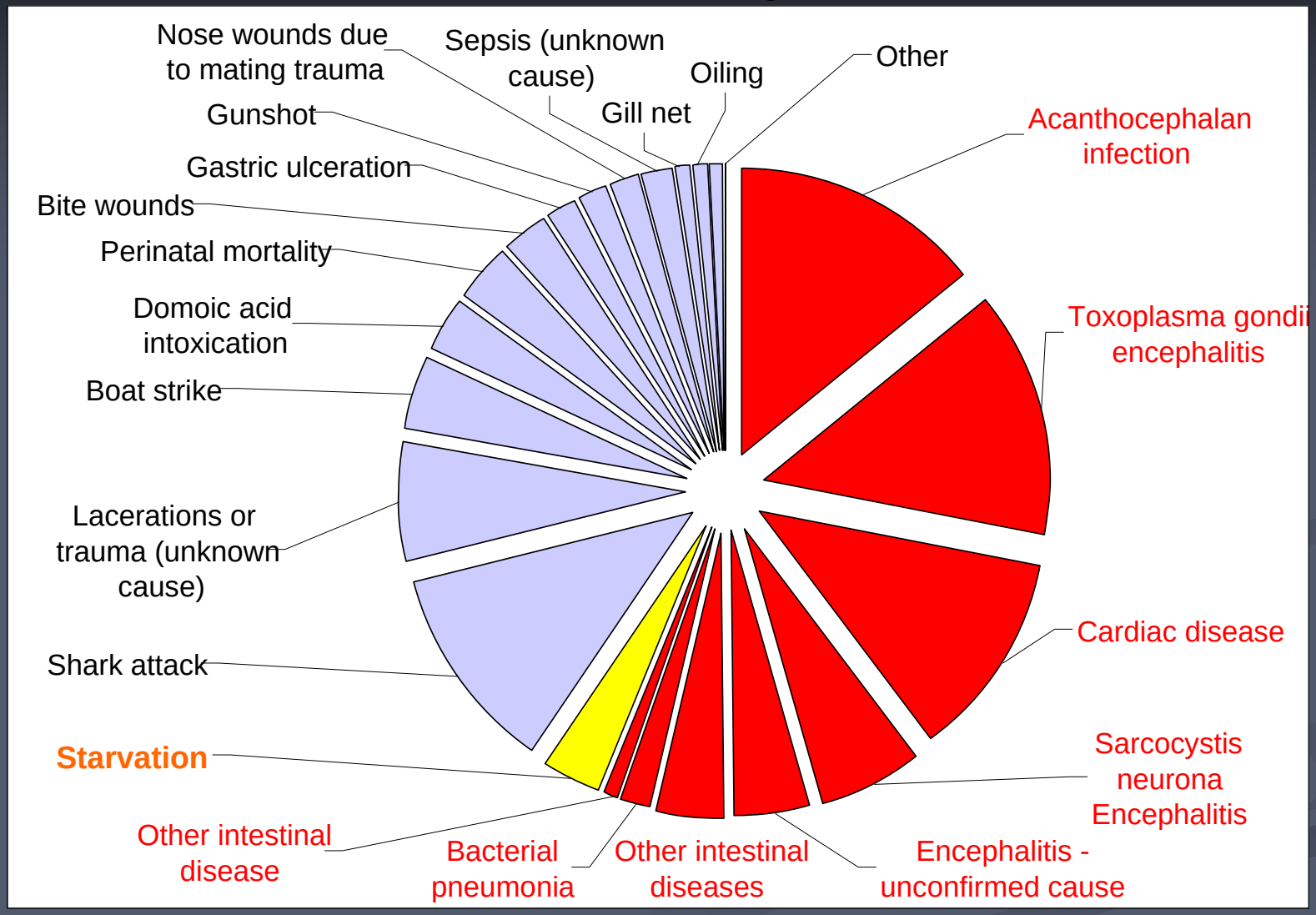
- Near-shore, rocky sub-tidal communities: model system for studying complex community responses to climate change?
  - Long history of monitoring
  - Much known about ecological processes
- Sea otter/kelp forest dynamics (spatial and temporal variation) are studied to determine:
  - What are key processes driving variation?
  - How are these processes affected by climate change?
  - What attributes of the system contribute to its resilience to perturbation?

Sea otters as sentinels

- As apex predators in near-shore marine system, they integrate impacts across trophic levels
- Distribution and behavior make them very easy to study
- Site-specific: reflect local processes

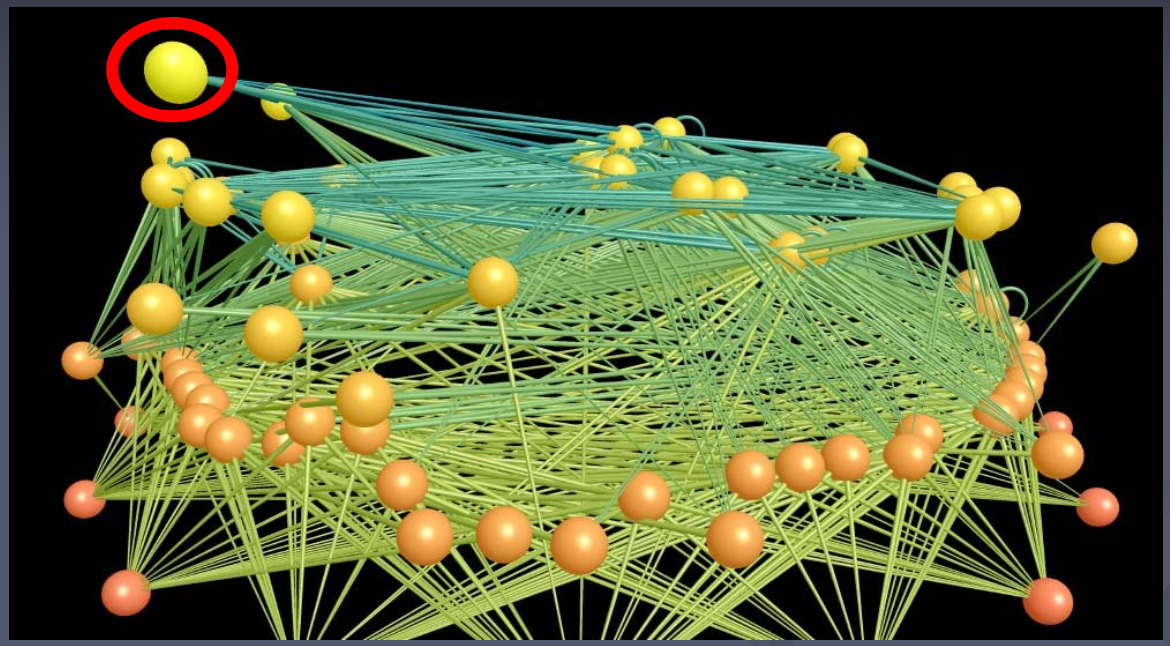
- Energetically "on the edge", susceptible to many perturbations (the Canary in the Coal Mine)
- Play a key role in near-shore food webs

Causes of Mortality in Sea Otters



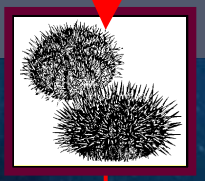
Adapted from: Kreuder, C. et al. 2003. Patterns of mortality in southern sea otters (Enhydra lutris nereis) from 1998-2001. Journal of Wildlife Diseases 39:495-509.

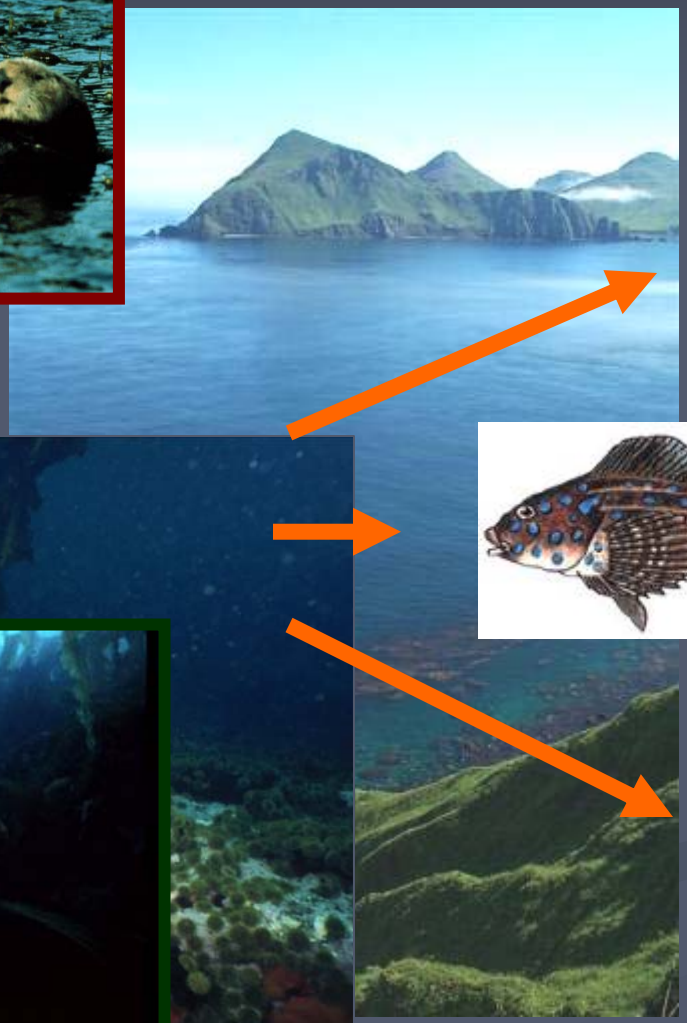
Food web complexity



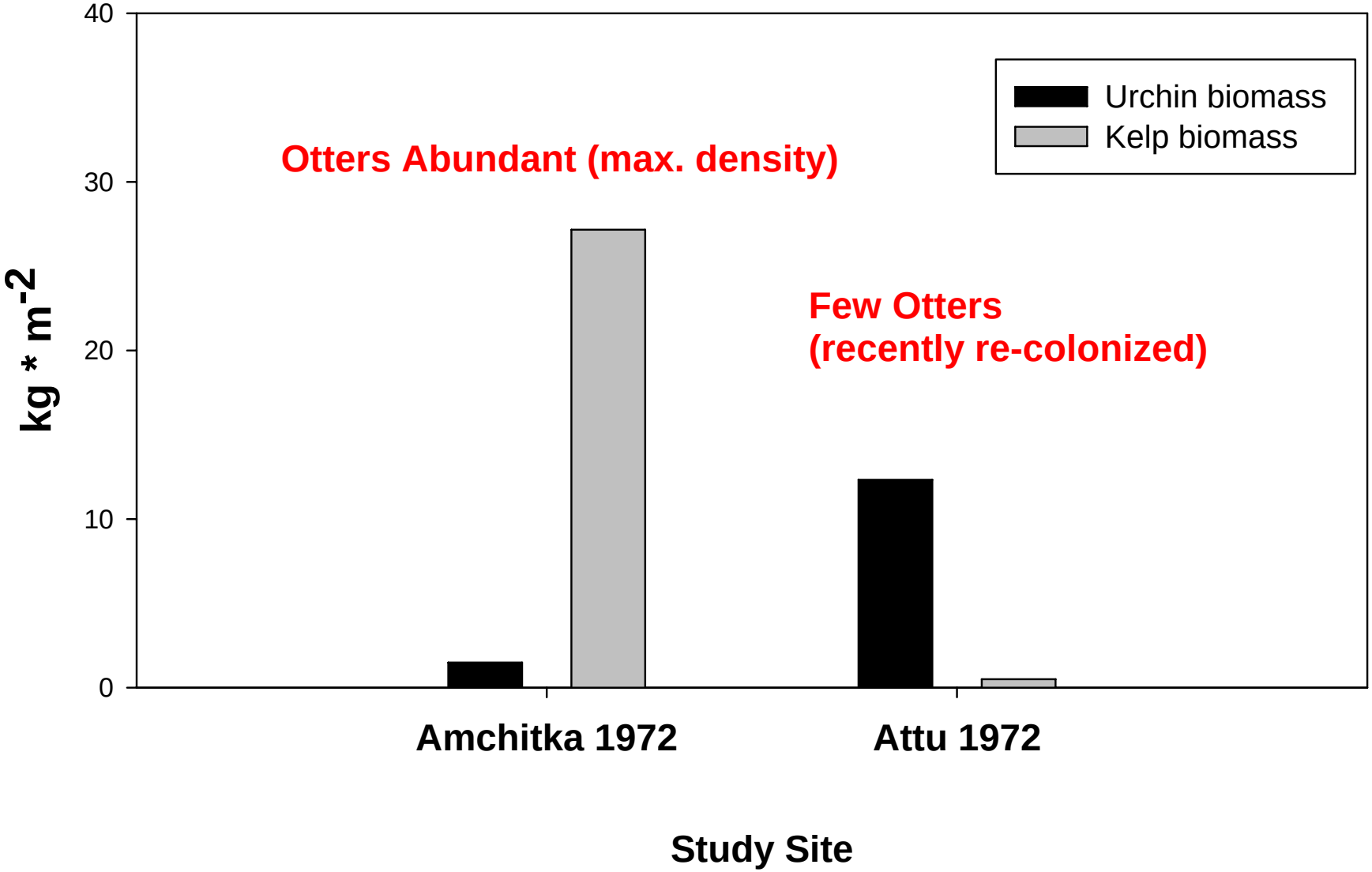
- Sea otters have extensive trophic connectivity (>80 species of prey), many strong interactions
- "Keystone species": direct and indirect effects of sea otter predation cascade through system

Trophic Cascades: Direct and Indirect Effects





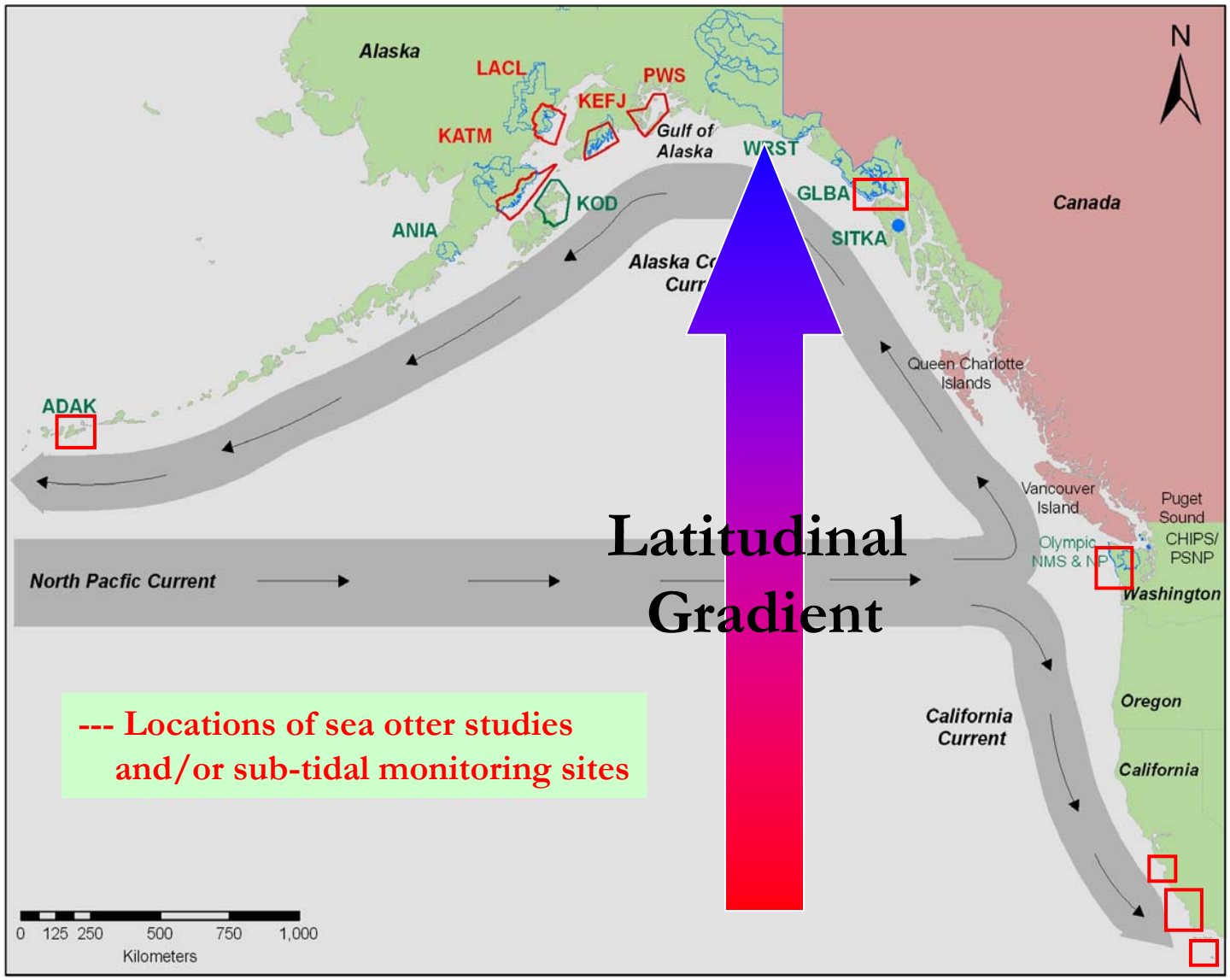
Sea otter effects on sub-tidal community



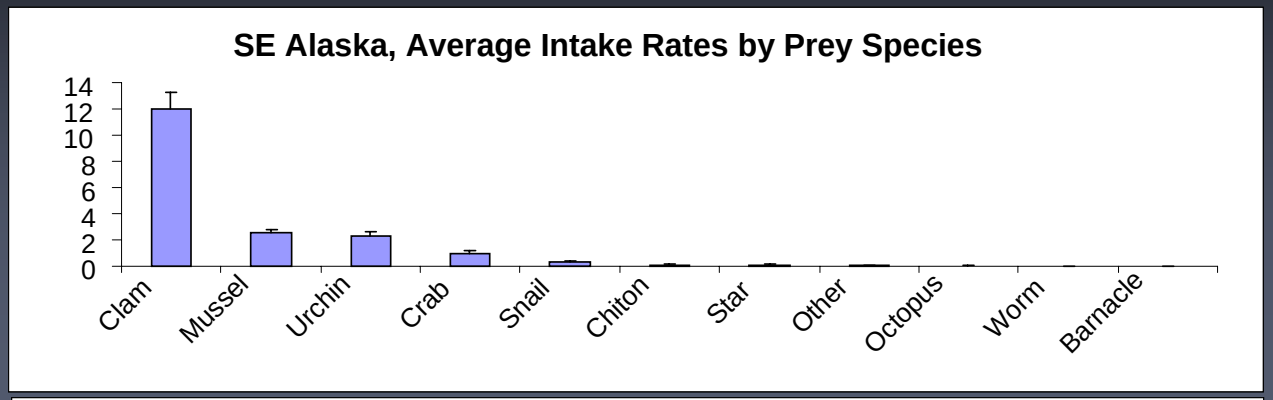
Focus on Ecosystem Function (rather than individual species)

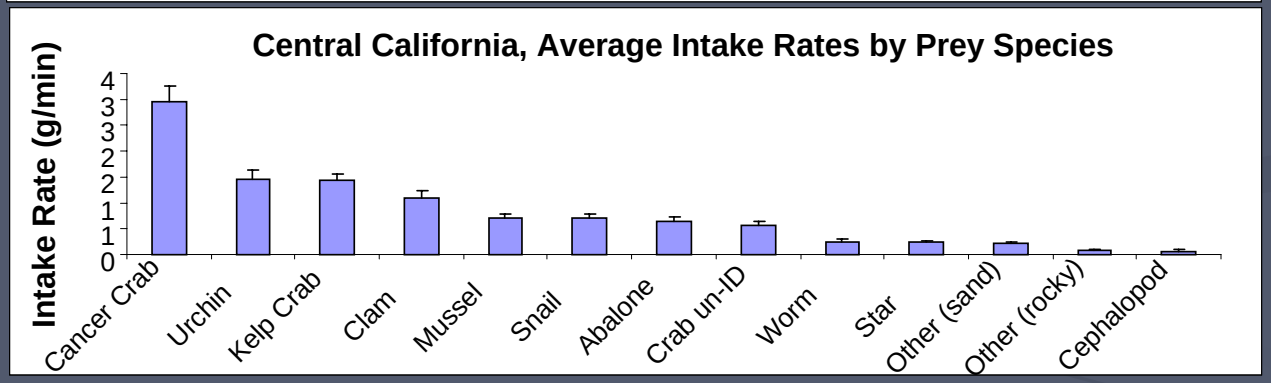
- Observation: Certain interactions enhance community diversity, stability, and/or resilience to perturbations
- Goal: forecast how these dynamics will be impacted by climate change
- Approach: use Geographic and Temporal Variation as "climate change analogs"

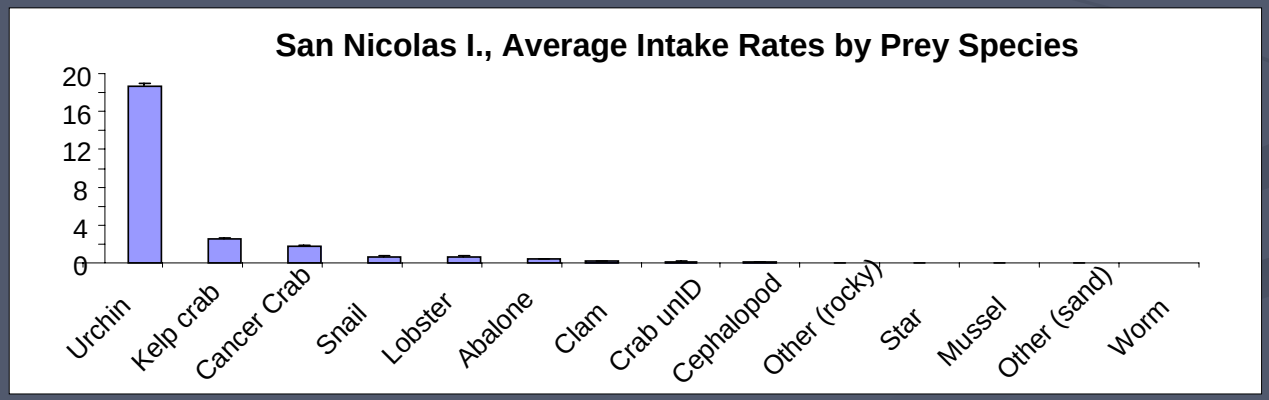
Geographic Variation



Geographic Variation in diet

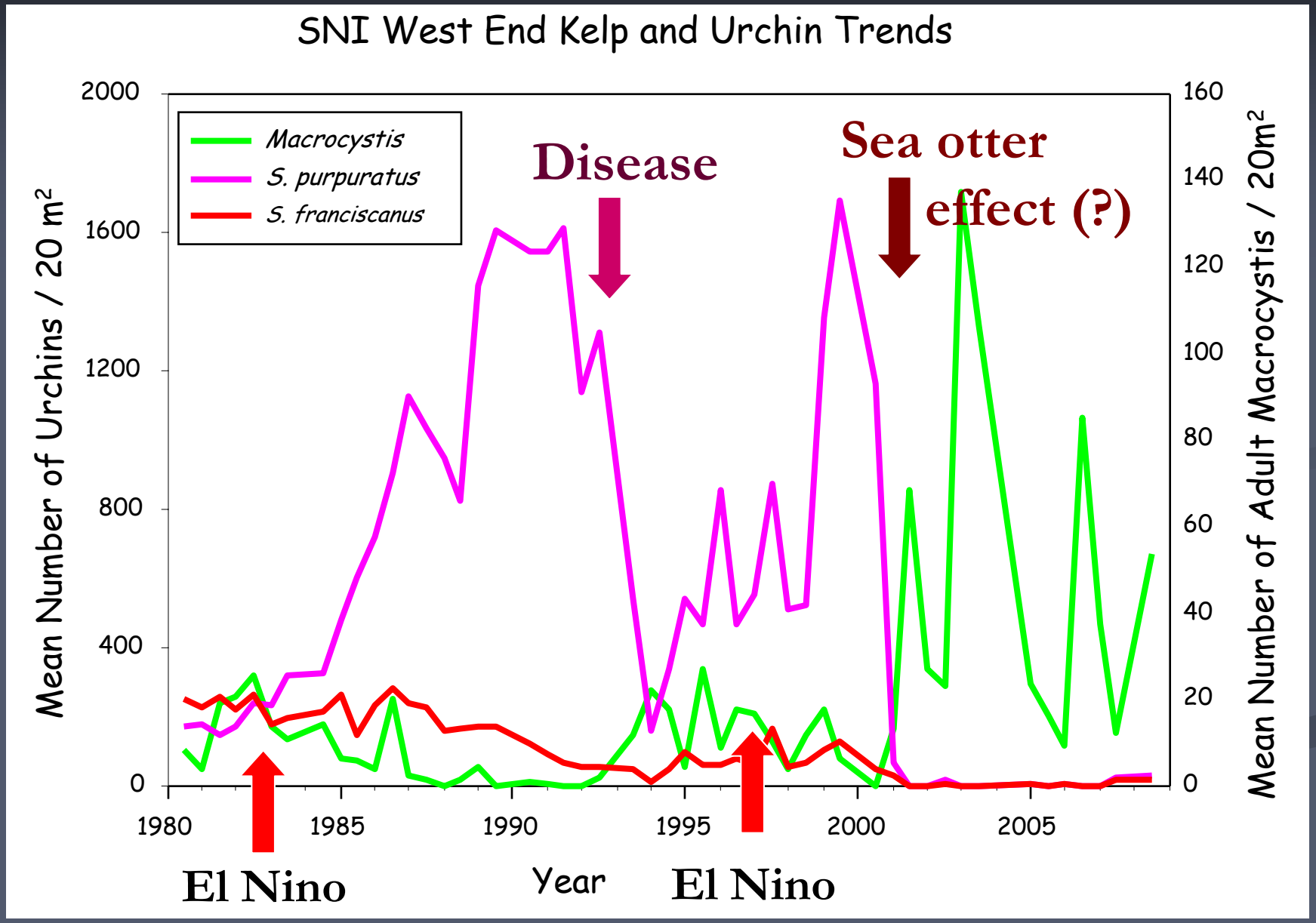






Latitudinal Gradient

Temporal Variation



Summary: advantages of long-term monitoring across latitudinal gradient

- Elucidate dynamics of key ecological processes, and forecast likely effects of climate change, by studying variation in:
  - Species presence/absence & abundances
  - Kelp-herbivore interactions
  - Sea otter trophic interactions, indirect effects
  - Mortality and disease patterns

Thank-you

Co-investigators

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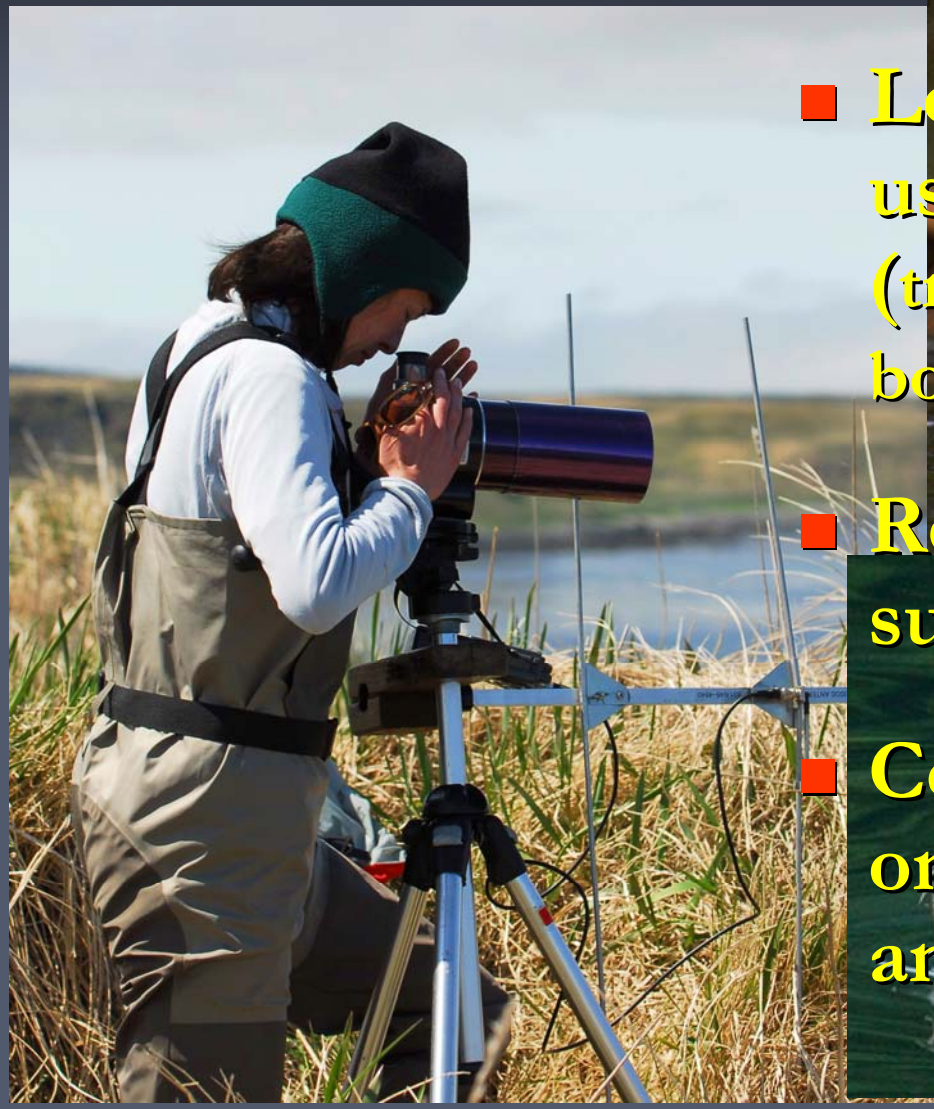
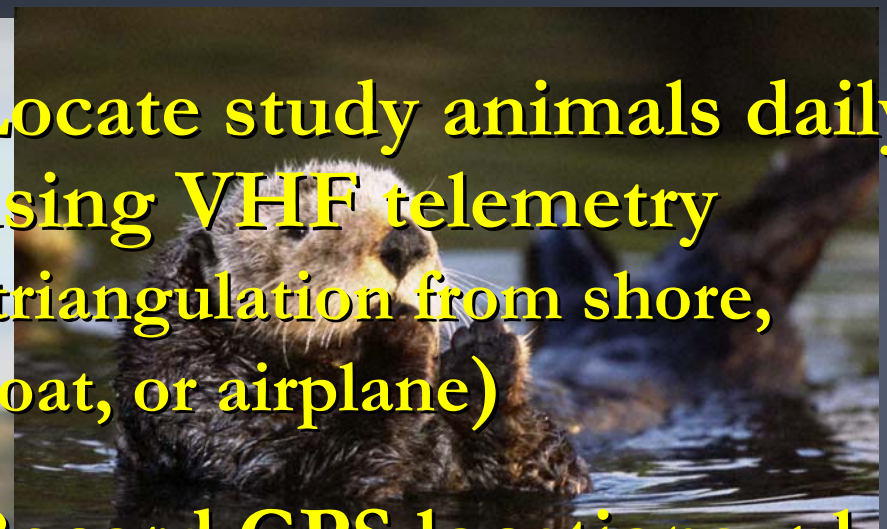
Field staff & volunteers whose hard work made this possible !

Field Research Methods

- Sea otters are captured, instrumented, & studied by observation and telemetry

Monitoring: observation and telemetry





- Locate study animals daily using VHF telemetry (triangulation from shore, boat, or airplane)
- Record GPS locations, plus survival and reproduction
- Collect observational data on diet, foraging behavior, and activity budgets