The seasonal cycle of zooplankton in the California Current System: a predator’s perspective

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Introduction

• Abundance of euphausiids varies spatially and temporarily

• Abundance influenced by local and basin-scale ocean climate conditions (e.g. SST, upwelling)

• Few studies of within-season trends in euphausiid abundance in California Current System (CCS)
Objectives:

(1) To examine the seasonal patterns of relative abundance of euphausiid crustaceans in the diet of an upper trophic level marine predator in the central CCS (Gulf of the Farallones)

(2) To describe relationships between relative euphausioid abundance in predator diet and sea-surface temperature (SST), unlagged and lagged up to 4 months prior to collection
Cassin’s Auklet
(*Ptychoramphus aleuticus*)

- Ranges from Alaska to Baja California
- Preys on meso/macro-zooplankton (primarily euphausiids and/or copepods)
- Forages (via wing-propelled pursuit diving) at depths of 20-40m
- Regurgitate undigested prey to nestlings
Sampling Methodology

• Zooplankton samples taken from auklets provisioning young

• Diet collection started in May and ended in August

• 8-10 samples collected weekly; ~100 samples collected annually

• Analyses of each diet sample included:
  ➢ species identification
  ➢ separation of age classes/developmental stages
  ➢ count of each species
  ➢ total wet and dry mass/species/sample
Characteristics of focal euphausiid prey species

- *Euphausia pacifica*: oceanic, young phases coastal, adults to ~2.5cm

- *Thysanoessa spinifera*: coastal, adults to ~3cm

- Species are similar in size and energy density (~5 kcal g⁻¹)

- Describing seasonal population characteristics and trends in actual abundance of these euphausiids is difficult due to infrequent vessel-based sampling
Central CCS: Seasonal (January-August) patterns of SST

Mean August SST (1929-2003)

Mean April SST (1929-2003)
Use of *E. pacifica* and *T. spinifera* by auklets show opposing seasonal trends.

Lines represent locally-weighted regressions.
Use of *E. pacifica* by auklets declines seasonally.

Proportion (by #) *E. pacifica*

Day of year
Use of *E. pacifica* declines while *SST* increases seasonally.

Use of *T. spinifera* by auklets increases seasonally.
Use of *T. spinifera* increases with SST seasonally

*T. spinifera* vs. SST: 1996 & 2003 sig.
Multiple regression for each euphausioid species, effects of SST controlling for DATE, YEAR

Where SST in models was:
1. not lagged (SST on diet collection date)
2. mean of SST 0-30 d prior to collection date
3. mean of SST 30-60 d
4. mean of SST 60-90 d
5. mean of SST 90-120 d
Multiple regression for effects of SST on *E. pacifica*, controlling for DATE, YEAR

<table>
<thead>
<tr>
<th>SST lag (days)</th>
<th>SST coefficient</th>
<th>SST p-value</th>
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<td>90-120</td>
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Multiple regression for effects of SST on *T. spinifera*, controlling for DATE, YEAR

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<th>SST p-value</th>
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<td>90-120</td>
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Summary and Discussion

• In the central CCS, *E. pacifica* and *T. spinifera* show opposing seasonal trends in use by auklets (*E. pacifica* ↓ and *T. spinifera* ↑)

• Results of multiple regressions:
  - Proportion of *E. pacifica* in diet positively related to SST 60-90 days prior to collection
  - No significant relationships between proportion of *T. spinifera* in diet and SST

• Significant correlations between each species and SST in some years, but results of multiple regressions suggest that we can’t always use these relationships to determine causal significance
Summary and Discussion

• Use caution when interpreting results

• Auklets may actively prey-switch within seasons, possibly in response to changing energetic requirements and/or nutritional demands, or in response to changes in prey availability or behavior

• Auklets may be unable to access prey >40 meters deep
Proportion (by #) annual diet composition

- Other
- Copepods
- Other Euphausiids
- N. simplex
- E. pacifica
- T. spinifera

Northern CCS transition zone
Gulf of the Farallones, central CCS
Southern California Bight, south-central CCS
Punta Eugenia upwelling center, southern CCS

Canada
U.S.A.
Mexico
N.E. Pacific Ocean
Data for all latitudes combined includes:

- 9 taxonomic groups within Crustacea
- 67 genera
- 66 species
- developmental stage for some species
• Spatial and temporal prey distribution and abundance must be considered

• Seabird foraging strategy and response to ecosystem fluctuations may vary differently within and between years/decades

• We are deploying seasonal hydroacoustic surveys of the auklet prey base in the central CCS to further elucidate these relationships
Acknowledgments

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