Zooplankton Monitoring in Puget Sound

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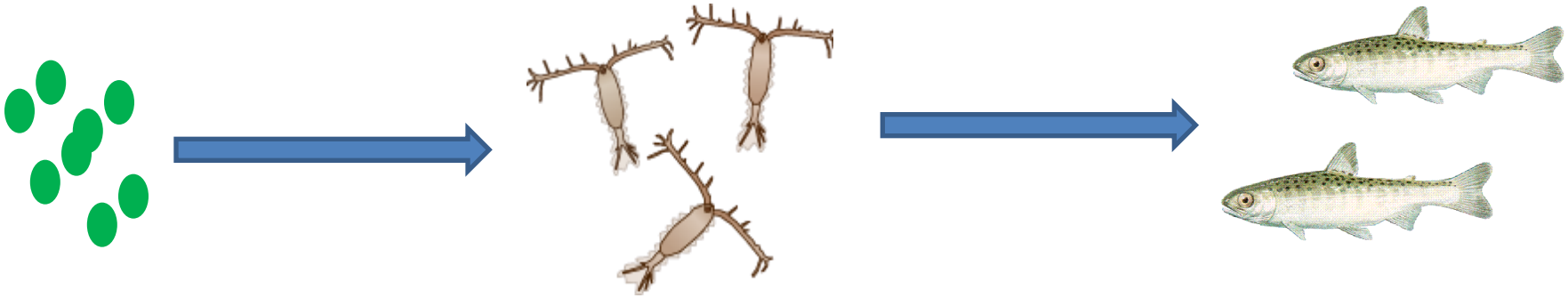
University of Washington

King County

SALISH SEA
MARINE SURVIVAL PROJECT
www.marinesurvivalproject.com

Why Monitor Zooplankton?

- **Good indicators of environmental variation**
- **Key intermediate step in marine food webs**
  - Fish recruitment controlled by prey availability



In hot water: zooplankton and climate change

Anthony J. Richardson

ICES Journal of Marine Science, 65: 279–295.

"Beacons of climate change"

ICES Journal of Marine Science, 62: 333–338 (2005)
doi:10.1016/j.icesjms.2005.01.002

Available online at www.sciencedirect.com

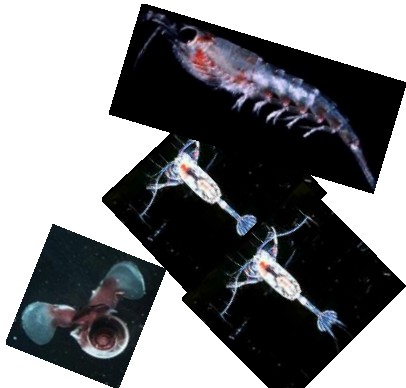
SCIENCE DIRECT

Monitoring pelagic ecosystems using plankton indicators

Grégory Beaugrand

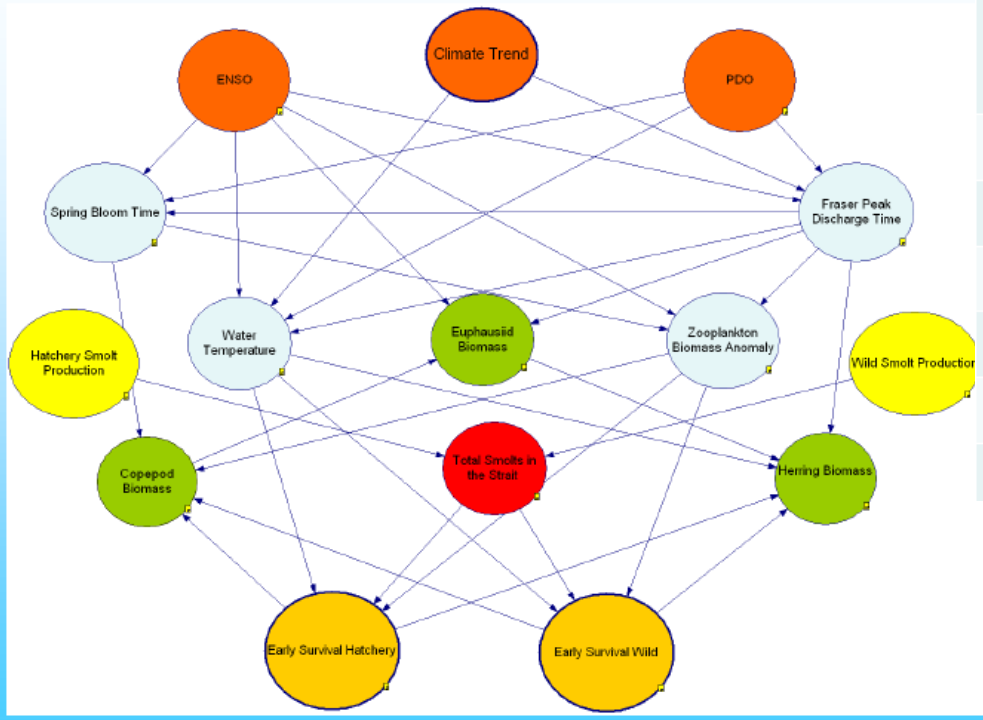
"Zooplankton integrate hydroclimatic forcing"

- ~1-3^{+} month life cycles ⟹ responsive to environmental change
- Strongly affected by advection and changes in temperature
- Most are not fished
- Critical in food webs



Strait of Georgia - Indicators for early marine survival of coho salmon

Bayesian network model to identify indicators for Coho salmon early marine survival :



Indicator	Diagnostic value
Zooplankton biomass anomaly	0.212
Calanoid copepod biomass	0.083
Herring biomass (pre-fishery)	0.073
Water temperature	0.056
Fraser peak discharge time	0.043
Euphausiid biomass	0.032
ENSO	0.029
PDO	0.021
Log spring bloom time	0.006

Slide courtesy of Ian Perry

Araujo et al. 2013 Prog. Oceanogr

What do we know about zooplankton in Puget Sound?

Confidence

Species composition
Which are important prey taxa

Life history patterns of several species*

Depth distributions

Seasonal cycles
Spatial patterns
Interannual variability

Terribly lacking:

- Time series spanning >2 years
- Consistent methodology

    - Seasonal cycles
    - Interannual variability

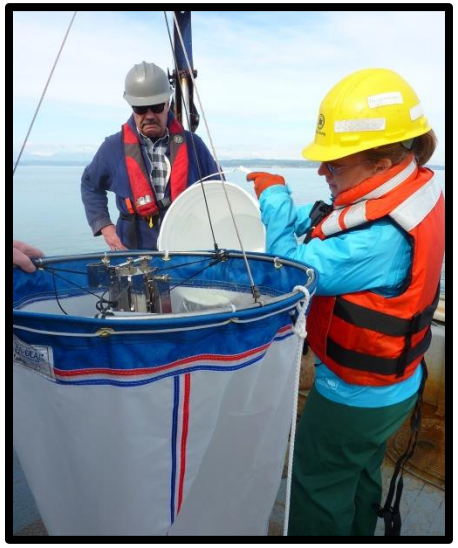
- Dynamics of critical prey taxa (crab larvae, euphausiids, amphipods) – difficult to capture with simple nets

- Spatial patterns and “hot-spots” of abundance

Zooplankton Information Needs

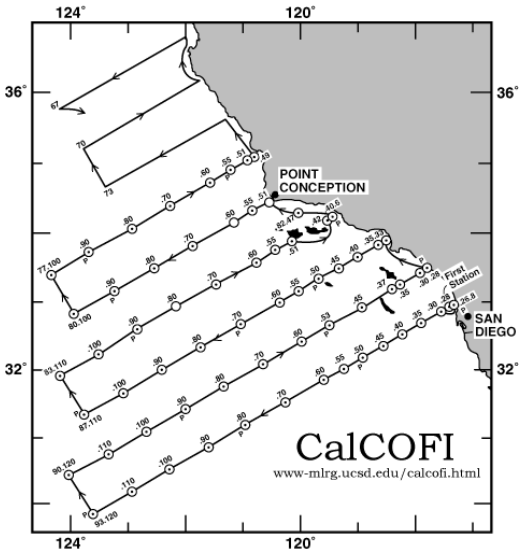
- Are zooplankton useful indicators of environmental conditions and ecosystem processes in Puget Sound?

- How is zooplankton variability related to salmon, forage fishes, and other organisms of interest?



Monitoring Program - Design tradeoffs:

Seasonal sampling of many locations



Advantages:

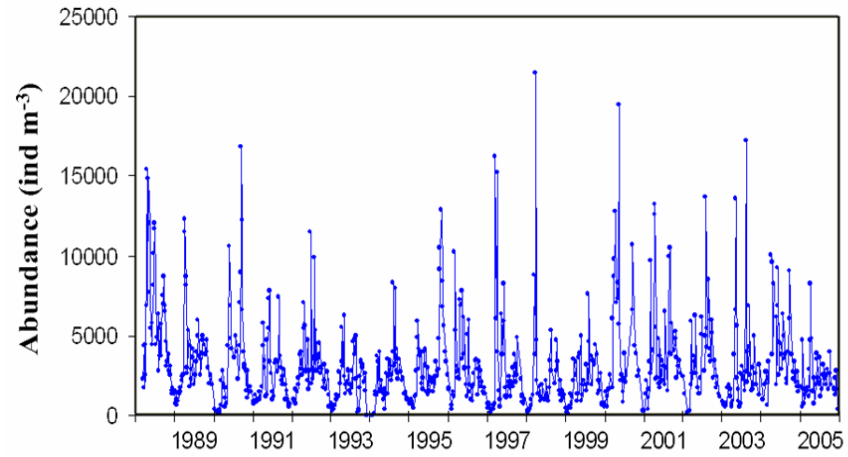
- Captures spatial patchiness well; can quantify and/or filter patchiness
- Can compare 2D patterns (chl a, T, S, currents)

Disadvantages:

- Requires large block of sampling time
- Does not resolve temporal cycles well
- Aliases phenology changes → artificial interannual variability

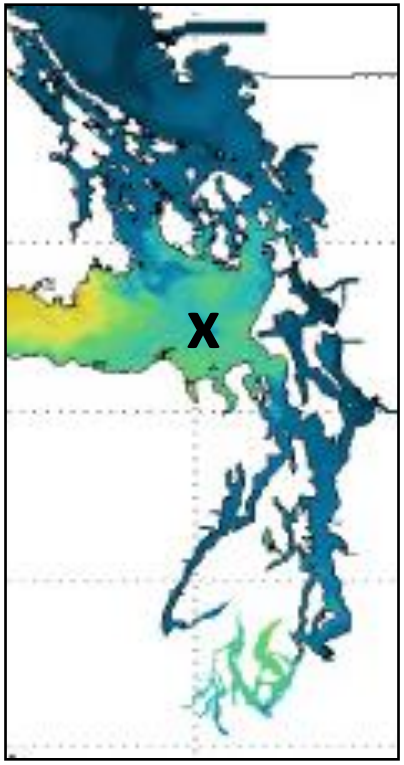
Design tradeoffs:

Regular, frequent sampling at a single location



Advantages:

- Simple to conduct
- Provides clear, intuitive time series – simple to analyze and visualize
- Data can be robustly compared to other time series data collected on similar time scales

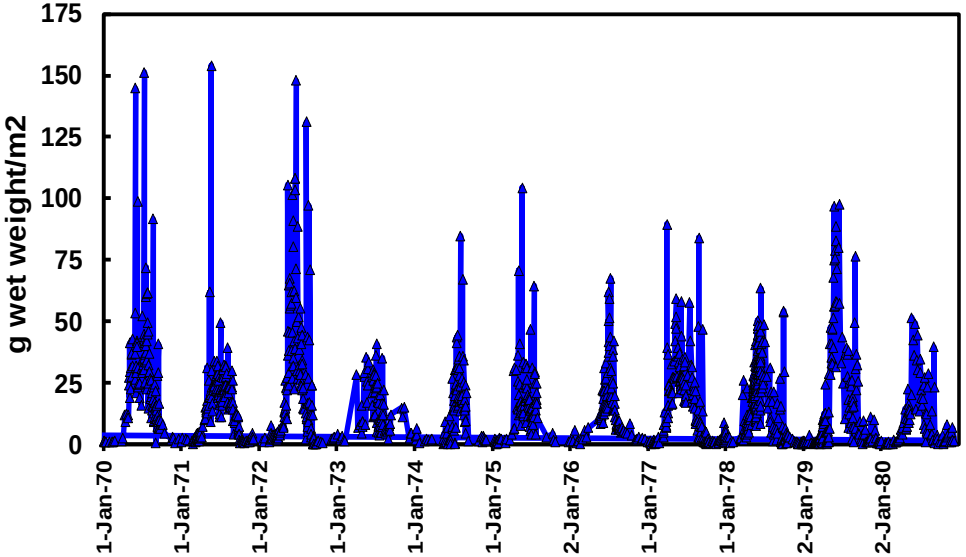


Disadvantages:

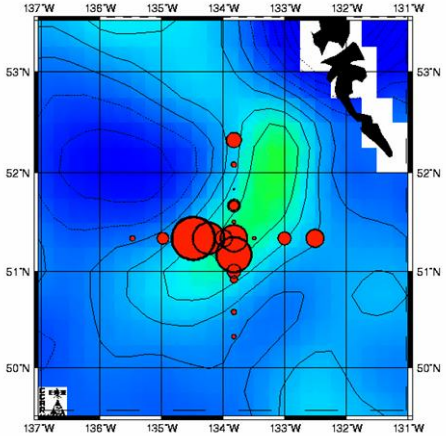
- Lacks information of spatial patchiness
- Lacks within-sampling period replication

Components of zooplankton variability to consider:

(1) seasonal cycles

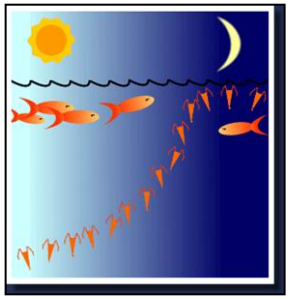


(3) small-scale and transient patchiness



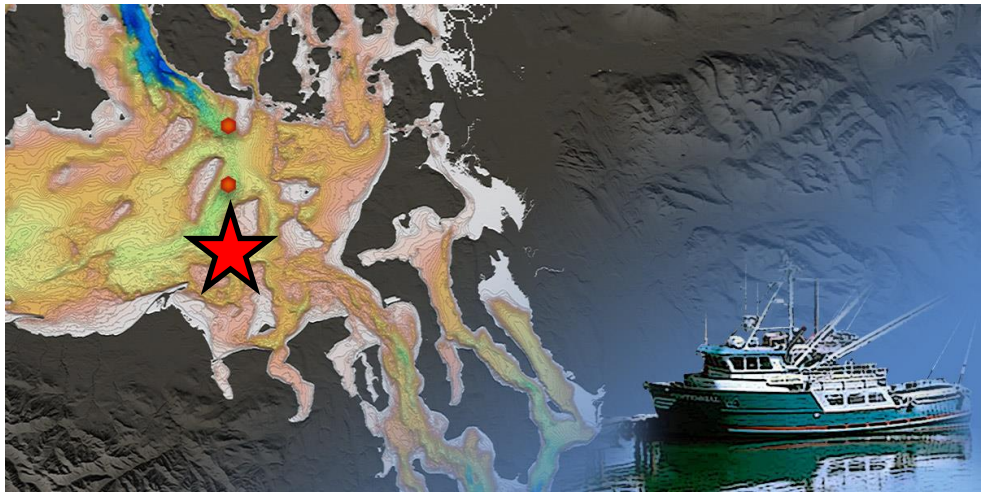
Pseudocalanus mimus abundance (red circles) near a coastal-origin eddy (mapped sea surface height). Mackas & Galbraith 2002.

(2) Changes in vertical distribution & catchability



JEMS Joint Effort to Monitor the Strait

Monthly zooplankton time series (11 yrs)



- CTD casts (T,S,D,DO)
- Bottle chlorophyll, nutrients, oxygen
- Zooplankton net tows: 75-cm diameter, 150µm mesh vertical tows

DEPARTMENT OF ECOLOGY
State of Washington

Sponsored by Washington Department of Ecology
Analysis funded by UW, LLTK, and (future) Pt Gamble S'Klallam Tribe

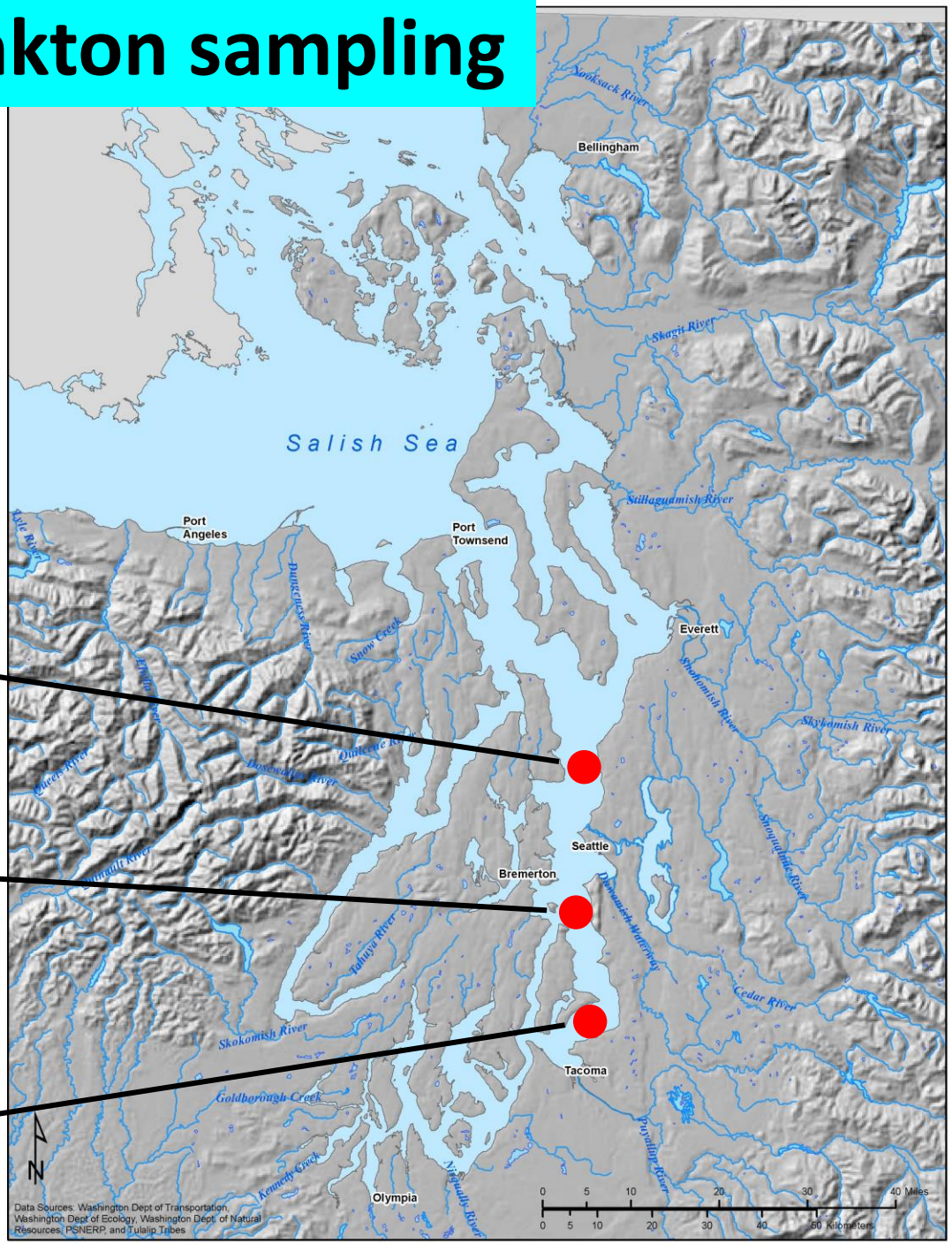
King County zooplankton sampling

Bi-weekly sampling begun in March, 2014

KSBP01

LSNT01

NSEX01



Salish Sea Marine Survival Project
U.S.-Canada collaboration

SALISH SEA
MARINE SURVIVAL PROJECT
www.marinesurvivalproject.com

What are the causes of juvenile salmon declines in the Salish Sea?

H: Prey fields limit salmon growth and survival

Objective 1: Initiate a zooplankton monitoring program in Puget Sound

- Collaborate with regional tribes, nonprofits, and other entities
- Refine program for improved efficiency of future collections

Objective 2: Explore relationships between prey availability and salmon survival

- Measure abundance of prey items in each region of Puget Sound
- Provide zooplankton data to enable comparisons to salmon growth and marine survival

Puget Sound sampling

At most locations:

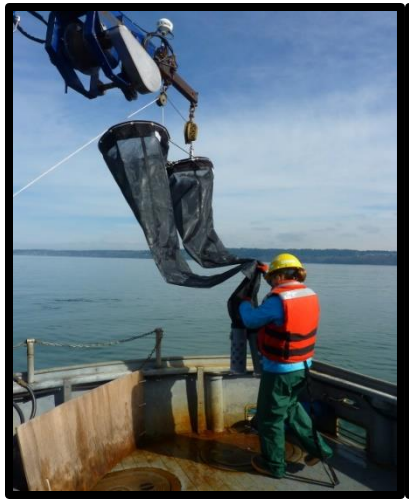
Bi-weekly sampling April-Oct

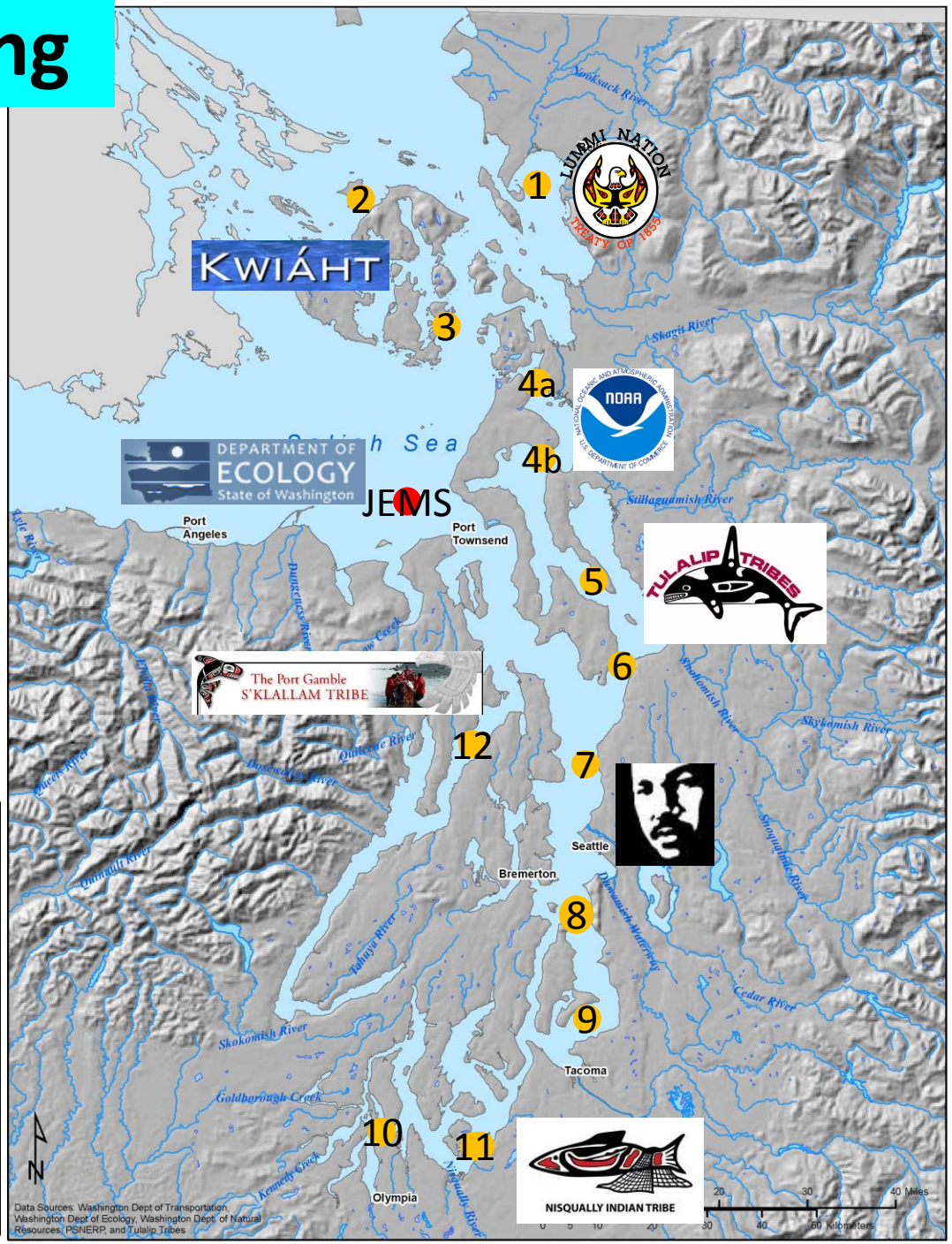
- **Oblique bongo net tows**

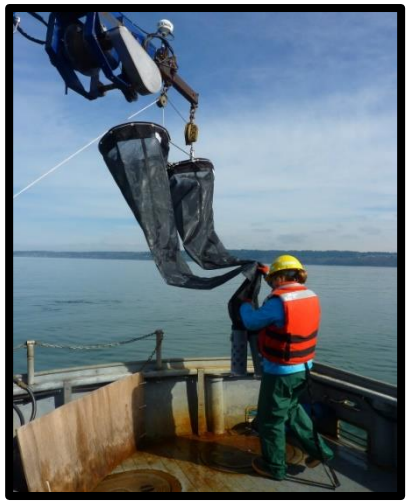
Upper 30 m
At locations ~30, 50, 100 m deep
60 cm dia., 335 µm mesh

- **Vertical net tows**

Full water column tows
in ~ 100 m depth
60 cm dia., 200 µm mesh







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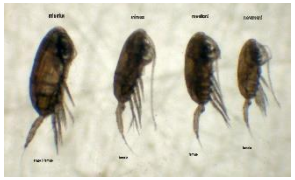
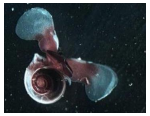
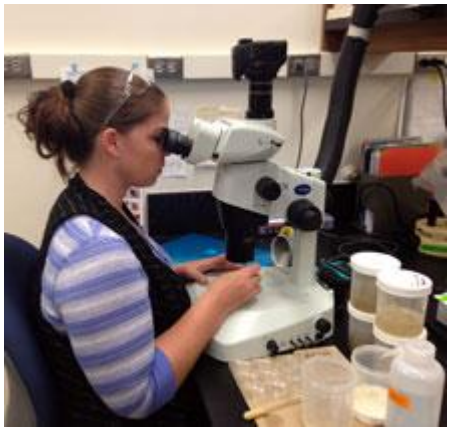
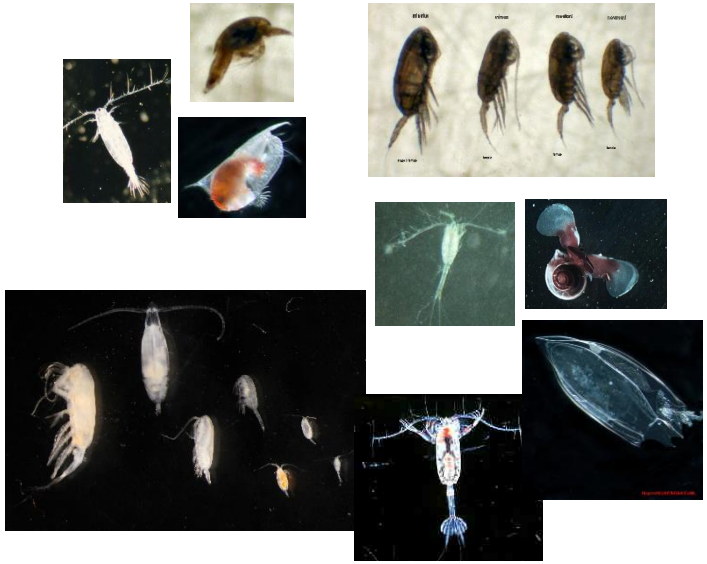
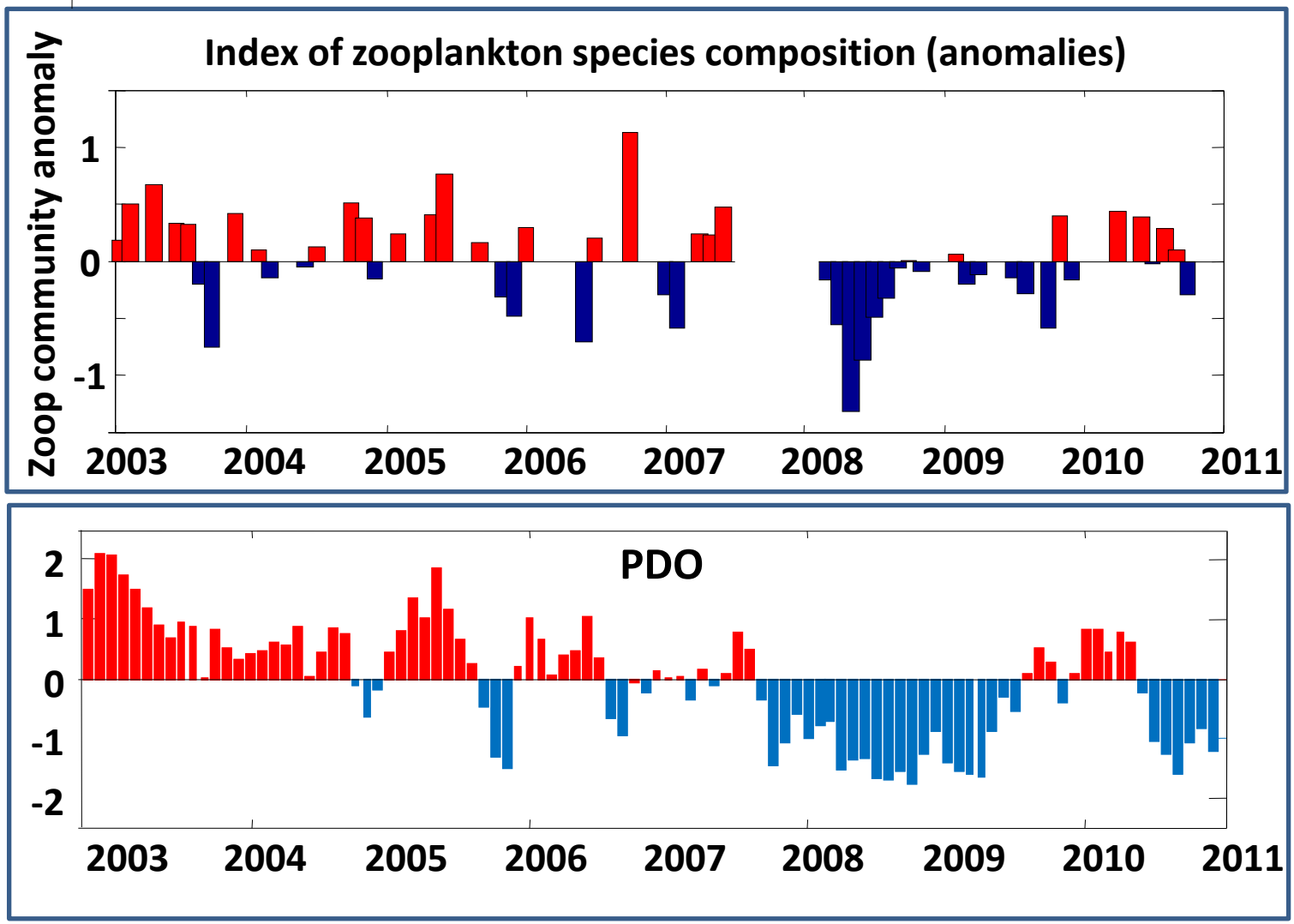




What are we learning?







Correlation with PDO with ~2 month lag

Zooplankton sampling has begun!

Partnerships & Funding

King County

LONG LIVE THE KINGS

Sea Grant Washington

NISQUALLY INDIAN TRIBE

NOAA

PACIFIC SALMON COMMISSION

KWIÁHT

LUMMI NATION TREATY OF 1855

UNIVERSITY OF WASHINGTON 1861

TULALIP TRIBES

The Port Gamble S'KLALLAM TRIBE

PugetSoundPartnership

LEADING PUGET SOUND RECOVERY

Tradeoffs

- **Need to balance:**
  - Costs vs. information gained
    - Sampling and analysis
  - Technical difficulty
    - Ship capabilities and size of net set the taxa that can be adequately sampled
    - Diversity of habitats sets the number of different sampling strategies
  - Statistical power
    - Irregular and ‘opportunistic’ sampling limits confidence in results