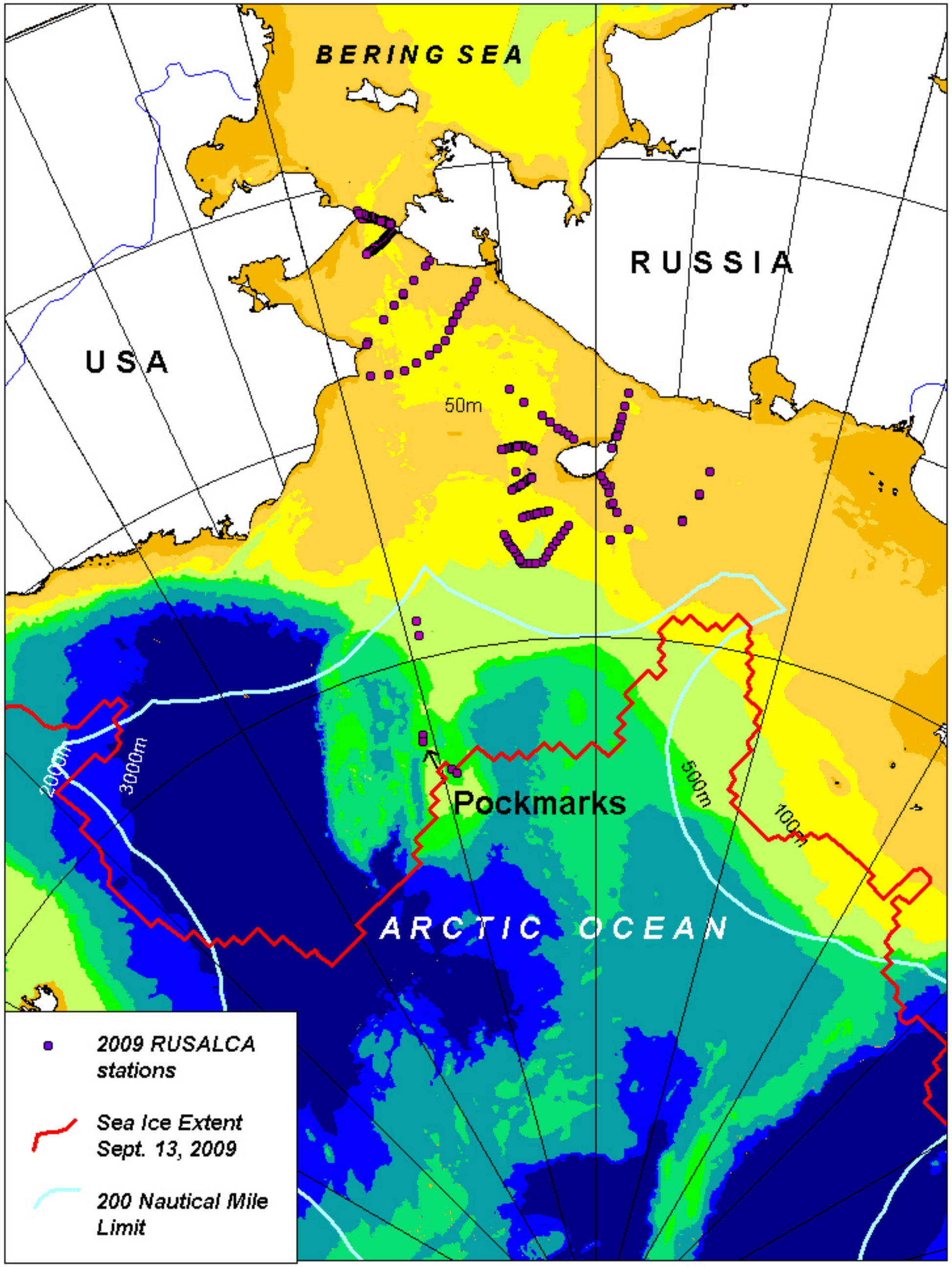
Fluxes and Change Detection in Nutrients, Chlorophyll, Phytoplankton Composition and Primary Production

Sang H. Lee, Terry E. Whitledge and Michael Kong

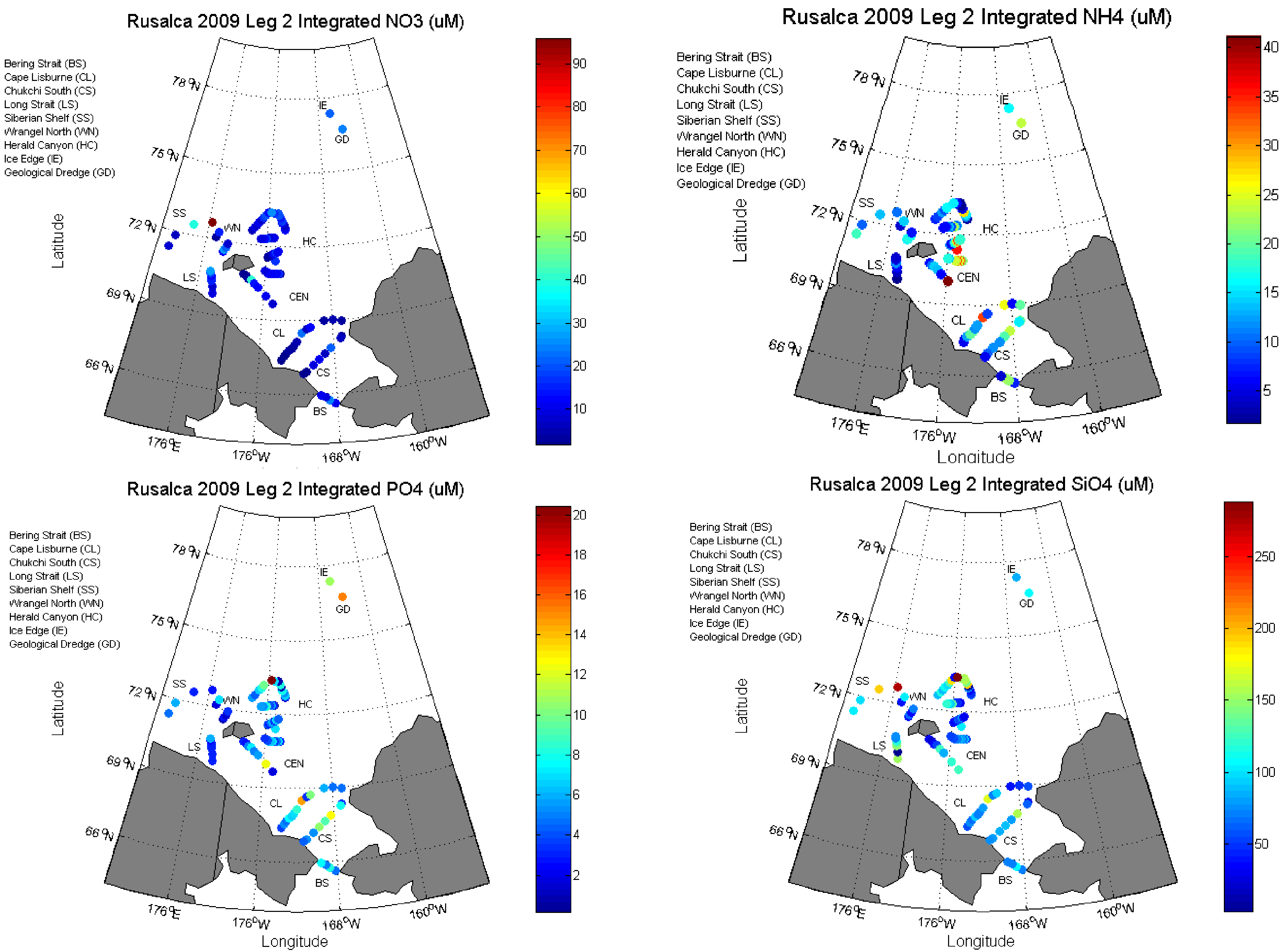
Dept. of Oceanographic Science, University of Busan
Institute of Marine Science, University of Alaska

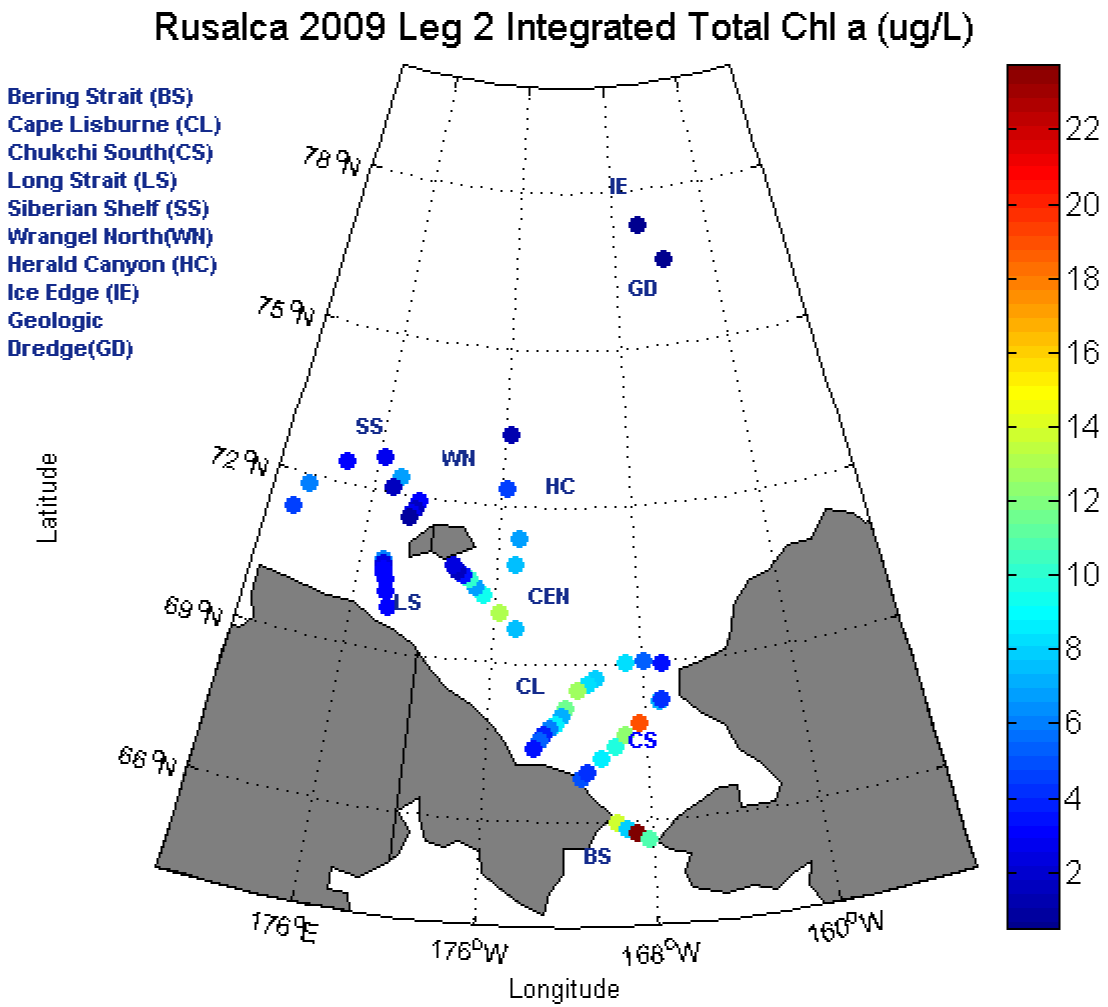
RUSALCA PI Meeting
Kotor, Montenegro
9-12 October 2010

2009 RUSALCA Hydrographic Sampling Stations

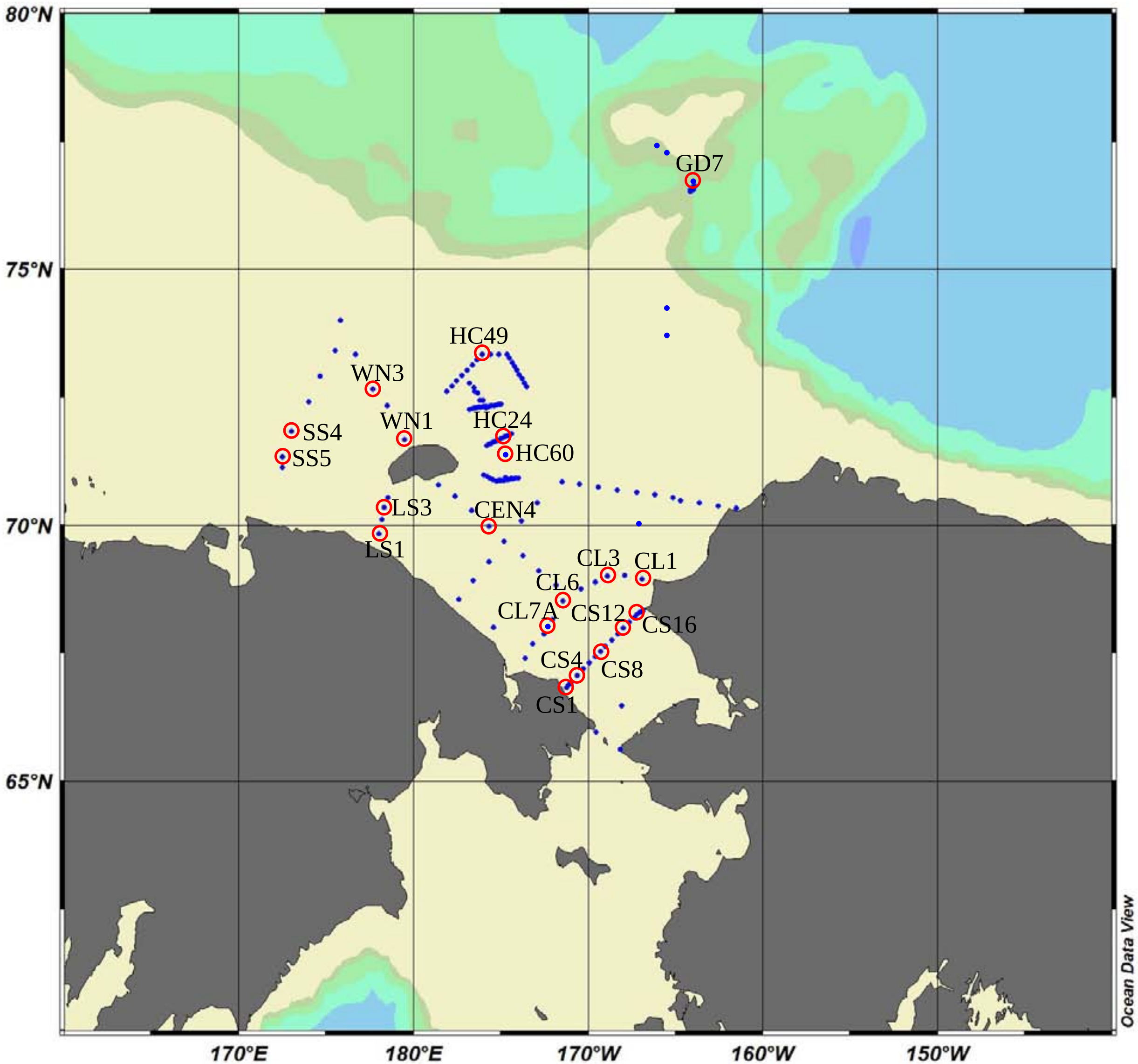


RUSALCA 2009 stations, bathymetry in meters

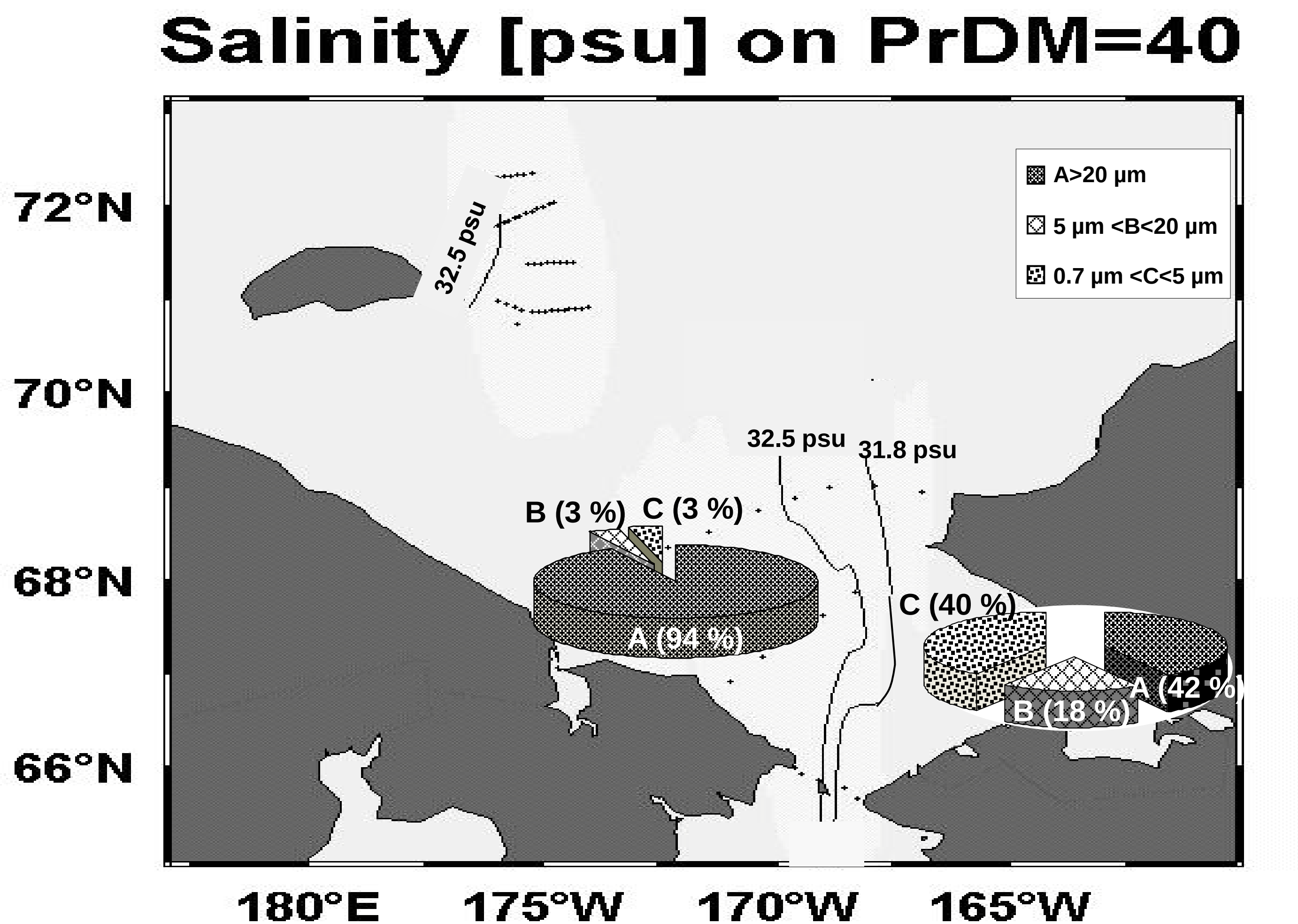

Rusalca 2009 Leg 2 Integrated NO3 (uM)
Bering Strait (BS)
Cape Lisburne (CL)
Chukchi South (CS)
Long Strait (LS)
Siberian Shelf (SS)
Wrangel North (WN)
Herald Canyon (HC)
Ice Edge (IE)
Geological Dredge (GD)
Latitude
78°N
75°N
72°N
69°N
66°N
IE
GD
SS
WN
HC
LS
CEN
CL
CS
BS
176°E
176°W
168°W
160°W
90
80
70
60
50
40
30
20
10
Rusalca 2009 Leg 2 Integrated NH4 (uM)
Bering Strait (BS)
Cape Lisburne (CL)
Chukchi South (CS)
Long Strait (LS)
Siberian Shelf (SS)
Wrangel North (WN)
Herald Canyon (HC)
Ice Edge (IE)
Geological Dredge (GD)
Latitude
Longitude
40
35
30
25
20
15
10
5
Rusalca 2009 Leg 2 Integrated PO4 (uM)
Bering Strait (BS)
Cape Lisburne (CL)
Chukchi South (CS)
Long Strait (LS)
Siberian Shelf (SS)
Wrangel North (WN)
Herald Canyon (HC)
Ice Edge (IE)
Geological Dredge (GD)
Latitude
Longitude
20
18
16
14
12
10
8
6
4
2
Rusalca 2009 Leg 2 Integrated SiO4 (uM)
Bering Strait (BS)
Cape Lisburne (CL)
Chukchi South (CS)
Long Strait (LS)
Siberian Shelf (SS)
Wrangel North (WN)
Herald Canyon (HC)
Ice Edge (IE)
Geological Dredge (GD)
Latitude
Longitude
250
200
150
100
50


Rusalca 2009 Leg 2 Integrated Total Chl a (ug/L)
Bering Strait (BS)
Cape Lisburne (CL)
Chukchi South(CS)
Long Strait (LS)
Siberian Shelf (SS)
Wrangel North(WN)
Herald Canyon (HC)
Ice Edge (IE)
Geologic
Dredge(GD)
IE
GD
SS
WN
HC
LS
CEN
CL
CS
BS
78°N
75°N
72°N
69°N
66°N
176°E
176°W
168°W
160°W
Latitude
Longitude
22
20
18
16
14
12
10
8
6
4
2

Primary Production Stations on Leg 2



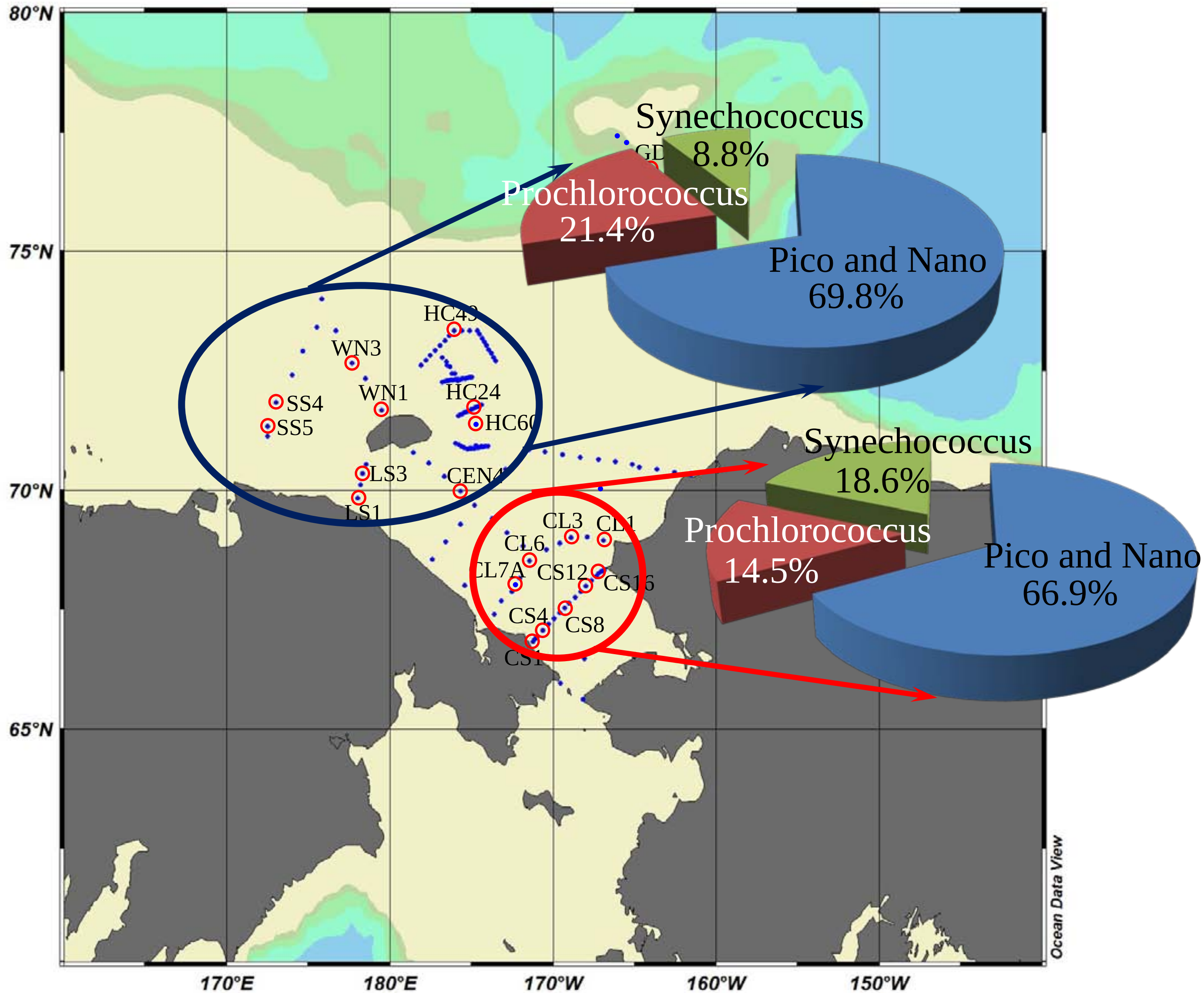
Two different size communities of phytoplankton



Lee et al. (2007)

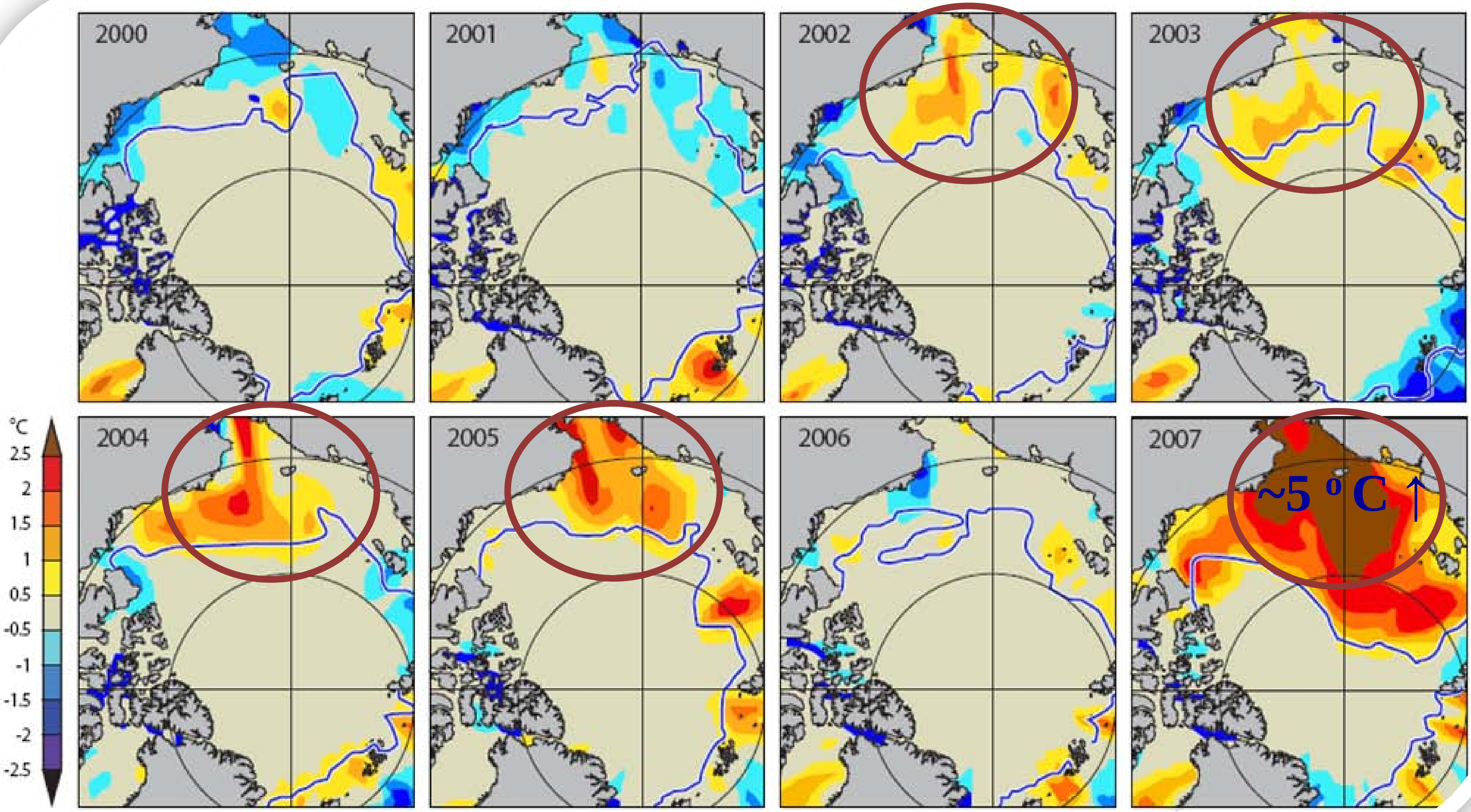
➔Depending on different water masses, there were two different communities of phytoplankton in the Chukchi Sea in 2004

Compositions of small phytoplankton (<20 μm)



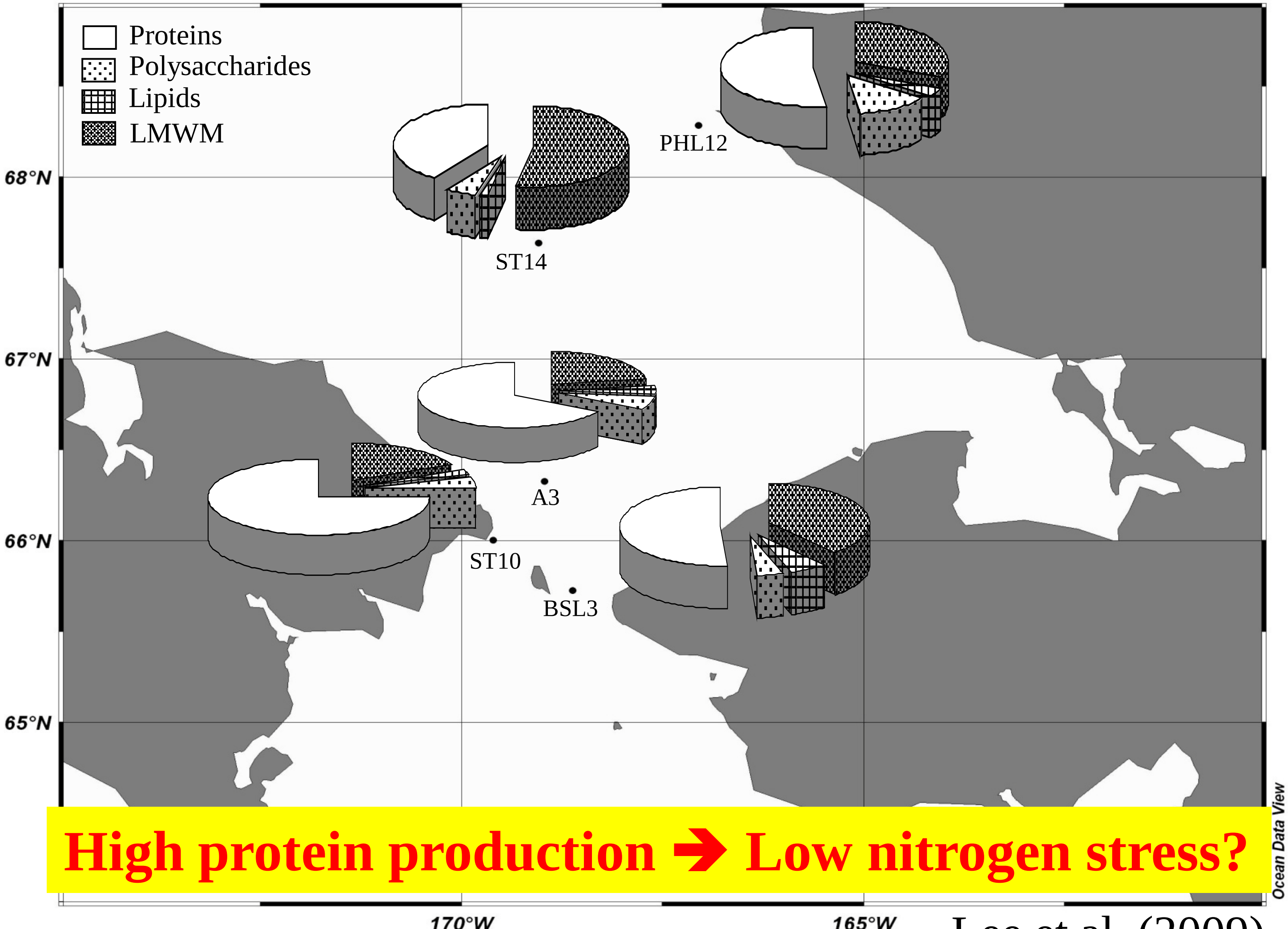
In 2009, synechococcus and prochlorococcus species were found among small phytoplankton communities (<20um) in our study sites. These species were limited in the Arctic cold waters. But, recently water temperatures in the Chukchi Sea (next slide) have increased up to 5 C in this region. So, these species could survive !

Warming Waters in the Chukchi Sea



AMAP 2009, Blue line : minimum sea ice extent

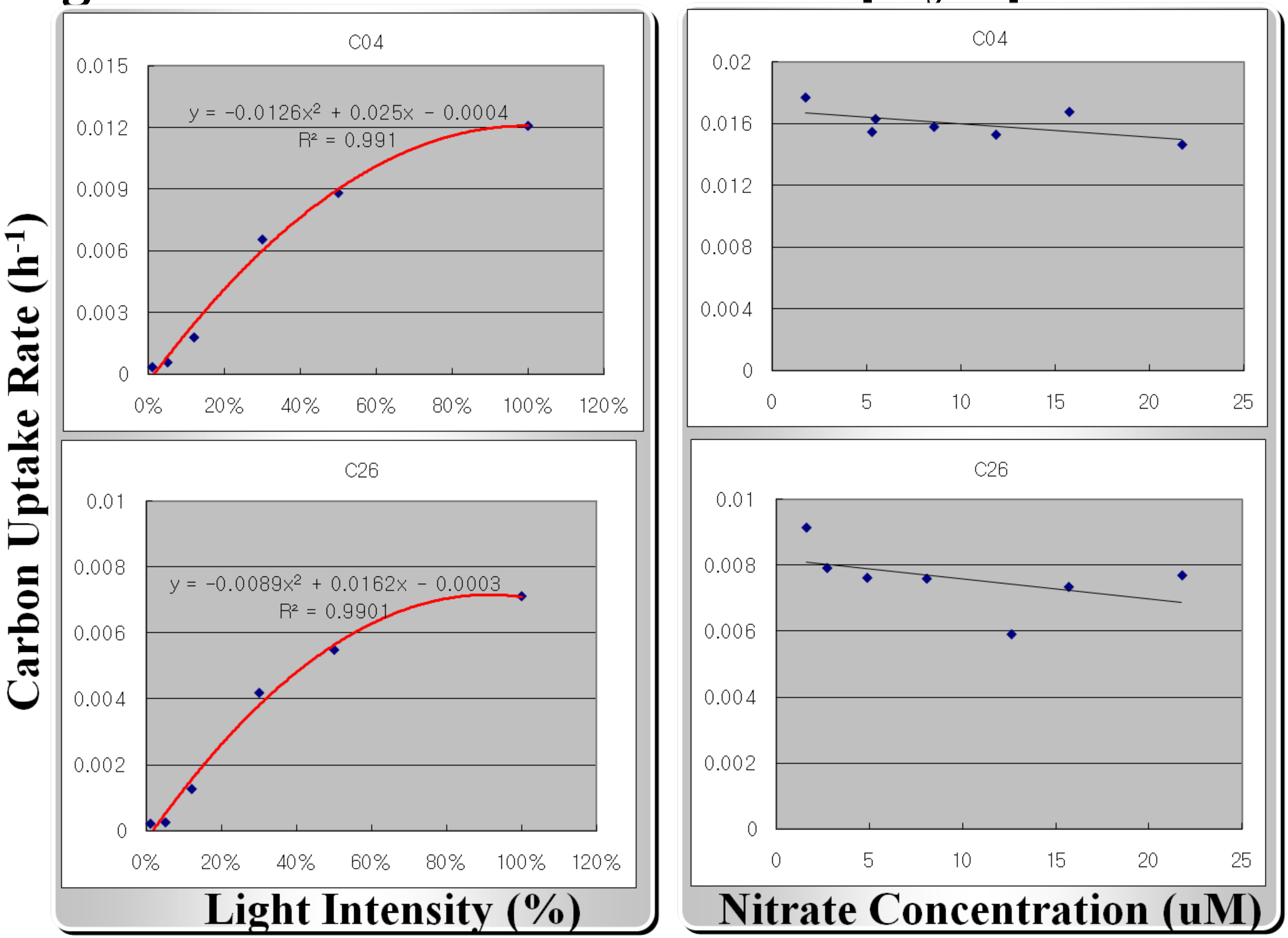
Macromolecular compositions of phytoplankton (averaged from 3 water depths, 100, 30, and 1% at each station)



Lee et al. (2009)

➔In general, phytoplankton produced more proteins than other macromolecular compositions such as lipids, Polysaccharides, and LMWM, which indicates that phytoplankton might not have a nitrogen limitation in the Chukchi Sea. This is an interesting result since phytoplankton especially in the Alaskan Costal Water were characterized as having nitrogen limitation before.

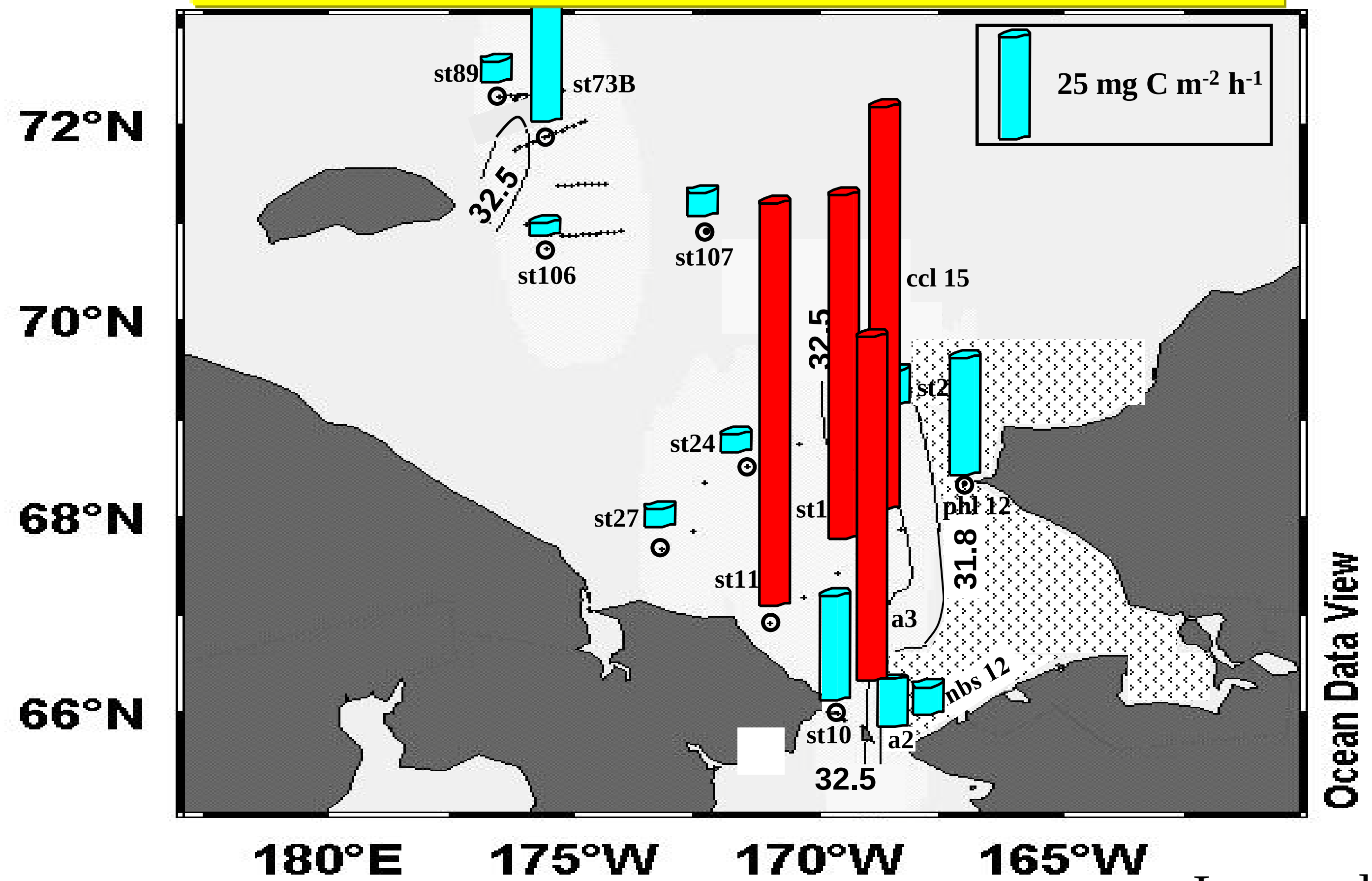
Light or Nutrients Limitations of phytoplankton



➔So, to try to find out which factor is more important for phytoplankton growth, enrichment experiments for light, nitrate, and ammonium were performed in 20009. Good PI curves from light enrichment experiments were obtained at every station, but not for nutrient enrichments. These results suggest light is a more important limiting factor for their growth at least in the 2009 cruise.

2004 carbon uptake rates in the Chukchi Sea

Average ± S.D.: 36.8±41.4 mg C m^{-2} h^{-1}



Lee et al. (2007)

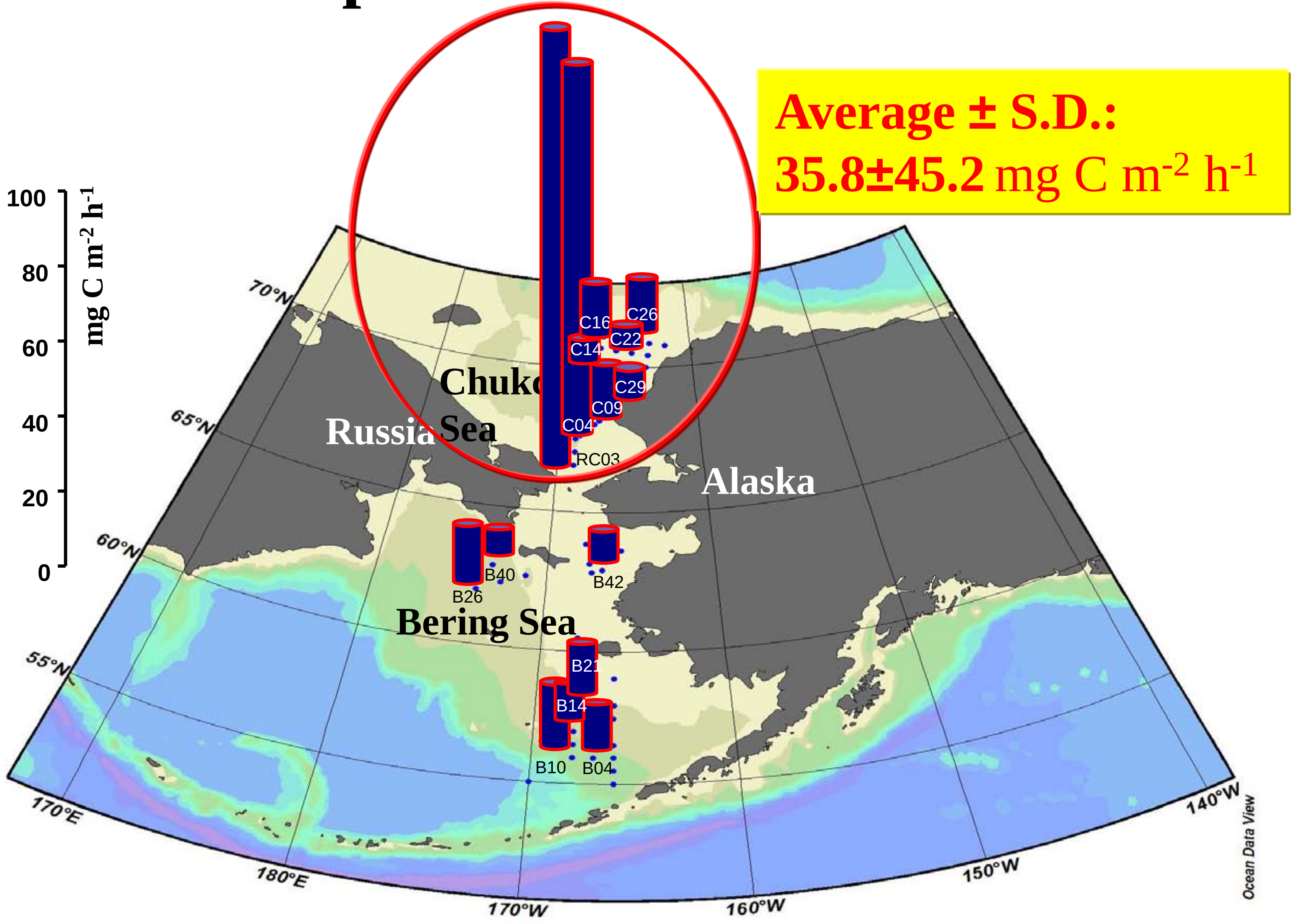
➔From the first Rusalca cruise in 2004, we got an average carbon uptake rate about 36.8 mg C m-2 h-1 in the Chukchi Sea!

Primary Productivity

Source	Productivity ($g\ C\ m^{-2}\ day^{-1}$)	Method	Place or Water mass	Season
McRoy et al. (1972)	**4.1**	^{14}C uptake	western Being Strait	June
Hameedi (1978)	**0.1-1.0** **> 3.0**	^{14}C uptake	Chukchi Sea central Chukchi Sea	July
Sambrotto et al. (1984)	**2.7**	NO_3^- disappearance	western Being Strait	
Springer (1988)	**1.5-16**	^{14}C uptake	central Chukchi Sea	11 July-2 August
Korsak (1992)	**1.7**	^{14}C uptake	Chukchi Sea	28 July-31 August
Zeeman (1992)	**1.6** **0.8**	^{14}C uptake	Chukchi Sea Bering Strait	28 July-31 August
Hansell et al. (1993)	**4.8- 6.0**	NO_3^- disappearance	Anadyr Water in the north of Bering Strait	
Springer and McRoy (1993)	**4.7**	^{14}C uptake and chl-a concentration	central Chukchi Sea	28 July-31 August
Hill and Cota (2005)	**0.8**	^{14}C uptake	northeastern Chukchi Sea	summer
Lee et al. (2007)	**0.6** **1.4**	^{13}C uptake	Chukchi Sea central Chukchi Sea	10-22 August

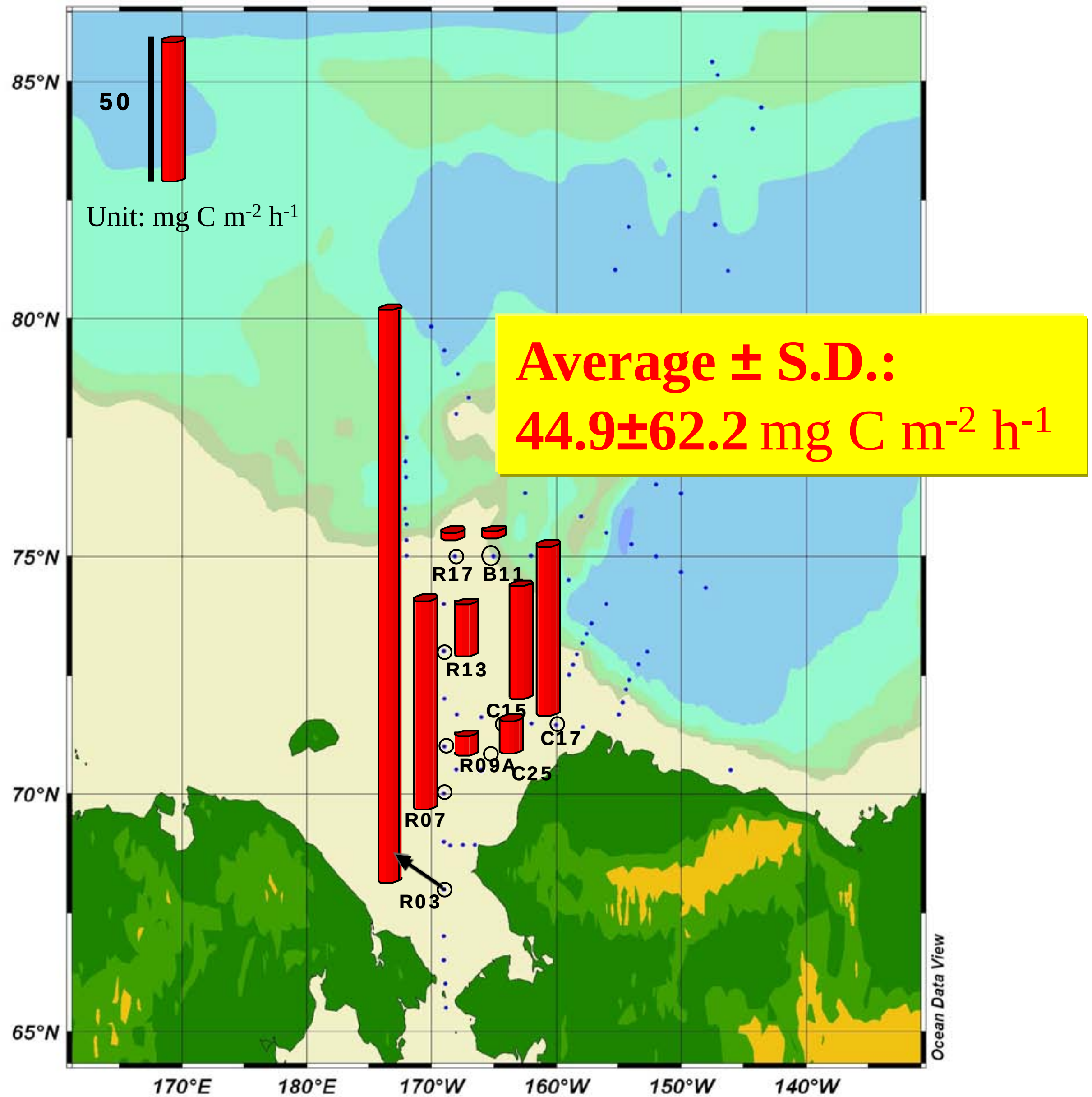
➔The 2004 primary production rates were 2 or 3 times lower than previous results in the Chukchi Sea! But, we were not certain whether this lower productivity came from seasonal and annual variations. So, we measured more PP from other international cruises.

2007 carbon uptake rates in the Chukchi Sea



➔From 2007 Oshoro Maru cruise (early August), we measured an almost identical average rate in the Chukchi Sea although the stations occupied were only on the US side.

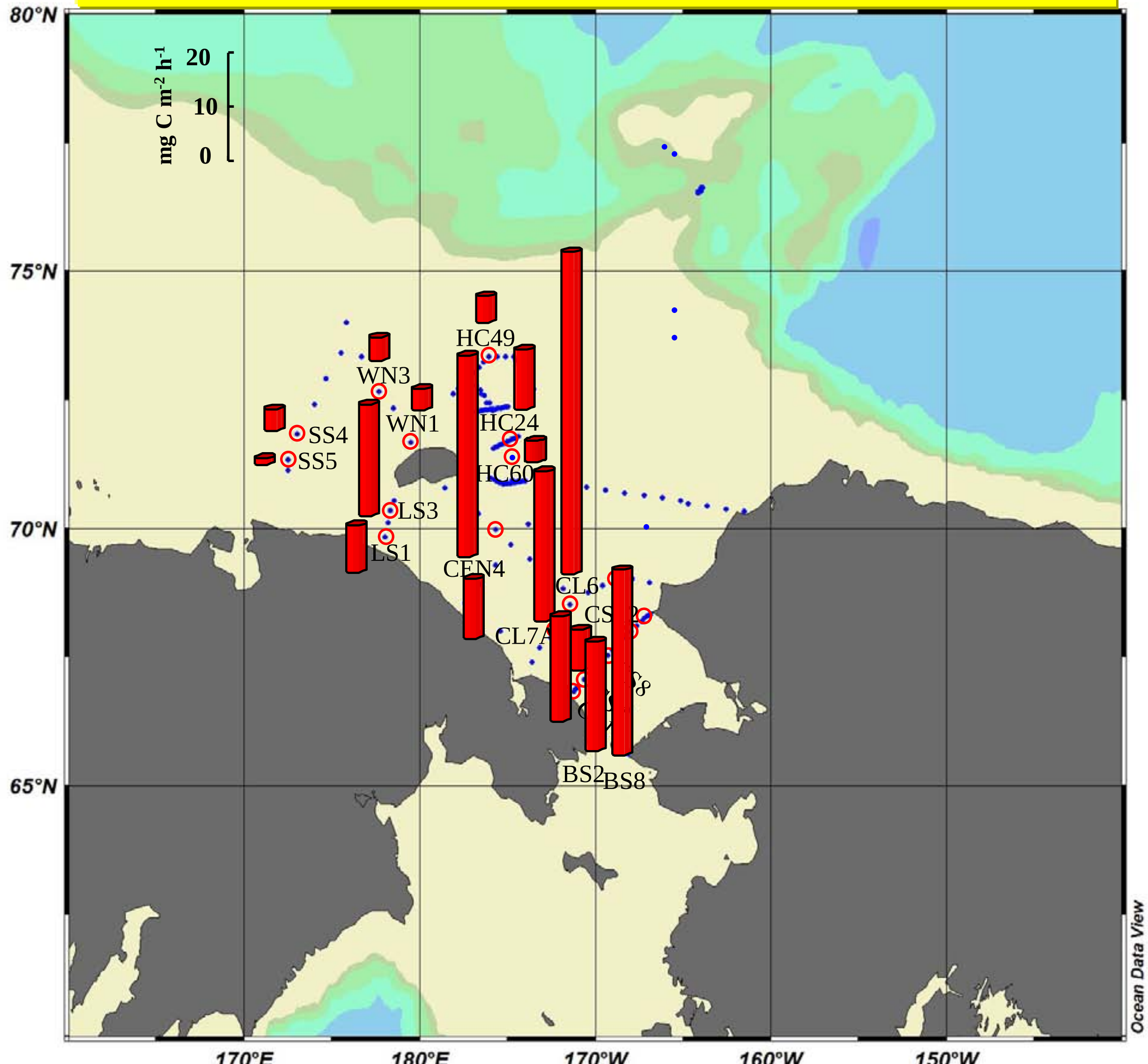
2008 carbon uptake rates in the Chukchi Sea



➔From 2008 Xuelong cruise (early-mid August), a slightly higher rate was obtained but within the same range.

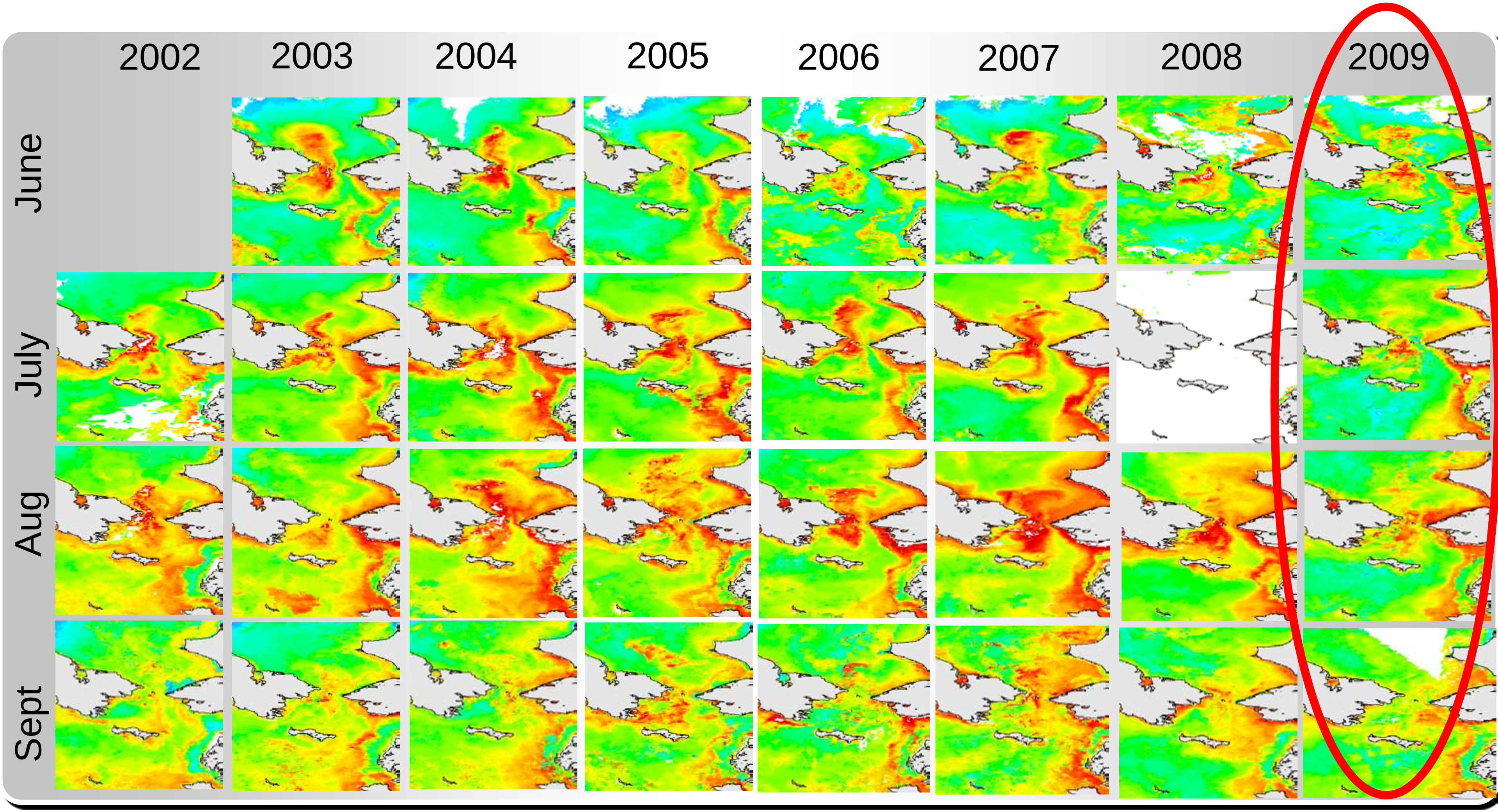
2009 rates in the Russian Chukchi Sea

Average ± S.D.: 16.3±15.7 mg C m^{-2} h^{-1}



➔In 2009 last year (Sept), the average rate was a much lower value than others. This might be due to a seasonal variation since phytoplankton normally have a lower productivity in September in the Chukchi Sea. But, from satellite images (SeaWifs), Chlorophyll-a conc and estimated PP in the Chukchi Sea in 2009 was significantly lower than other years (next slides).

Seasonal/Interannual Variations of PP



Conclusions.

Nutrients – ambient concentrations have decreased by 30-50%

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