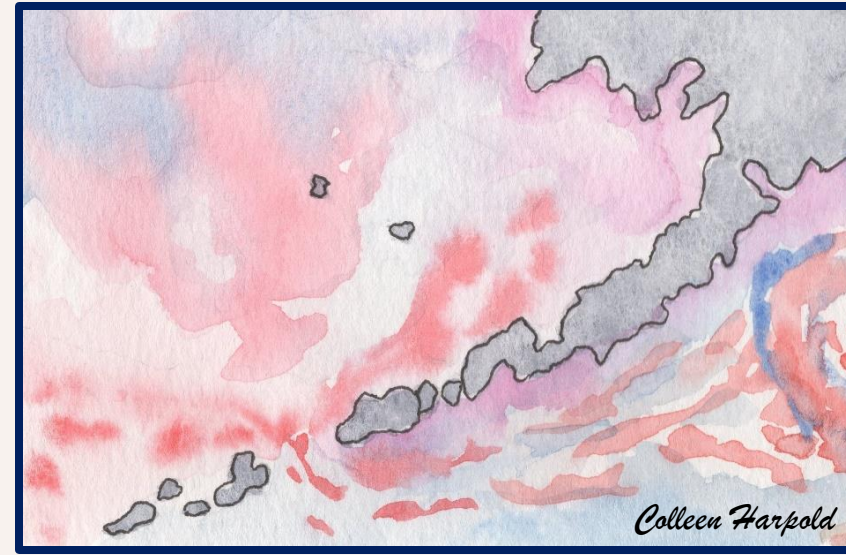


# Zooplankton community and transport dynamics in Bering Canyon and Unimak Pass: Bering Sea, Alaska



Colleen Harpold <sup>1</sup>, David Kimmel <sup>1</sup>  
Carol Ladd <sup>2</sup>, Phyllis Stabeno <sup>2</sup>



**NOAA  
FISHERIES**

<sup>1</sup> National Oceanic Atmospheric Administration: Alaska Fisheries Science Center  
<sup>2</sup> National Oceanic Atmospheric Administration: Pacific Marine Environmental Laboratory



# Bering Canyon Zooplankton

## Research Questions

- What are the species composition differences between zooplankton community assemblages?
- Seasonal patterns? Geographic patterns?
- What could be influencing these patterns?
- Do zooplankton community patterns match flow patterns?



# Why?

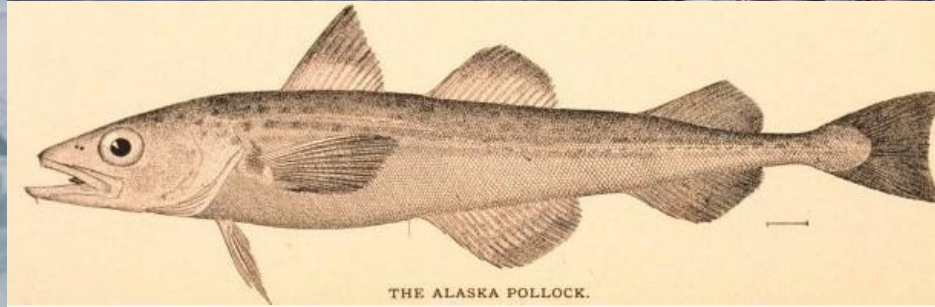
Changing Climate



Marine Mammals

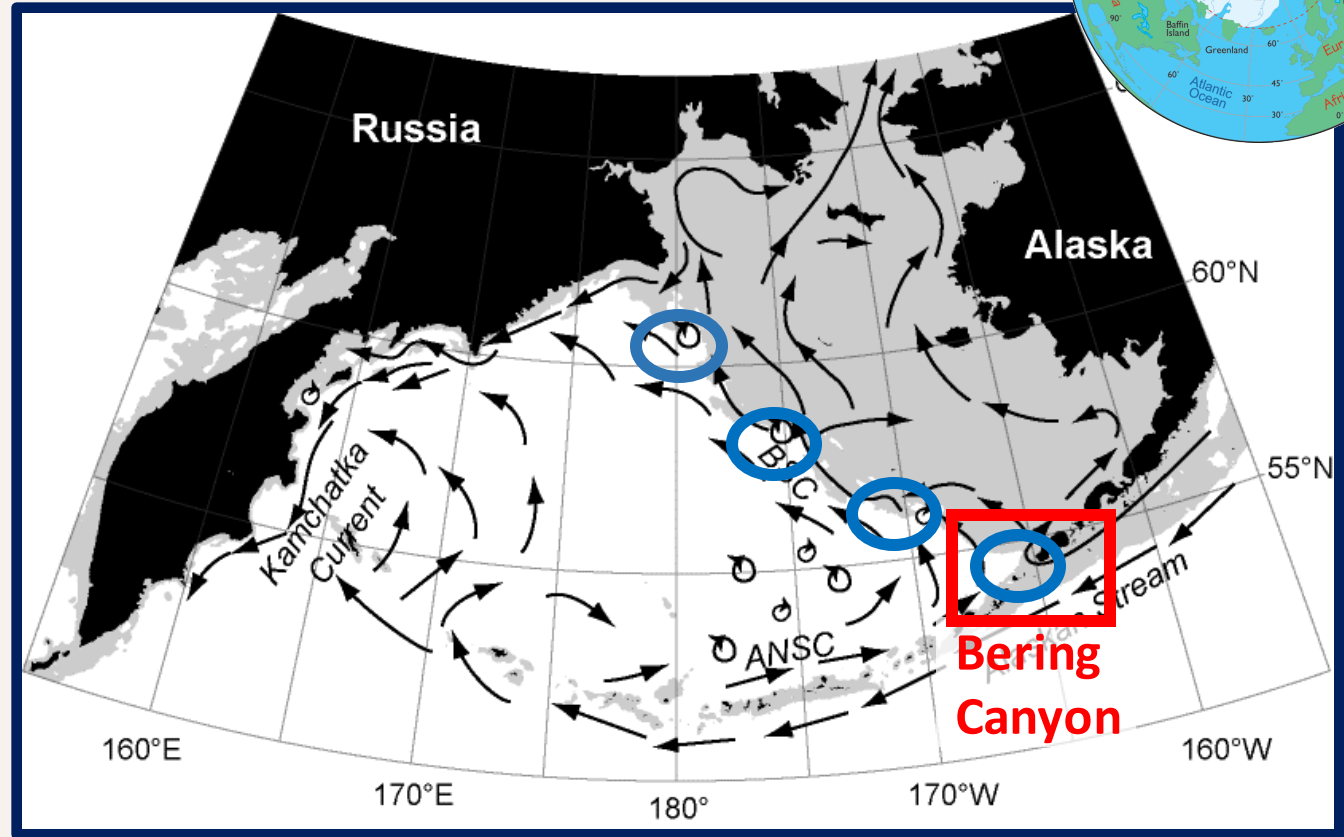


Fisheries



# Bering Sea 101

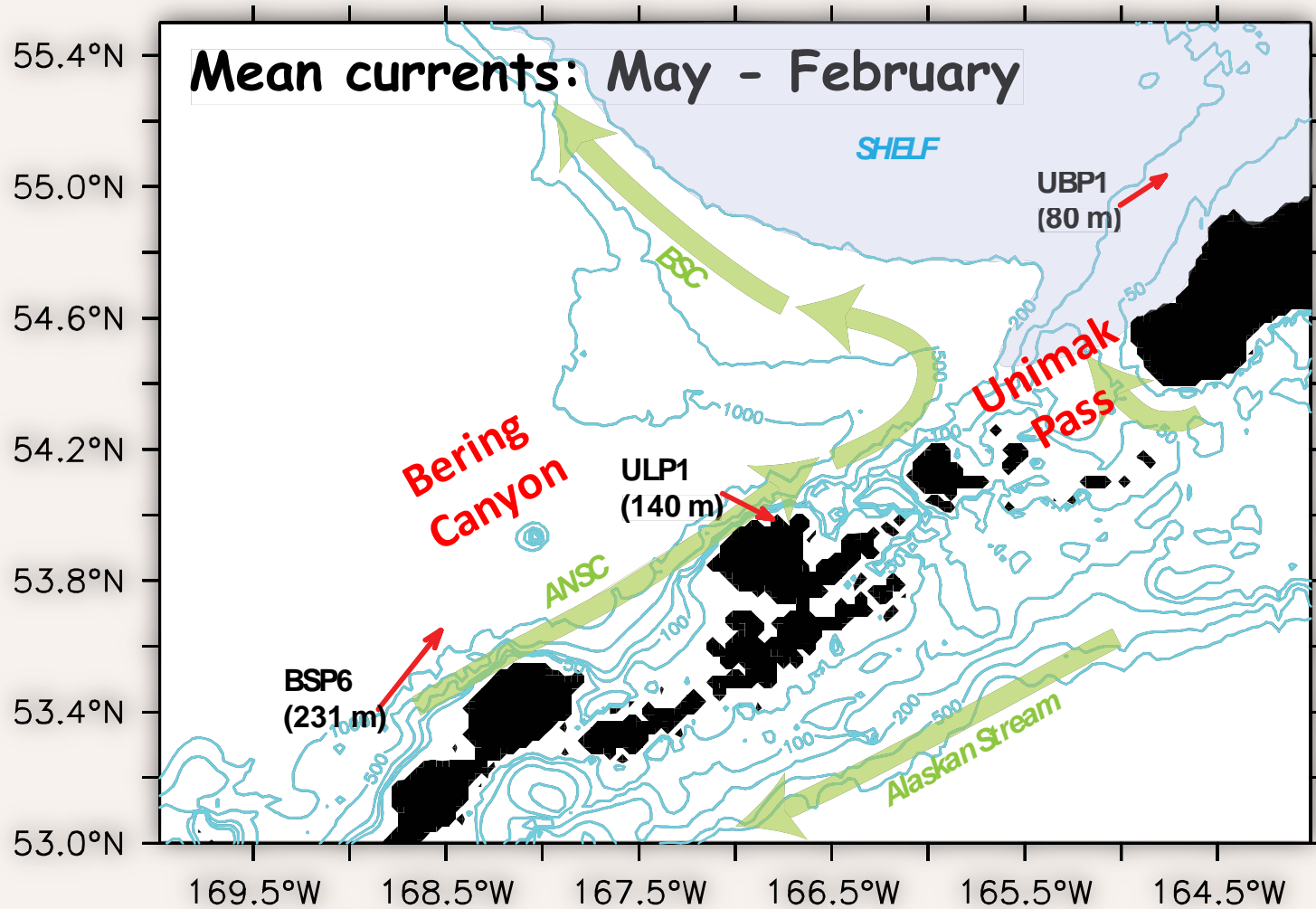
- Conduit between Arctic and Gulf of Alaska
- Wide shelf (gray)
- Canyons: Basin shelf exchange
  - Nutrients
  - open ocean plankton?



Stabeno, P.J., J.D. Schumacher, and K. Ohtani (1999)



# Bering Canyon & Unimak Pass



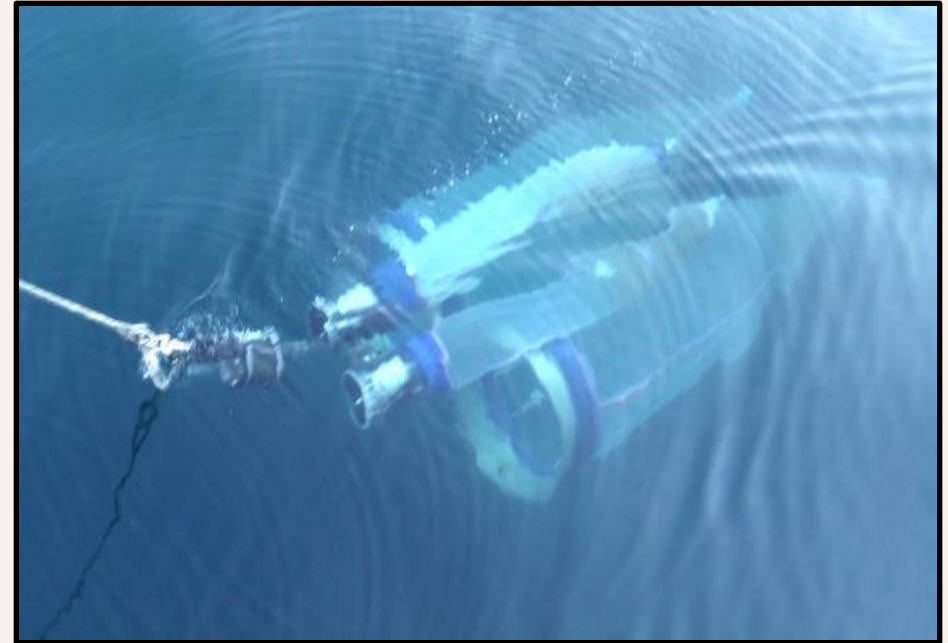
- ANSC: Aleutian North Slope Current
- BSC: Bering Slope Current
- Flow through Unimak Pass



# Methods: Sampling

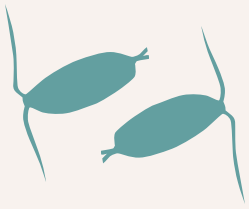


Spring 2014 & 2015, Fall 2014

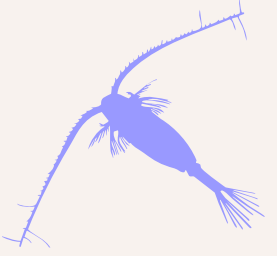


Bongo Array (153 & 505  $\mu\text{m}$  mesh)





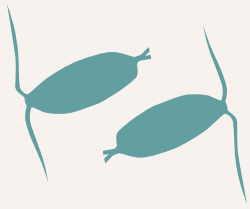
# Zooplankton Community Cluster Analysis



- **PRIMER: 4<sup>th</sup> root transformed abundance data**
- **56 stations and 72 species**
- **Similarity profile routine (Simprof)**
- **Similarity percentage (SIMPER)  
Species differences in clusters  
(% contribution)**

PRIMER-E, Clarke et al., 2014





# Zooplankton Community Patterns



Non-metric MDS

Transform: Fourth root  
Resemblance: S17 Bray-Curtis similarity

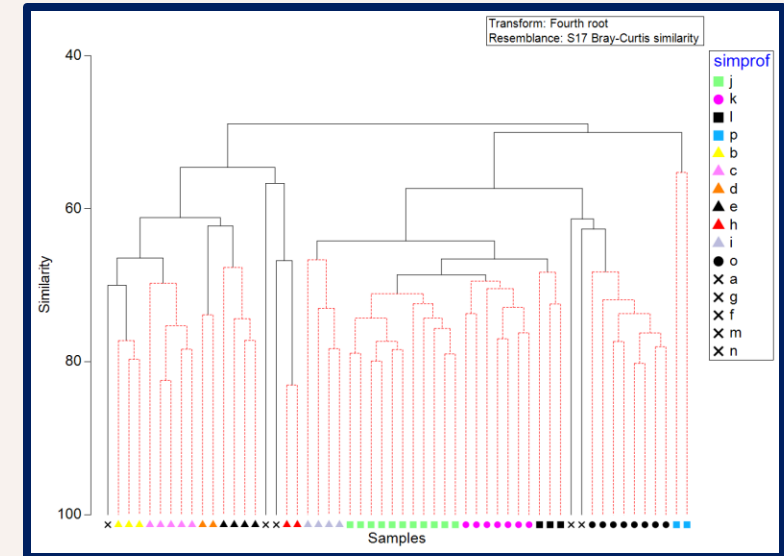
2D Stress: 0.15

Spring

Fall

simprof

- j
- k
- l
- p
- ▲ b
- ▲ c
- ▲ d
- ▲ e
- ▲ h
- ▲ i
- o
- × a
- × g
- × f
- × m
- × n



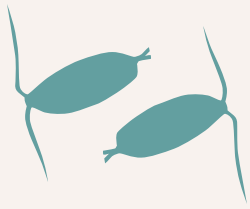
Fall 2014 (5 groups)

Spring 2014 (4 groups)

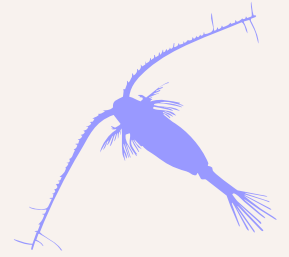
Spring 2015 (2 groups)

5 Outliers





# Zooplankton Community Patterns



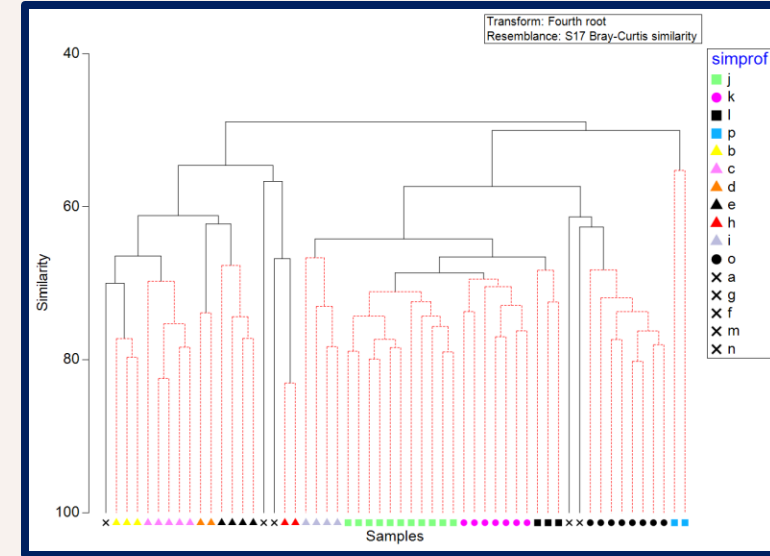
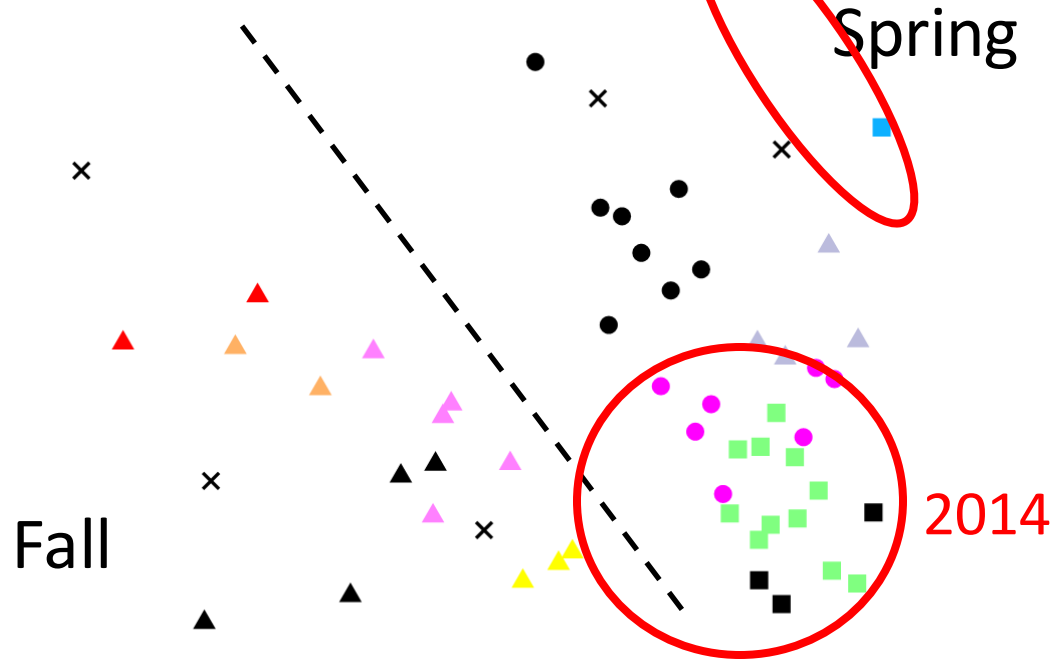
Non-metric MDS

Transform: Fourth root  
Resemblance: S17 Bray-Curtis similarity

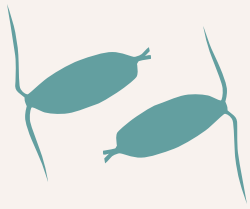
2D Stress: 0.15

simprof

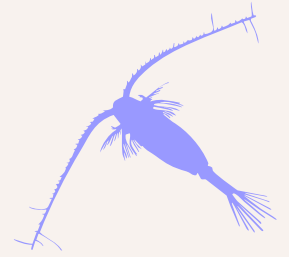
- j
- k
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- p
- ▲ b
- ▲ c
- ▲ d
- ▲ e
- ▲ h
- ▲ i
- o
- × a
- × g
- × f
- × m
- × n



Fall 2014 (5 groups)  
Spring 2014 (4 groups)  
Spring 2015 (2 groups)  
5 Outliers



# Zooplankton Community Patterns



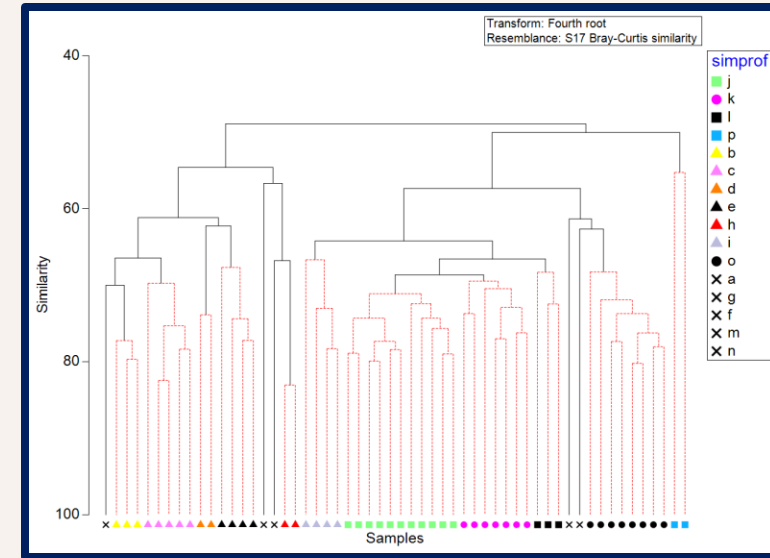
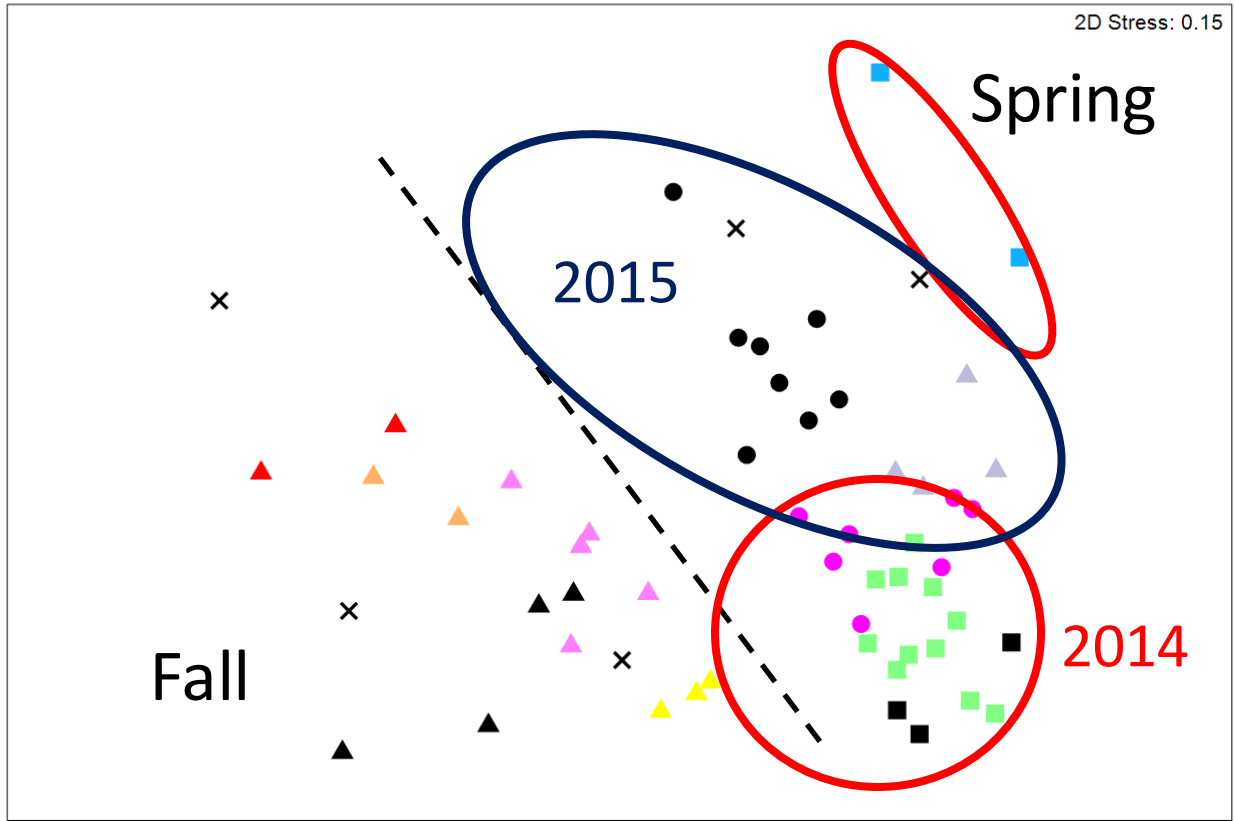
Non-metric MDS

Transform: Fourth root  
Resemblance: S17 Bray-Curtis similarity

2D Stress: 0.15

simprof

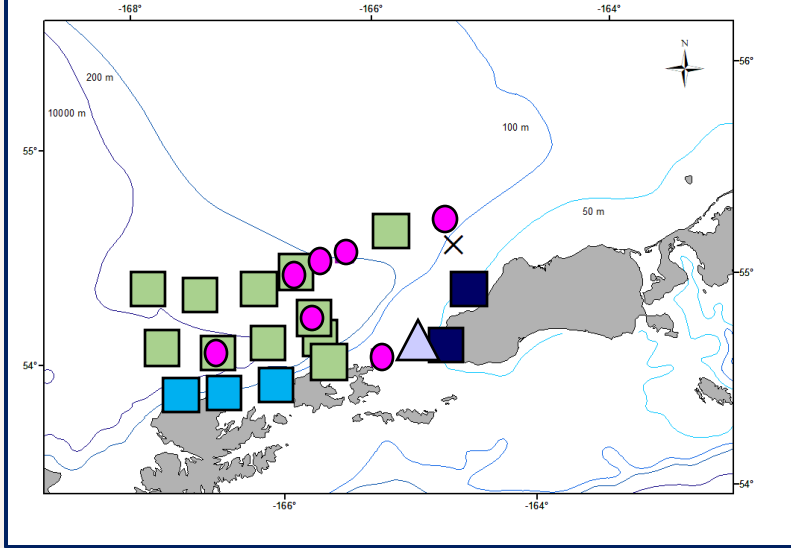
- j
- k
- l
- p
- ▲ b
- ▲ c
- ▲ d
- ▲ e
- ▲ h
- ▲ i
- o
- × a
- × g
- × f
- × m
- × n



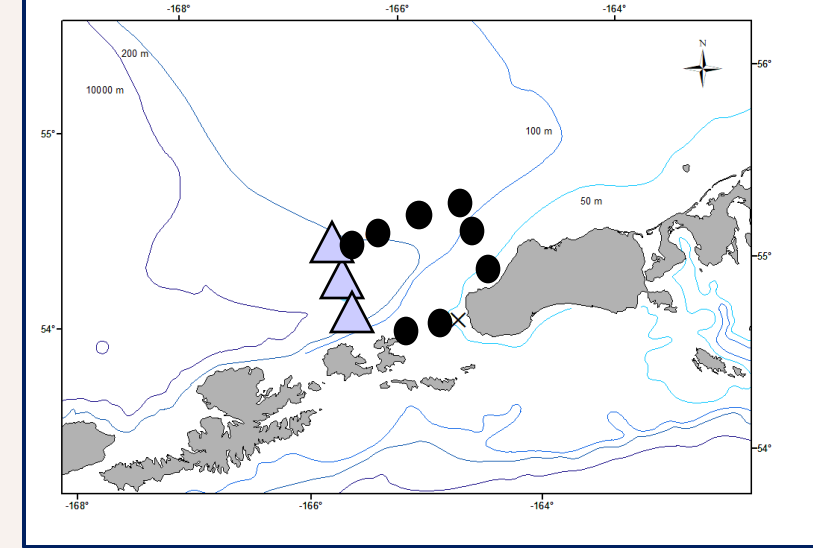
Fall 2014 (5 groups)  
Spring 2014 (4 groups)  
Spring 2015 (2 groups)  
5 Outliers

# Geographic Patterns: Spring

2014



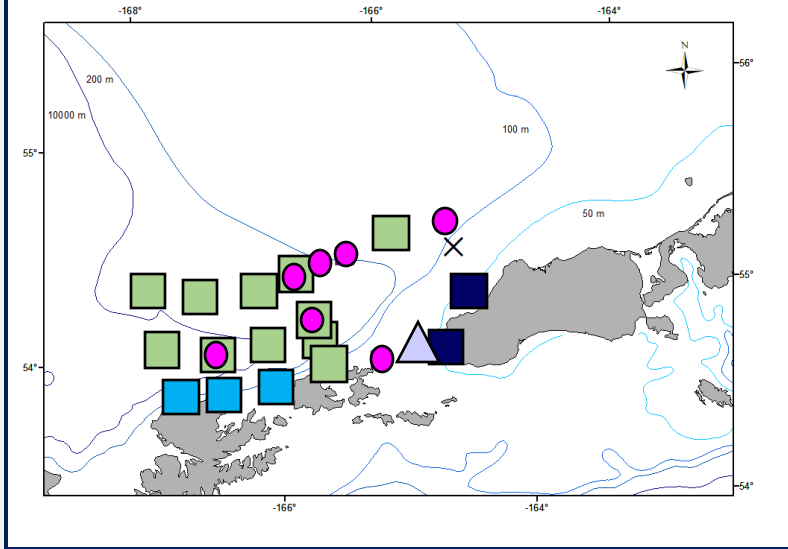
2015



How many stations	11	7	3	2	8	2015:3 2014:1
Symbol on map						
Rank % Contribution	j	k	l	p	o	i
1	<i>Oithona</i> spp.	<i>Oithona</i> spp.	<i>Olthona</i> spp.	<i>Olthona</i> spp.	<i>N. flemingeri</i>	<i>N. flemingeri</i>
2	<i>N. flemingeri</i>	<i>N. flemingeri</i>	<i>N. flemingeri</i>	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	<i>N. cristatus</i>
3	<i>N. plumchrus</i>	<i>Metridia pacifica</i>	<i>Metridia pacifica</i>	<i>N. flemingeri</i>	<i>Olthona</i> spp.	<i>Olthona</i> spp.
4	<i>Metridia pacifica</i>	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	Barnacle larvae	<i>Metridia pacifica</i>	<i>N. plumchrus</i>
5	<i>Microcalanus</i> spp.	<i>N. plumchrus</i>	<i>Triconia</i> spp.	Paguridae	<i>Acartia longipes</i>	<i>Metridia pacifica</i>
6	<i>Triconia</i> spp.	<i>Microcalanus</i> spp.	<i>Microcalanus</i> spp.	<i>Metridia pacifica</i>	<i>Calanus marshallae</i>	<i>Pseudocalanus</i> spp.
7	<i>Pseudocal</i> spp.	<i>N. cristatus</i>	<i>Fritillaria</i> spp.	Echinoderm	<i>N. cristatus</i>	<i>Microcalanus</i> spp.
8	<i>N. cristatus</i>	Echinoderm	<i>Calanus marshallae</i>	<i>Microcalanus</i> spp.	<i>Microcalanus</i> spp.	<i>Eucalanus bungii</i>
9	<i>Euphausiids</i> (young)	<i>Eucalanus bungii</i>	<i>N. plumchrus</i>	<i>Calanus marshallae</i>	<i>N. plumchrus</i>	NF / NP CI-II
10	<i>Eucalanus bungii</i>	NF / NP CI-II	<i>Euphausiids</i> (young)	<i>N. cristatus</i>	NF / NP CI-II	<i>Fritillaria</i> spp.

# Geographic Patterns: Spring

2014



## 3 *Neocalanus* species

*N. flemingeri*

*N. plumchrus*

*N. cristatus*

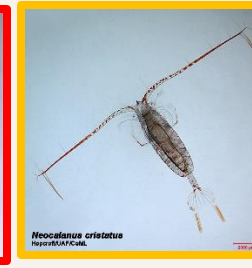
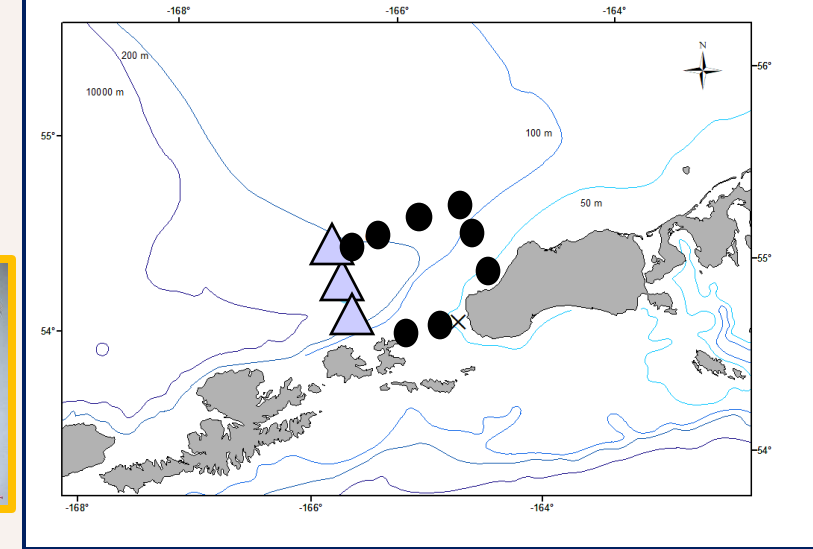


photo credit: Russ Hopcroft

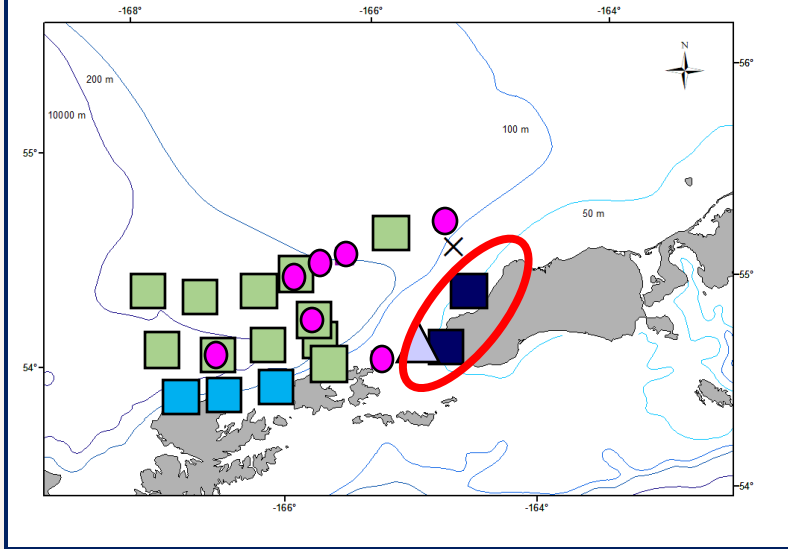
2015



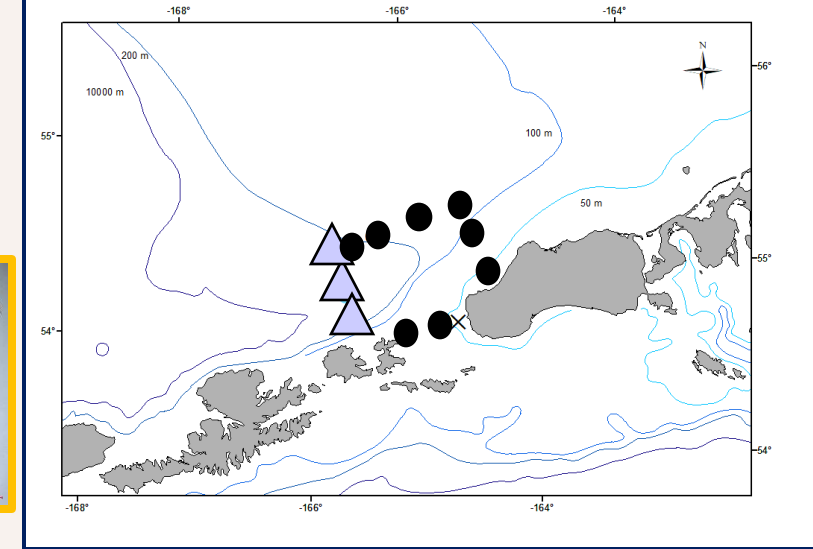
How many stations	11	7	3	2	8	2015:3 2014:1
Symbol on map						
Rank % Contribution	j	k	l	p	o	i
1	<i>Oithona</i> spp.	<i>Oithona</i> spp.	<i>Olthona</i> spp.	<i>Olthona</i> spp.	<i>N. flemingeri</i>	<i>N. flemingeri</i>
2	<i>N. flemingeri</i>	<i>N. flemingeri</i>	<i>N. flemingeri</i>	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	<i>N. cristatus</i>
3	<i>N. plumchrus</i>	<i>Metridia pacifica</i>	<i>Metridia pacifica</i>	<i>N. flemingeri</i>	<i>Olthona</i> spp.	<i>Olthona</i> spp.
4	<i>Metridia pacifica</i>	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	Barnacle larvae	<i>Metridia pacifica</i>	<i>N. plumchrus</i>
5	<i>Microcalanus</i> spp.	<i>N. plumchrus</i>	<i>Triconia</i> spp.	Paguridae	<i>Acartia longipes</i>	<i>Metridia pacifica</i>
6	<i>Triconia</i> spp.	<i>Microcalanus</i> spp.	<i>Microcalanus</i> spp.	<i>Metridia pacifica</i>	<i>Calanus marshallae</i>	<i>Pseudocalanus</i> spp.
7	<i>Pseudocal</i> spp.	<i>N. cristatus</i>	<i>Fritillaria</i> spp.	Echinoderm	<i>N. cristatus</i>	<i>Microcalanus</i> spp.
8	<i>N. cristatus</i>	Echinoderm	<i>Calanus marshallae</i>	<i>Microcalanus</i> spp.	<i>Microcalanus</i> spp.	<i>Eucalanus bungii</i>
9	<i>Euphausiids</i> (young)	<i>Eucalanus bungii</i>	<i>N. plumchrus</i>	<i>Calanus marshallae</i>	<i>N. plumchrus</i>	NF / NP CI-II
10	<i>Eucalanus bungii</i>	NF / NP CI-II	<i>Euphausiids</i> (young)	<i>N. cristatus</i>	NF / NP CI-II	<i>Fritillaria</i> spp.

# Geographic Patterns: Spring

2014



2015



## 3 *Neocalanus* species

*N. flemingeri*

*N. plumchrus*

*N. cristatus*

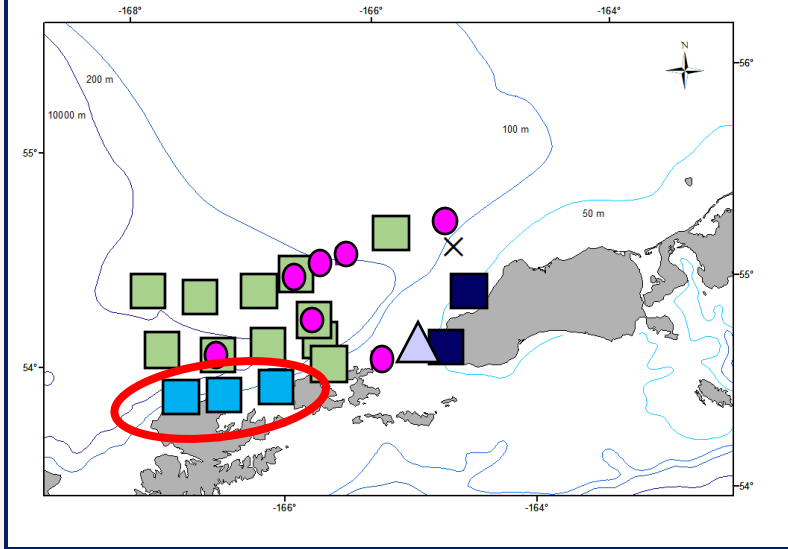


photo credit: Russ Hopcroft

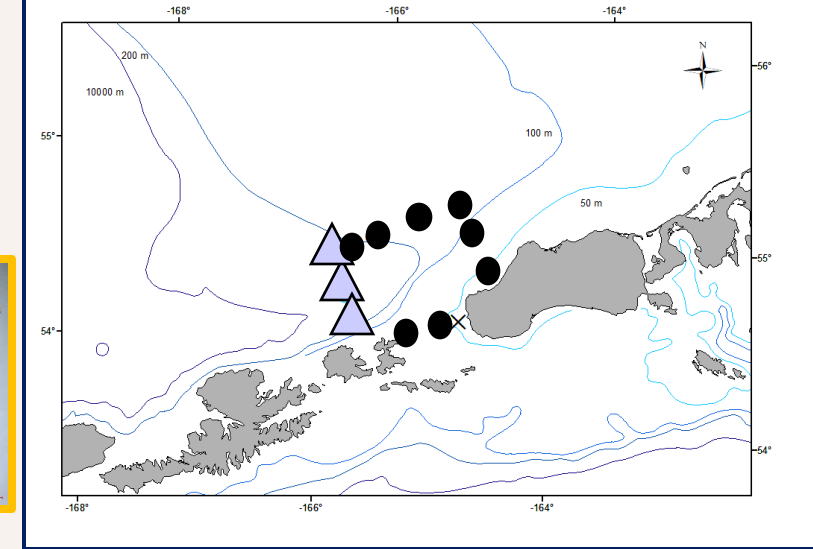
How many stations	11	7	3	2	8	2015:3 2014:1
Symbol on map						
Rank % Contribution	j	k	l	p	o	i
1	<i>Oithona</i> spp.	<i>Oithona</i> spp.	<i>Olthona</i> spp.	<i>Olthona</i> spp.	<i>N. flemingeri</i>	<i>N. flemingeri</i>
2	<i>N. flemingeri</i>	<i>N. flemingeri</i>	<i>N. flemingeri</i>	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	<i>N. cristatus</i>
3	<i>N. plumchrus</i>	<i>Metridia pacifica</i>	<i>Metridia pacifica</i>	<i>N. flemingeri</i>	<i>Olthona</i> spp.	<i>Olthona</i> spp.
4	<i>Metridia pacifica</i>	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	Barnacle larvae	<i>Metridia pacifica</i>	<i>N. plumchrus</i>
5	<i>Microcalanus</i> spp.	<i>N. plumchrus</i>	<i>Triconia</i> spp.	Paguridae	<i>Acartia longipes</i>	<i>Metridia pacifica</i>
6	<i>Triconia</i> spp.	<i>Microcalanus</i> spp.	<i>Microcalanus</i> spp.	<i>Metridia pacifica</i>	<i>Calanus marshallae</i>	<i>Pseudocalanus</i> spp.
7	<i>Pseudocal</i> spp.	<i>N. cristatus</i>	<i>Fritillaria</i> spp.	Echinoderm	<i>N. cristatus</i>	<i>Microcalanus</i> spp.
8	<i>N. cristatus</i>	Echinoderm	<i>Calanus marshallae</i>	<i>Microcalanus</i> spp.	<i>Microcalanus</i> spp.	<i>Eucalanus bungii</i>
9	<i>Euphausiids</i> (young)	<i>Eucalanus bungii</i>	<i>N. plumchrus</i>	<i>Calanus marshallae</i>	<i>N. plumchrus</i>	NF / NP CI-II
10	<i>Eucalanus bungii</i>	NF / NP CI-II	<i>Euphausiids</i> (young)	<i>N. cristatus</i>	NF / NP CI-II	<i>Fritillaria</i> spp.

# Geographic Patterns: Spring

2014



2015



## 3 *Neocalanus* species

*N. flemingeri*

*N. plumchrus*

*N. cristatus*

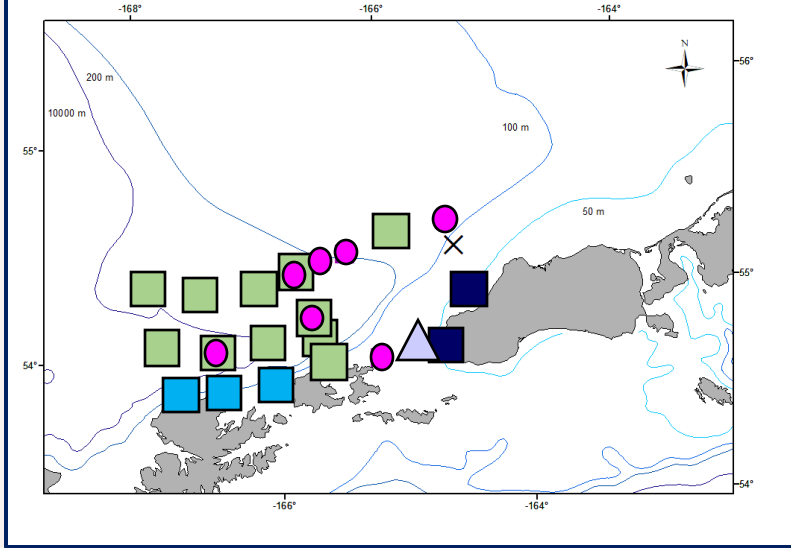


photo credit: Russ Hopcroft

How many stations	11	7	3	2	8	2015:3 2014:1
Symbol on map						
Rank % Contribution	j	k	l	p	o	i
1	<i>Oithona</i> spp.	<i>Oithona</i> spp.	<i>Olthona</i> spp.	<i>Olthona</i> spp.	<i>N. flemingeri</i>	<i>N. flemingeri</i>
2	<i>N. flemingeri</i>	<i>N. flemingeri</i>	<i>N. flemingeri</i>	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	<i>N. cristatus</i>
3	<i>N. plumchrus</i>	<i>Metridia pacifica</i>	<i>Metridia pacifica</i>	<i>N. flemingeri</i>	<i>Olthona</i> spp.	<i>Olthona</i> spp.
4	<i>Metridia pacifica</i>	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	Barnacle larvae	<i>Metridia pacifica</i>	<i>N. plumchrus</i>
5	<i>Microcalanus</i> spp.	<i>N. plumchrus</i>	<i>Triconia</i> spp.	Paguridae	<i>Acartia longipes</i>	<i>Metridia pacifica</i>
6	<i>Triconia</i> spp.	<i>Microcalanus</i> spp.	<i>Microcalanus</i> spp.	<i>Metridia pacifica</i>	<i>Calanus marshallae</i>	<i>Pseudocalanus</i> spp.
7	<i>Pseudocal</i> spp.	<i>N. cristatus</i>	<i>Fritillaria</i> spp.	Echinoderm	<i>N. cristatus</i>	<i>Microcalanus</i> spp.
8	<i>N. cristatus</i>	Echinoderm	<i>Calanus marshallae</i>	<i>Microcalanus</i> spp.	<i>Microcalanus</i> spp.	<i>Eucalanus bungii</i>
9	<i>Euphausiids</i> (young)	<i>Eucalanus bungii</i>	<i>N. plumchrus</i>	<i>Calanus marshallae</i>	<i>N. plumchrus</i>	NF / NP CI-II
10	<i>Eucalanus bungii</i>	NF / NP CI-II	<i>Euphausiids</i> (young)	<i>N. cristatus</i>	NF / NP CI-II	<i>Fritillaria</i> spp.

# Geographic Patterns: Spring

2014



*Calanus marshallae*

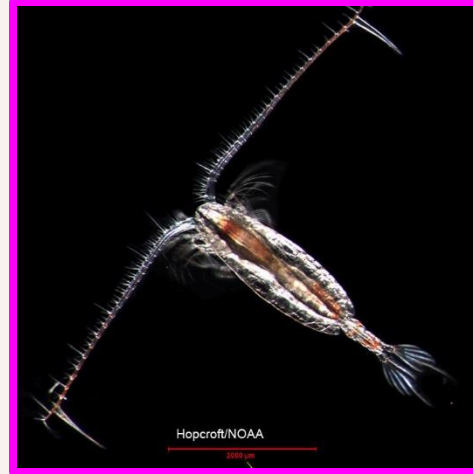
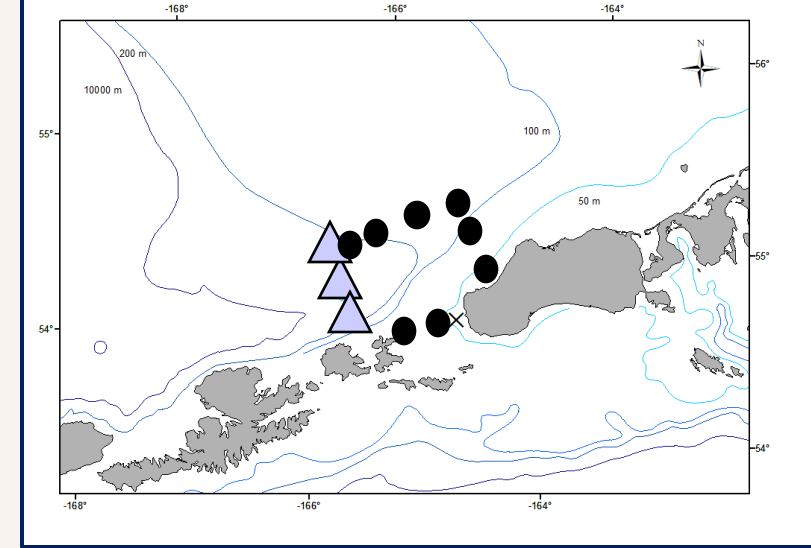


photo credit: Russ Hopcroft

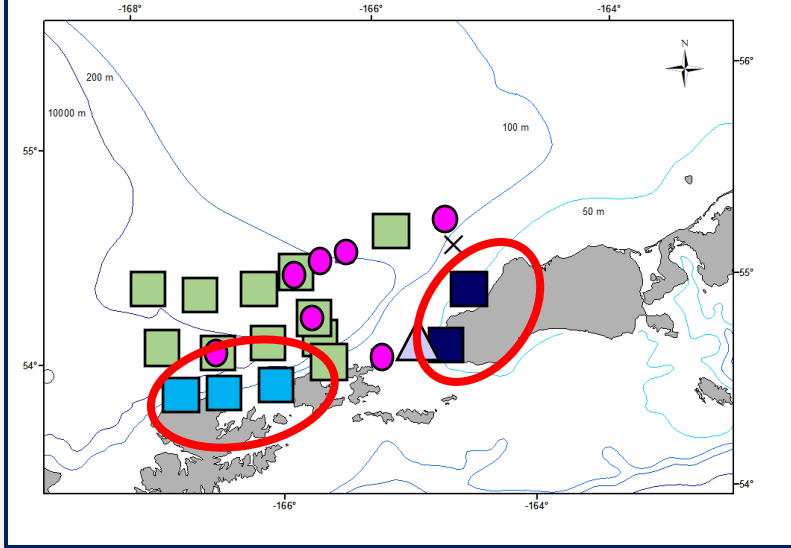
2015



How many stations	11	7	3	2	8	2015:3 2014:1
Symbol on map						
Rank % Contribution	j	k	l	p	o	i
1	<i>Oithona</i> spp.	<i>Oithona</i> spp.	<i>Olthona</i> spp.	<i>Olthona</i> spp.	<i>N. flemingeri</i>	<i>N. flemingeri</i>
2	<i>N. flemingeri</i>	<i>N. flemingeri</i>	<i>N. flemingeri</i>	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	<i>N. cristatus</i>
3	<i>N. plumchrus</i>	<i>Metridia pacifica</i>	<i>Metridia pacifica</i>	<i>N. flemingeri</i>	<i>Olthona</i> spp.	<i>Olthona</i> spp.
4	<i>Metridia pacifica</i>	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	Barnacle larvae	<i>Metridia pacifica</i>	<i>N. plumchrus</i>
5	<i>Microcalanus</i> spp.	<i>N. plumchrus</i>	<i>Triconia</i> spp.	Paguridae	<i>Acartia longipes</i>	<i>Metridia pacifica</i>
6	<i>Triconia</i> spp.	<i>Microcalanus</i> spp.	<i>Microcalanus</i> spp.	<i>Metridia pacifica</i>	<b><i>Calanus marshallae</i></b>	<i>Pseudocalanus</i> spp.
7	<i>Pseudocal</i> spp.	<i>N. cristatus</i>	<i>Fritillaria</i> spp.	Echinoderm	<i>N. cristatus</i>	<i>Microcalanus</i> spp.
8	<i>N. cristatus</i>	Echinoderm	<b><i>Calanus marshallae</i></b>	<i>Microcalanus</i> spp.	<i>Microcalanus</i> spp.	<i>Eucalanus bungii</i>
9	<i>Euphausiids</i> (young)	<i>Eucalanus bungii</i>	<i>N. plumchrus</i>	<b><i>Calanus marshallae</i></b>	<i>N. plumchrus</i>	NF / NP CI-II
10	<i>Eucalanus bungii</i>	NF / NP CI-II	<i>Euphausiids</i> (young)	<i>N. cristatus</i>	NF / NP CI-II	<i>Fritillaria</i> spp.

# Geographic Patterns: Spring

2014



*Calanus marshallae*

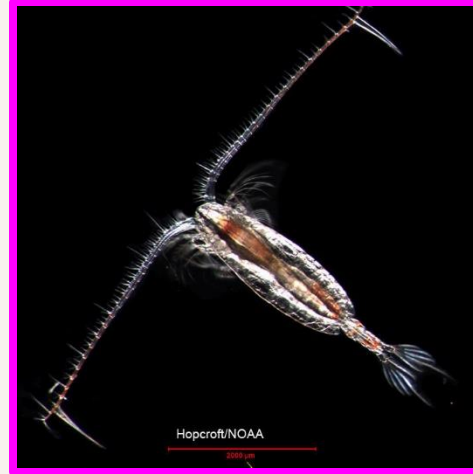
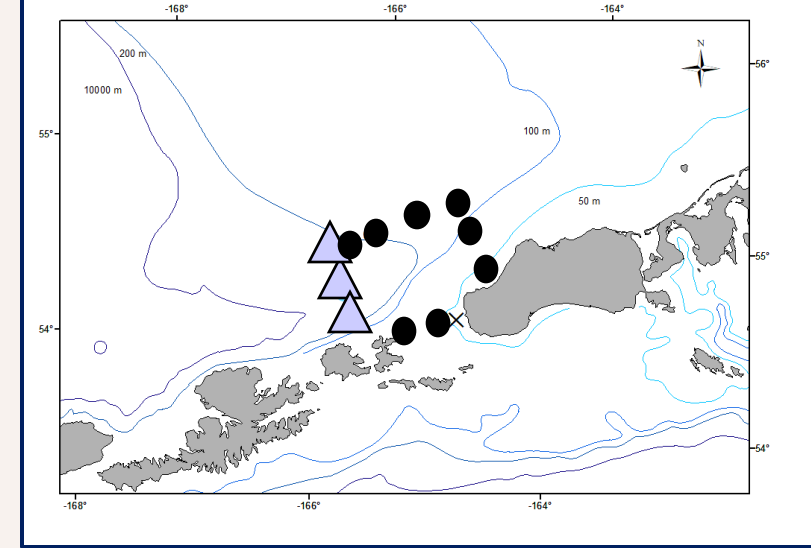


photo credit: Russ Hopcroft

2015

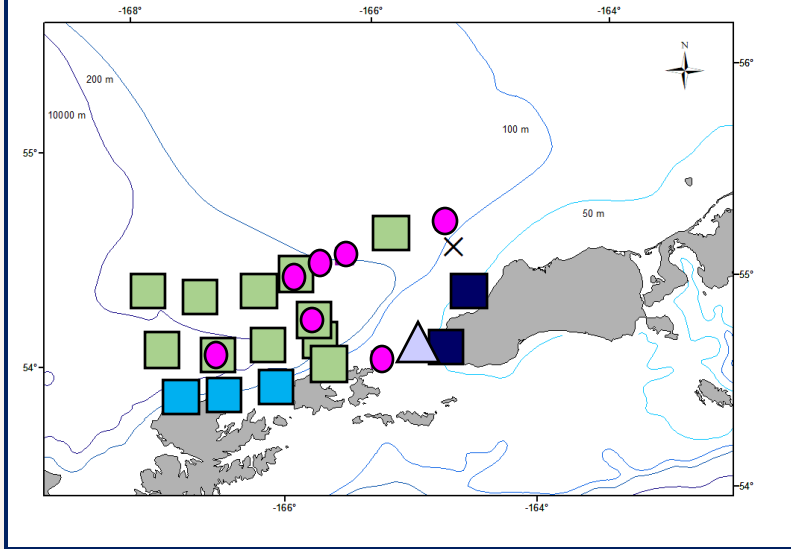


How many stations	11	7	3	2	8	2015:3 2014:1
Symbol on map						
Rank % Contribution	j	k	l	p	o	i
1	<i>Oithona</i> spp.	<i>Oithona</i> spp.	<i>Olthona</i> spp.	<i>Olthona</i> spp.	<i>N. flemingeri</i>	<i>N. flemingeri</i>
2	<i>N. flemingeri</i>	<i>N. flemingeri</i>	<i>N. flemingeri</i>	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	<i>N. cristatus</i>
3	<i>N. plumchrus</i>	<i>Metridia pacifica</i>	<i>Metridia pacifica</i>	<i>N. flemingeri</i>	<i>Olthona</i> spp.	<i>Olthona</i> spp.
4	<i>Metridia pacifica</i>	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	Barnacle larvae	<i>Metridia pacifica</i>	<i>N. plumchrus</i>
5	<i>Microcalanus</i> spp.	<i>N. plumchrus</i>	<i>Triconia</i> spp.	Paguridae	<i>Acartia longipes</i>	<i>Metridia pacifica</i>
6	<i>Triconia</i> spp.	<i>Microcalanus</i> spp.	<i>Microcalanus</i> spp.	<i>Metridia pacifica</i>	<b><i>Calanus marshallae</i></b>	<i>Pseudocalanus</i> spp.
7	<i>Pseudocal</i> spp.	<i>N. cristatus</i>	<i>Fritillaria</i> spp.	Echinoderm	<i>N. cristatus</i>	<i>Microcalanus</i> spp.
8	<i>N. cristatus</i>	Echinoderm	<b><i>Calanus marshallae</i></b>	<i>Microcalanus</i> spp.	<i>Microcalanus</i> spp.	<i>Eucalanus bungii</i>
9	<i>Euphausiids</i> (young)	<i>Eucalanus bungii</i>	<i>N. plumchrus</i>	<b><i>Calanus marshallae</i></b>	<i>N. plumchrus</i>	NF / NP CI-II
10	<i>Eucalanus bungii</i>	NF / NP CI-II	<i>Euphausiids</i> (young)	<i>N. cristatus</i>	NF / NP CI-II	<i>Fritillaria</i> spp.



# Geographic Patterns: Spring

2014



*Calanus marshallae*

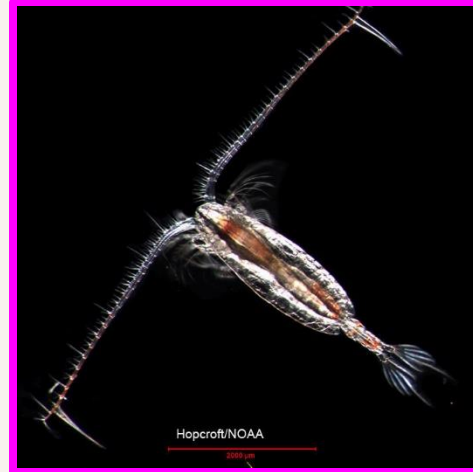
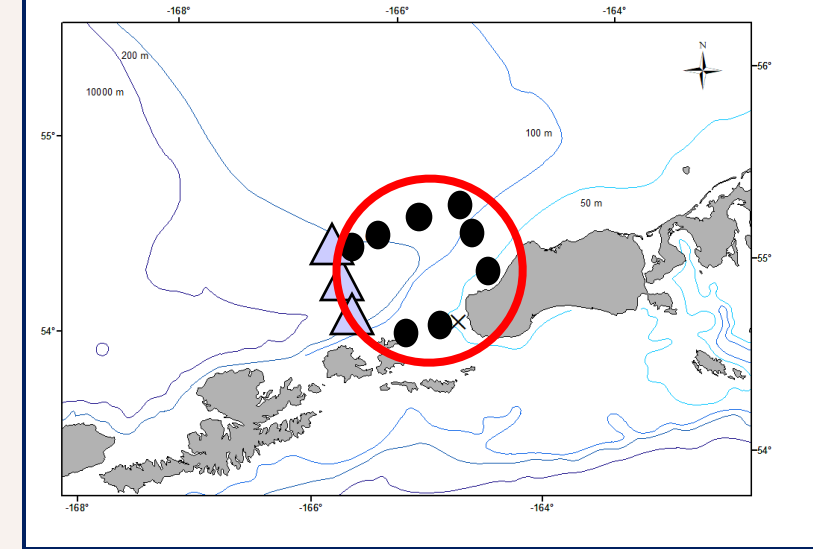


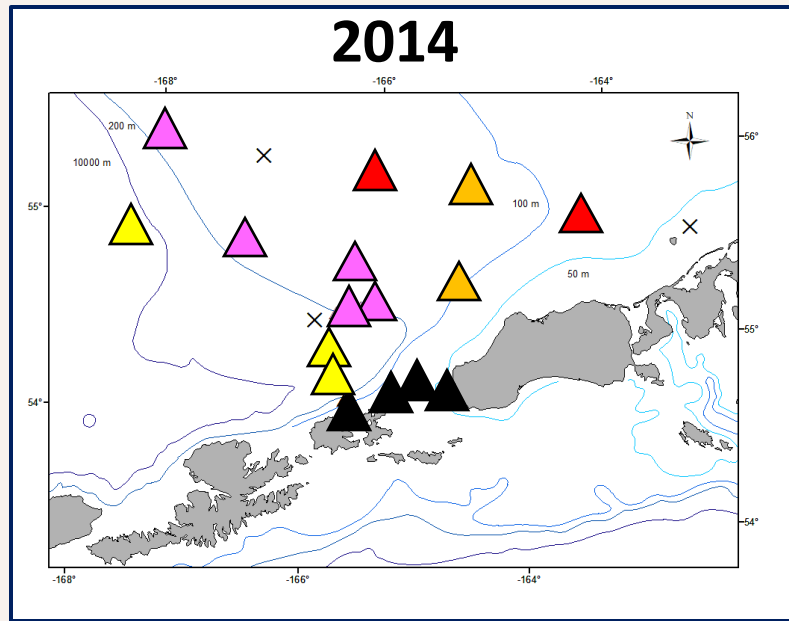
photo credit: Russ Hopcroft

2015



How many stations	11	7	3	2	8	2015:3	2014:1
Symbol on map							
Rank % Contribution	j	k	l	p	o	i	
1	<i>Oithona</i> spp.	<i>Oithona</i> spp.	<i>Olthona</i> spp.	<i>Olthona</i> spp.	<i>N. flemingeri</i>	<i>N. flemingeri</i>	
2	<i>N. flemingeri</i>	<i>N. flemingeri</i>	<i>N. flemingeri</i>	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	<i>N. cristatus</i>	
3	<i>N. plumchrus</i>	<i>Metridia pacifica</i>	<i>Metridia pacifica</i>	<i>N. flemingeri</i>	<i>Olthona</i> spp.	<i>Olthona</i> spp.	
4	<i>Metridia pacifica</i>	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	Barnacle larvae	<i>Metridia pacifica</i>	<i>N. plumchrus</i>	
5	<i>Microcalanus</i> spp.	<i>N. plumchrus</i>	<i>Triconia</i> spp.	Paguridae	<i>Acartia longipes</i>	<i>Metridia pacifica</i>	
6	<i>Triconia</i> spp.	<i>Microcalanus</i> spp.	<i>Microcalanus</i> spp.	<i>Metridia pacifica</i>	<b><i>Calanus marshallae</i></b>	<i>Pseudocalanus</i> spp.	
7	<i>Pseudocal</i> spp.	<i>N. cristatus</i>	<i>Fritillaria</i> spp.	Echinoderm	<i>N. cristatus</i>	<i>Microcalanus</i> spp.	
8	<i>N. cristatus</i>	Echinoderm	<b><i>Calanus marshallae</i></b>	<i>Microcalanus</i> spp.	<i>Microcalanus</i> spp.	<i>Eucalanus bungii</i>	
9	<i>Euphausiids</i> (young)	<i>Eucalanus bungii</i>	<i>N. plumchrus</i>	<b><i>Calanus marshallae</i></b>	<i>N. plumchrus</i>	NF / NP CI-II	
10	<i>Eucalanus bungii</i>	NF / NP CI-II	<i>Euphausiids</i> (young)	<i>N. cristatus</i>	NF / NP CI-II	<i>Fritillaria</i> spp.	

# Geographic Patterns: Fall



How many stations	3	3	2	4	2
Symbol on map					
Rank % Contribution	b	c	d	e	h
1	<i>Oithona</i> spp.	<i>Oithona</i> spp.	<i>Oithona</i> spp.	<i>Pseudocalanus</i> spp.	<i>Oithona</i> spp.
2	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	<i>Oithona</i> spp.	<i>Limacina helicina</i>
3	<i>Microcalanus</i> spp.	<i>Microcalanus</i> spp.	<i>Limacina helicina</i>	<i>Calanus marshallae</i>	<i>Calanus marshallae</i>
4	<i>Metridia pacifica</i>	<i>Metridia pacifica</i>	<i>Calanus marshallae</i>	<i>Oikopleura</i> spp.	<i>Pseudocalanus</i> spp.
5	<i>Limacina helicina</i>	<i>Calanus marshallae</i>	<i>Acartia longiremis</i>	<i>Limacina helicina</i>	Bivalve larvae
6	<i>Acartia longiremis</i>	<i>Acartia longiremis</i>	<i>Microcalanus</i> spp.	<i>Acartia longiremis</i>	<i>Acartia longiremis</i>
7	<i>Oncea</i> spp.	<i>N. plumchrus</i>	<i>N. plumchrus</i>	Bivalve larvae	<i>Eucalanus bungii</i>
8	<i>Triconia</i> spp.	<i>Limacina helicina</i>	<i>Centropages</i> spp.	<i>Metridia pacifica</i>	Echinoderm
9	Ostracoda	<i>Themisto pacifica</i>	<i>Metridia pacifica</i>	Echinoderm	<i>Parasagitta elegans</i>
10	<i>Fritillaria</i> spp.	Gastropoda	<i>Eucalanus bungii</i>	Gastropoda	Euphausiids (young)

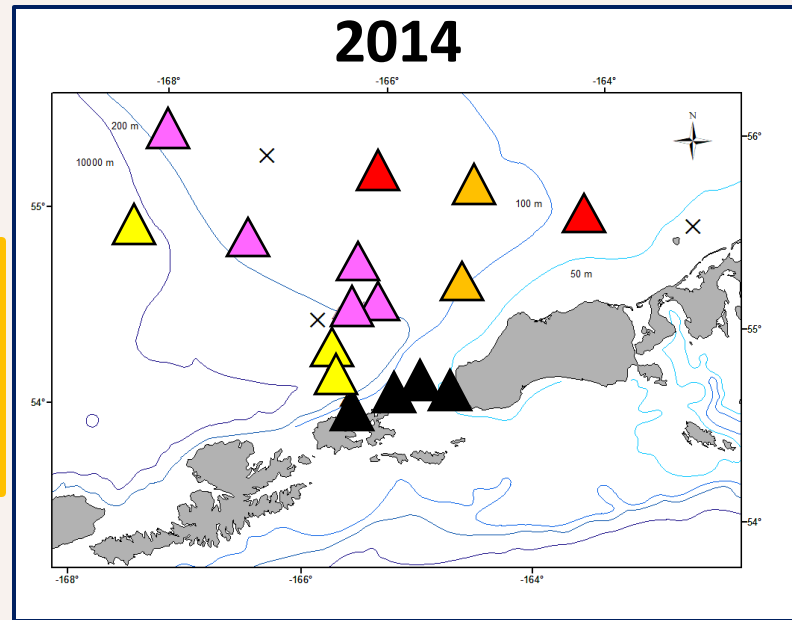
# Geographic Patterns: Fall

## 3 *Neocalanus* species

*N. flemingeri*   *N. plumchrus*   *N. cristatus*



photo credit: Russ Hopcroft



How many stations	3	3	2	4	2
Symbol on map					
Rank % Contribution	b	c	d	e	h
1	<i>Oithona</i> spp.	<i>Oithona</i> spp.	<i>Oithona</i> spp.	<i>Pseudocalanus</i> spp.	<i>Oithona</i> spp.
2	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	<i>Oithona</i> spp.	<i>Limacina helicina</i>
3	<i>Microcalanus</i> spp.	<i>Microcalanus</i> spp.	<i>Limacina helicina</i>	<i>Calanus marshallae</i>	<i>Calanus marshallae</i>
4	<i>Metridia pacifica</i>	<i>Metridia pacifica</i>	<i>Calanus marshallae</i>	<i>Oikopleura</i> spp.	<i>Pseudocalanus</i> spp.
5	<i>Limacina helicina</i>	<i>Calanus marshallae</i>	<i>Acartia longiremis</i>	<i>Limacina helicina</i>	Bivalve larvae
6	<i>Acartia longiremis</i>	<i>Acartia longiremis</i>	<i>Microcalanus</i> spp.	<i>Acartia longiremis</i>	<i>Acartia longiremis</i>
7	<i>Oncea</i> spp.	<b><i>N. plumchrus</i></b>	<b><i>N. plumchrus</i></b>	Bivalve larvae	<i>Eucalanus bungii</i>
8	<i>Triconia</i> spp.	<i>Limacina helicina</i>	<i>Centropages</i> spp.	<i>Metridia pacifica</i>	Echinoderm
9	Ostracoda	<i>Themisto pacifica</i>	<i>Metridia pacifica</i>	Echinoderm	<i>Parasagitta elegans</i>
10	<i>Fritillaria</i> spp.	Gastropoda	<i>Eucalanus bungii</i>	Gastropoda	Euphausiids (young)

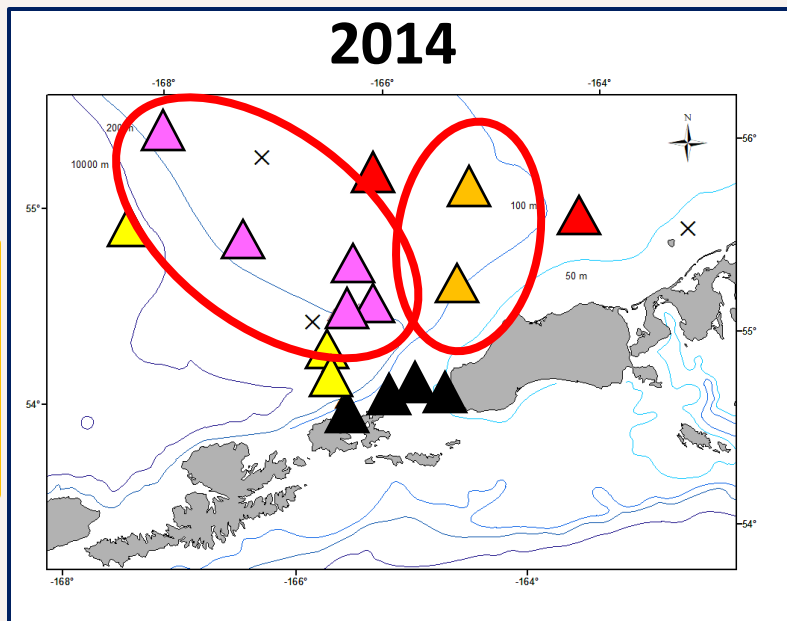
# Geographic Patterns: Fall

## 3 *Neocalanus* species

*N. flemingeri*   *N. plumchrus*   *N. cristatus*



photo credit: Russ Hopcroft



How many stations	3	3	2	4	2
Symbol on map					
Rank % Contribution	b	c	d	e	h
1	<i>Oithona</i> spp.	<i>Oithona</i> spp.	<i>Oithona</i> spp.	<i>Pseudocalanus</i> spp.	<i>Oithona</i> spp.
2	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	<i>Oithona</i> spp.	<i>Limacina helicina</i>
3	<i>Microcalanus</i> spp.	<i>Microcalanus</i> spp.	<i>Limacina helicina</i>	<i>Calanus marshallae</i>	<i>Calanus marshallae</i>
4	<i>Metridia pacifica</i>	<i>Metridia pacifica</i>	<i>Calanus marshallae</i>	<i>Oikopleura</i> spp.	<i>Pseudocalanus</i> spp.
5	<i>Limacina helicina</i>	<i>Calanus marshallae</i>	<i>Acartia longiremis</i>	<i>Limacina helicina</i>	Bivalve larvae
6	<i>Acartia longiremis</i>	<i>Acartia longiremis</i>	<i>Microcalanus</i> spp.	<i>Acartia longiremis</i>	<i>Acartia longiremis</i>
7	<i>Oncea</i> spp.	<b><i>N. plumchrus</i></b>	<b><i>N. plumchrus</i></b>	Bivalve larvae	<i>Eucalanus bungii</i>
8	<i>Triconia</i> spp.	<i>Limacina helicina</i>	<i>Centropages</i> spp.	<i>Metridia pacifica</i>	Echinoderm
9	Ostracoda	<i>Themisto pacifica</i>	<i>Metridia pacifica</i>	Echinoderm	<i>Parasagitta elegans</i>
10	<i>Fritillaria</i> spp.	Gastropoda	<i>Eucalanus bungii</i>	Gastropoda	Euphausiids (young)

# Geographic Patterns: Fall

## *Calanus marshallae*

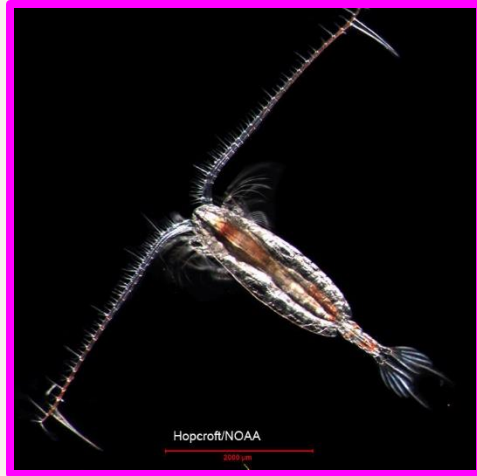
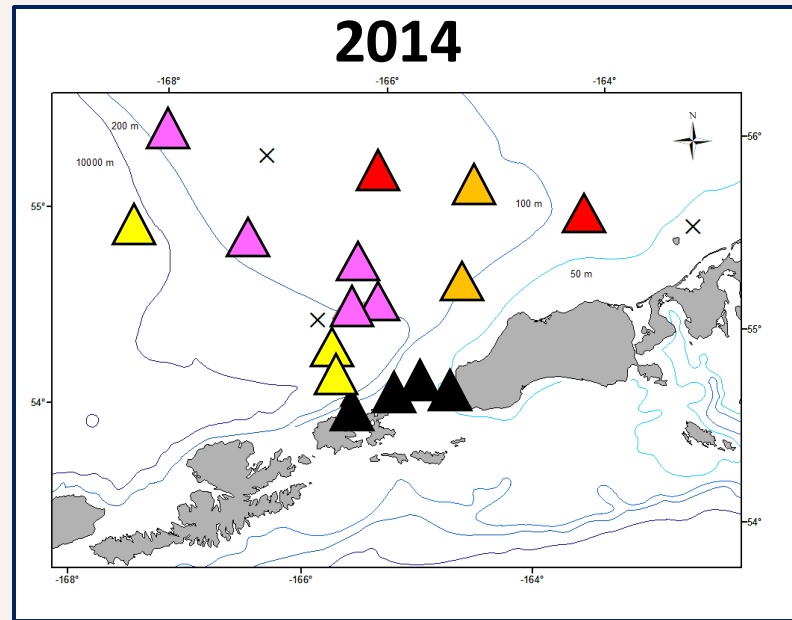


photo credit: Russ Hopcroft



How many stations	3	3	2	4	2
Symbol on map					
Rank % Contribution	b	c	d	e	h
1	<i>Oithona</i> spp.	<i>Oithona</i> spp.	<i>Oithona</i> spp.	<i>Pseudocalanus</i> spp.	<i>Oithona</i> spp.
2	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	<i>Oithona</i> spp.	<i>Limacina helicina</i>
3	<i>Microcalanus</i> spp.	<i>Microcalanus</i> spp.	<i>Limacina helicina</i>	<b><i>Calanus marshallae</i></b>	<b><i>Calanus marshallae</i></b>
4	<i>Metridia pacifica</i>	<i>Metridia pacifica</i>	<b><i>Calanus marshallae</i></b>	<i>Oikopleura</i> spp.	<i>Pseudocalanus</i> spp.
5	<i>Limacina helicina</i>	<b><i>Calanus marshallae</i></b>	<i>Acartia longiremis</i>	<i>Limacina helicina</i>	Bivalve larvae
6	<i>Acartia longiremis</i>	<i>Acartia longiremis</i>	<i>Microcalanus</i> spp.	<i>Acartia longiremis</i>	<i>Acartia longiremis</i>
7	<i>Oncaea</i> spp.	<i>N. plumchrus</i>	<i>N. plumchrus</i>	Bivalve larvae	<i>Eucalanus bungii</i>
8	<i>Triconia</i> spp.	<i>Limacina helicina</i>	<i>Centropages</i> spp.	<i>Metridia pacifica</i>	Echinoderm
9	Ostracoda	<i>Themisto pacifica</i>	<i>Metridia pacifica</i>	Echinoderm	<i>Parasagitta elegans</i>
10	<i>Fritillaria</i> spp.	Gastropoda	<i>Eucalanus bungii</i>	Gastropoda	Euphausiids (young)

# Geographic Patterns: Fall

## *Calanus marshallae*

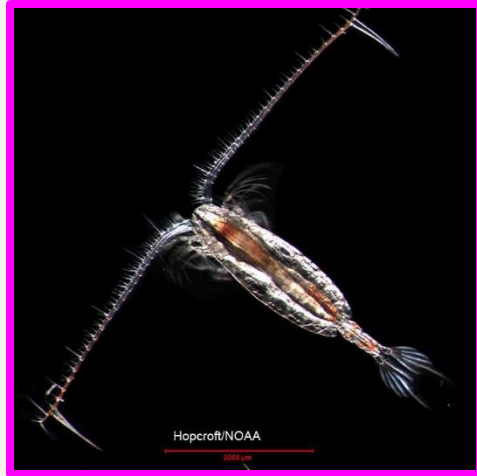
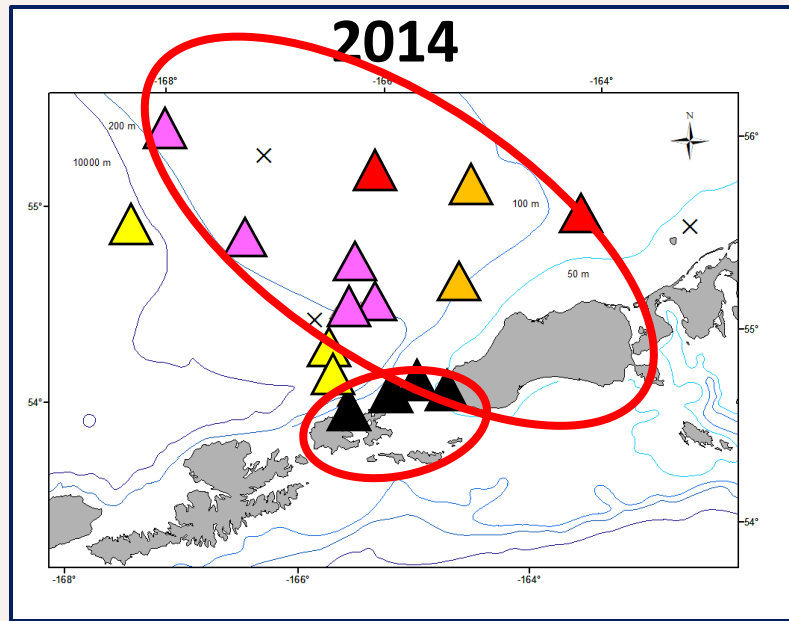


photo credit: Russ Hopcroft



How many stations	3	3	2	4	2
Symbol on map					
Rank % Contribution	b	c	d	e	h
1	<i>Oithona</i> spp.	<i>Oithona</i> spp.	<i>Oithona</i> spp.	<i>Pseudocalanus</i> spp.	<i>Oithona</i> spp.
2	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	<i>Oithona</i> spp.	<i>Limacina helicina</i>
3	<i>Microcalanus</i> spp.	<i>Microcalanus</i> spp.	<i>Limacina helicina</i>	<b><i>Calanus marshallae</i></b>	<b><i>Calanus marshallae</i></b>
4	<i>Metridia pacifica</i>	<i>Metridia pacifica</i>	<b><i>Calanus marshallae</i></b>	<i>Oikopleura</i> spp.	<i>Pseudocalanus</i> spp.
5	<i>Limacina helicina</i>	<b><i>Calanus marshallae</i></b>	<i>Acartia longiremis</i>	<i>Limacina helicina</i>	Bivalve larvae
6	<i>Acartia longiremis</i>	<i>Acartia longiremis</i>	<i>Microcalanus</i> spp.	<i>Acartia longiremis</i>	<i>Acartia longiremis</i>
7	<i>Oncaea</i> spp.	<i>N. plumchrus</i>	<i>N. plumchrus</i>	Bivalve larvae	<i>Eucalanus bungii</i>
8	<i>Triconia</i> spp.	<i>Limacina helicina</i>	<i>Centropages</i> spp.	<i>Metridia pacifica</i>	Echinoderm
9	Ostracoda	<i>Themisto pacifica</i>	<i>Metridia pacifica</i>	Echinoderm	<i>Parasagitta elegans</i>
10	<i>Fritillaria</i> spp.	Gastropoda	<i>Eucalanus bungii</i>	Gastropoda	Euphausiids (young)

# Geographic Patterns: Fall

Spring

*Calanus marshallae*

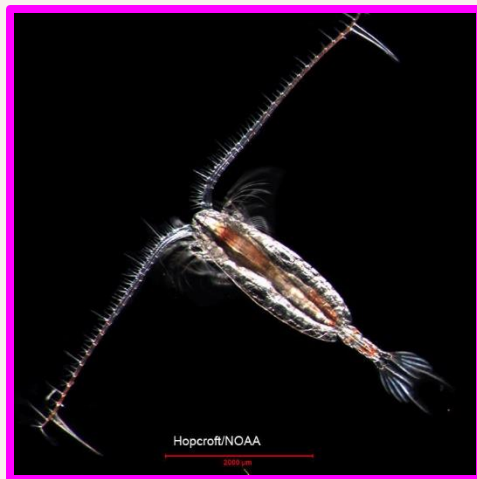
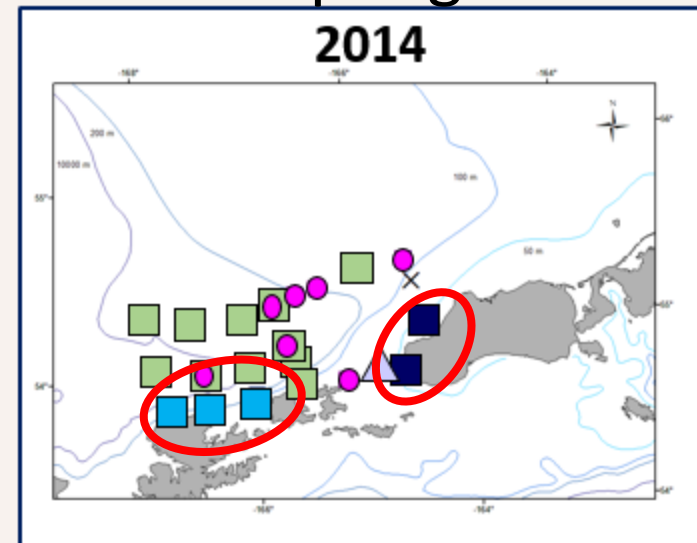
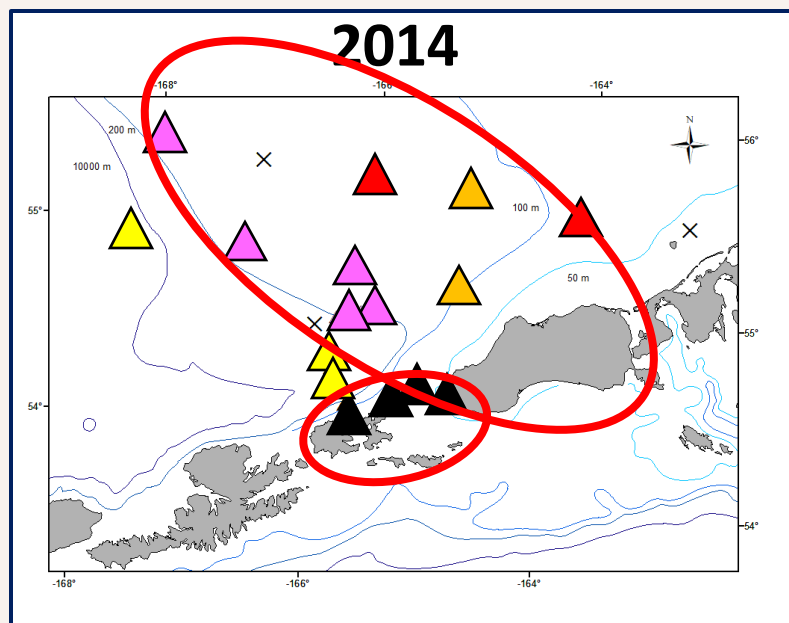


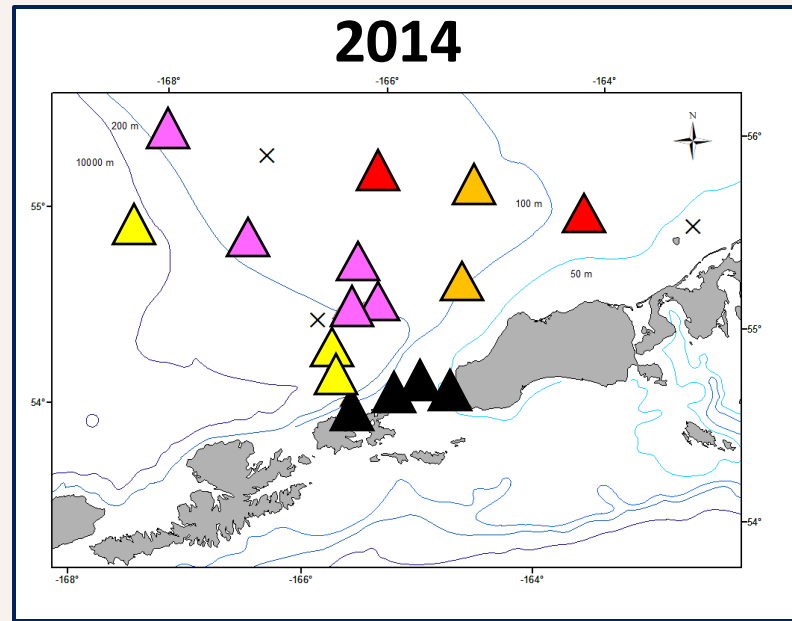
photo credit: Russ Hopcroft



How many stations	3	3	2	4	2
Symbol on map					
Rank % Contribution	b	c	d	e	h
1	<i>Oithona</i> spp.	<i>Oithona</i> spp.	<i>Oithona</i> spp.	<i>Pseudocalanus</i> spp.	<i>Oithona</i> spp.
2	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	<i>Oithona</i> spp.	<i>Limacina helicina</i>
3	<i>Microcalanus</i> spp.	<i>Microcalanus</i> spp.	<i>Limacina helicina</i>	<i>Calanus marshallae</i>	<i>Calanus marshallae</i>
4	<i>Metridia pacifica</i>	<i>Metridia pacifica</i>	<i>Calanus marshallae</i>	<i>Oikopleura</i> spp.	<i>Pseudocalanus</i> spp.
5	<i>Limacina helicina</i>	<i>Calanus marshallae</i>	<i>Acartia longiremis</i>	<i>Limacina helicina</i>	Bivalve larvae
6	<i>Acartia longiremis</i>	<i>Acartia longiremis</i>	<i>Microcalanus</i> spp.	<i>Acartia longiremis</i>	<i>Acartia longiremis</i>
7	<i>Oncaea</i> spp.	<i>N. plumchrus</i>	<i>N. plumchrus</i>	Bivalve larvae	<i>Eucalanus bungii</i>
8	<i>Triconia</i> spp.	<i>Limacina helicina</i>	<i>Centropages</i> spp.	<i>Metridia pacifica</i>	Echinoderm
9	Ostracoda	<i>Themisto pacifica</i>	<i>Metridia pacifica</i>	Echinoderm	<i>Parasagitta elegans</i>
10	<i>Fritillaria</i> spp.	Gastropoda	<i>Eucalanus bungii</i>	Gastropoda	Euphausiids (young)

# Geographic Patterns: Fall

*Limacina helicina*



Absent from top 10 species in Spring

How many stations	3	3	2	4	2
Symbol on map					
Rank % Contribution	b	c	d	e	h
1	<i>Oithona</i> spp.	<i>Oithona</i> spp.	<i>Oithona</i> spp.	<i>Pseudocalanus</i> spp.	<i>Oithona</i> spp.
2	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	<i>Pseudocalanus</i> spp.	<i>Oithona</i> spp.	<i>Limacina helicina</i>
3	<i>Microcalanus</i> spp.	<i>Microcalanus</i> spp.	<i>Limacina helicina</i>	<i>Calanus marshallae</i>	<i>Calanus marshallae</i>
4	<i>Metridia pacifica</i>	<i>Metridia pacifica</i>	<i>Calanus marshallae</i>	<i>Oikopleura</i> spp.	<i>Pseudocalanus</i> spp.
5	<i>Limacina helicina</i>	<i>Calanus marshallae</i>	<i>Acartia longiremis</i>	<i>Limacina helicina</i>	Bivalve larvae
6	<i>Acartia longiremis</i>	<i>Acartia longiremis</i>	<i>Microcalanus</i> spp.	<i>Acartia longiremis</i>	<i>Acartia longiremis</i>
7	<i>Oncea</i> spp.	<i>N. plumchrus</i>	<i>N. plumchrus</i>	Bivalve larvae	<i>Eucalanus bungii</i>
8	<i>Triconia</i> spp.	<i>Limacina helicina</i>	<i>Centropages</i> spp.	<i>Metridia pacifica</i>	Echinoderm
9	Ostracoda	<i>Themisto pacifica</i>	<i>Metridia pacifica</i>	Echinoderm	<i>Parasagitta elegans</i>
10	<i>Fritillaria</i> spp.	Gastropoda	<i>Eucalanus bungii</i>	Gastropoda	Euphausiids (young)

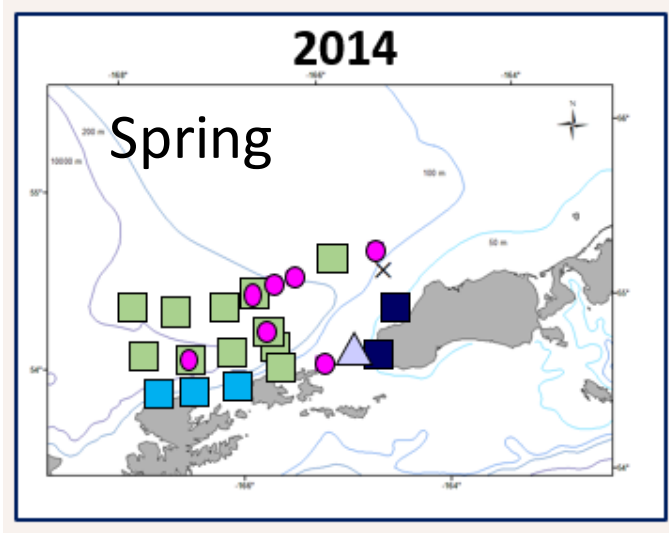


# Seasonal Patterns? Geographic Patterns?

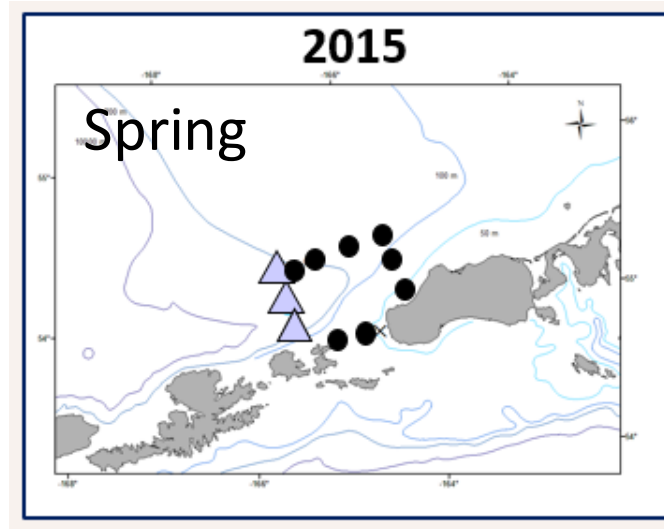
- *Neocalanus plumchrus* remained in fall which was a surprise due to life history
- *Calanus marshallae* high % contribution inshore in Spring and on the shelf in Fall
- *Limacina helicina* (pteropod) high % contribution in Fall throughout study area



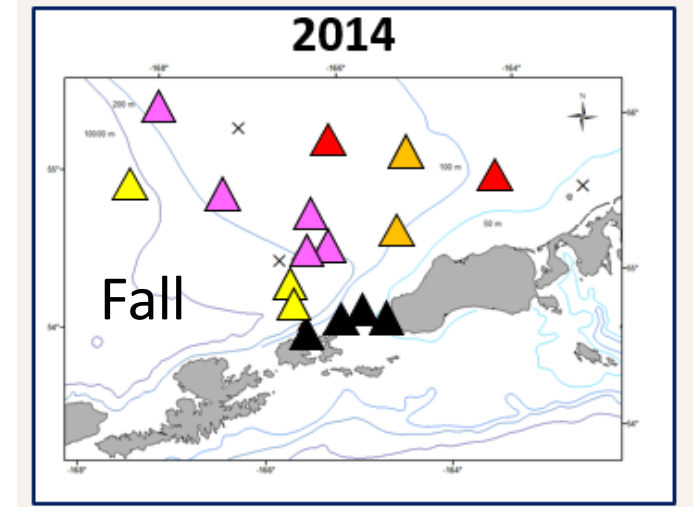
ANSC = Aleutian North Slope Current



# Flow Patterns?



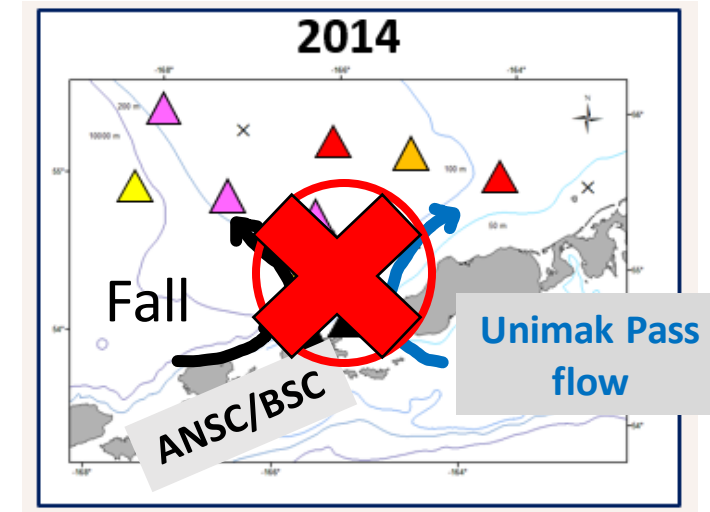
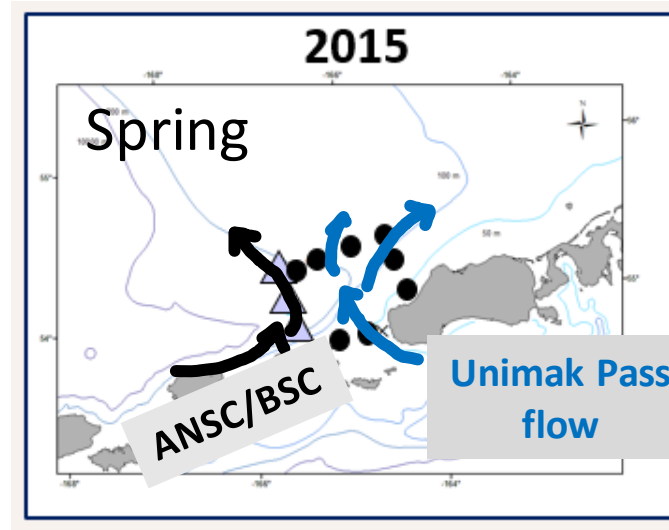
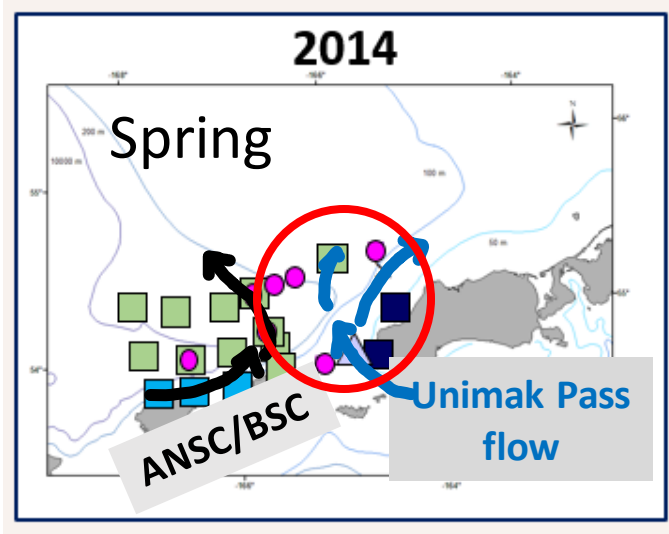
BSC = Bering Slope Current



# Flow Patterns?

ANSC = Aleutian North Slope Current

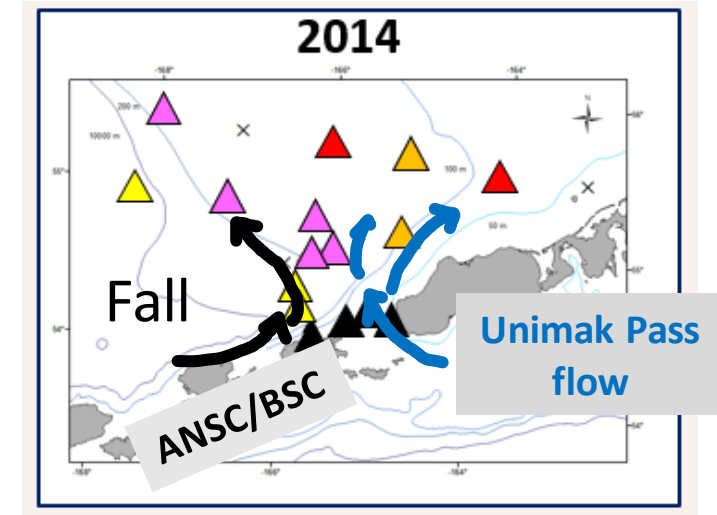
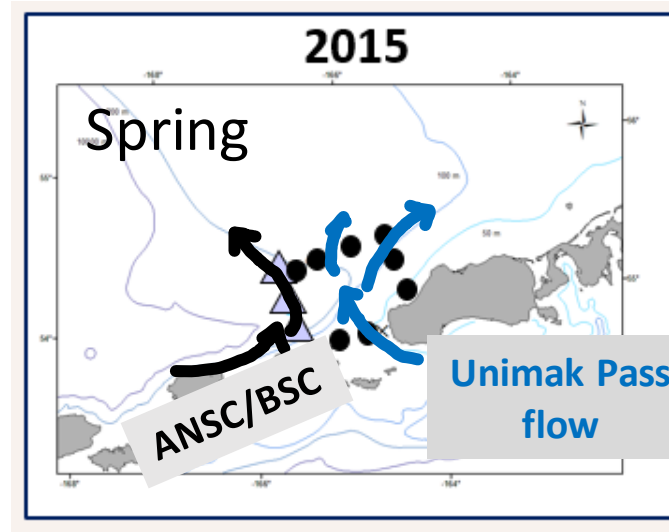
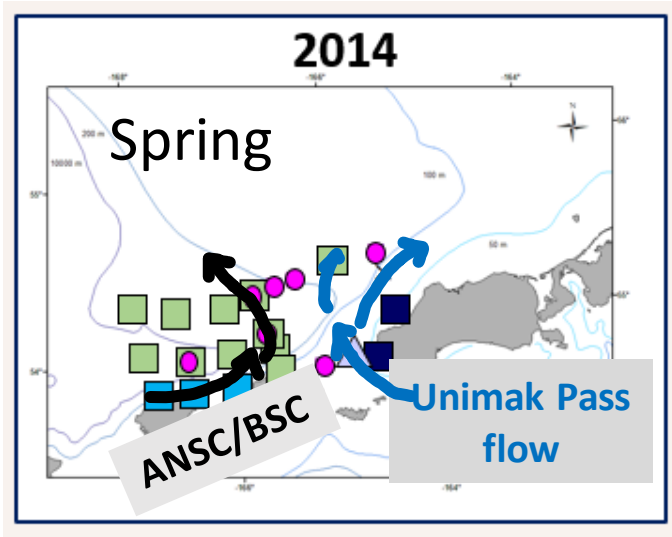
BSC = Bering Slope Current



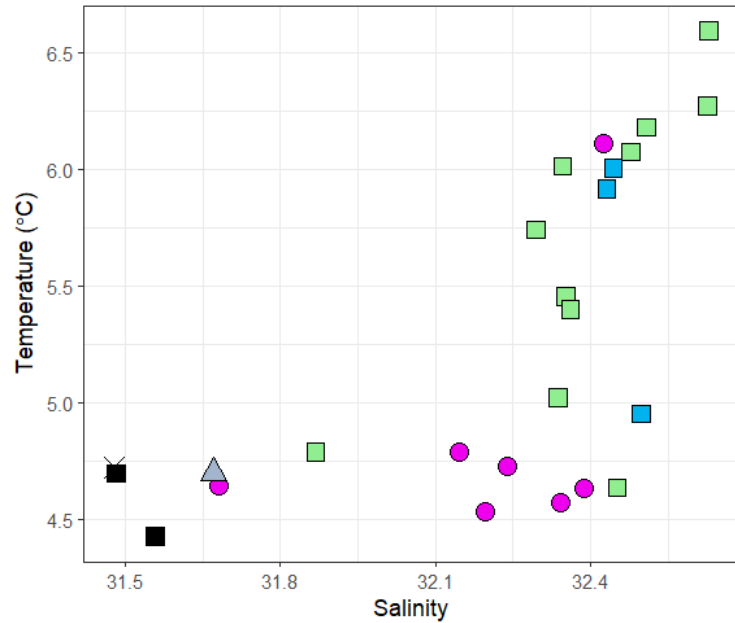
ANSC = Aleutian North Slope Current

# Temperature & Salinity?

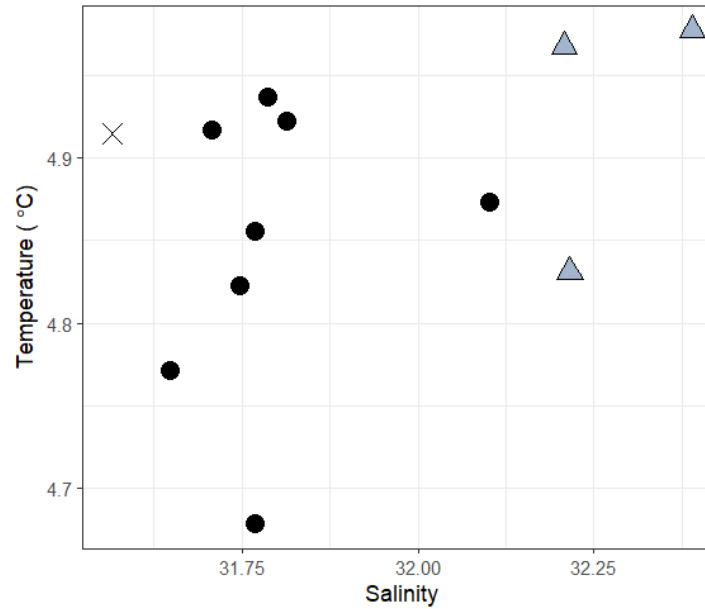
BSC = Bering Slope Current



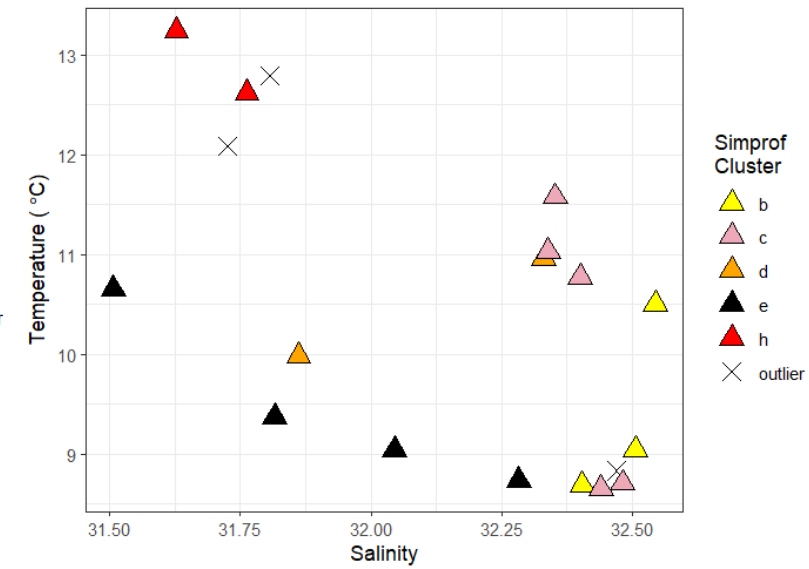
Spring 2014



Spring 2015



Fall 2014

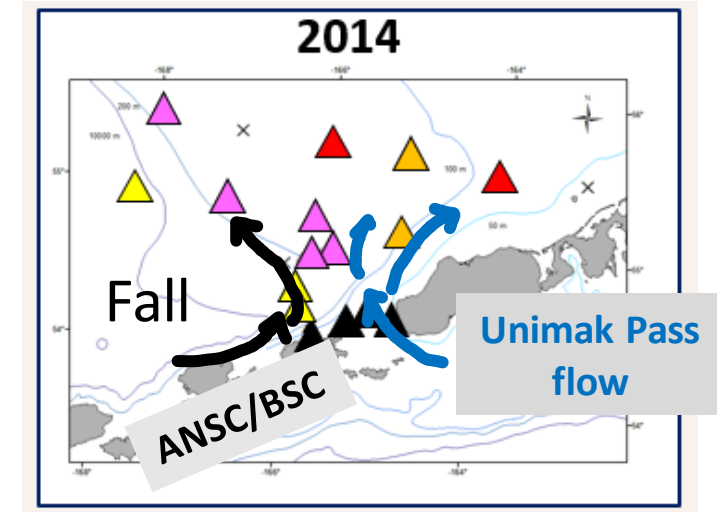
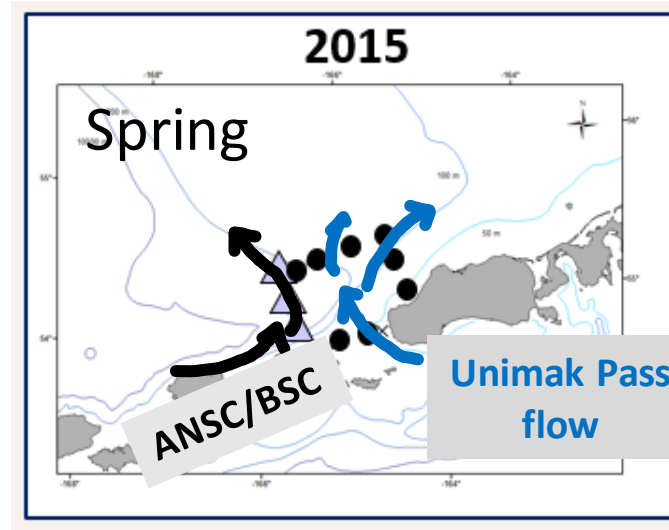
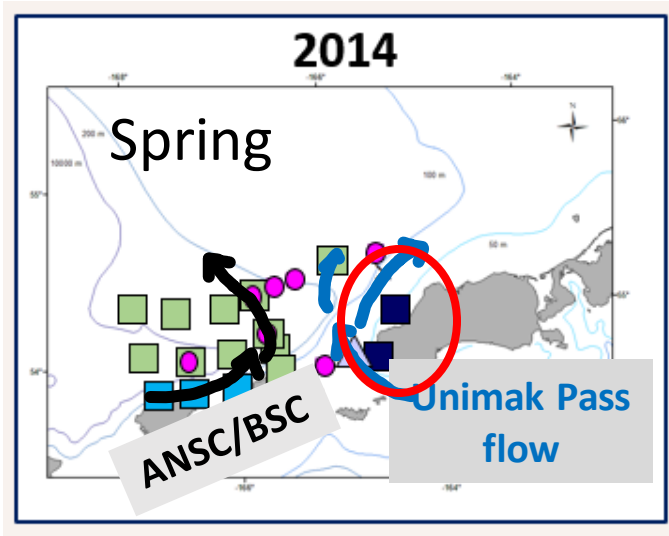


Temperature and salinity are different scales

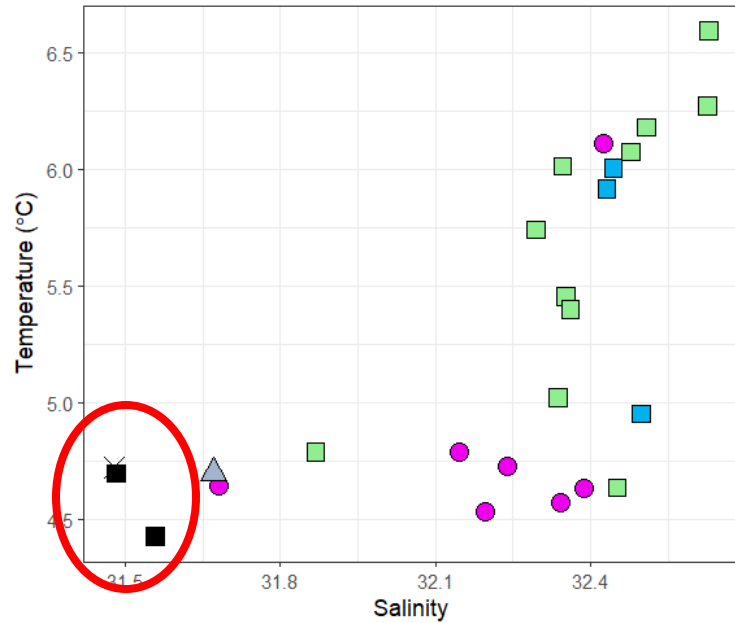
ANSC = Aleutian North Slope Current

# Temperature & Salinity?

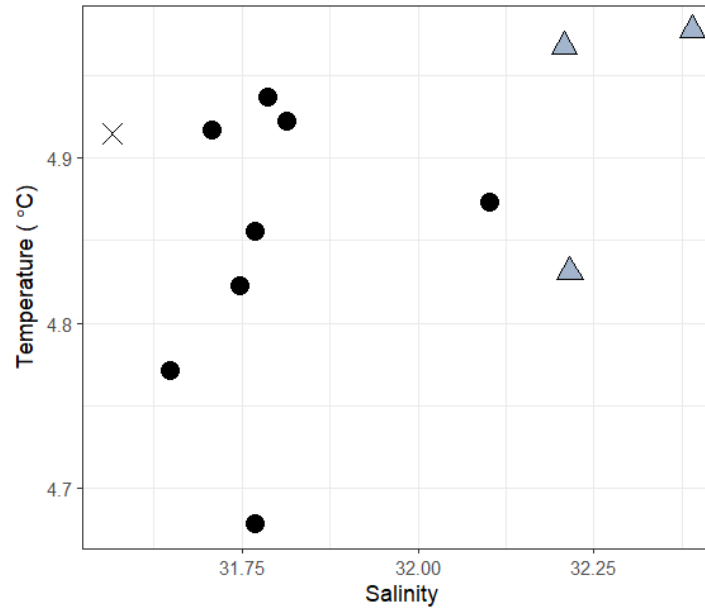
BSC = Bering Slope Current



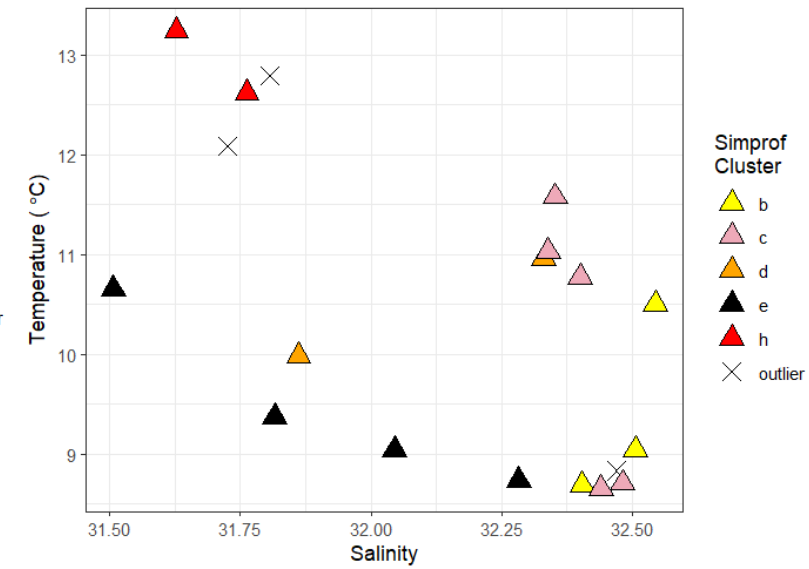
Spring 2014



Spring 2015



Fall 2014

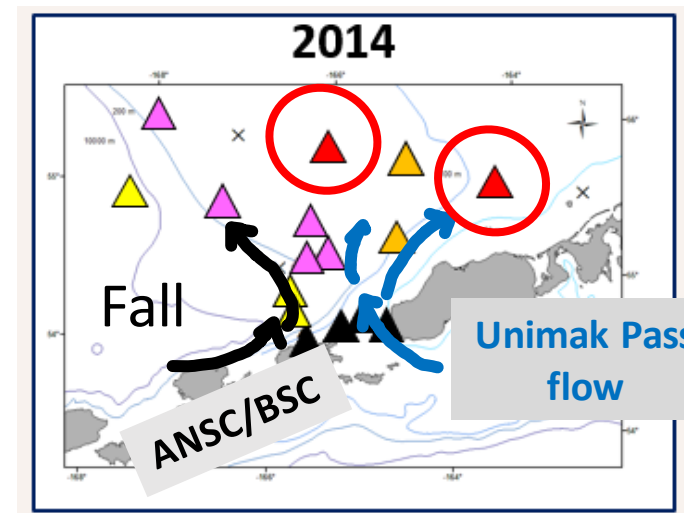
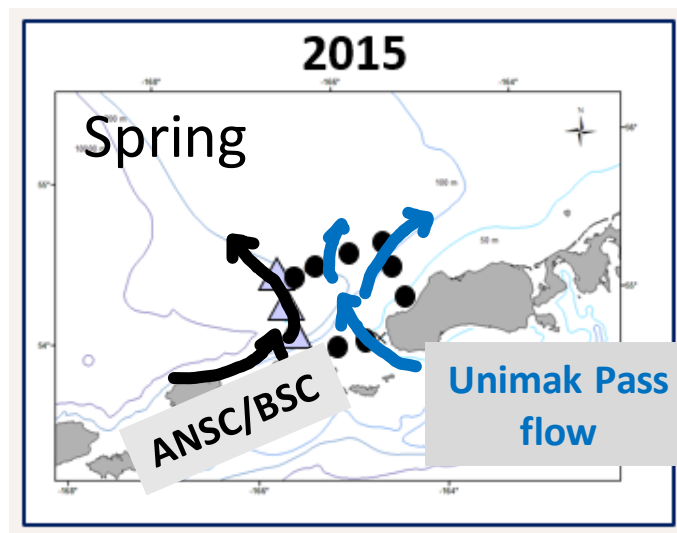
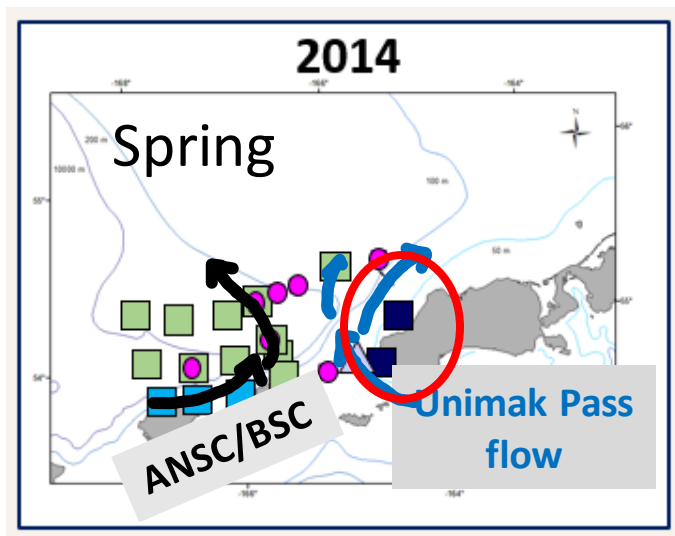


Temperature and salinity are different scales

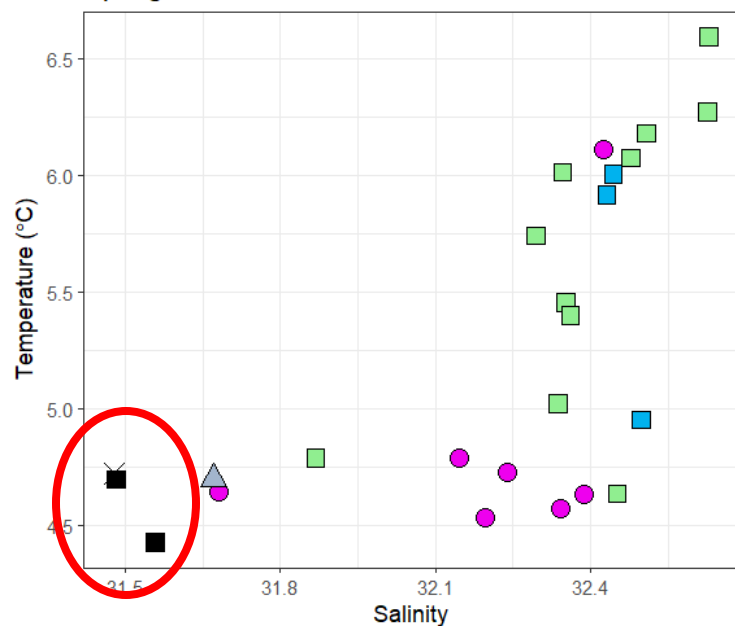
ANSC = Aleutian North Slope Current

# Temperature & Salinity?

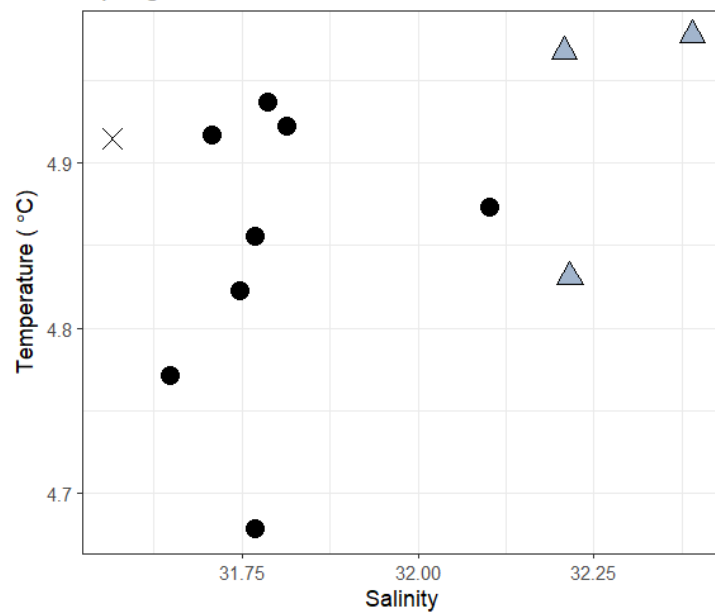
BSC = Bering Slope Current



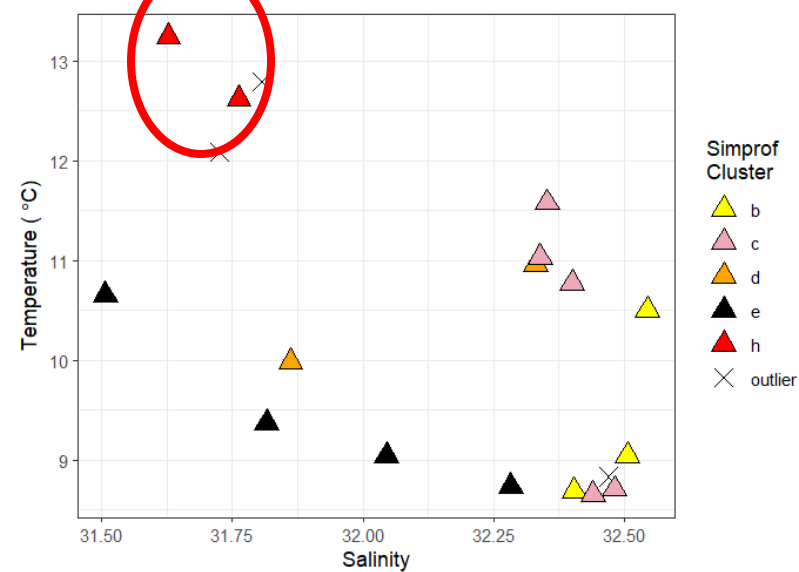
Spring 2014



Spring 2015



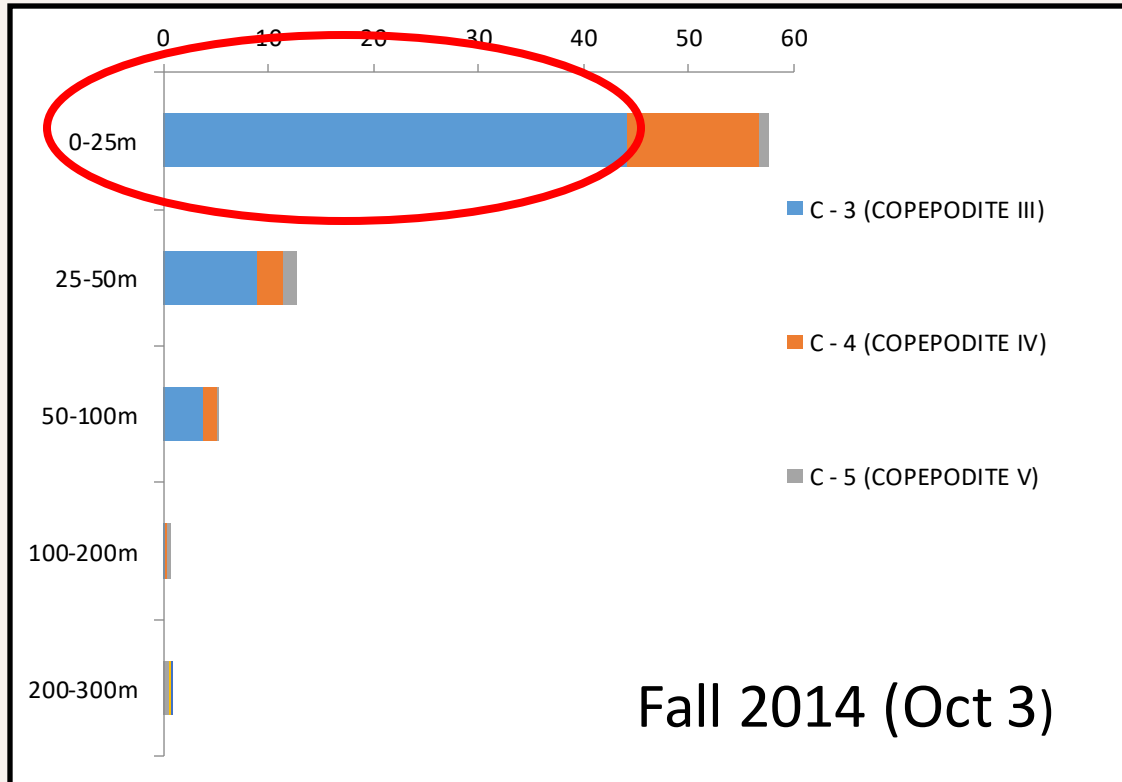
Fall 2014



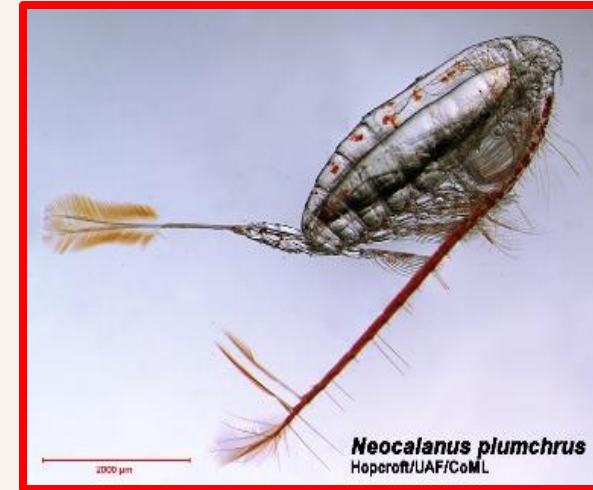
Temperature and salinity are different scales

# Next Step

High abundance of stage CIII



*Neocalanus plumchrus*



Second cohort in warm year of 2014?

Investigate stages in clusters, more years and wider area

# Acknowledgements

## Co-Authors

David Kimmel: guidance and support, R  
Carol Ladd: proposal lead, oceanography  
Phyllis Stabeno: oceanography

## Project Help

Lisa Eisner: sampling, training & Primer  
Kathy Mier: Primer  
Janet Duffy-Anderson: project vision & support  
Steve Porter: bongo sampling  
Nissa Ferm: taxonomic advice  
Shaun Bell: temperature data

Plankton Sorting Institute in Poland  
NOAA ship Oscar Dyson crew and scientists

Julie Keister, Deana Crouser, Adam Spear, Jesse  
Lamb, Libby Logerwell, David Kimmel

Contact: [colleen.Harpold@noaa.gov](mailto:colleen.Harpold@noaa.gov)



**NOAA  
FISHERIES**



## Funding from NPRB

**Deana Crouser**

**This afternoon 2:45 pm  
S06: Grand Ballroom 1**

**Changes in copepod size  
in response to warm and  
cold conditions during  
spring in the Eastern  
Bering Sea**

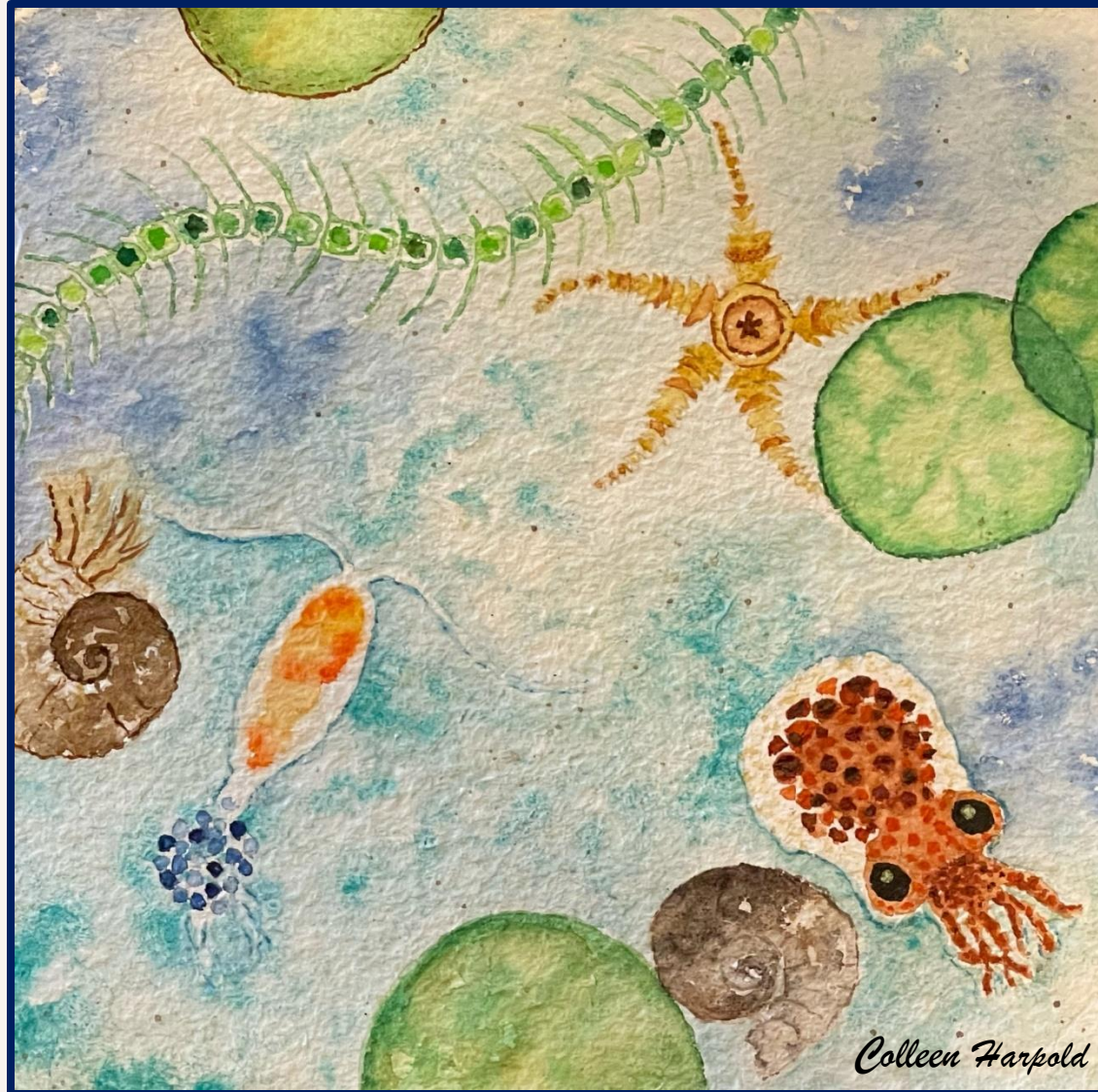




# Questions?

## Zooplankton Art Exhibition

Featuring 30  
artists



Open until  
March 22<sup>nd</sup>

Tasmanian Museum  
and Art Gallery  
10am-5pm