Anomalously low crustacean zooplankton production rates along the west coast of Vancouver Island in the spring of 2015

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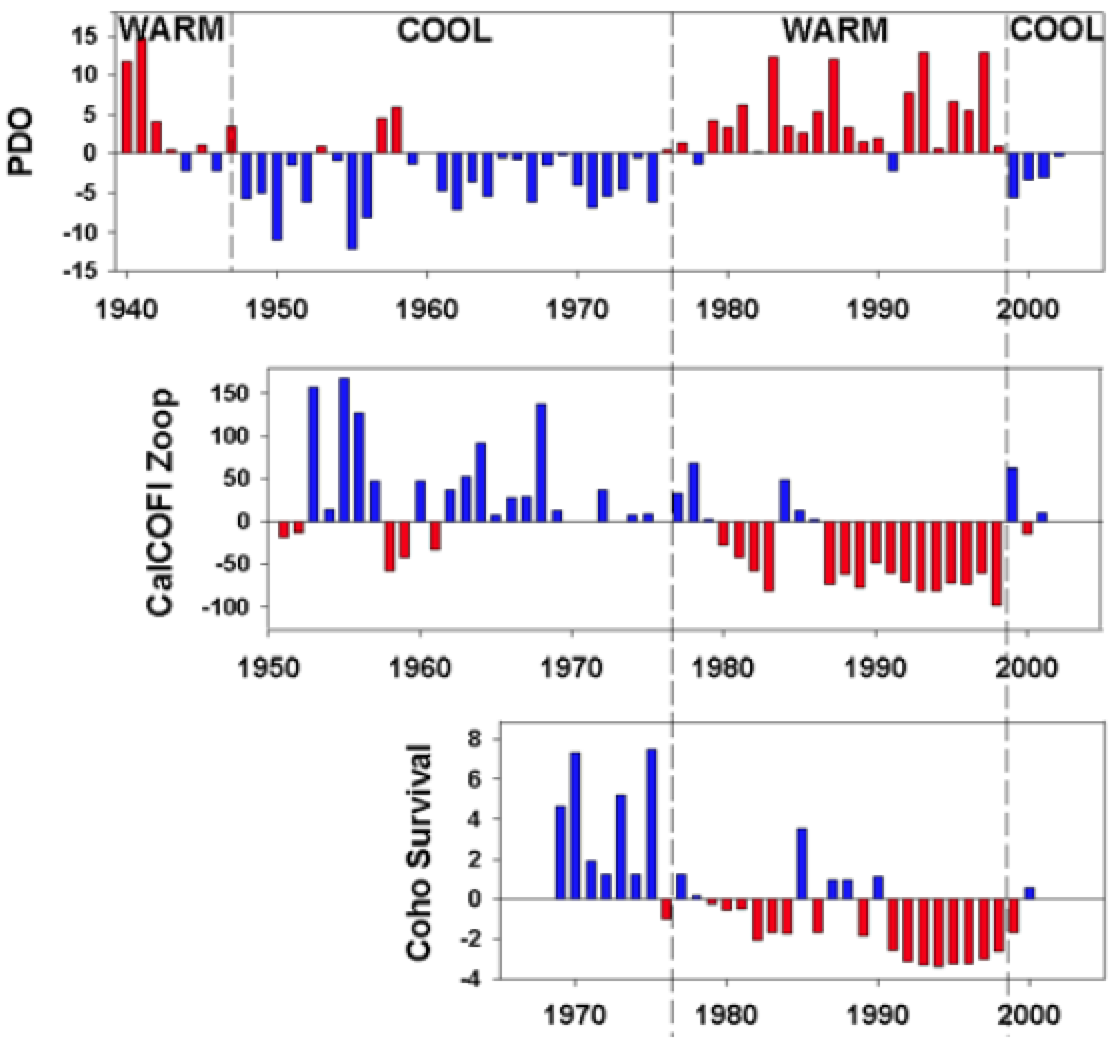
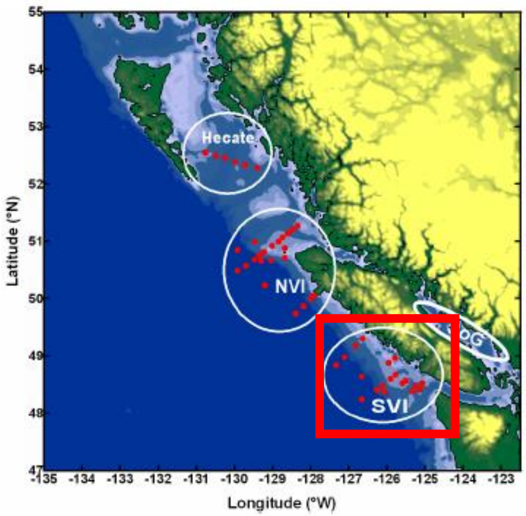
PDO, Zooplankton, and Salmon



(Peterson and Schwing 2003. *Geophysical Res. Letters*)

Cold regimes characterized by higher northern zooplankton biomass

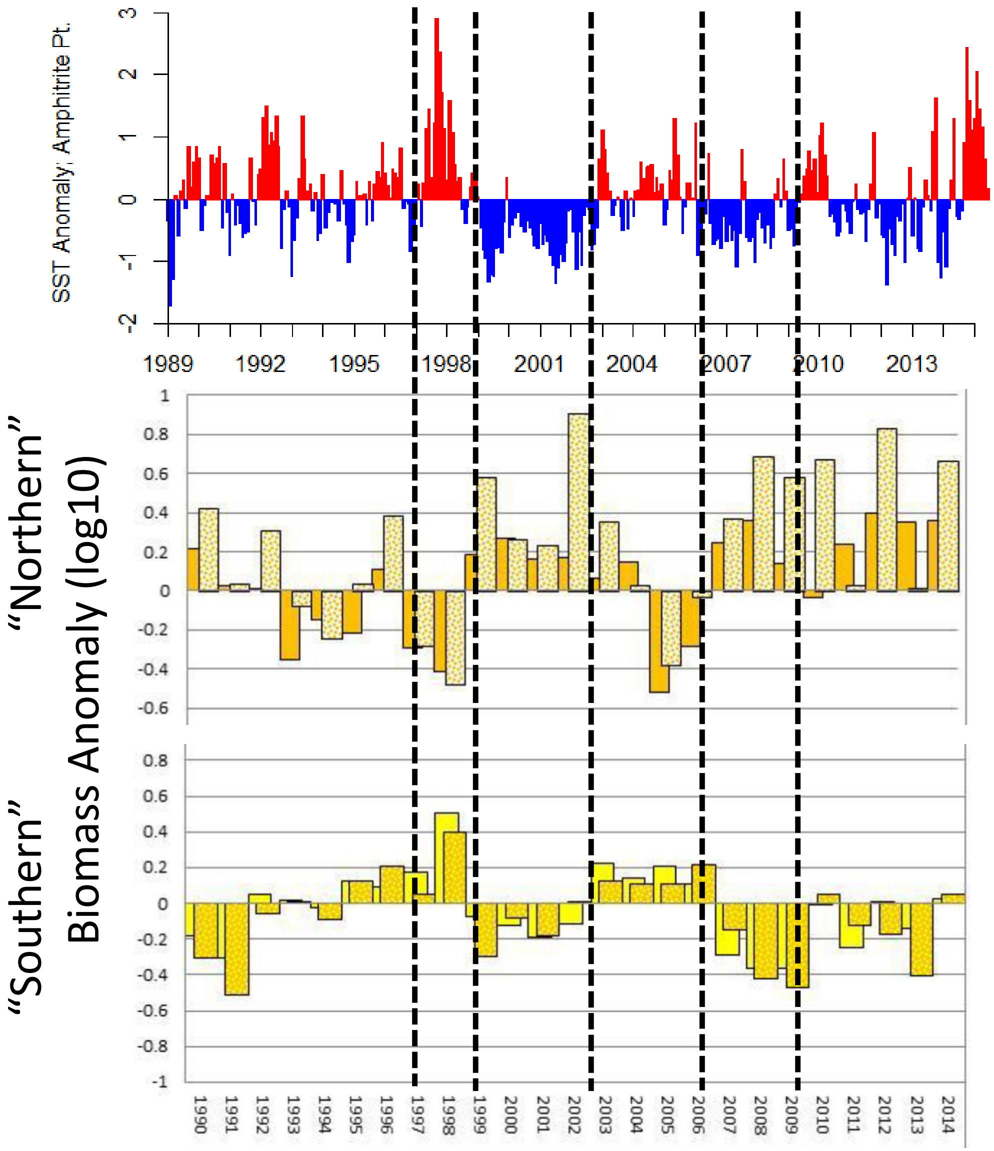
Poor salmon survival linked to anomalously low biomass of northern zooplankton



1. **‘Northern’ vs. ‘Southern’ biomass ≈ cold vs. warm**

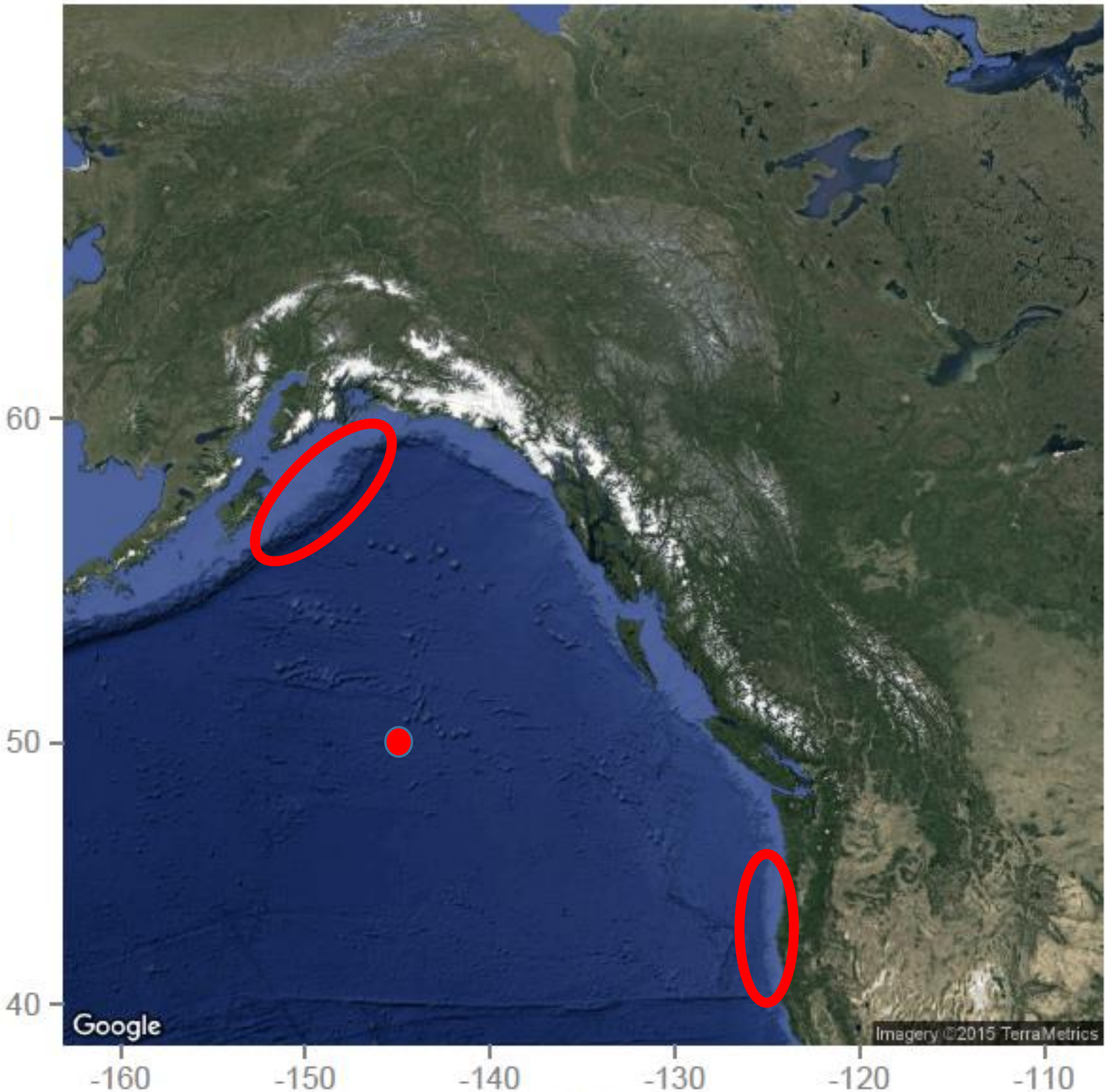
2. **Temporal patterns influence higher trophic level survival**
   (Mackas et al. 2007)

3. **Difficult to translate biomass patterns to quantitative estimates of food web efficiency**



(Galbraith et al *in*: Chandler, King, and Perry 2015, Can. Tech. Fish. Aquat. Sci.)

In situ Zooplankton Productivity Estimates



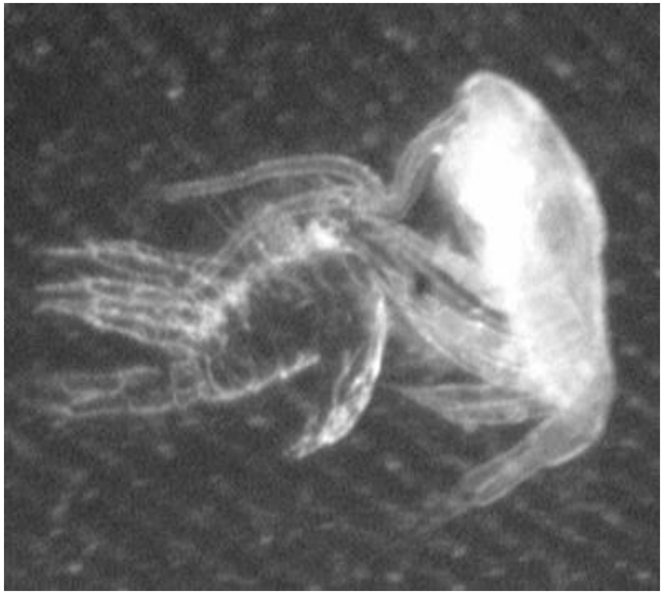
- **Calculations of transfer efficiency demand secondary production rate estimates**
- **Weight-specific growth rates for dominant copepod and euphausiid species (GOA, Oregon coast, Stn.P)**
- **<u>No historical community-level</u> measurements in Canadian Pacific**

Methods : Zooplankton Production Rates

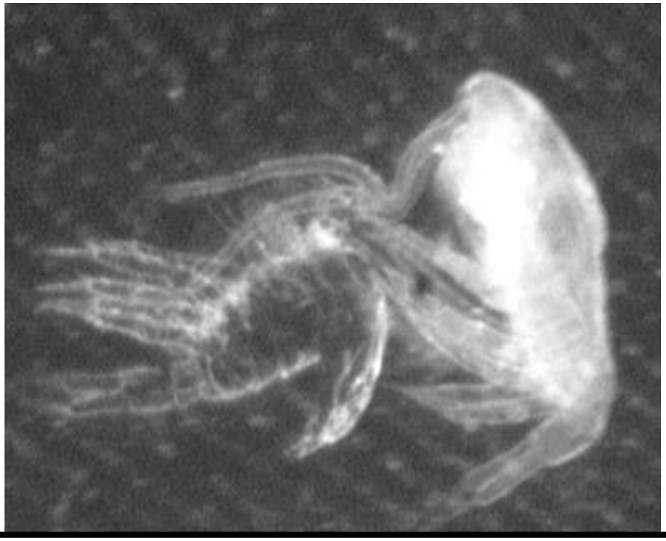
Chitobiase Method:

1) Enzyme breaks down chitin in old exoskeleton and recycles chitin for synthesis of new exoskeleton

2) Chitobiase is liberated into water when animal moults



Methods : Zooplankton Production Rates

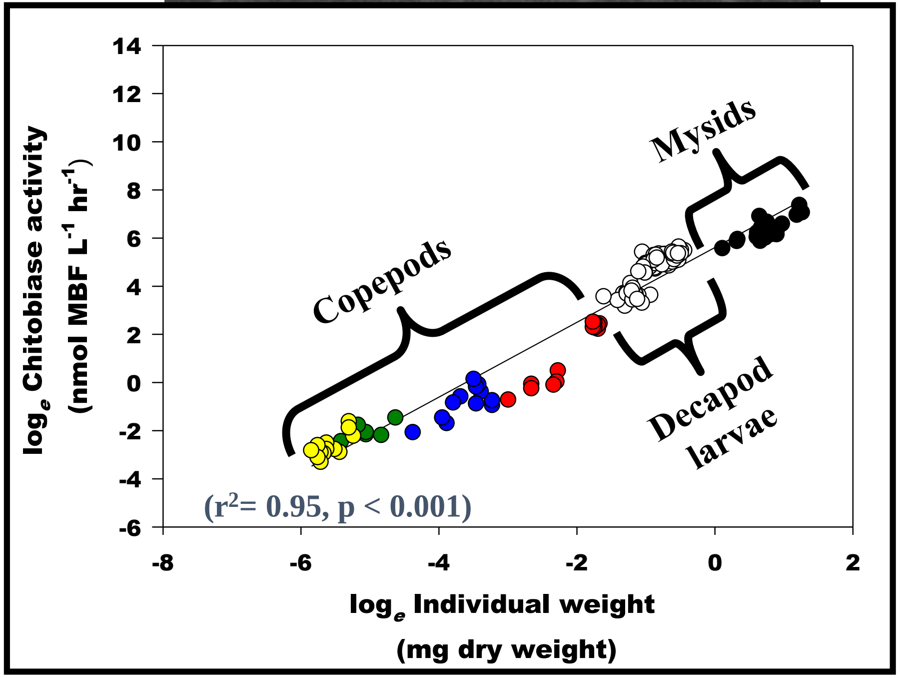


Chitobiase Method:

1) Enzyme breaks down chitin in old exoskeleton and recycles chitin for synthesis of new exoskeleton

2) Chitobiase is liberated into water when animal moults

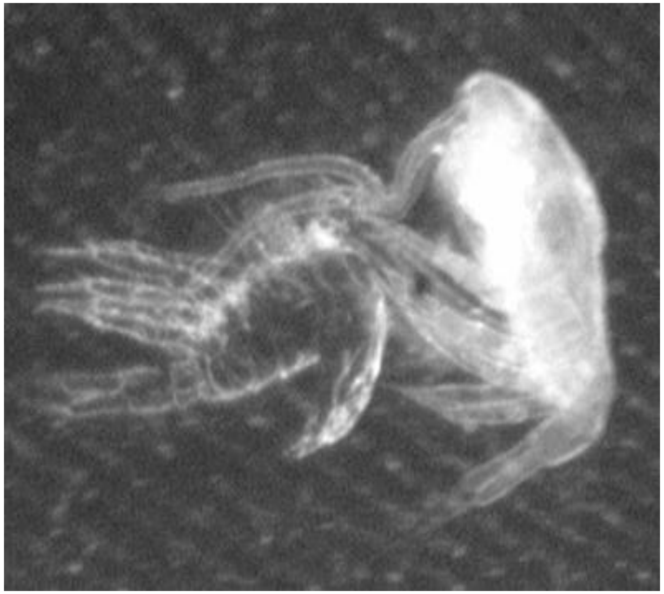
3) **Activity varies with individual body size, developing biomass and increment of growth for the community**



(Sastri & Dower 2009 *Mar. Ecol. Prog. Ser.*)

Methods : Zooplankton Production Rates

Chitobiase Method:

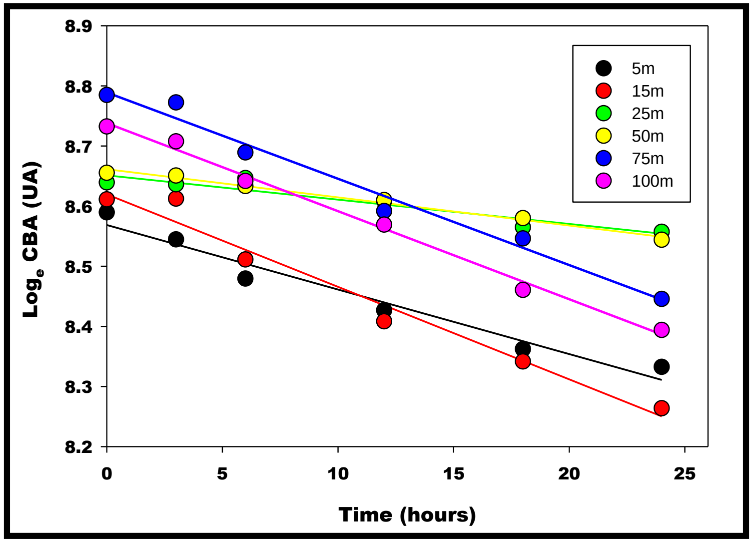


1) Enzyme breaks down chitin in old exoskeleton and recycles chitin for synthesis of new exoskeleton

2) Liberated into water when animal moults

3) Activity varies with individual body size, developing biomass and increment of growth for the community

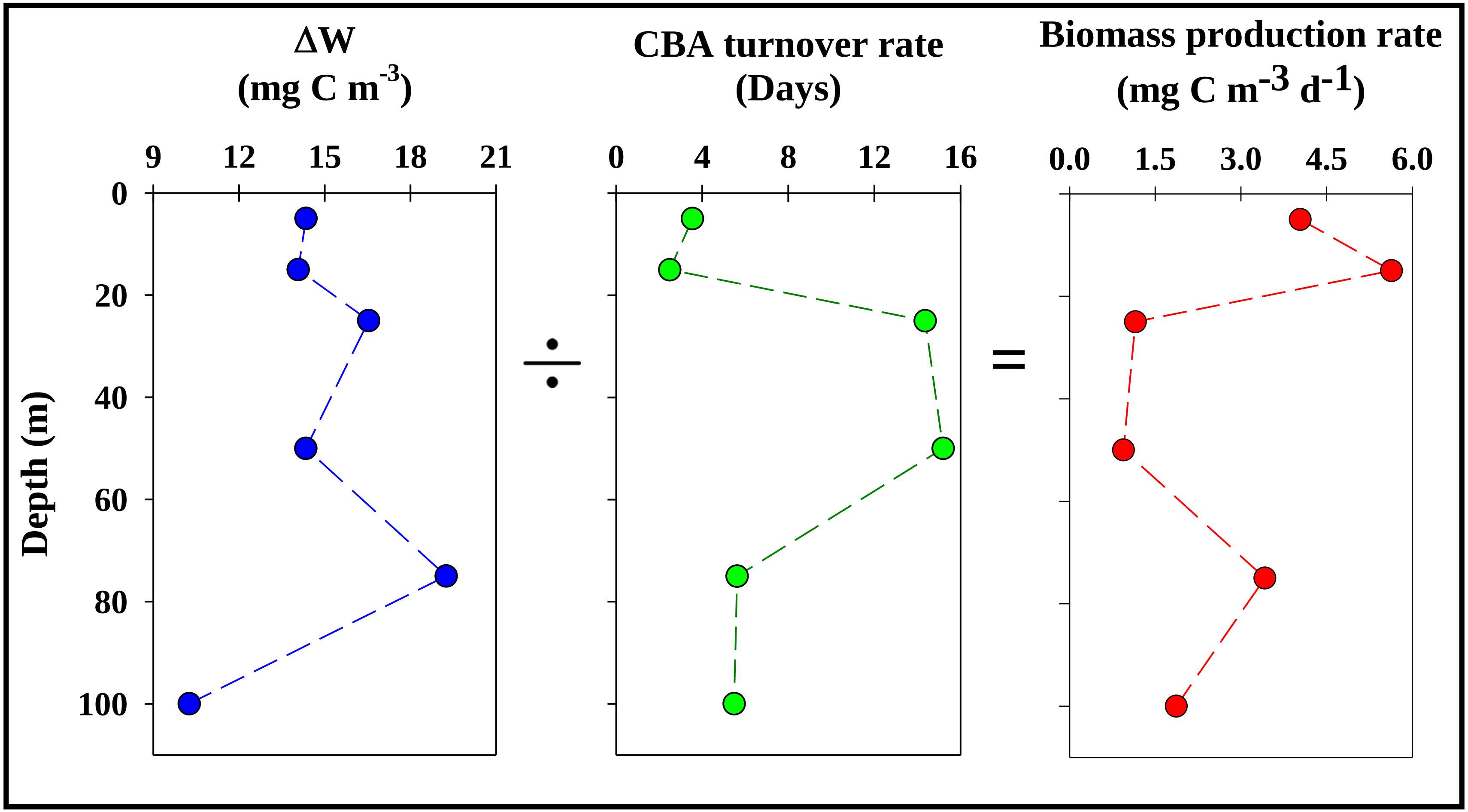
4) The rate of production of the enzyme in the water = biomass production rate



5) Measure enzyme decay rates assuming balance between production & degradation

A Field Example (Gulf of Alaska: July 2009)

Production rate = ΔB / T_{CBA}

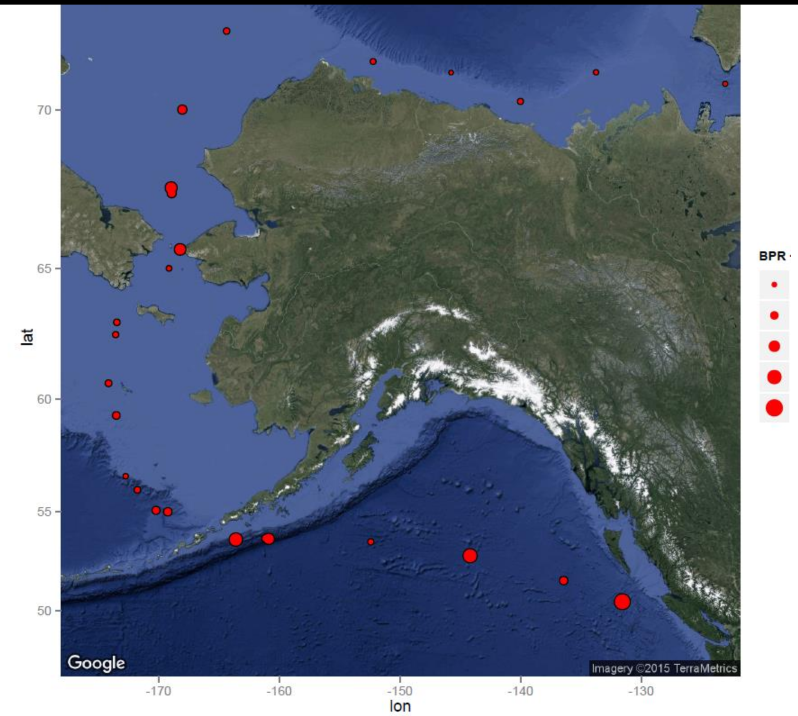


= 2.41 mg C m^{-3} d^{-1}

Broad-scale production rate patterns

1. **Sampling July'08, July'09, and October'09**

2. **Production rates varied in space ($0.15-4$ mg C m^{-3} d^{-1})**



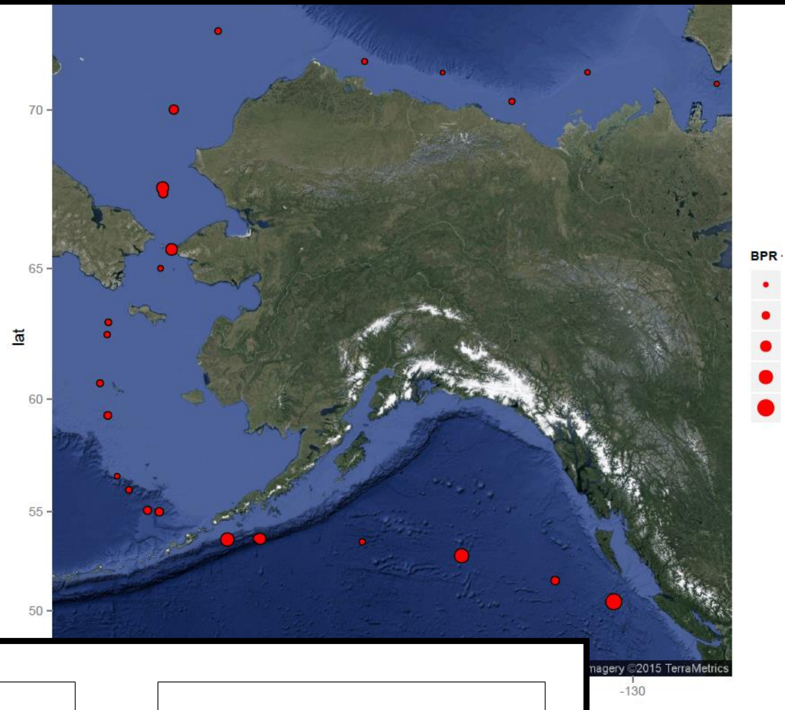
(Sastri et al. 2012 *J. Exp. Mar. Ecol. Biol.*)

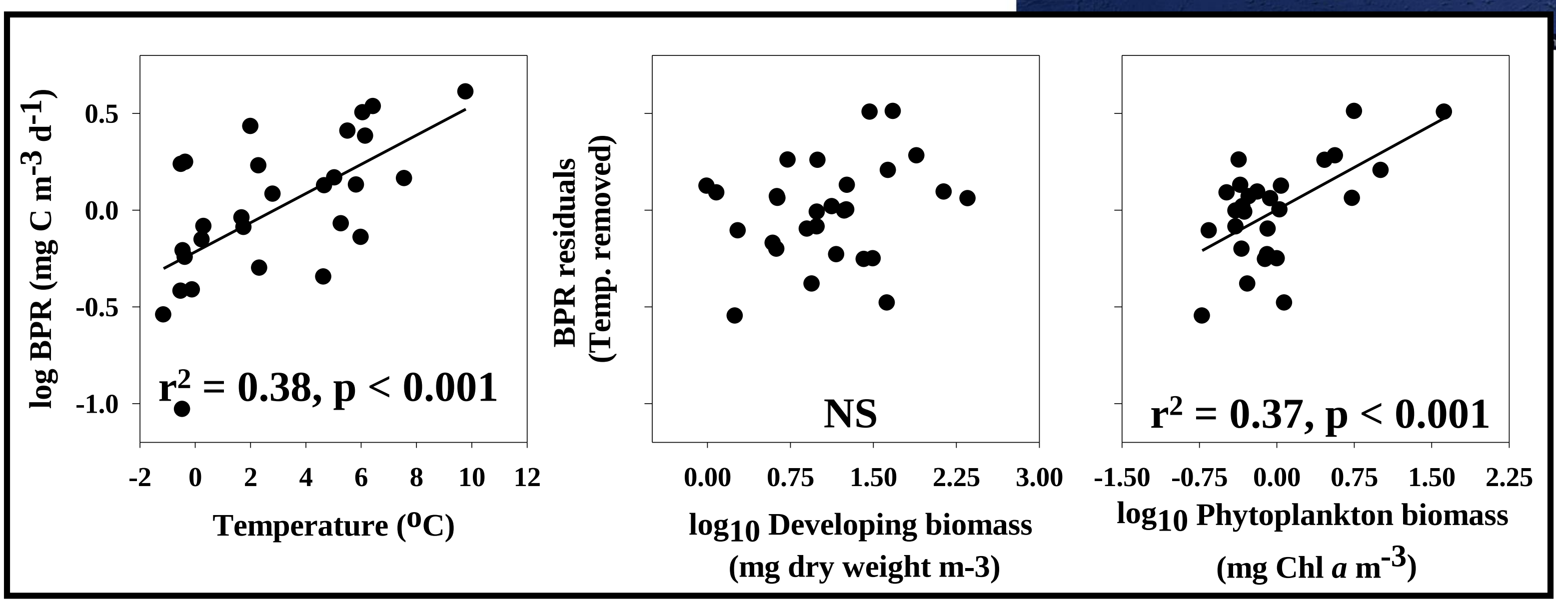
Broad-scale production rate patterns

1. Sampling July'08, July'09, and October'09

2. Production rates varied in space ($0.15\text{-}4$ mg C m^{-3} d^{-1})

3. Production rates varied significantly with temperature and phytoplankton biomass ($r^2=0.67$, $p<0.001$)

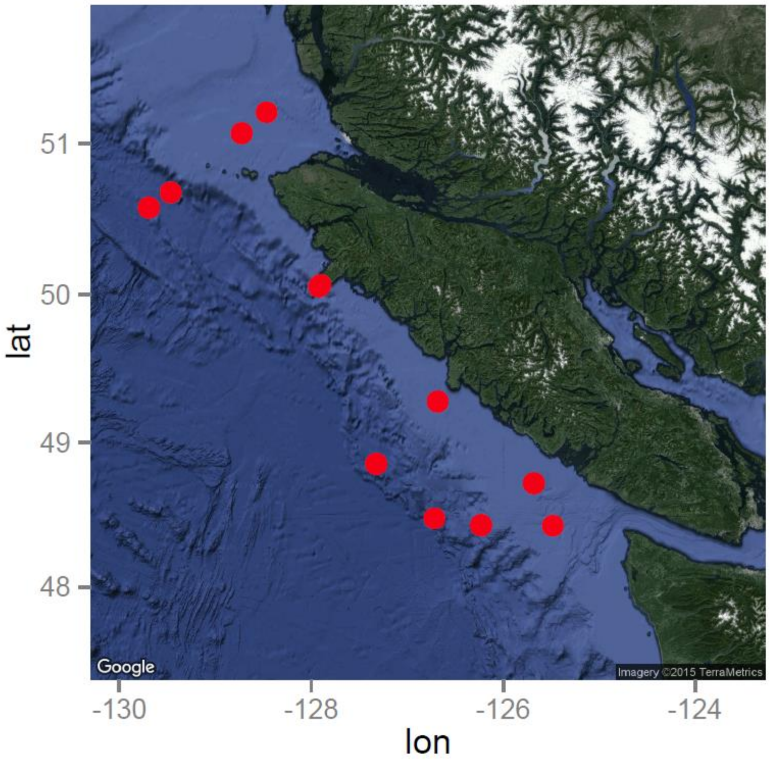




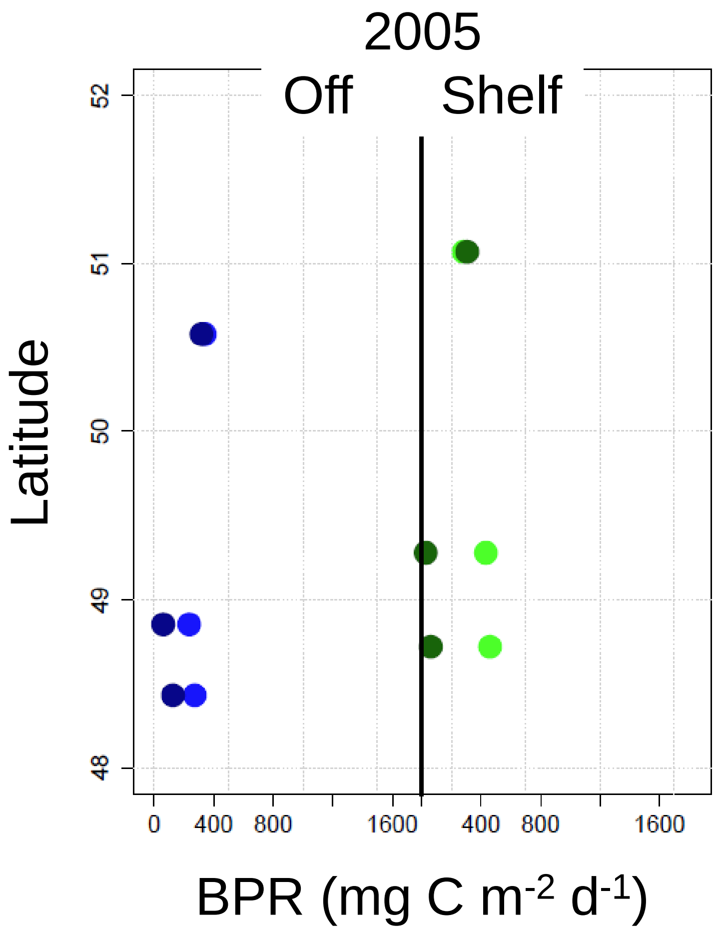
(Sastri et al. 2012 *J. Exp. Mar. Ecol. Biol.*)

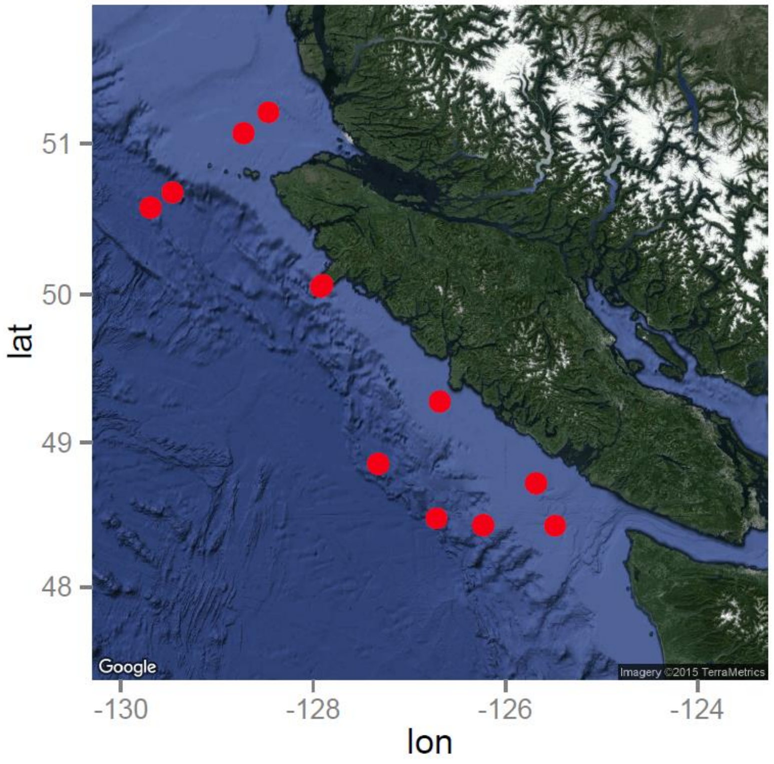
Production rates : La Perouse/WCVI

1. **Chitobiase activity and decay dynamics measured at several stations**
2. **Included on- and off- shelf stations**
3. **Up to 2 trips per year (June, September)**
4. **2005 – spring/summer (6 Stns/cruise)**
5. **2009-2011 – summer (6 Stns/cruise)**
6. **2015 – spring/summer (8 Stns/cruise)**



Zooplankton Production Rates: 2005

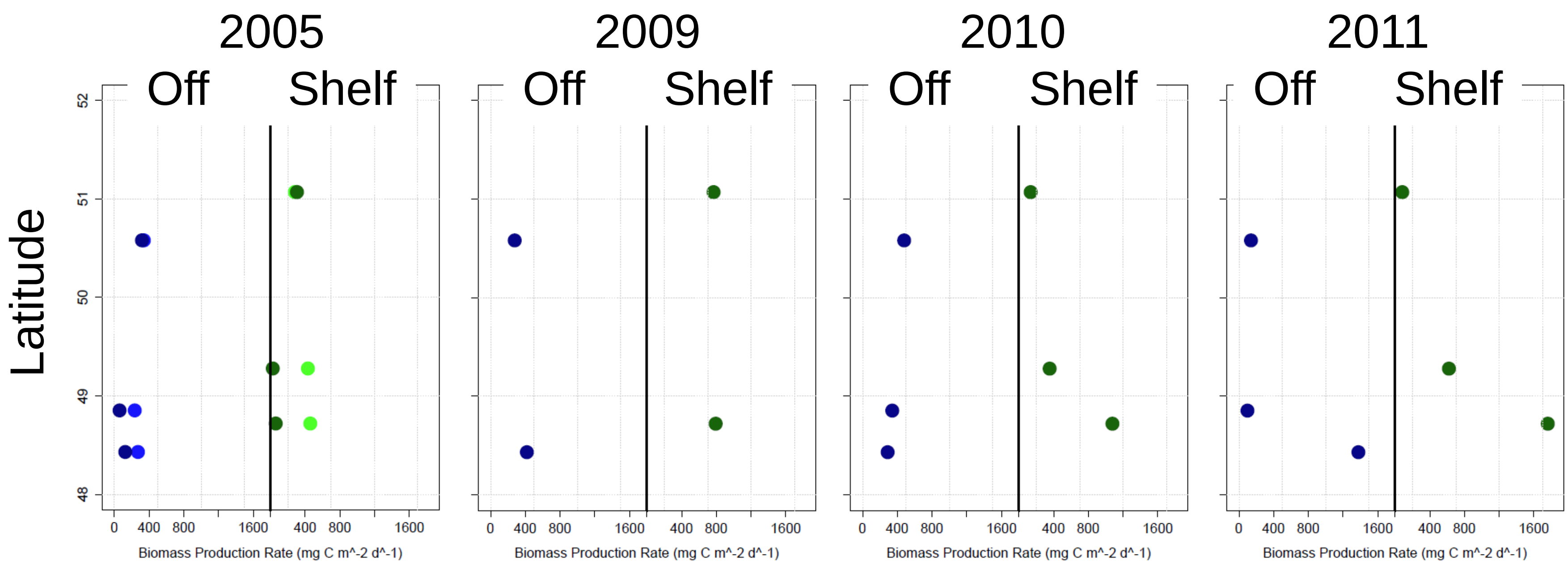




South VI: **Production rates greater on shelf and offshore in June relative to September (very low)**

North VI : **No particular inter-cruise differences on or off-shelf**

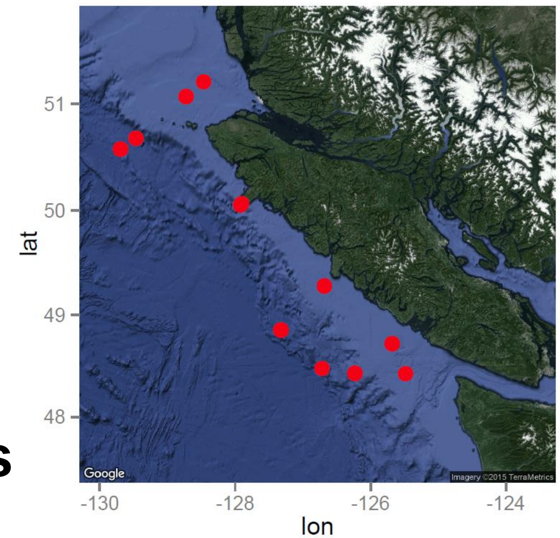
Spatial patterns of production 2005-2011



1. **Shelf production typically greater in the south**

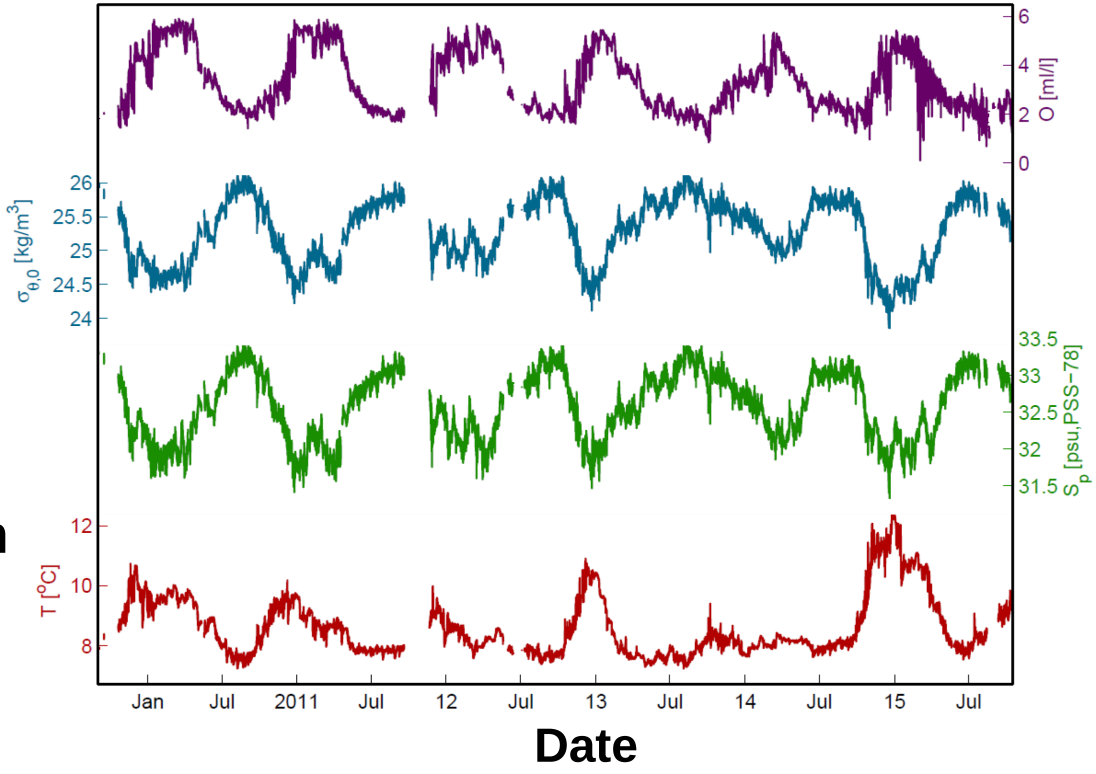
2. **No systematic N-S trend for offshore stations**

3. **Production rates measured in cool years (2009,2011) > warm years (2005,2010)**

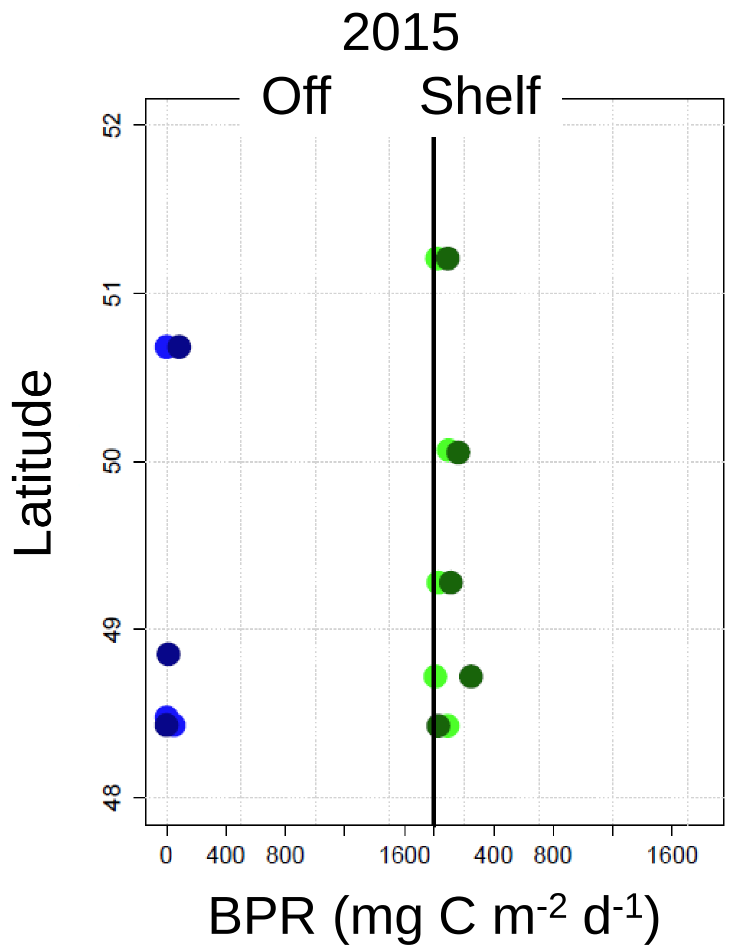


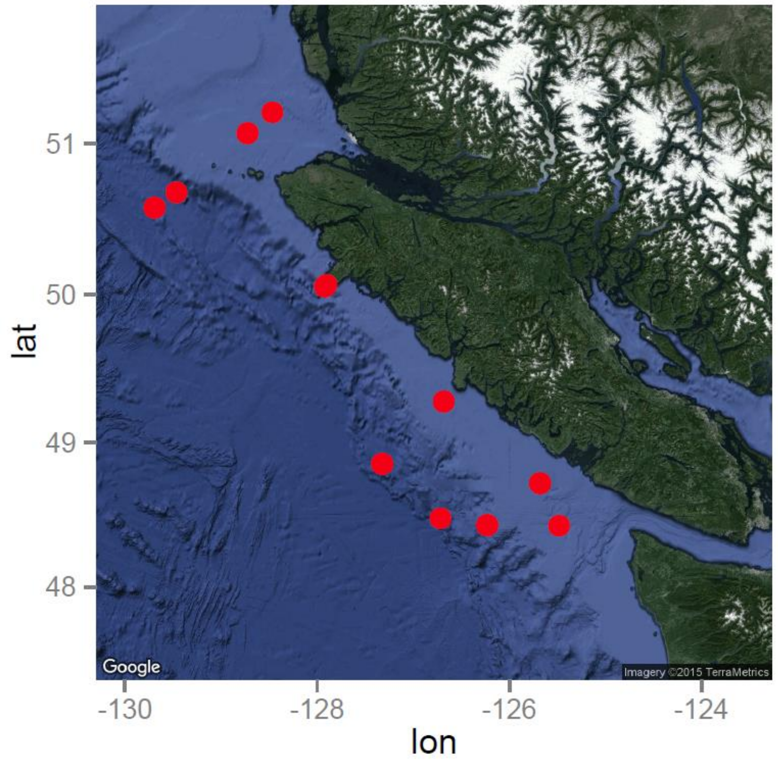
Warm shelf waters 2014/2015

1. **Sea-floor CTD on shelf at 96m**
2. **Captures seasonal pattern of upwelling and downwelling water onto shelf**
3. **Weak downwelling in <u>2013/2014 winter</u> (blob development)**
4. **Warm (~2°C>) fresher water downwelled onto shelf <u>2014/2015 winter</u>**
5. **Atypically warm on southern shelf through spring/early summer**



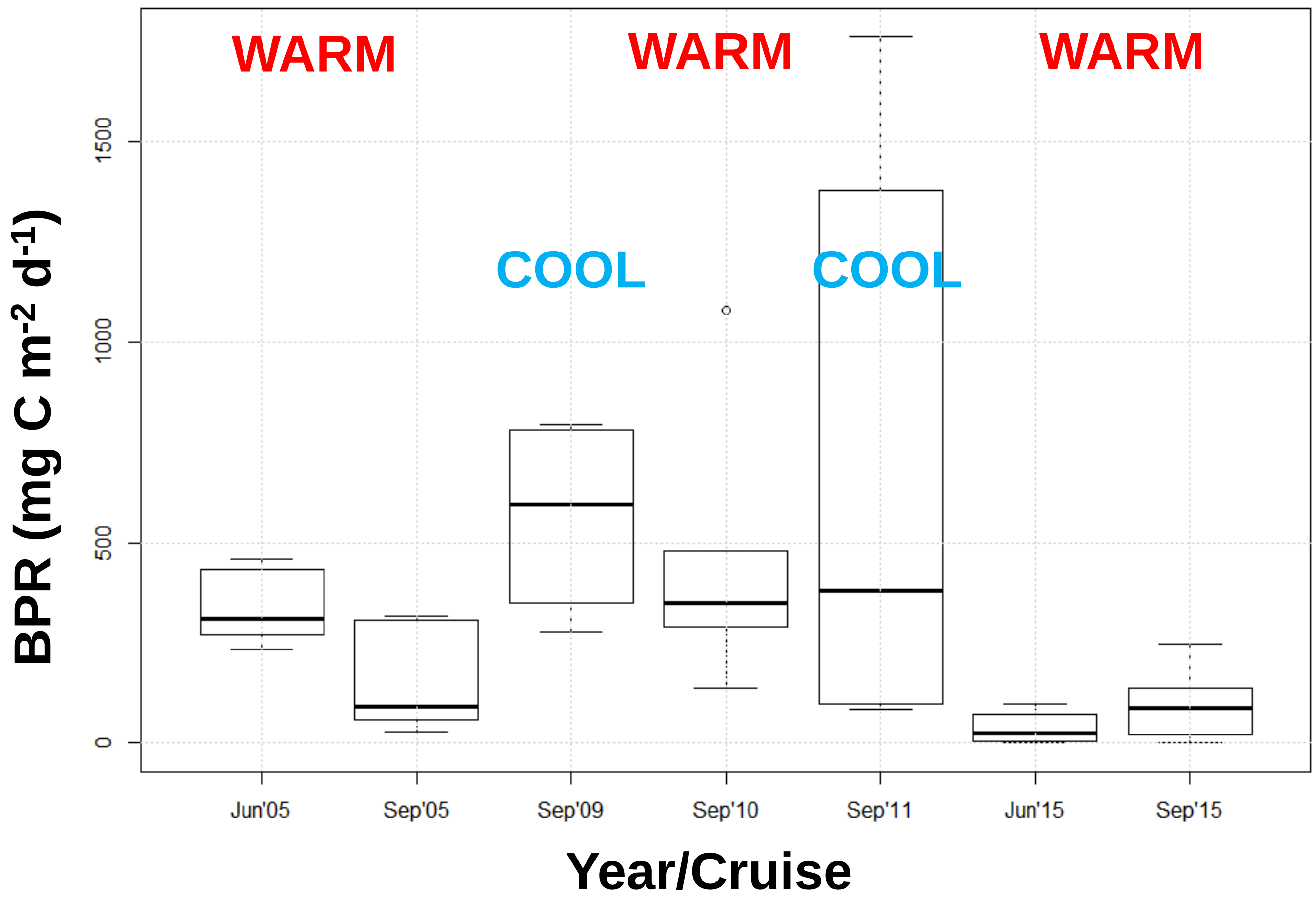
Zooplankton Production Rates: 2015



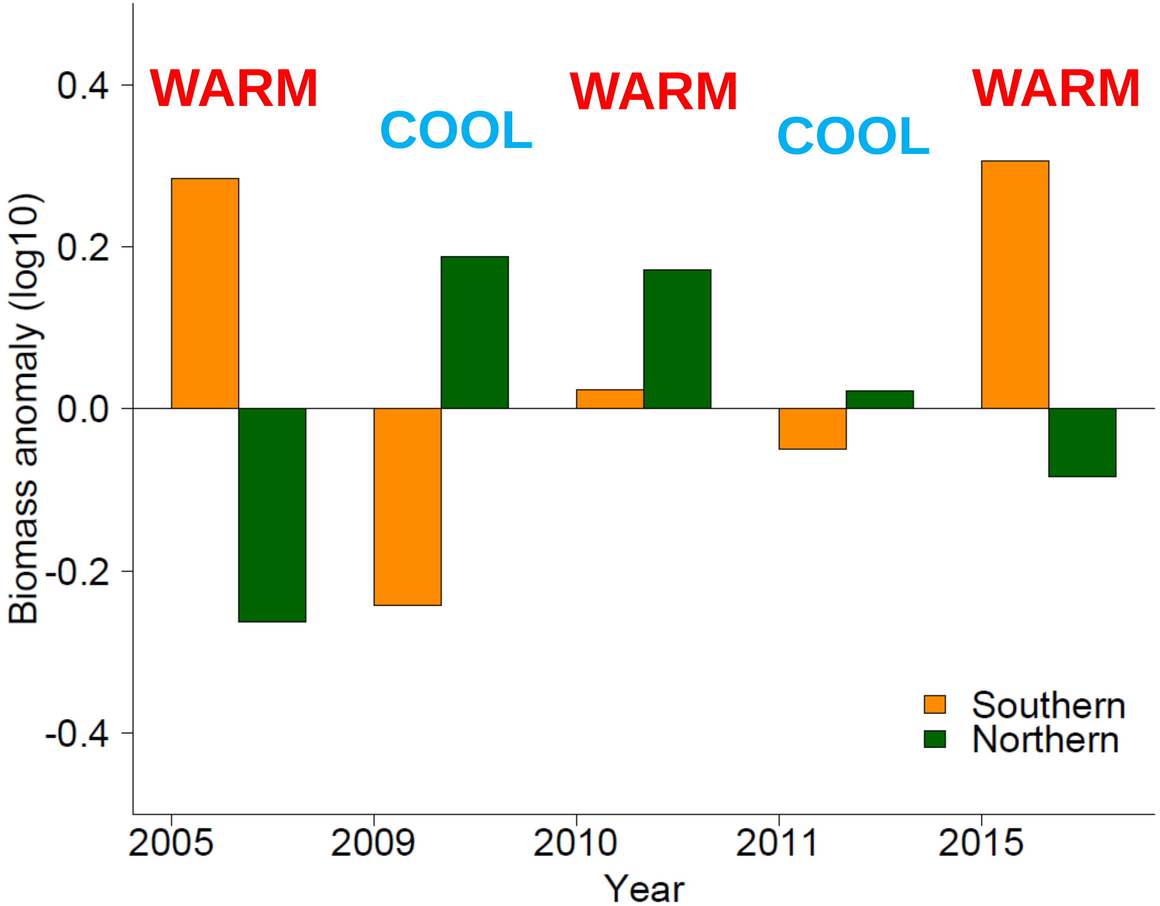


1. **Production rate low and limited to the upper 10m**
2. **No north-south trend**
3. **Rates ~0 in June, marginally higher in September**
4. **Production rate elevated on southern shelf but ‘0’ off shelf in Sept.**

Year-specific zooplankton production rates



Biomass patterns: Copepods



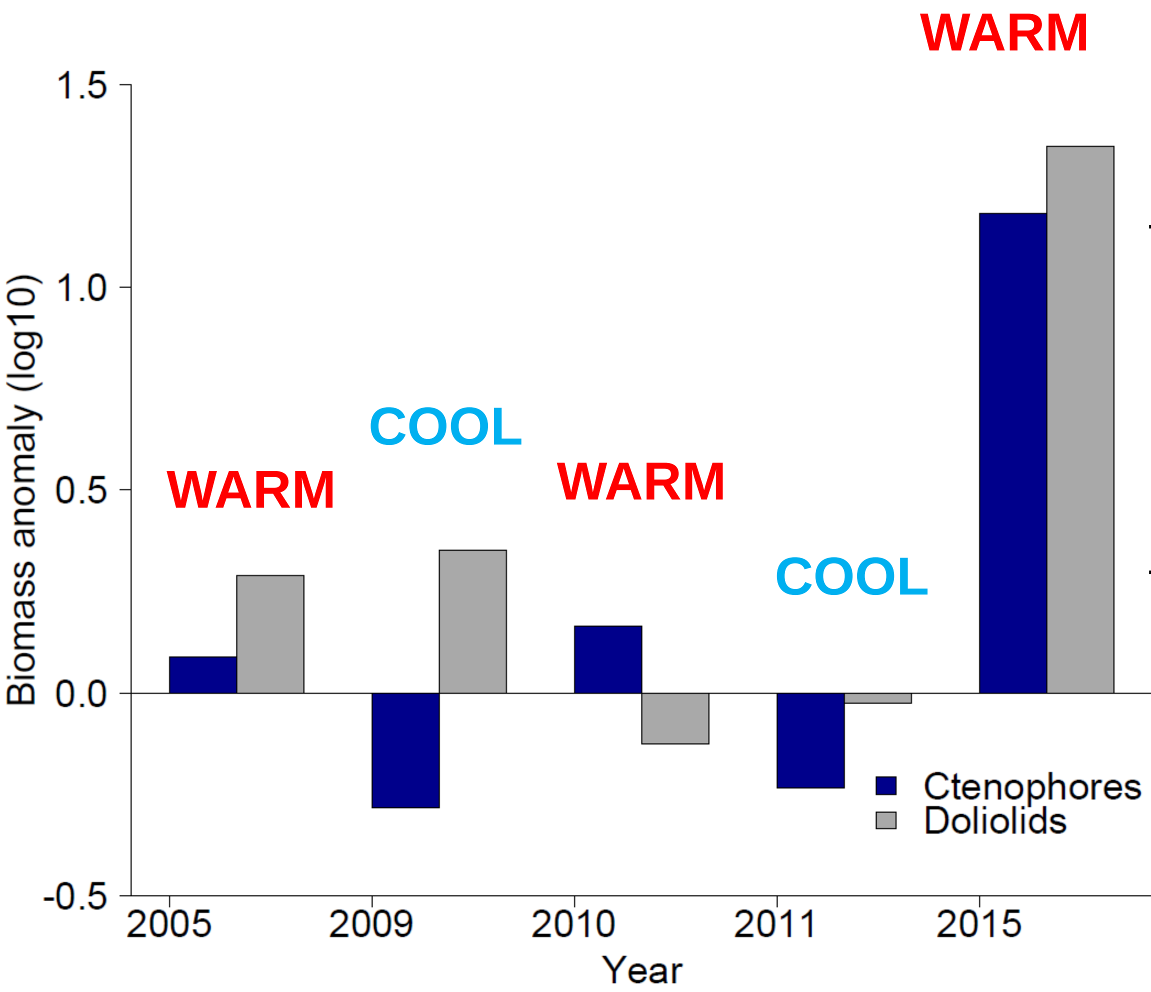
Southern species anomaly:

- High in 2005 & 2015
- Positive but low 2010
- Negative in 2009 & 2011

Northern species anomaly:

- Low in 2005 & 2015
- Positive in 2010
- Positive in 2009 & 2011

Biomass patterns: Gelatinous Zooplankton



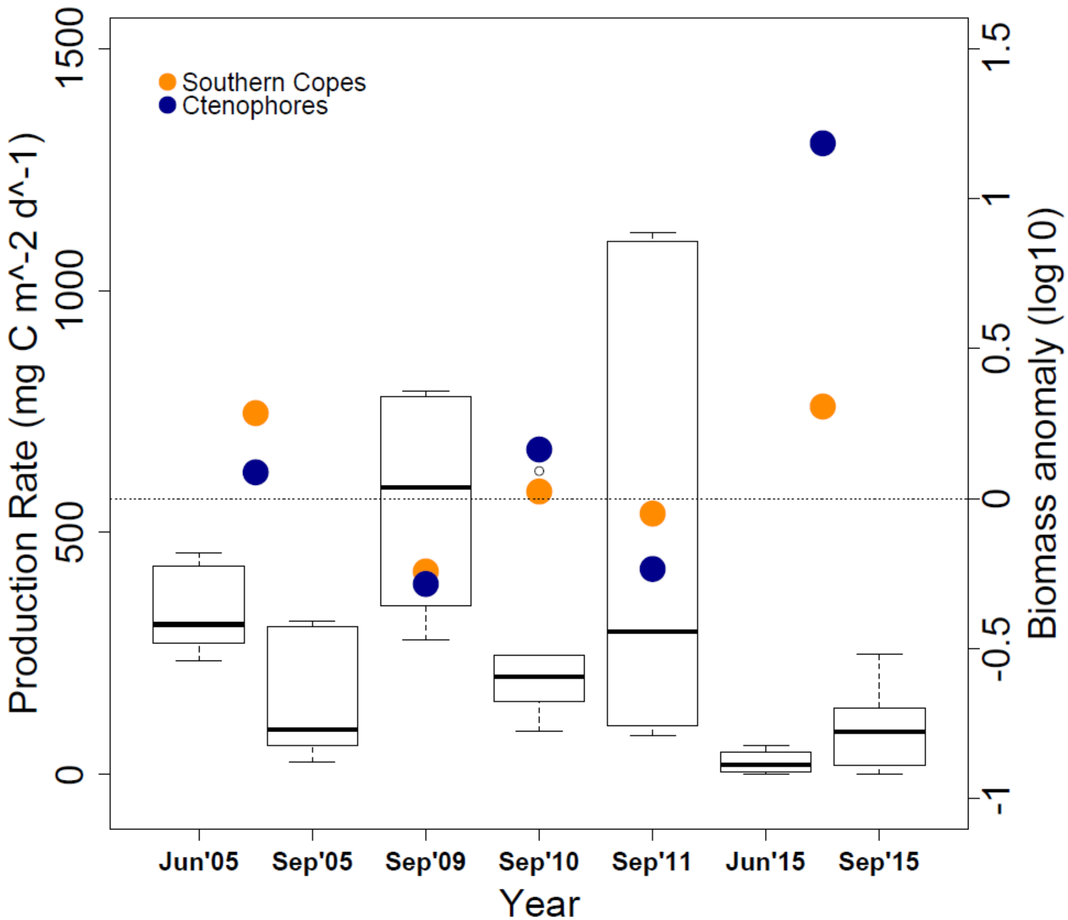
<u>Ctenophore anomaly:</u>

- Very high in 2015
- Positive in 2005 & 2010
- Negative in 2009 & 2011

<u>Doliolid anomaly:</u>

- Very high in 2015
- Positive in 2005 & 2009
- Negative in 2010 & 2011

Patterns of production rates and zooplankton biomass



<u>Rank correlations VS median BPR:</u>

- **Southern** = -1.0, p <0.001*
- **Ctenophores** = -0.9, p <0.05*
- Northern = 0.8, p=0.10
- Doliolids = -0.3, p=0.63

1. Temporal patterns of southern copepod and ctenophore biomass anomaly similar to crustacean zooplankton production rates

Summary

1. Production rate in June 2015 ~0 throughout the WCVI
2. Biomass (and composition) significantly altered
3. Warm conditions during the preceding winter probably to blame
4. Production rates slightly improved in September 2015, yet still very low
5. Poor production rates in ‘warm’ years (2005,2015) covaries with southern copepod and ctenophore biomass anomalies. Poor growth? High predation-based mortality?