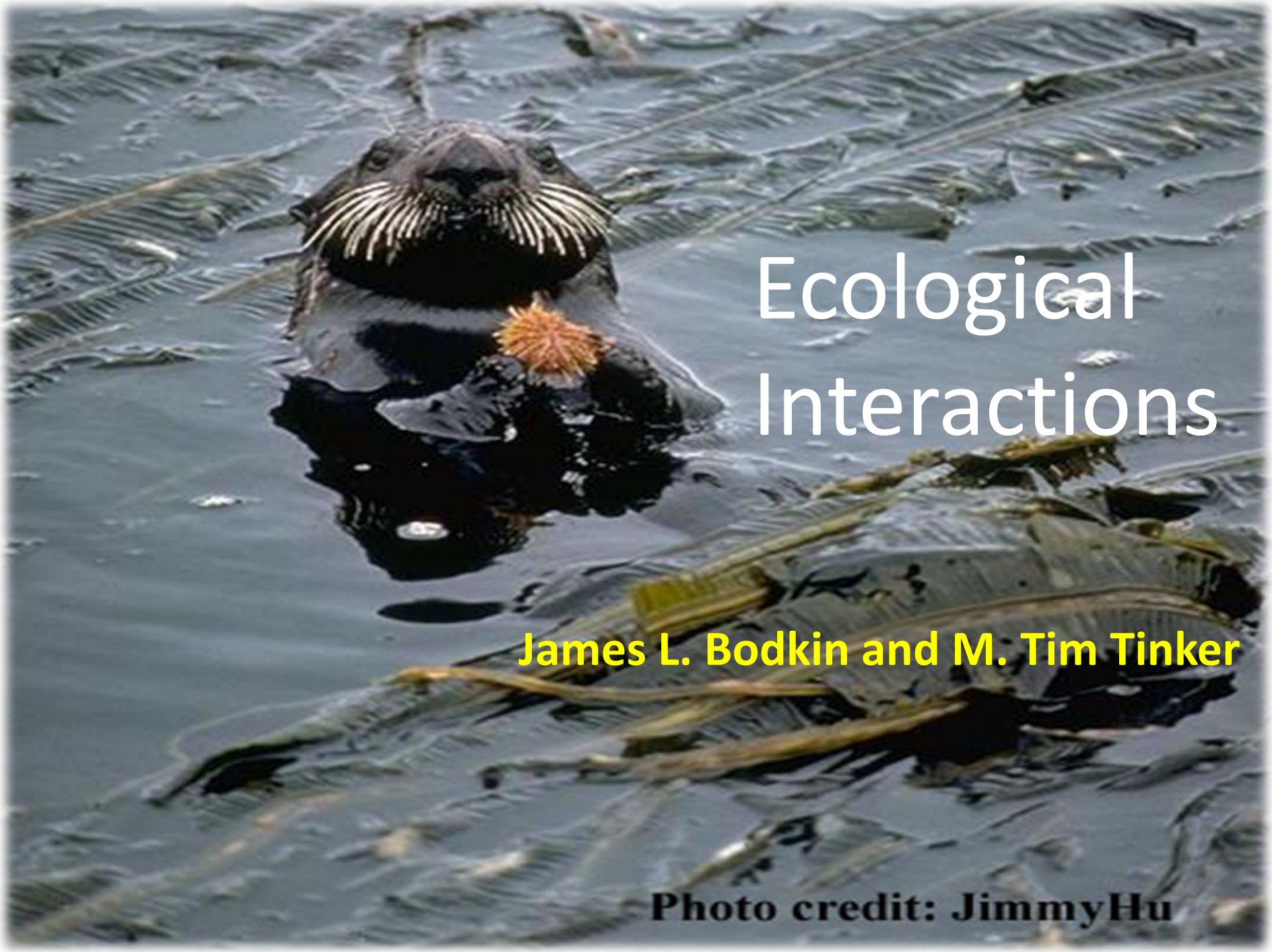

Ecological Interactions
James L. Bodkin and M. Tim Tinker
Photo credit: JimmyHu

Prey

Direct Effects



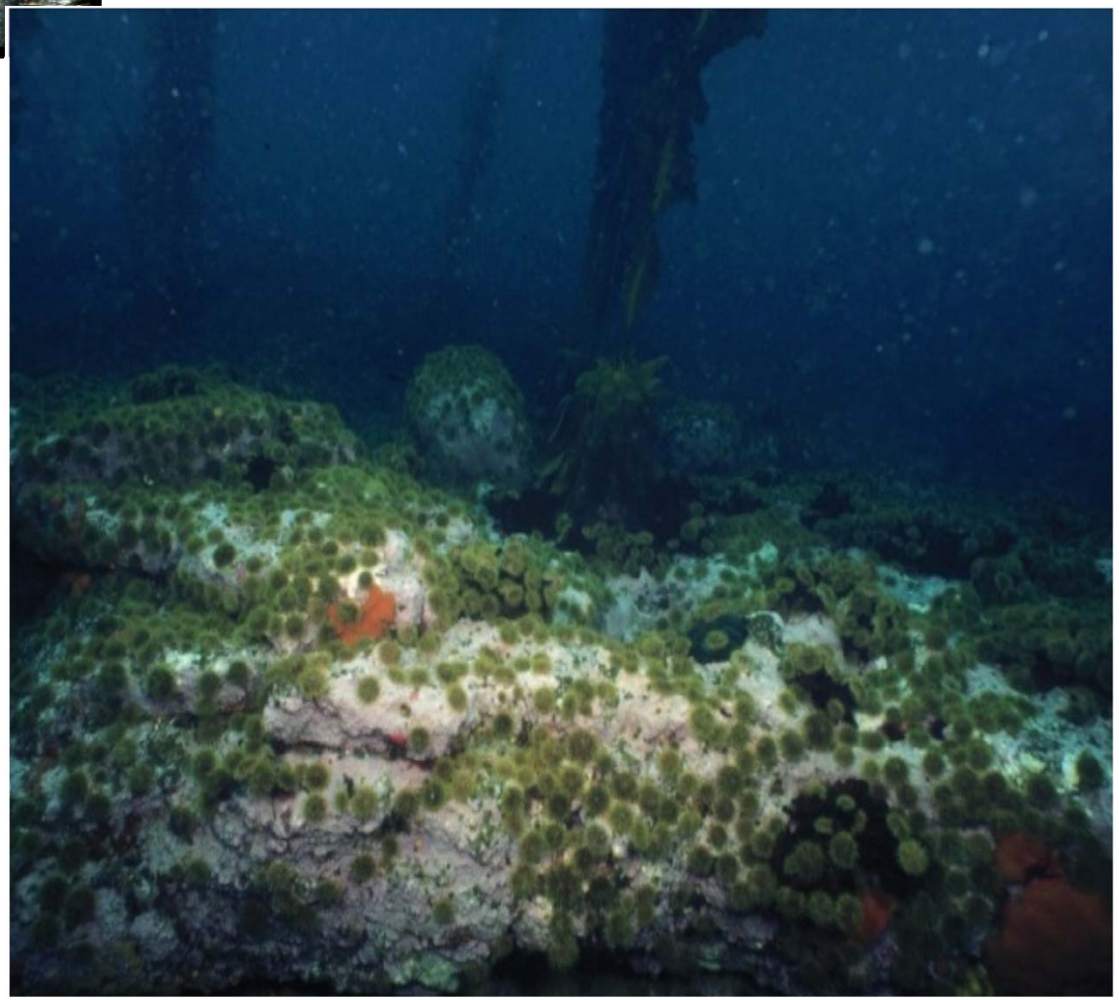




Indirect Effects

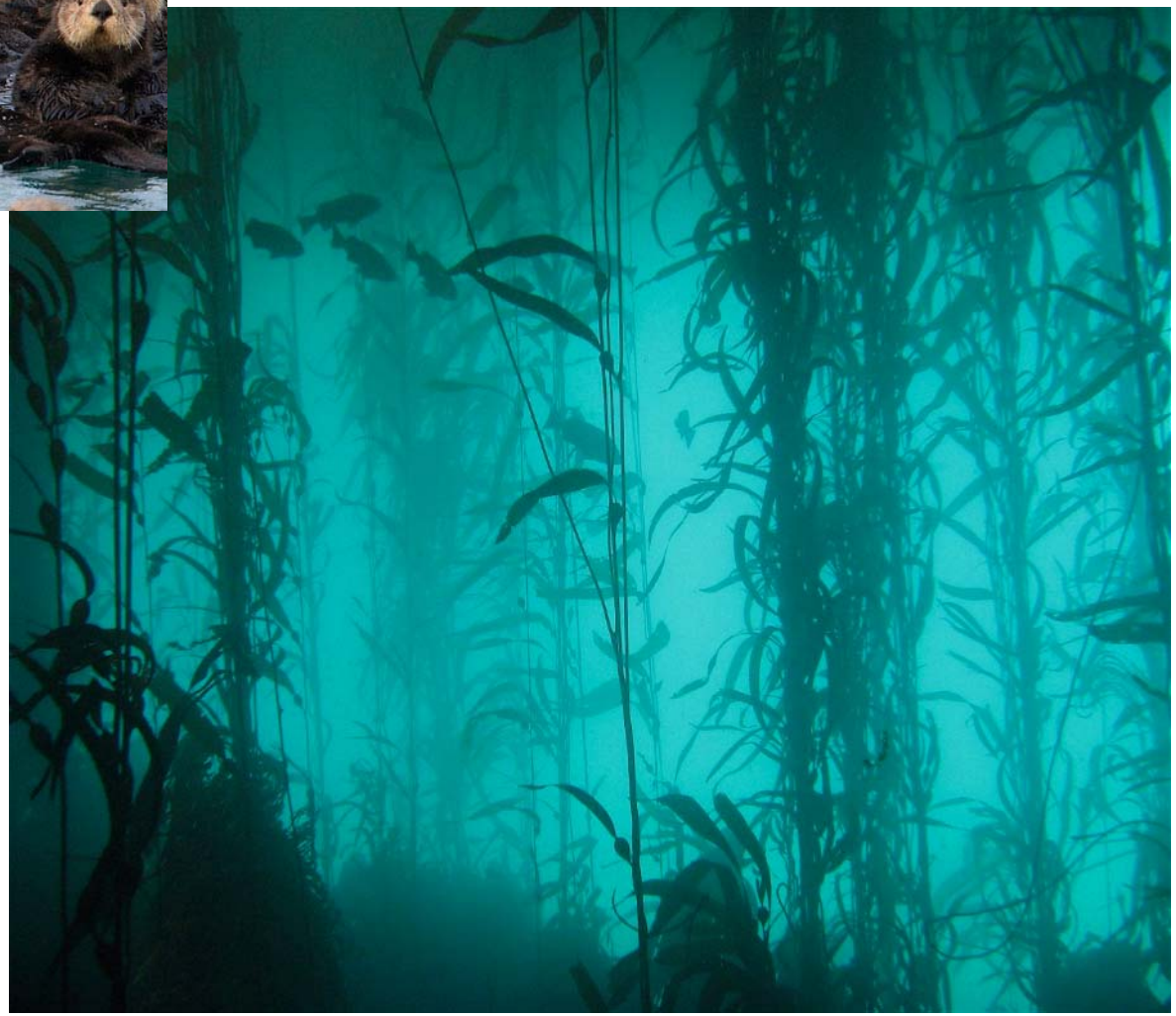


Sea Otters
Rare or Absent



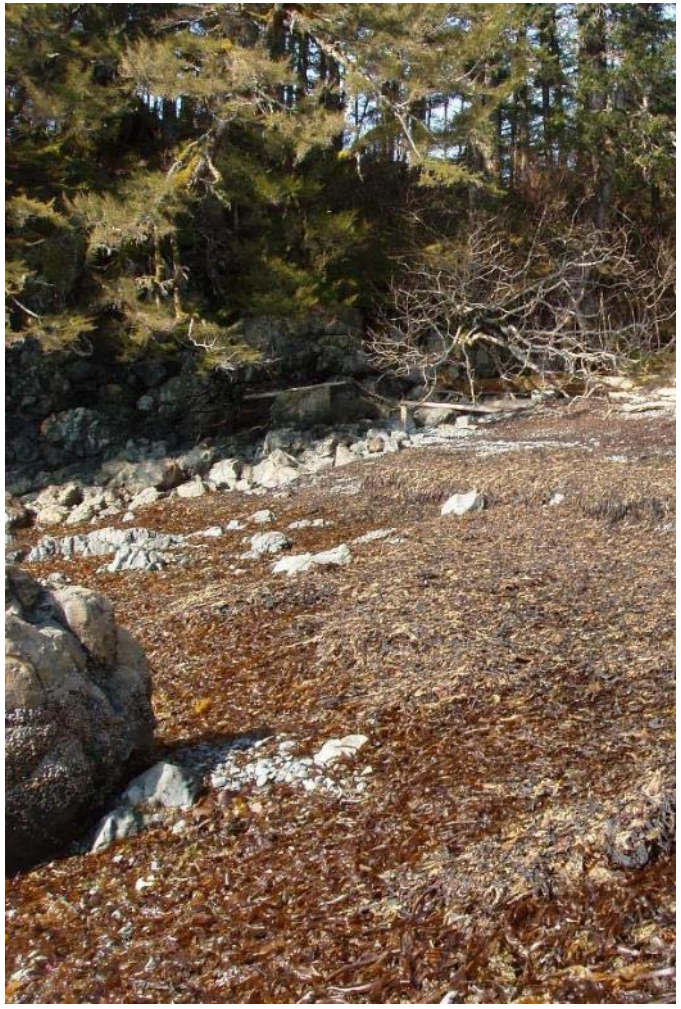
Urchins large,
& abundant,
Kelps rare

Sea Otters Abundant



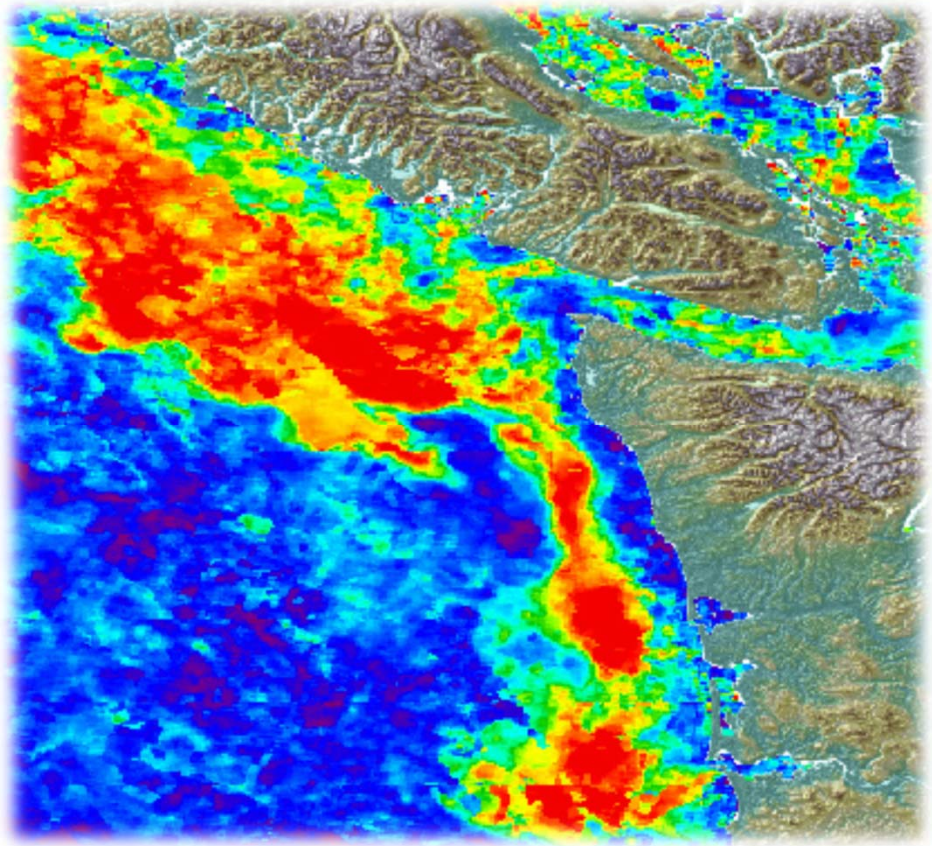
Urchins small & Kelps abundant

MACROPHYTES and ECOSYSTEM STRUCTURE & FUNCTION



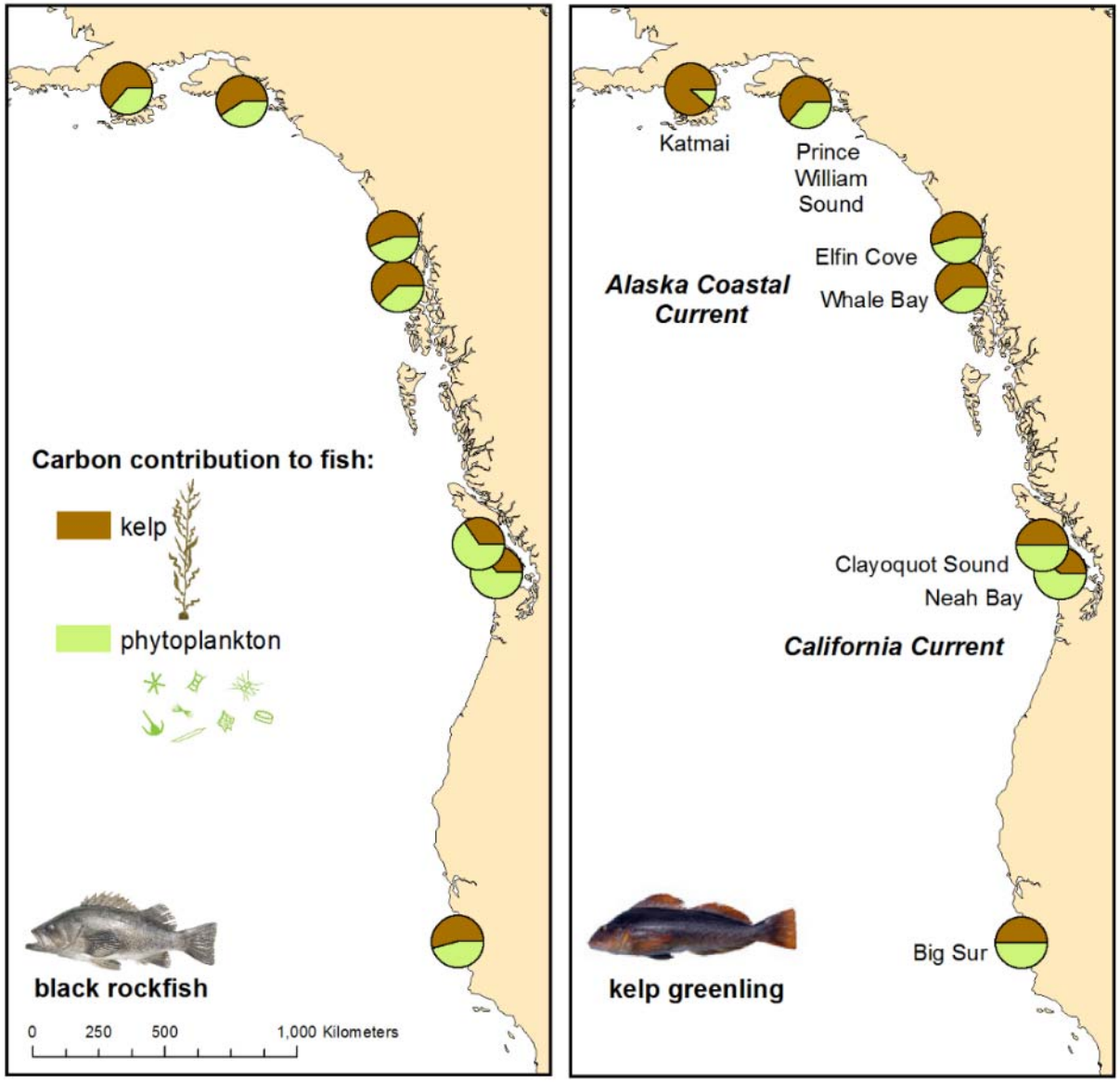
- Structural complexity
- Habitat diversity
- Species diversity
- Refugia
- Complementary production
- Food web subsidies
- Hydrodynamics
- Carbon sequestration
- Primary production

Micro versus macro algae contributions to nearshore food webs



Indirect effects on fish

vonBiela et al. 2015



Most carbon in muscle of these fish derived from macro algae, in some locations up to 90%

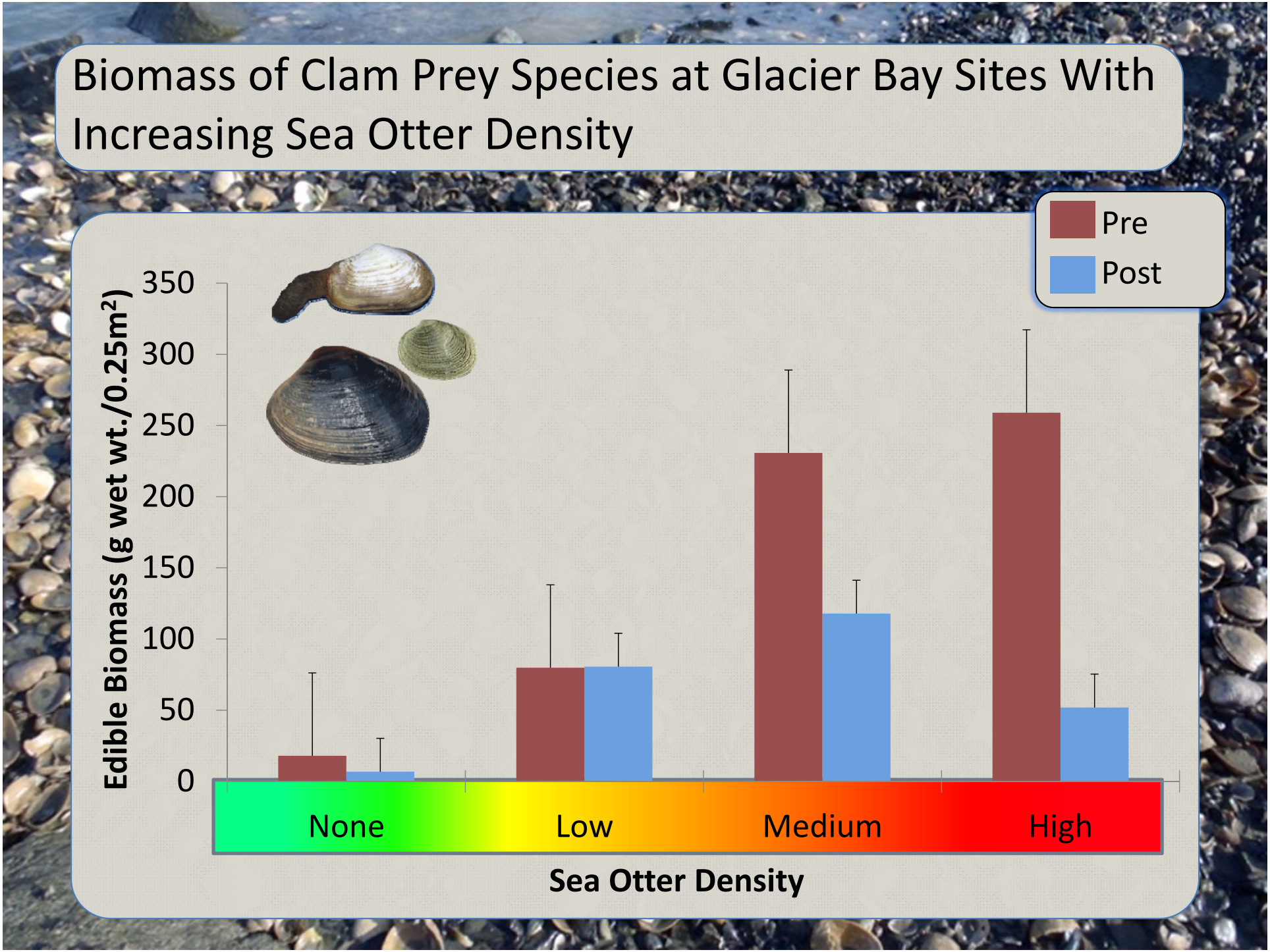
Similar work demonstrates importance of kelp derived carbon in other nearshore taxa (invertebrates, fishes, birds, mammals) as well as export of kelp-derived carbon to offshore food webs

Dunton et al. 1987, Duggins et al. 1989 Bustamante and Branch 1996, Fredrickson et al. 2003, Estes et al. 2004, Reisewitz et al. 2006 .....

Ecological Interactions: Nearshore Mixed Sediment Habitats

- Sheltered Shores
  - Macrophyte production (understory kelps and eel grass)
  - Sediment excavations/disturbance
  - Altered abundance & size classes of infaunal bivalves
  - Modified filtration rates
- Exposed Shores
  - Perhaps the most under-studied of the sea otter habitats

Biomass of Clam Prey Species at Glacier Bay Sites With Increasing Sea Otter Density

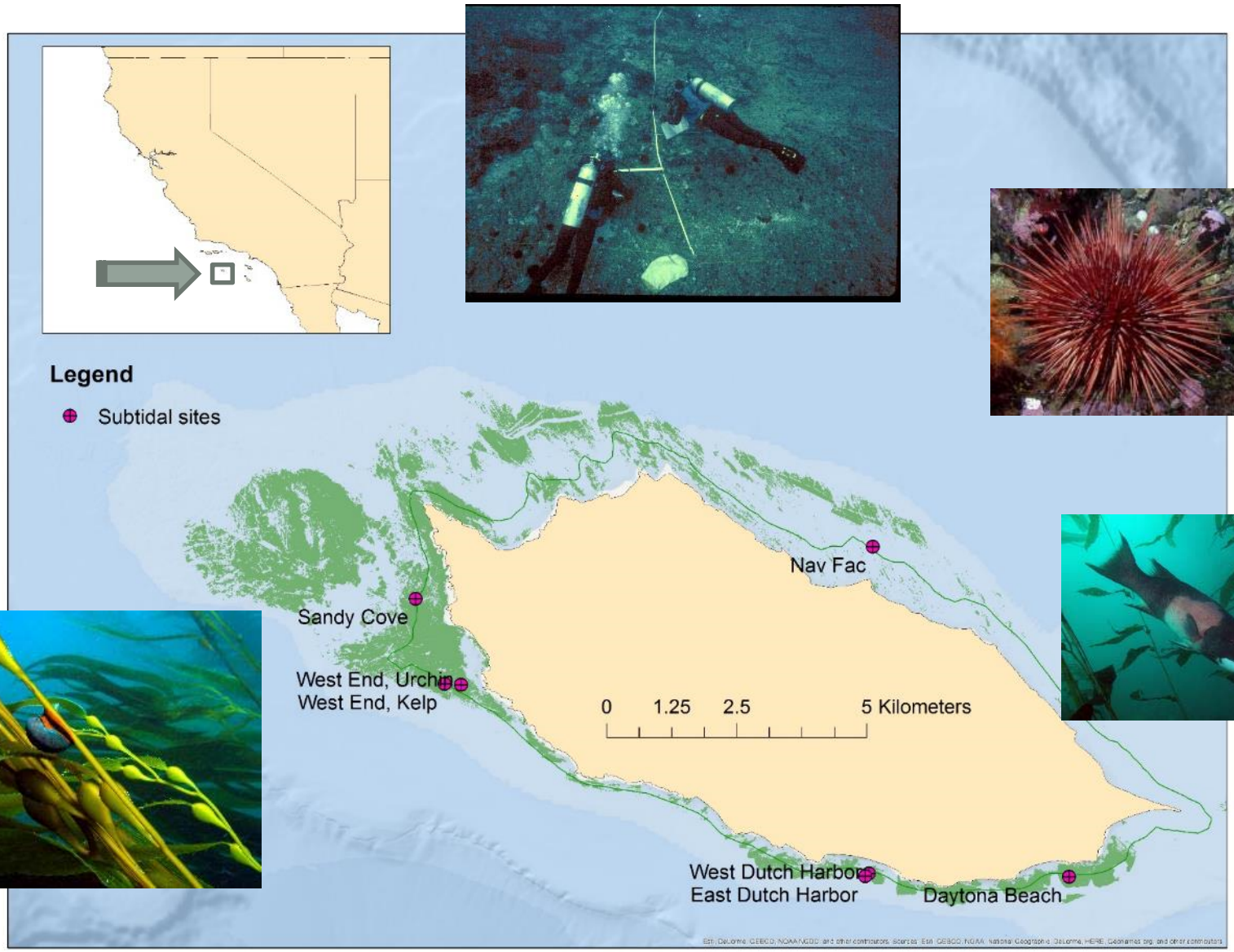


Summary Ecological Interactions, SEAK

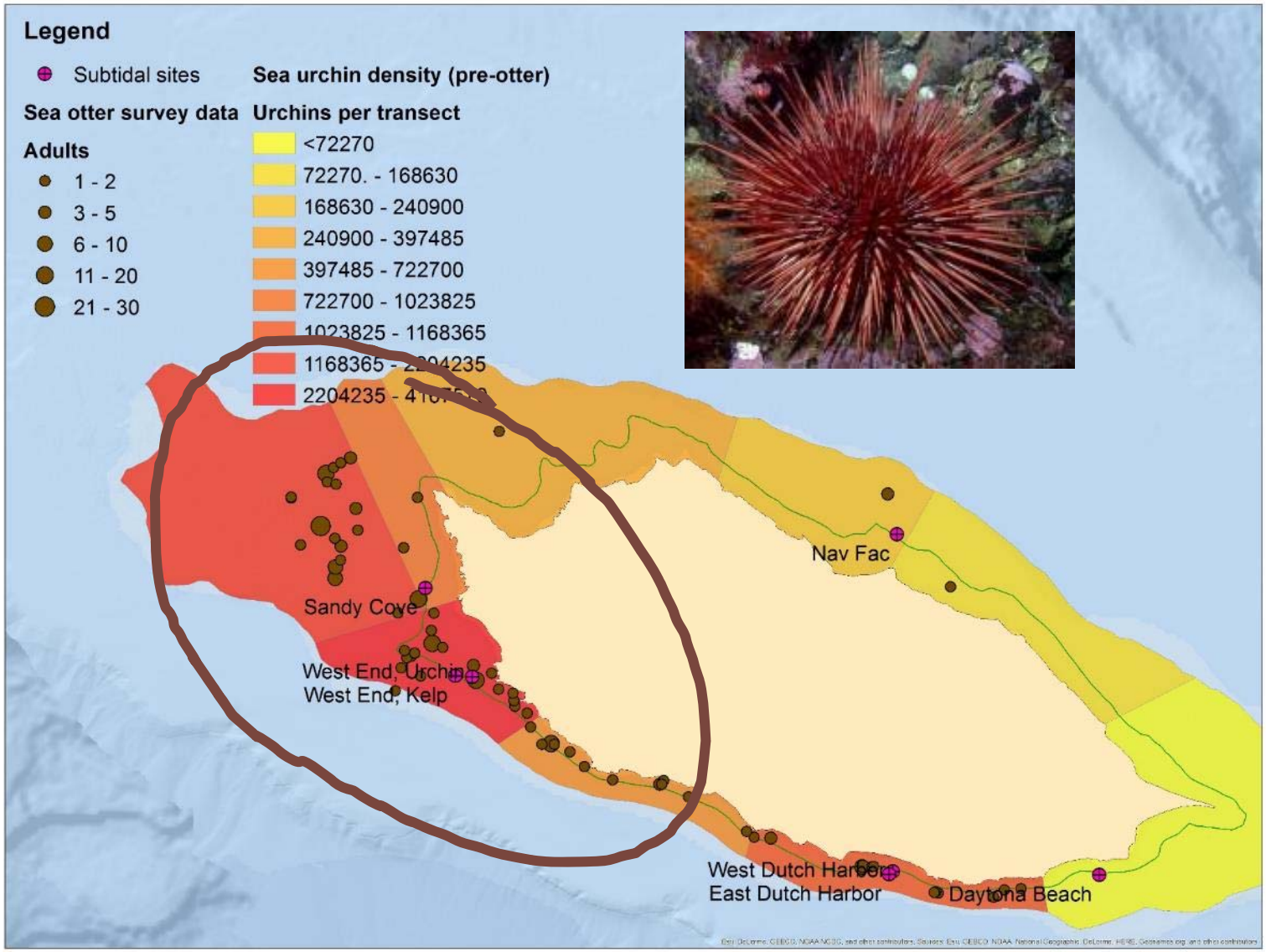
- Current status of sea otters and nearshore marine ecosystems are an artifact of human activities over 250 years
- Direct effects of otter predation can include maintenance of abundance, sizes, and biomass of prey
- Indirect effects of reduced herbivory documented across many habitats following the removal of sea urchins
- Restoration of kelp forests & other macrophytes have ecosystem level effects related to habitat and increased primary production
- Our understanding of long term direct & indirect effects of sea otter recovery are still incomplete

Sea Otters and Ecological Interactions, California

San Nicolas Sub-tidal sites



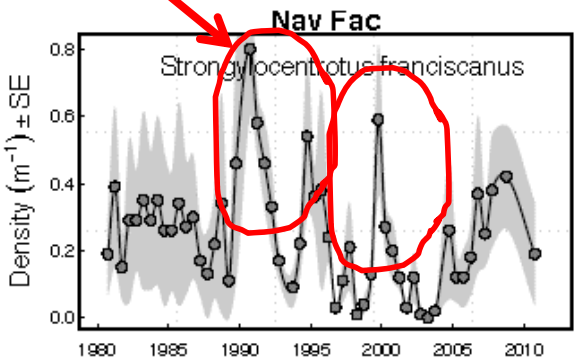
Spatial variation in predators and prey



San Nicolas, North Side **(low otter effect)**

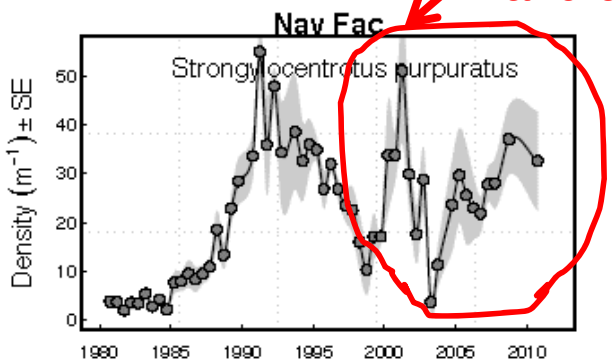
Frequent crashes of urchin pop'n.s… most likely disease driven

Otter effect



Otter effect

No relationship between otters and urchins

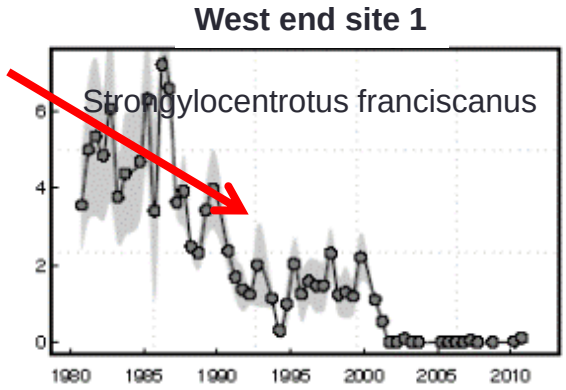


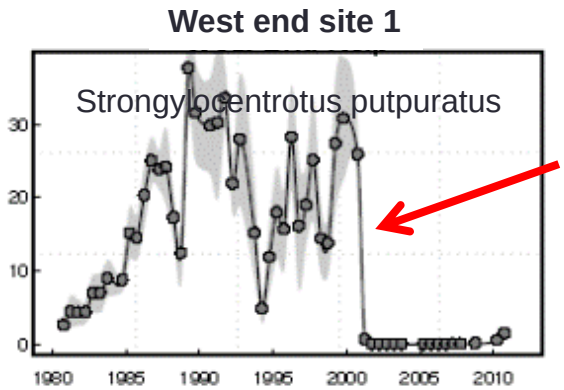
San Nicolas West End **(high otter effect)**

Otter effect

Otter effect

Red urchins start to decline by mid 1990s



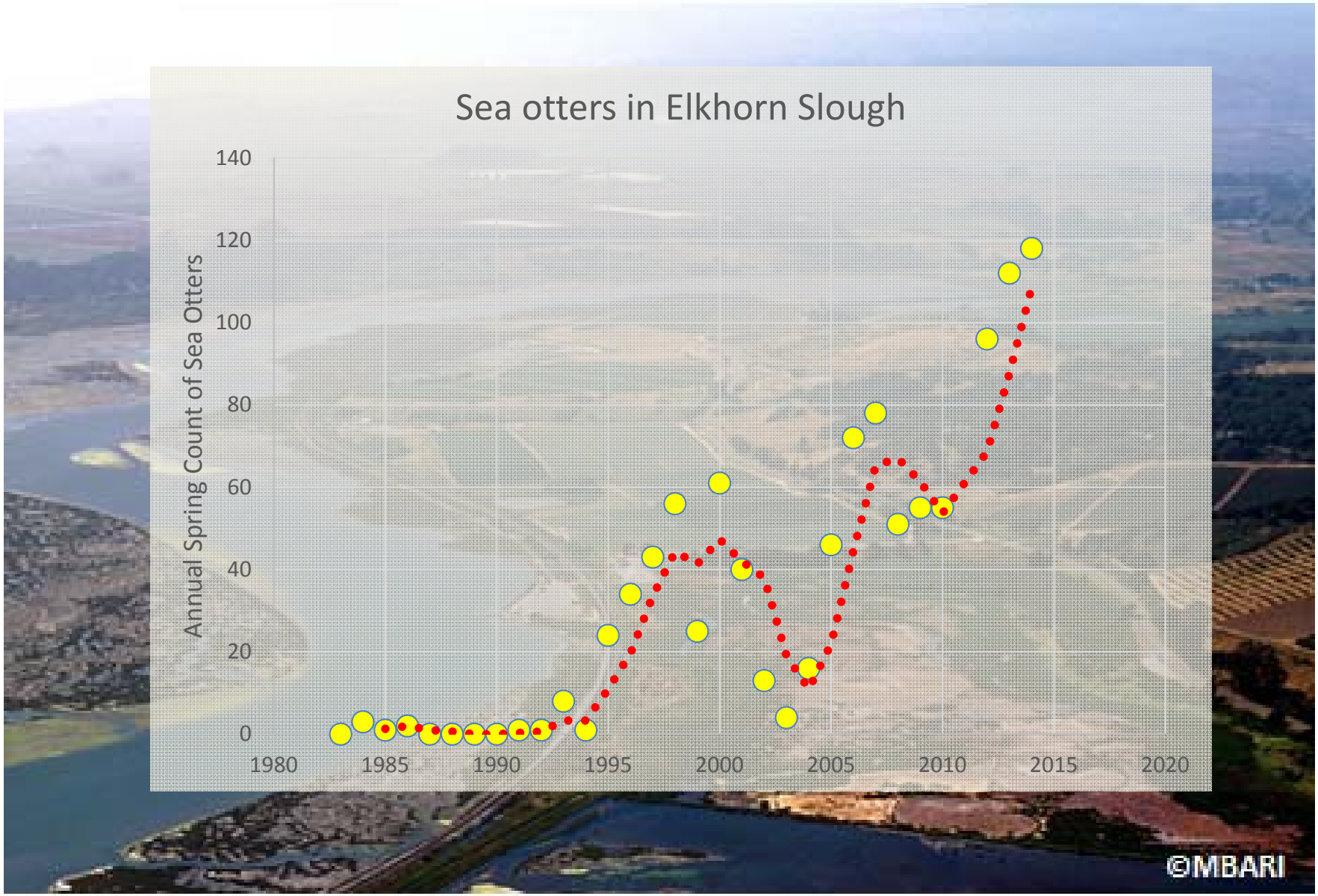


Purple urchins abundant until early 2000s

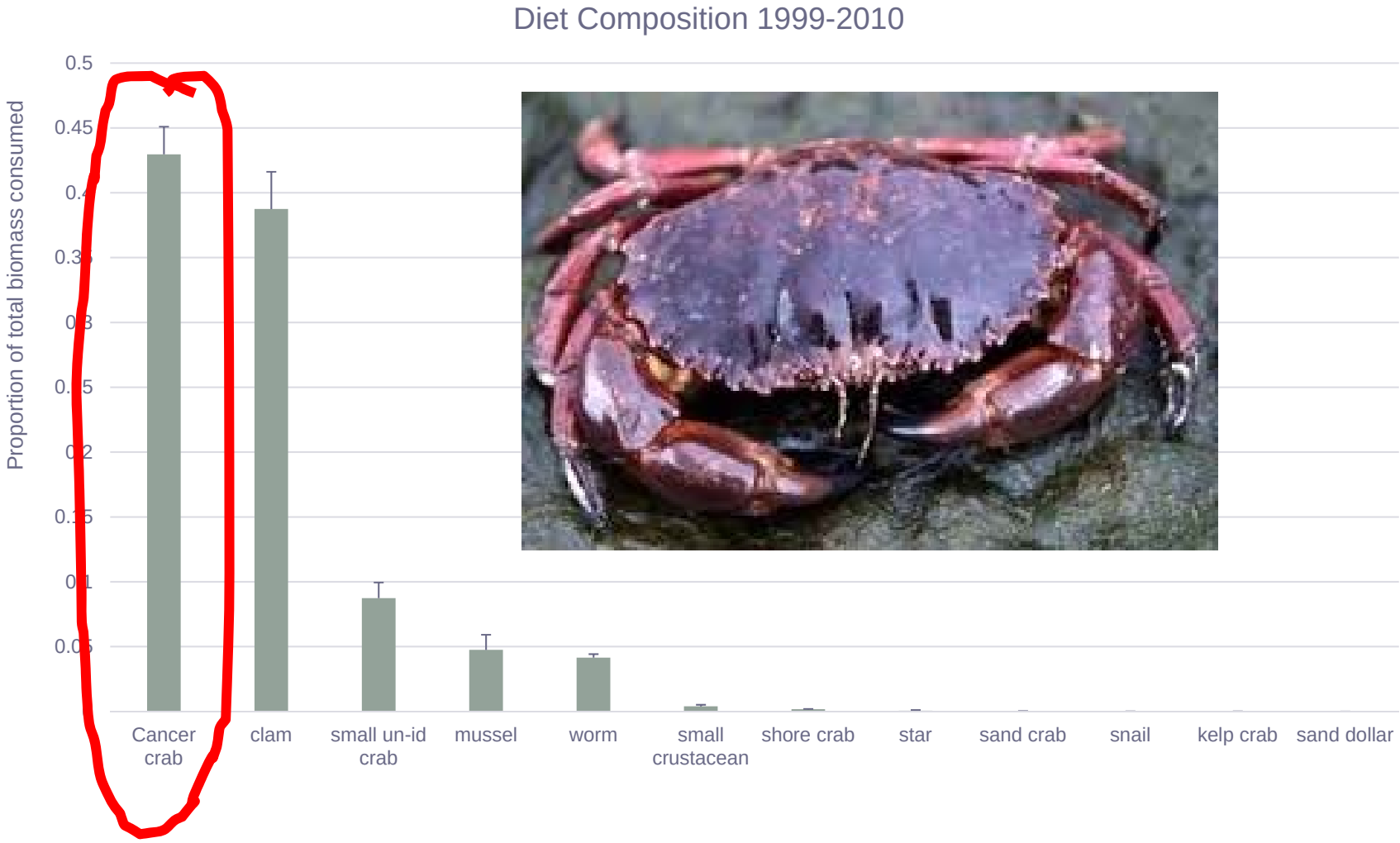
Kenner, M.C. and M.T. Tinker 2018. Stability and change in kelp forest habitats at San Nicolas Island. Western Naturalist. 78(4): 1-11

What about other coastal habitats, such as estuaries?

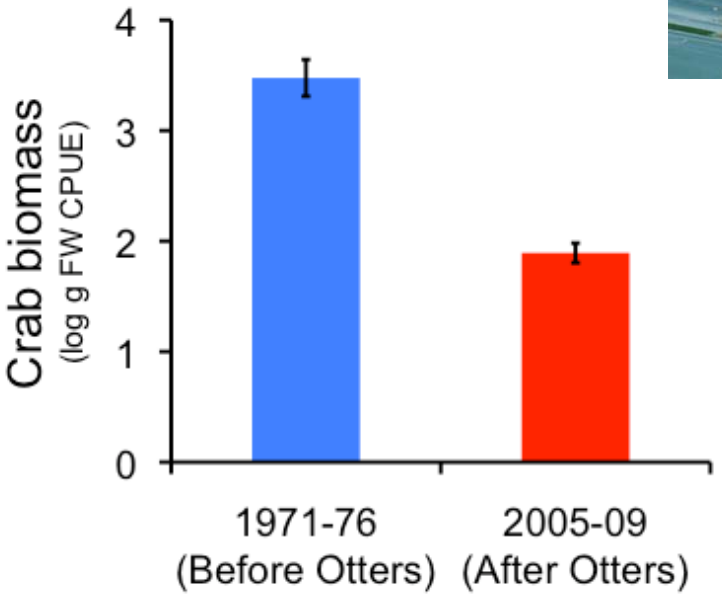
Sea otter colonization of Elkhorn Slough

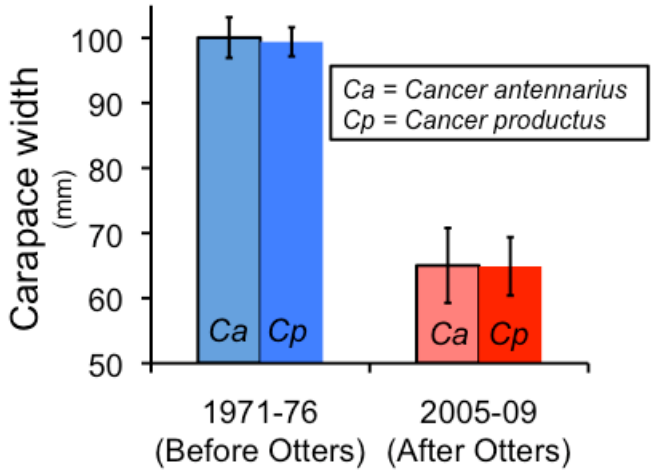


Trophic Impacts to Estuarine food webs: early stages (1990s – 2010)



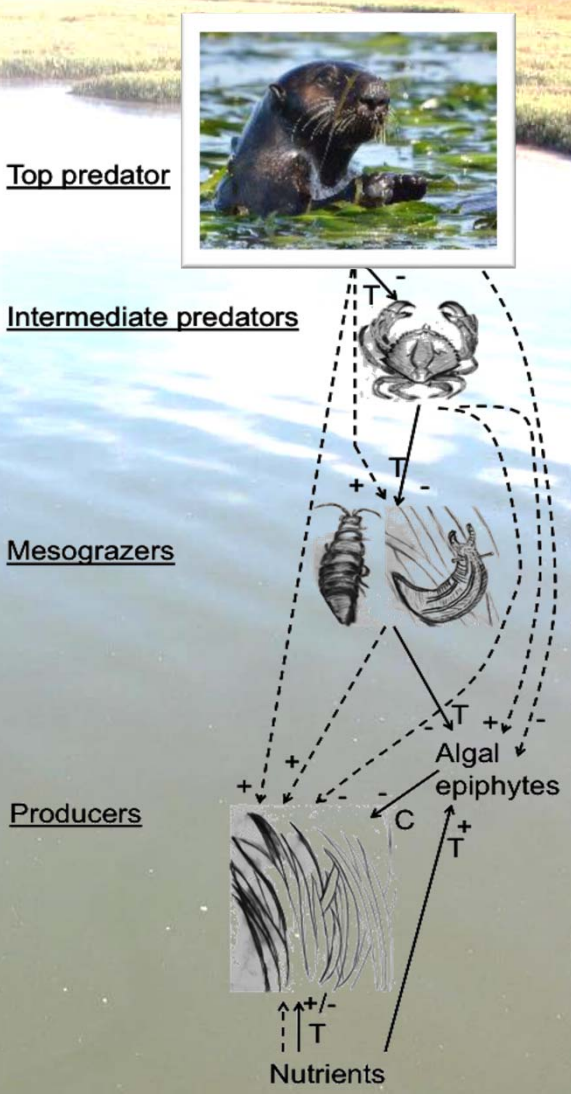
Top-down effects: Sea otters reduced the overall biomass and size of crabs





Hughes, B. B., R. Eby, E. Van Dyke, M. T. Tinker, C. I. Marks, K. S. Johnson, and K. Wasson. 2013. Recovery of a top predator mediates negative eutrophic effects on seagrass. Proceedings of the National Academy of Sciences, doi:10.1073/pnas.1302805110

Trophic Cascade in Sea Grass Habitat



Hughes, B. B., R. Eby, E. Van Dyke, M. T. Tinker, C. I. Marks, K. S. Johnson, and K. Wasson. 2013. Recovery of a top predator mediates negative eutrophic effects on seagrass. Proceedings of the National Academy of Sciences, doi:10.1073/pnas.1302805110

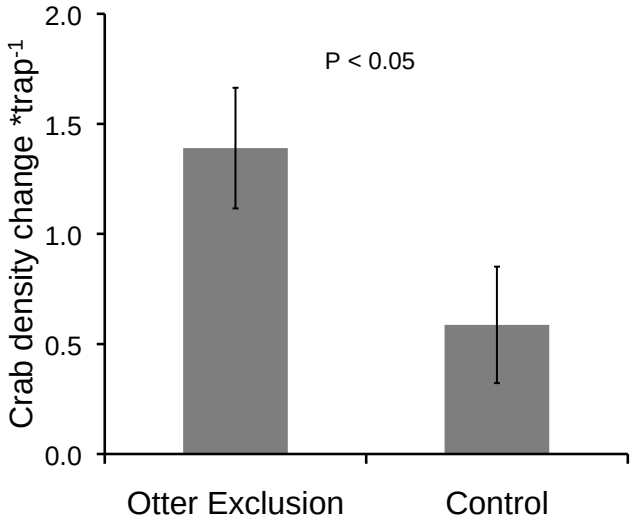
Trophic Impacts to Estuarine food webs: later stages (2012– 2015)

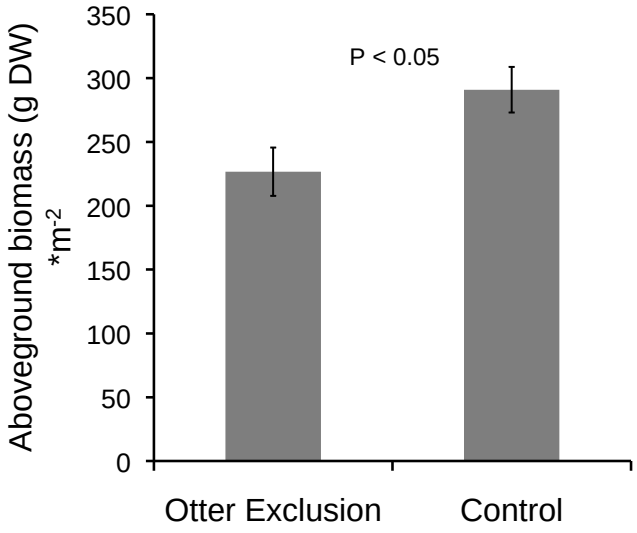
Sea otter diets in upper estuary

Reduction in burrowing → healthier marsh

Otter Exclusion

Procedural Control





Conclusions: Sea otter ecosystem effects vary between coastal habitats

Kelp forests

- ↑ primary productivity, ↑ species diversity, enhanced nursery habitat for fish, shoreline stability, carbon fixation, etc.

Seagrass:

- Sea otters reduce crab populations, facilitating grazers in seagrass beds
- Positive effects for eelgrass resilience.

Salt marsh:

- Sea otters reduce burrowing crabs, → healthier pickleweed
- Appear to reduce bank erosion & marsh loss (ms. in prep)

SEA OTTERS AND FISHERIES, SOUTHEAST ALASKA

Ginny L. Eckert
Juneau Center, College of Fisheries and Ocean Sciences,
University of Alaska Fairbanks

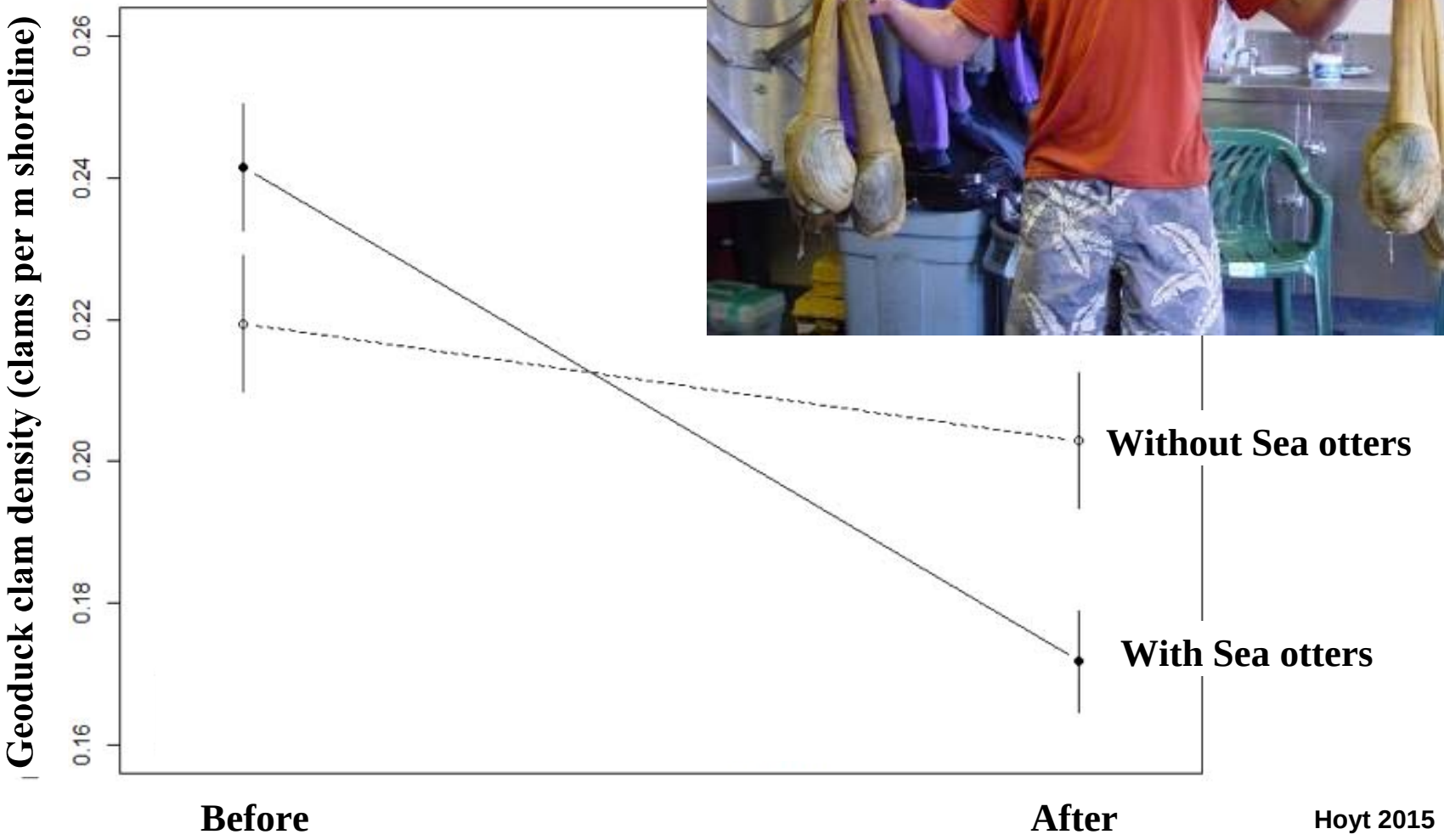
UAF UNIVERSITY OF ALASKA FAIRBANKS

APECS

Sea Grant Alaska

Photo credit:
Deborah Mercy

Geoduck clam density



Hoyt 2015

What are sea otters eating?


Pinto abalone
Haliotus kamtchatKana


Red sea urchin,
Strongylocentrotus franciscanus


Geoduck clam,
Panopea generosa

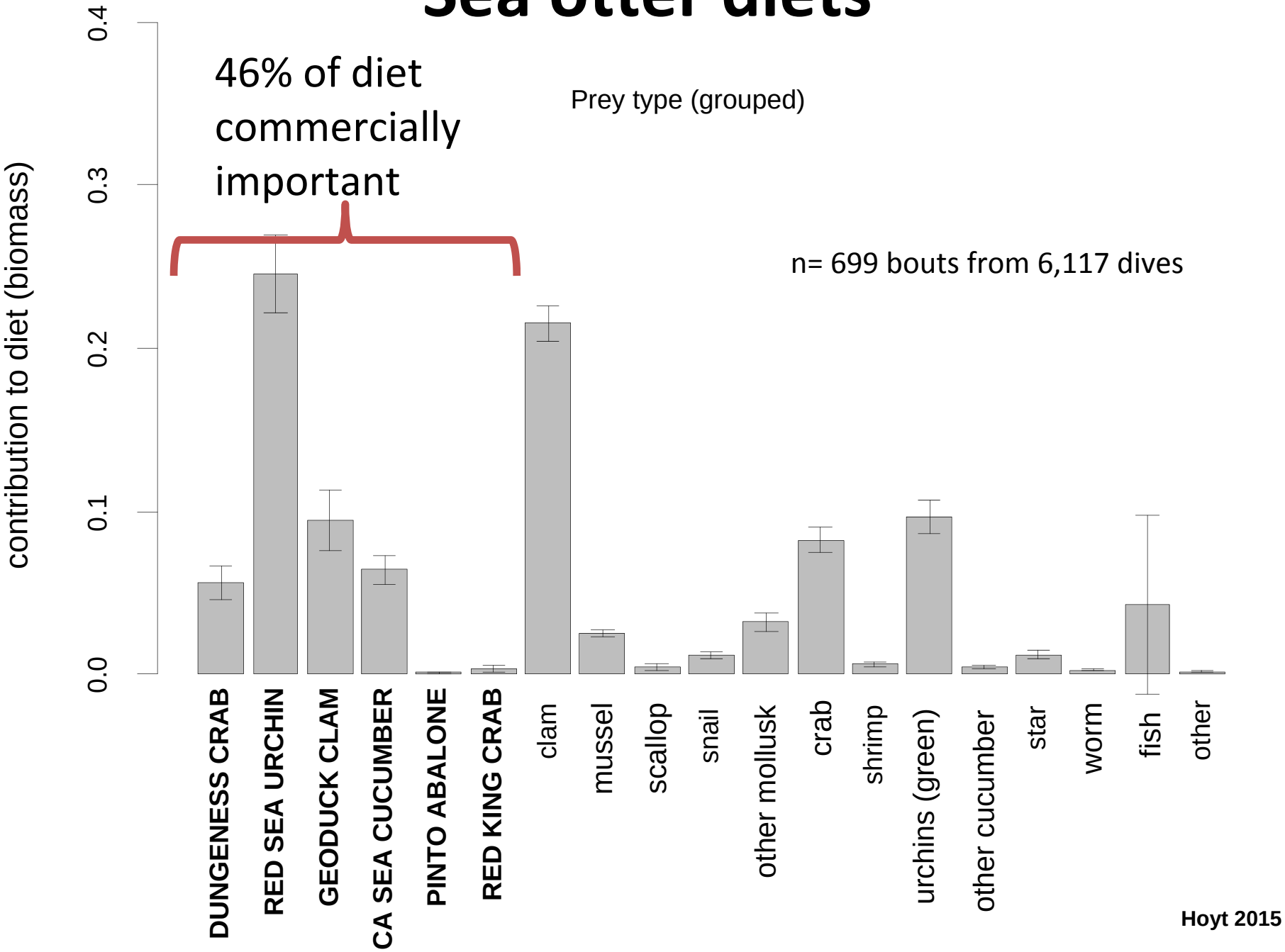

California sea cucumber,
Parastichopus californicus


Dungeness crab,
Cancer magister

Photo credit:
Phillip Collaç

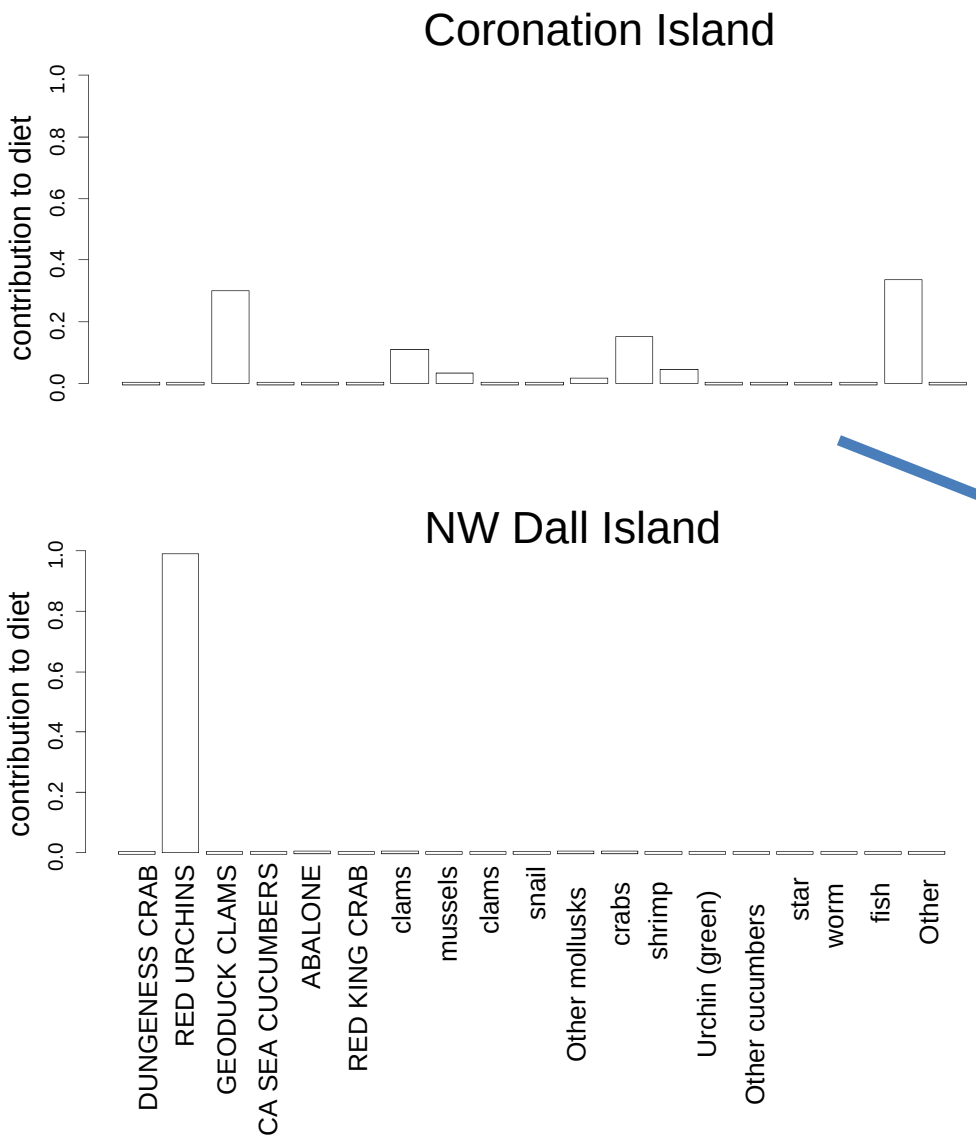

BRUNDEN

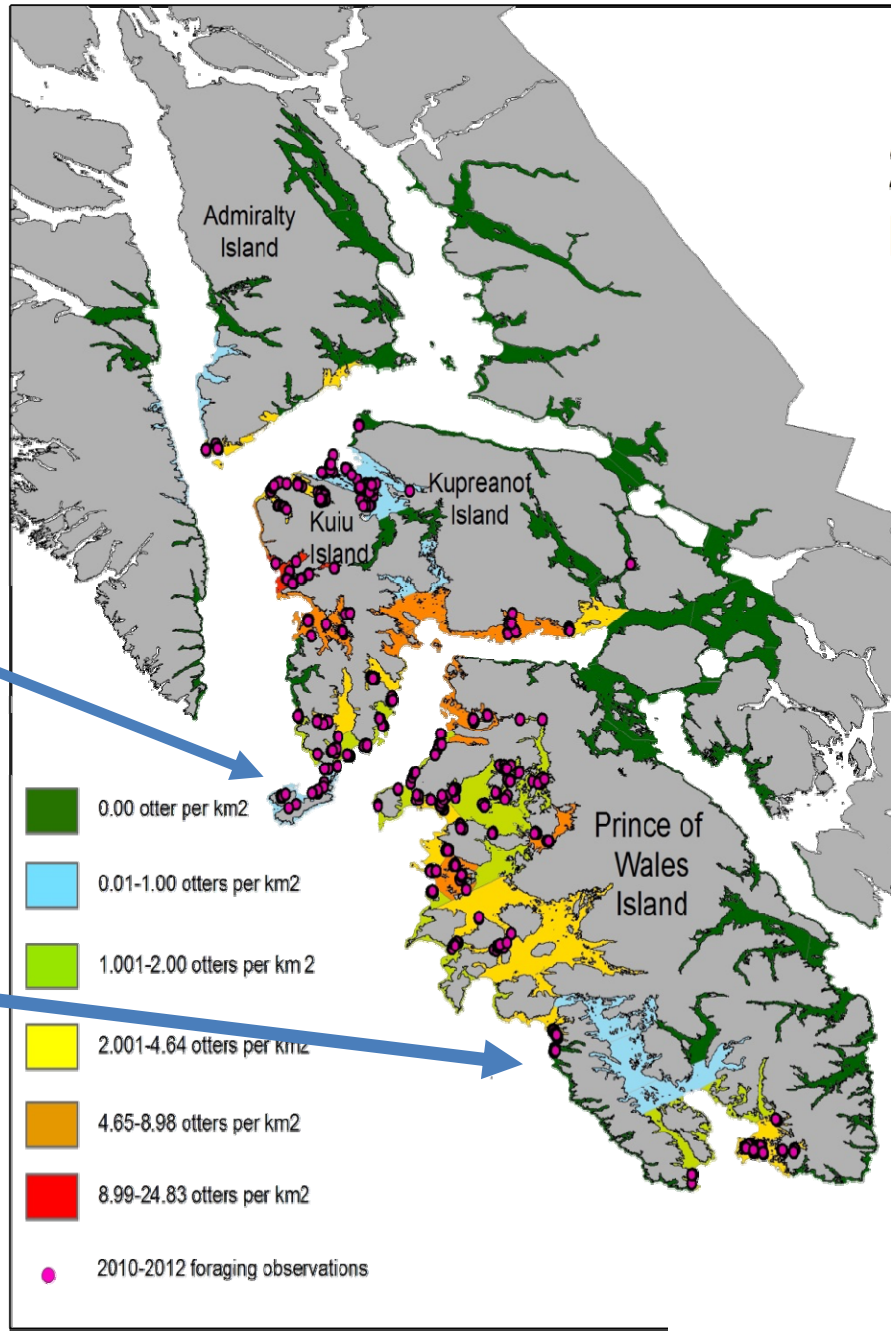
Sea otter diets



Hoyt 2015

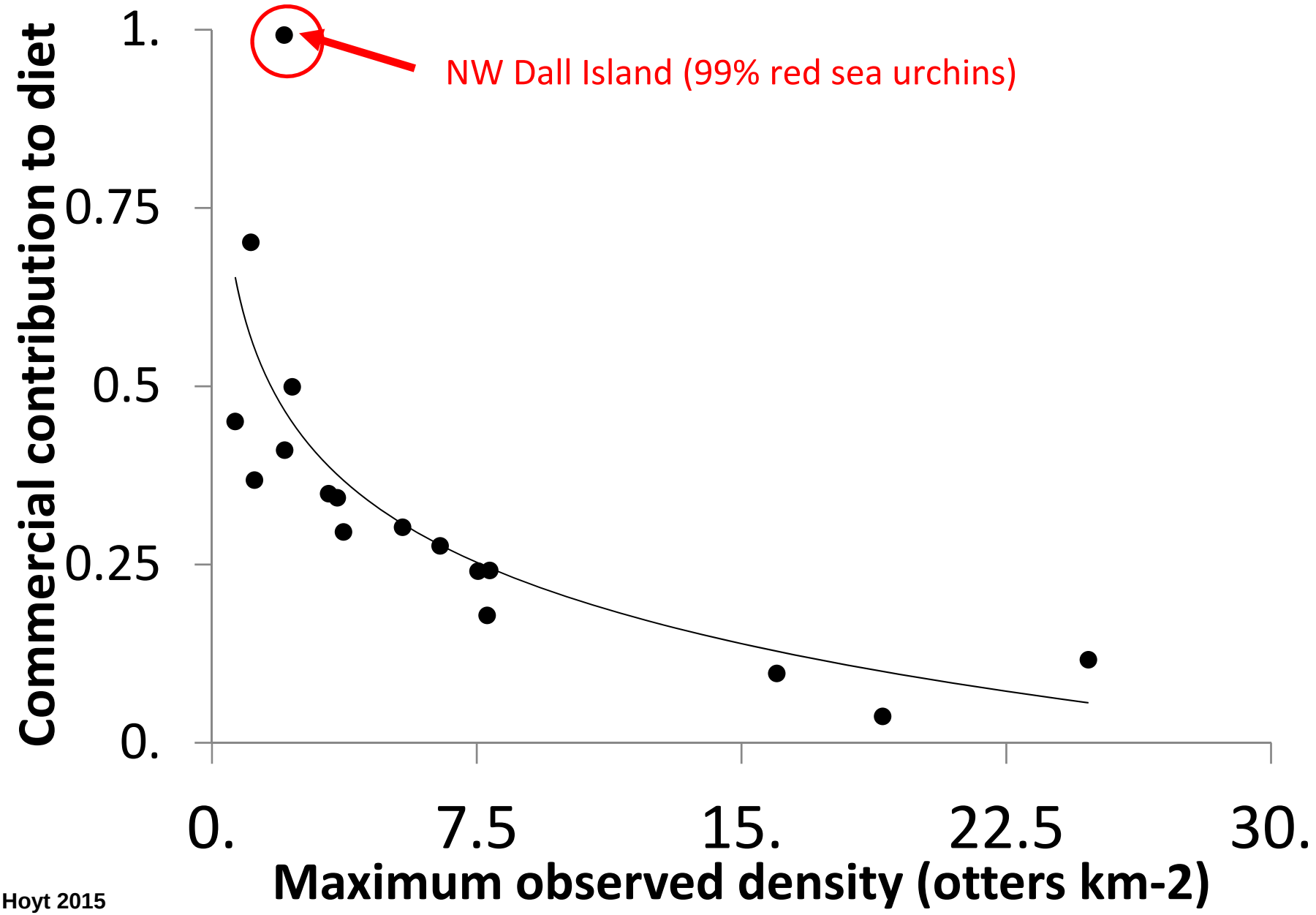
Geographic differences in diet





Hoyt 2015

Commercial contribution as a log-linear function of density



Hoyt 2015

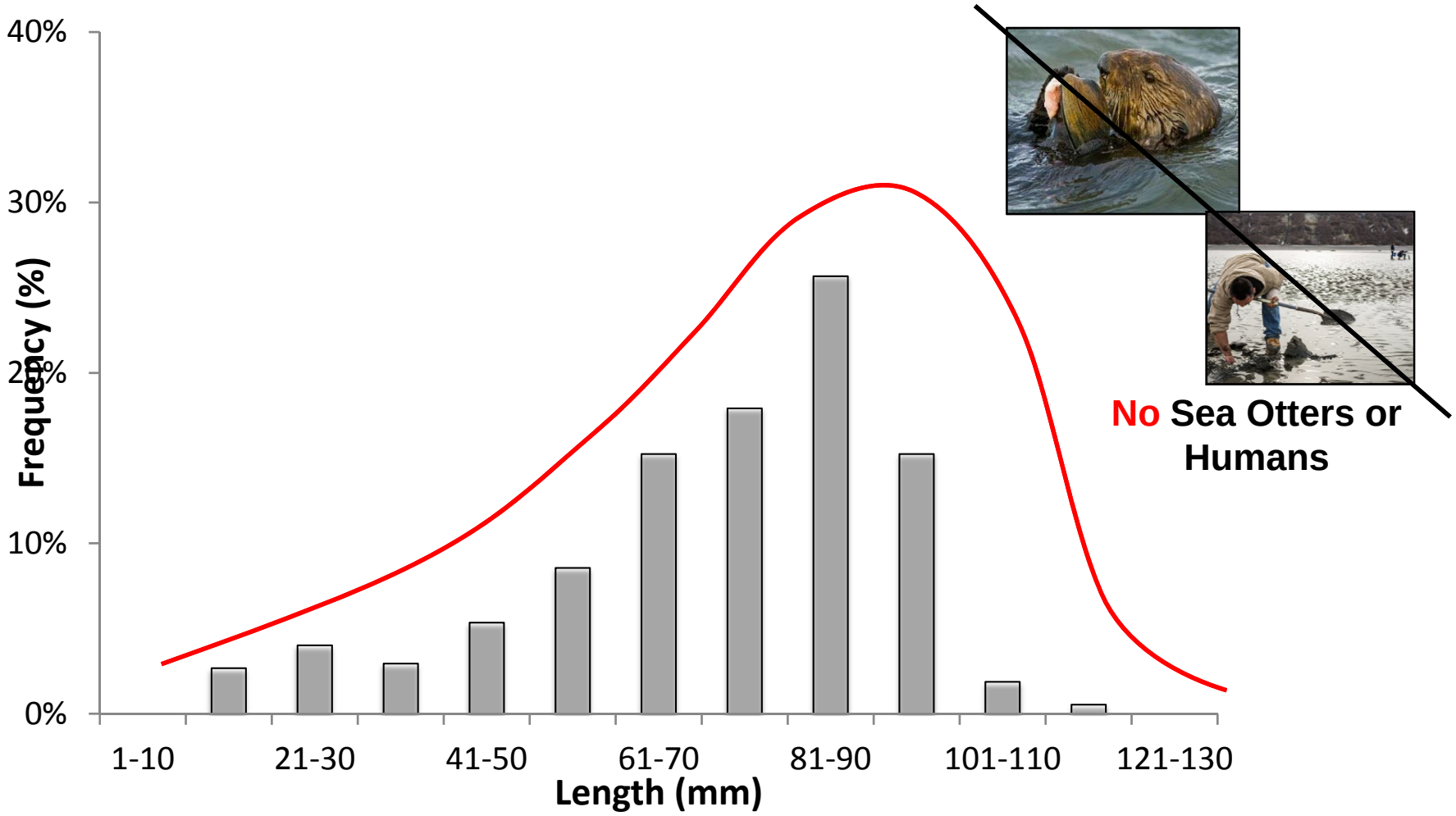
HUMANS-SEA OTTERS-BUTTER CLAMS

Photo Credit: Enrique R. Aguirre Aves

Sea Otter by Victor Tumuluk (Hydaburg)

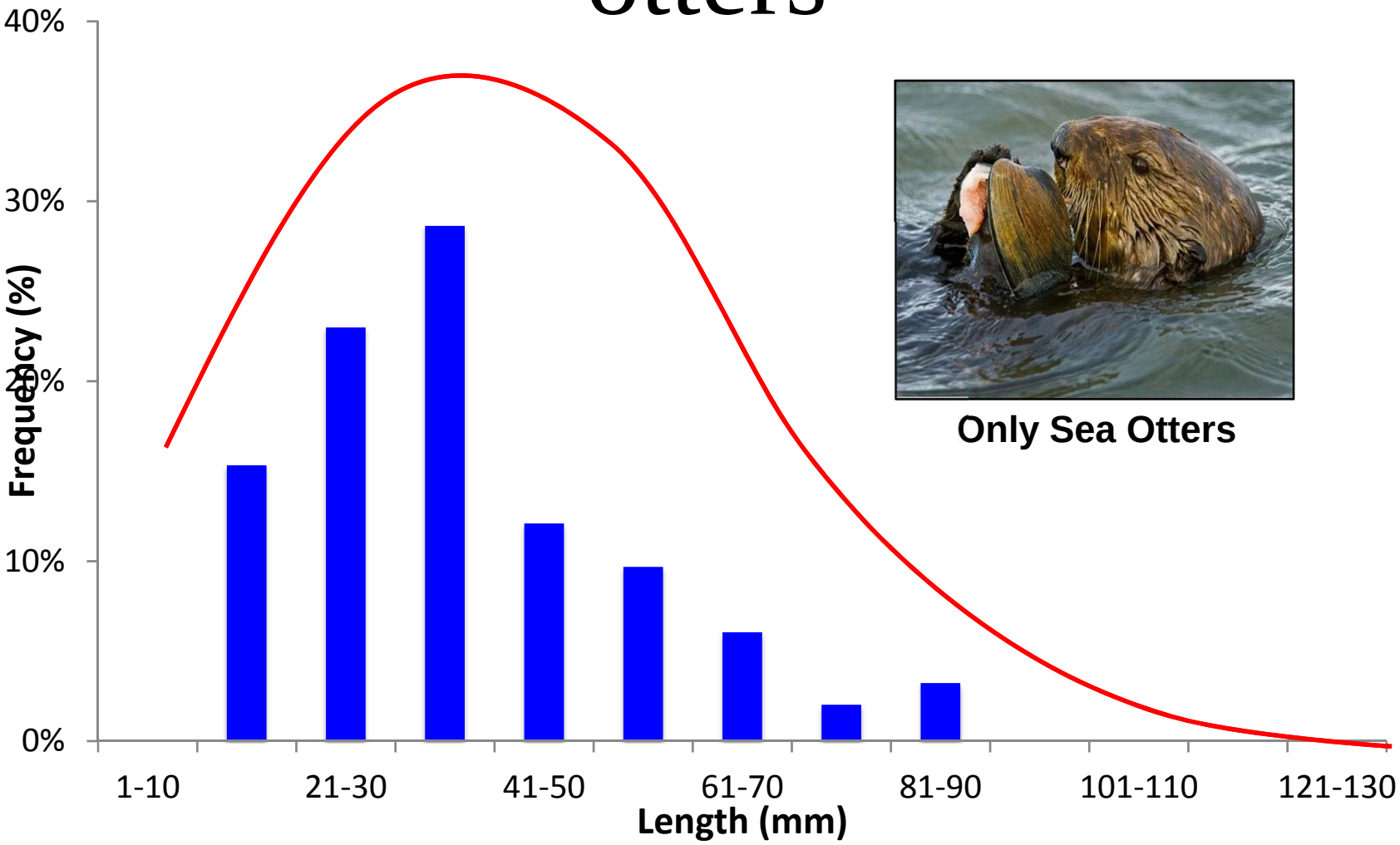
Ibarra in progress

Clam size distribution without sea otters



Ibarra in progress

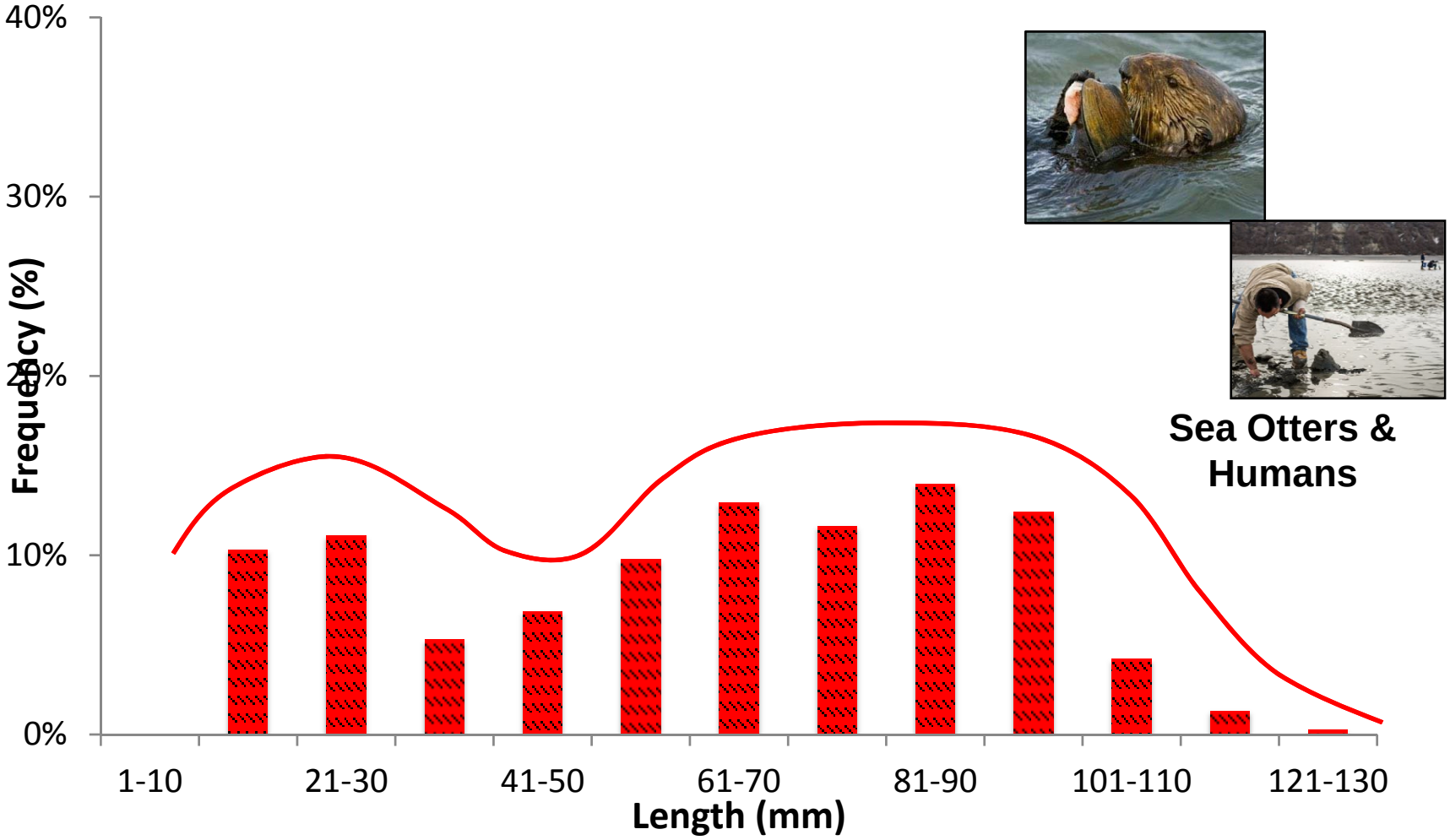
Clam size distribution with sea otters



Only Sea Otters

Ibarra in progress

Clam size distribution with sea otters & humans



Ibarra in progress

Sea otters and humans

- Commercial species in diet greatest early after colonization: long-established populations supported by clams
- Effect on subsistence clam populations, both abundance and size structure
- Coexistence will be challenging: must account for spatial structure of sea otter populations, and dynamic nature of diet and interactions

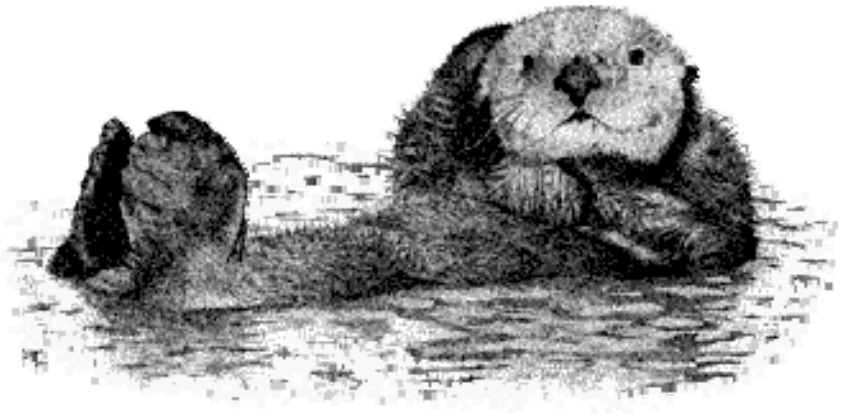


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Photo credit:
Deborah Mercy