The relative importance of advective vs. in-situ production to mesozooplankton biomass on the Eastern Bering Sea shelf

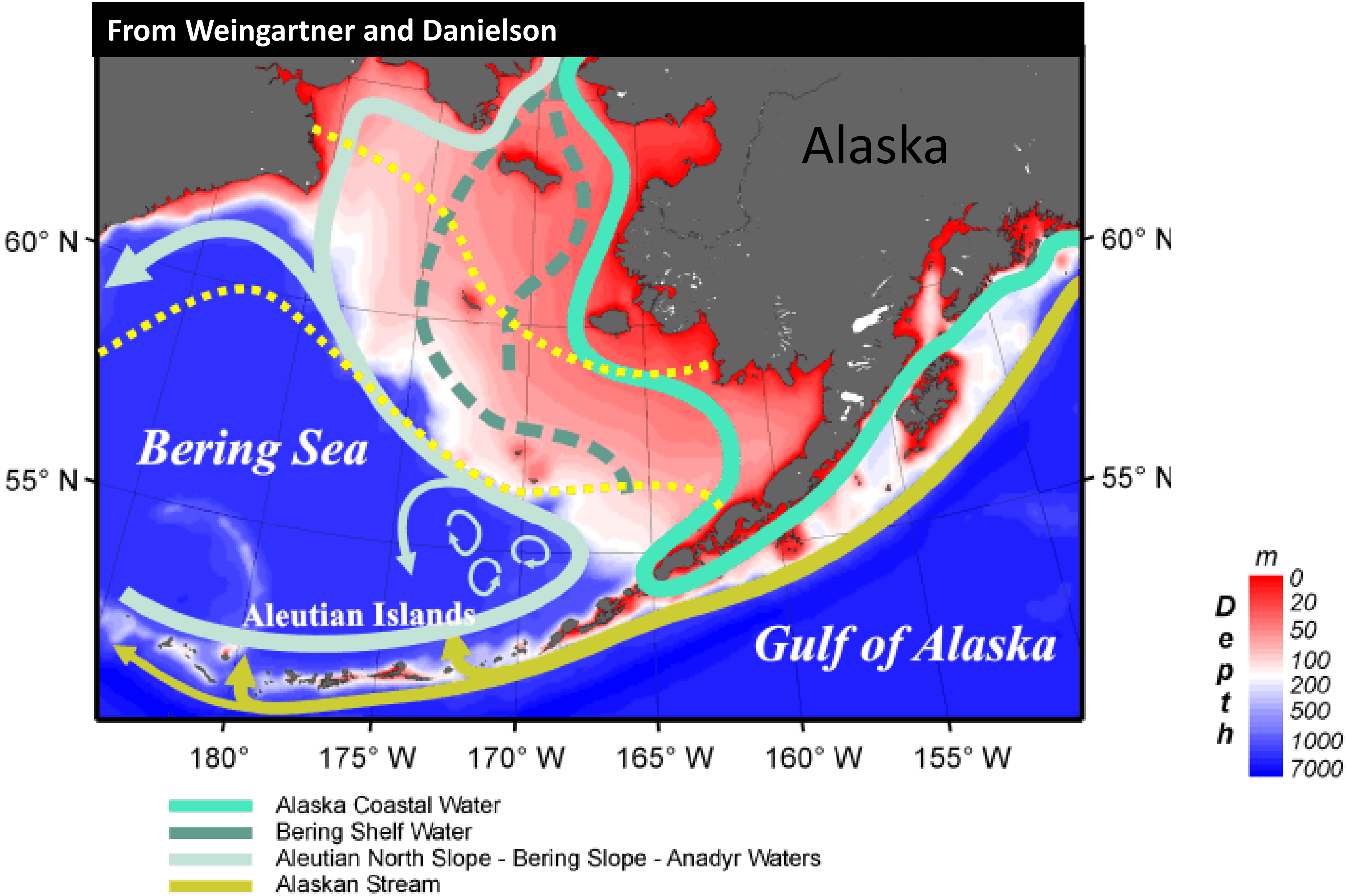
Georgina Gibson

International Arctic Research Center, ggibson@iarc.uaf.edu

A. Hermann, K. Coyle, K. Hedstrom, E. Curchitser

PICES Annual Meeting, Yesou, Oct 2014

Bering Sea Physical Overview

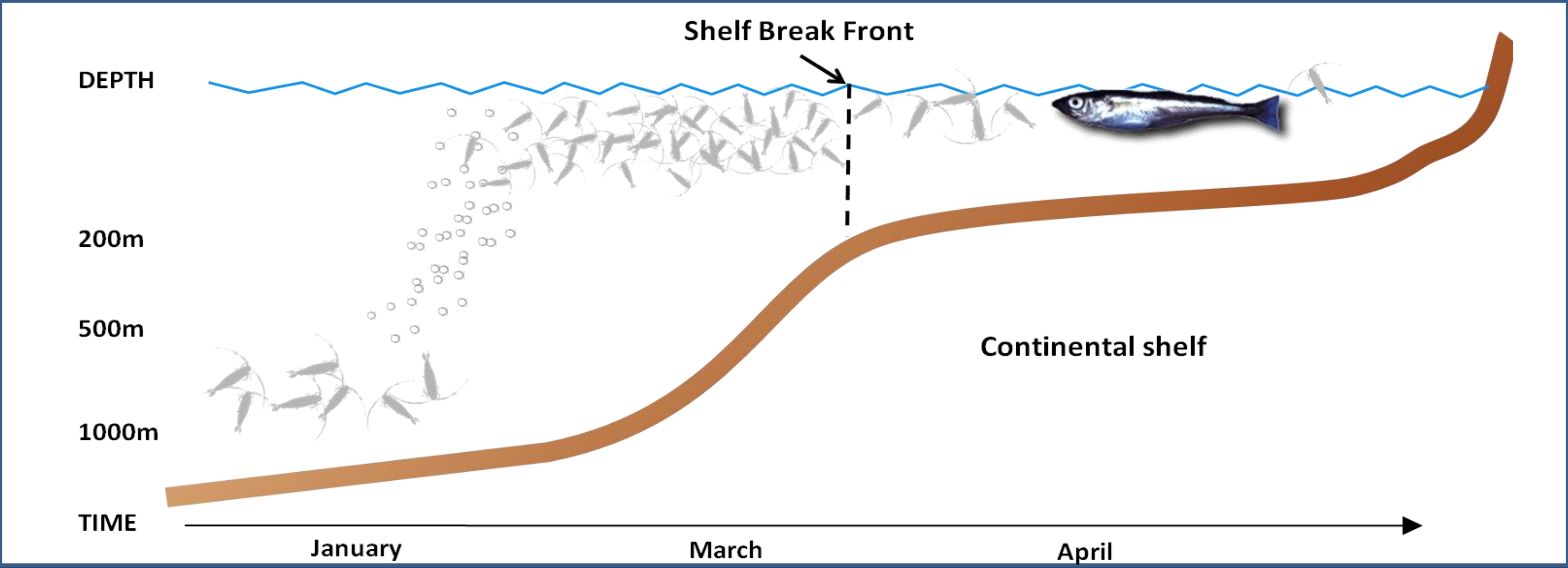


Mesozooplankton

Annual differences in upper trophic levels may depend on climatic conditions promoting: in-situ *secondary production* or *advection* of mesozooplankton into or throughout region.

On-shelf advection

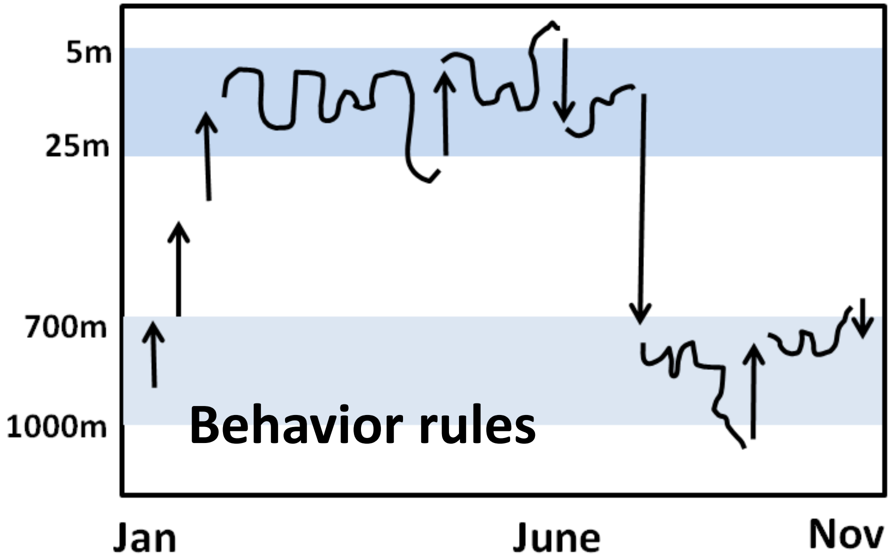
- Large bodied oceanic mesozooplankton require deep water off shelf to complete lifecycle.
- Despite frontal restrictions to cross shelf transport often dominate outer-shelf biomass.

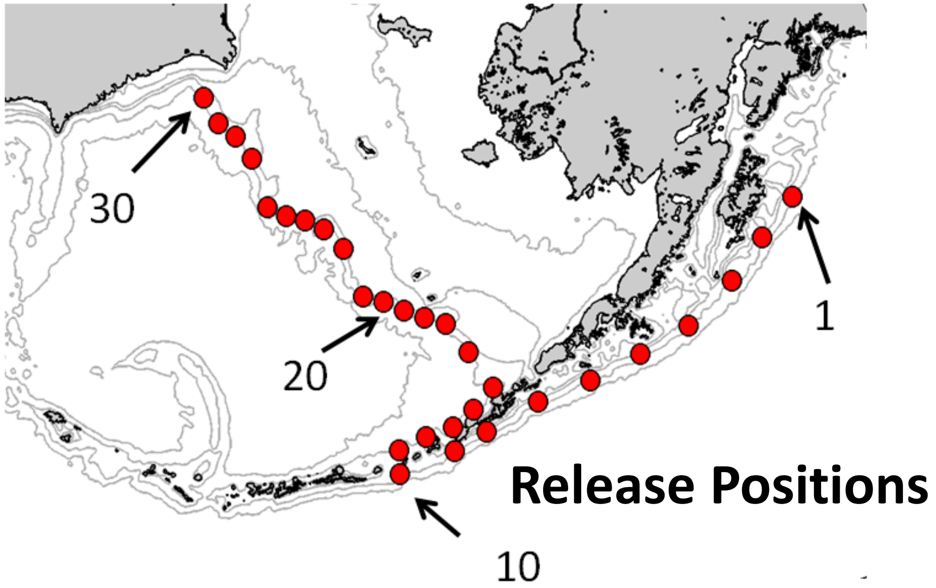


- Shelf break front leaky and variable in effectiveness (Mackas and Coyle, 2005)
- What environmental conditions promote on-shelf transport?

Lagrangian float tracking model to explore on-shelf zooplankton transport

- ROMS 4km physical oceanography model
- Behavior rules added to floats to simulate seasonal vertical migration of *Neocalanus.*
- At 30 locations along the 1000 m isobath floats were initialized at 700m depth.
- Floats released every 2 hours throughout Jan and Feb -> 708 from each location -> 21240 total.
- Explored impact of: air temperature, river runoff, wind strength, wind direction on where/when floats crossed onto shelf, and shelf residence time.

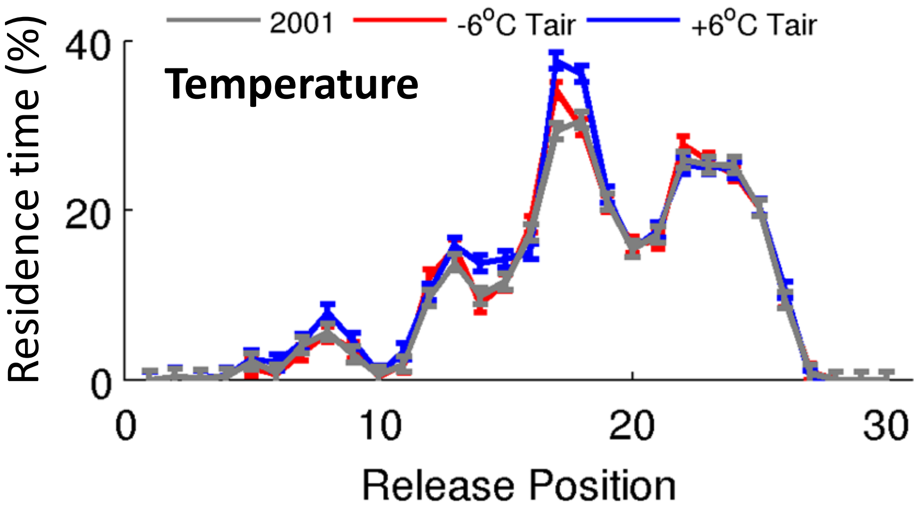


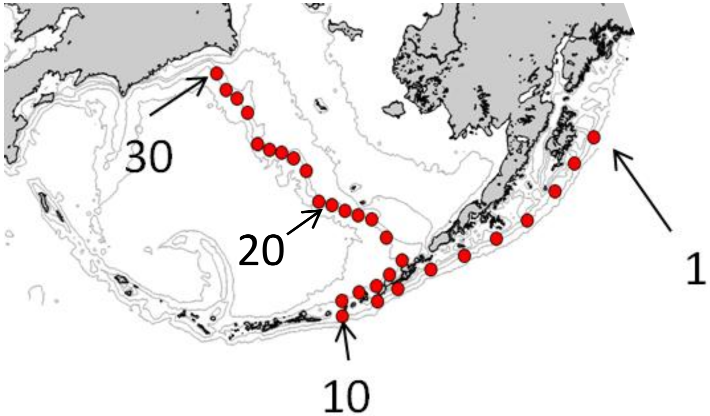


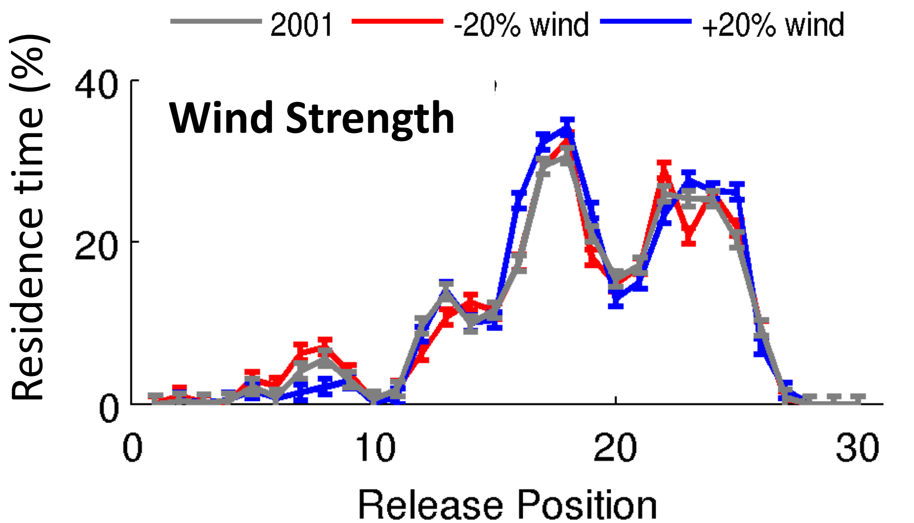
Effect of Environment on Shelf Residence Time

Residence on Southern Outer Shelf

In general air temperature, fresh water input and wind strength did not make large difference to on shelf advection or residence time



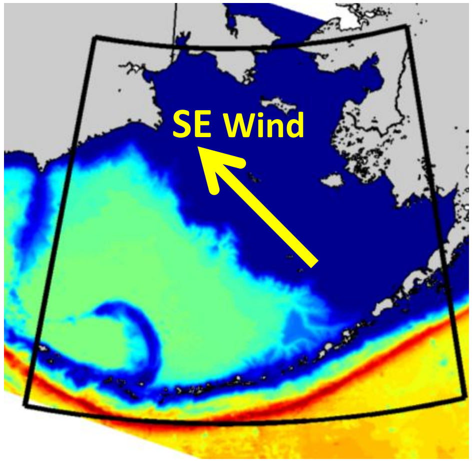


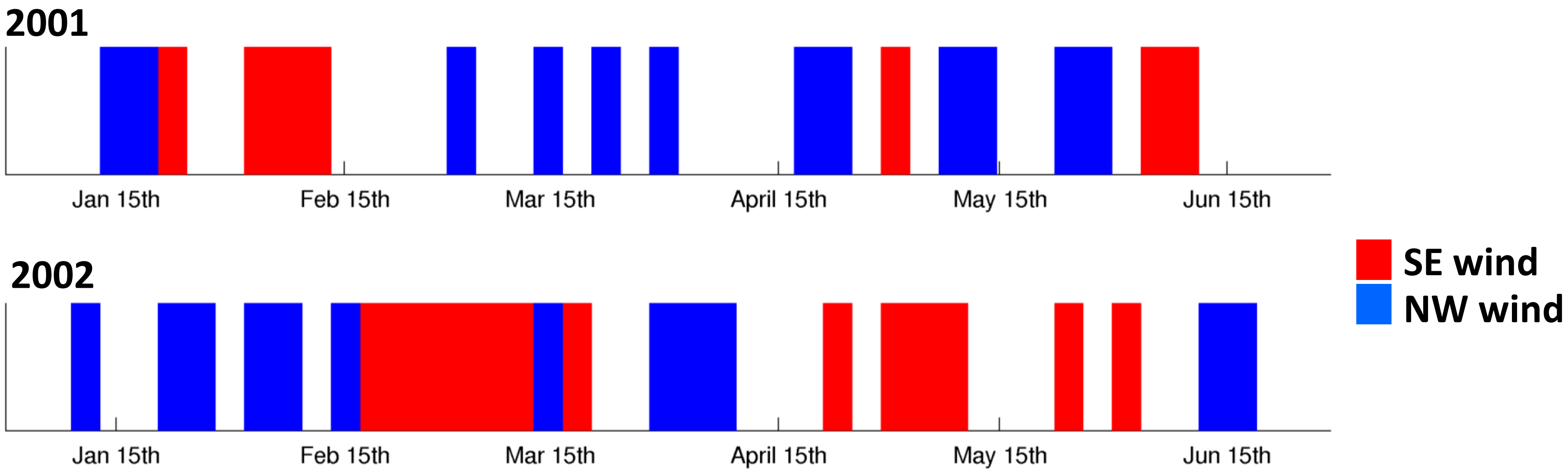


Inter-annual variability in wind direction

➢2001: Period of south-easterly wind late January to early February but wind was not from this direction again until a brief period in May.

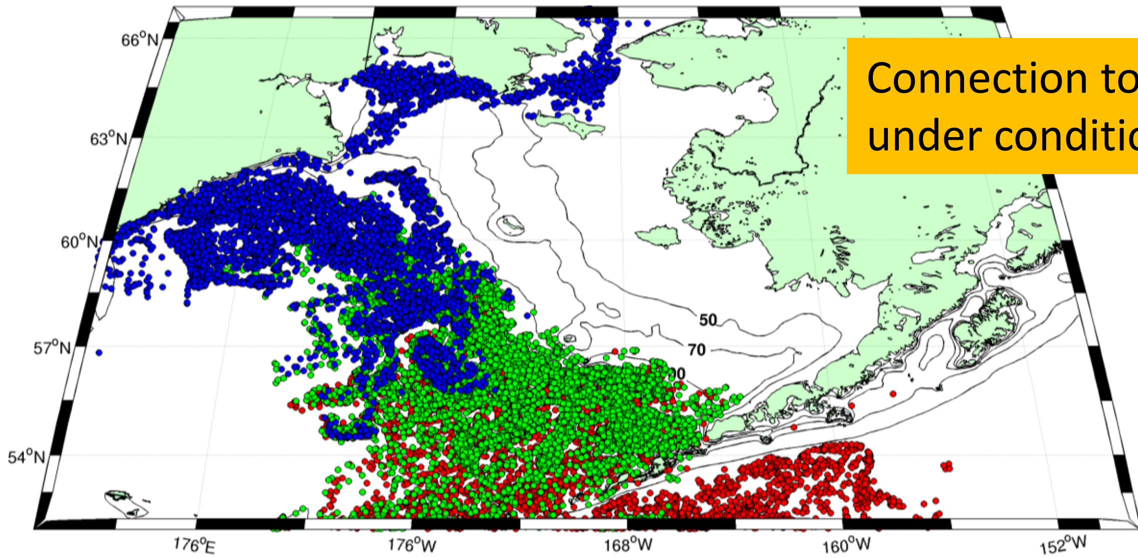
➢2002: South-easterly wind late February - mid March and again from the end of April through May.





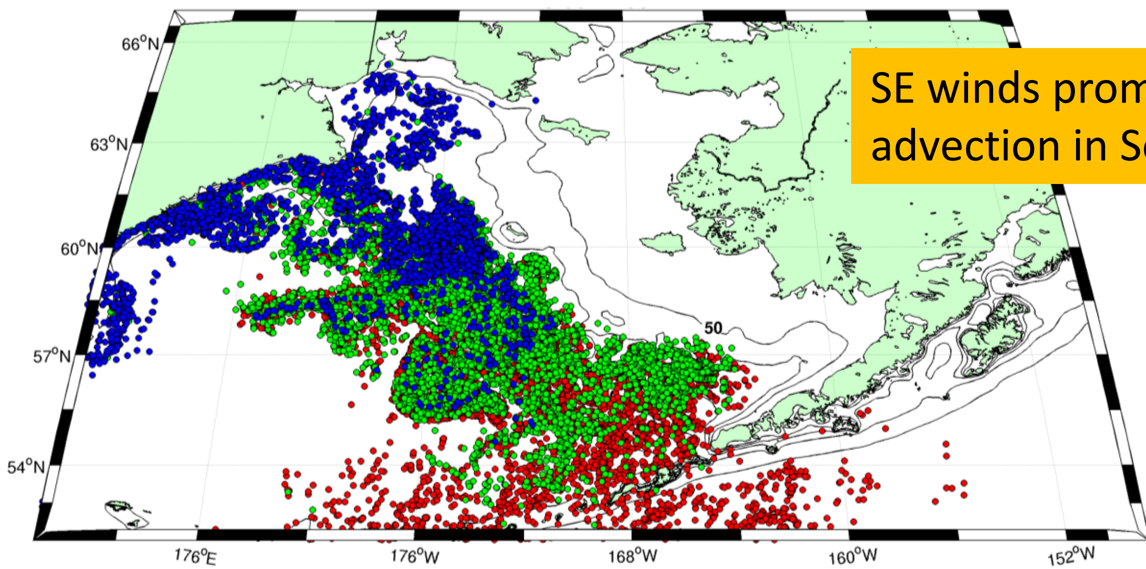
Inter-annual difference in on-shelf transport

2001



Connection to Arctic reduced under conditions of SE winds

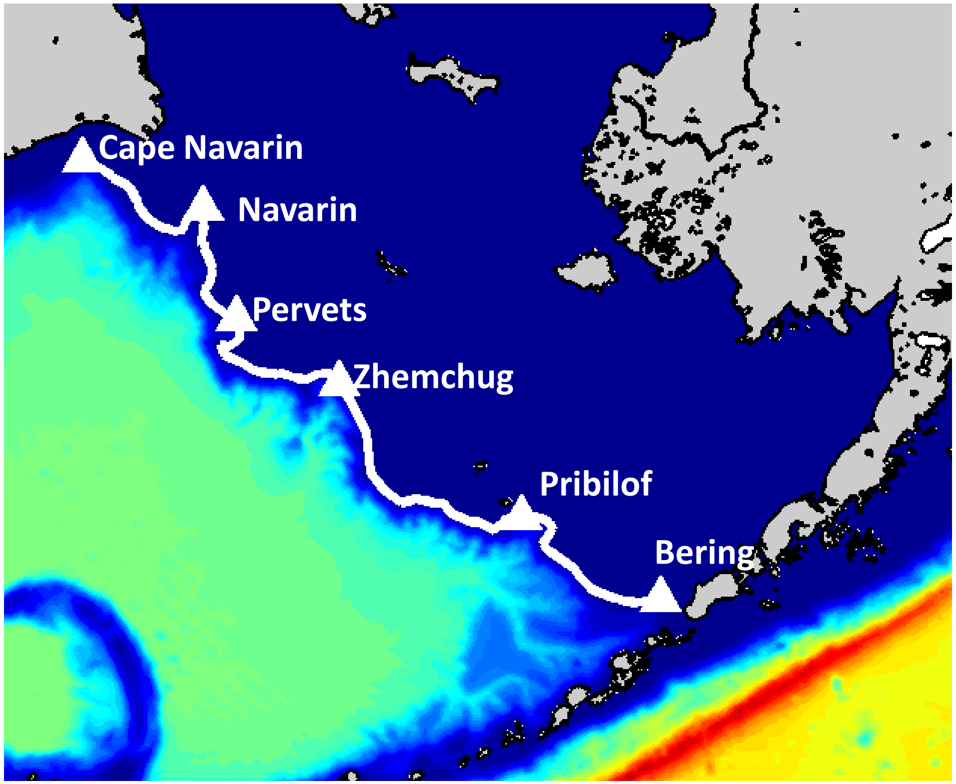
2002

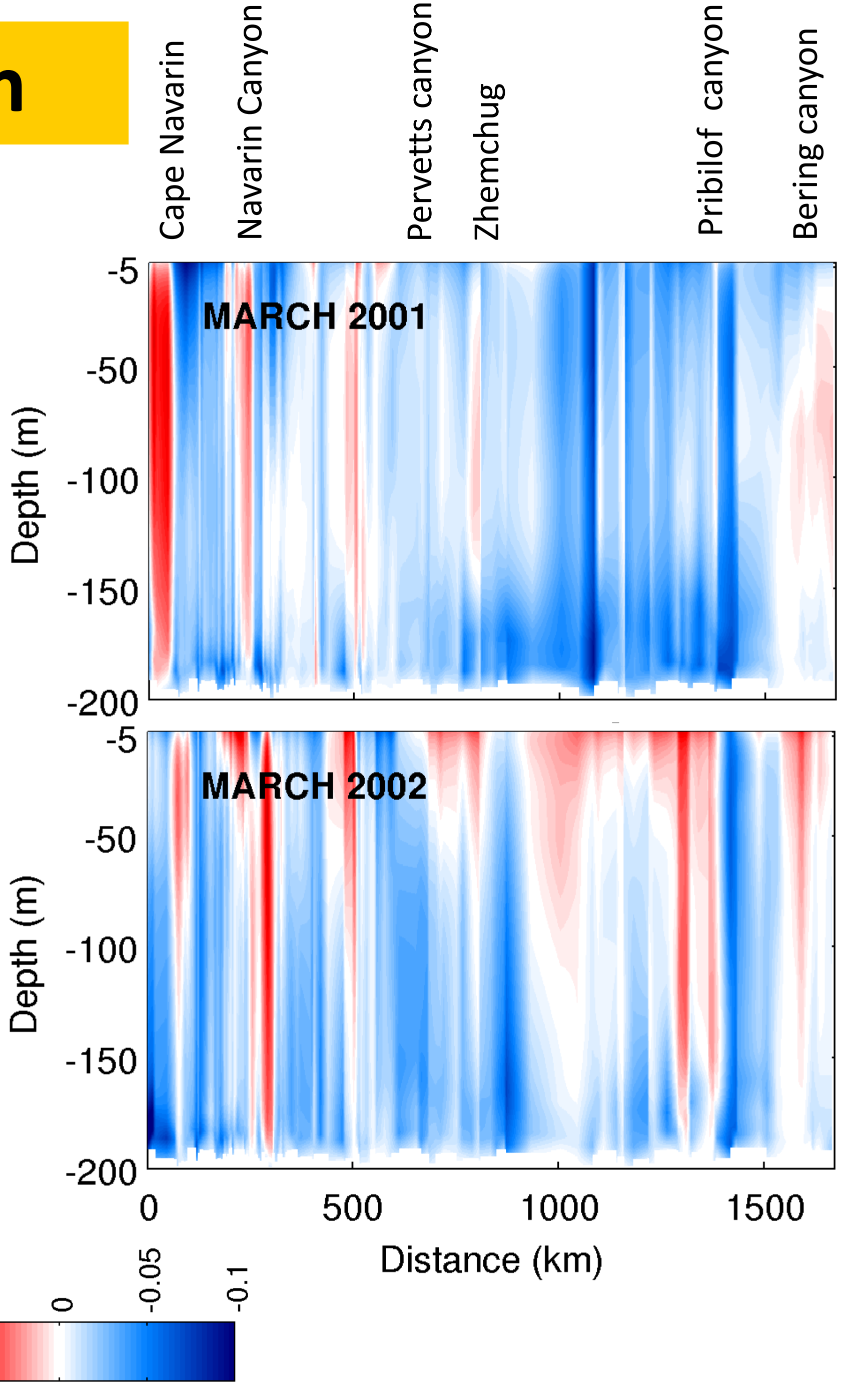


SE winds promote on-shelf advection in Southern BS

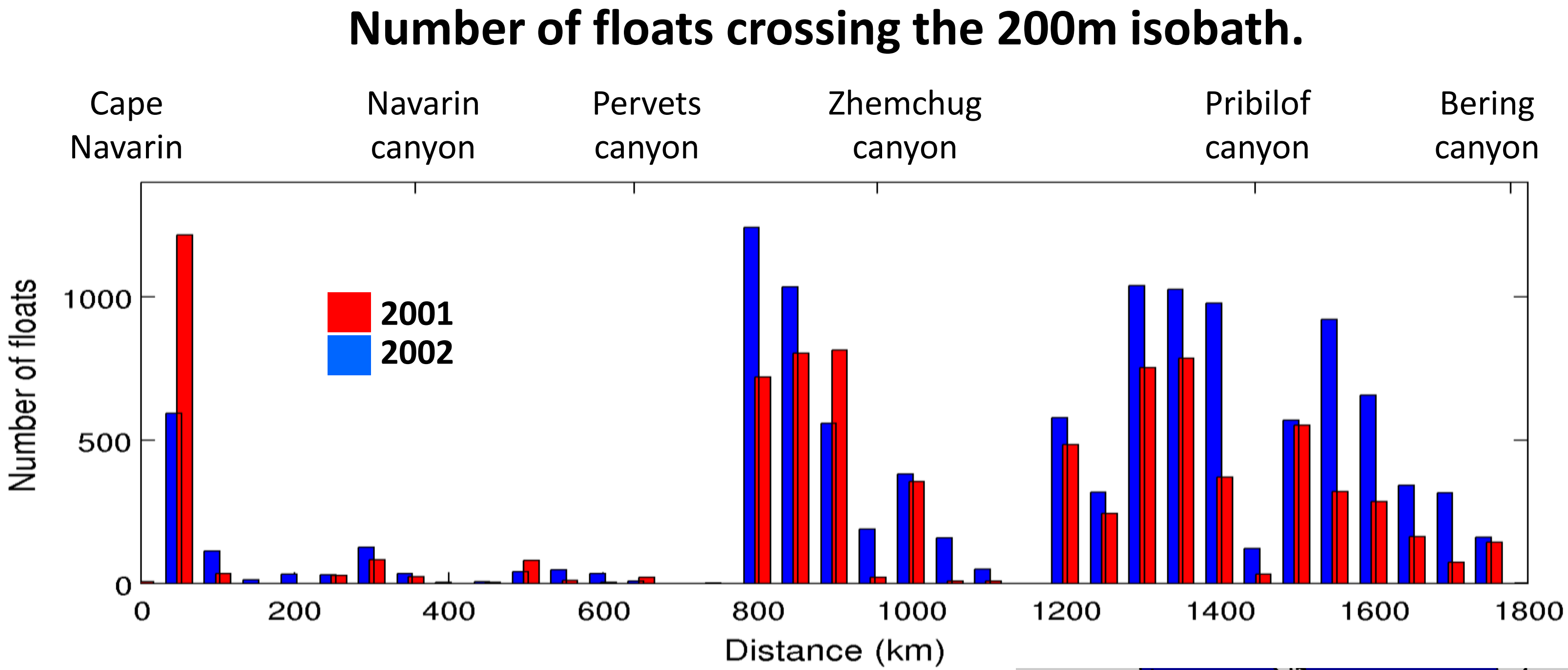
Velocity across 200m isobath

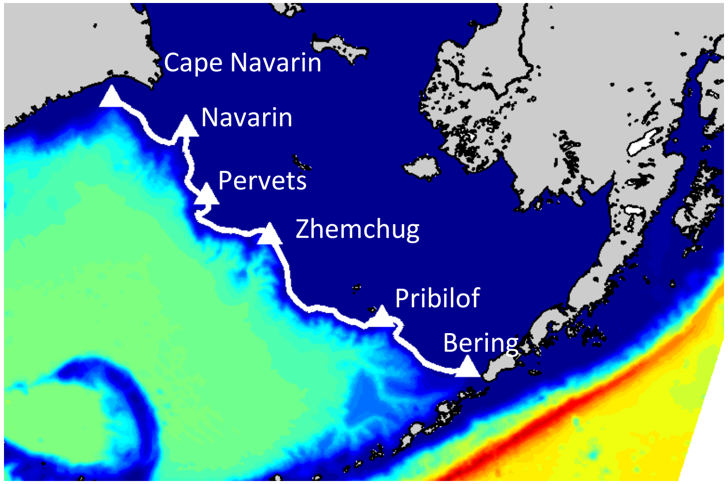
Spring





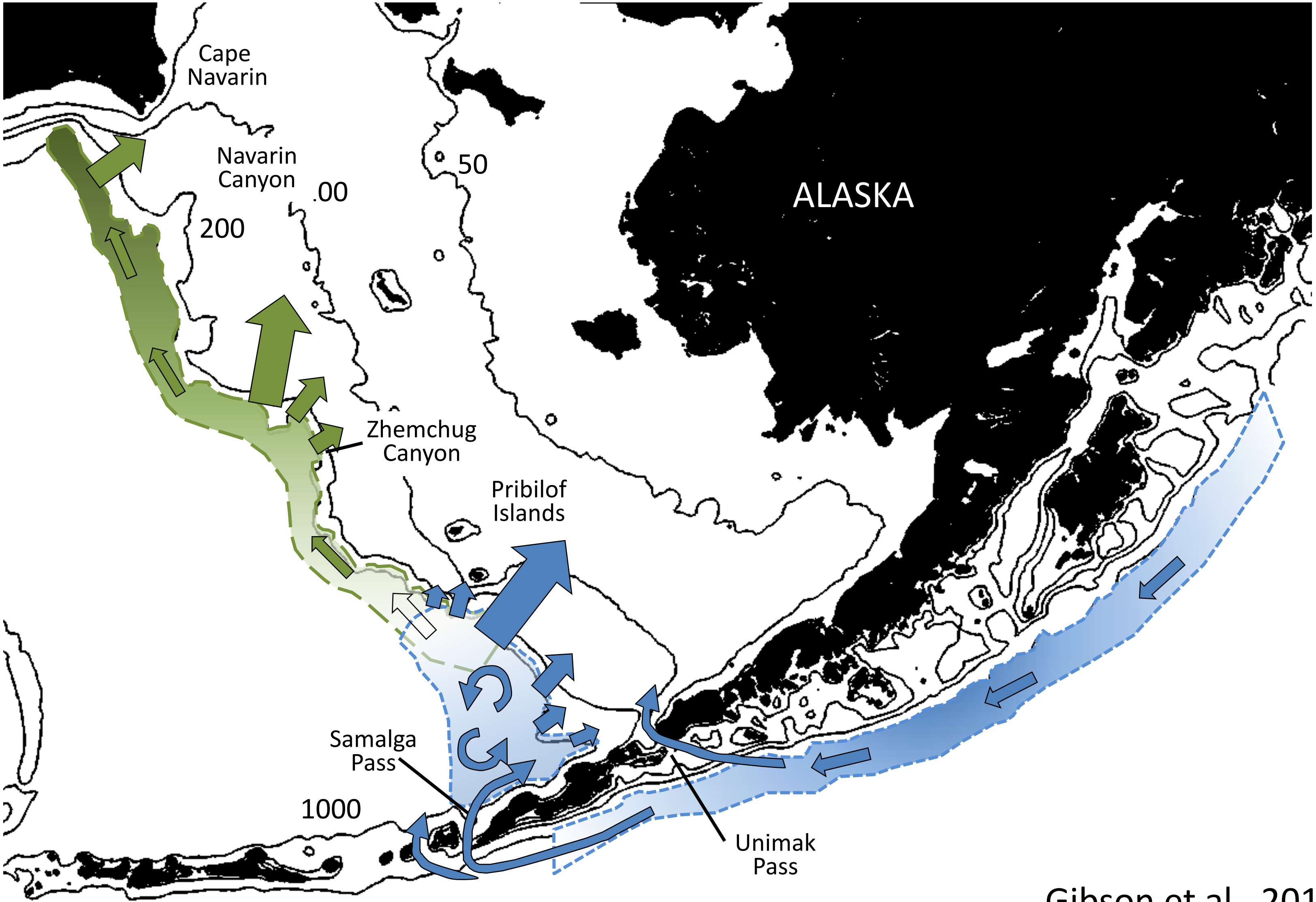
Location of on-shelf transport





- On-shelf transport **heterogeneous** along the shelf break.
- Northern and Southern shelf respond in opposite direction

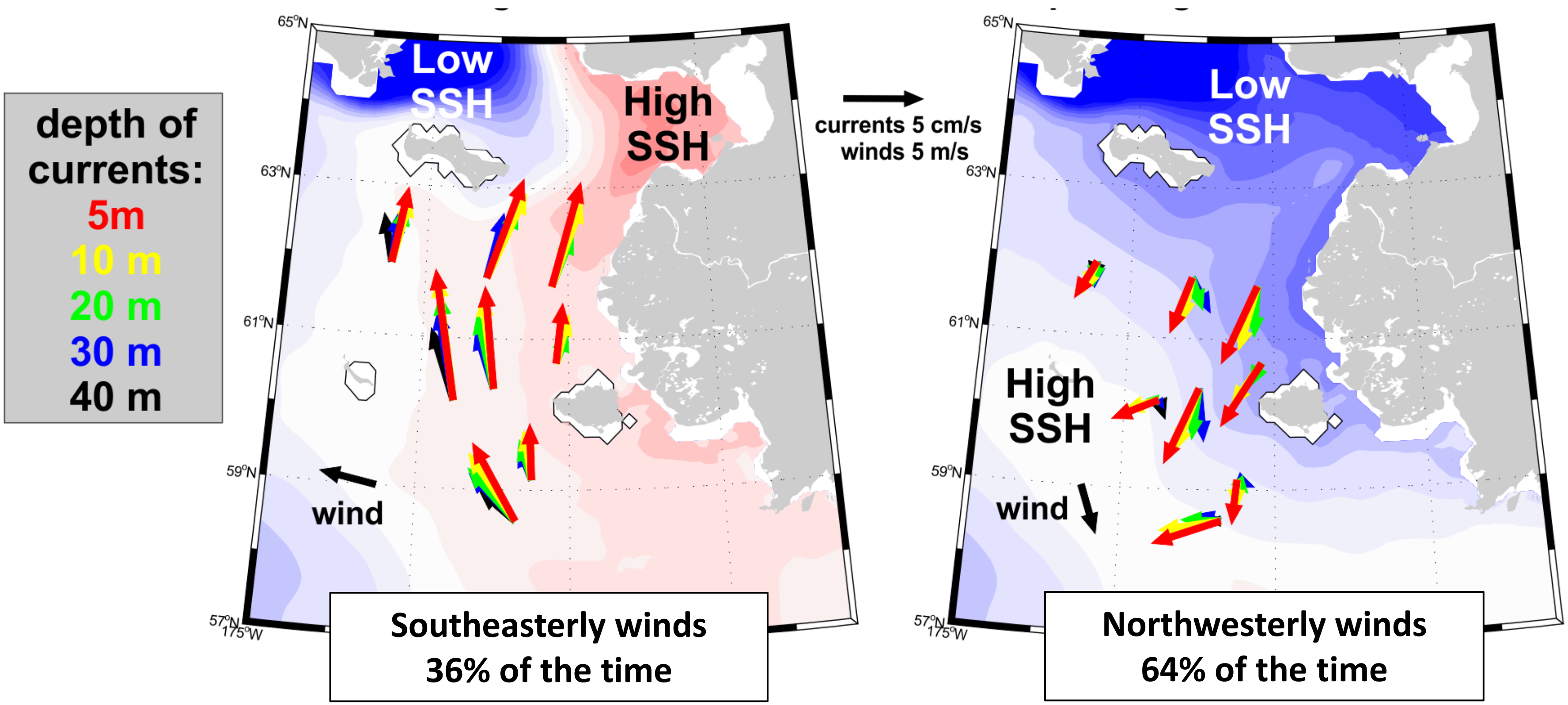
Transport pathways for oceanic zooplankton



Gibson et al., 2012

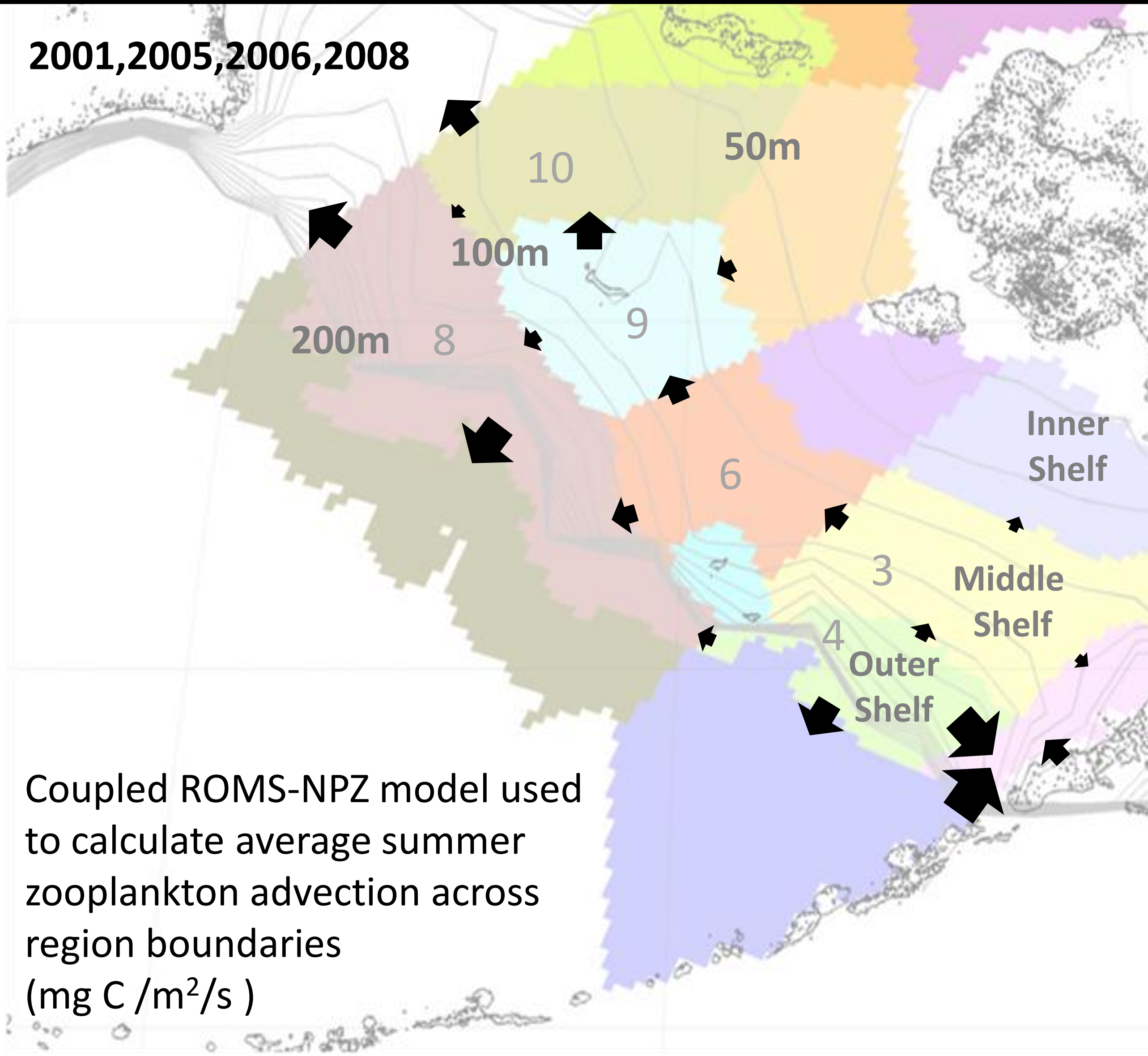
Shelf circulation: Two modes based on wind direction

[Danielson, et al., 2012.]

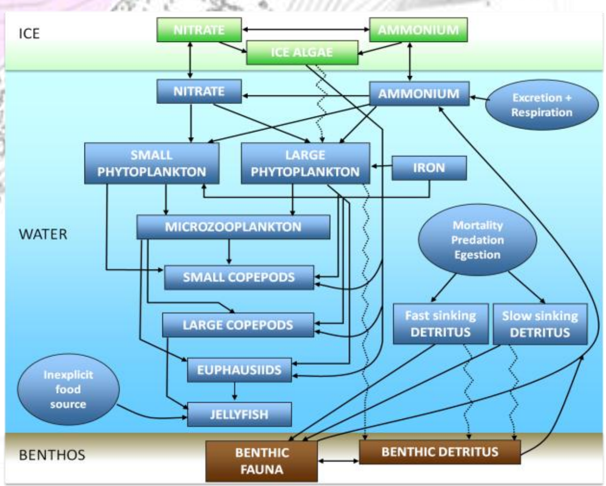


Shelf Euphausiid advection
- for years with predominantly NW winds

2001,2005,2006,2008

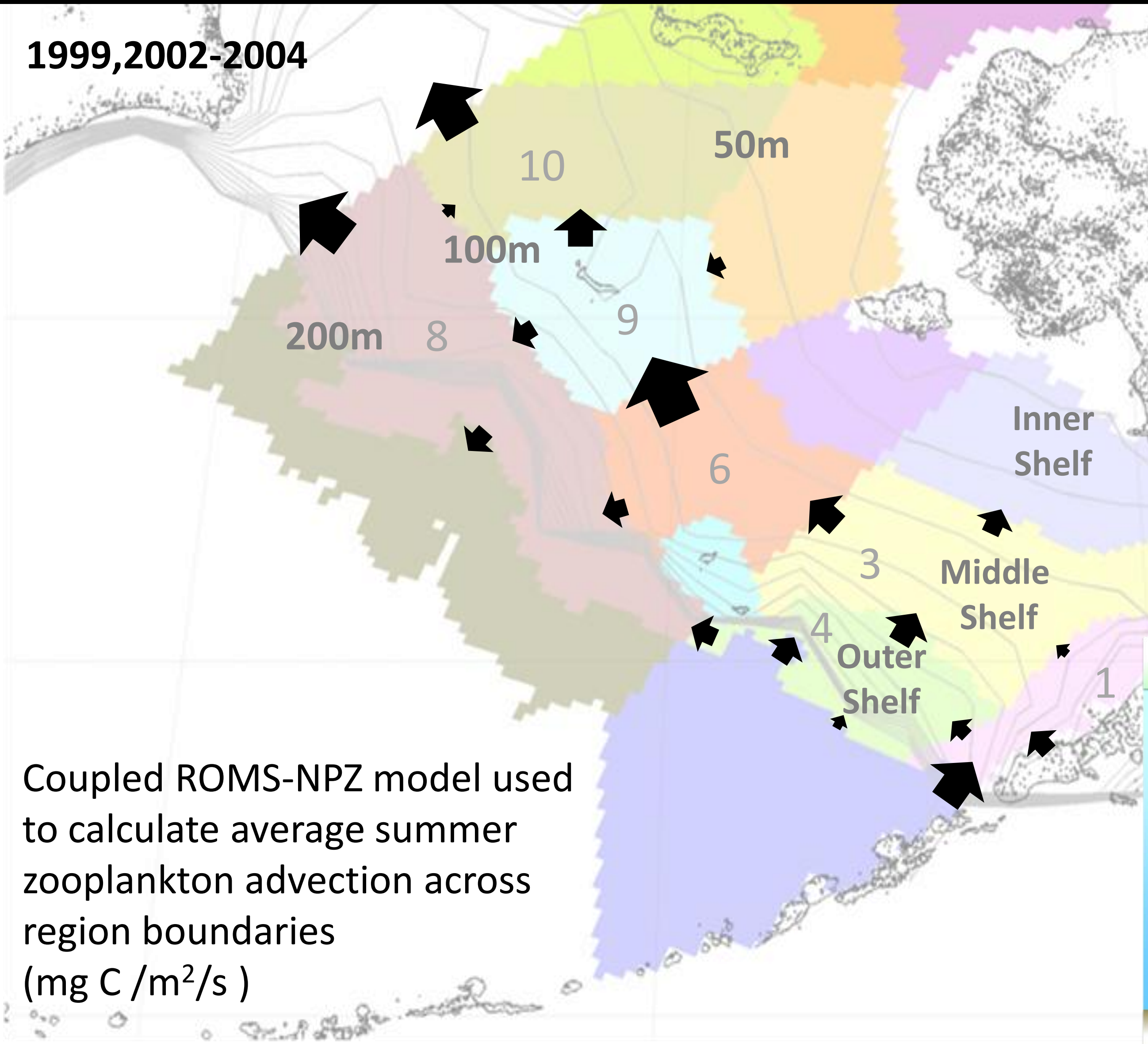


Coupled ROMS-NPZ model used to calculate average summer zooplankton advection across region boundaries
(mg C /m^2/s)

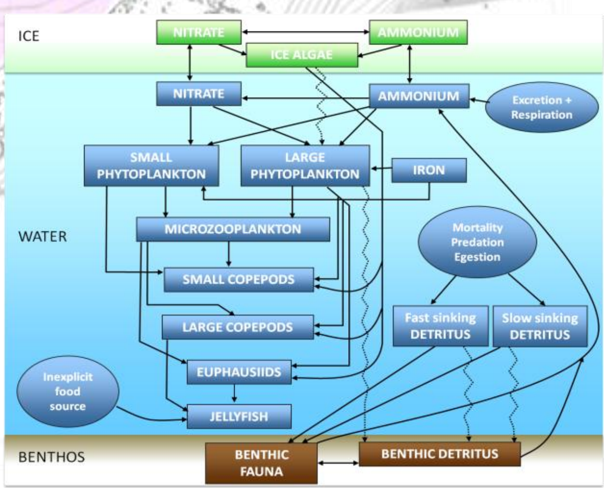


Shelf Euphausiid advection
- for years with predominantly SE winds

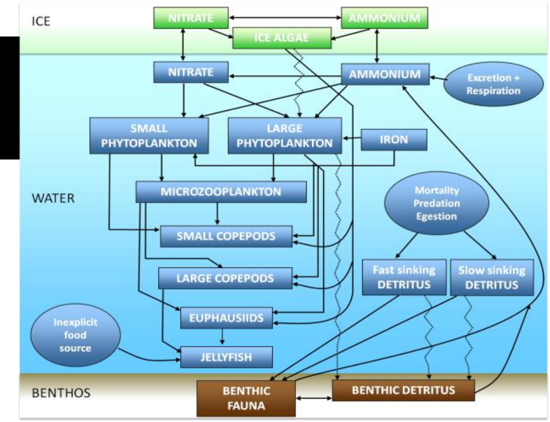
1999,2002-2004



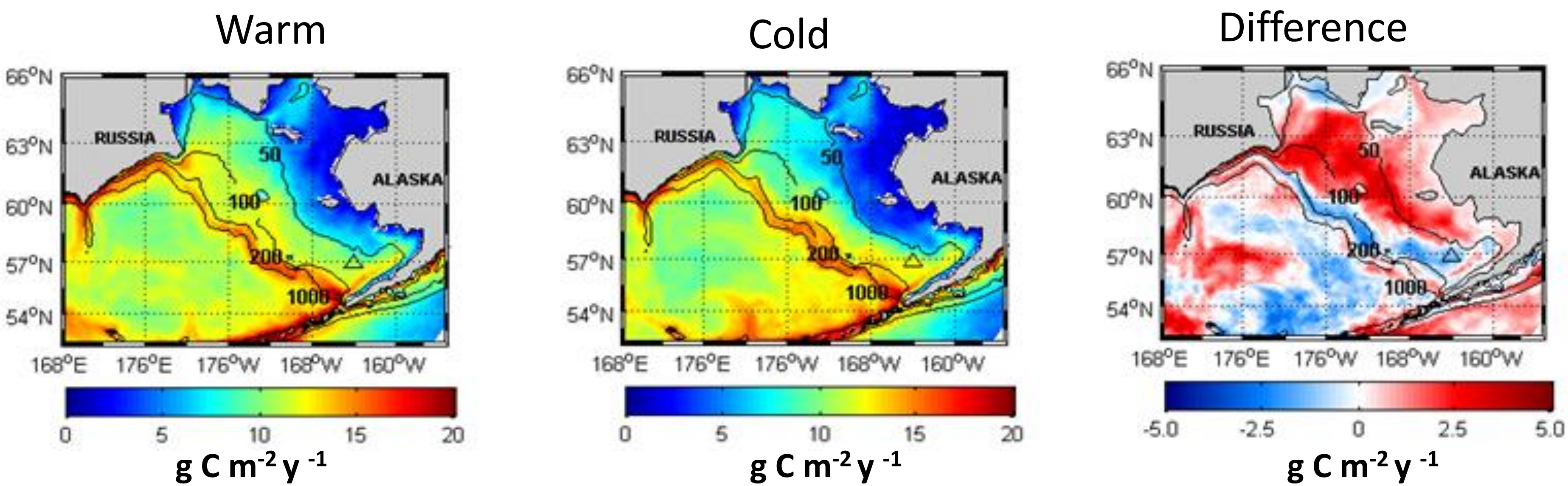
Coupled ROMS-NPZ model used to calculate average summer zooplankton advection across region boundaries
(mg C /m^2/s)



Modeled Euphausiid production



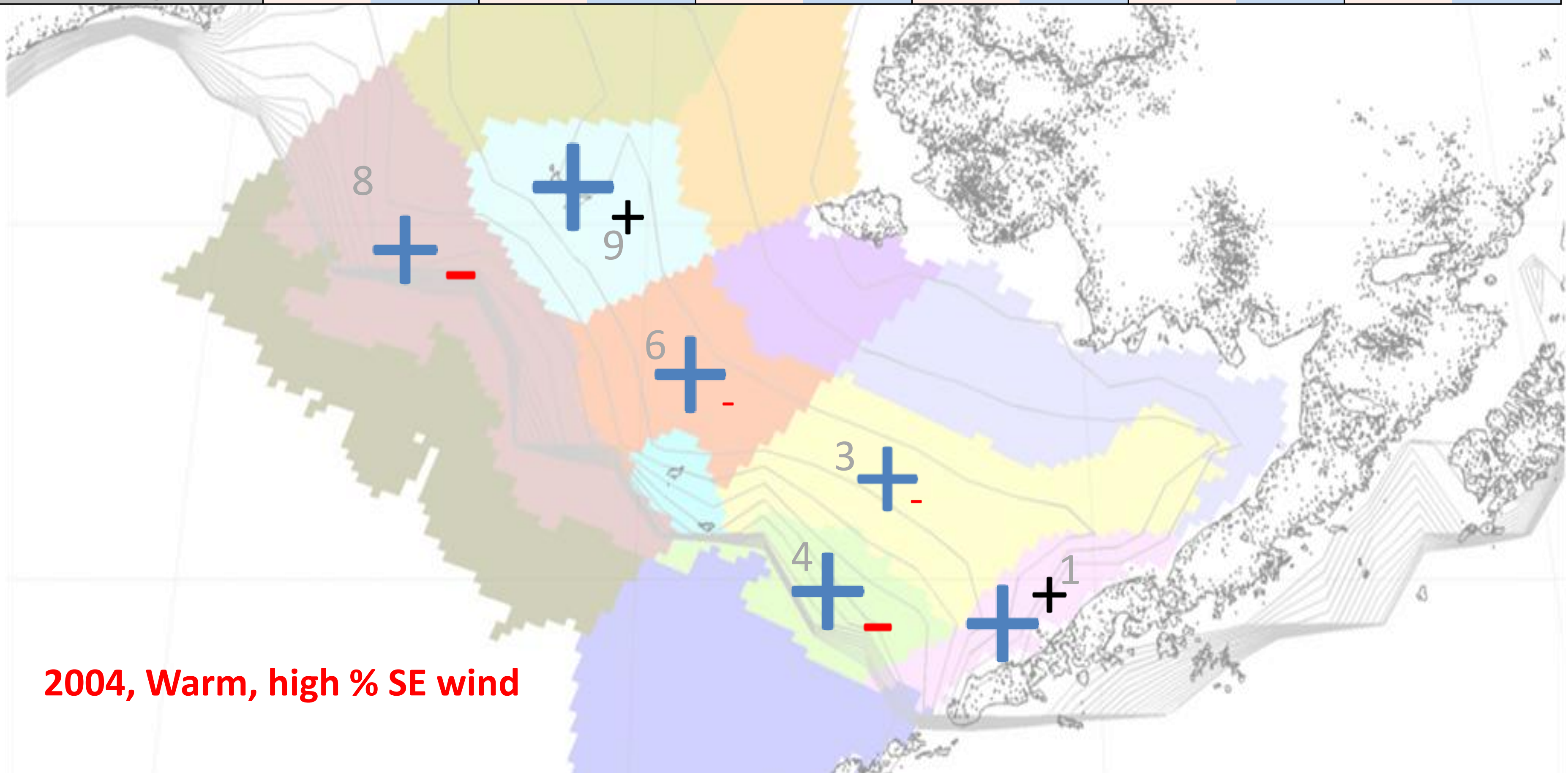
Cold years: **1999, 2007-2009**
Warm years: **2001-2005**



- **Inter-annual differences in euphausiid production not spatially uniform**
- **Euphausiid production higher in south in cold years but higher in north in warm years**

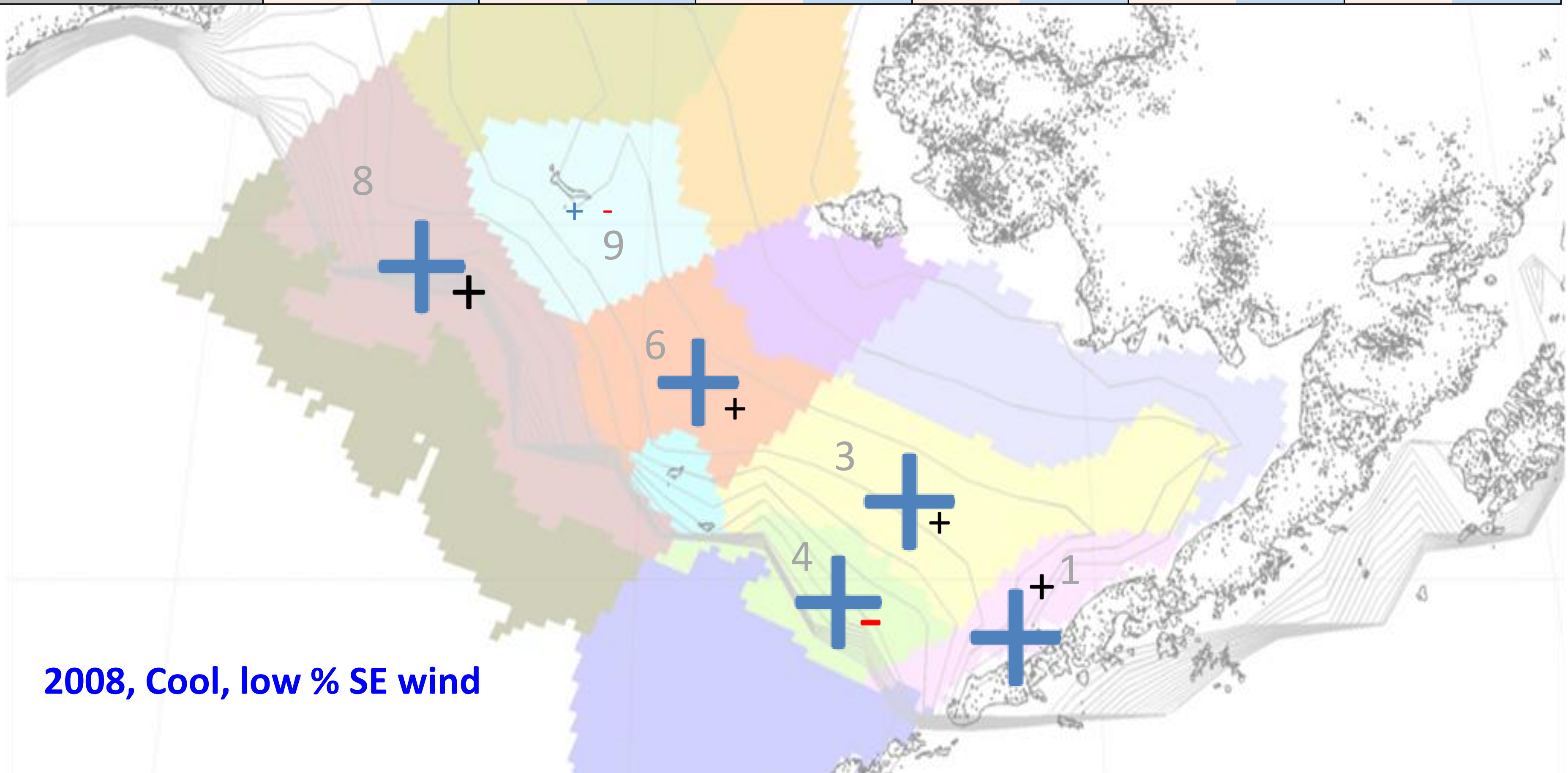
Regional contribution of advection and production

SUMMER	Region 1		Region 3		Region 4		Region 6		Region 8		Region 9	
mg C m^{-2} d^{-1}	2004	2008	2004	2008	2004	2008	2004	2008	2004	2008	2004	2008
Flux in	48.709	41.929	12.16	14.413	29.156	18.354	11.888	10.906	22.267	20.817	13.581	3.471
Flux Out	36.822	33.174	12.756	14.236	56.983	37.167	14.165	10.829	34.948	18.679	7.8814	11.909
Difference	**11.888**	**8.7545**	**-0.596**	**0.1768**	**-27.83**	**-18.81**	**-2.277**	**0.0767**	**-12.68**	**2.1373**	**5.6996**	**-8.438**
Production	**54.564**	**68.036**	**45.465**	**68.125**	**54.397**	**66.037**	**53.352**	**61.223**	**48.505**	**65.445**	**61.584**	**8.4435**
Biomass (mg C m^{-2})	2975	3656.1	2440.1	3708.6	3000	3438.3	2955.2	3600.1	2611.4	3566.4	3626.1	3534.2



Regional contribution of advection and production

SUMMER	Region 1		Region 3		Region 4		Region 6		Region 8		Region 9	
mg C m^{-2} d^{-1}	2004	2008	2004	2008	2004	2008	2004	2008	2004	2008	2004	2008
Flux in	48.709	41.929	12.16	14.413	29.156	18.354	11.888	10.906	22.267	20.817	13.581	3.471
Flux Out	36.822	33.174	12.756	14.236	56.983	37.167	14.165	10.829	34.948	18.679	7.8814	11.909
Difference	**11.888**	**8.7545**	**-0.596**	**0.1768**	**-27.83**	**-18.81**	**-2.277**	**0.0767**	**-12.68**	**2.1373**	**5.6996**	**-8.438**
Production	**54.564**	**68.036**	**45.465**	**68.125**	**54.397**	**66.037**	**53.352**	**61.223**	**48.505**	**65.445**	**61.584**	**8.4435**
Biomass (mg C m^{-2})	2975	3656.1	2440.1	3708.6	3000	3438.3	2955.2	3600.1	2611.4	3566.4	3626.1	3534.2



Take home thoughts

- Wind direction more critical than wind strength, temperature or runoff to on-shelf advection of zooplankton.
- Bering Sea shelf does not respond homogeneously to wind forcing.
- Mesoscale space and time scales important.
  - Transport pathways may be very localized i.e. in the vicinity of sub-marine canyons.
  - Short periods of winds in favorable directions can have large impact on advection.
- Connection to Arctic reduced in years with lots of SE wind.
- On-shelf advection important to species composition
- Relative to production, advection contribution to biomass of shelf mesozooplankton is generally quite small.