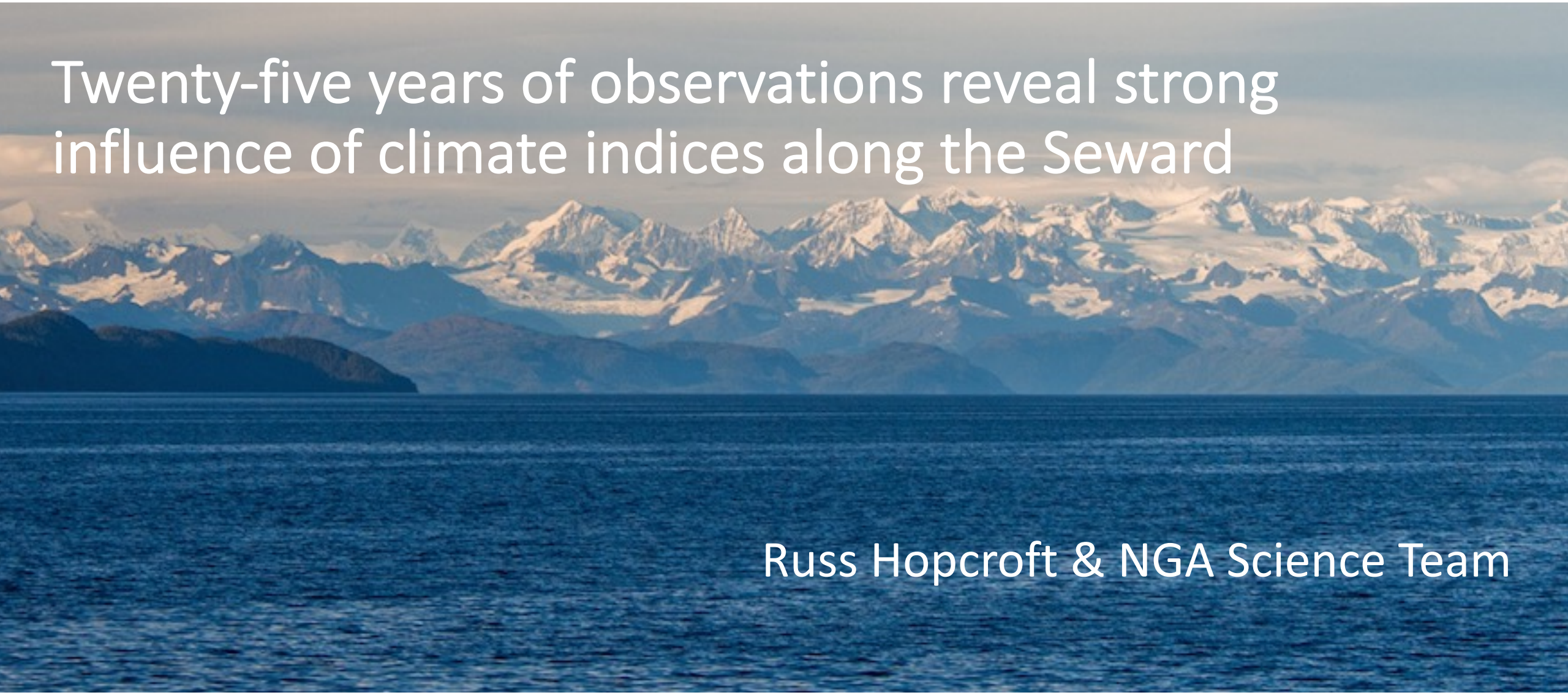
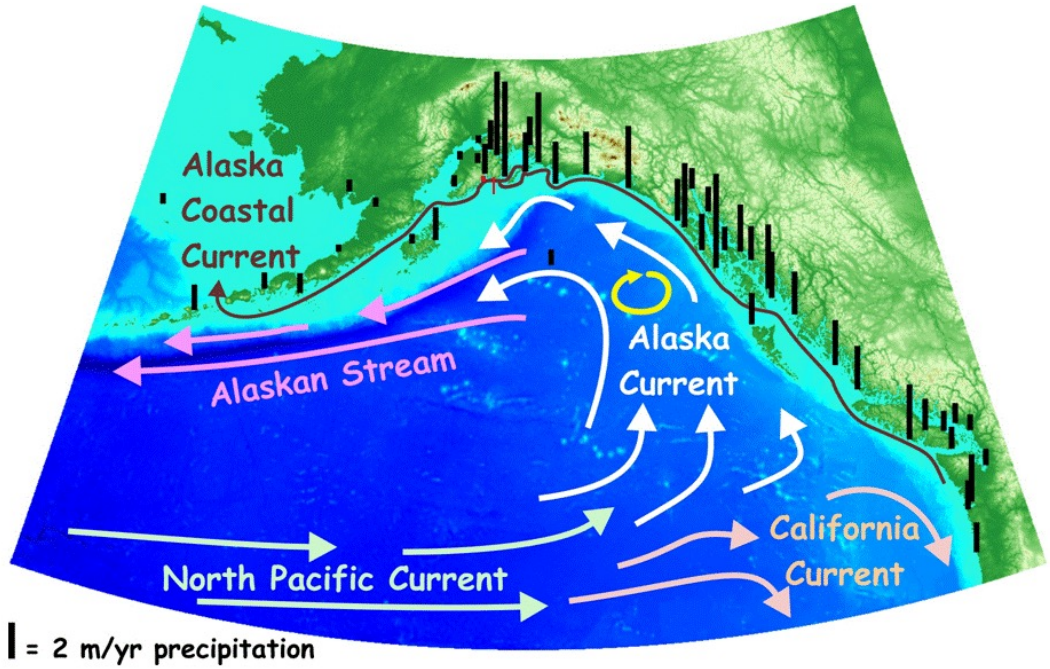
Twenty-five years of observations reveal strong influence of climate indices along the Seward



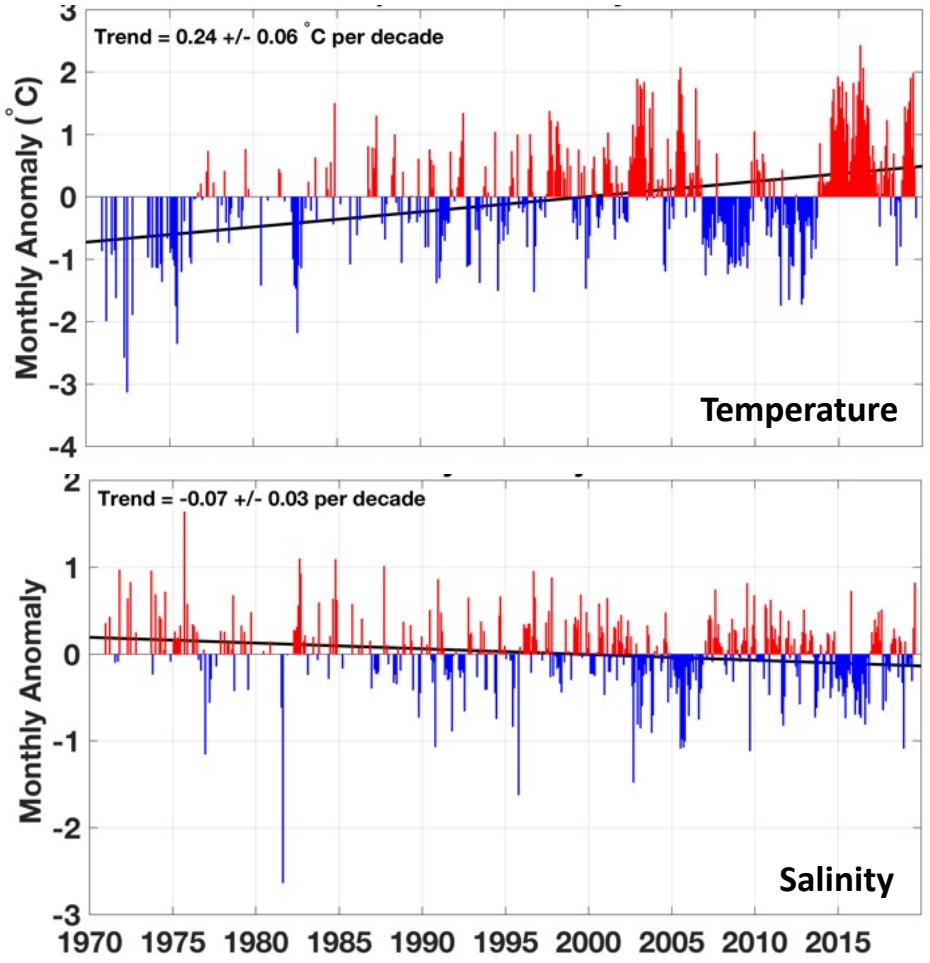
Russ Hopcroft & NGA Science Team

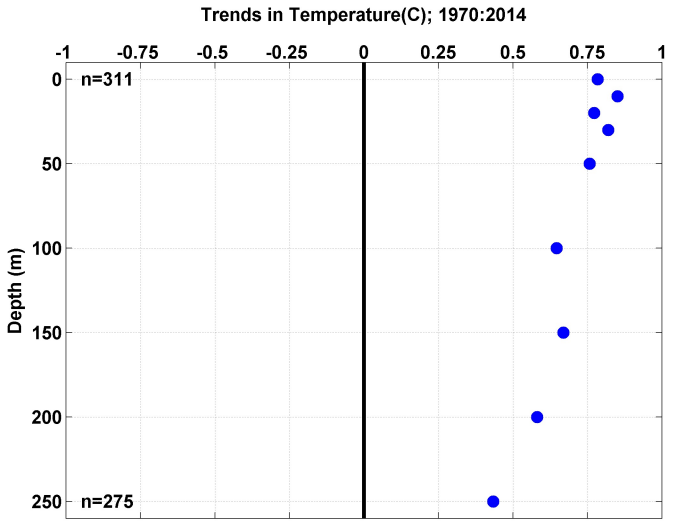
Gulf of Alaska overview

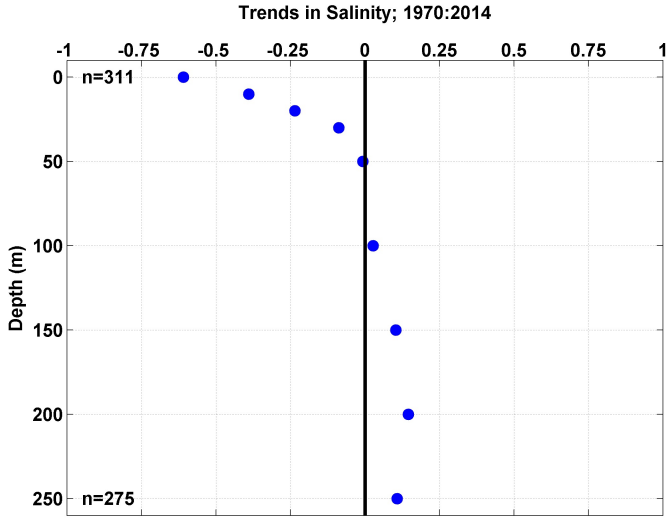
- Huge annual precipitation creates a fresher coastal current, rich in iron.
- Strong downwelling in winter, weak downwelling in summer
- A strong boundary current separates a productive shelf from a high-nutrient low-chlorophyll offshore
- Accelerated alongshore transport in both the Alaska Coastal Current and Alaska Stream
- Both currents start far to the south near faunal boundaries



GAK1 – 50 years







Warming throughout water column

Strongest near surface

Increasing stratification with time

Opposite trends near surface and seafloor

Increasing stratification with time

Bloom timing

Nutrient supply

At some point ecosystem responds to forcing….

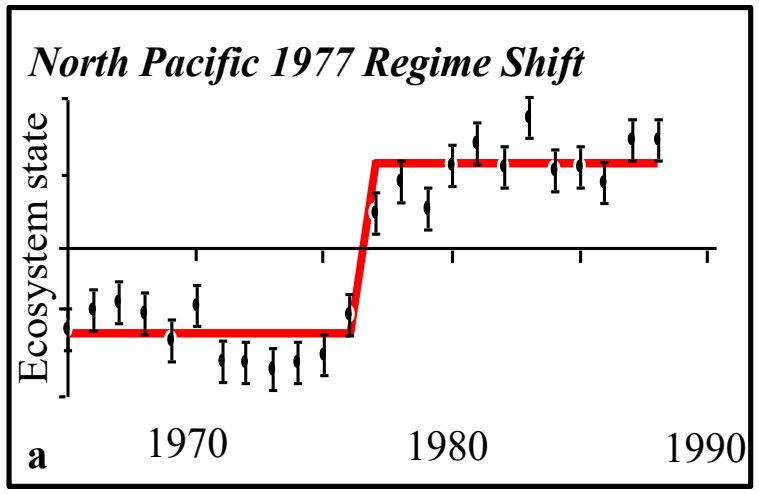
Sustained climate variation can alter ecosystem function & harvestable resources

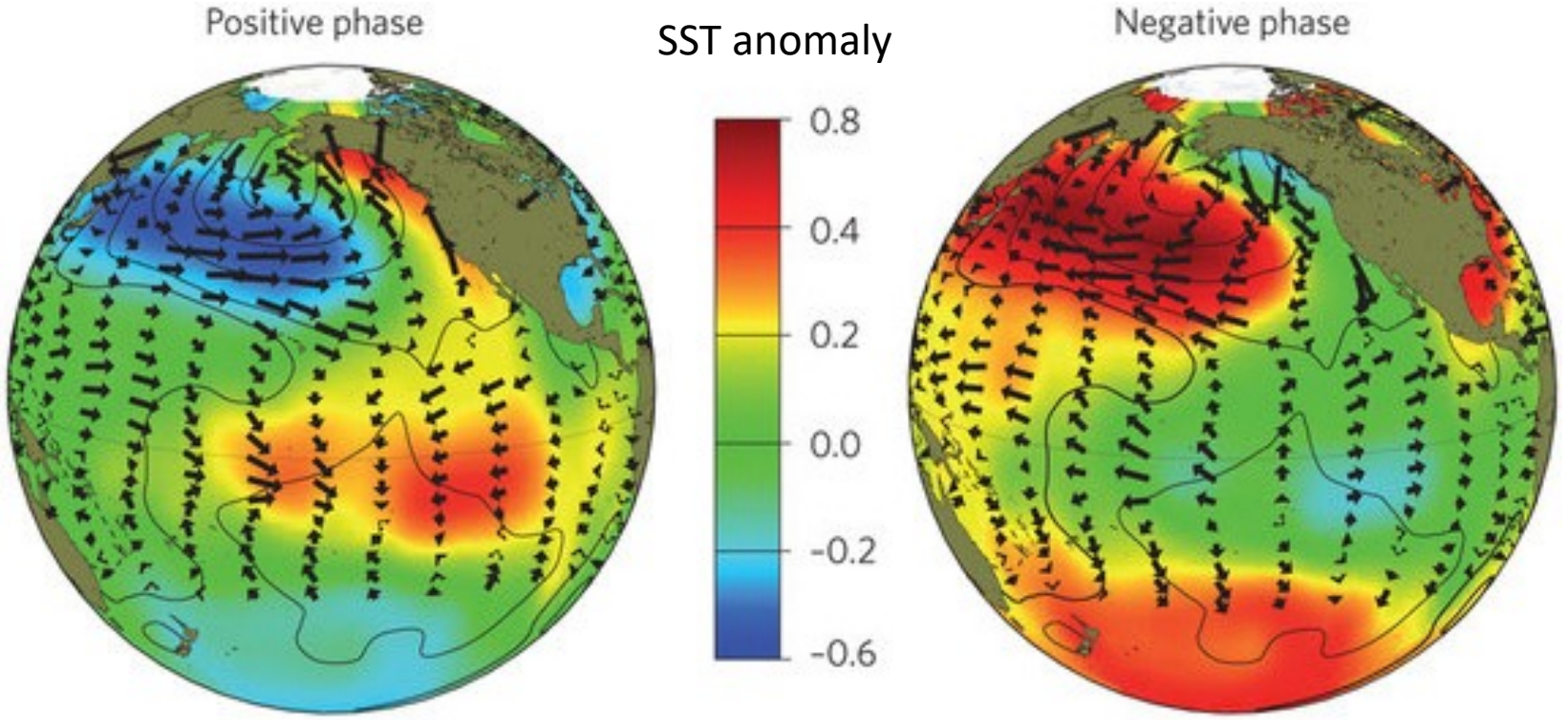
Late 1960's

Early 1980's

Changes catches in a small mesh bottom trawl in Pavlof Bay, Alaska, through the regime shift of the mid-1970s.

The Pacific Decadal Oscillation implicated as trigger

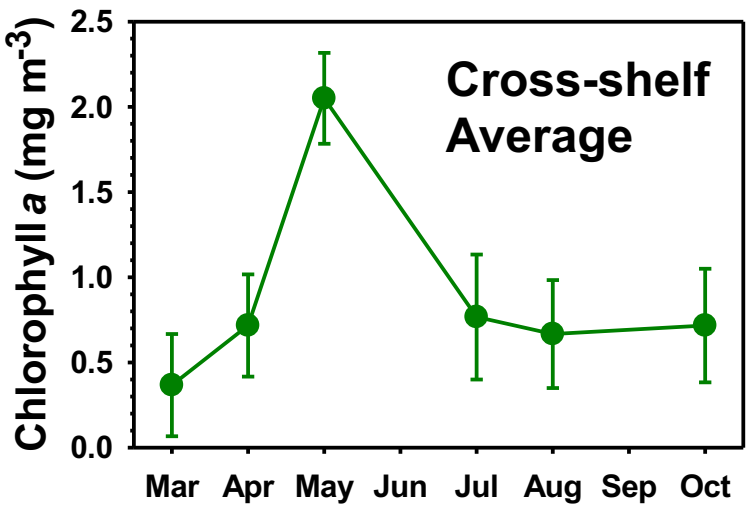


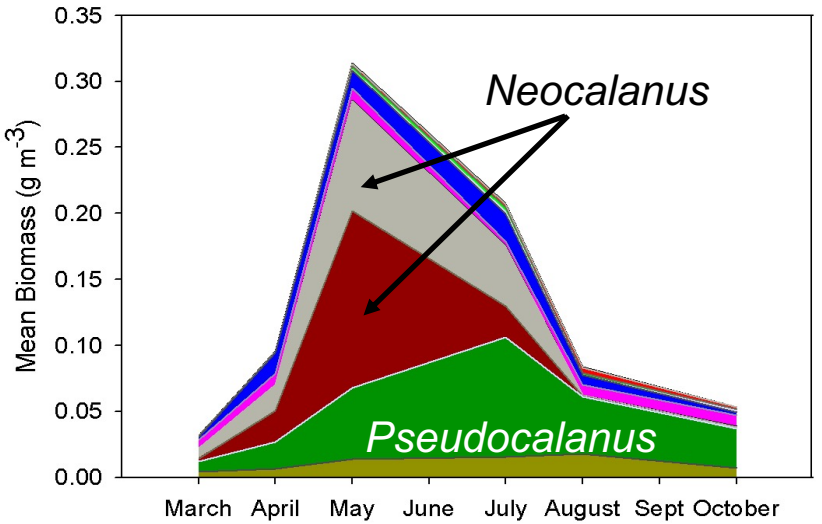


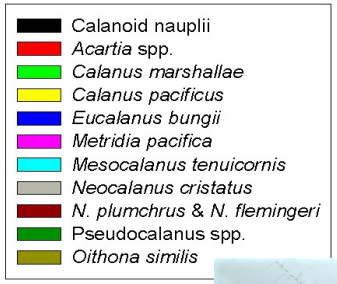
Positive PDO creates warmer water in NGA in part from increased coastal transport (& increased wind)

Seward Line long-term observations begin 1997

- **Physics** (Temperature, Salinity)
- **Chemistry** (Maconutrients)
- **Lower trophic levels**
  - Chlorophyll
  - Phytoplankton, microzooplankton
- **Middle trophic levels**
  - Metazoan zooplankton
- **Upper trophic levels**
  - NOAA fisheries data
  - Seabirds/marine mammal observer

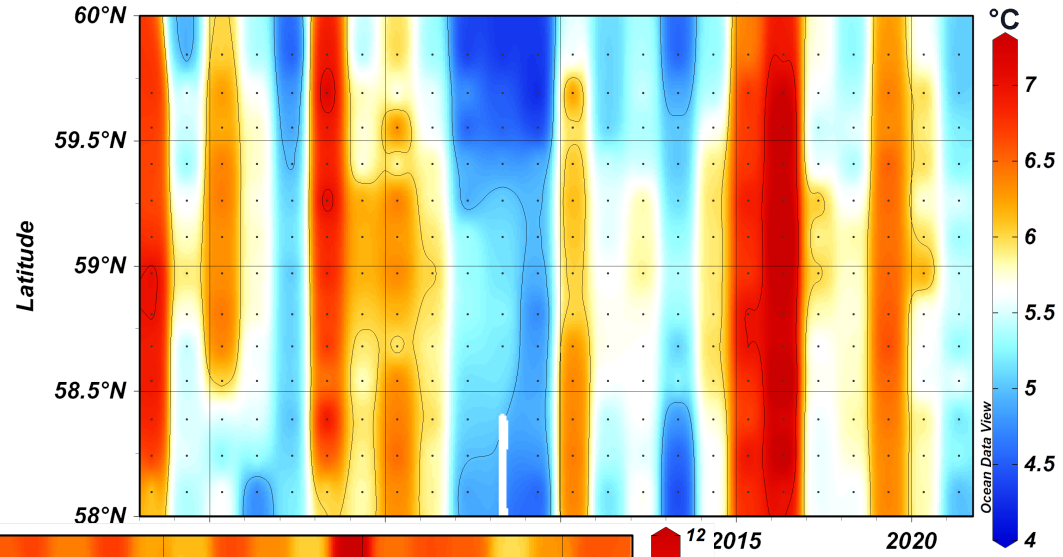


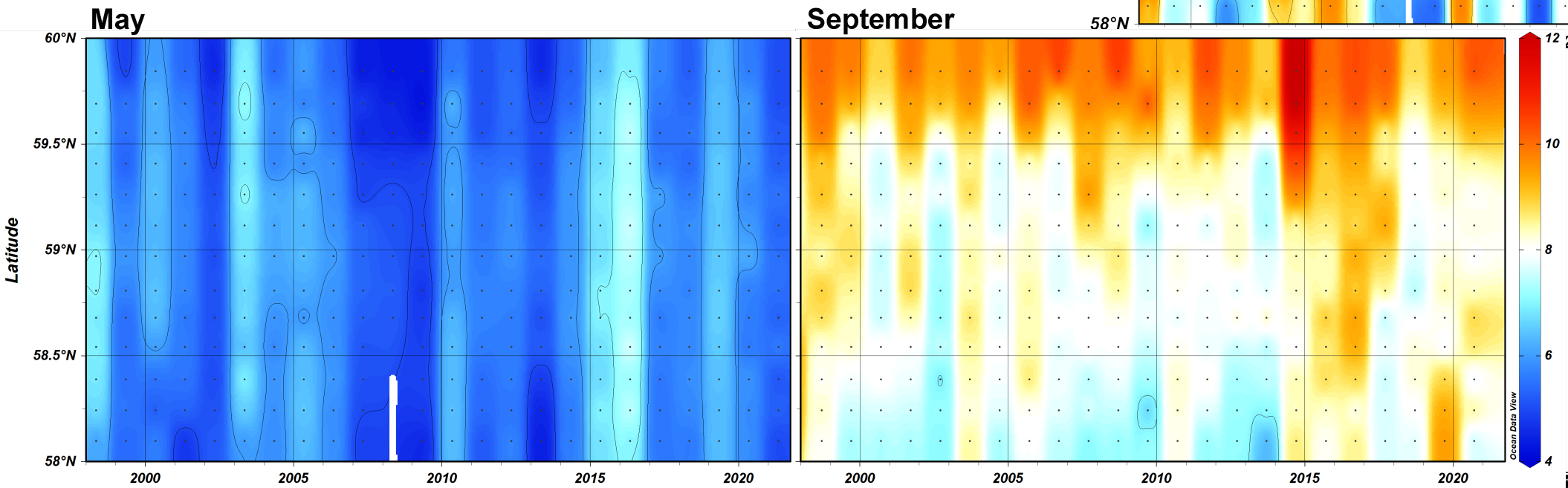




Seward Line physics

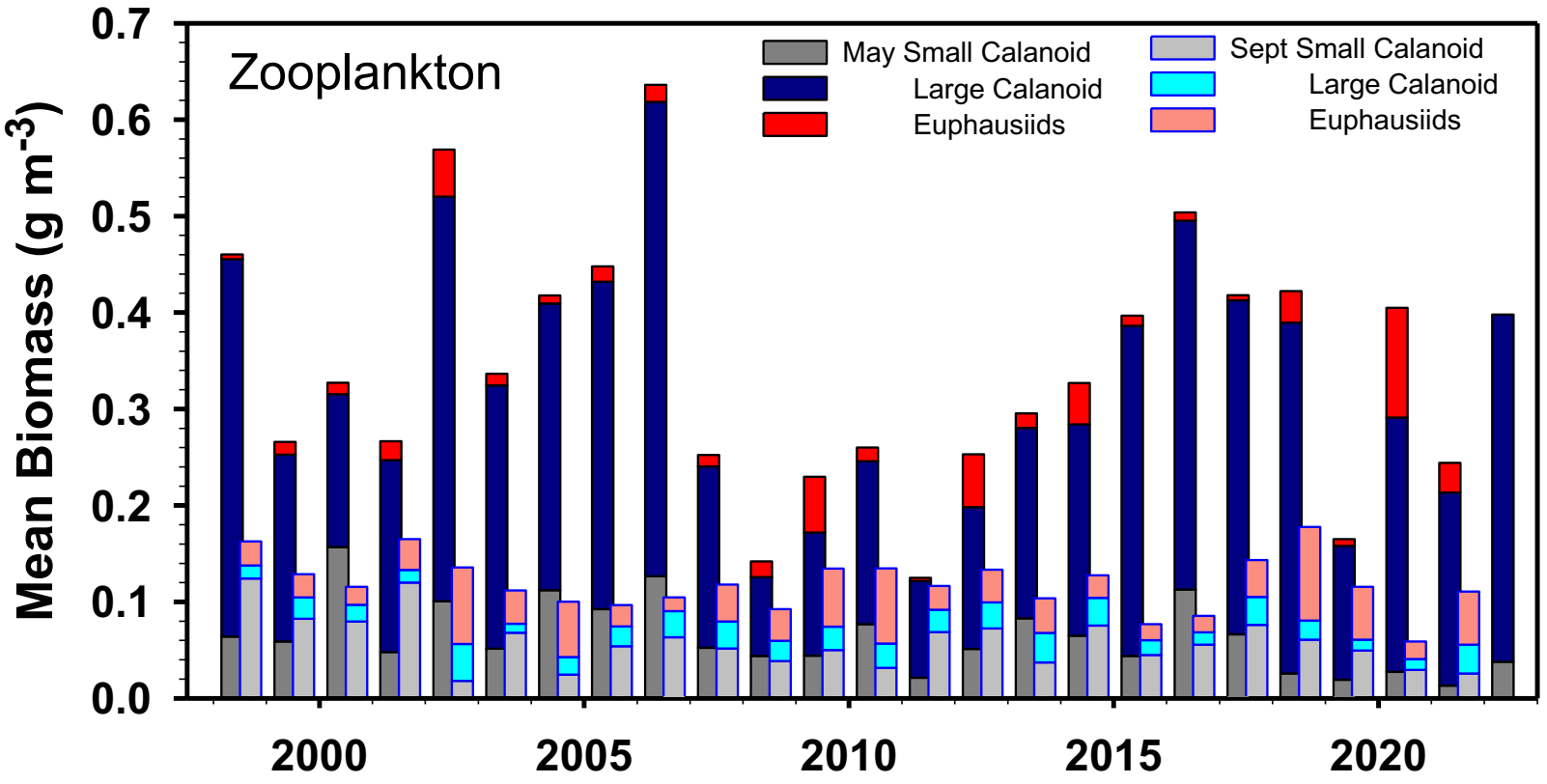
- Continuous May and “fall” data since GLOBEC began in fall 1997
- Often multiyear periods of hot and cold
- Coastal waters warmer than offshore during fall





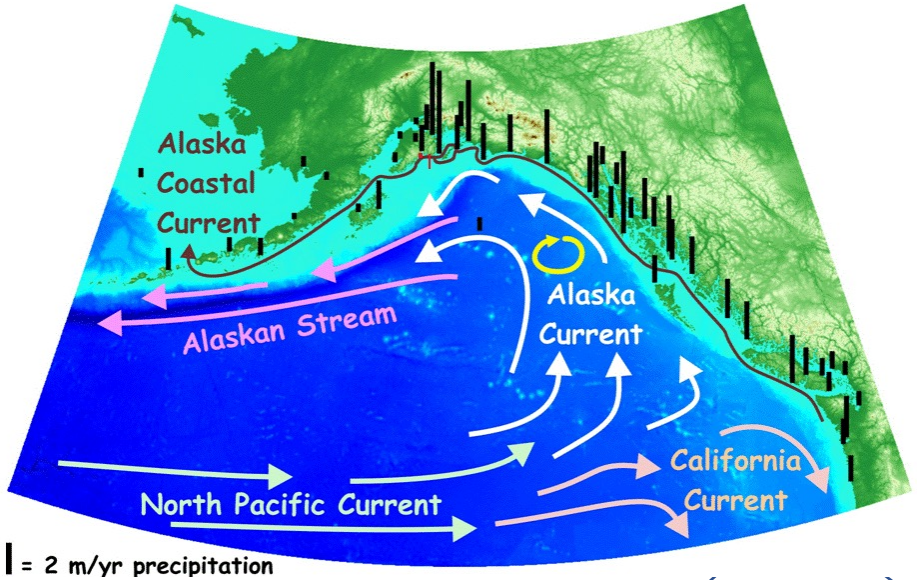
Zooplankton

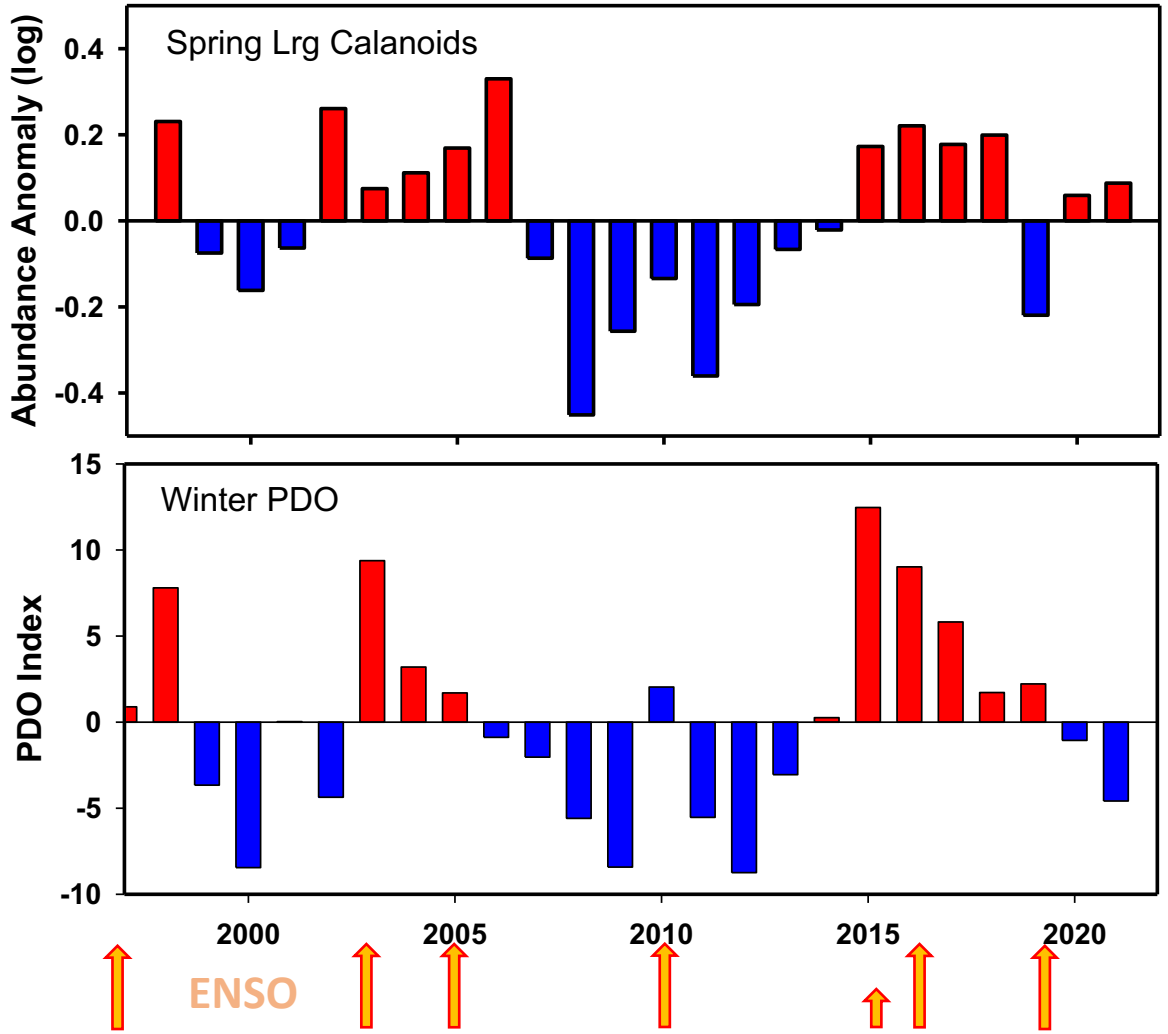
- Zooplankton biomass is highly seasonal
- Spring is dominated by large copepods
- Smaller copepods (and krill) dominate summer
- **Relatively** stable biomass across years in both seasons despite variable climate



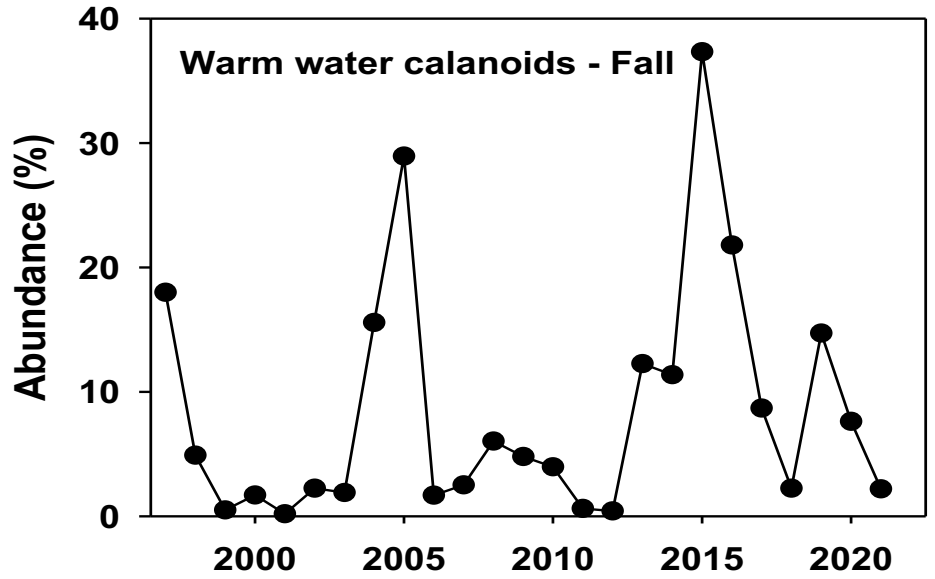
- Portfolio of life-history strategies and functional redundancies maintain “predictability” at this trophic “level” across time even though species shuffle from year-to-year

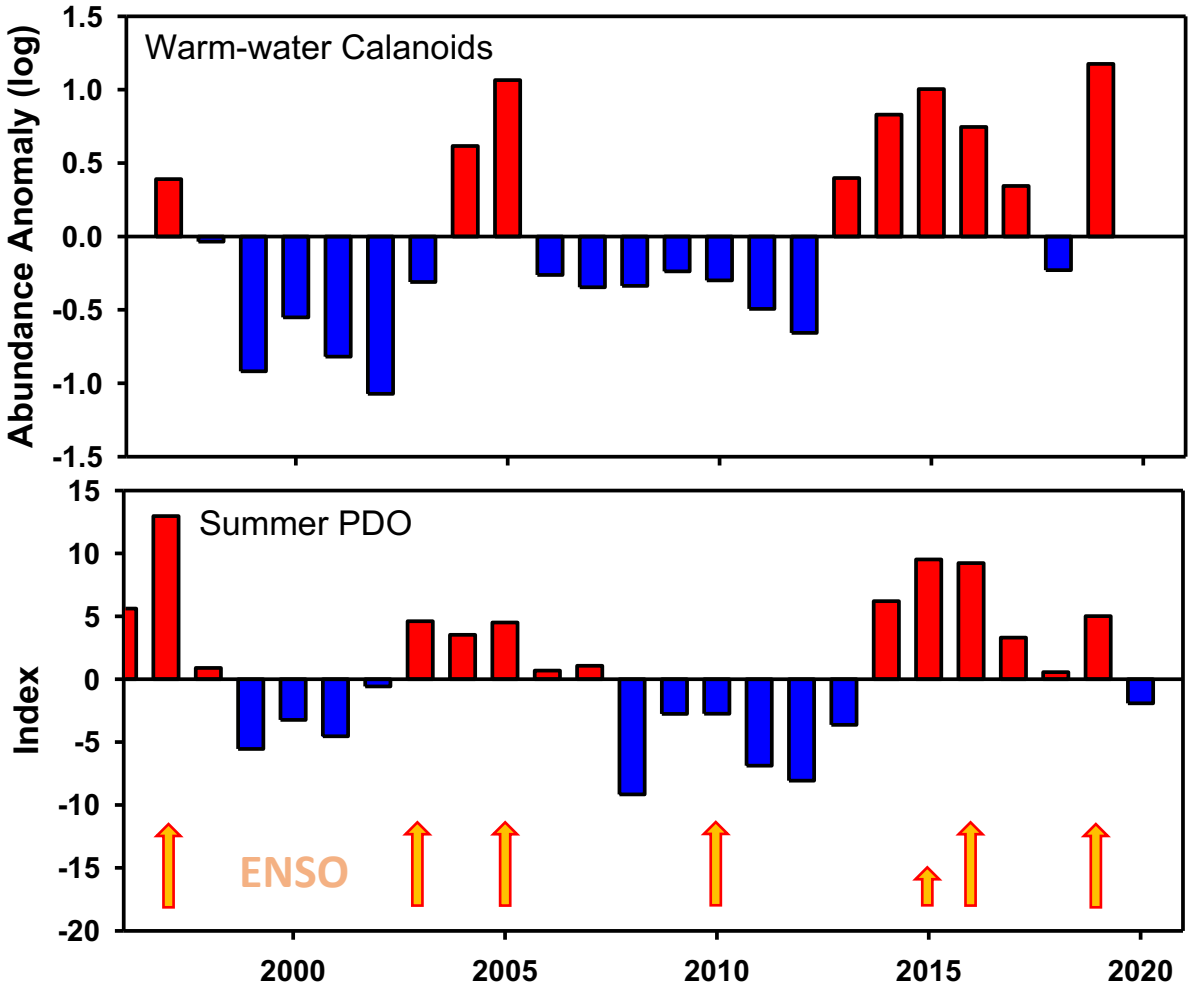
- Recall that PDO is coupled to circulation patterns in the NGA
- Winter PDO (Oct-Mar) correlated to biomass of large spring copepods (r^2~0.37)
- Increased PDO winds strengthen downwelling, moving large spring copepods onto the shelf where growth is favorable





- Summer PDO (Apr-Sept) is highly correlated to warm water copepods during September (r^2~0.51)
- Increased PDO transport brings southern species further north, quicker, and with higher rates of survival





Seward Line value

- Short term studies can only detect short-term changes (e.g., El Nino/La Nina, or heat waves)
- Long-term observations are required to tease out patterns from simple interannual variability: Seward Line is now long enough to detect multidecadal climatic signals like PDO
- Not every phase shift of the PDO has the same consequences, but it can be an ecosystem state-change trigger
- Will the northern Gulf of Alaska prove to be resilient to ongoing warming trends or will it undergo another major regime change such as occurred in the mid-1970s as climate continues to warm?
- Does the 2015/2016 heatwave (when both PDO and ENSO were positive) foreshadow such changes?

Thanks to funding agencies
(and reviewers)
for playing the long game