Spatial match-mismatch between juvenile walleye pollock (*Gadus chalcogrammus*) and zooplankton prey in the eastern Bering Sea may contribute to recruitment variability.

Elizabeth Calvert Siddon, Trond Kristiansen, Franz J Mueter, Kirstin K Holsman, Ron A Heintz, Edward V Farley
INTRODUCTION

Kristiansen et al., 2011
INTRODUCTION

Stabeno et al., 2012
INTRODUCTION

Oscillating Control Hypothesis

Zooplankton  Age-0  Adults  Age-1

Winter starvation

Hunt et al., 2011
BACKGROUND: Warm-Cold differences

2005: Warm
- Age-0 pollock = 0.08 fish m$^2$

2010: Cold
- Age-0 pollock = 0.001 fish m$^2$
BACKGROUND: Warm-Cold differences

2005: Warm
- Age-0 pollock = 0.08 fish m$^{-2}$
- Water temperature
  - upper 30m: 8.8°C

2010: Cold
- Age-0 pollock = 0.001 fish m$^{-2}$
- Water temperature
  - upper 30m: 7.6°C
BACKGROUND: Warm-Cold differences

2005: Warm
- Age-0 pollock = 0.08 fish m\(^{-2}\)
- Water temperature
  - upper 30m: 8.8°C
  - below 40m: 4.5°C

2010: Cold
- Age-0 pollock = 0.001 fish m\(^{-2}\)
- Water temperature
  - upper 30m: 7.6°C
  - below 40m: 2.9°C
## BACKGROUND: Warm-Cold differences

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<tr>
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## BACKGROUND: Warm-Cold differences

### 2005: Warm
- **Age-0 pollock** = 0.08 fish m\(^{-2}\)
- **Water temperature**
  - upper 30m: 8.8°C
  - below 40m: 4.5°C
- **Zooplankton metrics**
  - 1,841 m\(^{3}\)
  - 0.1 g m\(^{3}\)
  - 4.07 kJ g\(^{-1}\)
- **Age-0 pollock diet:**
  - 39% small copepods (Acartia, Pseudocalanus)
  - 0% large copepods

### 2010: Cold
- **Age-0 pollock** = 0.001 fish m\(^{-2}\)
- **Water temperature**
  - upper 30m: 7.6°C
  - below 40m: 2.9°C
- **Zooplankton metrics**
  - 2,921 m\(^{3}\)
  - 0.28 g m\(^{3}\)
  - 4.6 kJ g\(^{-1}\)
- **Age-0 pollock diet:**
  - 0% small copepods
  - 25% large copepods (Calanus)

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GOALS

1) Identify growth ‘hot spots’ based on prey and temperature conditions

2) Examine spatial overlap of pollock with growth ‘hot spots’ in a warm and a cold year
**APPROACH**

1) **Biocnergetics Model**
   - Wisconsin-type
   - Predator and prey energy density
   - Consumption parameter = 1
   → **Maximum growth**
     (Growth potential)

   \[
   \text{Growth} = \text{Consumption} - \text{Respiration} - \text{Waste}
   \]

2) **Individual-based Model**
   - Mechanistic feeding component
   - Size-based
   - Vertical behavior
   → **“Realized” growth**

[Diagram showing growth cycle and stages]
Need average energy density by station and year:
- Taxon-specific energy density based on % lipid
- Compute biomass-weighted average energy density across all taxa

Heintz et al 2013 DSR II
RESULTS: age-0 pollock abundance

2005: Warm

2010: Cold
RESULTS: prey energy

2005: Warm  2010: Cold

Staet al., 2013, PLoS ONE
RESULTS: bioenergetics model

2005: Warm  2010: Cold

Staddon et al., 2013, PLoS ONE
RESULTS: optimal prey size (IBM)

2005: Warm  2010: Cold

Stodd et al., 2013, PLoS ONE
RESULTS: observed pollock condition

Heinle et al. 2013 DSR II
RESULTS: Pollock recruitment response

Receutis/Spawner vs. Average energy content (kJ/fish)

R² = 0.79

Heinr et al. 2013 DSR II
CONCLUSIONS

1) Spatial patterns in prey and temperature lead to growth ‘hot spots’; survival may depend on the overlap of fish and ‘hot spots’.
CONCLUSIONS

1) Spatial patterns lead to growth ‘hot spots’
2) Spatial mismatch in 2005 associated with poor recruitment; greater overlap in 2010 associated with improved recruitment.

Siddon et al., 2013
PLoS ONE