# SPATIAL AND TEMPORAL VARIABILITY OF COCCOLITHOPHORE BLOOMS IN THE EASTERN BERING SEA

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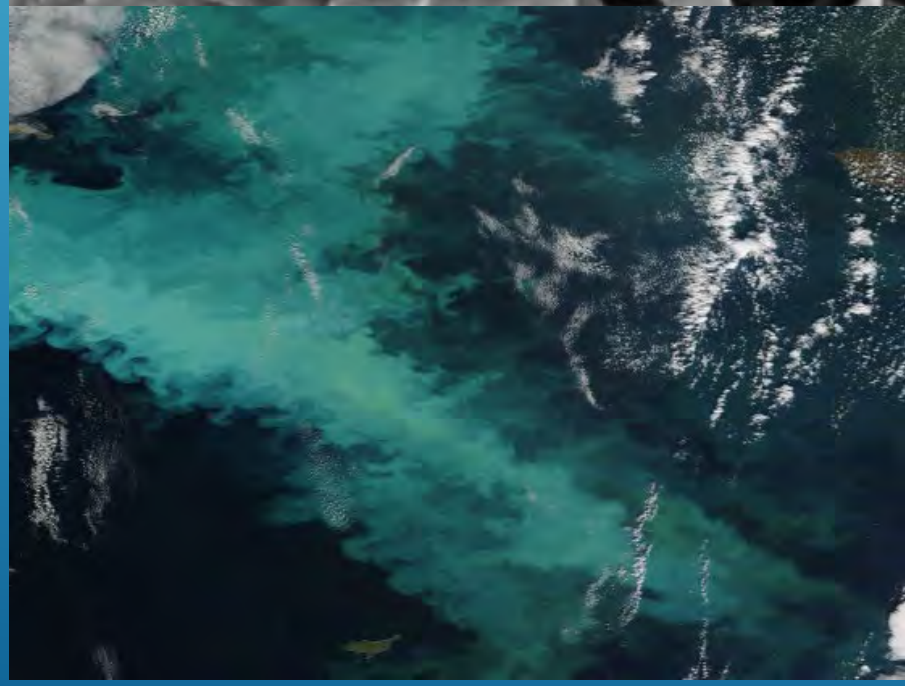
NOAA

PMEL

# COCCOLITHOPHORES

- Small (3-10 µm) phytoplankton cells with exoskeleton plates of calcium carbonate
- Blooms thought to develop in stratified, nutrient depleted surface waters
- Blooms may affect visual predators (fish, seabirds)
- Blooms may promote a less productive & longer food web
- Coccolithophore $CaCO_3$ precipitation contributes to carbon sequestration on planetary scales (Westbroek et al., 1993)

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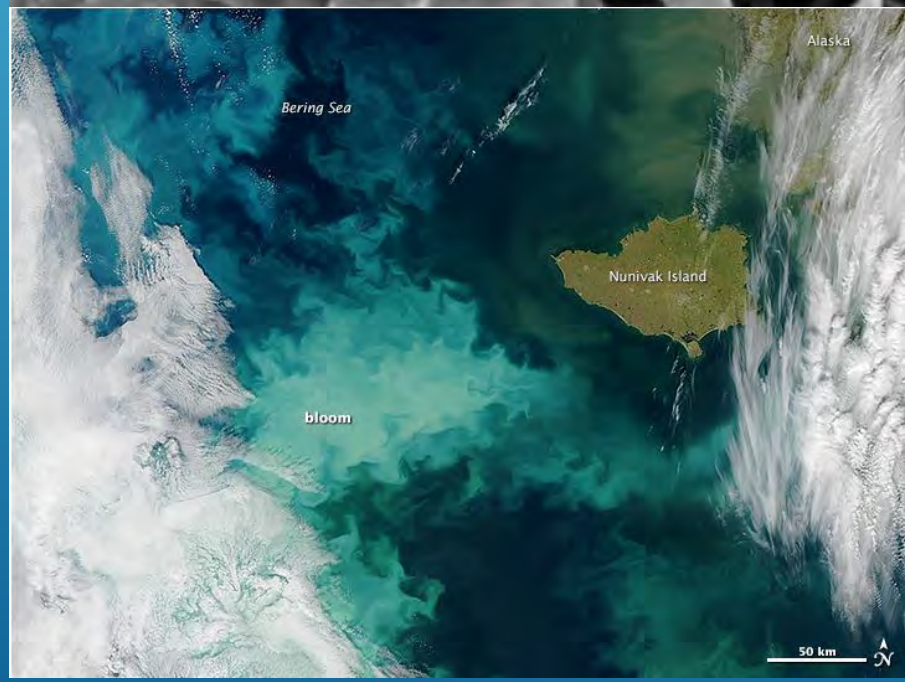

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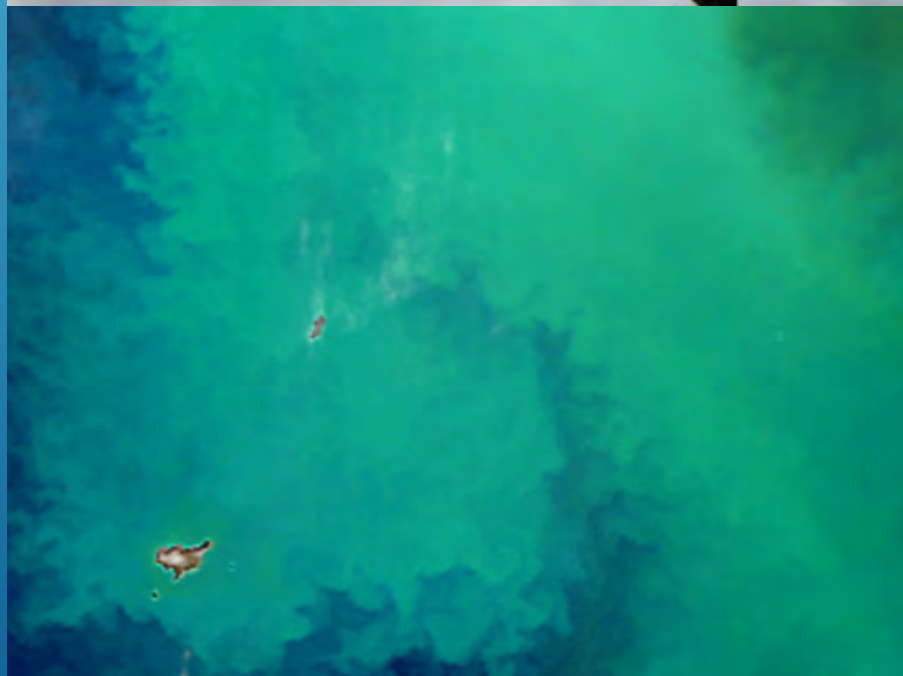

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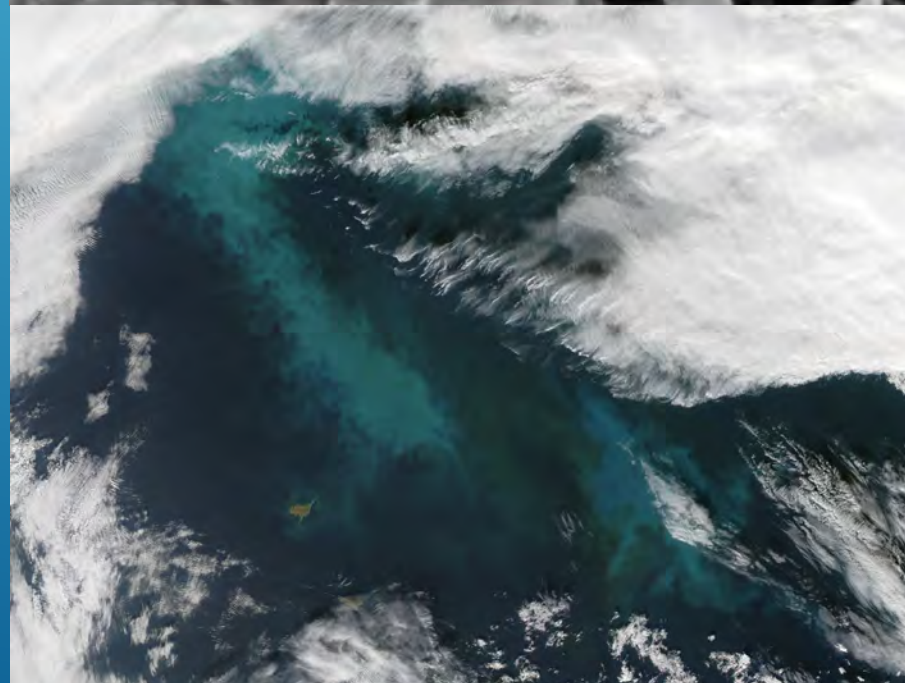
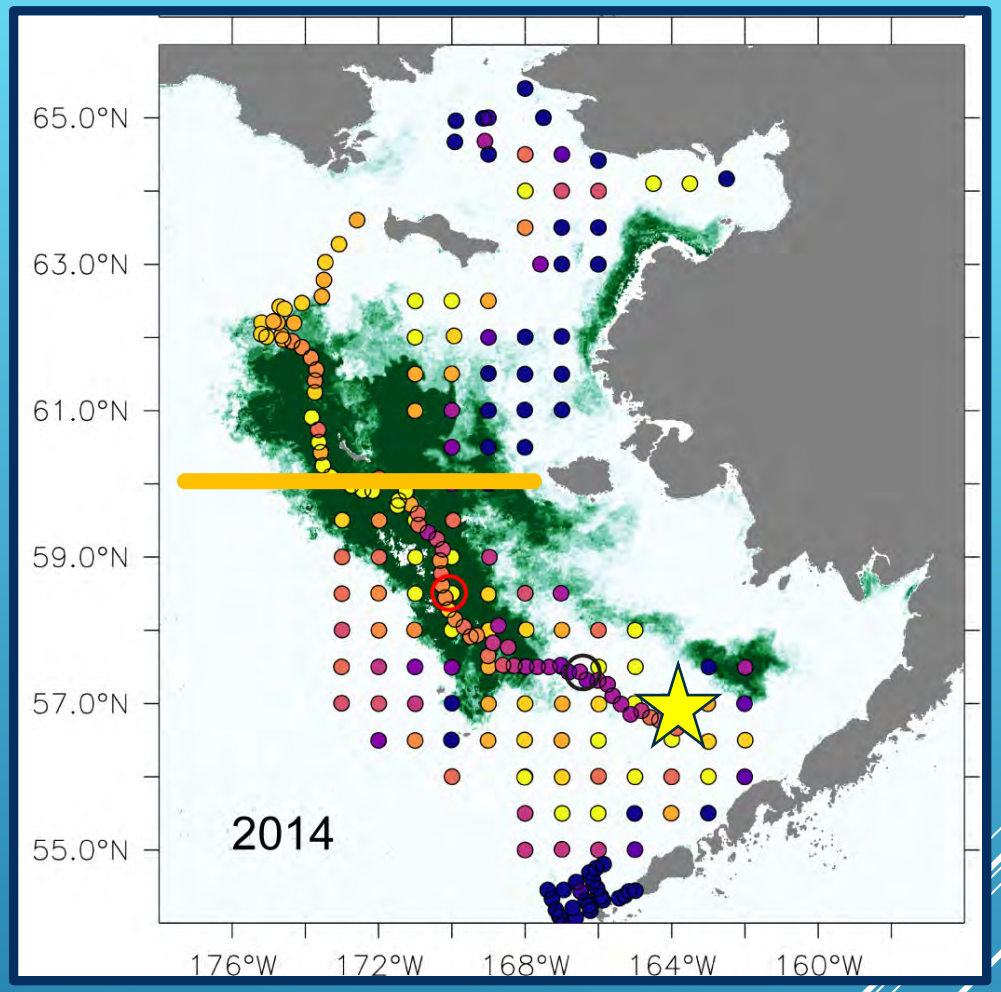


# BERING SEA

- Wide shelf (>500 km)
- 3 shelf domains (inner, middle shelf, and outer shelf)
- Marginal Ice zone
- Sea ice, temperature, stratification important to ecosystem

# DATA

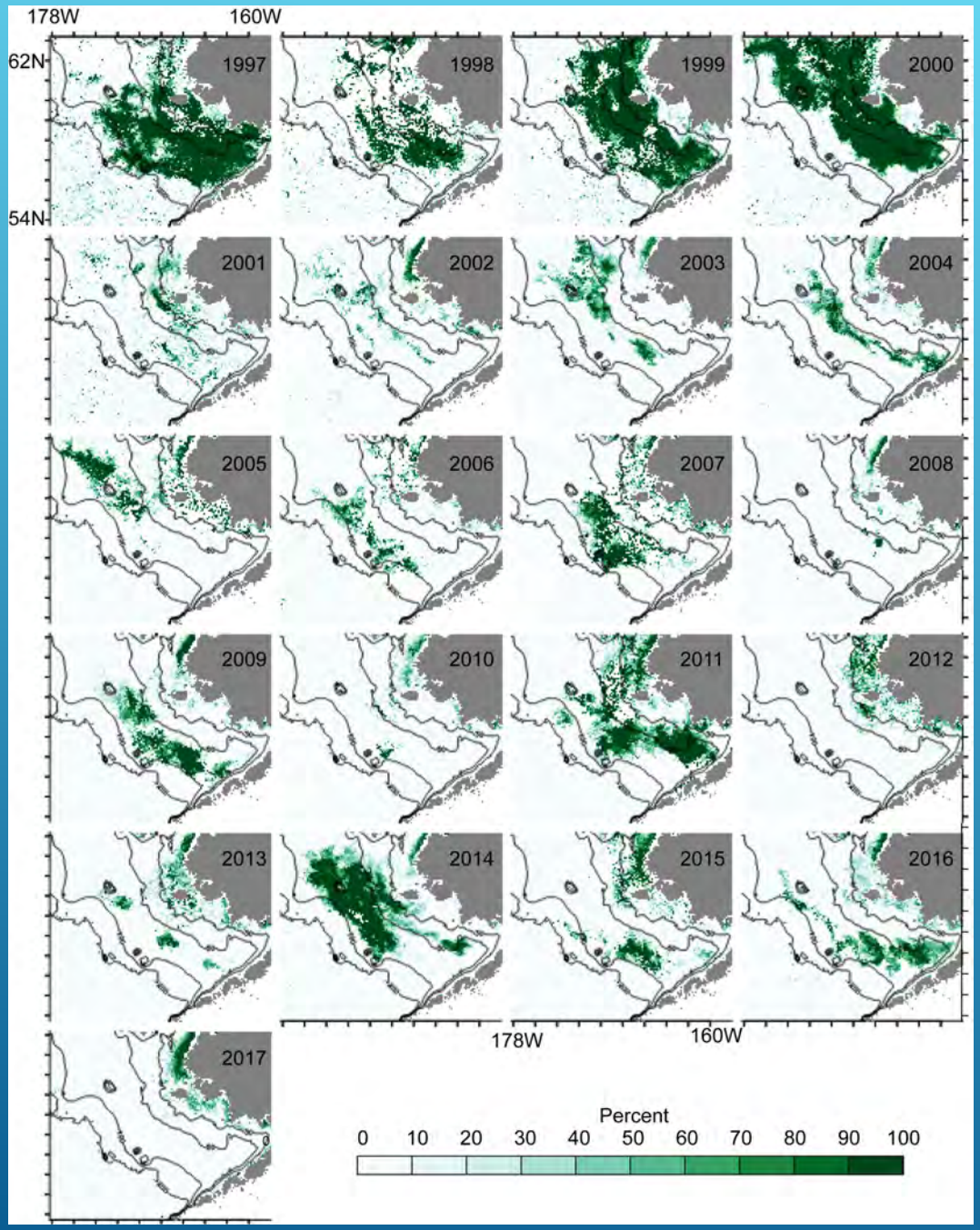
- Coccolithophore Bloom Index
  - SeaWiFS 1998-2001
  - MODIS 2002-present
- Stratification Index
  - ★ Moored temperature data (M2): Mixed Layer Temp – Deep Temp
- Cruise Data (August/September 2009, 2011, 2014)
  - Gridded Survey
  - 70m isobath transect

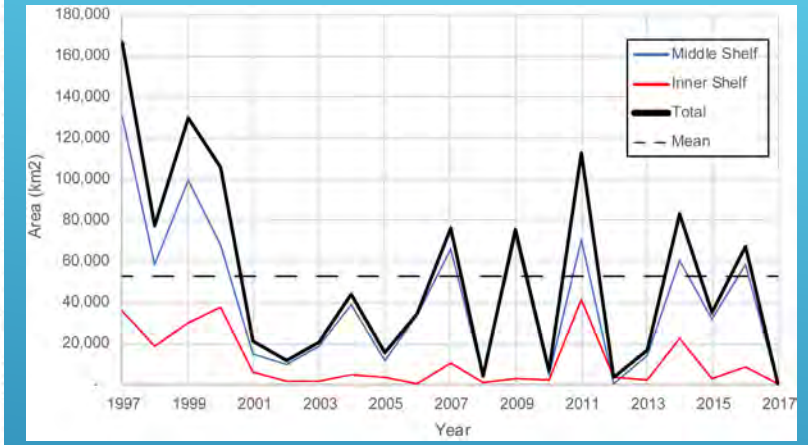


# COCCOLITHOPHORE BLOOM INDEX (CBI)

- Methodology developed by lida et al. (2012; 2002) to identify satellite ocean color pixels associated with coccolithophores
  - SeaWiFS 1998-2001
  - MODIS 2002-present
- Estimated average area ($km^2$) covered by coccolithophore blooms during September each year
- Two indices calculated: one for the middle shelf and one for the inner shelf south of 60°N
  - middle shelf (50 – 100m depth)
  - inner shelf (30 – 50m depth)

# COCCOLITHOPHORE BLOOM INDEX (CBI)




***(Ladd et al., 2017)***
Alaska Marine Ecosystem Considerations
http://access.afsc.noaa.gov/reem/ecoweb/Index.php

# COCCOLITHOPHORE BLOOM INDEX (CBI)

| Year | Satellite | Middle Shelf | Inner Shelf | Total |
|---|---|---|---|---|
| 1997 (C) | SeaWiFS | 130,391 | 36,141 | **166,532** |
| 1998 (W) | SeaWiFS | 58,776 | 18,983 | **77,759** |
| 1999 (C) | SeaWiFS | 99,791 | 30,344 | **130,134** |
| 2000 (A) | SeaWiFS | 68,306 | 37,566 | **105,873** |
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| 2008 (C) | MODIS | 3,579 | 862 | 4,441 |
| 2009 (C) | MODIS | 72,576 | 3,279 | **75,855** |
| 2010 (C) | MODIS | 4,608 | 2,109 | 6,717 |
| 2011 (C) | MODIS | 70,772 | 41,802 | **112,574** |
| 2012 (C) | MODIS | 273 | 3,656 | 3,930 |
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| 2014 (W) | MODIS | 60,658 | 22,268 | **82,927** |
| 2015 (W) | MODIS | 32,302 | 2,893 | 35,195 |
| 2016 (W) | MODIS | 58,797 | 8,767 | **67,563** |
| 2017 (A) | MODIS | 9 | 431 | 440 |
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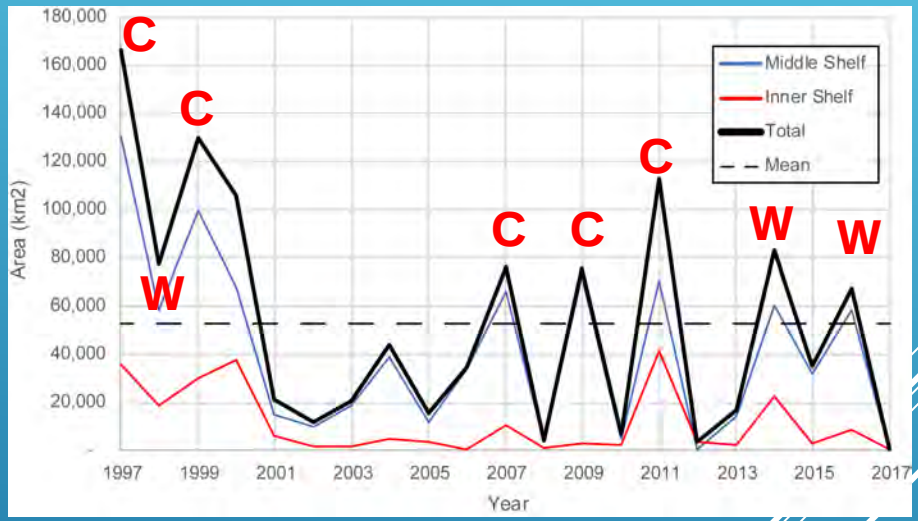
| Mean | | 41,470 | 11,460 | 52,930 |
| Standard Deviation | | 35,753 | 13,774 | 47,332 |

**Table 1. CBI: Area covered by bloom in September**

**W/C/A designation of each year refers to warm, cold, or average conditions**

**Bloom years**

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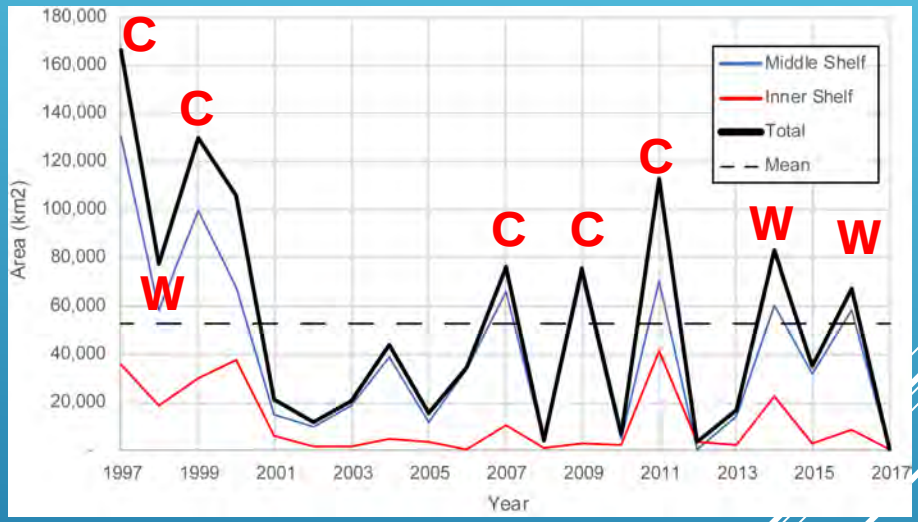
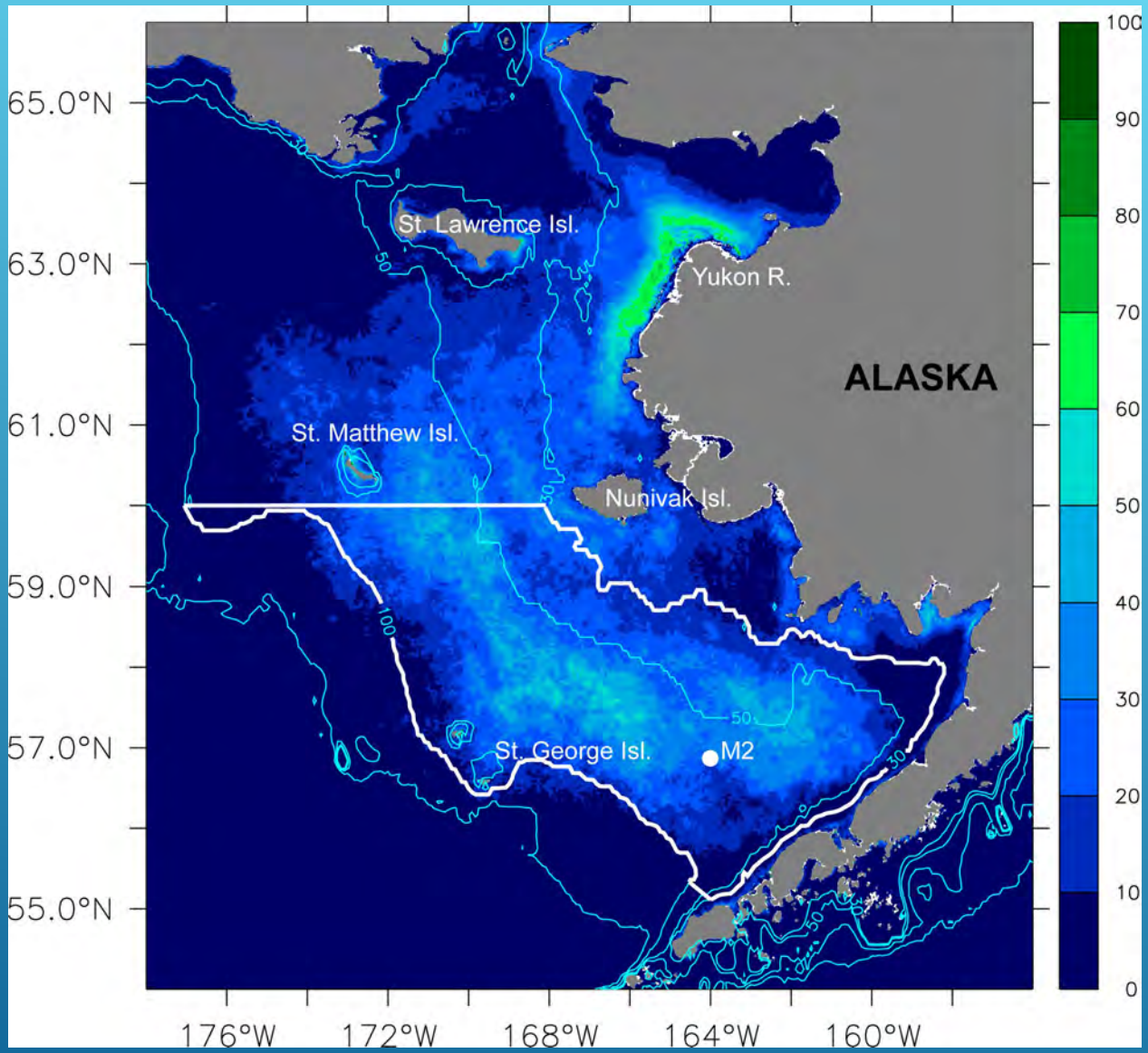



Bloom Years NOT associated with warm/cold (or ice extent)

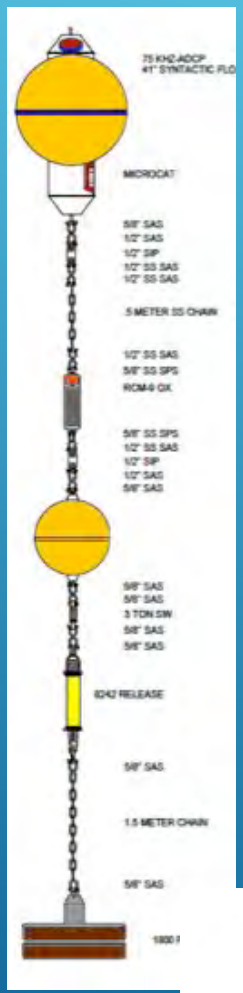


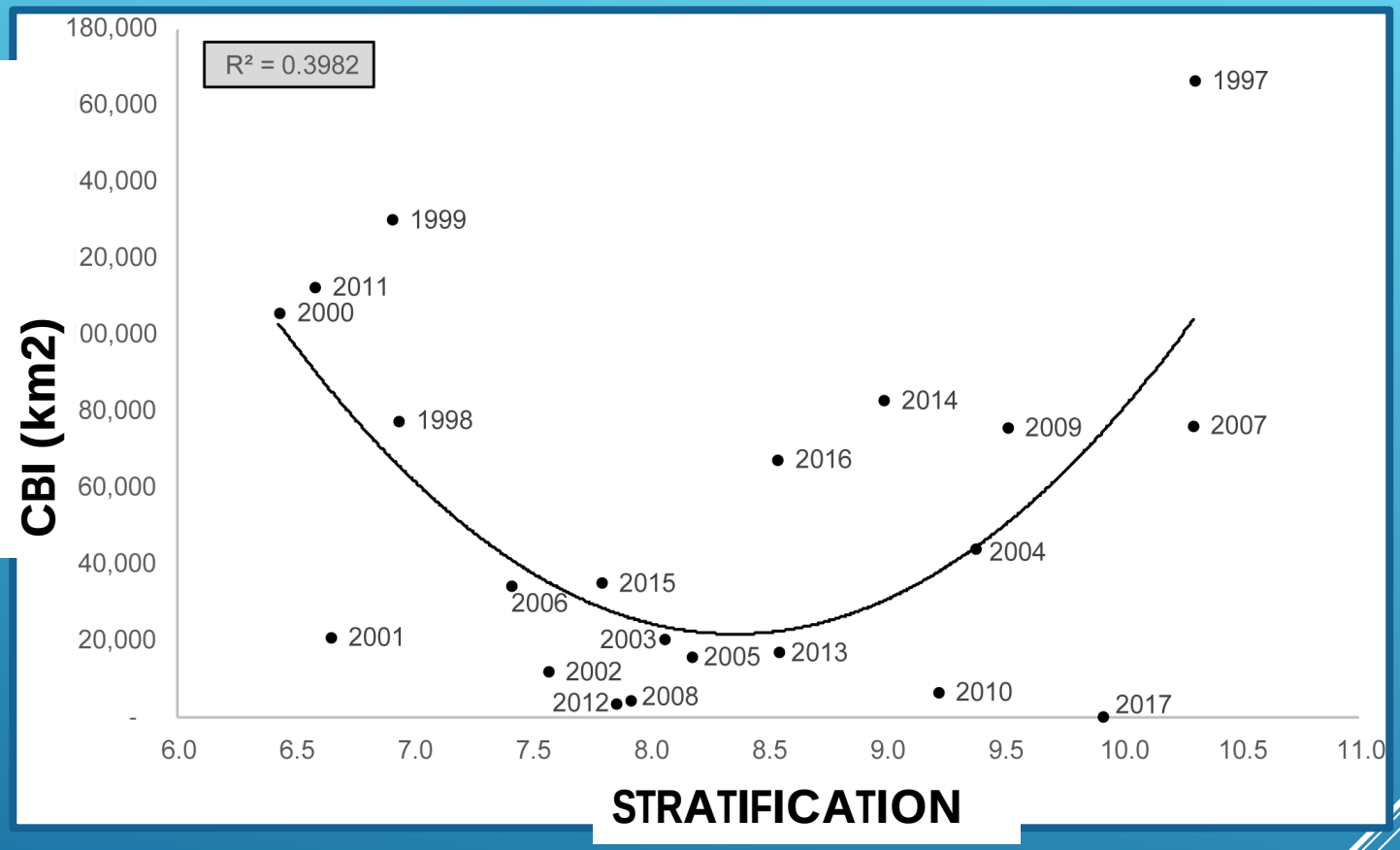

# COMPOSITE CBI (1997 – 2016)

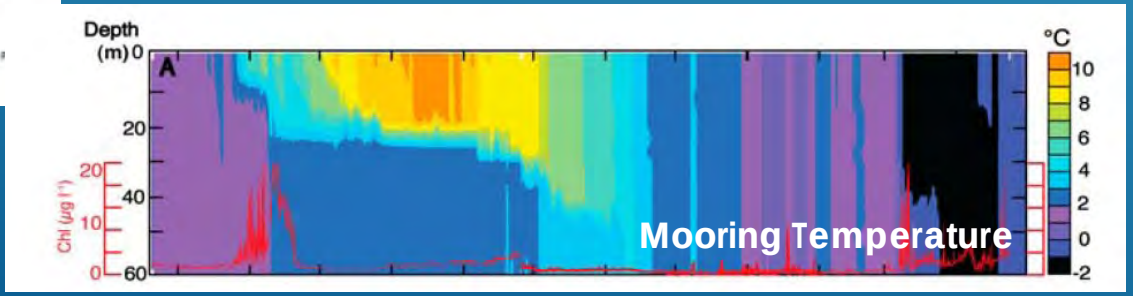
22% Inner Shelf

78% Middle Shelf

# CBI VS STRATIFICATION





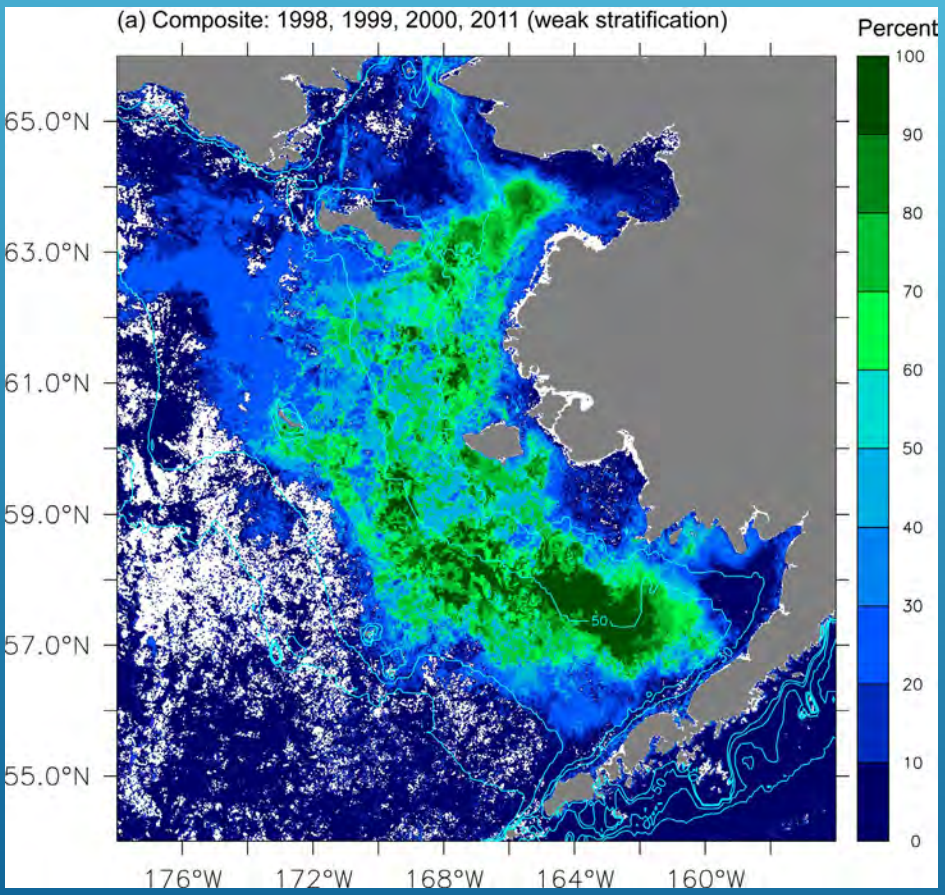
# STRATIFICATION AFFECTS LOCATION OF BLOOM

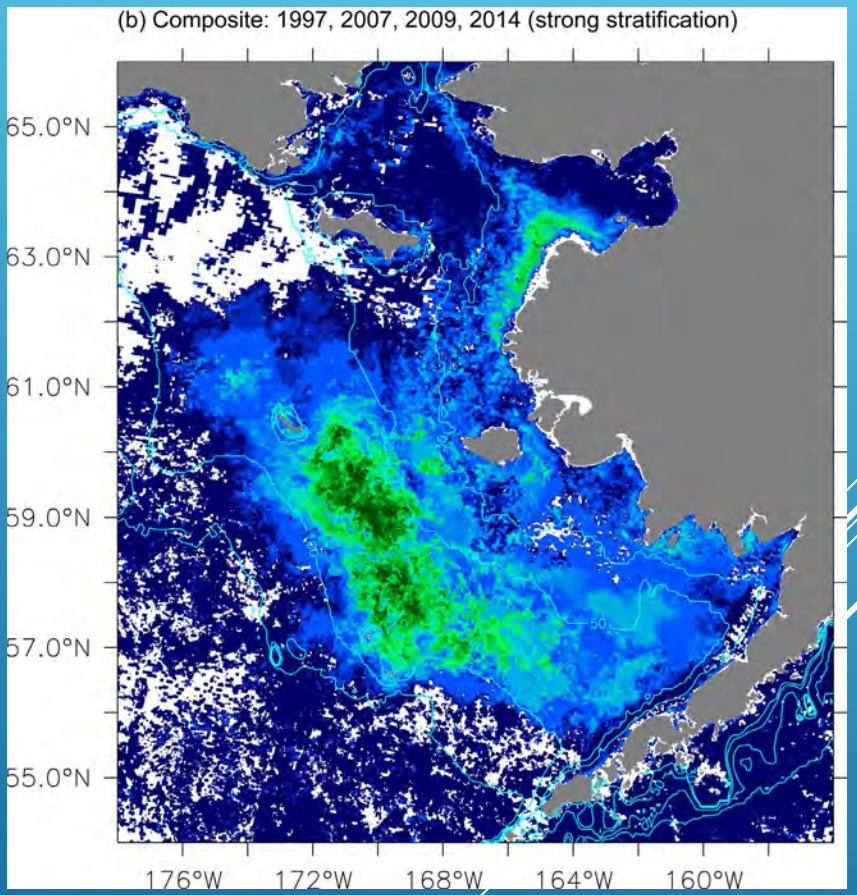
**Weak stratification years**

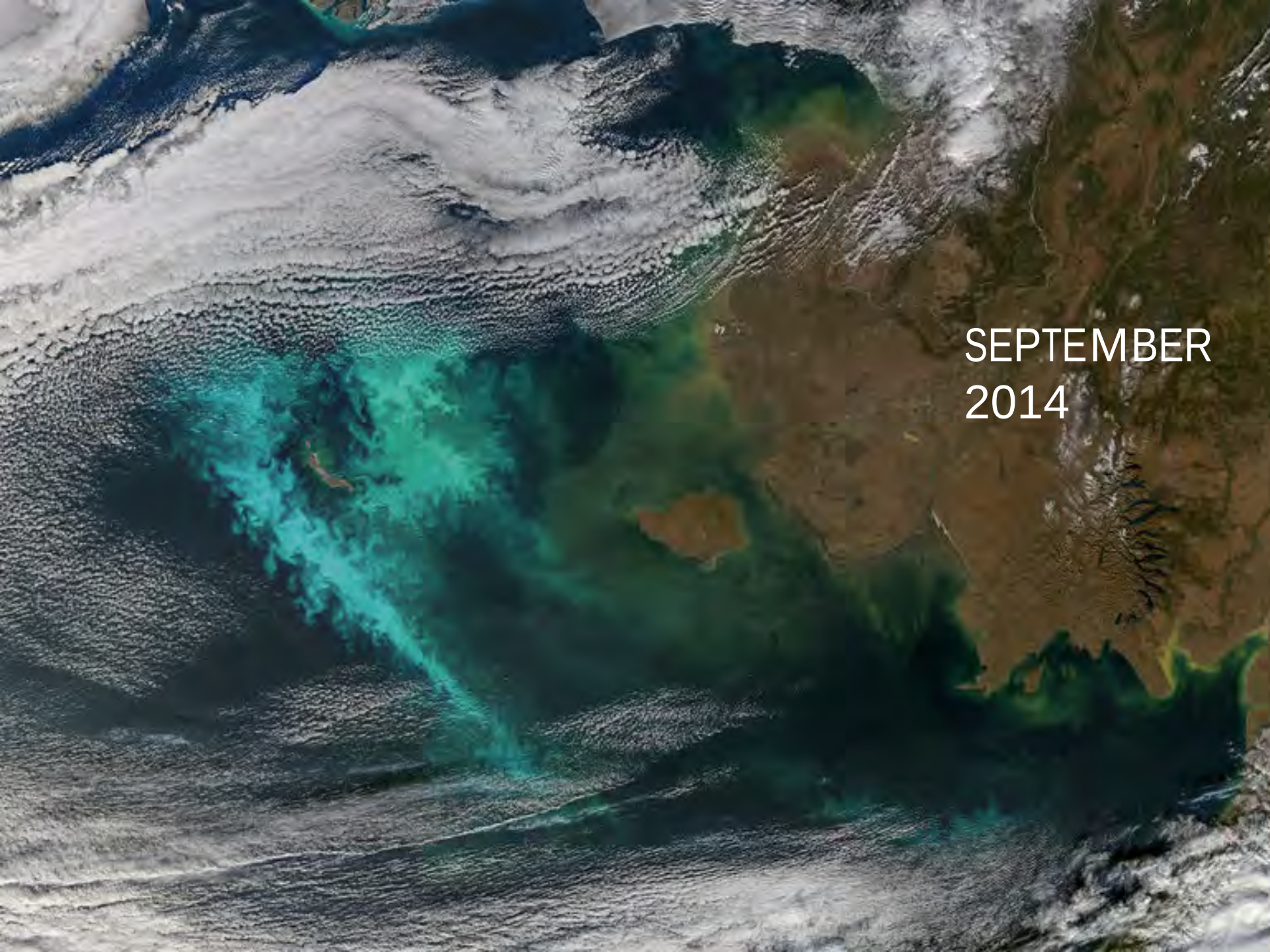
⇒ **more bloom on inner shelf**

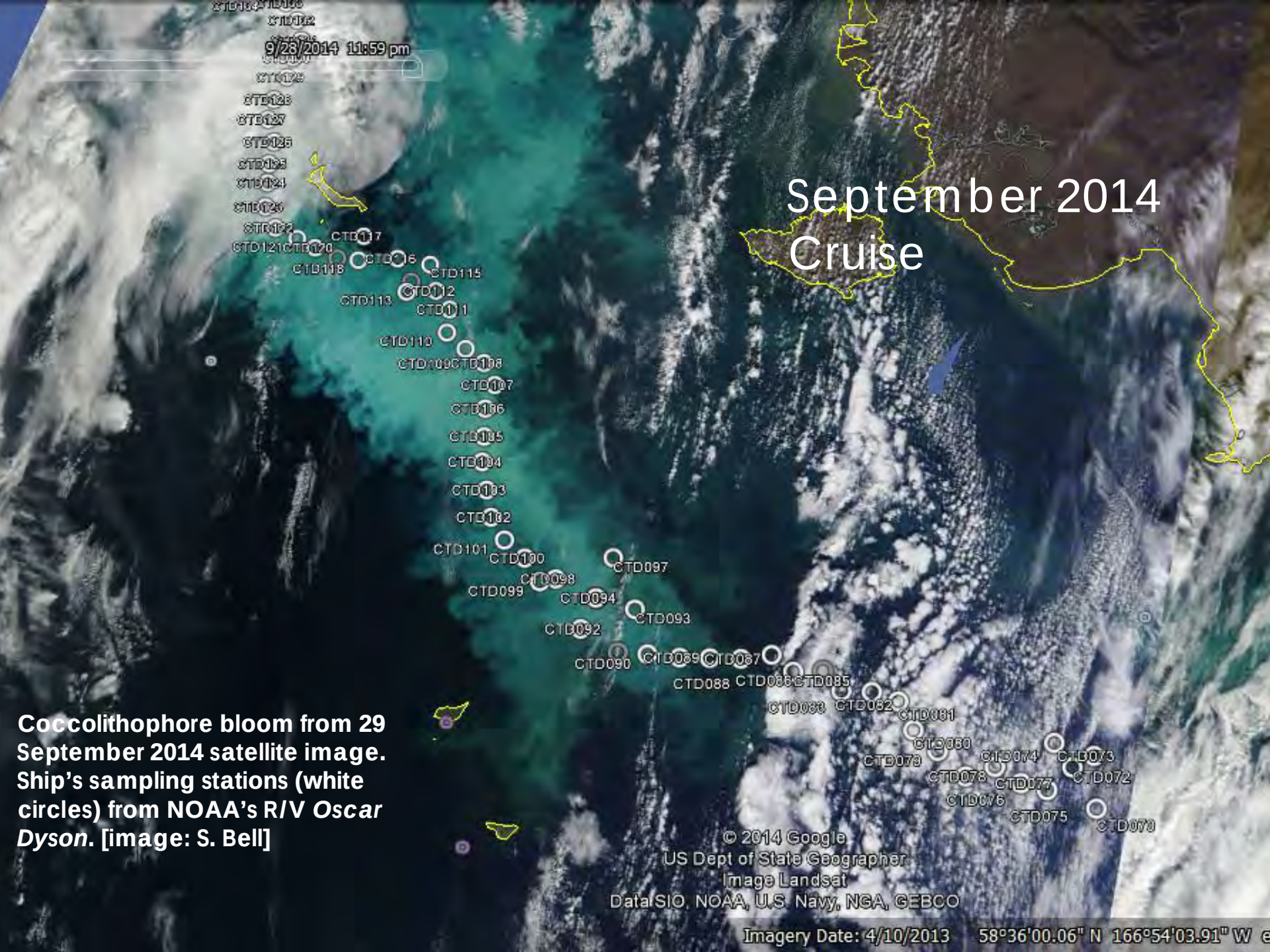
**Strong stratification years**

⇒ **more bloom on middle shelf**

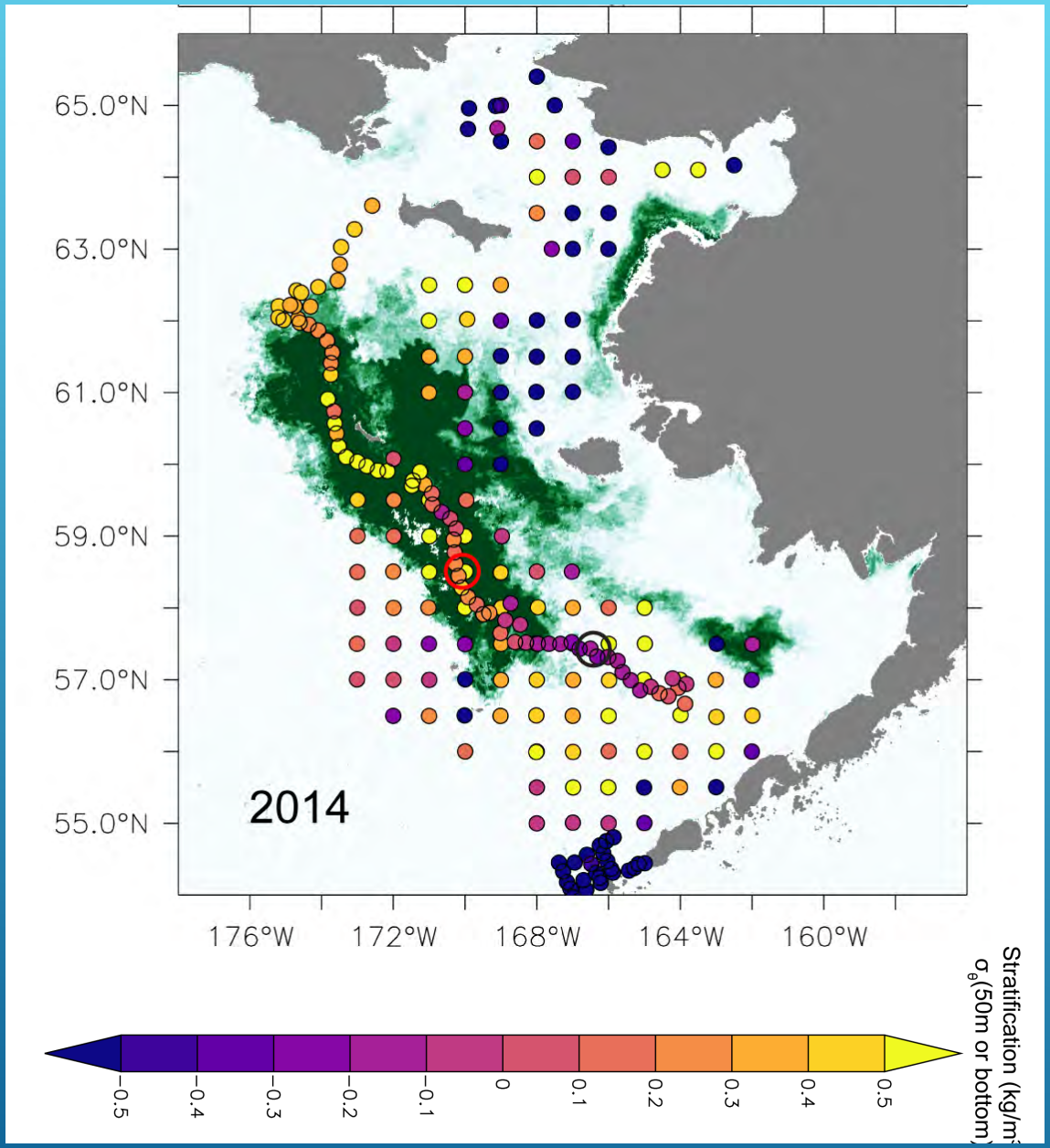



SEPTEMBER
2014




**Coccolithophore bloom from 29 September 2014 satellite image. Ship's sampling stations (white circles) from NOAA's R/V *Oscar Dyson*. [image: S. Bell]**

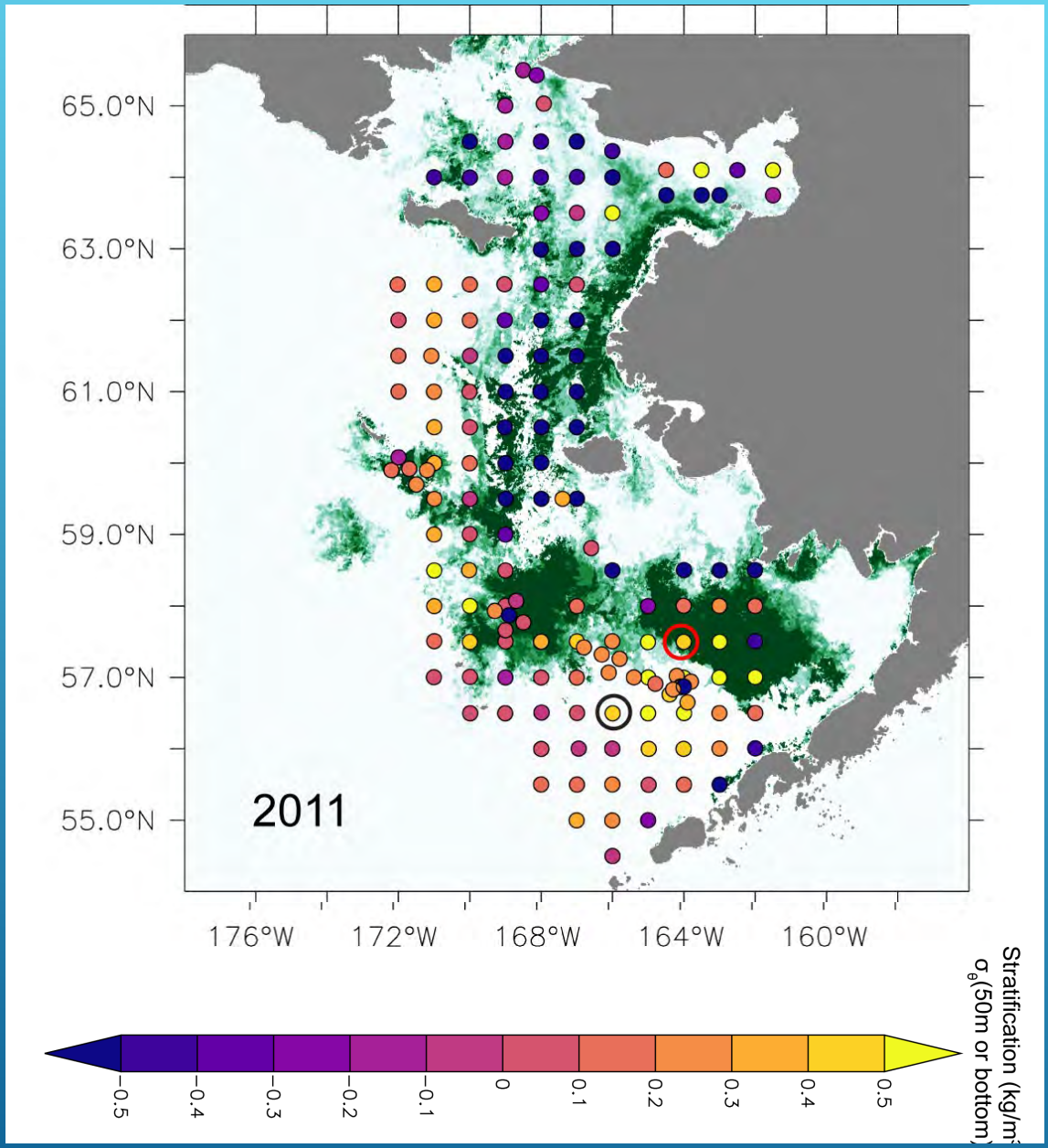



# 2014 SEPTEMBER CRUISE DATA

2014: relatively strong stratification

Bloom (middle shelf) is coincident with

- Stronger stratification




# 2011 SEPTEMBER CRUISE DATA

## 2011: weak stratification

Bloom (inner shelf)

is coincident with

- Weaker stratification

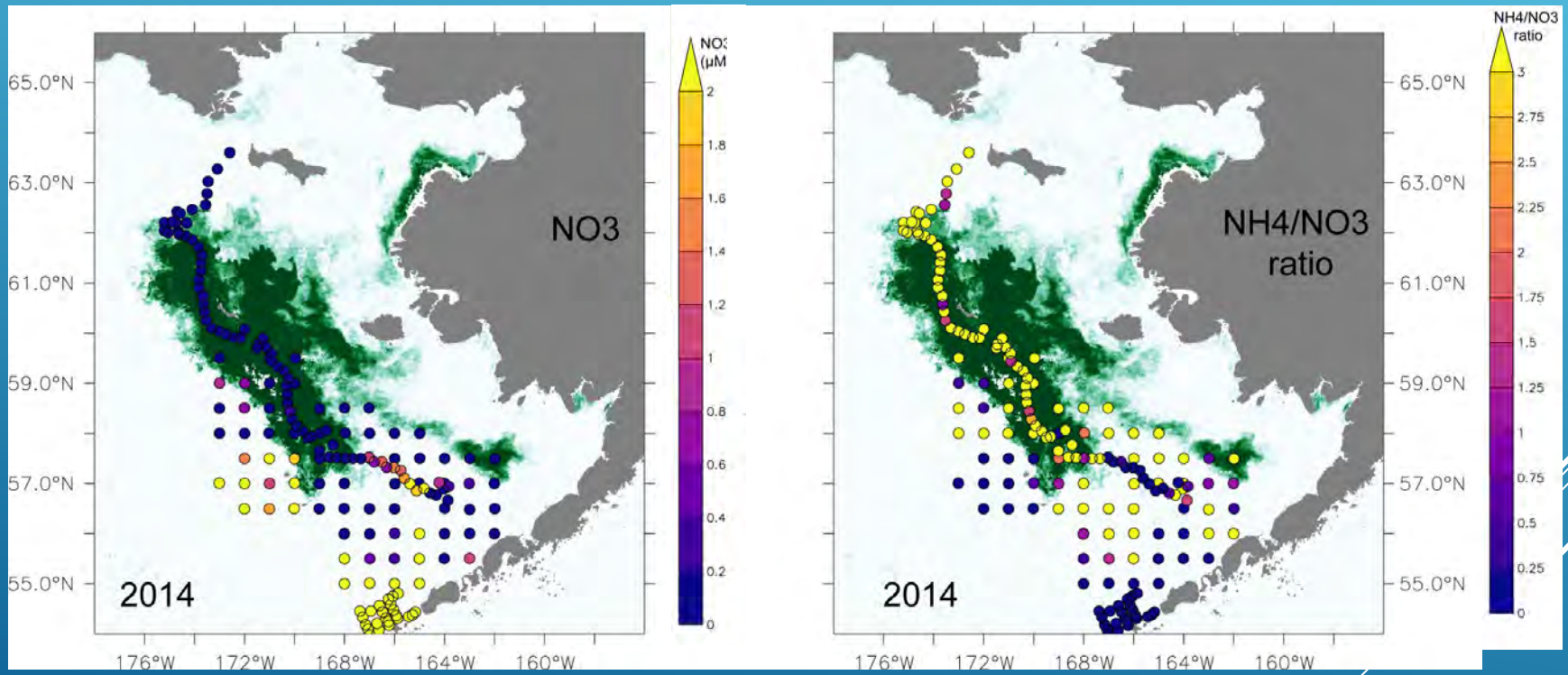
# 2014 SEPTEMBER CRUISE DATA

Bloom (middle shelf)

is coincident with

- Lower NO3/higher NH4

2014: relatively strong stratification



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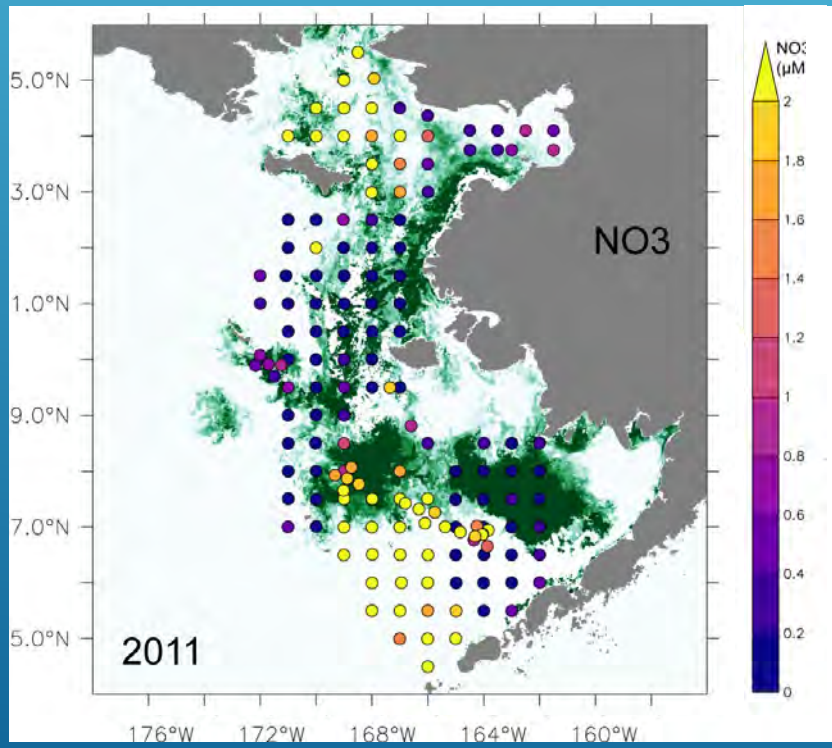


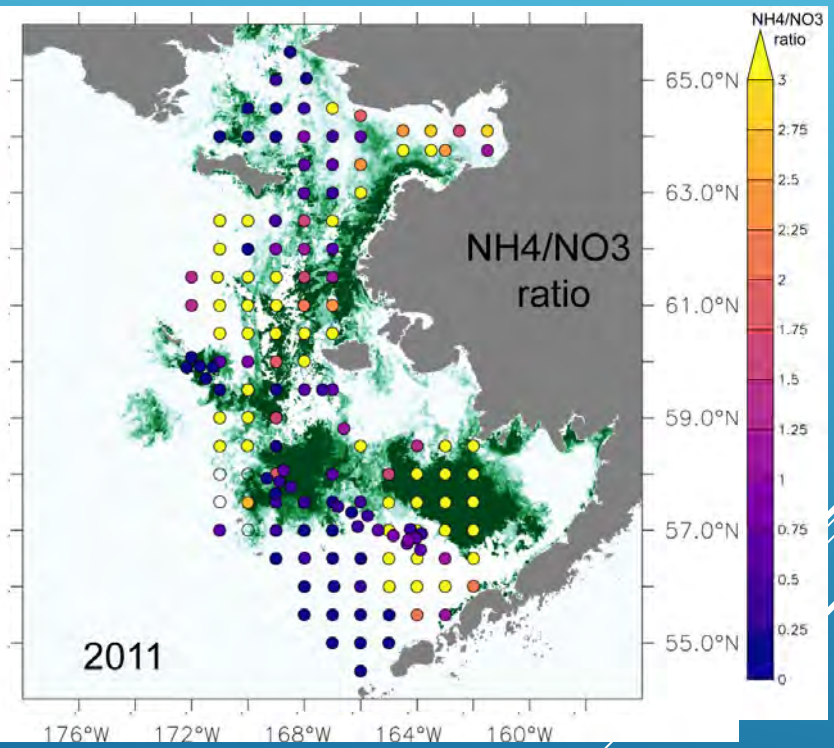

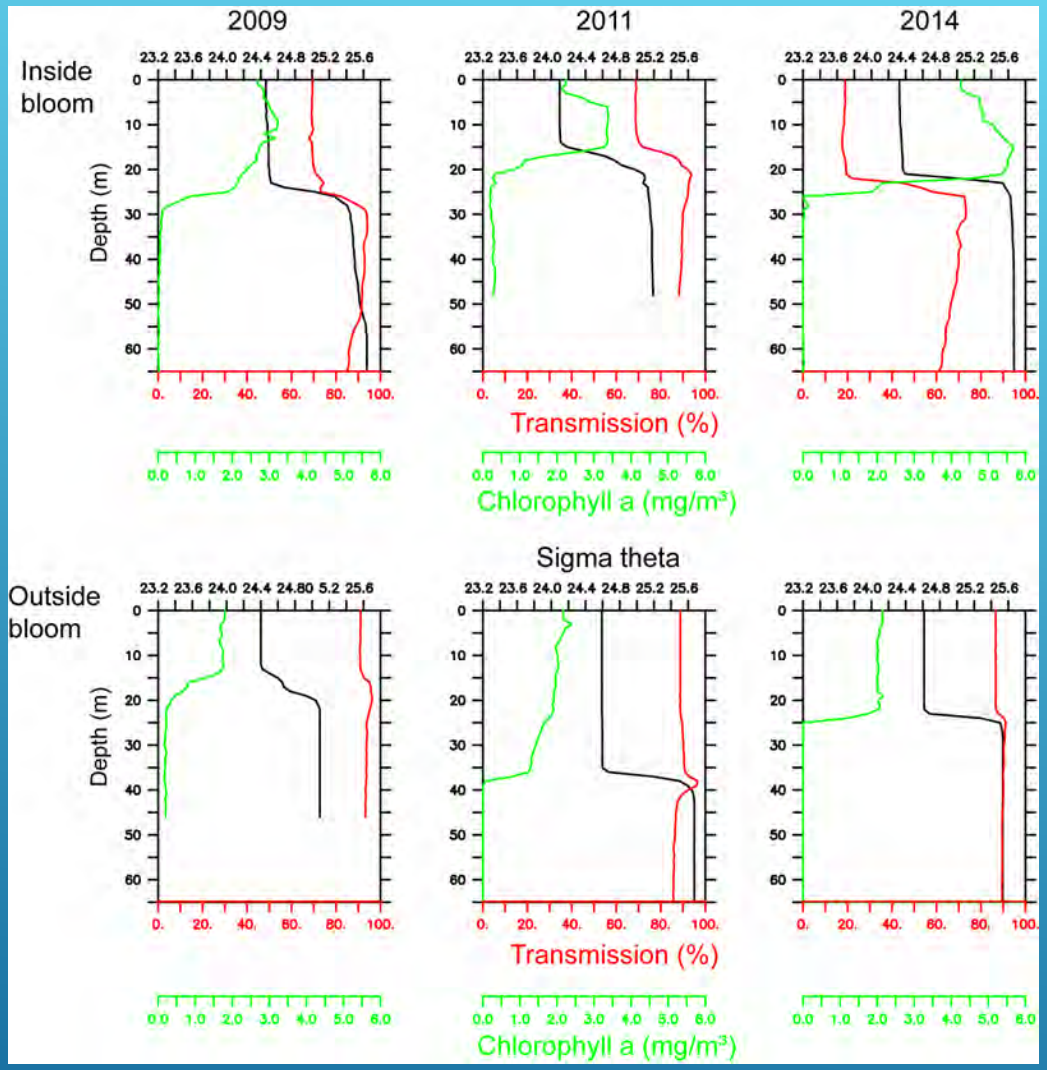


# 2009, 2011, 2014 CRUISE DATA

**Inside bloom:**

- High Chl a above pycnocline
- Low light transmission above pycnocline

**Outside bloom:**

- High light transmission throughout water column

# CONCLUSIONS

- Coccolithophore Bloom Index (CBI) has been developed for monitoring and reporting to Ecosystem Managers
- High interannual variability
  (not associated with temperature regime)
- Blooms typically occur over middle shelf of Bering Sea
- Location of bloom associated with stratification: Low stratification resulted in spatial shift of bloom toward shallower inner shelf water
- Blooms associated with both very high and very low stratification
- Spatial correspondence between areal extent of bloom and:
  - Low nitrate/high ammonium concentrations