Variability in the copepod community structure, diversity, and biomass in the northeast Pacific (Newport, Oregon, USA) over the last 22 years

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Studied zooplankton in the NE Pacific off Oregon with Oregon State University in the 1970’s and returned with NOAA, sampling the Newport Hydrographic Line 1996-2017
Large scale and local physical forces influence biological processes important for ocean productivity and food web structure.

We measure a suite of physical and biological metrics to index ocean conditions that relate to different fisheries.
Basin scale influences: different phases of the Pacific Decadal Oscillation = different SST patterns

Negative PDO
(cool coastal phase)

Weaker Aleutian Low
Blue is anomalously cold

Increased equatorward transport

Positive PDO
(warm coastal phase)

Stronger Aleutian Low
Red is anomalously warm

Increased poleward transport

Peterson and Schwing, 2003
Local influences: upwelling drives primary and secondary productivity...
Seasonal cycle of winds and currents influence copepod community structure

- **Winter**
  - Winds from the South = downwelling
  - Poleward-flowing Davidson Current
  - Southern copepods are transported northward & onshore

- **Summer**
  - Strong winds from the North = upwelling
  - Equatorward alongshore transport
  - Boreal/northern copepods transported southward
Basin and local forcings: PDO and Upwelling index

- From 1925-1998, PDO shifted every 20-30 years
- Recent periods of persistent sign changes:
  - 1999-2002
  - 2003-2006
  - 2009-10 El Niño
  - 2014-2017 Blob/El Niño

Seasonal structure of coastal upwelling
Pacific Decadal Oscillation

- From 1925-1998, PDO shifted every 20-30 years
- Recent periods of persistent sign changes:
  - 1999-2002
  - 2003-2006
  - 2009-10 El Niño
  - 2014-2107 Blob/El Niño
- Monthly anomalies of upwelling index show no coupling to PDO
Newport Hydrographic Line:
44.6°N off coast of Oregon

- Sampled biweekly
- 1996 - present
- 7 stations: 1 – 25 nm (46 km)
- CTD, nutrients, chl-\(a\)
- Phytoplankton, zooplankton, ichthyoplankton
- NH-5 (9 km), 60 m water depth, sentinel station
Copepod Community Structure over 22 years
>40 species of copepods

X-axis explains 76% of the variance
Y-axis explains 9% of the variance
X-axis score shows seasonality of the copepod community at NH-5

Copepod Community Composition

Warm water community; usually in winter
Cold water community; usually in summer

Small lipid poor
Large lipid-rich
Copepod species richness and biomass varies seasonally: larger northern copepods in summer = greater biomass
X-axis score shows seasonality of the copepod community at NH-5

Warm water community; usually in winter
Cold water community; usually in summer
Monthly anomalies of the Copepod Community resemble patterns of the PDO and Oceanic Nino Index.
Copepod diversity increases during warm events

Recent warm anomalous event brought greater species richness than seen prior off of Oregon
Summer copepod biomass vs. basin and local-scale forcing

Basin scale forcing

Local scale upwelling

Summer copepod biomass (May-Sept)

In the basin scale forcing graph, the correlation coefficient (r) is 0.65:

r = 0.65

Summer copepod biomass (May-Sept)

PDO (May-Sept)

Summer copepod biomass (May-Sept)

Upwelling index (May-Sept)
Secondary (egg) production is also NOT driven by upwelling.

Seasonality

n = 138 incubations 2002 - 2015

Calanus marshallae
Climatology = 26.7 eggs female\(^{-1}\) d\(^{-1}\)

Basin-scale variability

Local-scale upwelling

R\(^2\) = 0.51, \(p = 0.002\)
Is copepod species richness increasing?

NH-5 Summer (May-Sept)

\[ p < 0.001; R^2 = 0.12 \]

NH-5 Winter (Oct-Apr)

\[ p < 0.001; R^2 = 0.15 \]
Copepod species richness increasing? (1996 - 2018)

NH-5 Summer (May-Sept)

NH-5 Winter (Oct-Apr)

p < 0.001; R² = 0.09

p < 0.001; R² = 0.08
Ecosystem implications of a warm ocean: persistence of warm water copepods (from 7 past El Niño events)

Intensity = average monthly SST during the ‘event’ times the number of months there was a +0.5° SST

Fisher et al. 2015, Global Change Biology
Ecosystem implications of a warm ocean: persistence of warm water copepods (from 7 past El Niño events *plus* the anomalous warming of 2014-17)

~3 years
Summary and Future Questions

• The highest frequency signal in the copepod community is the seasonal cycle

• Inter-annual fluctuations in the biomass and diversity of copepod communities relate to basin scale forcing

• Species richness may be increasing?

• The last anomalously warm ocean conditions resulted in 3 years of lipid poor copepod communities

• Short and long-term is uncertain. Currently a mix of southern and northern species

• Need a mechanistic understanding of how basin scale processes affect local scale drivers (e.g., transport, upwelling)
  - Advertising for a postdoc to explore linkages between basin-scale drivers, local coastal upwelling, and zooplankton communities
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