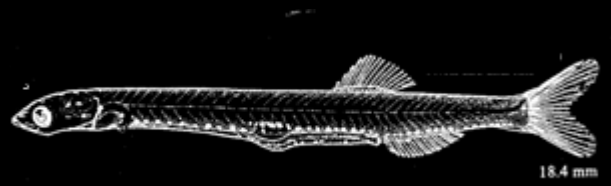
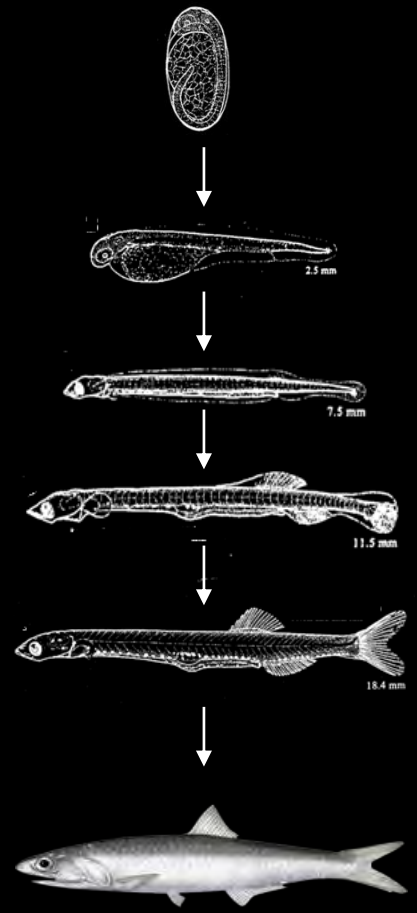
IS THE CONDITION AND GROWTH OF EARLY LIFE STAGES OF NORTHERN ANCHOVY RELATED TO THE BIOCHEMICAL CLIMATOLOGY OF THE NORTHERN CALIFORNIA CURRENT?



Jessica A. Miller[1], William T. Peterson[2], Louise Copeman[3], Marisa N. C. Litz[1], Angela L. Sremba[1], and Laurelyn Perry[1]

[1]Oregon State University, Hatfield Marine Science Center, Newport, Oregon USA, [2]NOAA Fisheries, Northwest Fisheries Science Center, Newport, Oregon USA, [3]Cooperative Institute of Marine Resources Studies, Oregon State University, Newport, Oregon USA

Background: Northern anchovy (*Engraulis mordax*)



spawn mid-May to mid-September (12-15°C)

hatch at 2.5-3.0 mm TL

rapid growth, short lifespan (<7 yr), early maturity (1 yr)

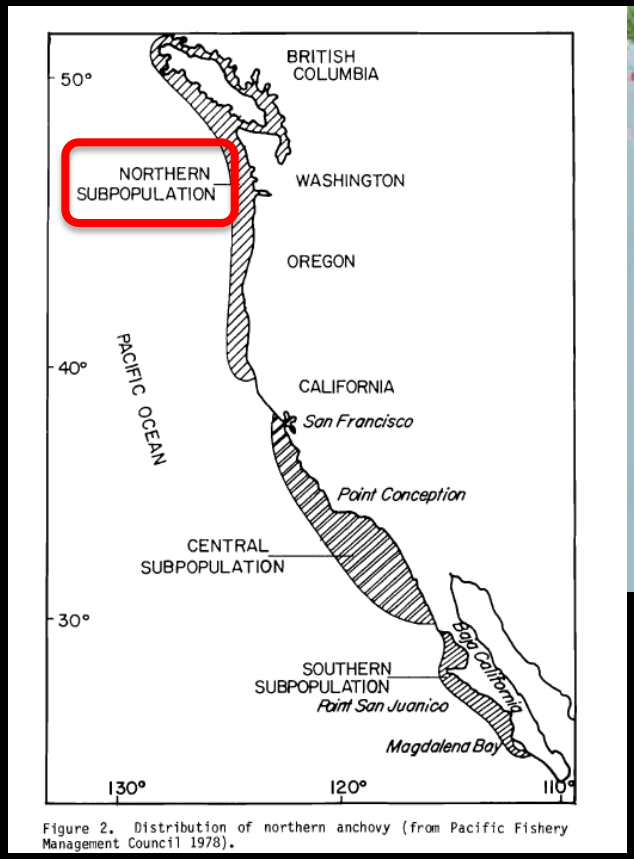
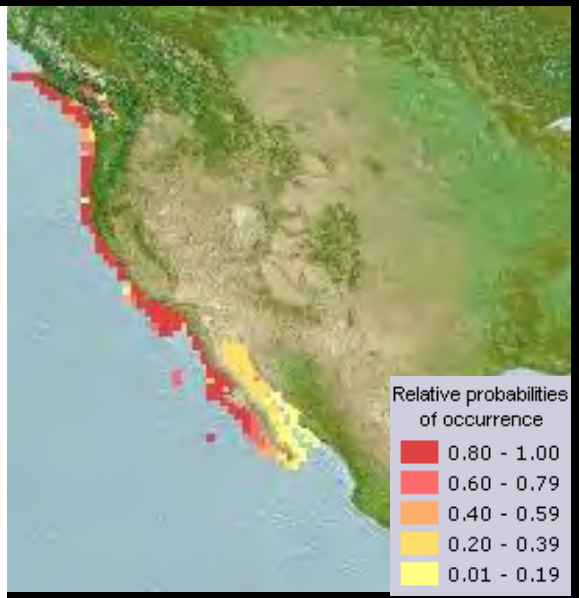


Figure 2. Distribution of northern anchovy (from Pacific Fishery Management Council 1978).



Background: Climate variation and recruitment

Early feeding & growth

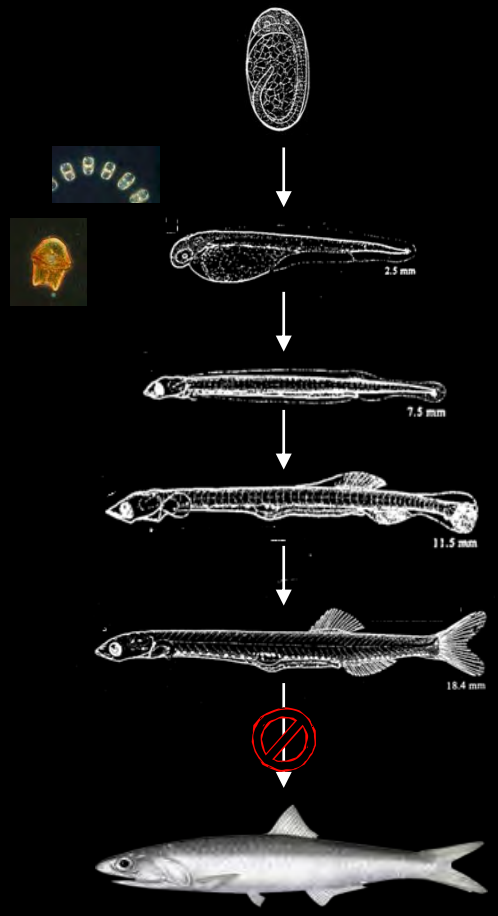
Stable Ocean Hypothesis

(Hjort 1914; Lasker 1975; Peterman & Bradford 1987)

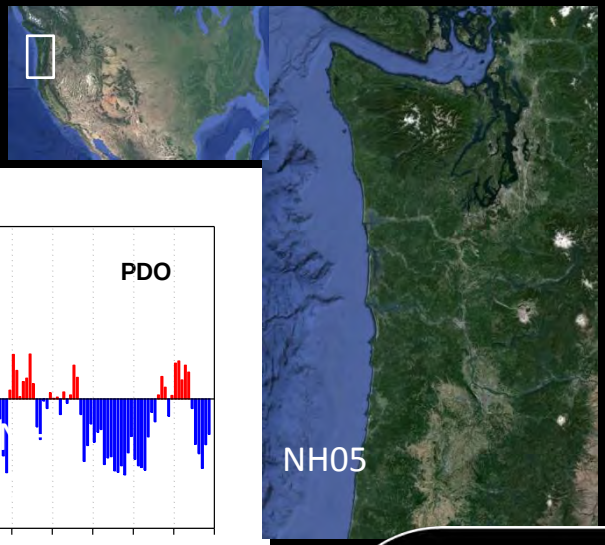
No relationship between larval abundance and Age-1 recruits – focus on older larvae more informative (*Peterman et al. 1988)*

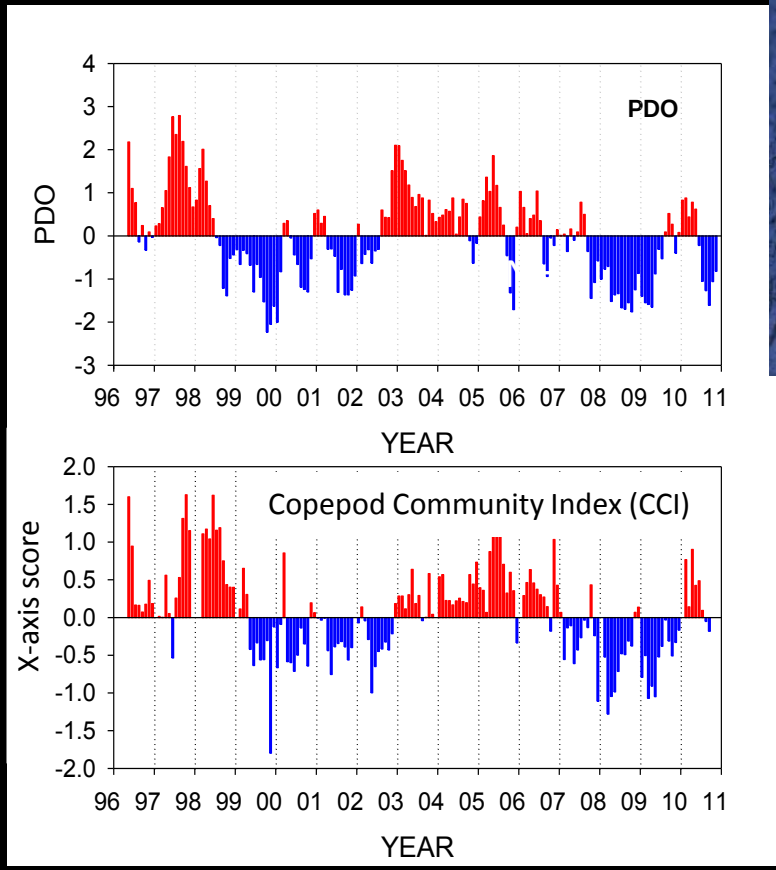
Abundance of Age-1 related to boreal copepod biomass during ELH stages *(Litz et al. 2008)*

Evidence that interannual variation in growth during ELH related to copepod community composition & biomass of boreal copepods *(Takahashi et al. 2012)*



Background: Variation in copepod community in Northern California Current





Bill Peterson, NOAA.
Morgan et al. 2003, Hooff & Peterson 2006, Keister et al. 2012

The sign of the PDO is associated with relatively warm or cold water along the coast

"warm" and "cold" water zooplankton communities in coastal waters are associated with positive or negative phases of the PDO, with a lag

Variation in the copepod community composition has been well correlated with salmon survival (Peterson & Schwing 2003, Bi et al. 2011), marine growth of juvenile salmon (Tomaro et al. 2012), and the early growth and survival of northern anchovy (Litz et al., 2008, Takahashi et al. 2012).

WHY?

Hypotheses

Prey Quality/Essential Fatty Acid Hypothesis

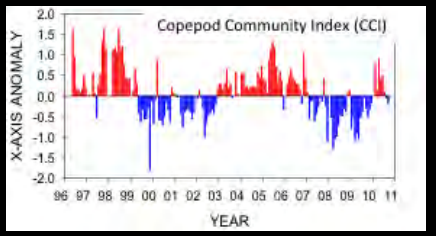
Climate-mediated changes in the availability of essential fatty acids can have community-level effects *(Litzow et al. 2006).*

Greater lipid content of the boreal copepods results in higher growth and survival of juvenile salmon and northern anchovy *(Bill Peterson and others).*

The relative importance of prey composition, abundance, and quality are not yet well understood.

Hypotheses & Objectives

Ho_1: The lipid and fatty acid composition of the copepod community covaries with the CCI. Greater lipid levels during spring/summer & in cooler years -- more negative CCI values.



Ho_2: Growth rates of early stage northern anchovy are positively related to lipid levels and certain fatty acids in the copepod community.

Characterize seasonal & interannual variation in lipid classes and fatty acids in particulate organic matter, zooplankton, and early stages of northern anchovy and relate that variation to early growth in anchovy.

Methods: Copepod community composition

- Biweekly collections
- NH05, 60 m depth
- 50-cm diameter, 202-µm mesh ring net
- "Copepod Patty"
- 20-µm mesh sample –POM/phytoplankton

Copepod patty

- Copepod Community Index (CCI)
- Northern Copepod Biomass Anomaly
- Southern Copepod Biomass Anomaly

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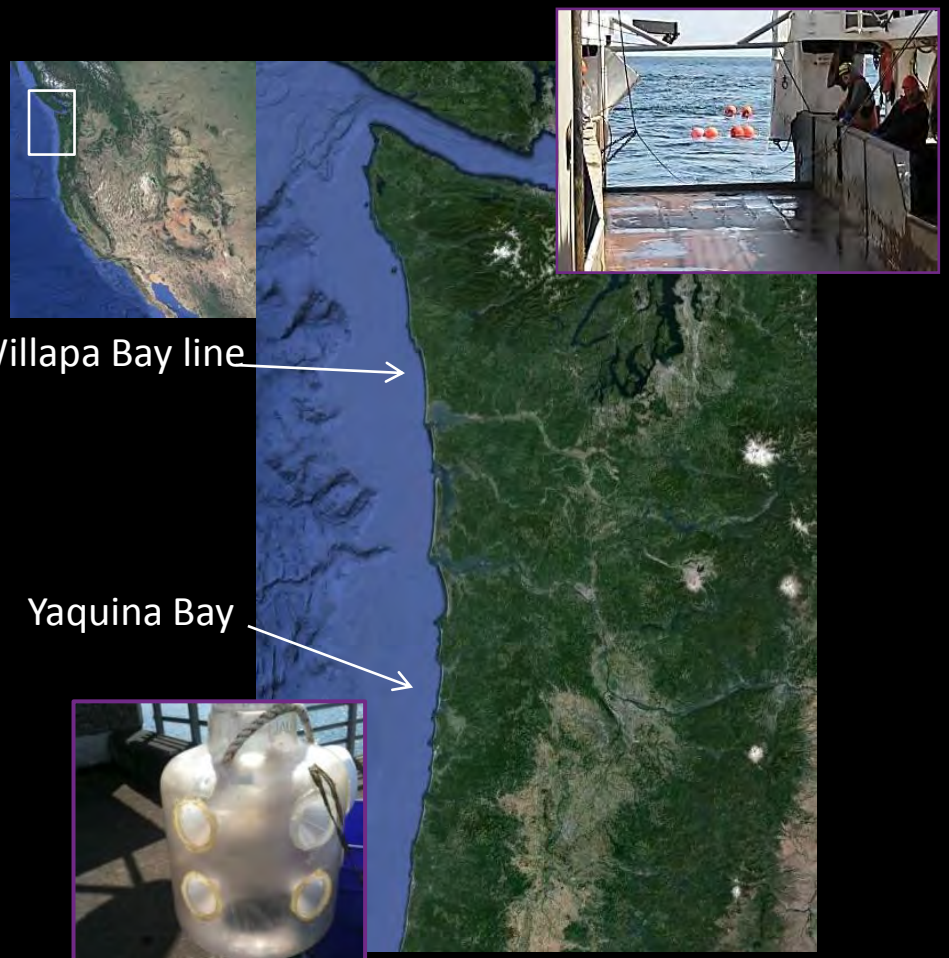
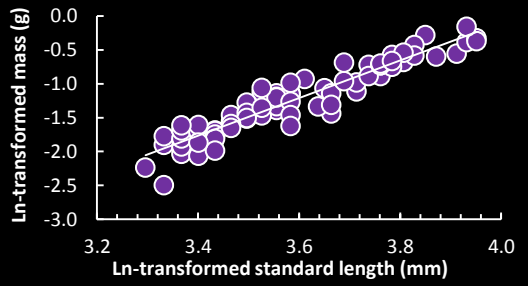
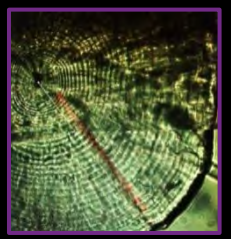
Methods: Early stages of northern anchovy (*Engraulis mordax*)



- 264-rope trawl with a small-mesh liner
- Light traps
- Condition Index (length-mass residuals)



- Age, hatch date, growth rate: otolith analysis

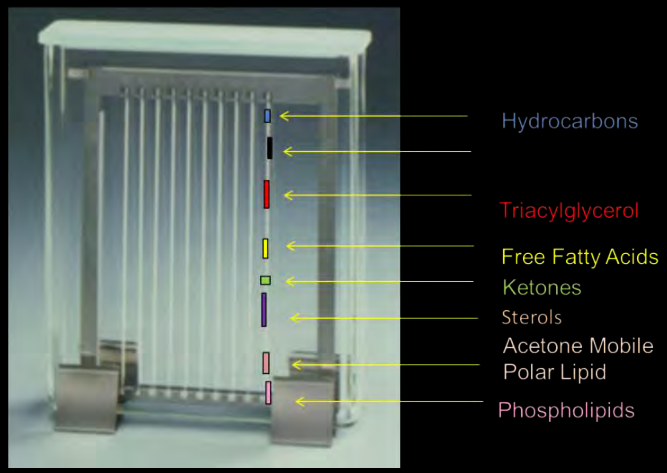


Methods: Lipid classes and fatty acid composition

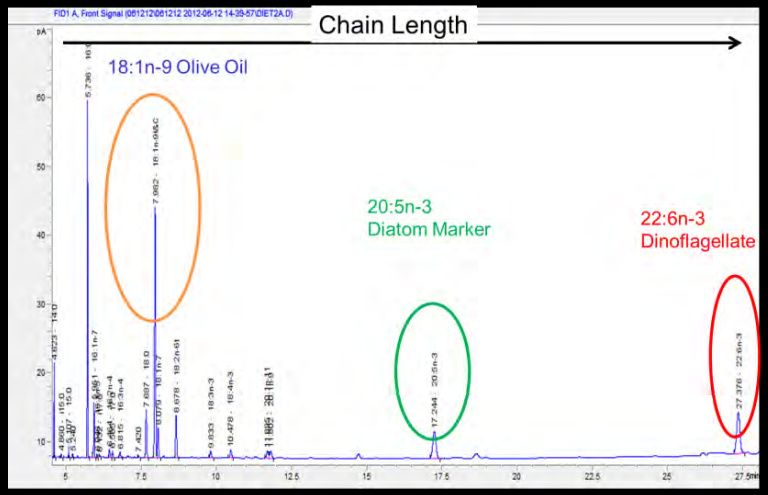
OSU Cooperative Institute for Marine Resources Studies (CIMRS) Lipid Lab (Dr. Louise Copeman)

- Phytoplankton, copepod patty, *Calanus marshallae*, northern anchovy
- Modified Folch procedure (extraction)
- TLC-FID (lipid classes)
- GC-FID (fatty acids)

Chromarod Development



GC Chromatograms



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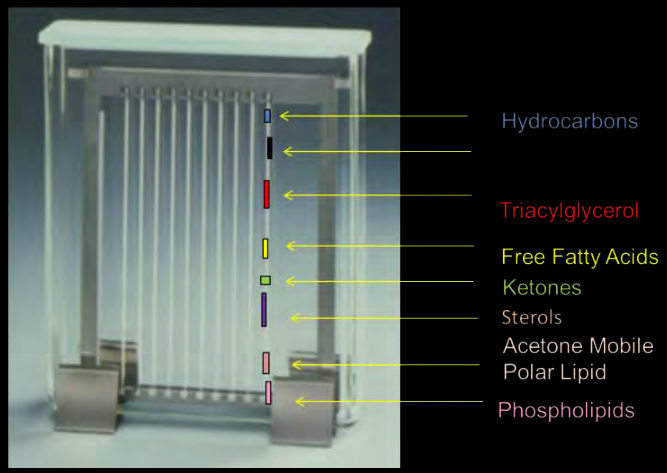

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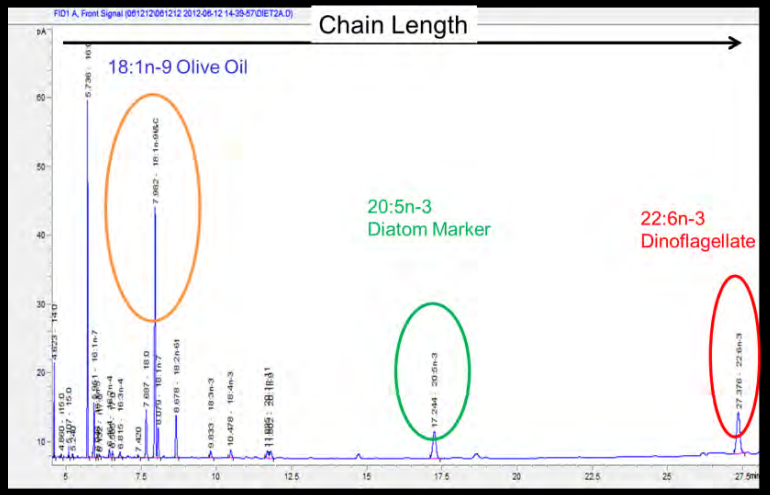
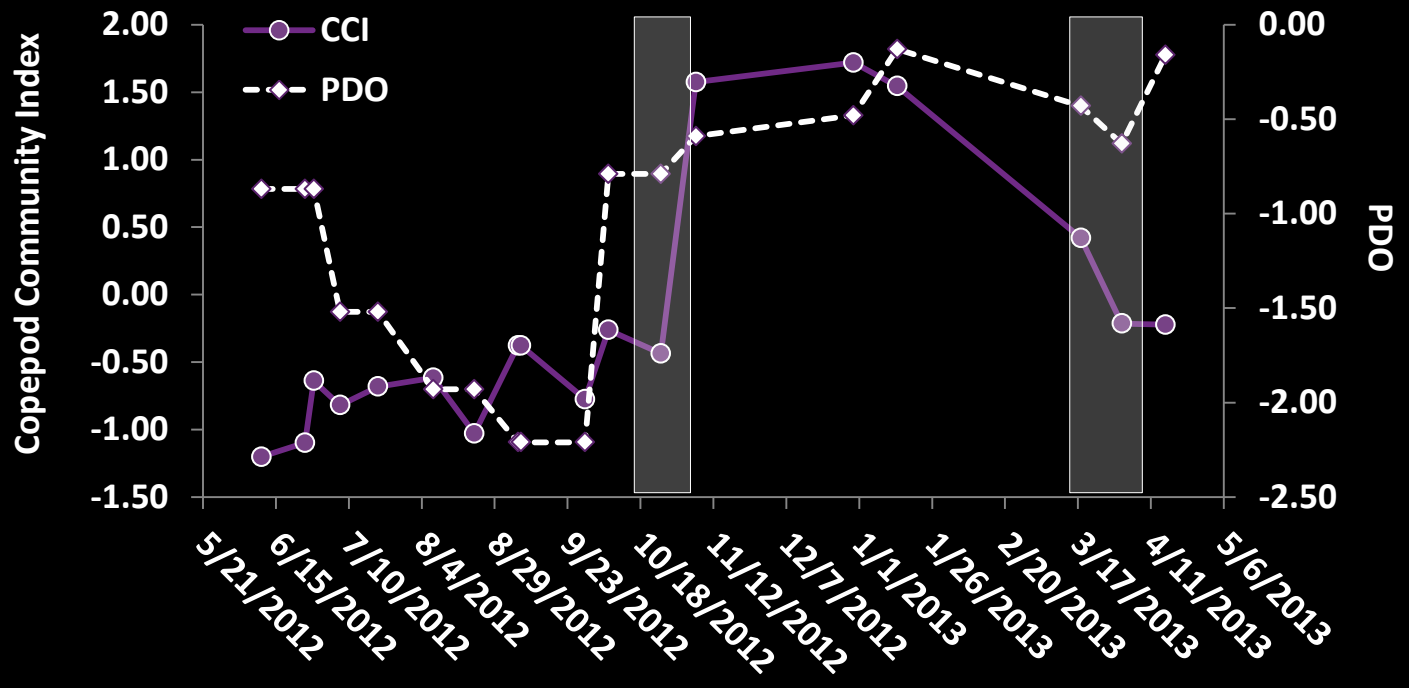


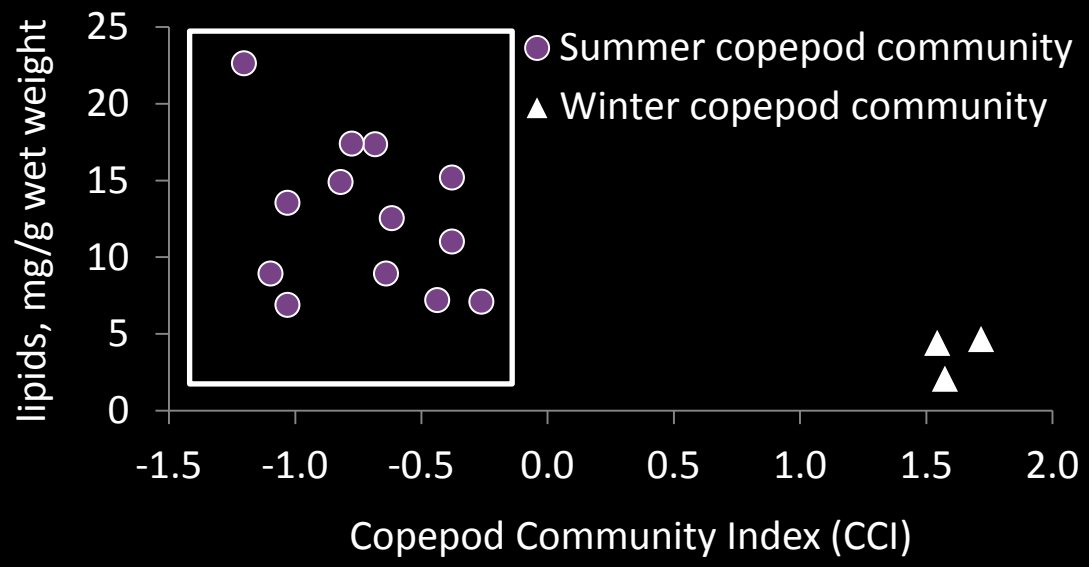
Methods: Temporal coverage



---------Phytoplankton & Copepods---------

Northern anchovy

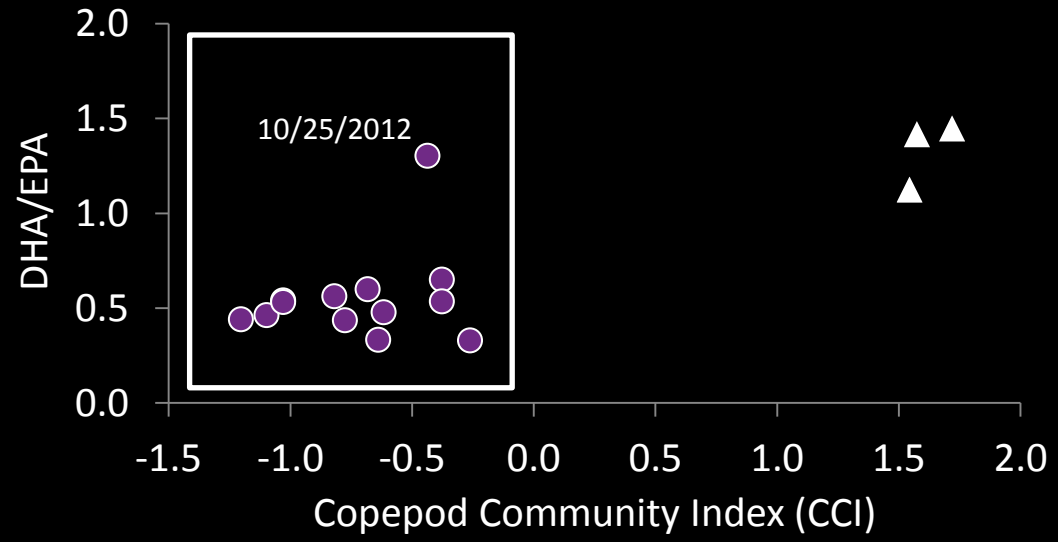
Results: Copepod Community Index



↓ in total lipids after fall transition

– in DHA/EPA after fall transition

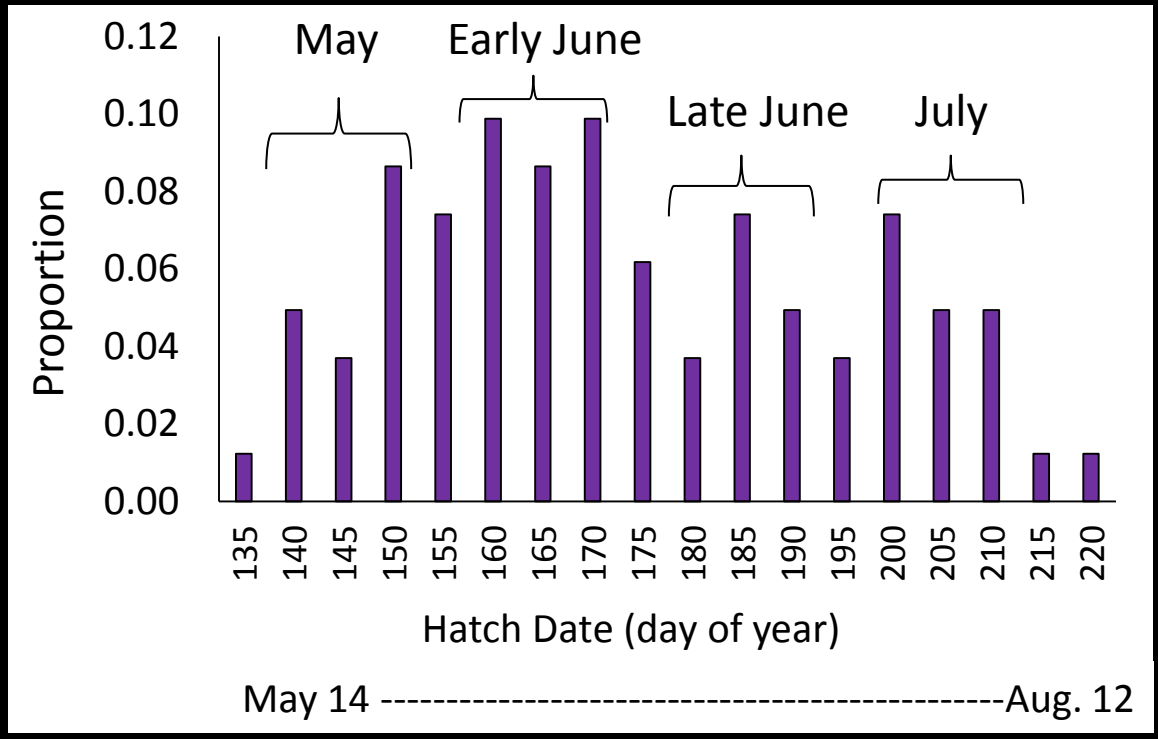
Biochemical response precedes change in Community Copepod Index (CCI)



DHA/EPA = docosahexaenoic acid/ eicosapentaenoic acid (~dinoflagellates/diatoms)

Results: Growth & condition of early stages of northern anchovy

- 96 individuals collected
- 36.8 (±7.6 SD) mm SL
- Mean age: 82 d (±20) (n = 73)
- Age range: 42-129 d



Results: Growth & condition of early stages of northern anchovy

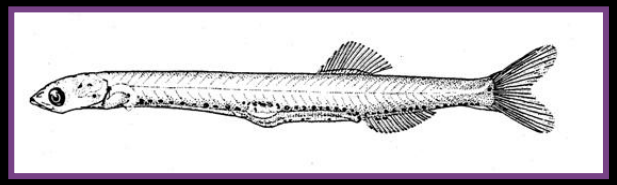
Cohorts based on hatch date: Growth

May 14-20, n = 15
Early June 3-18, n = 25
Late June (June 23-July 8), n = 16
July (July 18- Aug 2), n = 11

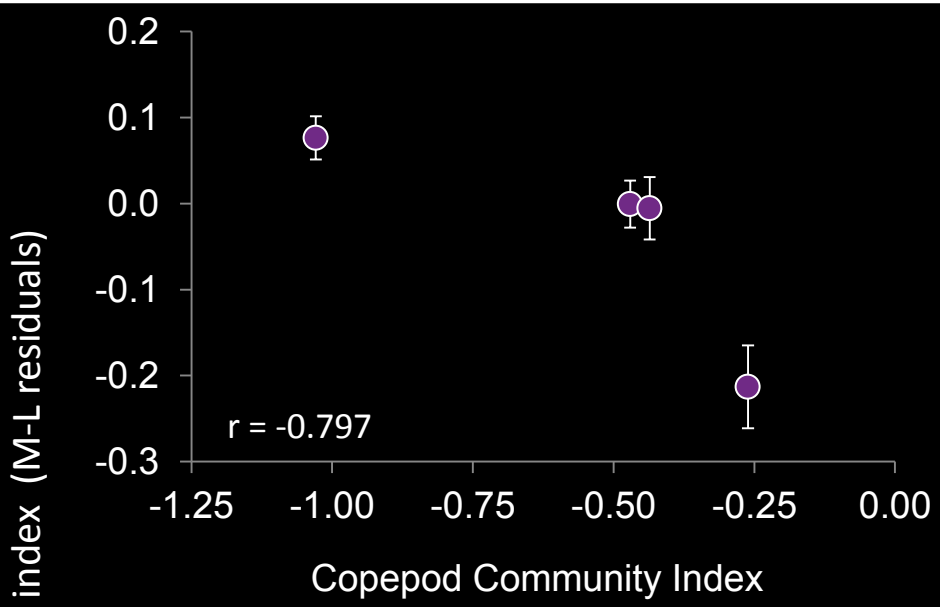
Capture date: Size & Condition

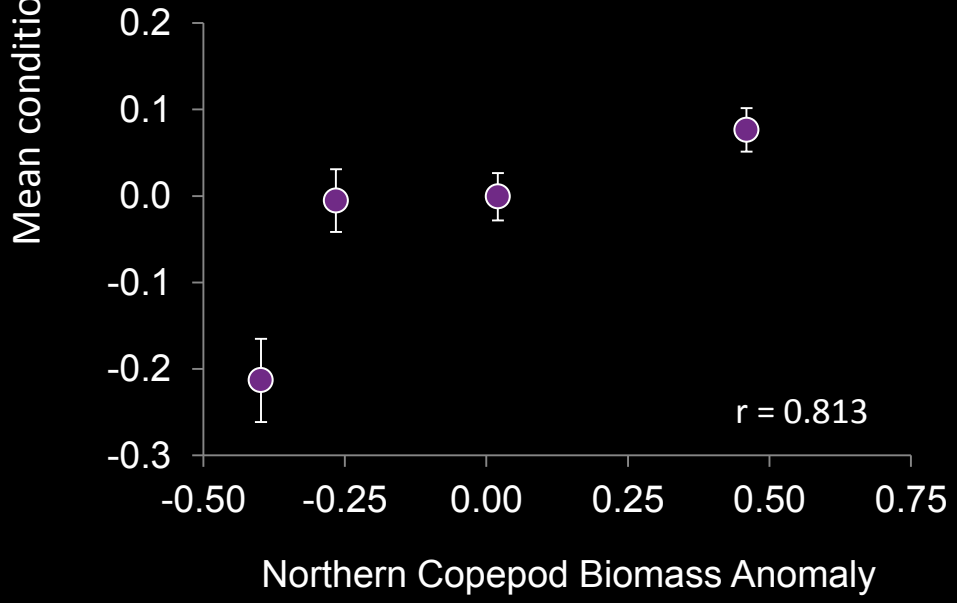
Lipids

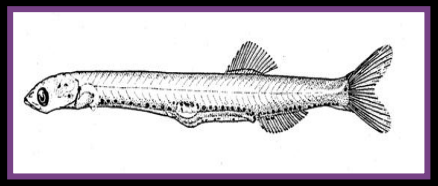
July 21-22, n = 19 → n = 12
August 23, n = 28 → n = 14
October 7-8 ,n = 15 → n = 10
October 22-23, n = 18 → n = 10
Nov. 4, n = 3 → n = 2



Results: Northern anchovy condition at capture

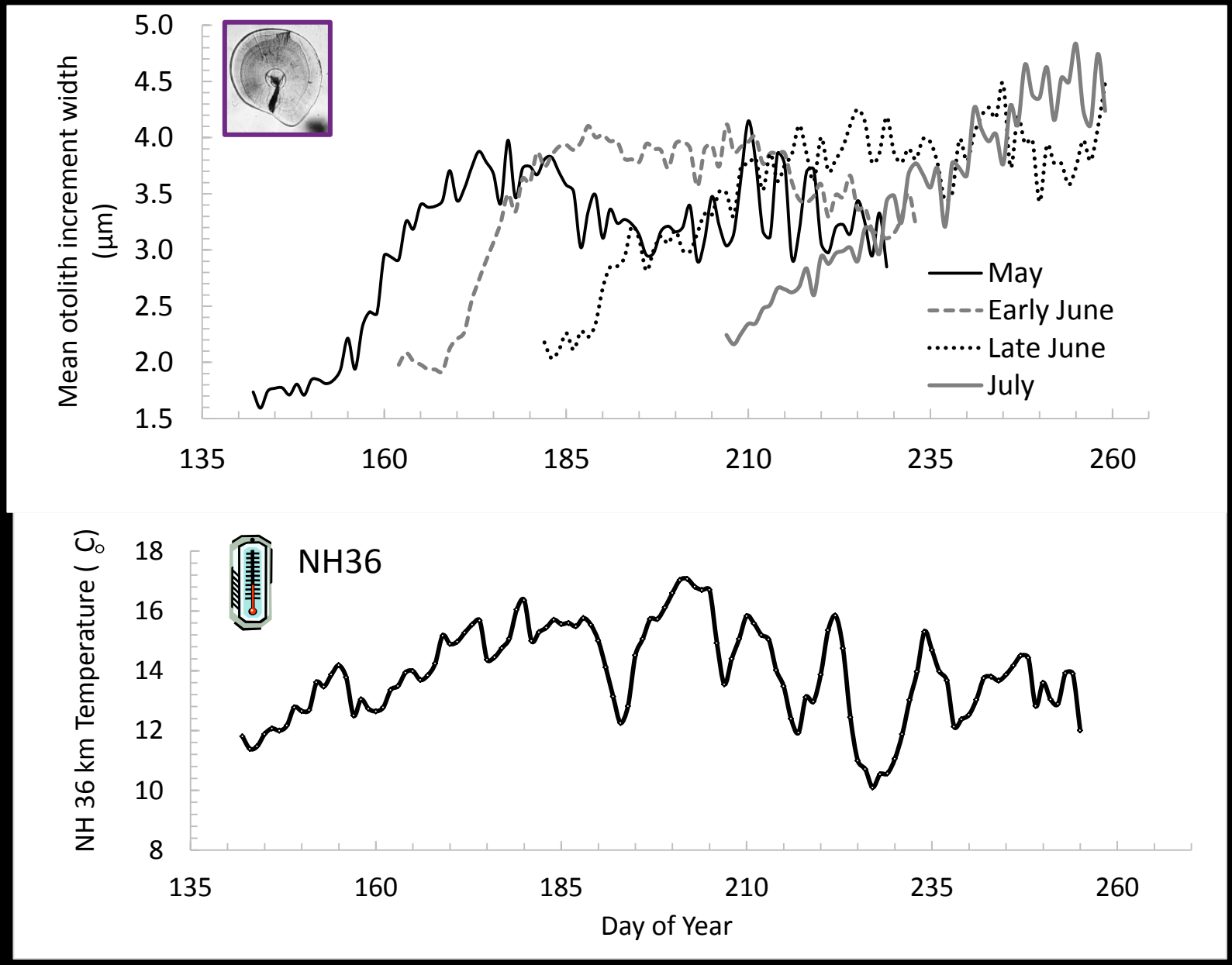






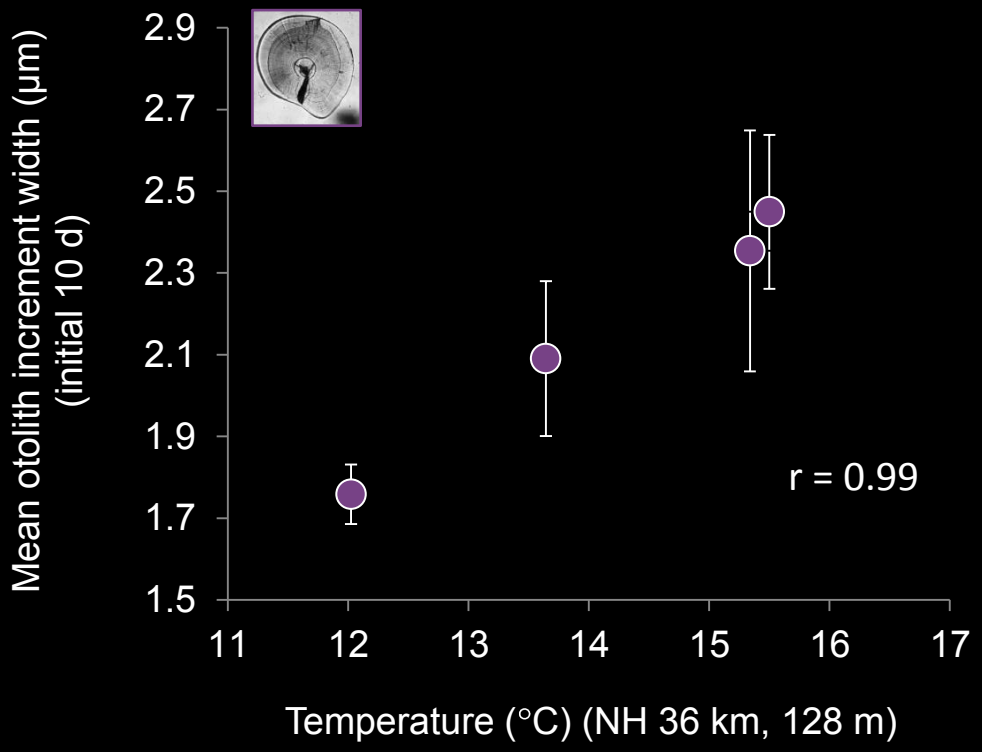
Higher condition when boreal, lipid-rich species are dominant and have greater biomass

Results: Northern anchovy cohort growth

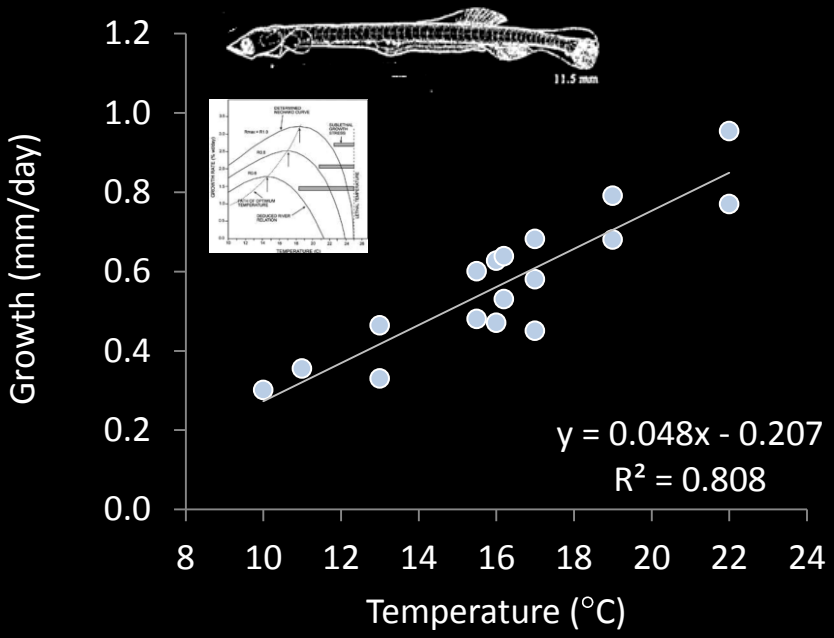


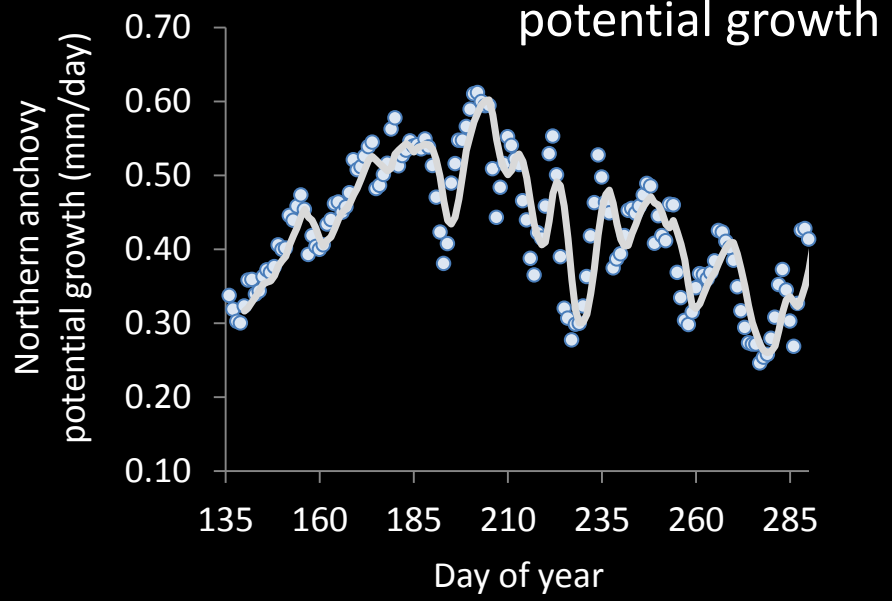
Results: Temperature effects on growth

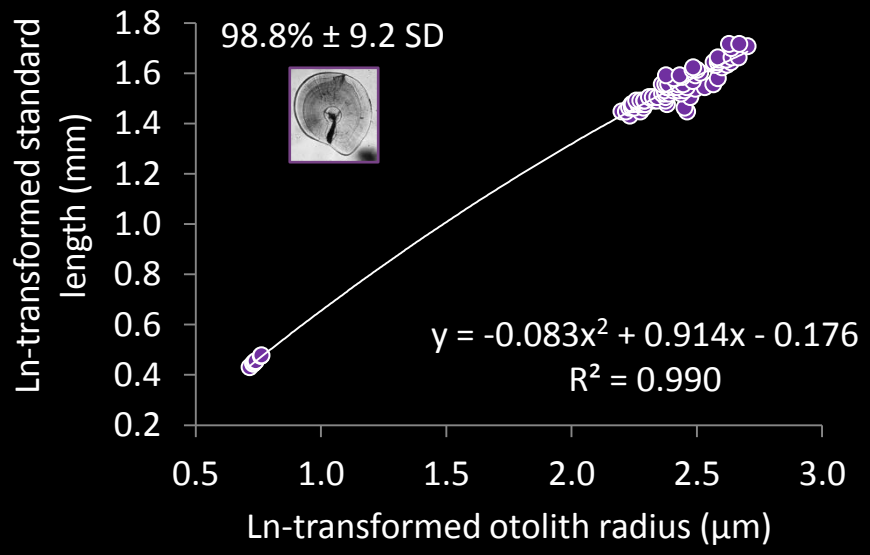
Early otolith growth positively correlated with temperature

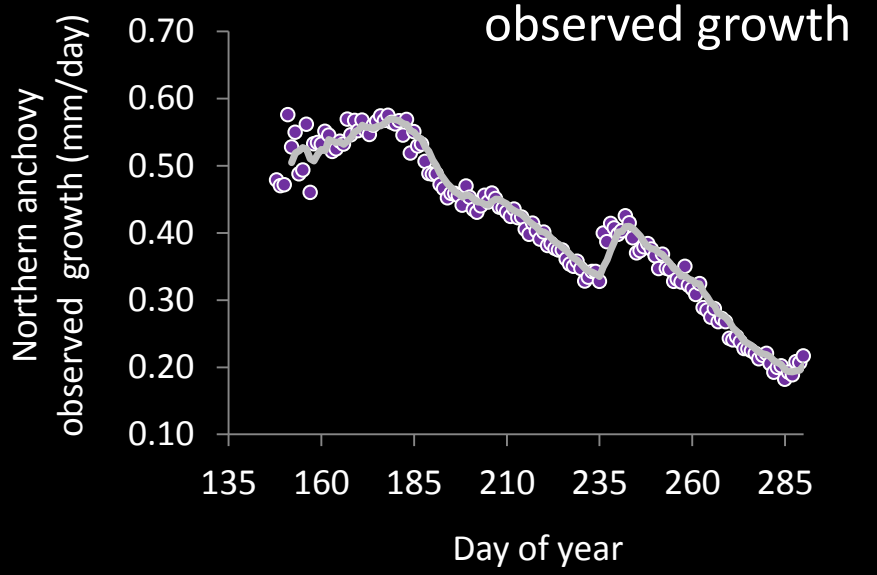


Results: Growth & condition of early stages of northern anchovy

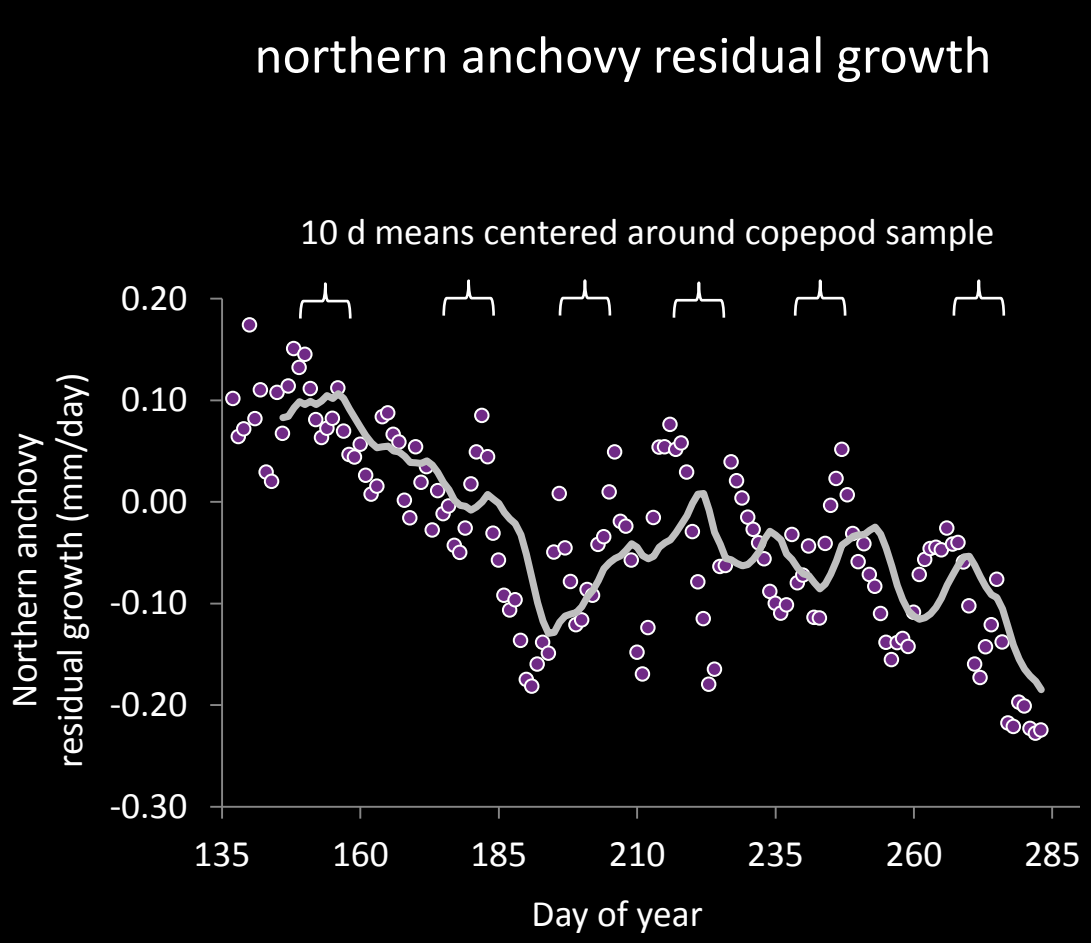




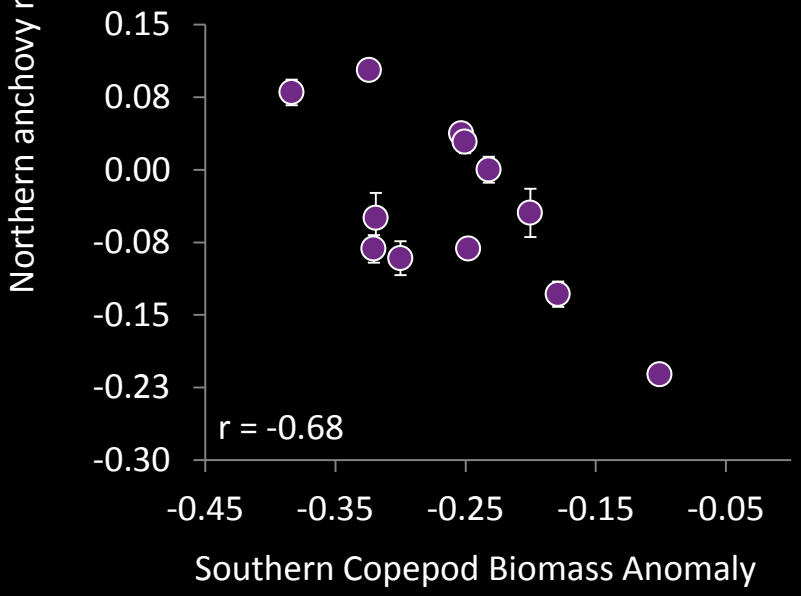


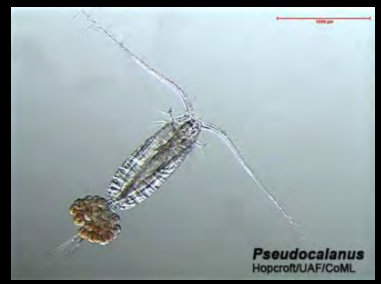


Results: Growth & condition of early stages of northern anchovy

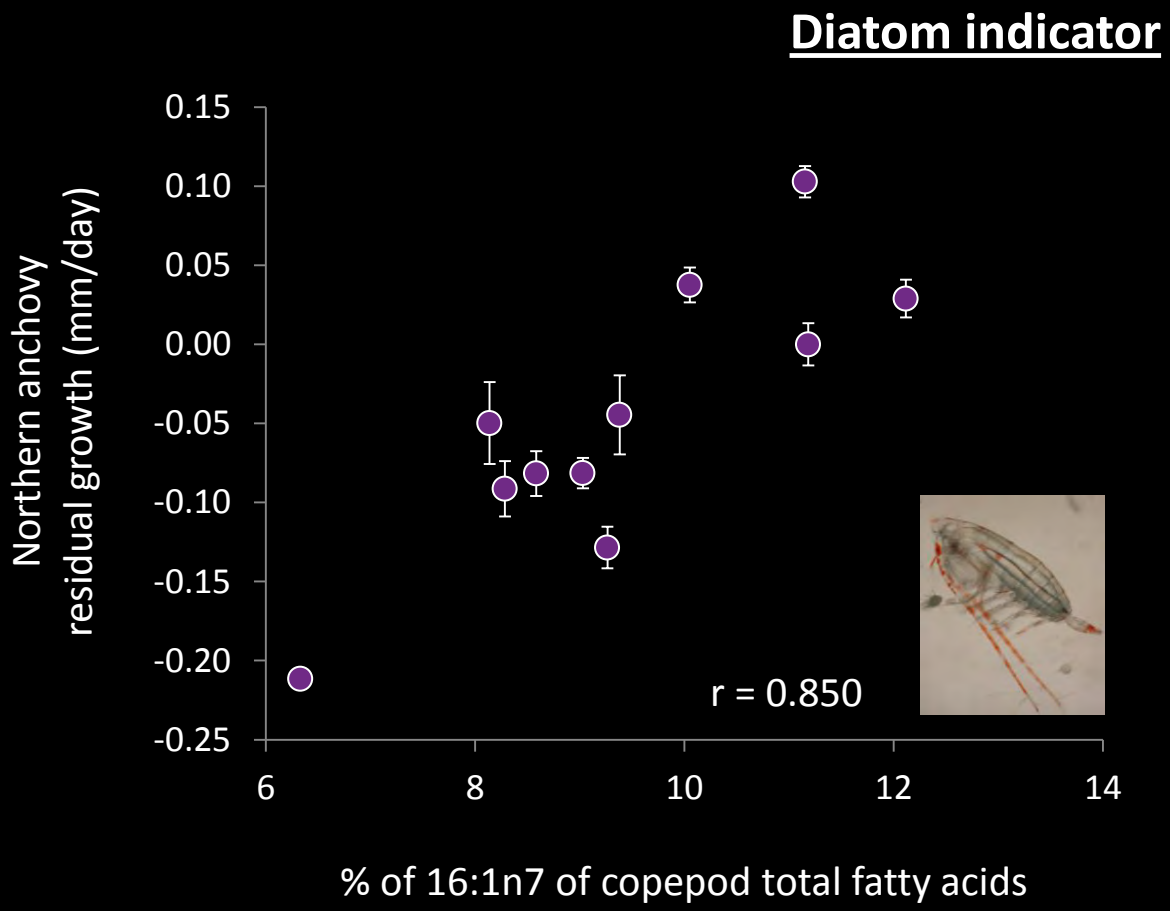


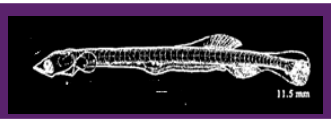
Results: Growth of early stages of northern anchovy & copepods



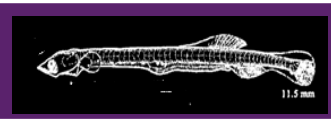


Results: Growth of early stages of northern anchovy





Summary & Future Directions



- ✓ Clear seasonal variation in lipids classes and FA within the copepod community

- ✓ Substantial intra-annual variation in anchovy growth – related to temperature and copepod community composition

- ✓ Intra-annual variation in early growth of northern anchovy related to FA in copepod community (diatom indicators)

- ✓ Those diatom indicators are better described by variation in the *biomass* of northern copepods than the Copepod Community Index (CCI) ($r = 0.55$ vs. $r = 0.30$)

- ✓ Early growth of northern anchovy influenced by both the community and relative biomass/abundance (individual size, abundance, and density)

Analysis ongoing*….second year of data collection, multivariate approaches, more detailed analysis of how changes in the copepod community relate to FA variation and anchovy growth*

Acknowledgements

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Thomas Murphy, OSU