# Highlights of Decadal Scale Biological Studies in the RUSALCA program

**Jackie Grebmeier[1], and the RUSALCA PIs[2]**

**Highlights from May 21-23, 2013 RUSALCA PI Meeting in St. Petersburg, Russia**

[1]Chesapeake Biological Laboratory, University of Maryland Center for Environmental Sciences, Solomons, Maryland, USA
[2]RUSALCA PIs at St. Petersburg, Russia meeting, see co-author list in slide 2)

# RUSALCA PI Meeting, St. Petersburg, Russia, May 2013

**PIs US+co-PIs**

| | |
|---|---|
| Jacqueline Grebmeier | University of Maryland |
| Russell Hopcroft | University of Alaska Fairbanks |
| Bodil Bluhm | University of Alaska Fairbanks |
| Catherine Mecklenburg | Pt. Stephens Research |
| Robert Pickart and Maria Pisareva | Woods Hole Oceanographic Institution |
| Terry Whitledge | University of Alaska |
| Carin Ashjian | Woods Hole Oceanographic Institution |
| Brenda Holladay | University of Alaska |
| Kate Stafford | University of Washington |
| Kevin Wood | University of Washington/JISAO |
| Jonathan Whitefield | University of Alaska |

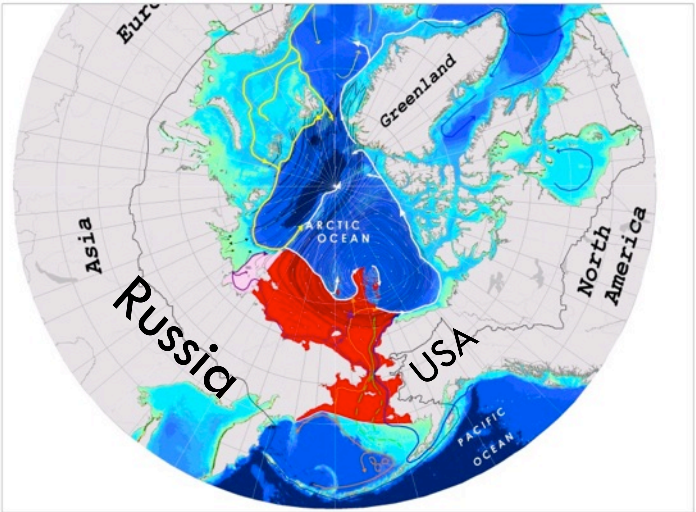
**PIs Russia+others**

| | |
|---|---|
| Vladimir Smolin | GNINGI |
| Yuri Frolov | MTB |
| Tatiana Matveeva | VNIIOkeangeologia, St. Petersburg |
| Ksenia Kosobokova | Shirshov Institute of Oceanology, Moscow |
| Alexander Savvichev | Institute of Microbiology, RAS, Moscow |
| Stanislav Denisenko | Zoological Institute (ZIN), RAS |
| Maria Pisareva | Shirshov Institute of Oceanology, Moscow |
| Elizaveta Logvina | VNIIOkeangeologia, St. Petersburg |
| Natalia Chernova | ZIN, RAS |

# Russian American Long-term Census of the Arctic (RUSALCA)

1. **Take observations where Arctic sea ice reduction is a maximum in the Pacific Arctic**
2. **Monitor fresh water, heat, nutrient fluxes and transport pathways through the Pacific Gateway to the Arctic**
3. **Monitor ecosystem indicators of climate change in the Pacific Arctic**
4. **Model and forecast changes in ecosystems and Arctic wide physical systems that impact global climate and ecosystem stability**
5. **Improve Russian-U.S. Arctic science relations**
6. **Explore the unknown Arctic**

Pacific Arctic AMA A.O. Negative

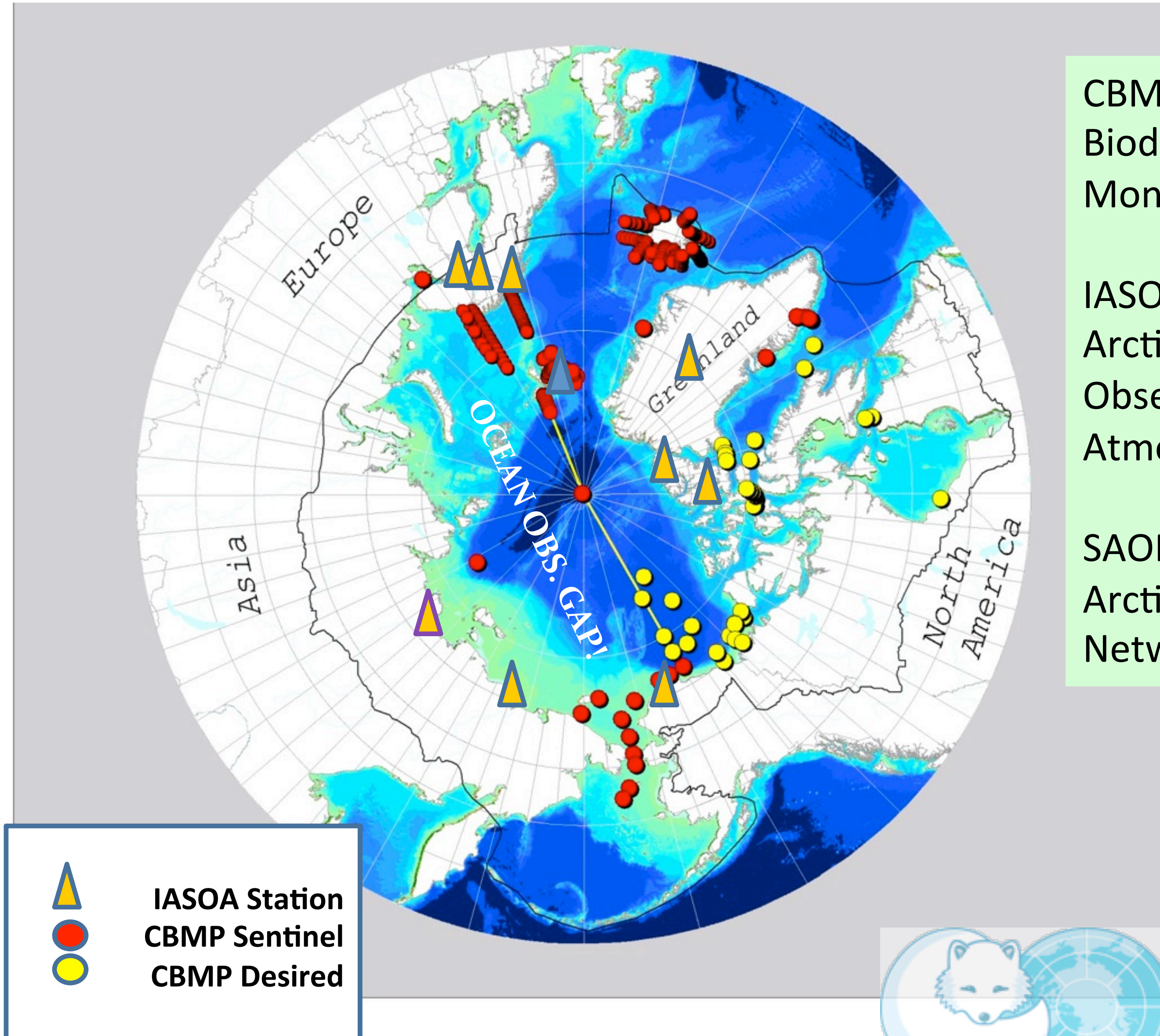



In A.O. Negative periods, the Pacific Arctic AMA is bound by the Lena River Outflow, the Atlantic Water Boundary Current, the Barrow Canyon and the Maximum Average Ice Extent in the Bering Sea

**The Pacific Arctic Region**

**Co-funding with NSF, RAS, FWS**

# Arctic Council Endorsed Observing Networks, including US-endorsed RUSALCA time series sites




CBMP=Circumpolar Biodiversity Monitoring Program

IASOA=International Arctic Systems for Observing the Atmosphere

SAON=Sustaining Arctic Observing Network

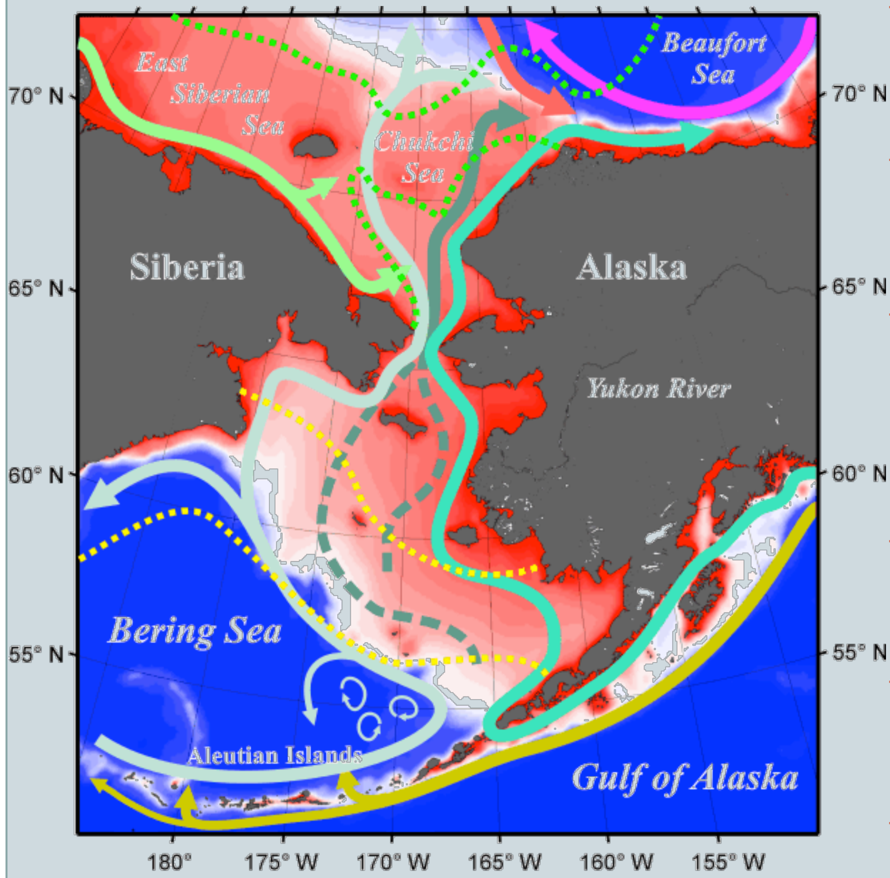
SAON SUSTAINING ARCTIC OBSERVING NETWORKS

CIRCUMPOLAR BIODIVERSITY MONITORING PROGRAM

ARCTIC COUNCIL

**IASOA and CBMP Stations**

# Introduction-Chukchi Sea




- Seasonally highly productive, but spatially heterogenous Arctic sea
- Northward flow from the Pacific Ocean in a mixture of currents
- Historically, data collection limited to either the Russian or U.S. side of the area –including Bering Strait
- Physical forcing: Atmospheric via winds, buoyancy flux, E-P
- Lateral inputs: Bering Strait, shelf-break, rivers
- Sea ice extent/timing retreat changing

Alaska Coastal Current

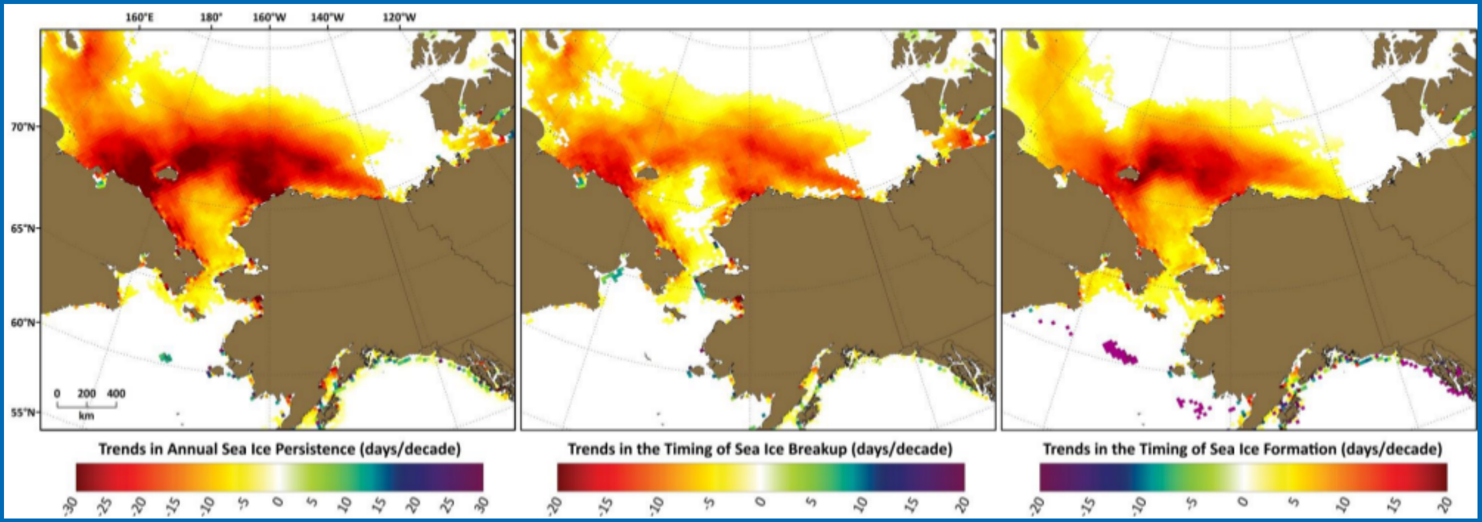
Bering Sea Current

Anadyr Current

East Siberian Sea Current

# Trends in sea ice coverage

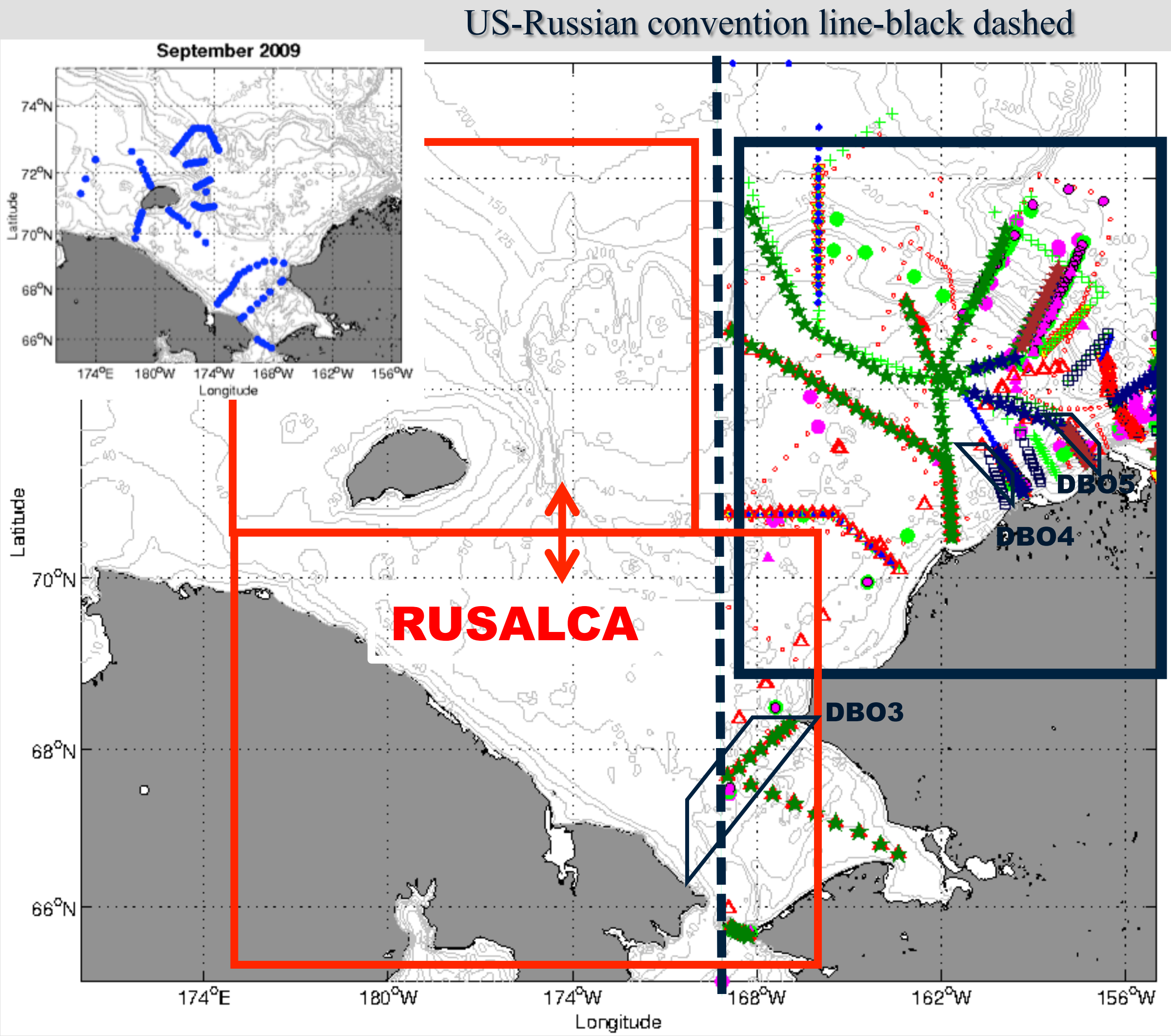
Annual persistence | Break up | Formation




From K. Frey

- **Dramatic reduction of sea ice in the Chukchi Sea**
- **Earlier sea ice break-up**
- **Later sea ice formation**
- **Both atmospheric and oceanographic influence on sea ice dynamics**

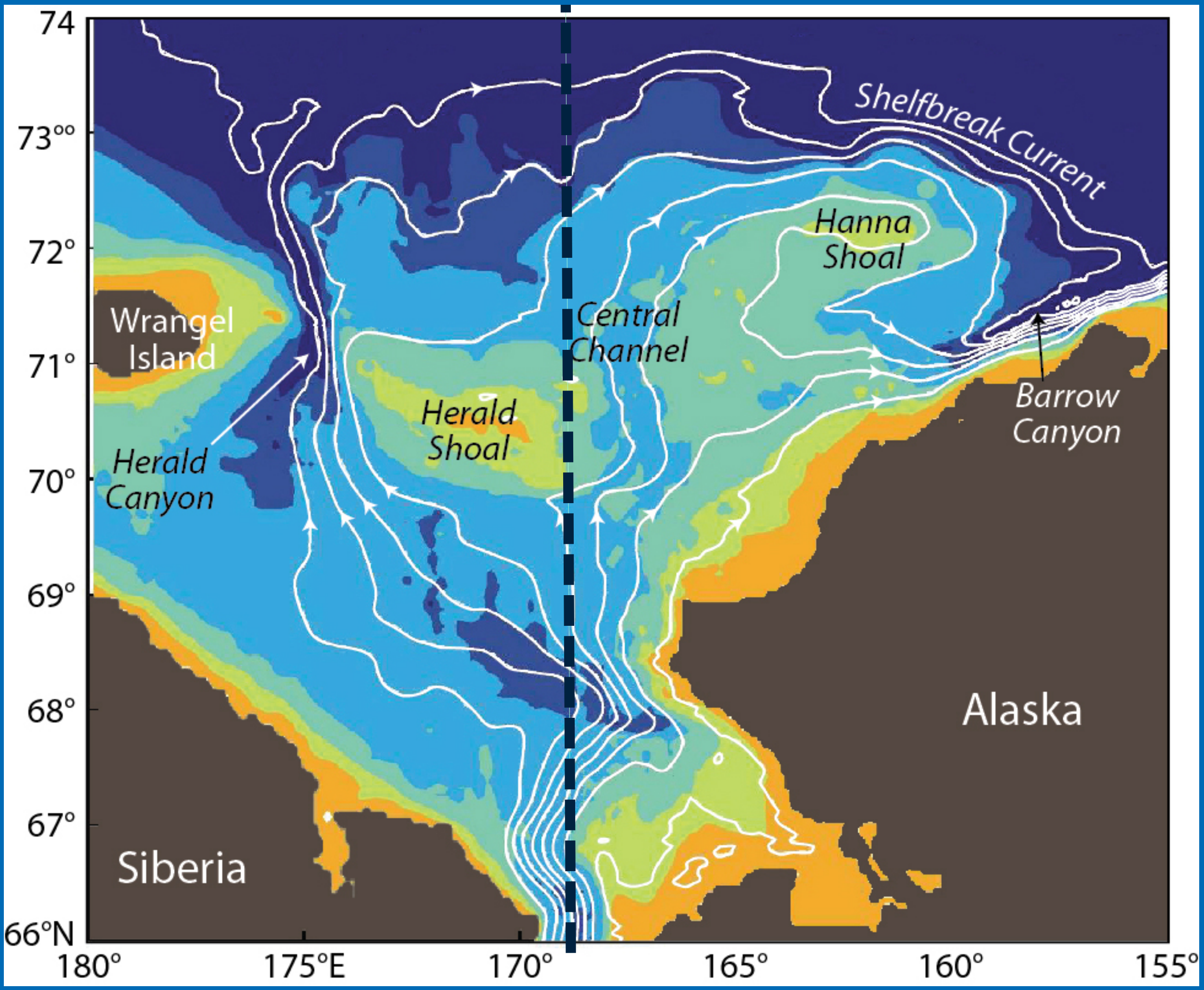
# Station occupations in the Chukchi Sea-last 10 yrs
## [updated graphic from R Pickart]




**RUSALCA only US program on Russian side in Chukchi Sea**

- **Colored transect lines: SBI and ICESCAPE programs (2002-2011)**
- **Black box include study areas:**
  - **AON Pickart NE Chukchi Sea/ Beaufort lines**
  - **AON Ashjian Barrow Canyon region**
  - **COMIDA Chukchi and Benthos (CAB) and Hanna Shoal (HS) programs 2008-2014 (BOEM)**
  - **Chukchi Sea Environmental Studies Program (CSESP; (Shell-Conoco Phillips-Statoil) 2008-2013**
  - **NOAA CHAOZ and ArcWest programs**
  - **DBO (Distributed Biological Observatory) international lines**
  - **International cruises: Canada, China, Japan, Korea**

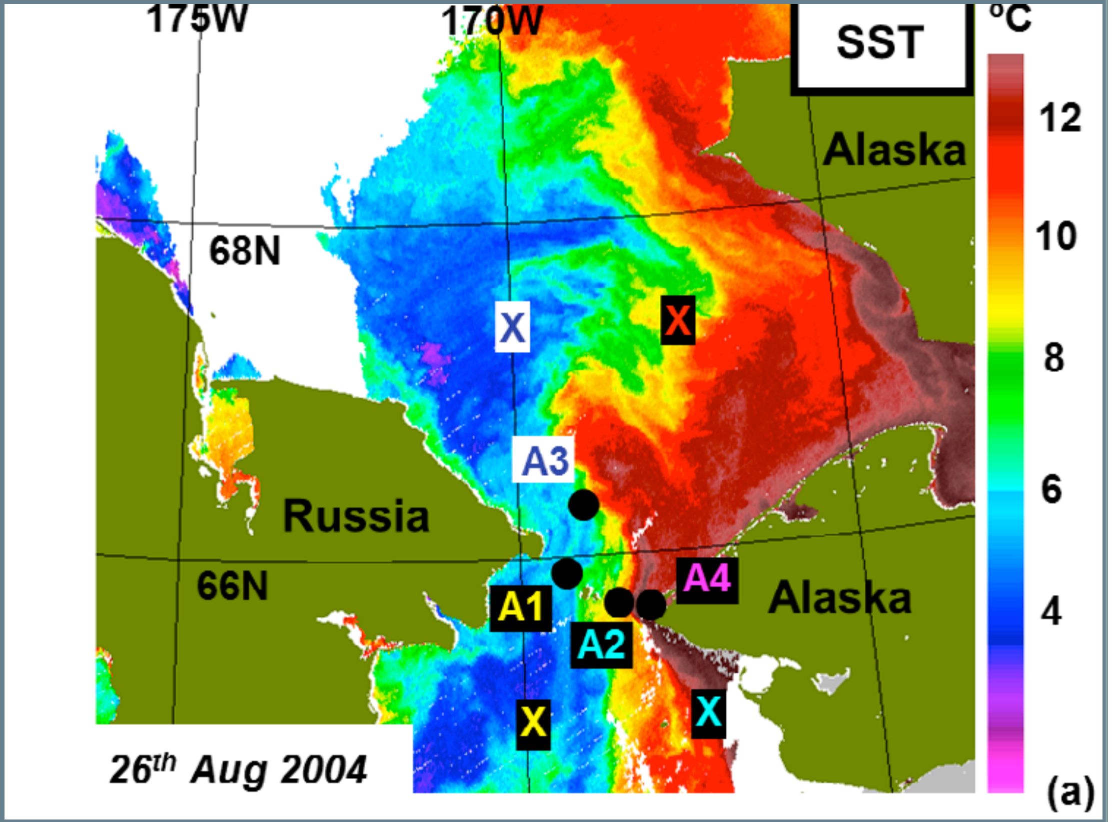
# Streamlines of Pacific Water flowing through the Chukchi Sea



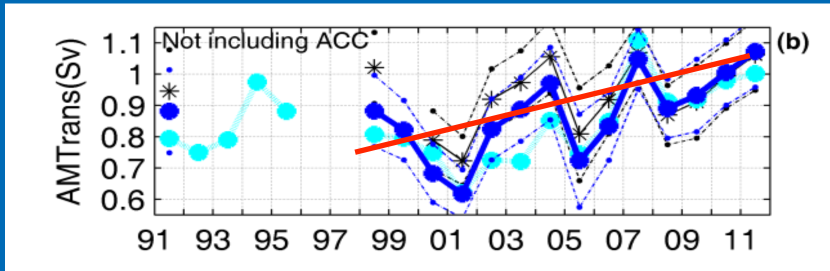

from Spall (2007)

# Moorings: Jonathan Whitefield, Tom Weingartner (UAF), Rebecca Woodgate (UW)- [NOTE Full mooring ppt for ARP review on NOAA website]

- Moorings deployed in the Bering Strait almost continuously since 1990.
- IPY and RUSALCA increased the number to 7 in the Strait since 2007, and another ~60km to the north – A3.
- Is A3 a true representation of flow in Bering Strait?
  - Does it truly account for the ACC?

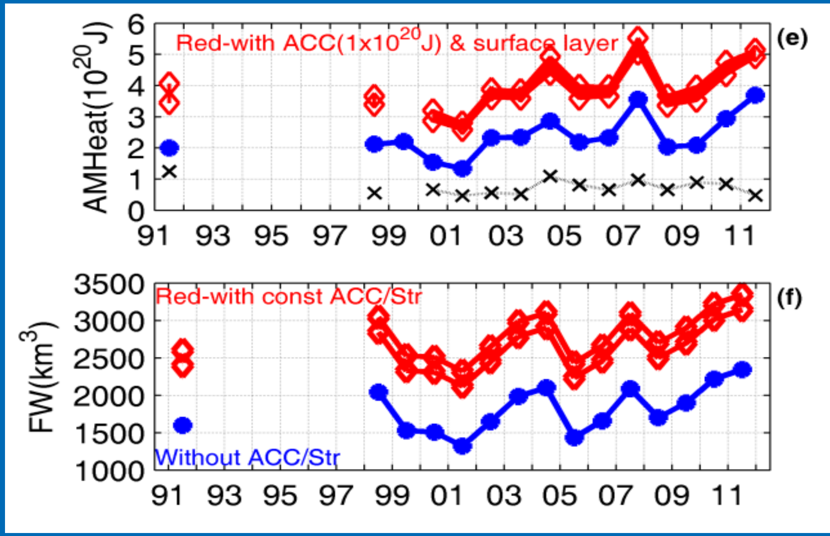



Bering Strait summer SST image (MODIS) showing main moorings (●) and NCEP wind grid points (X)




- Volume transport-increasing trend

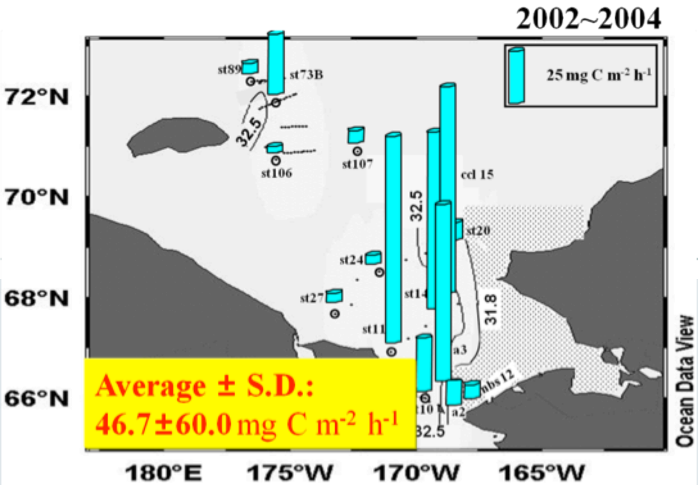
# Interannual variability of Bering Strait fluxes



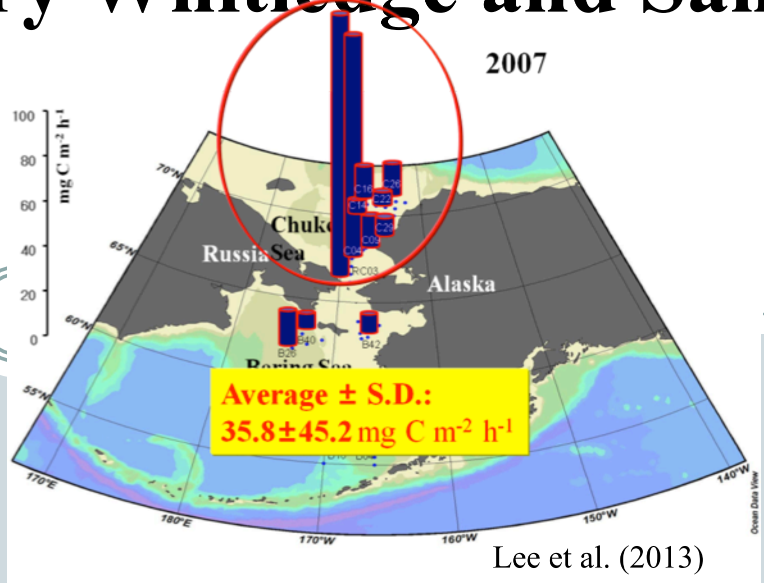

- Heat transport-increasing trend
- Freshwater transport-increasing trend

From Woodgate et al. (2013)

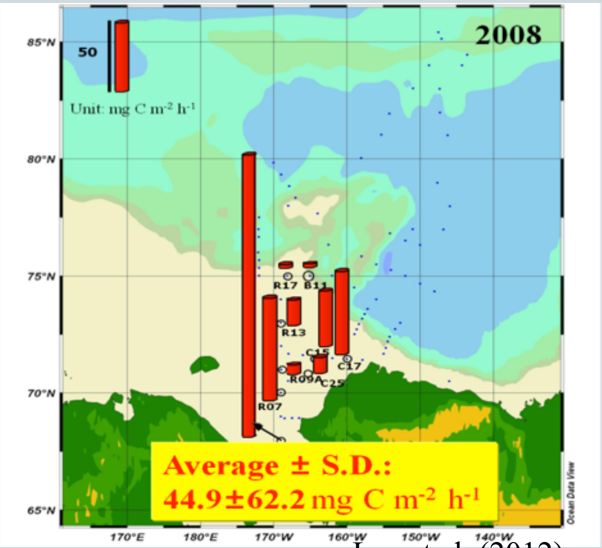
# Continuing measurement for Primary Productivity in the Chukchi Sea-Terry Whitledge and Sang Lee



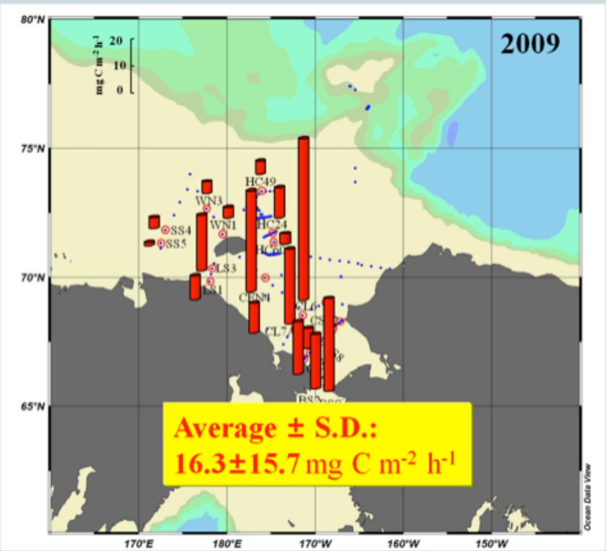

Lee et al. (2007)




Lee et al. (2013)



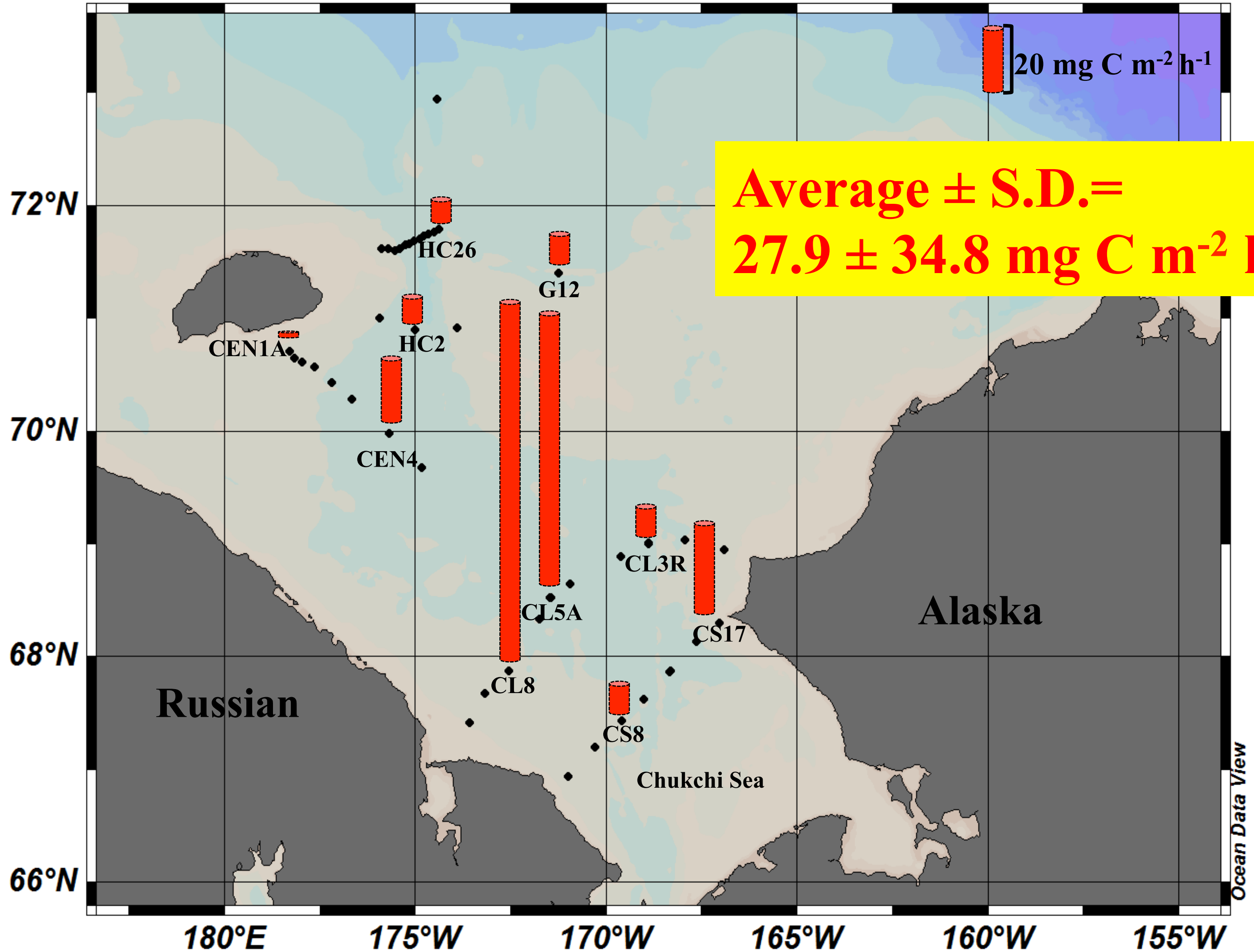

Lee et al. (2012)




Lee et al. (in preparation)

➔ Recent productivity is ~3 times lower than decade(s) ago in the Chukchi Sea!

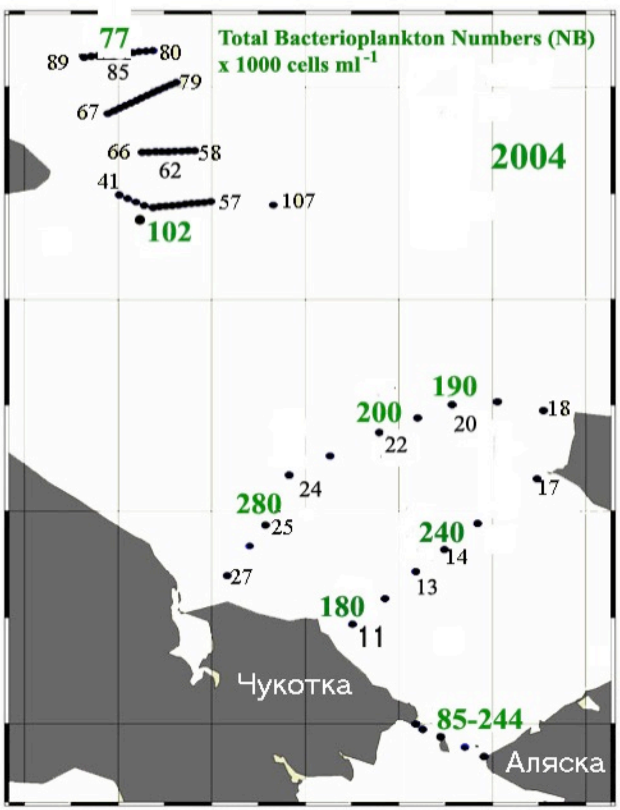
# Primary Productivity in the Chukchi Sea, 2012 (RUSALCA)



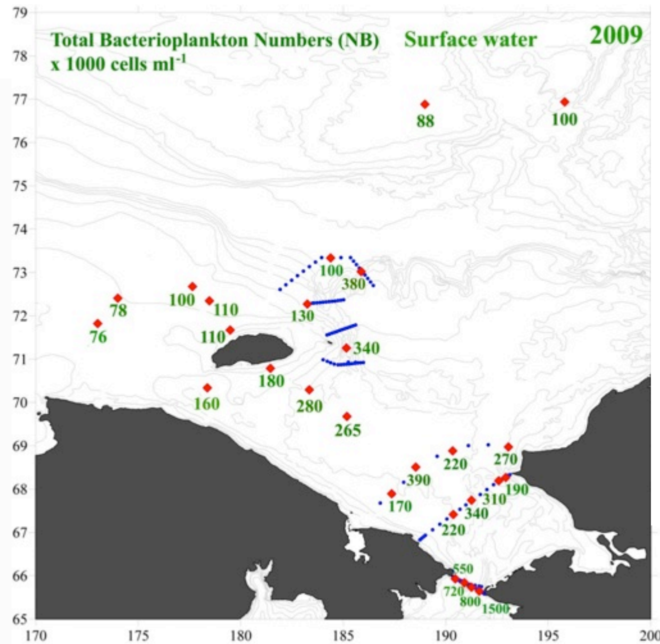

**Average ± S.D.= 27.9 ± 34.8 mg C $m^{-2}$ $h^{-1}$**

➔ 2012 productivity in the Chukchi Sea was still 3 times lower than decade(s) ago!

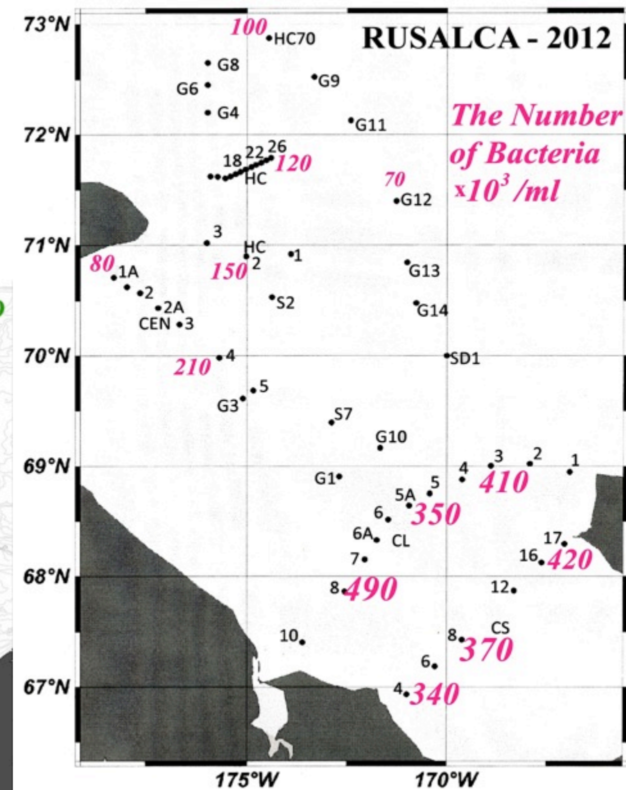
# Number of bacterioplankton in water column
# Savvichev Alexander, Russia




- 70 x $10^3$ cell per ml (in Herald canyon) to 280 x $10^3$ cell per ml (near Chukotka Peninsula).
- Average 170 x $10^3$ cell per ml .




- Bering Strait varied from 550 x $10^3$ cell per ml (near Chukotka) to 1500 x $10^3$ cell per ml (near Alaska);
- For Chukchi Sea –from 88 x $10^3$ cell per ml (north) to 380 x $10^3$ cell per ml (Herald Canyon)
- in East Siberian Sea from 76 x $10^3$ to 160 x $10^3$ (Longa Strait)
- Average 210 x $10^3$ cell per ml

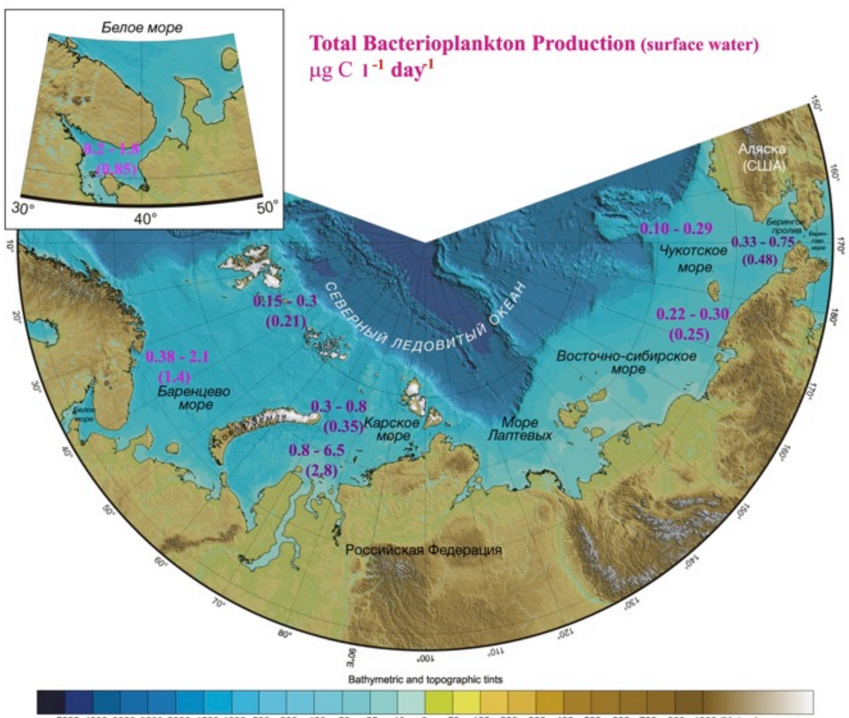


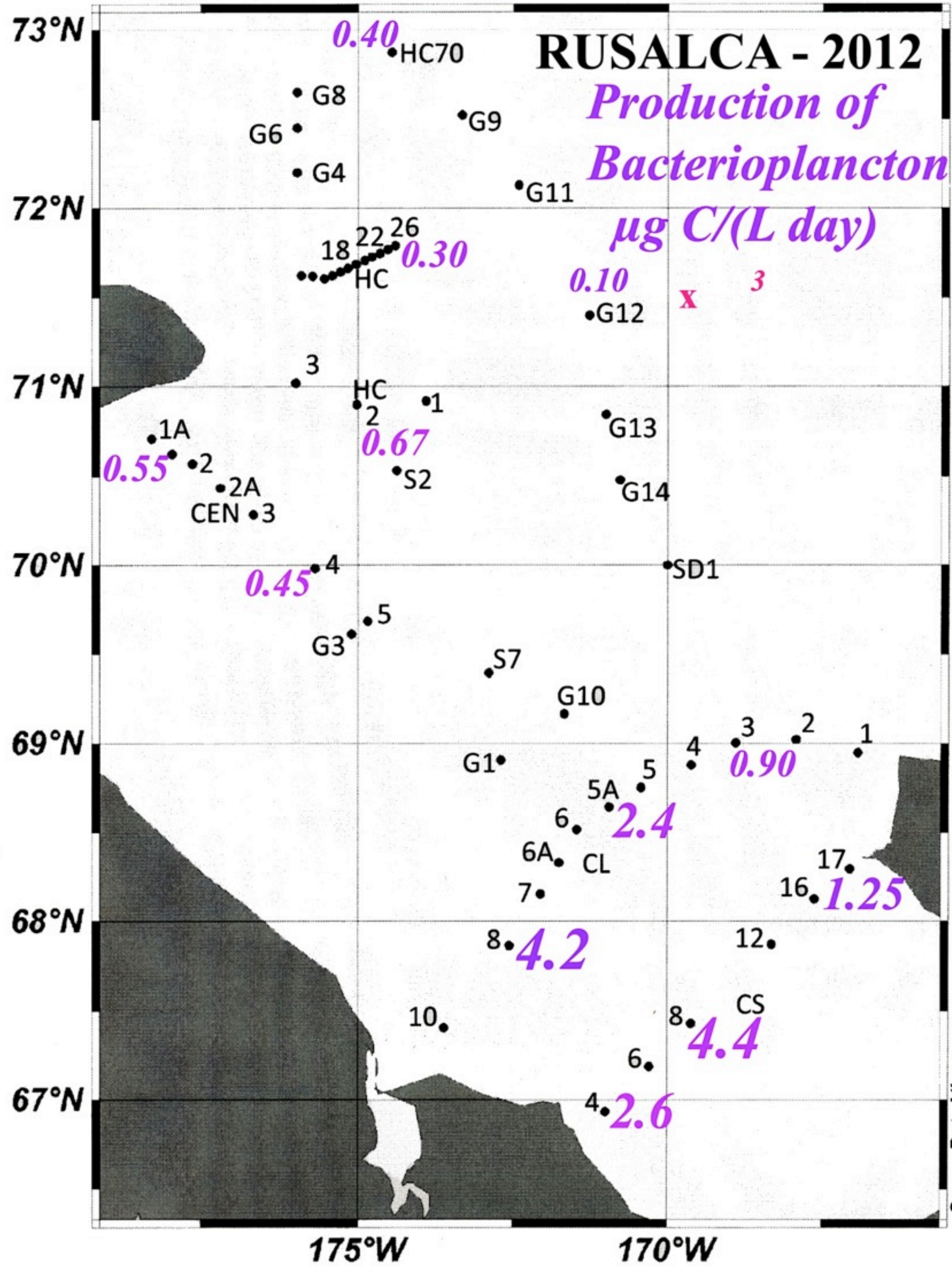

- 70-100 x $10^3$ cell per ml (North of Herald Canyon and Chukchi Sea) to 490 x $10^3$ cell per ml (near Chukotka)
- average 240 x $10^3$ cell per ml
- Region divided into two parts: the northern and southern as Number of bacterioplankton in these parts differ by 3 times.
- average total number of bacterioplankton in late summer for a three-year study ranged from 170 to 240,000 cells

**RIGHT:** The value of production of bacterioplankton in Chukchi Sea in 2012 was clearly different in the northern and southern part of the Chukchi Sea. In 2004 and 2009 this pattern was not so clear.

- **North 0.10 – 0.67**
- **South 0.90 – 4.4 (μg C $l^{-1}$ $day^{-1}$)**

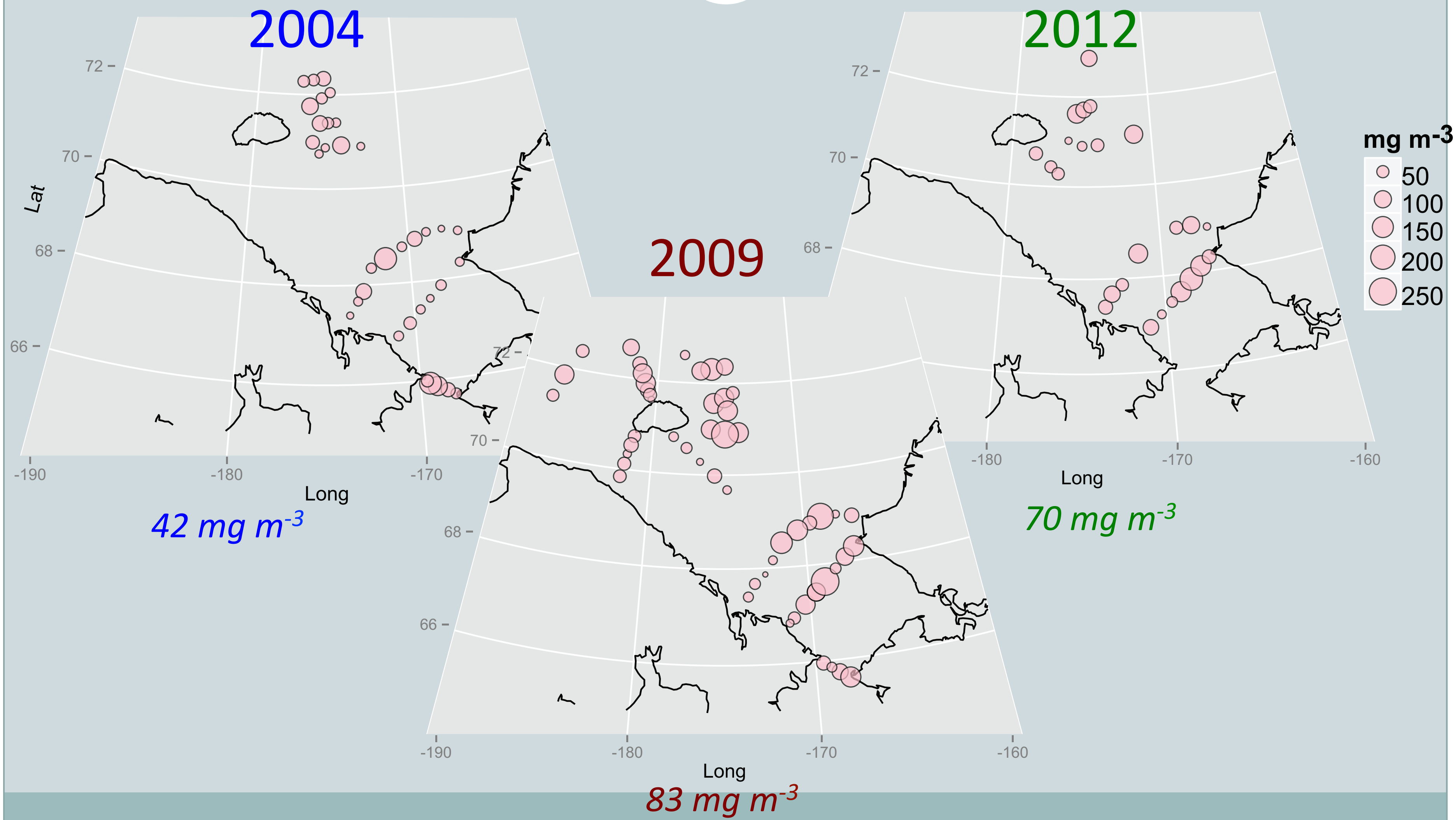
**BELOW:** Production of bacterioplankton in Chukchi Sea in 1.5 - 3 times more low, than in White Sea, Barents Sea and Kara Sea



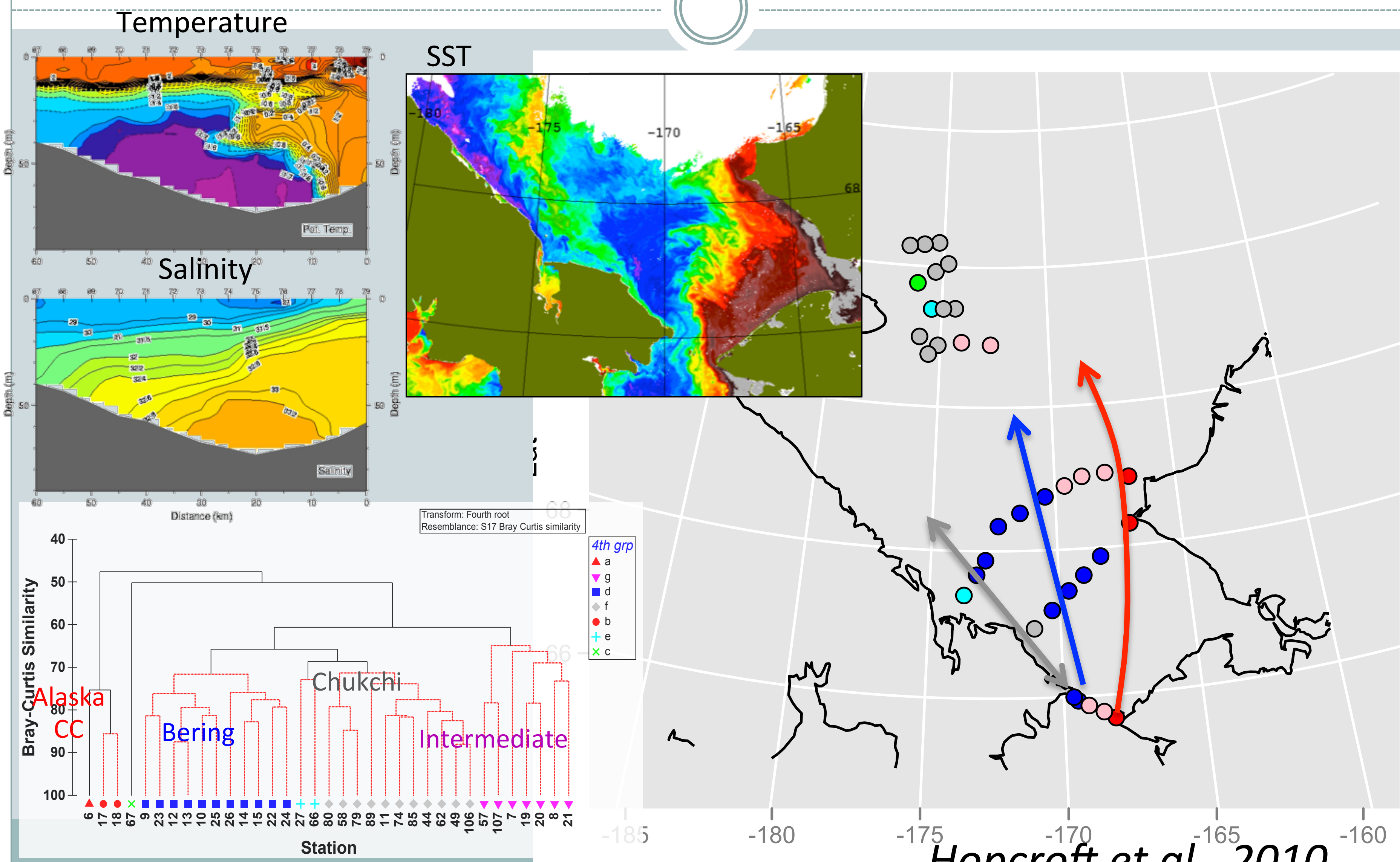



# Zooplankton Communities: Elizaveta Ershova, Russ Hopcroft, UAF, and Ksenia Kosobokova, Shirsov Inst. Of Oceanology

## Key players: Copepods (3-5 species dominate by biomass)

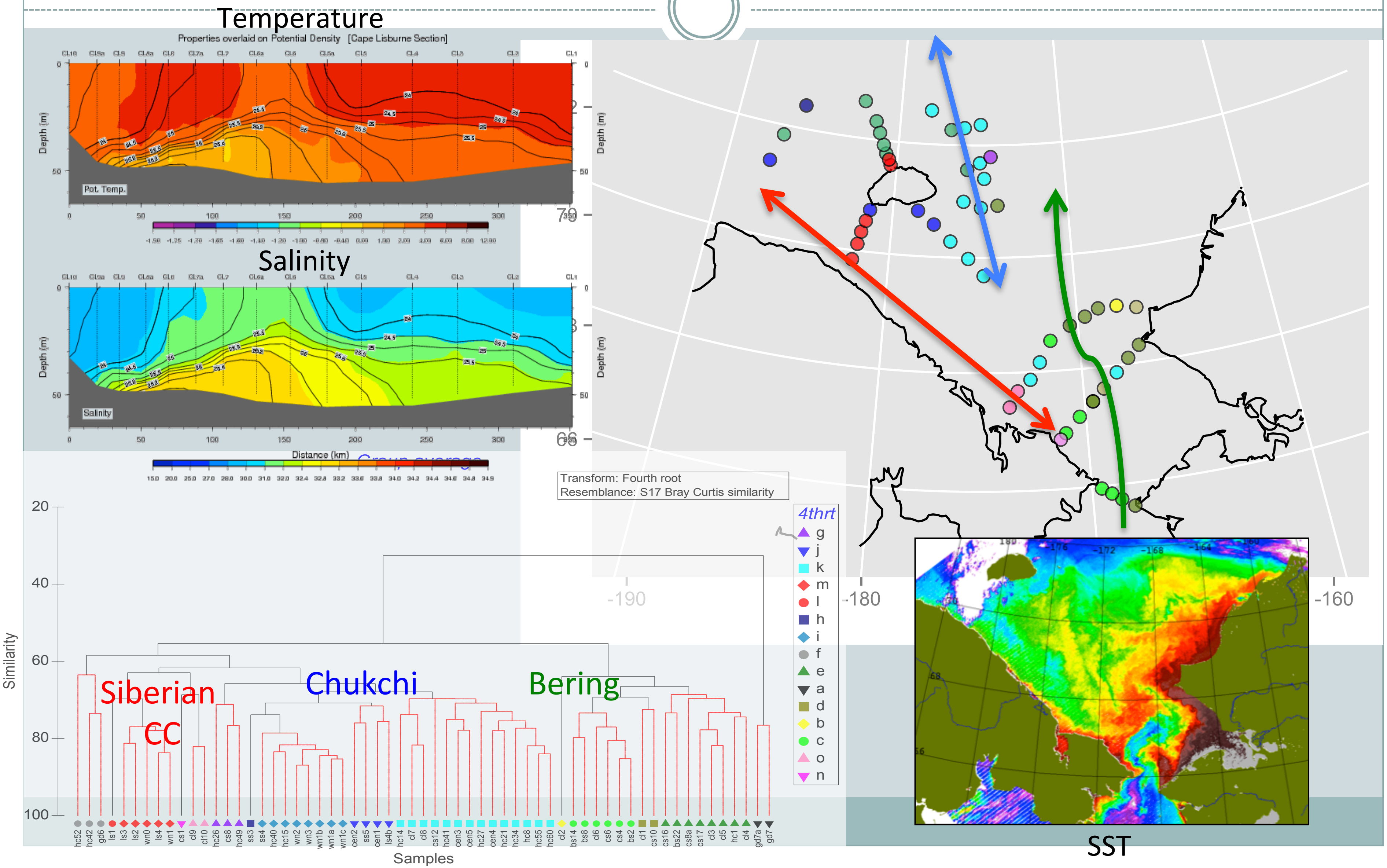


# Community patterns - 2004

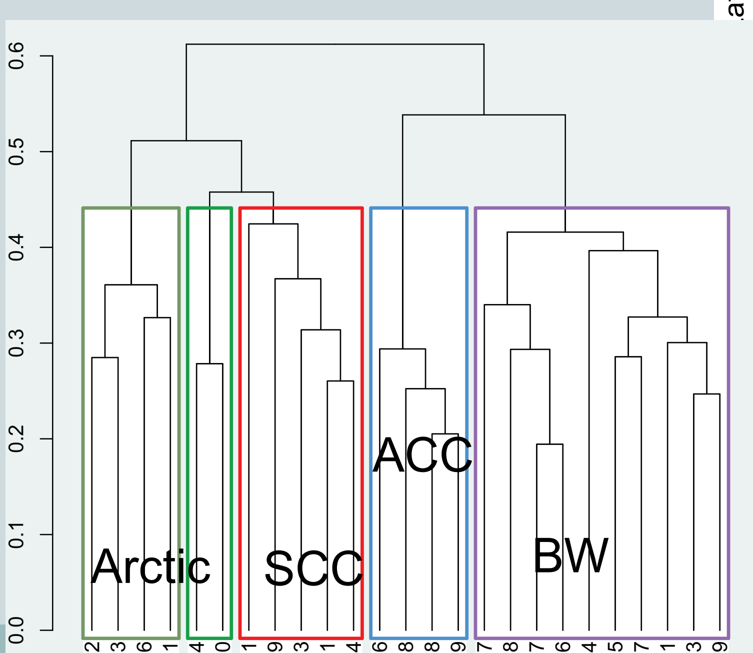


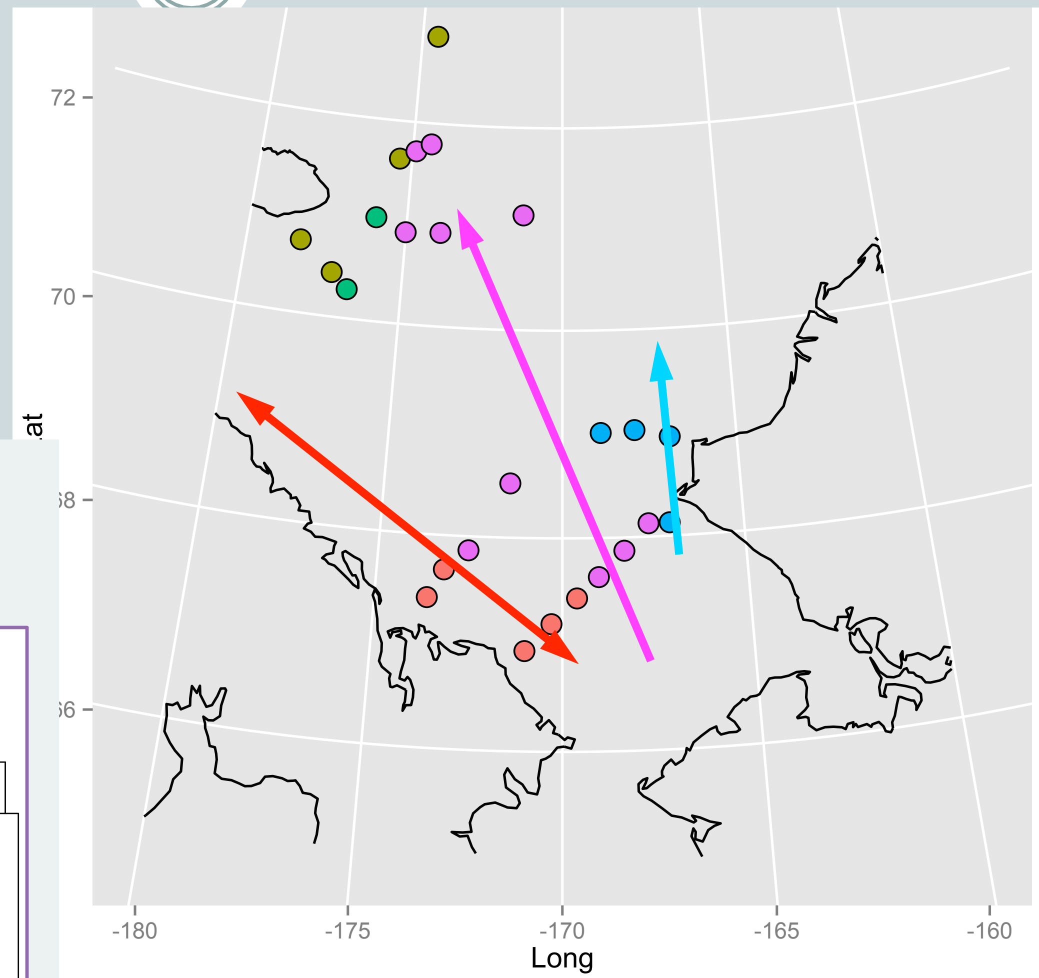

*Hopcroft et al., 2010*

# Community patterns- 2009



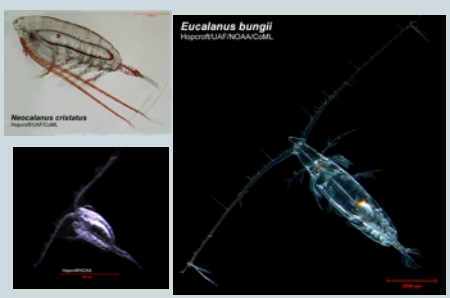
# Community patterns – 2012



# Community structure

**Bering oceanic forms (Anadyr Current)**
*Neocalanus spp.*
*Eucalanus bungii*
*Metridia pacifica*
*Microcalanus*





**Bering Shelf forms**
*Metridia pacifica*
*Pseudocalanus spp.*
*Aglantha digitale*
*Acartia longiremis*
*Meroplankton*

**Low salinity, neritic (Alaska Coastal Current )**
*Acartia hudsonica*
*Centropages hamatus*
*Eurytemora spp.*
*Evadne, Podon*
Meroplankton

Bering Strait

## Objectives

• evaluate carbon export to benthos via sediment oxygen uptake and nutrient exchange studies (HAPS corer)

• sediment indicators (TOC, chl a, grain size)

• benthic infaunal population structure and biomass (133 $cm^2$ cores and 0.1 $m^2$ van Veen grabs)

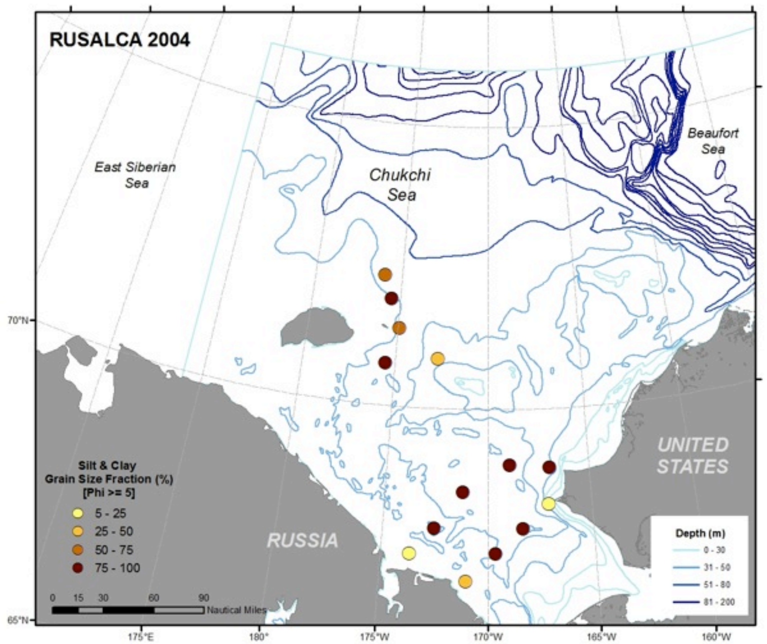
• stable and radioisotope analyses

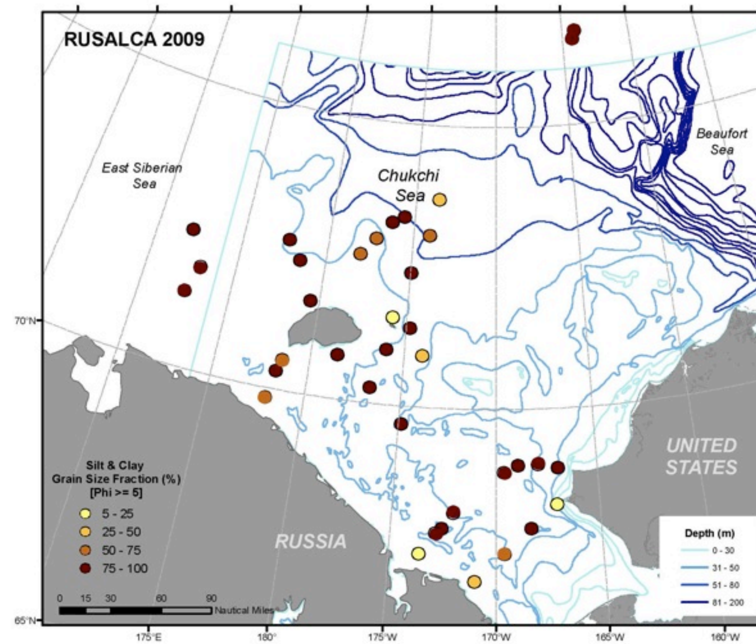
RUSALCA

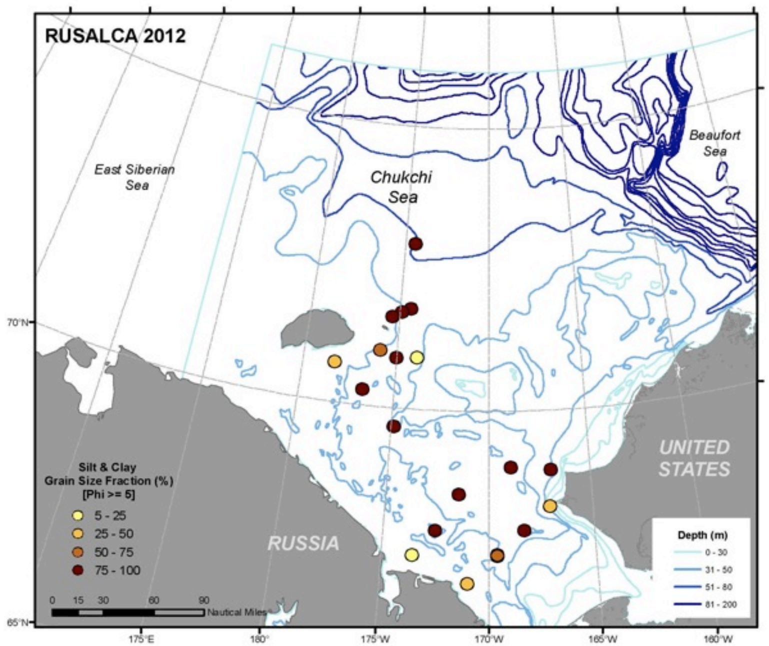
NOAA

PIs: Jackie Grebmeier and Lee Cooper, UMCES/CBL, Solomons, MD, USA

# % Silt and clay content-indicator of deposition zones

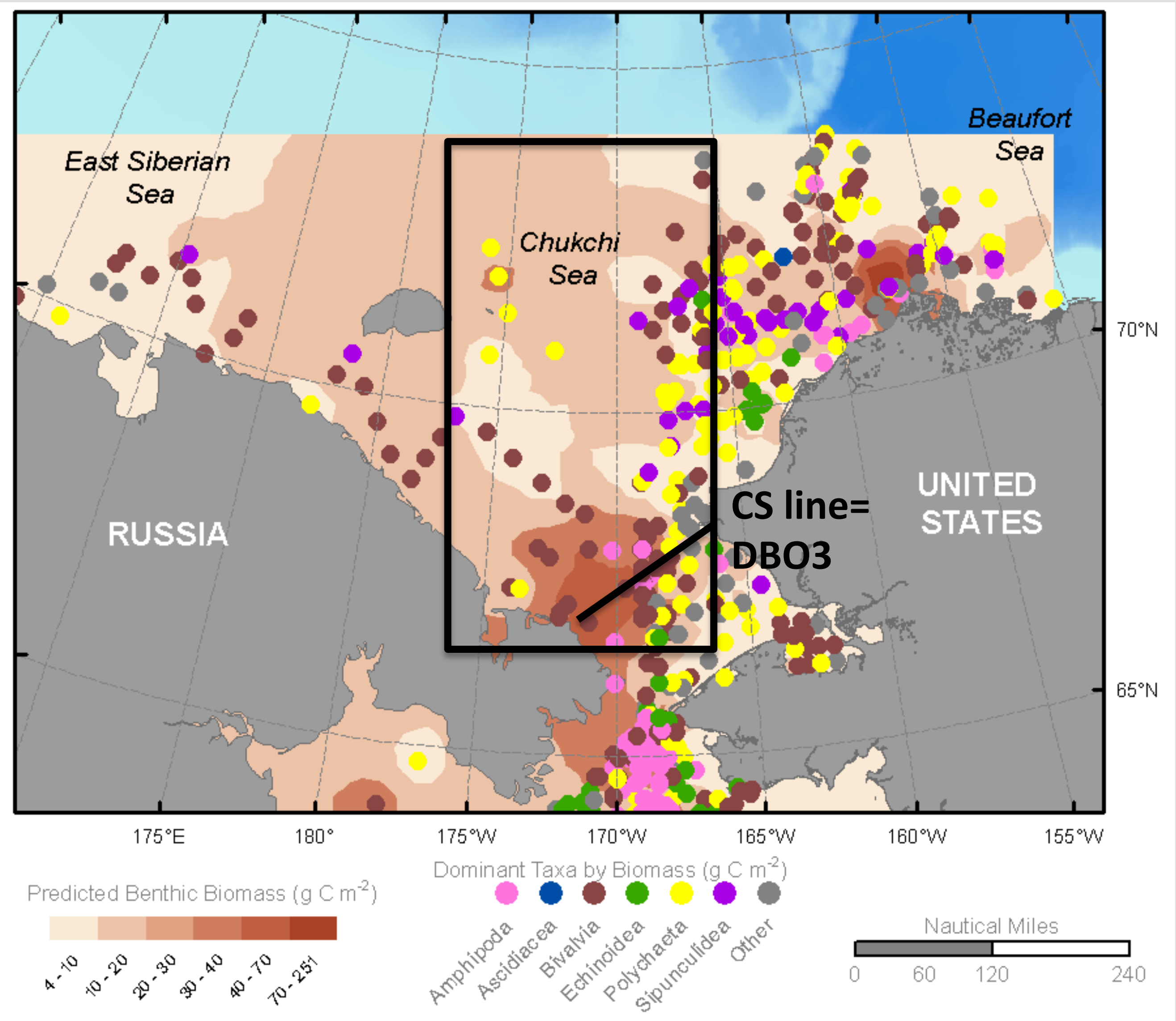



- Higher silt and clay (%) in upper/central Herald Valley and western side of Herald Canyon; also around Wrangell Island
- Sandy sediments (low % silt/clay) along the Alaskan and Chukotka coastline
- Indication of few station coarsening of grain size NW of Bering Strait perhaps related to recent flow increase
- Percent Total organic carbon has similar patterns

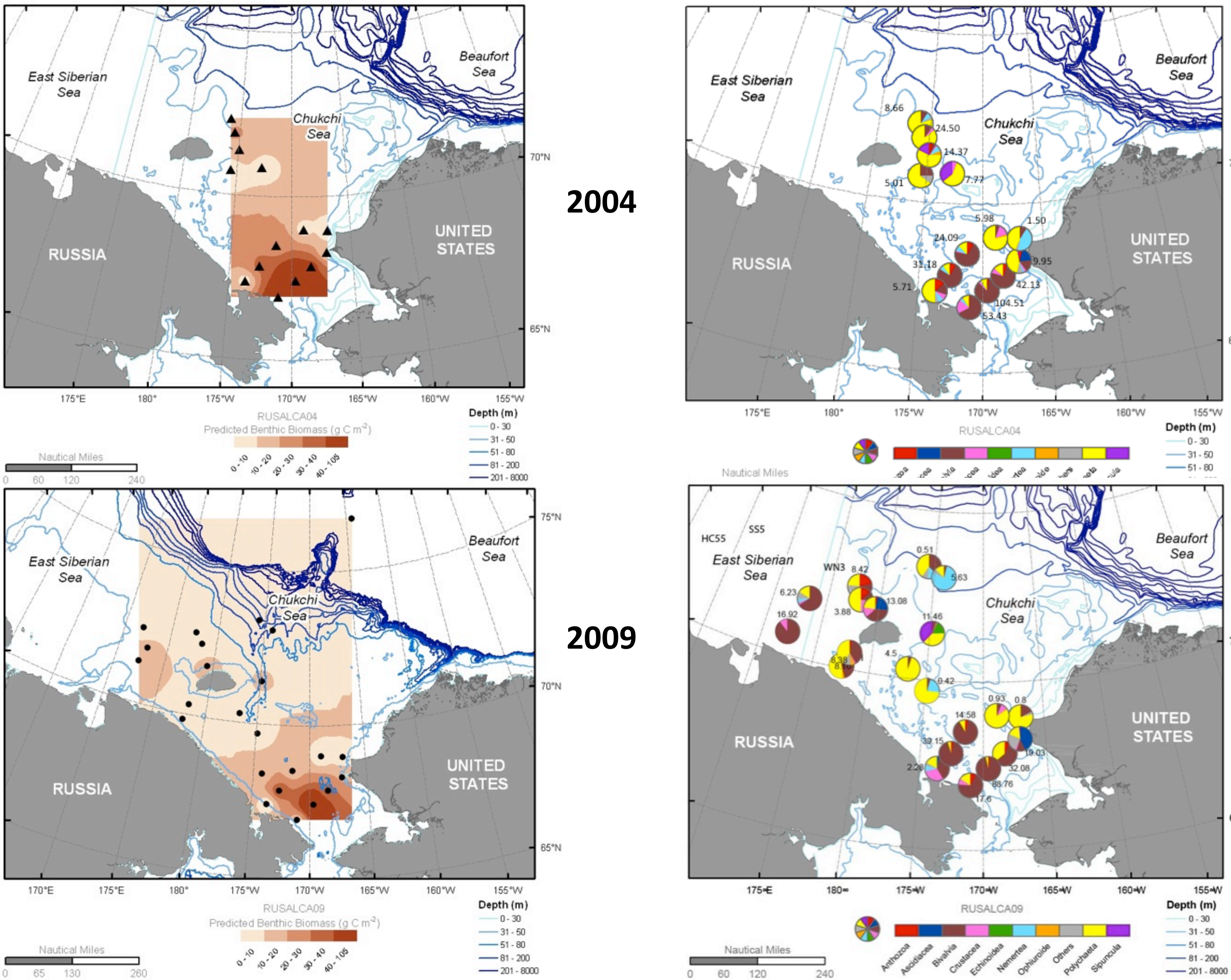
# Rich benthic communities on the western side of the Bering/Chukchi Sea system 1970-2010




- **"footprints"** of high benthic biomass reflect pelagic-benthic coupling and export of carbon to sediments
- advection of organic carbon also influences biomass patterns

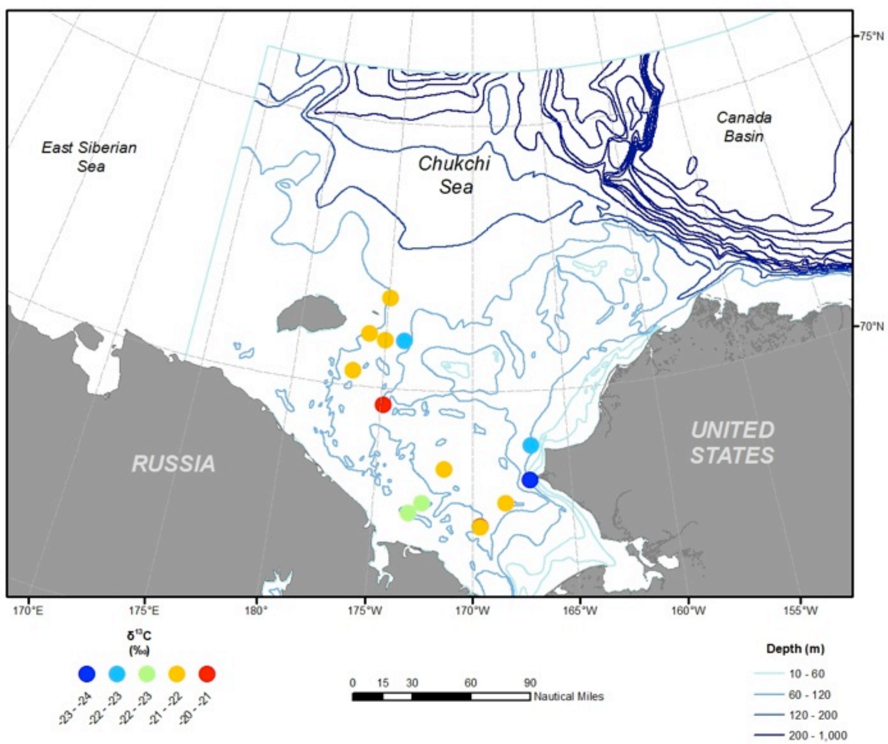
[updated from Grebmeier et al. 2006a]

# Infaunal biomass and community composition during RUSALCA04 and 09

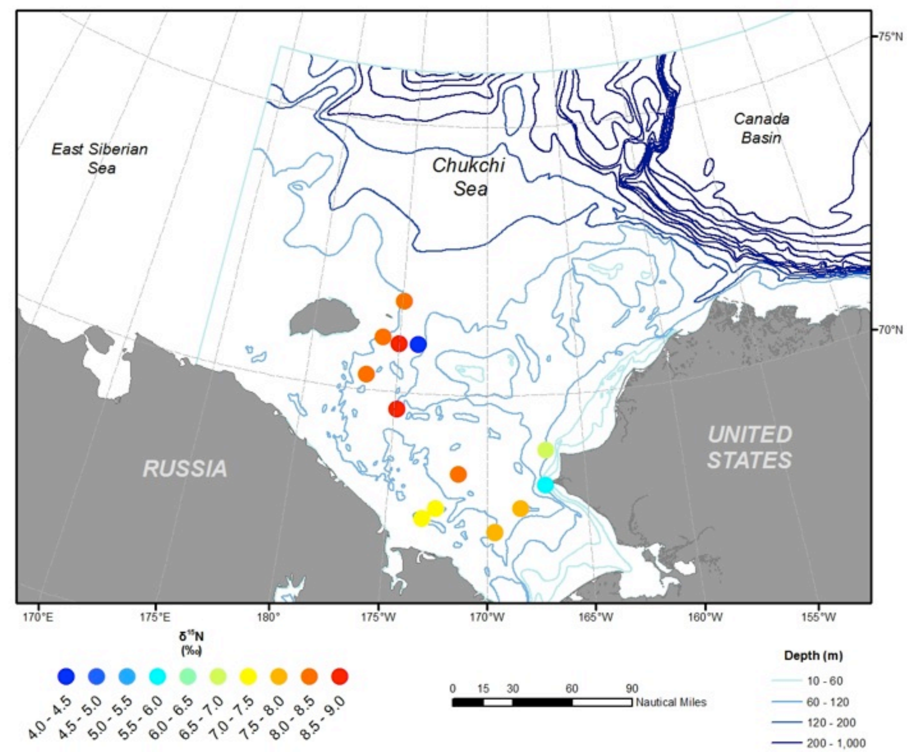


# Stable isotopes analyses identify C and N processing in RUSALCA12

Sediment $\delta^{13}C$




Sediment $\delta^{15}N$

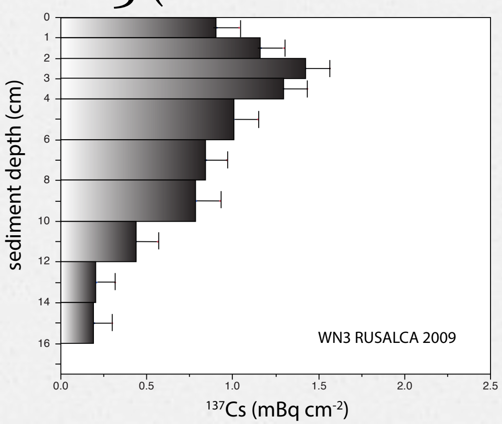



- $\delta^{13}C$ more enriched in carbon in high productivity Anadyr Water transiting SE to NW down Herald Valley and western side of Herald Canyon
- $\delta^{13}C$ more depleted in areas of higher terrestrial material along coastlines and eastern side of Herald Canyon

- higher $\delta^{15}N$ values in Herald Canyon reflect enrichment of N-15 following nitrogen cycling processes (nitrification and denitrification) as materials are cycled and then advected north across the continental shelf; lower numbers close to shore represent terrestrial runoff north of Chukotka and within Alaska Coastal Water.

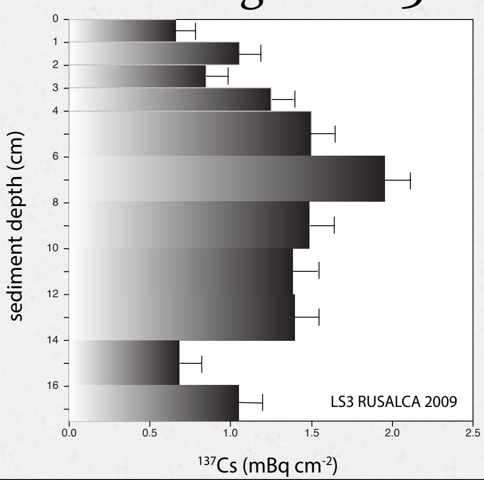
# Sedimentation rate to interpret variable current flow and influence of bioturbation on shelf carbon cycling

## WN 3 (East Siberian Sea)



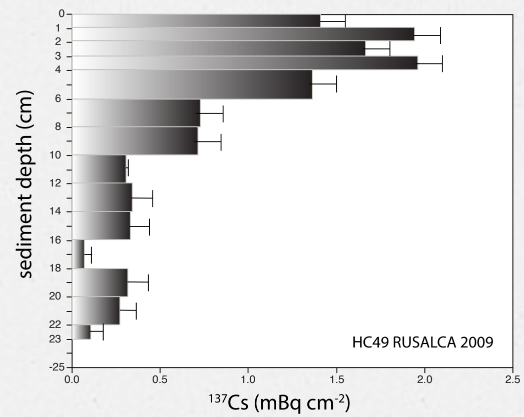

- Lower sedimentation (apparent bomb fallout peak at 3 cm); lower bioturbation; well preserved profile suggests lower current flow

## Long Strait 3




- More depositional system, implying lower currents than in Herald Canyon; radiocesium present to bottom of core due to bioturbation; maximum deposition at 6-8 cm (~1964 bomb fallout peak)

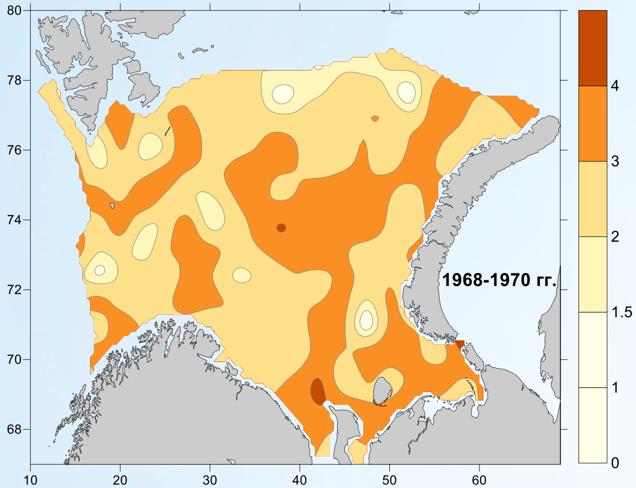
## Herald Canyon 49




- Low depositional environment, i.e. higher current flow; modest bioturbation

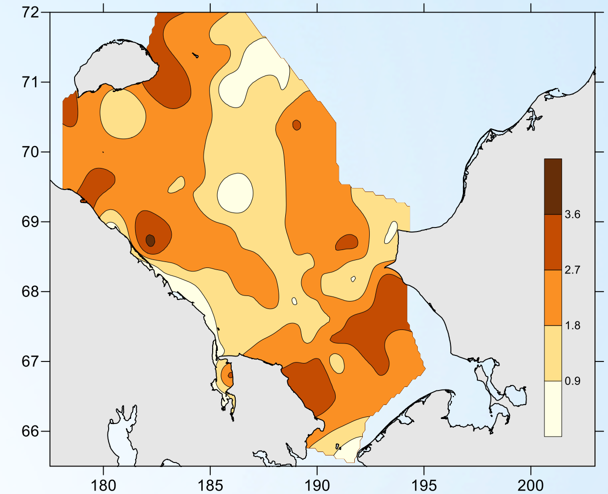
# MODERN CLIMATE-HYDROLOGICAL FLUCTUATIONS AND ZOOBENTHOS RESPONSE: Regional biodiversity

*Skvortsov Vladimir.[2,1] & Denisenko Stanislav.[1,2], ZIN, RAS*

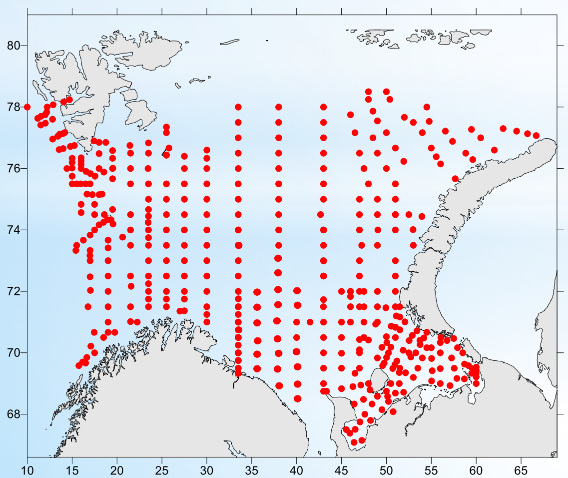



Barents Sea

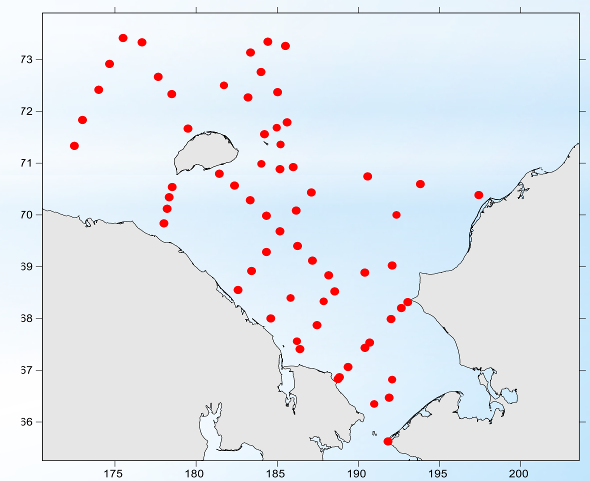
***Information biodiversity of zoobenthos***




Chukchi Sea

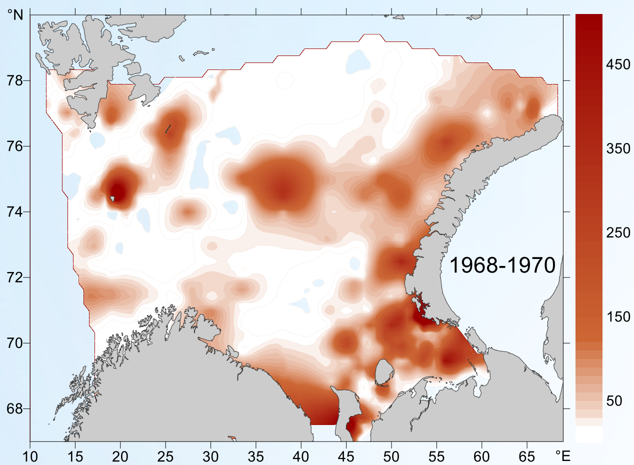


***Zoobenthos sampling stations***

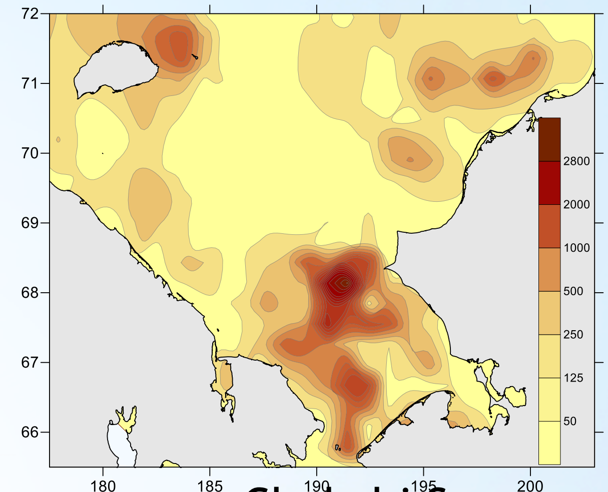


# Regional and local functional characteristics

*Skvortsov Vladimir.*[2,1] *& Denisenko Stanislav.*[1,2]

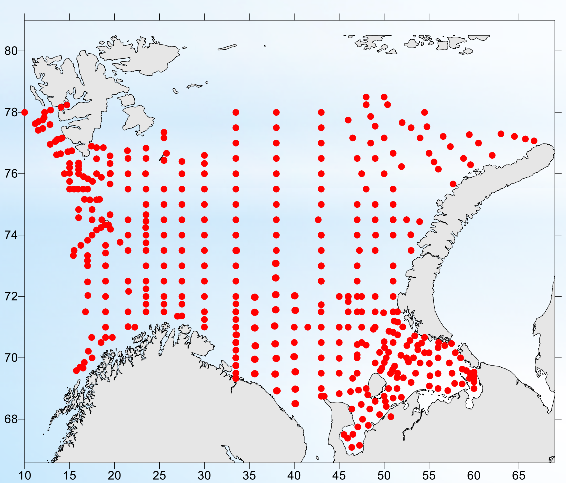


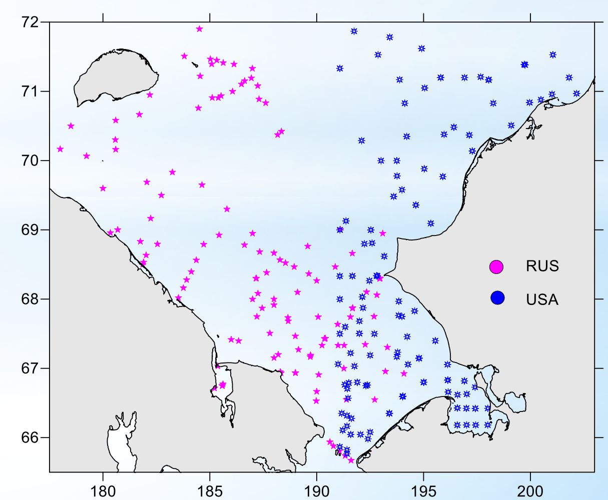

Barents Sea



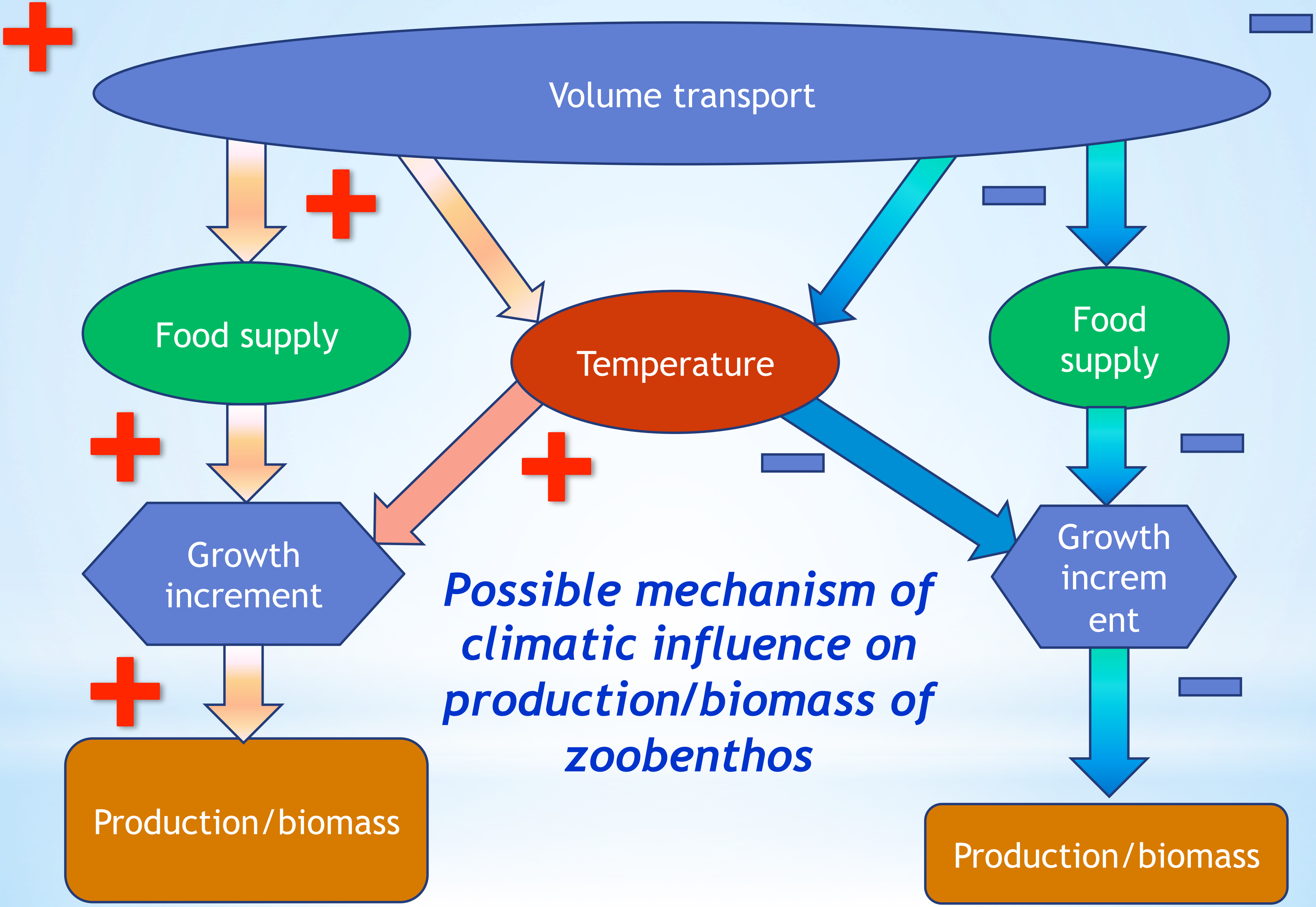

Chukchi Sea

***Zoobenthos biomass***

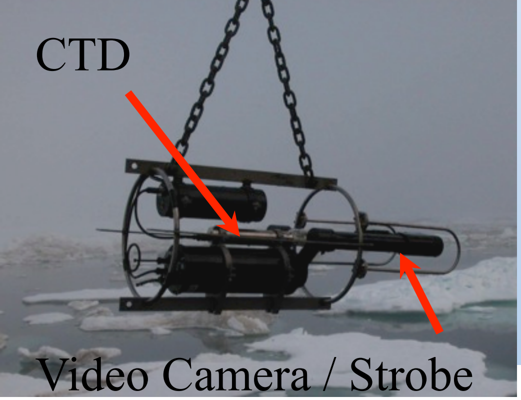



***Zoobenthos sampling stations***

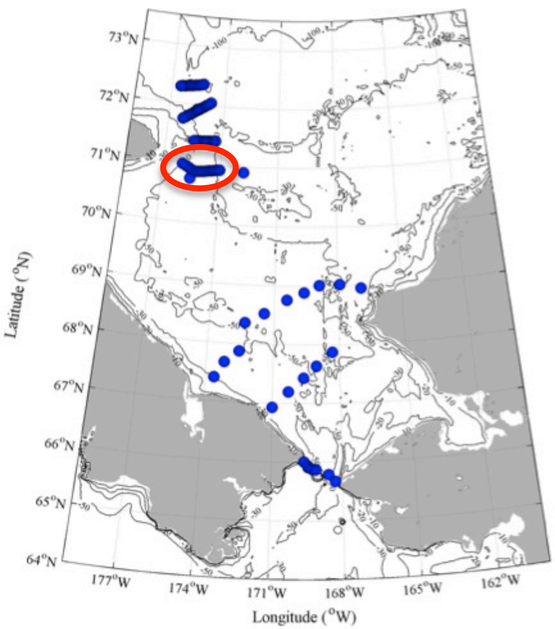


Volume transport
Food supply
Temperature
Food supply
Growth increment
Growth increm ent
Possible mechanism of climatic influence on production/biomass of zoobenthos
Production/biomass
Production/biomass



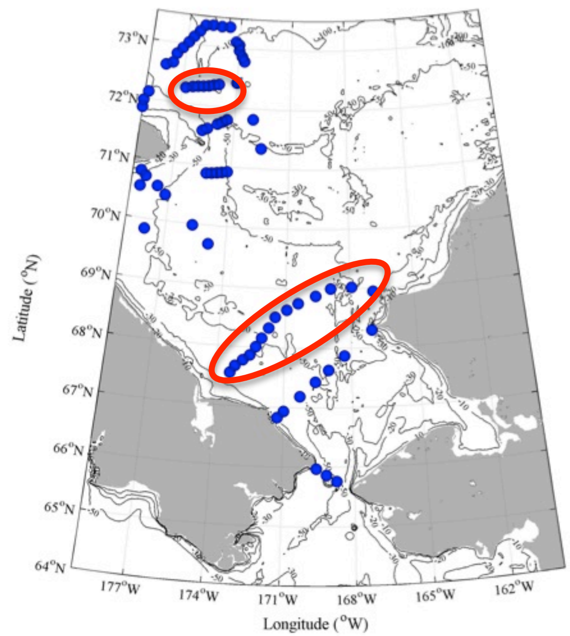

# Locations of VPR Casts- Carin Ashjian (WHOI)

2004



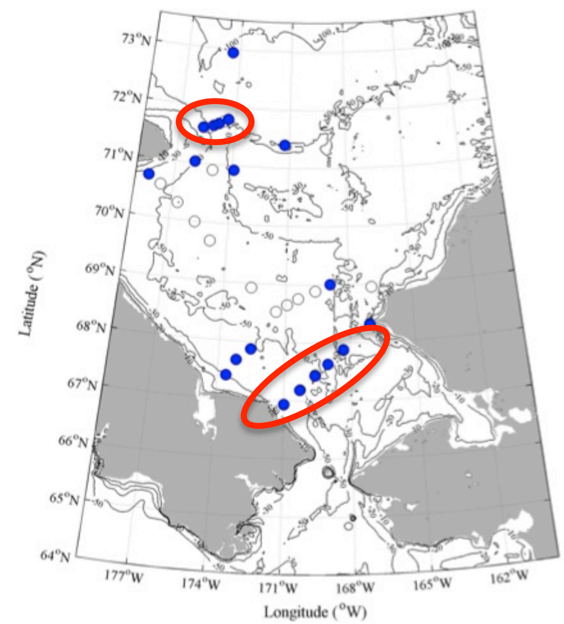

75 Casts

2009



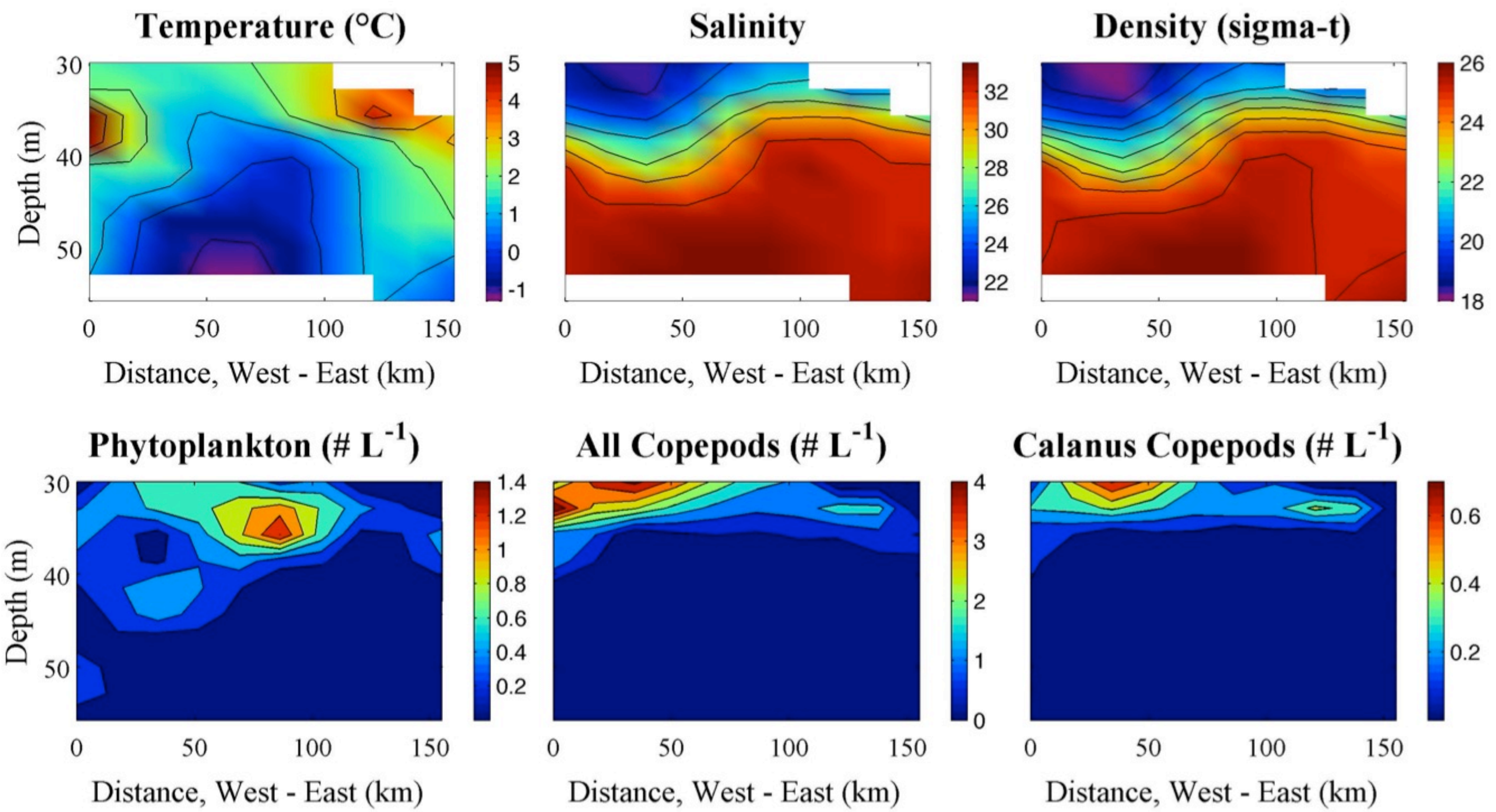

74 Casts

2012




38 (20) Casts

# 2012 - CS Distributions (DBO 3)



# Epifauna and Demersal Fish

BA Bluhm, BL Norcross, K Iken, F Huettmann, BA Holladay (all University of Alaska Fairbanks), BI Sirenko (Zoological Institute RAS)

- Plumb-staff beam trawl, 7 mm mesh (4 mm in cod end)
- 2-5 min hauls on bottom
- Sort, count, weight, identify
- 2004-2009, 165 fish st, 42 epifauna st

# Why care?

**Epibenthos and Fish**

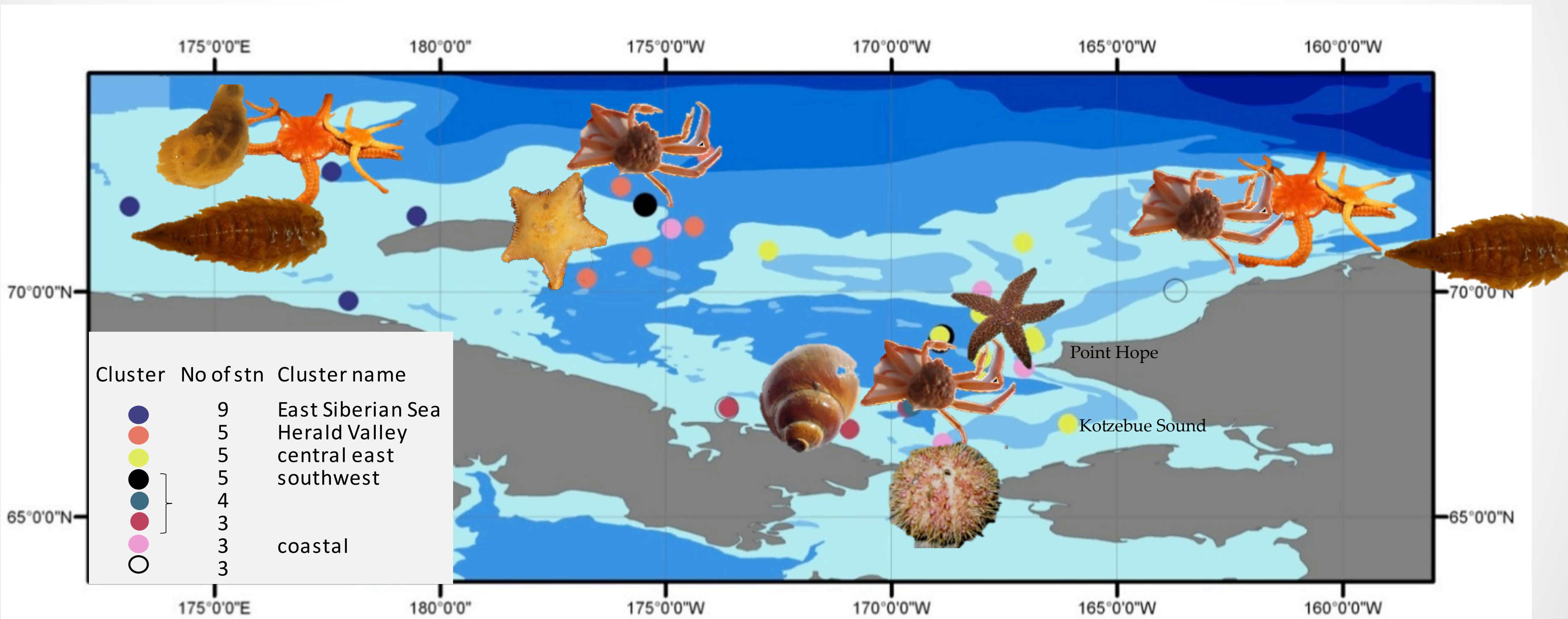
- Climate signal integrators (long-lived)
- Prey for subsistence species
- Species of potential subsistence and commercial fisheries (snow crab)
- Contribution to carbon cycling

**Food web**

- Carbon flow
- Food web length – carbon transfer efficiency
- Pelagic-benthic coupling

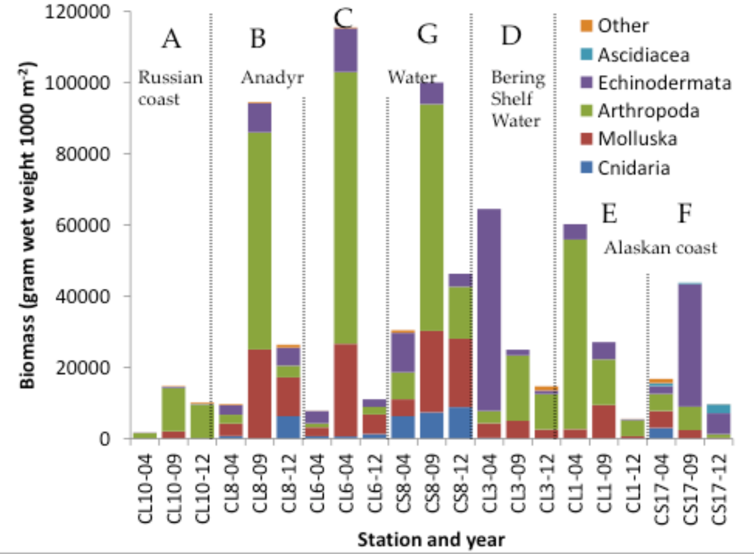
- Commitment to Circum-polar Biodiversity Monitoring Program (CBMP of Arctic Council)

# Characteristic epibenthic species

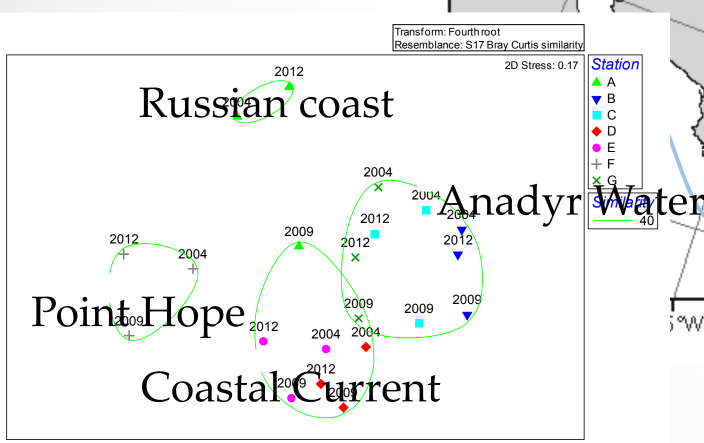



Taxa contributing ≥10% to within cluster similarity (fish species contributed ≤7%)
Mean fish biomass per cluster 2-10% of total haul biomass

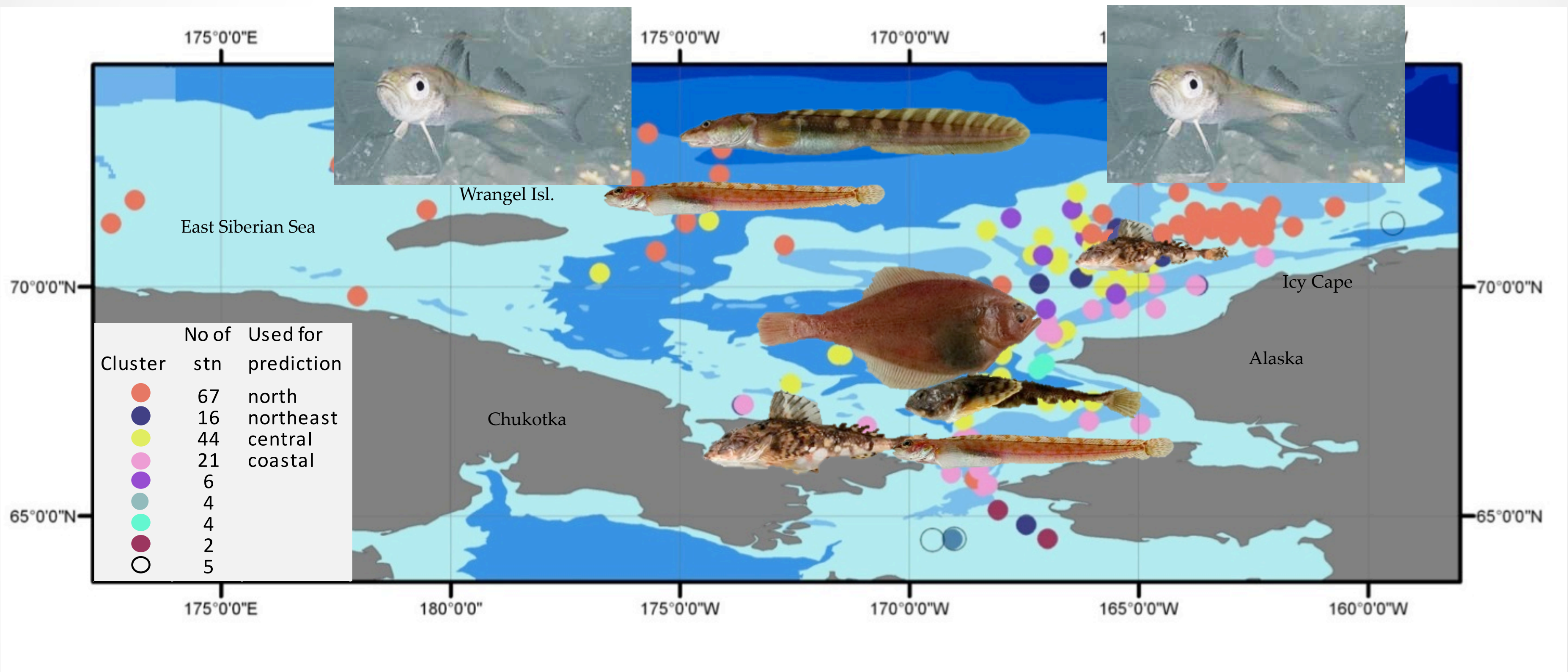
Time series epibenthic stations-BA Bluhm, KB Iken, C Serratos (all University of Alaska Fairbanks), B Sirenko (Zoological Institute RAS)







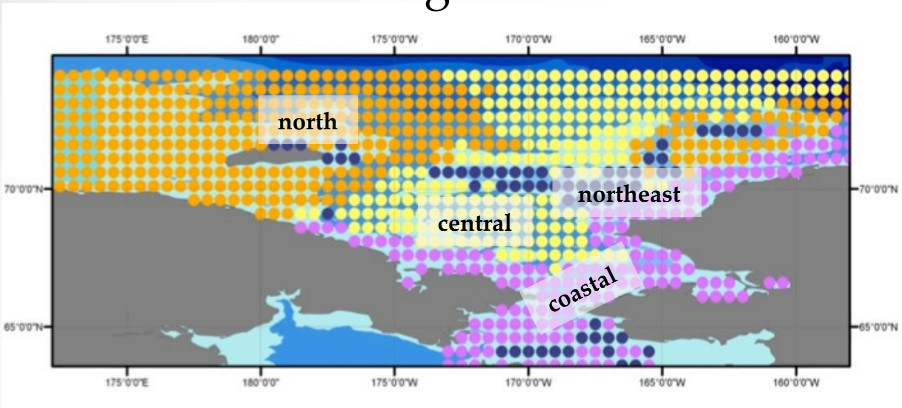
# Characteristic species within fish assemblages



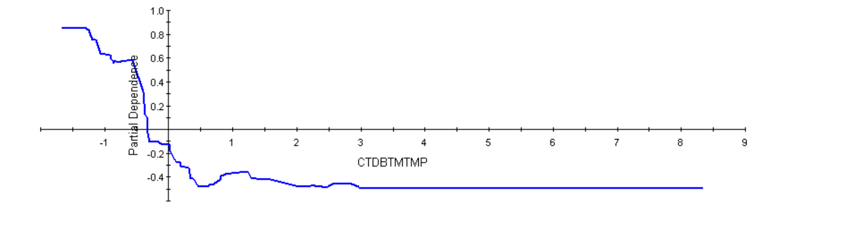

Taxa contributing ≥10% to within cluster similarity

# Environmental niches for fish assemblages

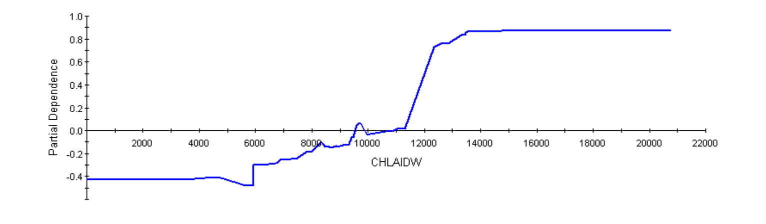
Predicted assemblages from model



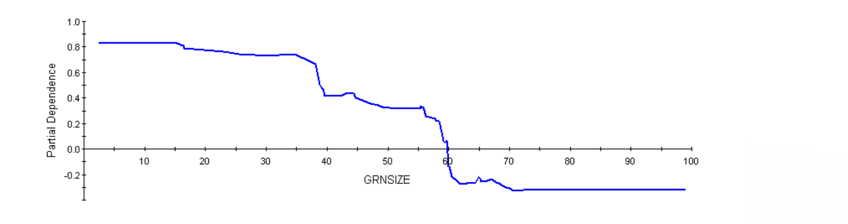

**North**: near mean summer sea ice extent, low bottom temperature



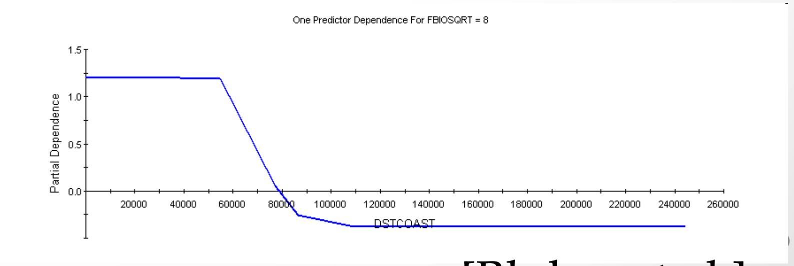

**Central** : high chlorophyll a, near ice edge, muddy sediment, >40 m




**Northeast**: coarse sediment, <40 m, high (er) bottom temperature, rel. low chlorophyll

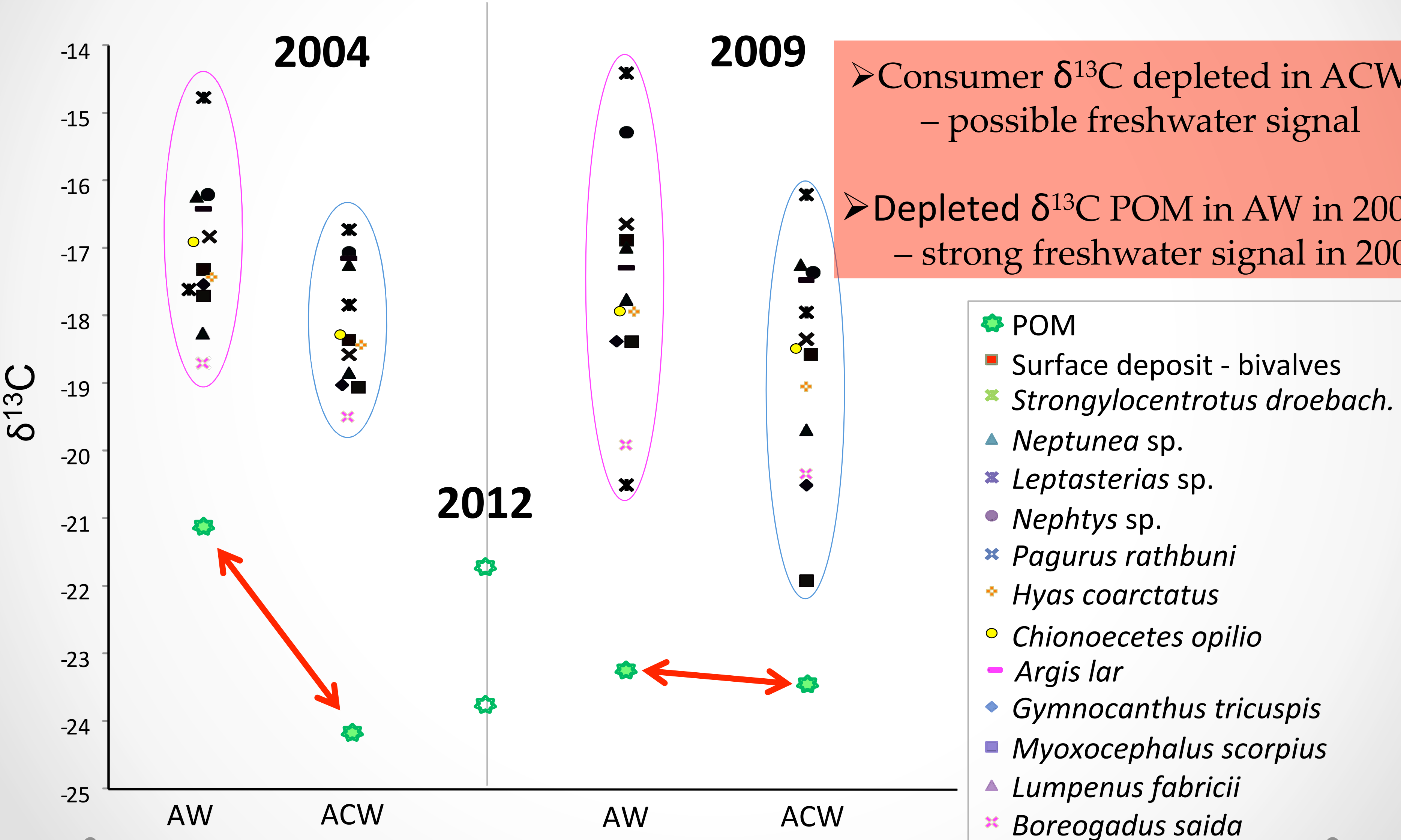



**Coastal**: near coast, high surface and bottom temperatures, far from ice edge



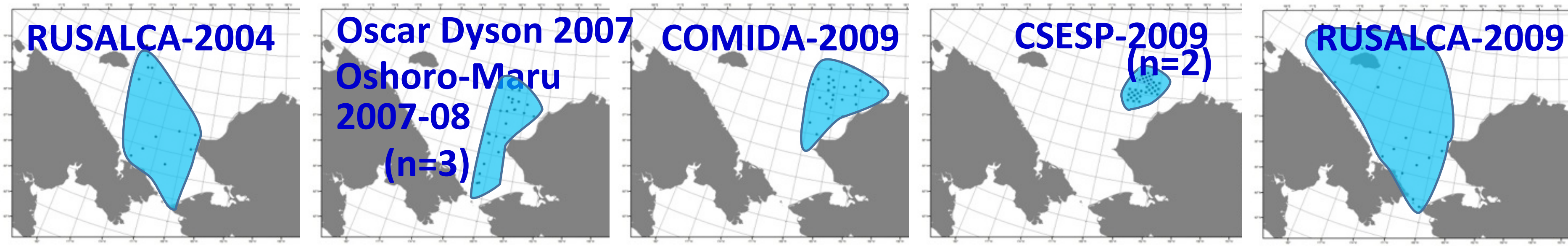

[Bluhm et al.]

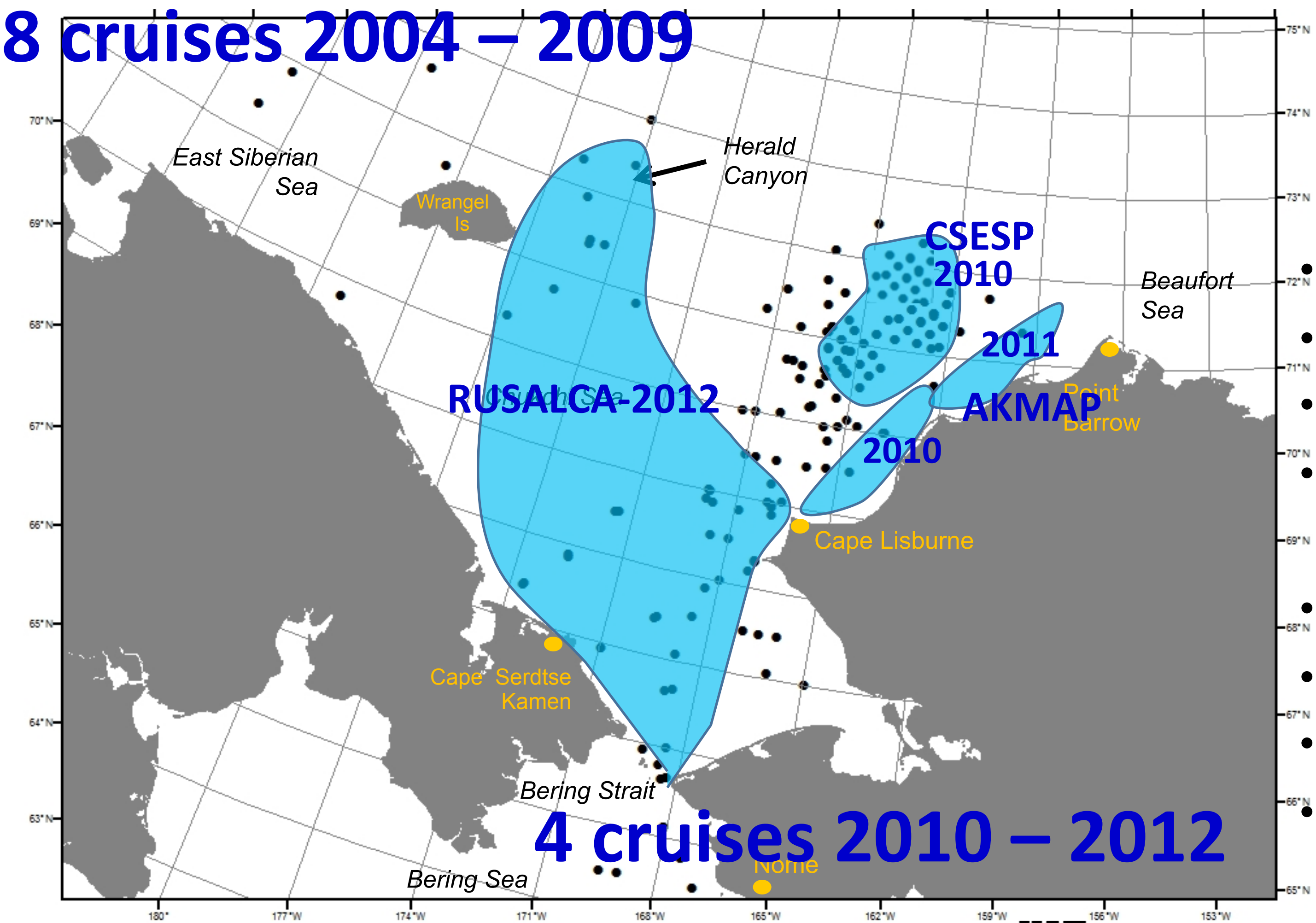
# Food web – carbon source




- Consumer $\delta^{13}C$ depleted in ACW – possible freshwater signal
- Depleted $\delta^{13}C$ POM in AW in 2009 – strong freshwater signal in 2009

2004 results: Iken K et al (2010) *Deep-Sea Research II* 57: 71-85




# Demersal Fish

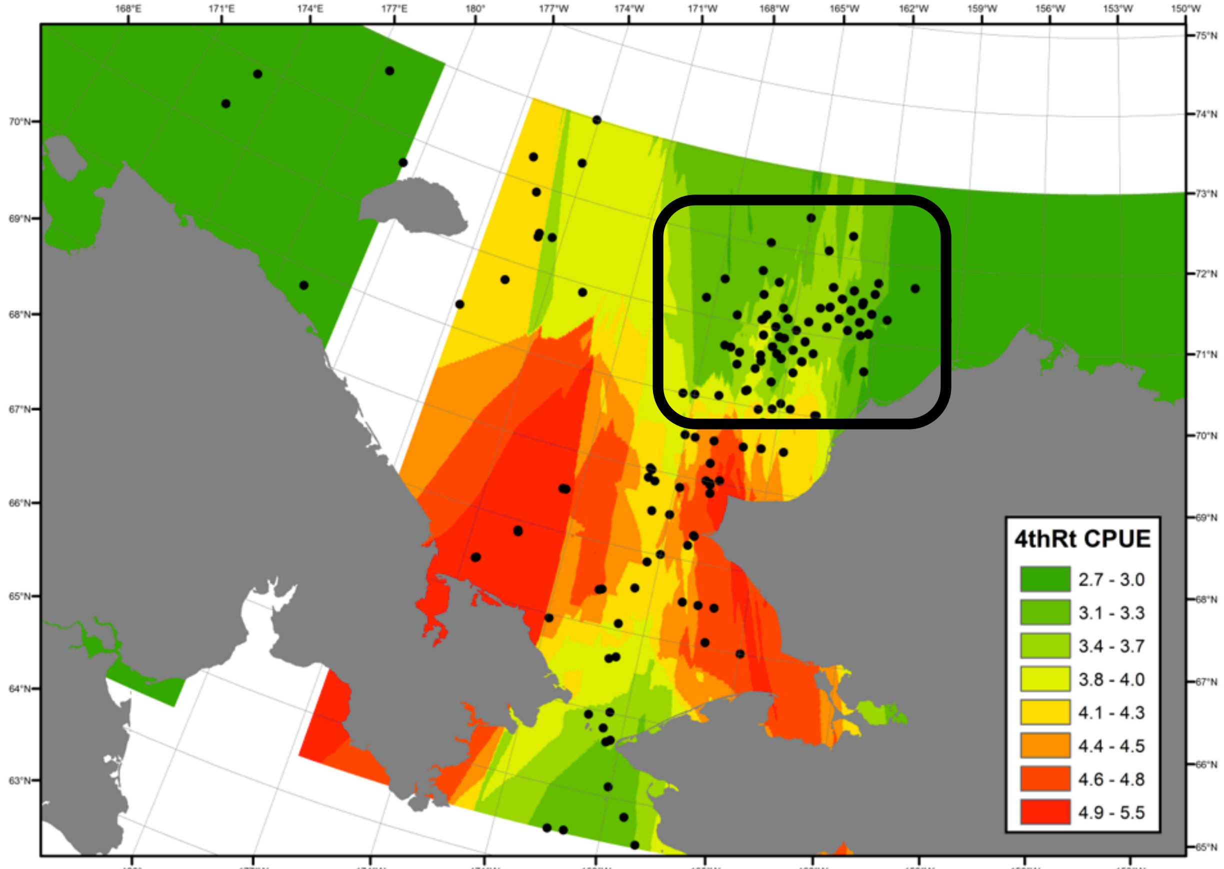
- Broad scale
- Spatially focused
- Interannual
- Seasonal (July-Oct)
- Offshore
- Nearshore
- West (Russia
- East USA

Norcross et al., St. Petersburg, May-2013

# 2004-2012 Synthesis of demersal fish

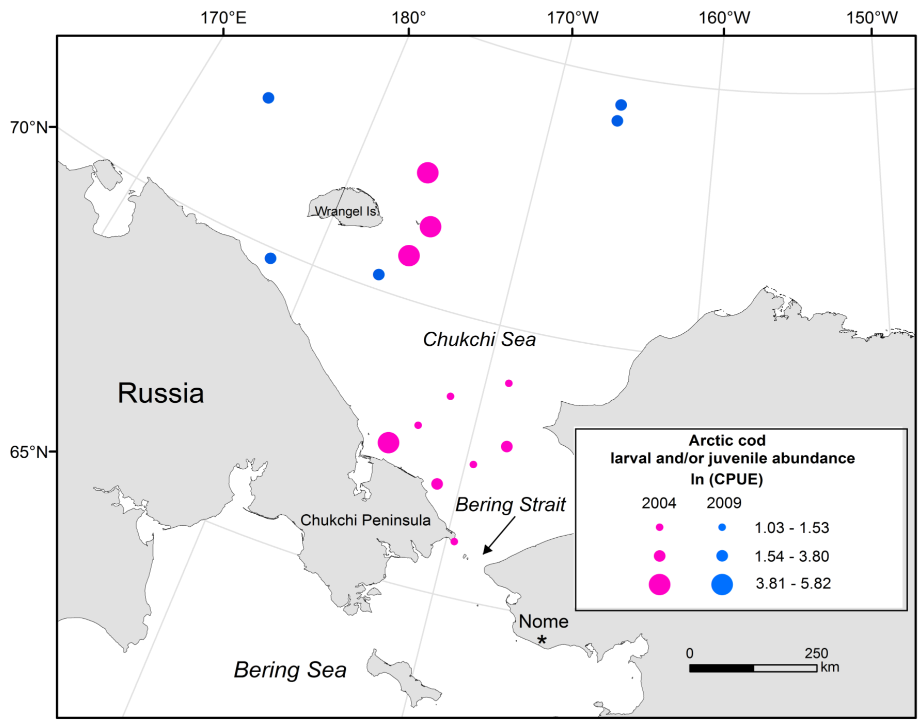
**Broad-scale patterns**

- High on both sides of southern Chukchi Sea
- Low in Bering Strait and northern areas
- Higher in the northwestern Chukchi Sea than the northeastern Chukchi Sea

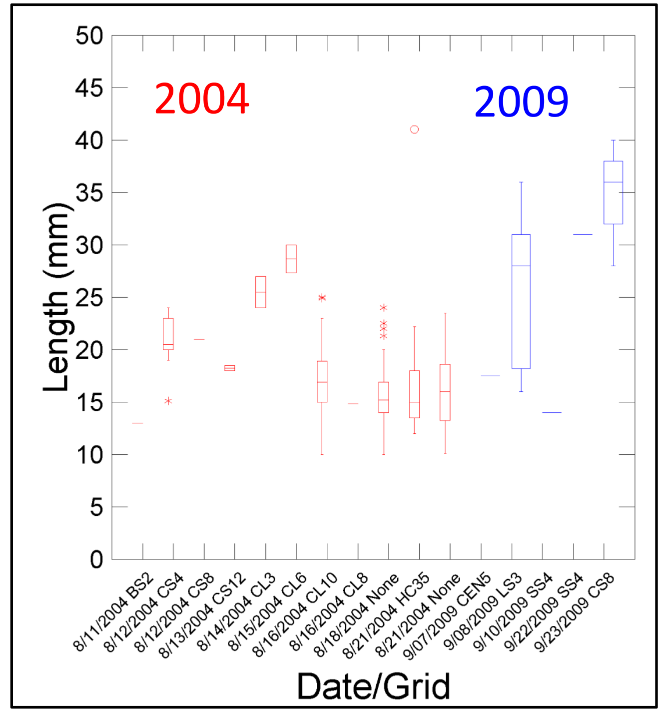


# Ichthyoplankton

## Arctic cod (*Boreogadus saida*) comparisons between August 2004 and September 2009




**Abundance (#/10 m²)**




**Mean length**

Cod: *Boreogadus saida* 28 mm

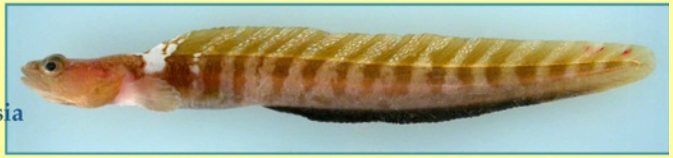
RUSALCA results from
Busby, Norcross, Holladay, Meier. Arctic Wakefield Symposium, Anchorage Alaska, March 2013, Poster

UAF UNIVERSITY OF ALASKA FAIRBANKS

Norcross et al., St. Petersburg, May-2013

# RUSALCA 2013, Synthesis & Publications

St. Petersburg, Russia
21 May 2013

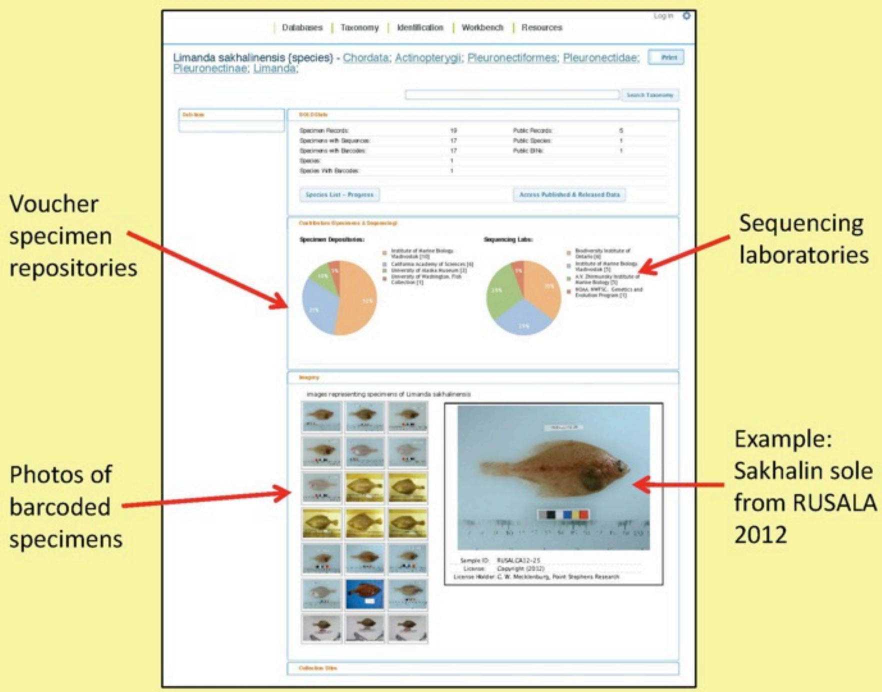


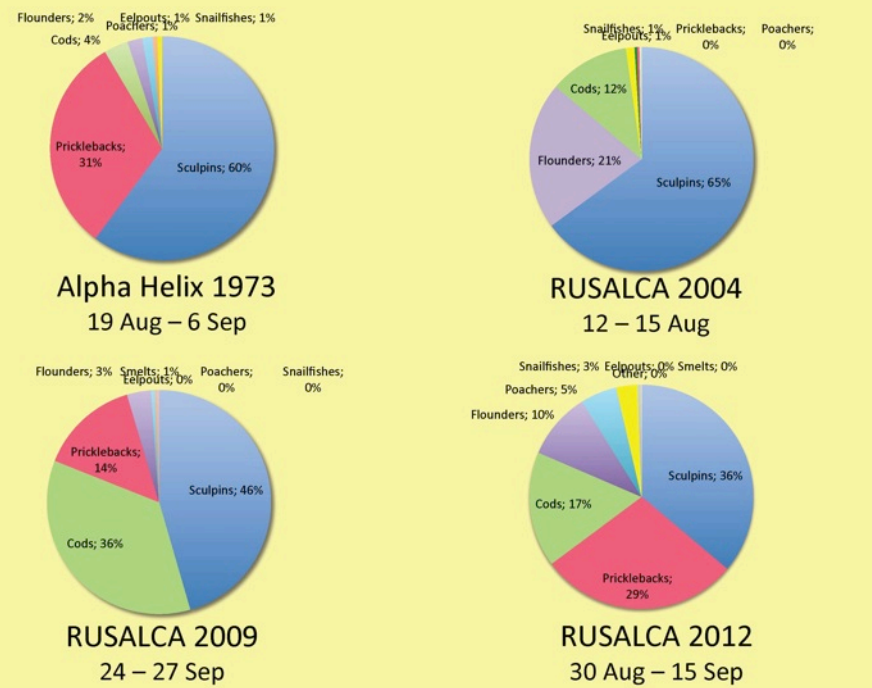
# Moving forward: Monitoring Arctic fish diversity and distribution


Presentation by
Catherine W. Mecklenburg
T. Anthony Mecklenburg
Arve Lynghammar

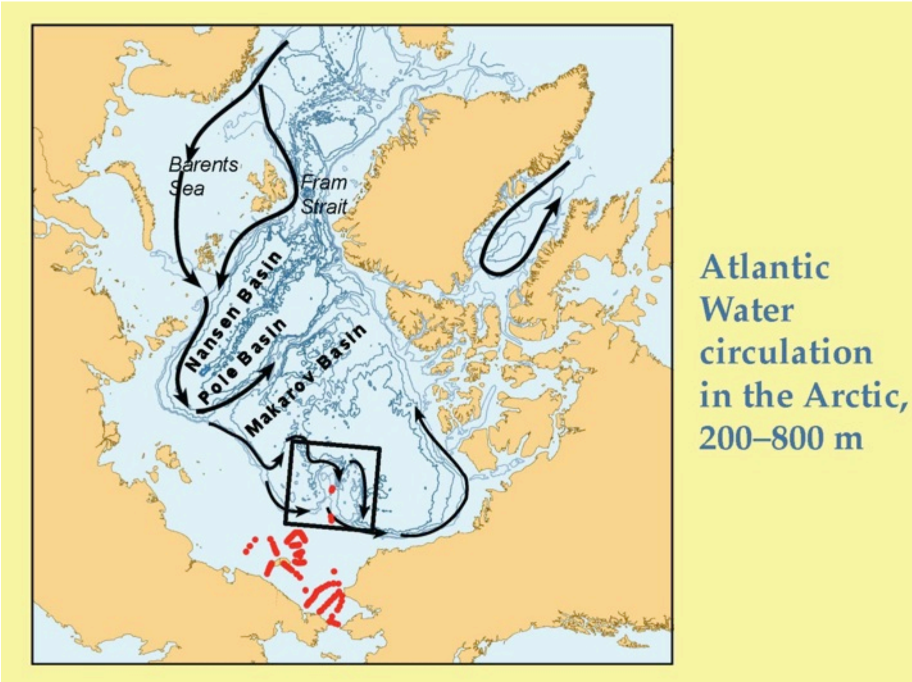


Otter trawl stations, RUSALCA 2004, 2009, 2012

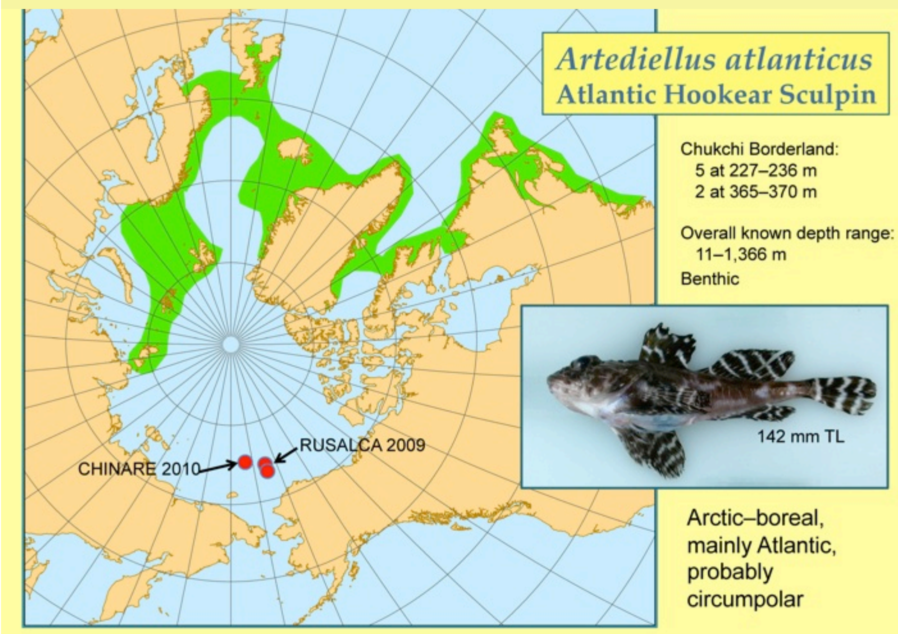


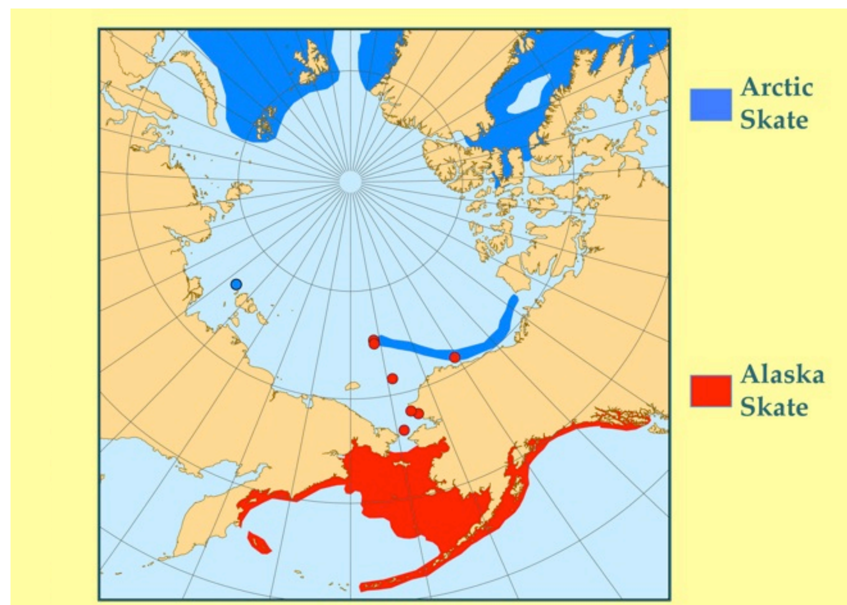



# Connection Atlantic and Pacific waters in basin







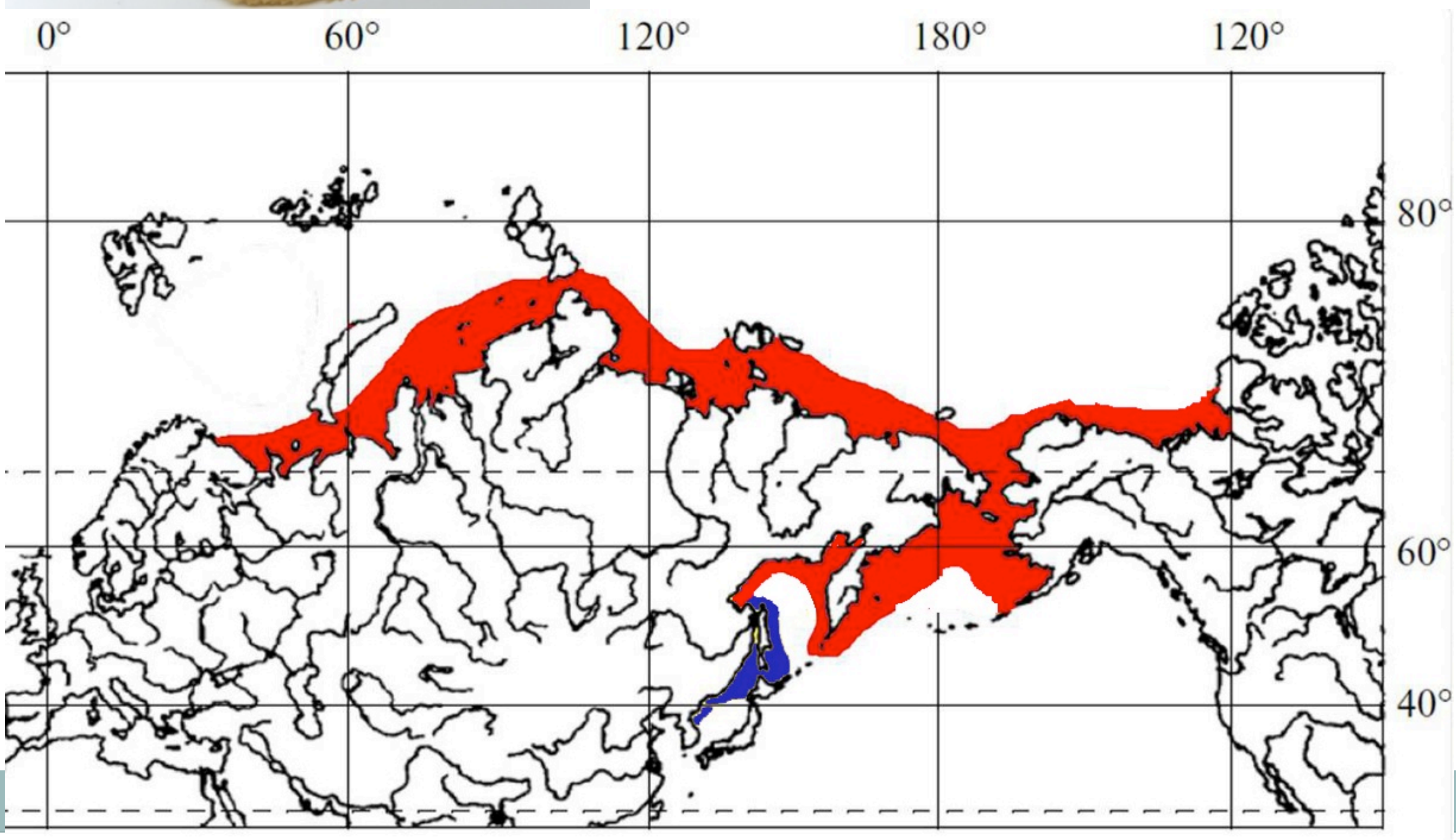



*Liopsetta glacialis*
Arctic

# Biodiversity of Flatfishes

***Elena Voronina***
***Boris Sheiko***
***ZIN RAS***

*Liopsetta pinnifasciata*
Boreal Pacific



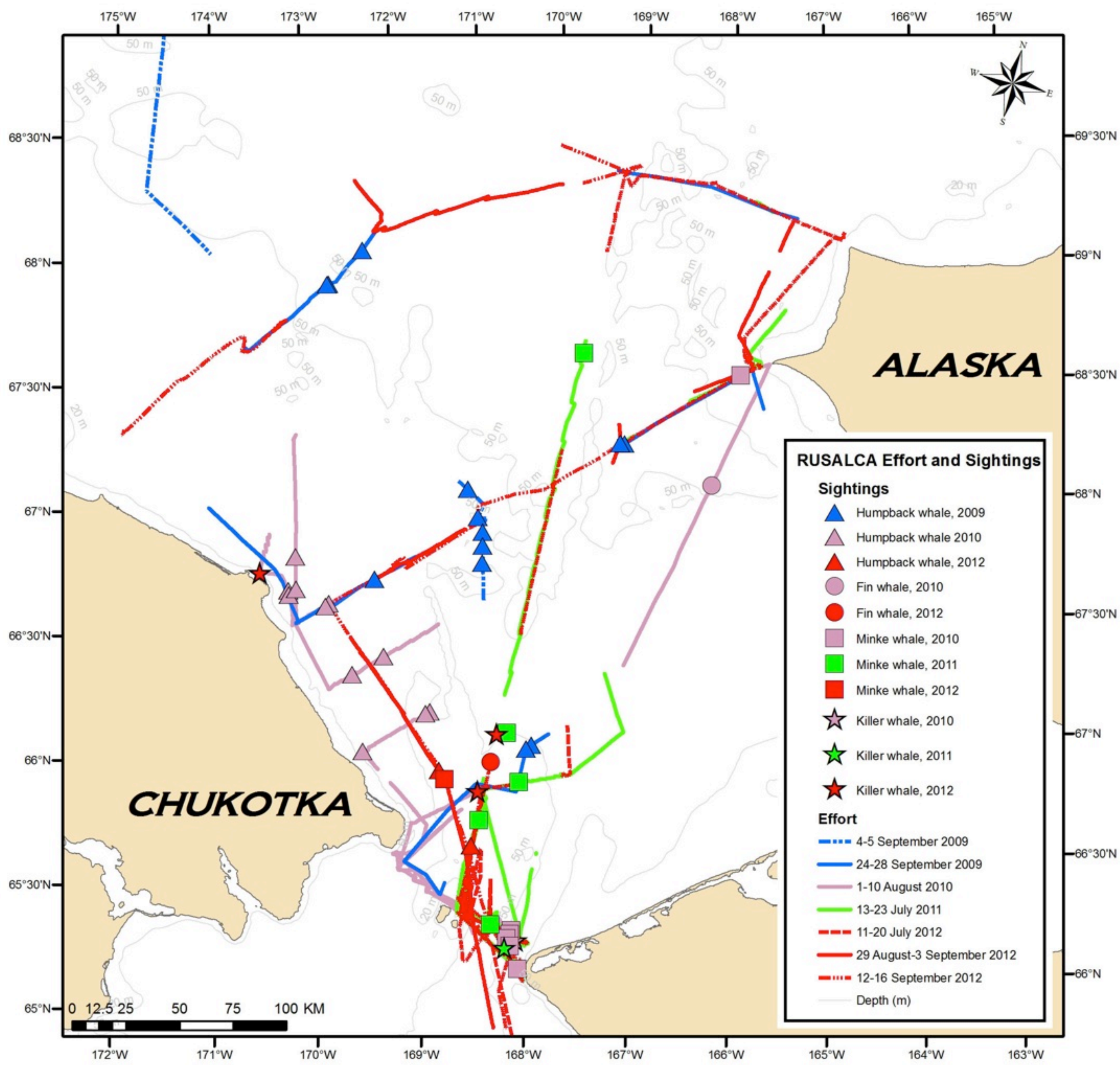
# Marine Mammals-Kate Stafford
# University of Washington

Bering Strait

- Migratory pathway for Arctic marine mammals that move between the Bering and Beaufort and Chukchi Seas
  - Bowhead and beluga whales
  - Walrus, ice seals
- Used seasonally (summer/fall) by sub-Arctic spp
  - Fin, Humpback, minke, killer whales, gray whales

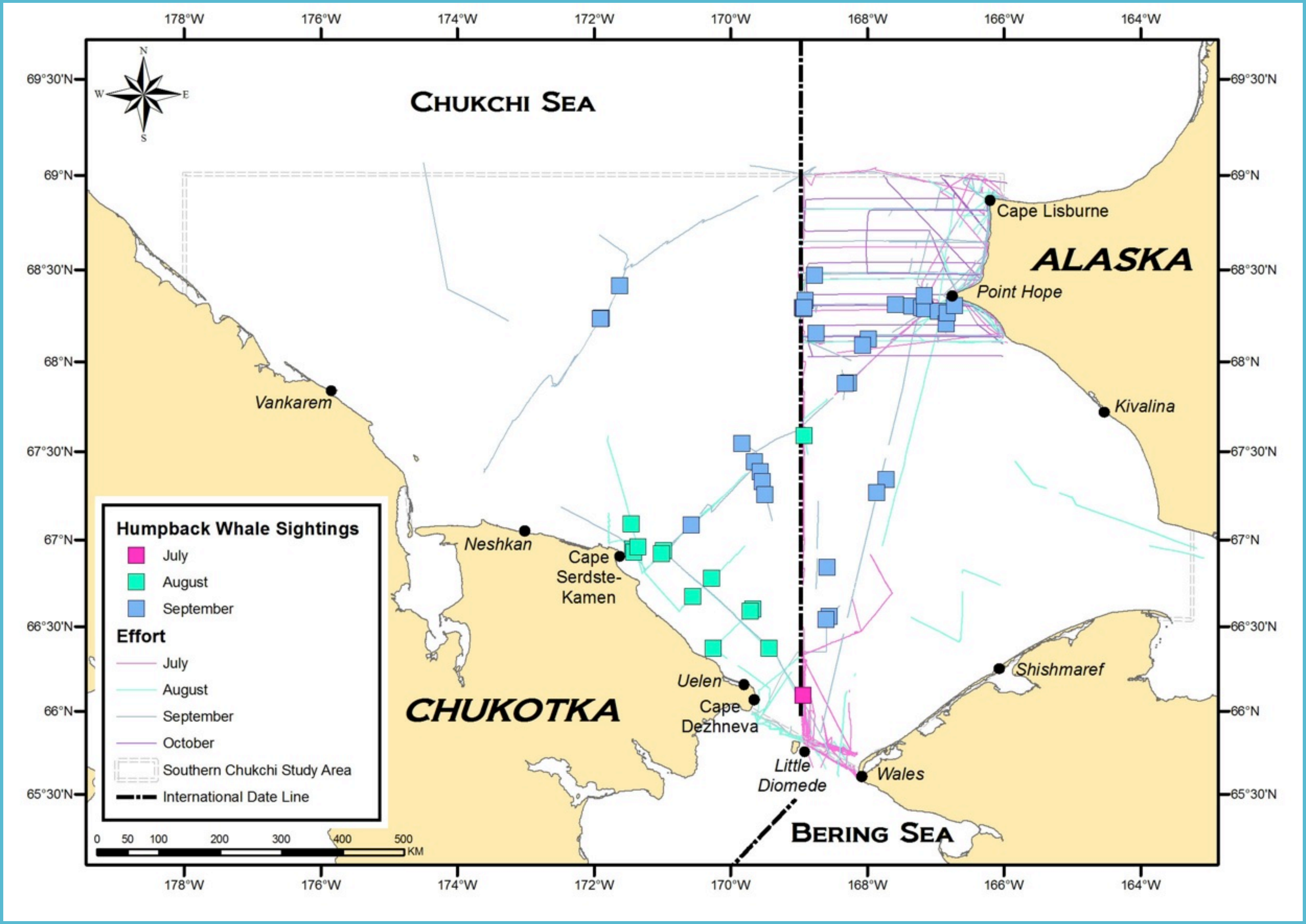
- Decrease in habitat for walrus, polar bears, ice seals, bowheads (?)
- Increased habitat for sub-Arctic spp
- Increase in shipping and O&G exploration = increases in ambient noise
  - Increase in ship strikes of large whales?

# All Rusalca sightings by species, 2009-2012




Cruises with marine mammal observations
2009 (1)*
2010 (1)*
2011 (1)
2012 (2)*
* Surveys in Russian EEZ

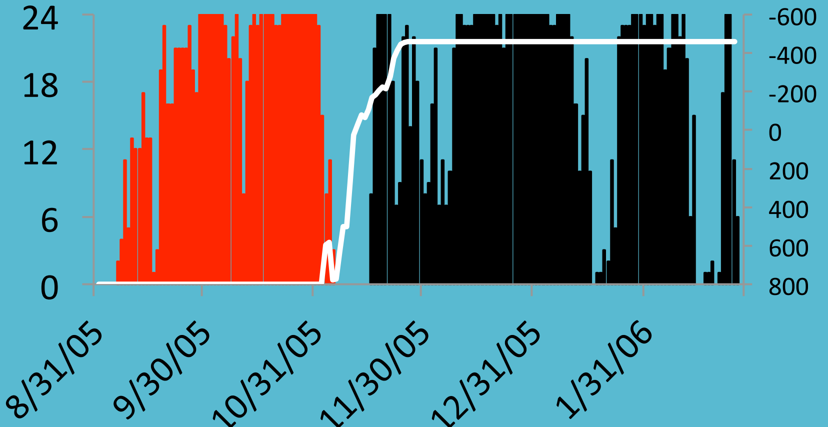
# Humpback whale sightings-by season



# Species detected in Bering Strait

-best way to monitor bowhead and beluga whales, bearded and ribbon seals and walrus is Passive Acoustic Monitoring (PAM)

- Bowhead (Nov-Feb, Apr)
- Walrus (October – Dec, April-Jun)
- Bearded seal (year-round)
- Beluga (Oct-Dec, Apr-May)
- Ribbon seal (Oct)
- Fin whales (Aug-Oct)
- Humpback whales (Aug-Nov)
- Killer whales (Sept-Oct)




Humpback and bowhead detections
A3

# Summary of RUSALCA Results

**Sections and moorings:** Whitefield, Tom Weingartner (UAF), Rebecca Woodgate (UW)
- Interannual variability of  Bering Strait fluxes
- Volume transport-increasing trend
- Heat transport-increasing trend
- Freshwater transport-increasing trend

**Physical oceanography: Robert Pickart (see separate ARP ppt)**
- Herald Canyon has complex circulation/dynamics as Pacific water in canyon is re-routed and mixes
- Polynya activity in vicinity Wrangell Island forms winter water that may feed the canyon
- Physical drivers in Chukchi Sea are changing dramatically (sea ice, air and water temperaures, storms, freshwater input, Bering Strait inflow)-have impact on biological system

**Hydrography: Terry Whitledge (see separate ARP ppt)**
- Strong gradients & large scale horizontal variability in nutrients and chlorophyll
- Large temporal variations over short and long time periods some indications from station and mooring data that nitrate concentrations have decreased over the past two decades

**Phytoplankton, Primary productuvity**: **Terry Whitledge and Sang Lee (Korea)-(see separate ARP ppt)**
- Phytoplankton –  smaller size classes appear to have increased
- Chlorophyll –  integrated biomass decreased by 40%
- Primary Production – rates are reduced 2-3 fold since 1980's

**VPR: Carin Ashjian**
- Copepods, phytoplankton, and marine snow were consistently observed and showed distributions that were associated with hydrography each cruise
- Interannual variability in abundance other taxa (e.g.,  larvaceans, echinoderm larvae,  *Phaeocystis)*

# Summary of RUSALCA Results (cont.)

**Bacterioplankton: Alexander Savvichev**

- RUSALCA region divided into two parts: the northern and southern as Number of bacterioplankton in these parts differ by 3 times, average total number of bacterioplankton in late summer for a three-year study ranged from 170 to 240,000 cells
- Production of bacterioplankton in Chukchi Sea in 1.5 - 3 times more low, than in White Sea, Barents Sea and Kara Sea

**Zooplankton: Russ Hopcroft, Elizaveta Ershova, and Ksenia Kosobokova**

- Copepods make up 60-90% biomass at most stations, 3-5 species dominate biomass
- Dominant copepods for biomass *Calanus glacialis/marshallae*, *Neocalanus* spp.
- Zooplankton community members determined by water mass type

**Benthic marcroinfauna and sediments: Jackie Grebmeier and Lee Cooper**

- highest carbon export to benthos coincident with highest areas of infaunal biomass ($gCm^2$), indicating strong pelagic-benthic coupling
- Dominant infauna: bivalves and polychates; important prey to walrus gray whales, and bearded seals
- Sedimebt stable carbon isotopes indicate marine vs. terrestrial influenced carbon
- Sedimentation rates vary from low values in high current regimes (Herald Canyon) to moderate deposition rate in Long Strait; bioturbation has impact on profiles

**Benthic populations: Skvortsov Vladimir and Denisenko Stanislav**

- Biodiversity greatest in SE Chukchi Sea and western Chukchi Sea
- Biomass largest SE Chukchi Sea and NE of Wrangell Island

# Summary of RUSALCA Results (cont.)

**Epifauna and foodweb dynamics: Bodil Bluhm, Katrin Iken**

- Biomass variable between years
- Individual species can drive tends (stock fluctuations in snow crab?)
- Community structure stable in area, different by substrate and water mass
- Food web reflects water masses (tight pelagic-benthic coupling in AW)
- Food web structure stable between 2004 and 2009; Food source signal variable
- Combination of metrics tell more than one metrics

**Demersal fish and Icthyoplankton:Brenda Holliday and Brenda Norcross, UAF**

- Arctic cod (*Boreogadus saida*) more abundance in Anadry water
- Demersal fish high on both sides of southern Chukchi Sea, Low in Bering Strait and northern areas
- Higher in the northwestern Chukchi Sea than the northeastern Chukchi Sea

**Biodiversity fishes: Catherine Mecklenburg**

- Identification new species and location
- Northern regions have Atlantic species, with Pacific species in SE Chukchi Sea

**Biodiversity flatfish: Elena Voronina** and **Boris Sheiko, ZIN**

- examples demonstrate that using pleuronectid distribution for the investigation of the biodiversity and climate change effect monitoring as well as evolution of the group require:
- Accuracy of the different rank taxonomy – family (Pleuronectidae), genus (e.g. *Pleuronectes*)
- Accuracy of the identification and redetermination of the specimens (*Acanthopsetta*, *Hippoglossoides* species)
- Revision of taxa (*Platichthys, Reinhardtius*) supported by molecular analysis