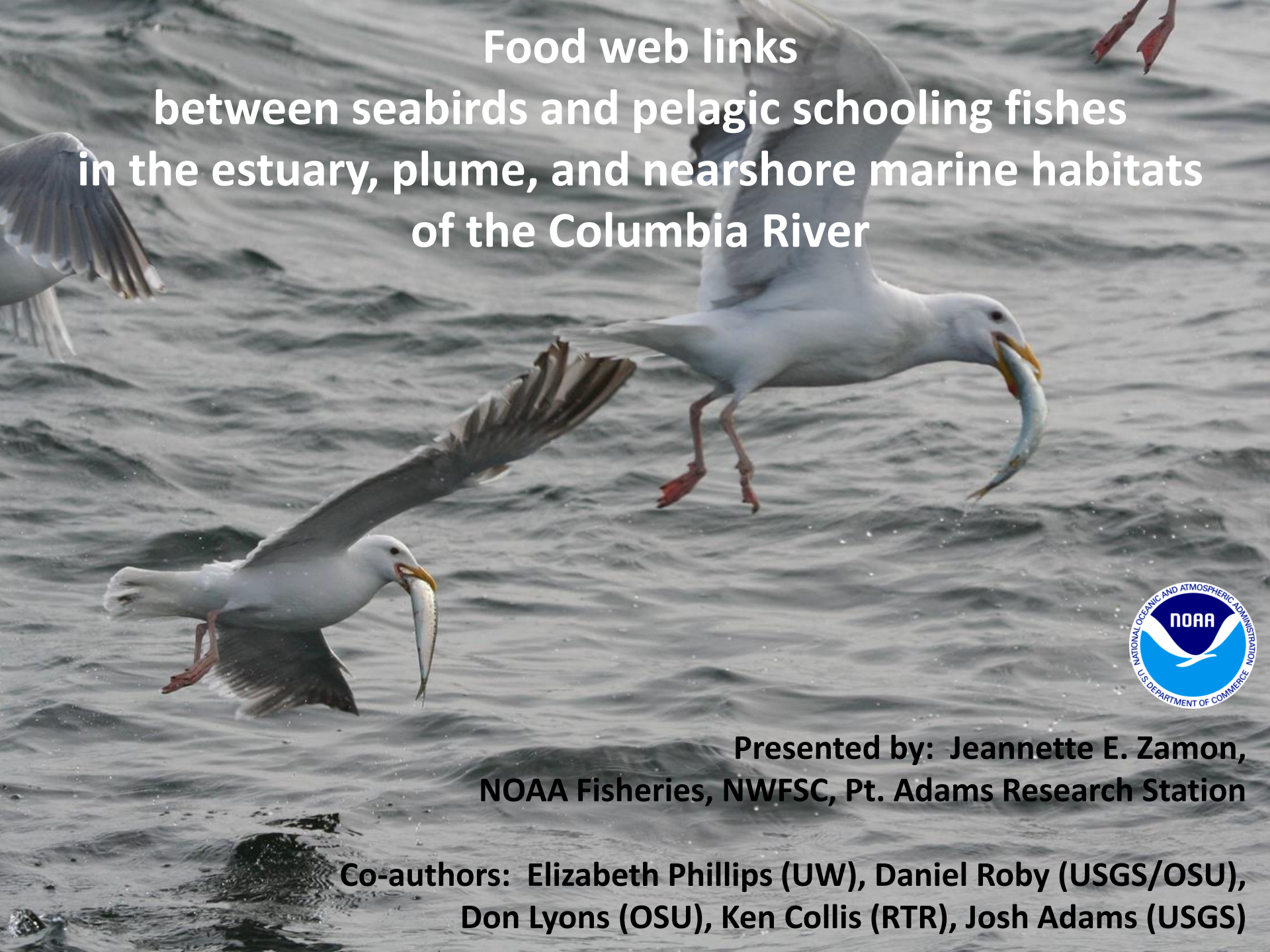
# Food web links between seabirds and pelagic schooling fishes in the estuary, plume, and nearshore marine habitats of the Columbia River

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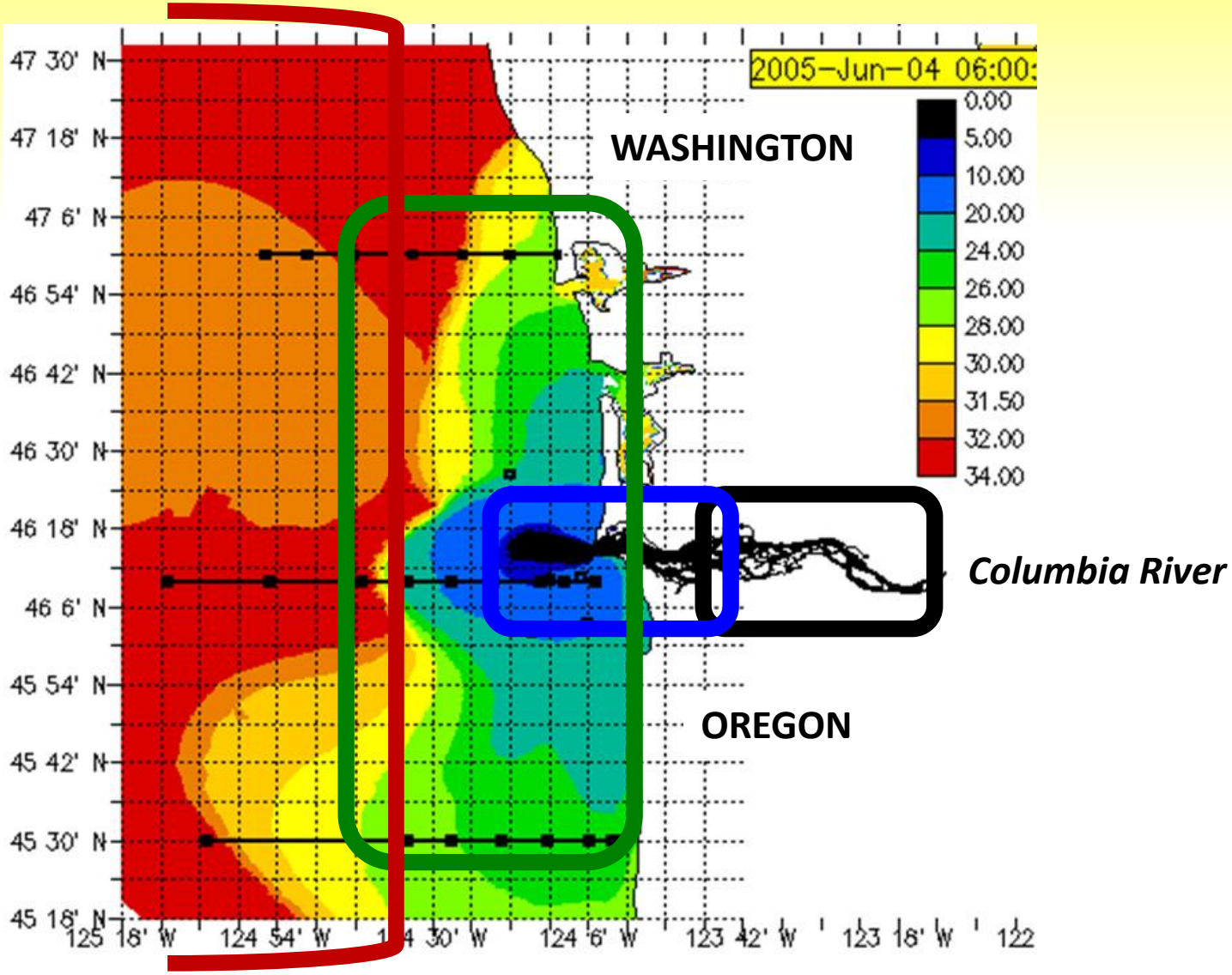
# CONCEPTUAL FRAMEWORK – Estuary/plume continuum

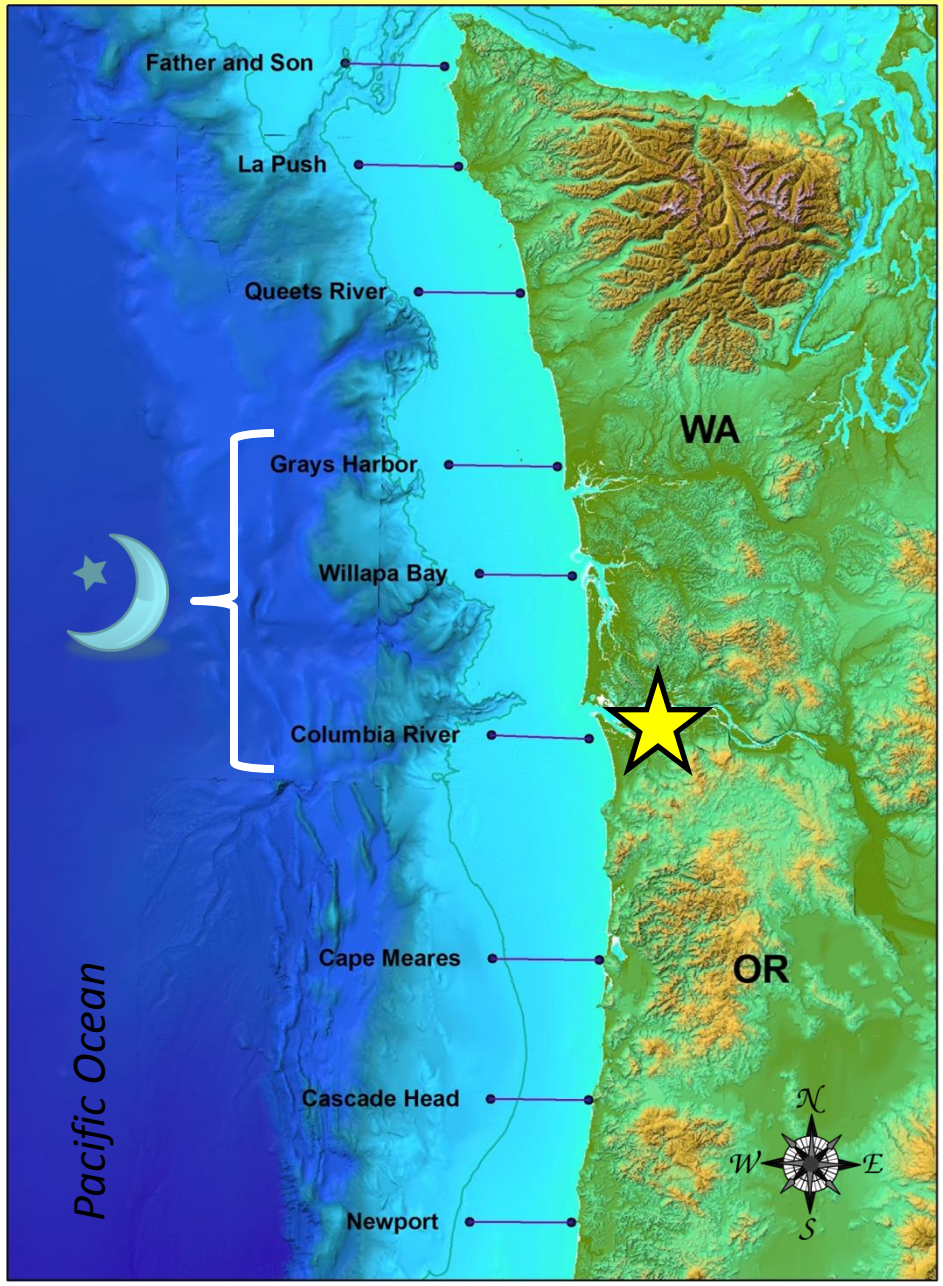



- **Pacific Ocean**
- **Plume**
- **Estuary**
- **Tidal freshwater**

*Model data & images courtesy www.stcmop.org*

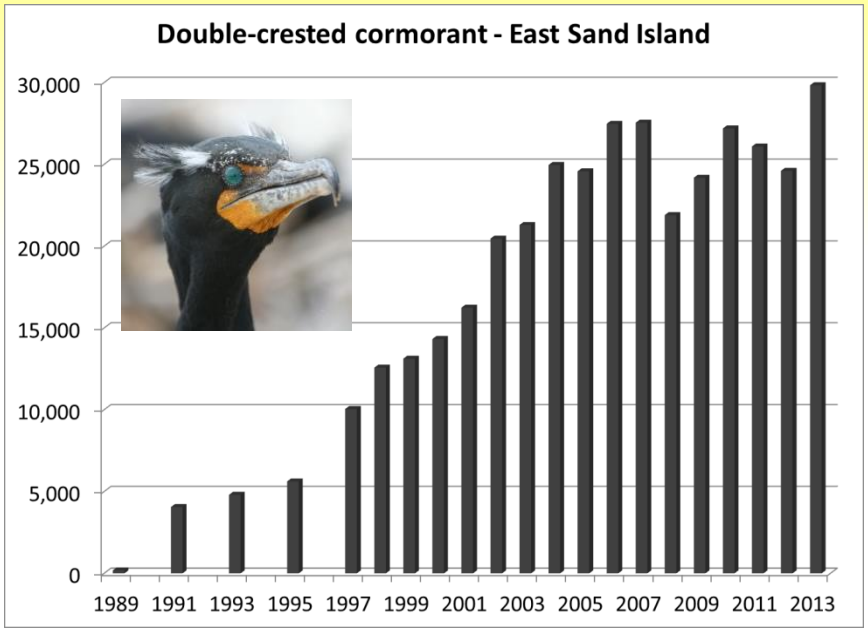
# Data sources

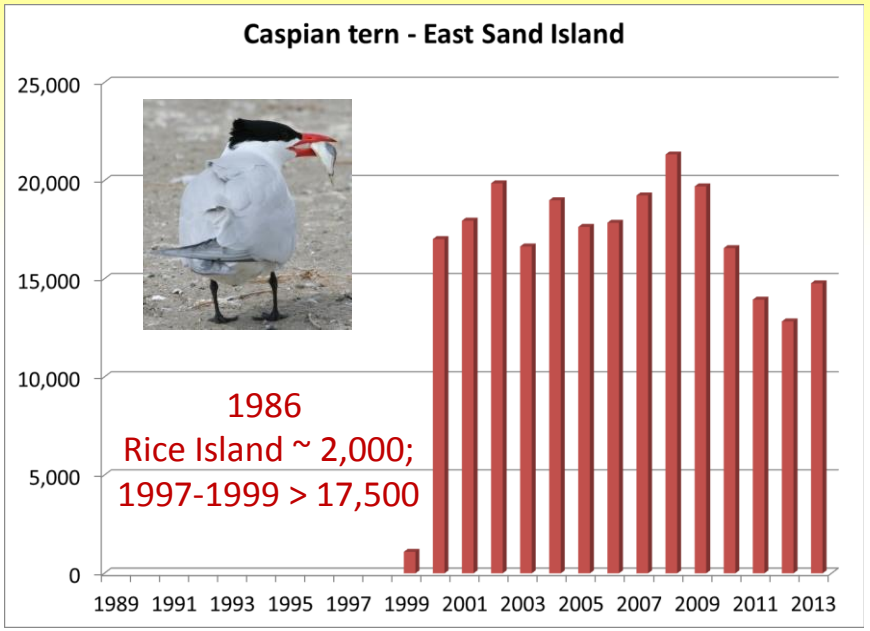
- NOAA Fisheries, Bird Research Northwest
- Estuary (yellow star):
  - Roby, Collis et al. waterbird studies
  - Weitkamp et al. estuary purse seines
- Plume (transect lines):
  - Zamon, Phillips, Guy et al. marine bird surveys
  - Casillas/Fresh et al. daytime surface trawls
  - Emmett, Bentley, Litz et al. nighttime surface trawls

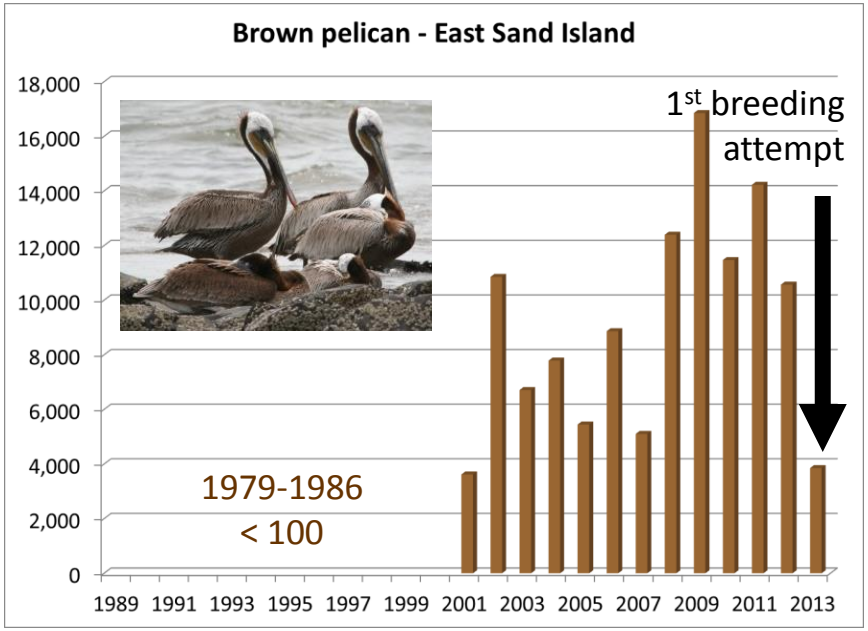


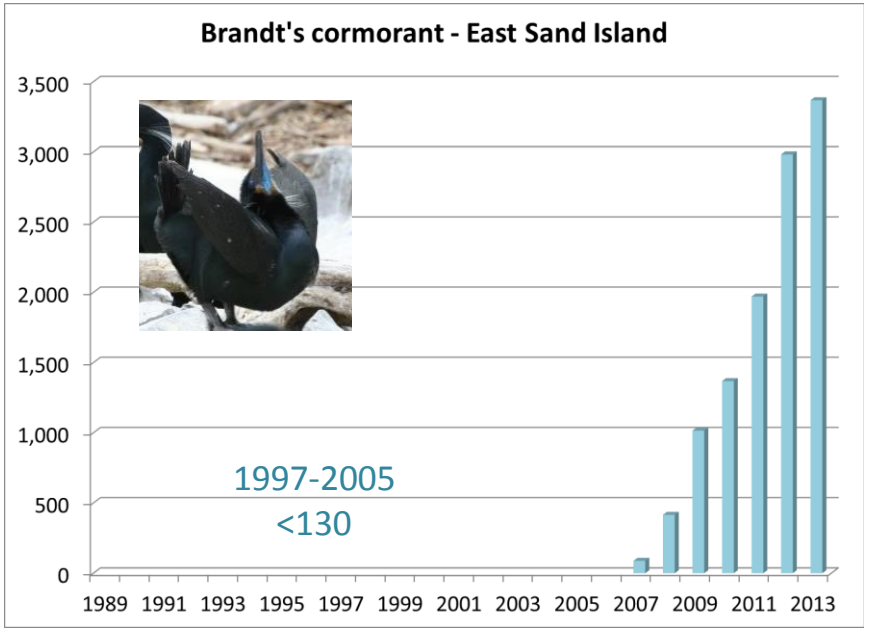
# RESULTS: Estuary populations > 65K

Estimated total number of individual birds

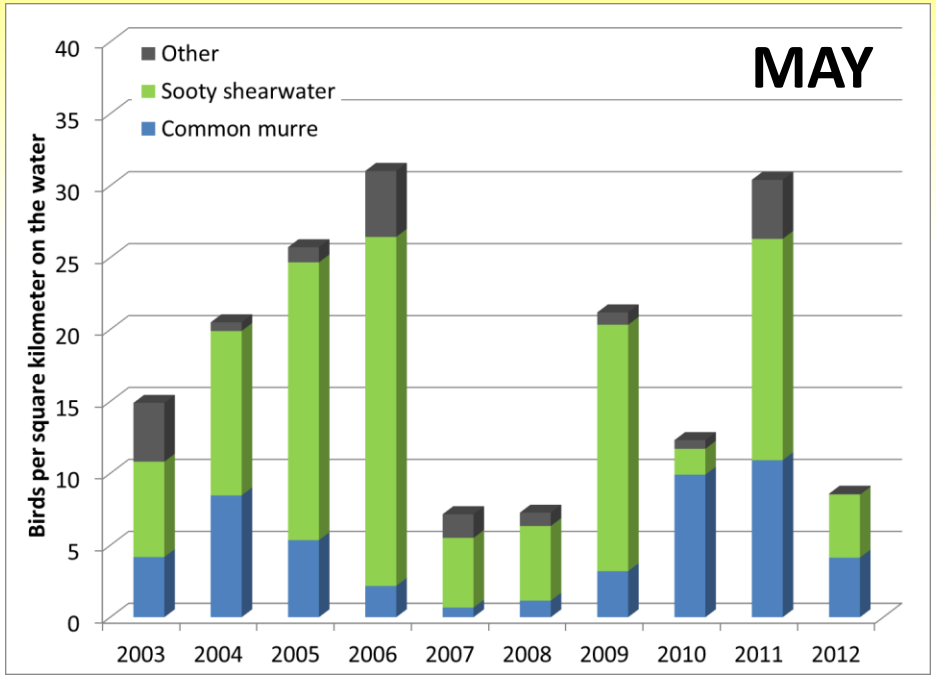


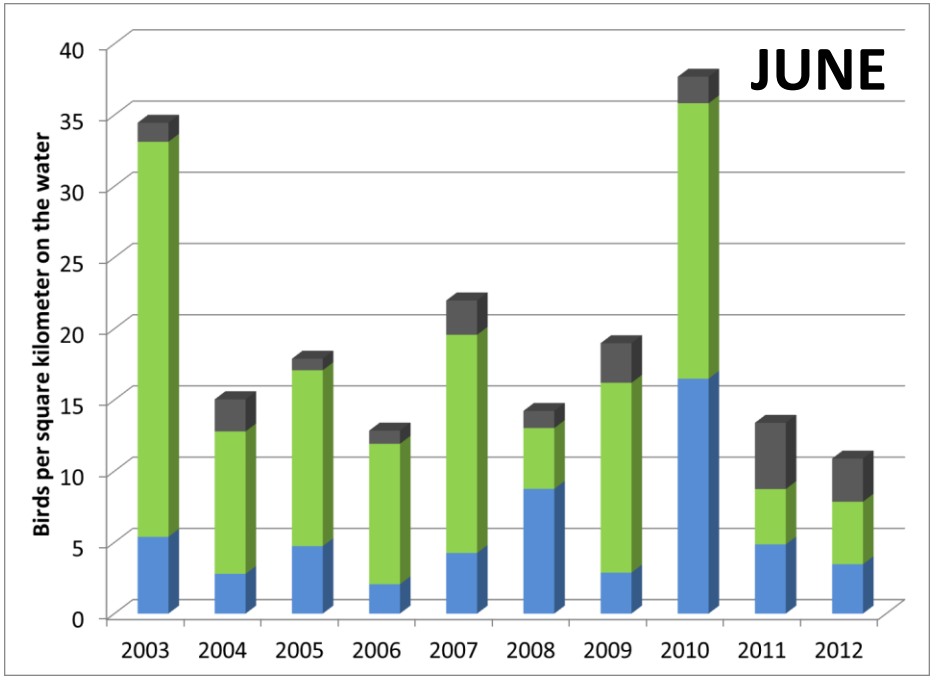



# RESULTS – Plume populations 2-4 x $10^6$

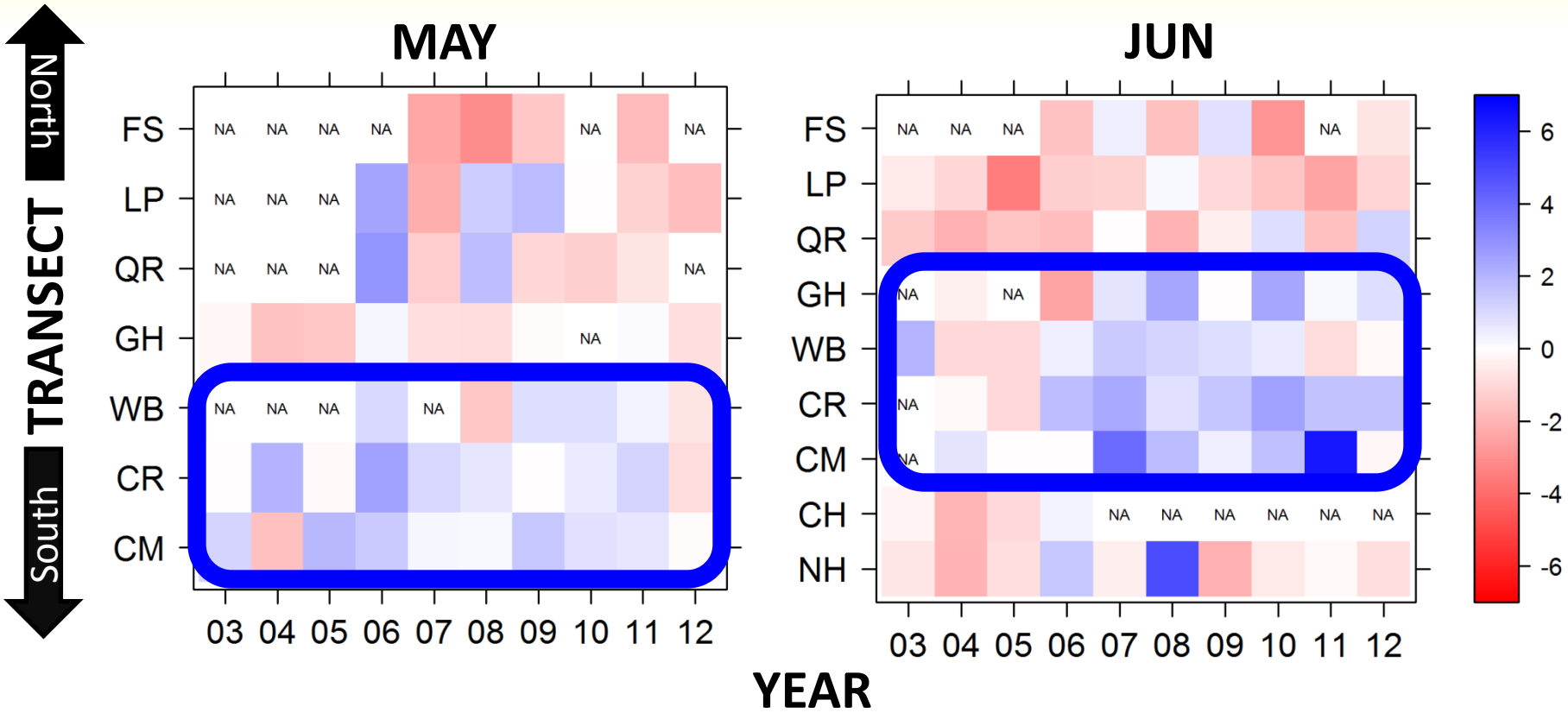



- Numerical dominants
  - Common murres
  - Sooty shearwaters
- Minimum mean densities 7-37 birds·km$^{-2}$





# Plume region has anomalously high common murre & sooty shearwater densities

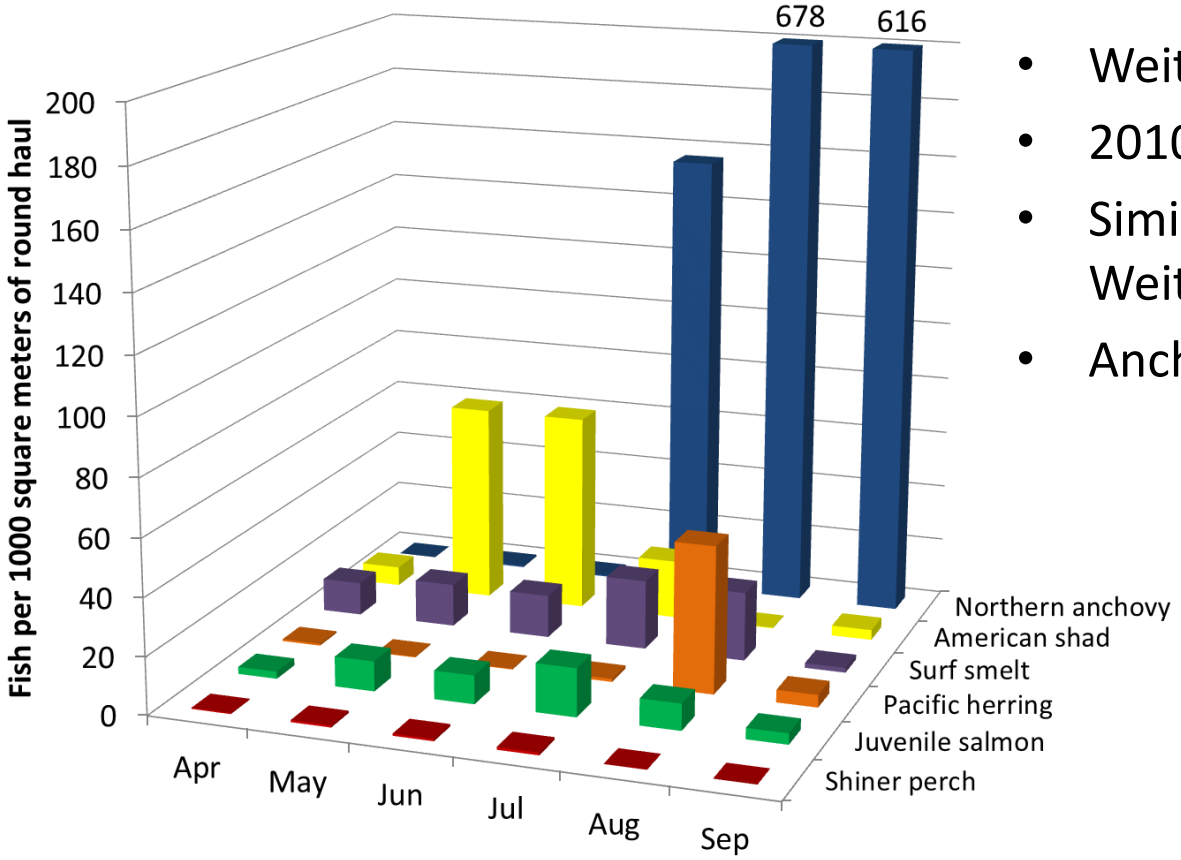



- Transect-by-year comparisons
- Density anomalies relative to global mean


WHAT FOOD SOURCES SUPPORT
SO MANY FISH-EATING BIRDS?

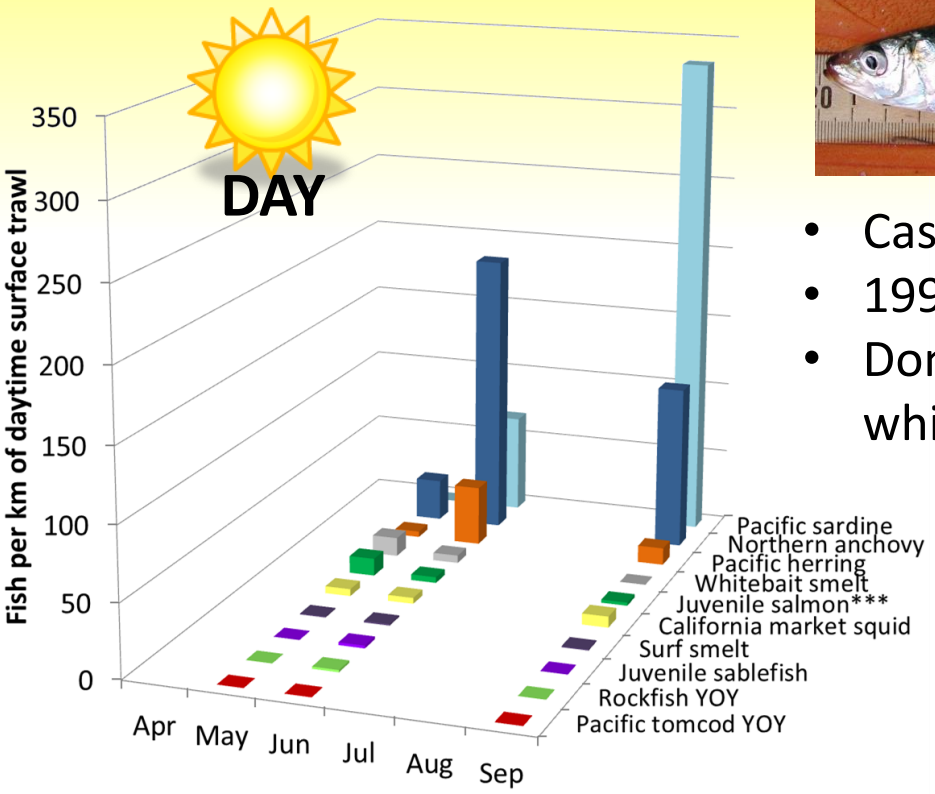
# RESULTS – Estuary fishes



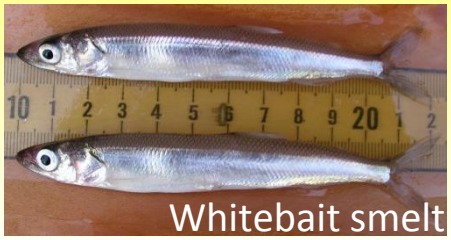




- Weitkamp et al. unpublished data
- 2010-2012, ~27 taxa in total
- Similar rankings as 2007-2010 (see Weitkamp et al. 2012)
- Anchovy, shad, surf smelt, herring

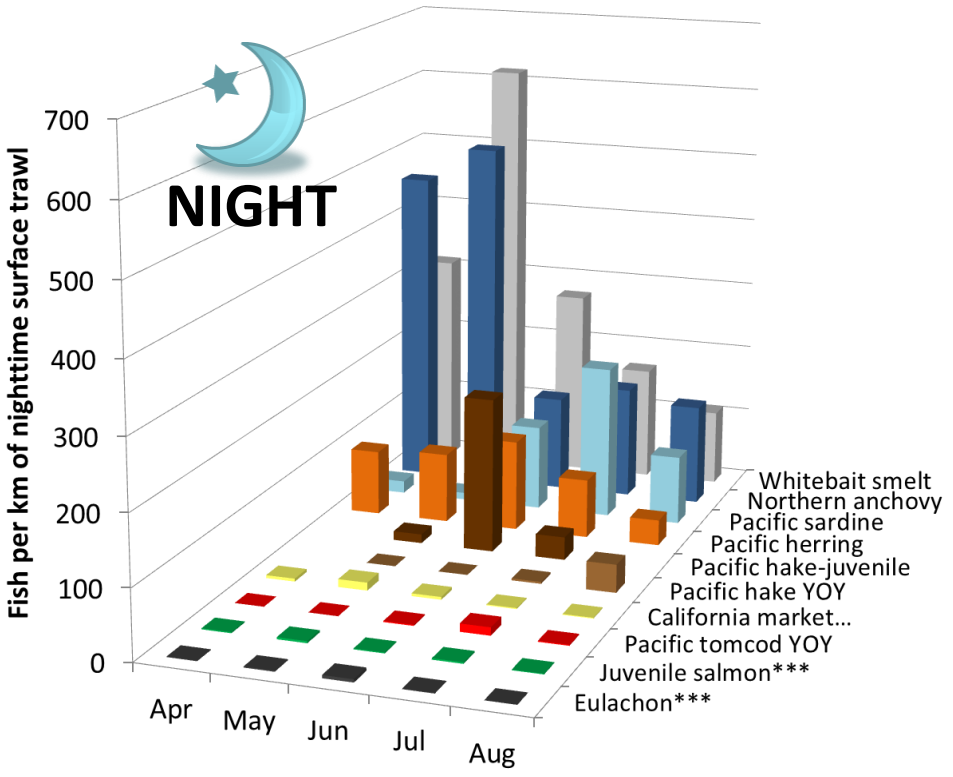
# RESULTS – Plume fishes







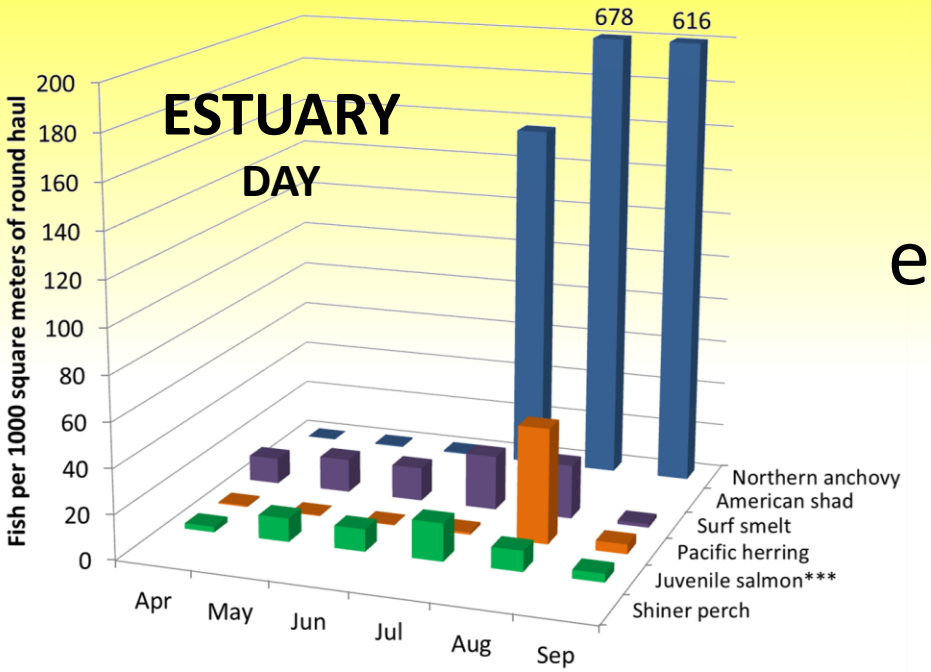

- Casillas/Fresh et al. unpublished data
- 1999-2013, ~ 100 taxa in total, ≤ 250 mm
- Dominated by sardine, anchovy, herring, whitebait smelt

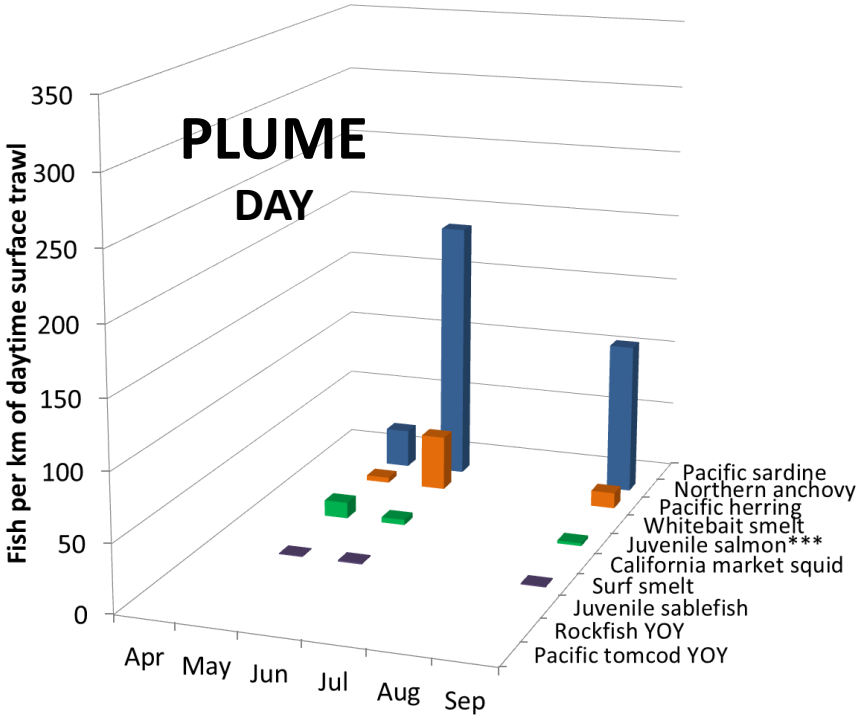


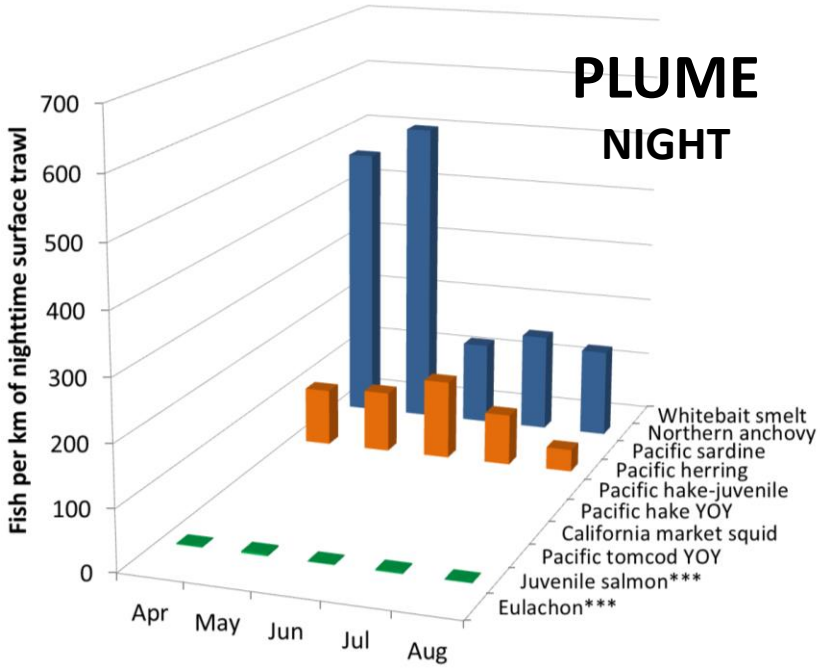

- Emmett et al. unpublished data
- 1999-2011, similar to 1999-2009 (see Litz et al. 2013), ~ 100 taxa in total
- Whitebait smelt, anchovy, sardine, herring

# RESULTS – Fishes common across estuary/plume continuum

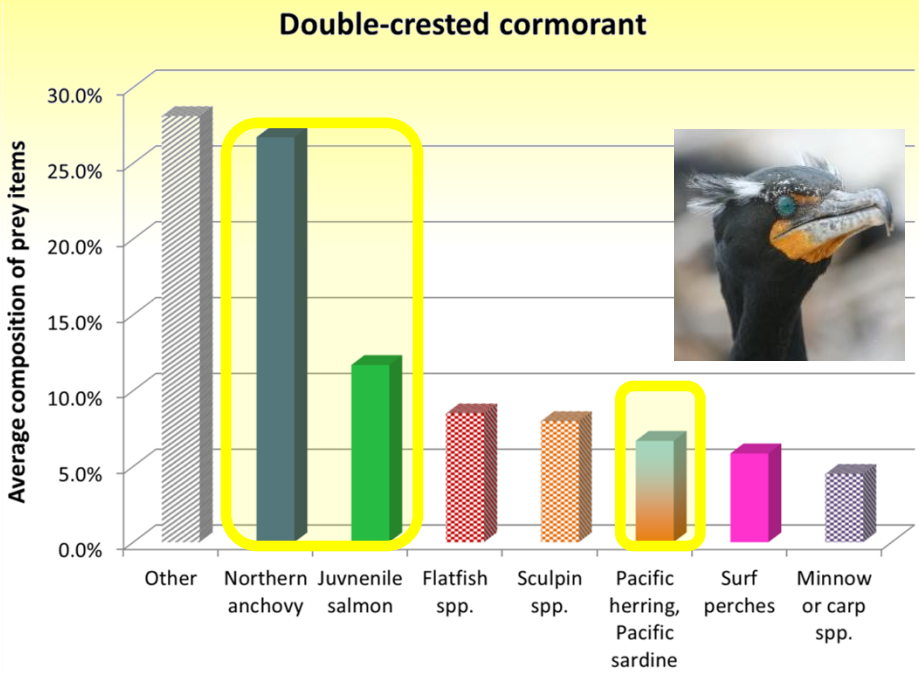
- Northern anchovy
- Surf smelt
- Pacific herring
- Juvenile salmon



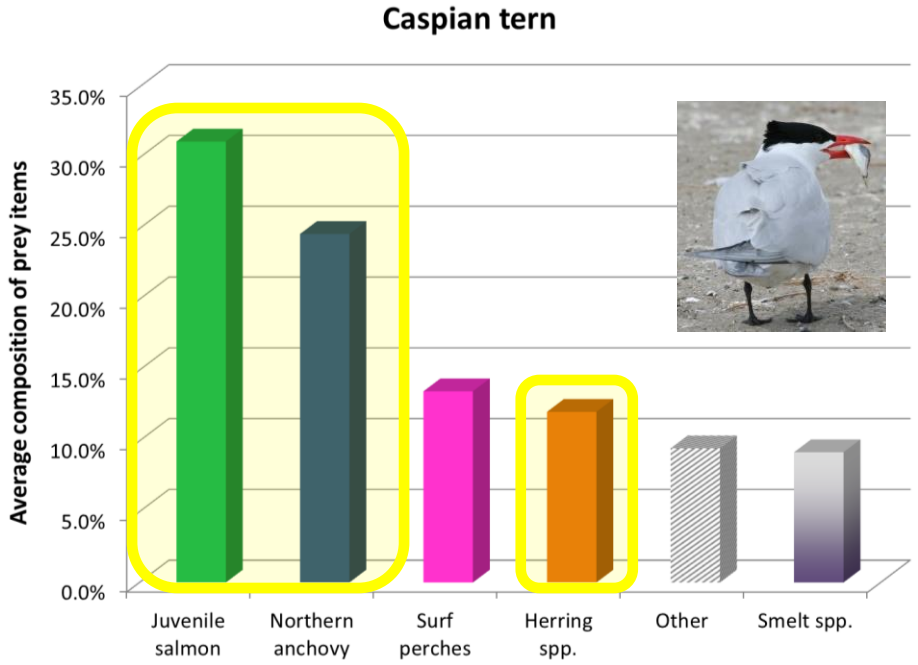



# RESULTS – Estuary bird diet




- Mean composition, 2000-2013
- Over 45% of cormorant diet by mass, 67% of tern diet by number contains anchovy, salmon, herring

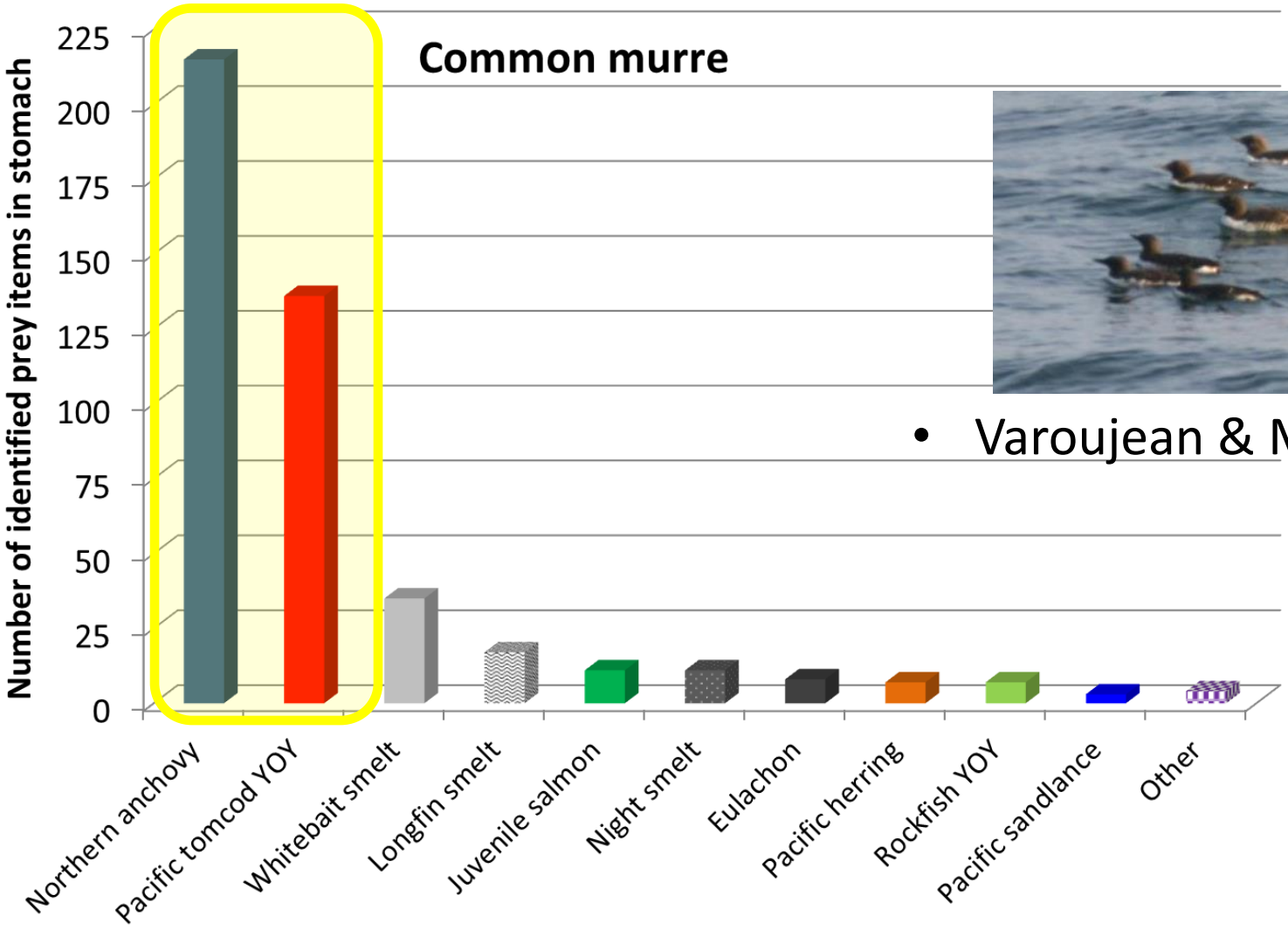
- "Other" includes mix of 3-spined stickleback, gunnels, additional 8+ taxa comprising <5% of prey items



# RESULTS – Plume bird diet

Very few data available:

- Zamon et al. (unpublished)
  - Anchovy most prevalent in sooty shearwater (n=35) & common murre (n=43) samples






- Varoujean & Matthews 1983 (n = 77)

# MANAGEMENT & CONSERVATION APPLICATION

- Marine spatial planning
  - Wind/wave/tidal energy
  - Oil spill planning & response
- Ecosystem science
  - Trophic “hot spots”
  - Climate/ecosystem change
  - Food web models
- Ecosystem management
  - Critical, sensitive, protected habitat
  - Recovery planning for ESA-listed species
  - Coastal pelagics/forage fish

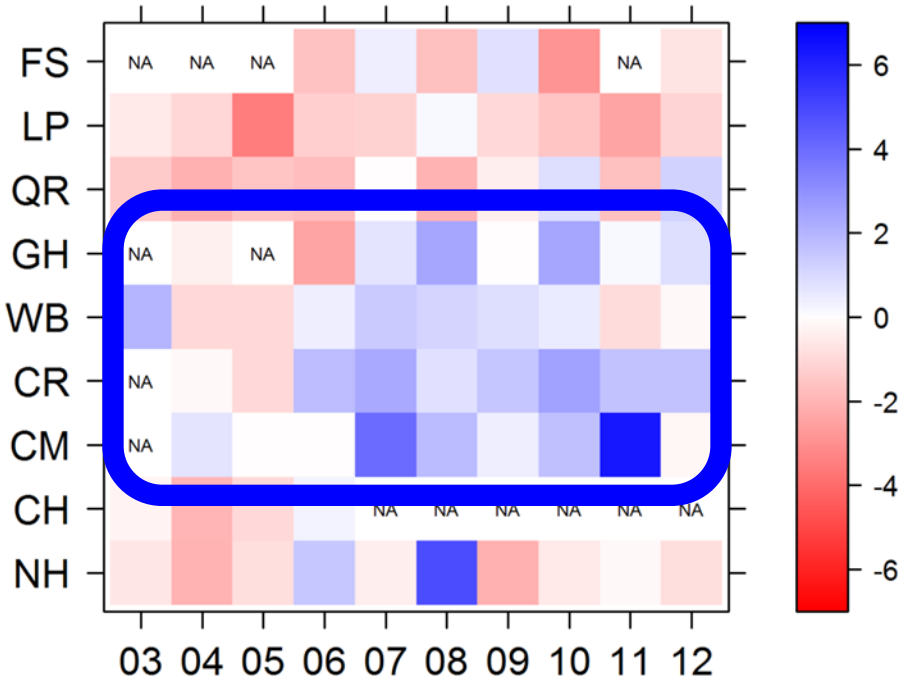
Wreck of oil barge *Millicoma*, Columbia River mouth, 2005

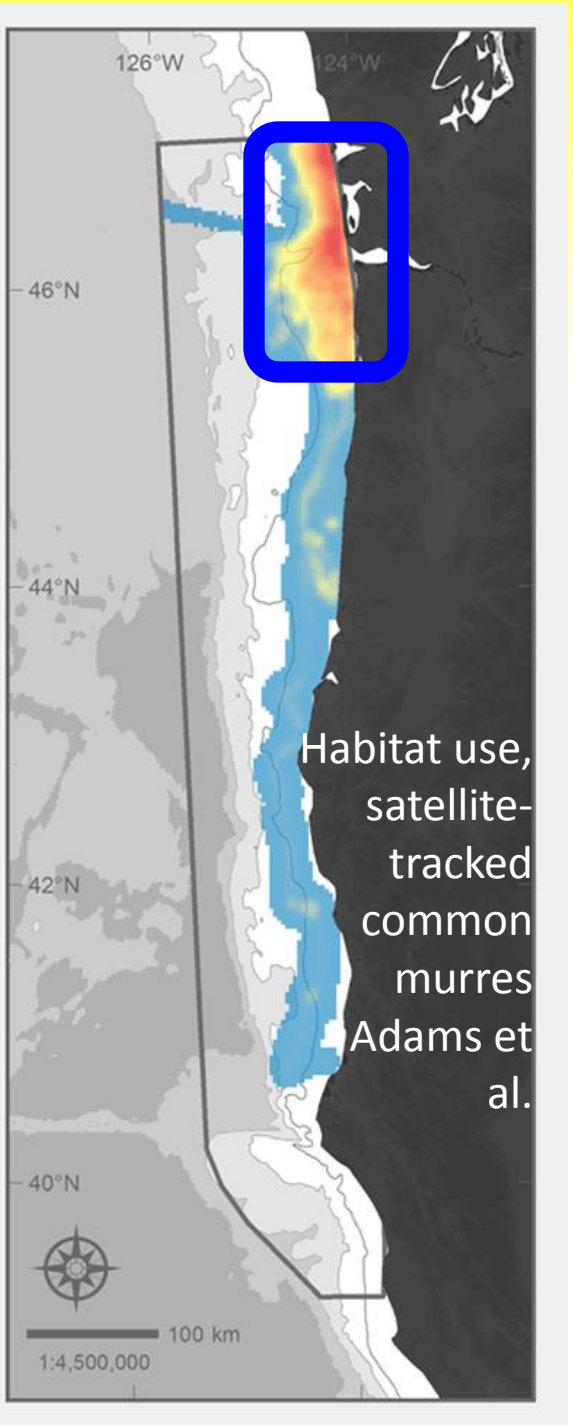
# TAKE HOME MESSAGES – Estuary/plume

1. The estuary/plume continuum supports very large numbers of fish-eating seabirds during Apr–Sep
2. Anchovy, herring, smelt, and juvenile salmon probably provide most of the food resources to support birds in the estuary/plume.
3. Seabird-fish food web interactions create a plume-associated "ecological hotspot" relevant to multiple issues of management & conservation concern.

# NEXT STEPS

- Merge transect & telemetry data sets
- Quantitative diet information in plume
- Study forage fish ecology across the estuary-plume continuum: anchovy, herring, smelt



# ACKNOWLEDGMENTS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