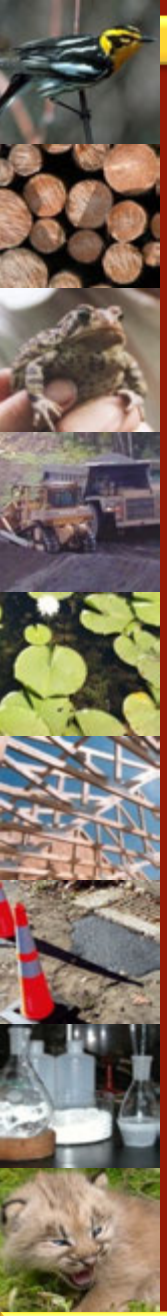

Lake Superior collections

- Pelagic monitoring
- Sediment cores

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Sea Grant

Minnesota Pollution Control Agency

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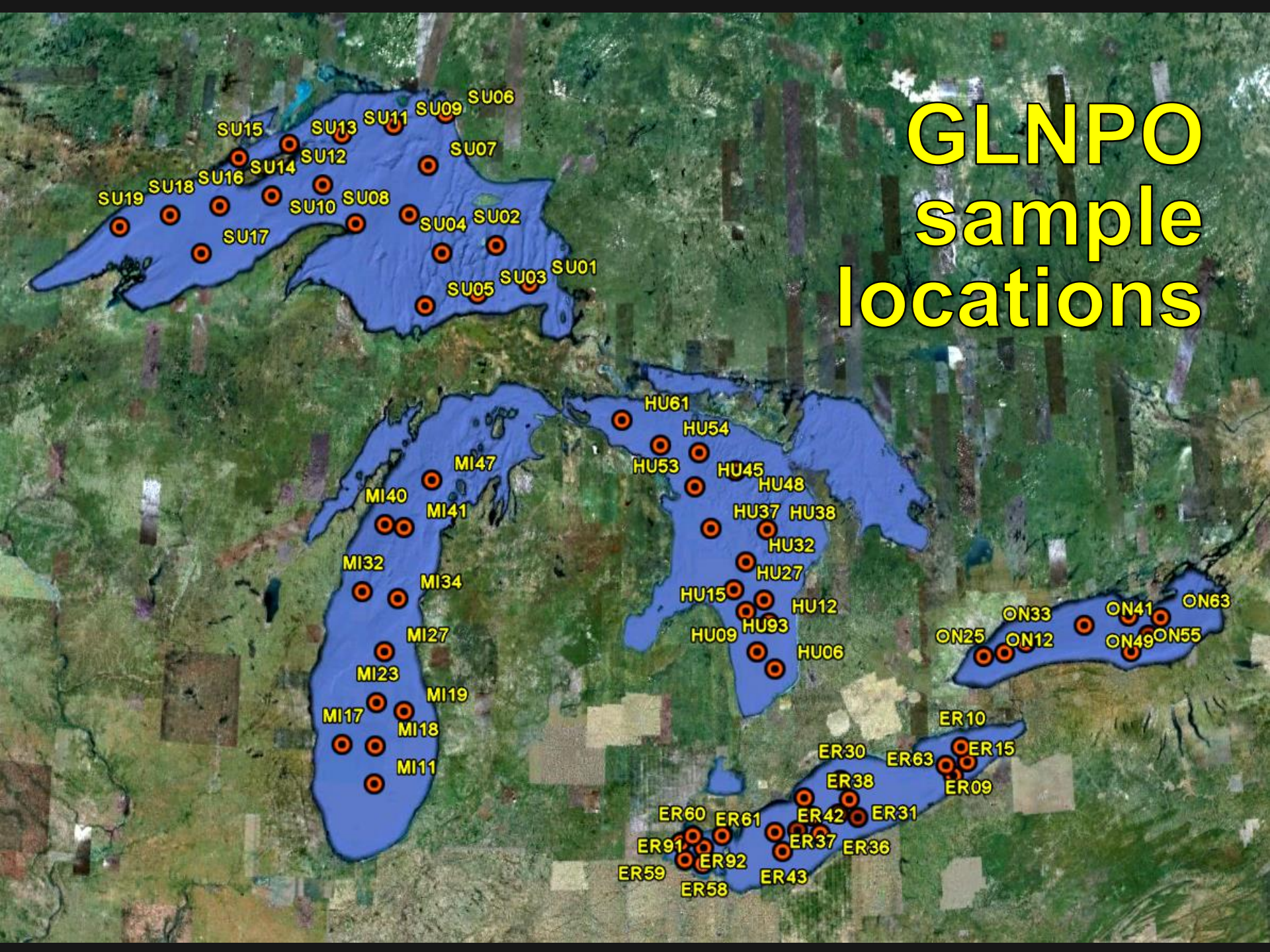
Driven to Discover

Growing Strong Industries ~ Developing New Ideas ~ Nurturing Natural Resources

EPA's biological monitoring program - highlights

- Initiated 1983
- Whole system is sampled twice a year (early spring and late summer)
- Water quality, zooplankton, phytoplankton, benthic invertebrates, & sediments
- assess compliance with requirements under GLWQA (IJC 1978)

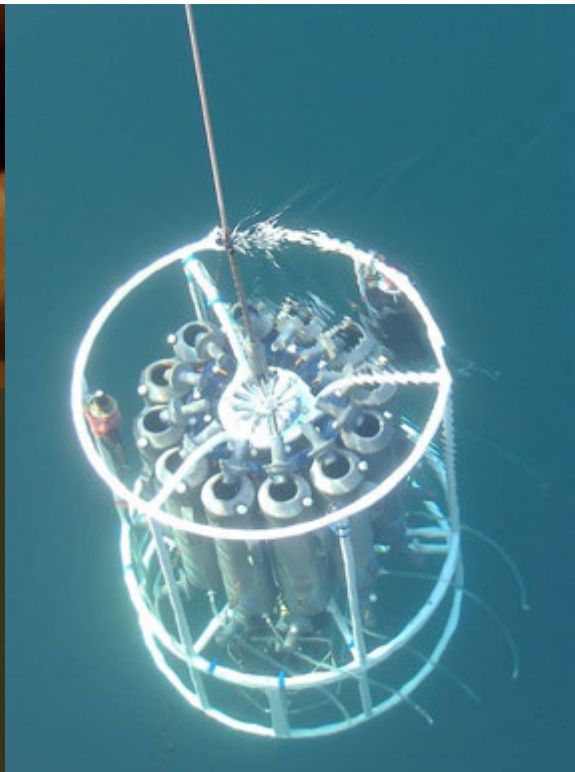
R/V Peter Wise
Lake Guardian


GLNPO
sample
locations
SU01
SU02
SU03
SU04
SU05
SU06
SU07
SU08
SU09
SU10
SU11
SU12
SU13
SU14
SU15
SU16
SU17
SU18
SU19
MI11
MI17
MI18
MI19
MI23
MI27
MI32
MI34
MI40
MI41
MI47
HU06
HU09
HU12
HU15
HU27
HU32
HU37
HU38
HU45
HU48
HU53
HU54
HU61
HU93
ON12
ON25
ON33
ON41
ON49
ON55
ON63
ER09
ER10
ER15
ER30
ER31
ER36
ER37
ER38
ER42
ER43
ER58
ER59
ER60
ER61
ER63
ER91
ER92

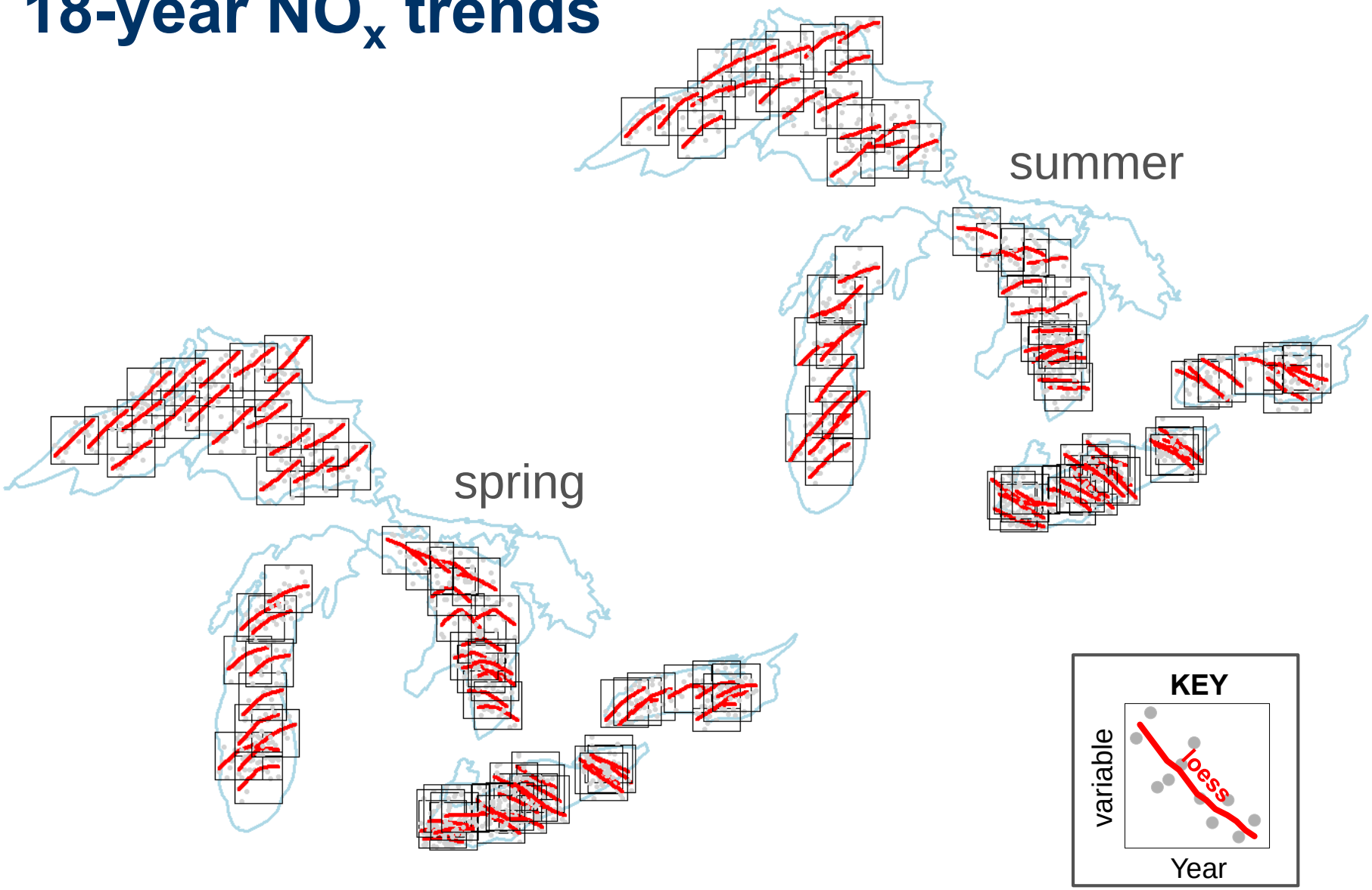
Environmental variables

Chemical and particulate variables
Total phosphorus
Total nitrogen
Chlorophyll *a*
Suspended solids
Turbidity
Fluorescence
pH
Temperature
Specific conductivity
Oxygen
Alkalinity
Ammonium
Nitrite
Dissolved organic carbon
Dissolved inorganic carbon

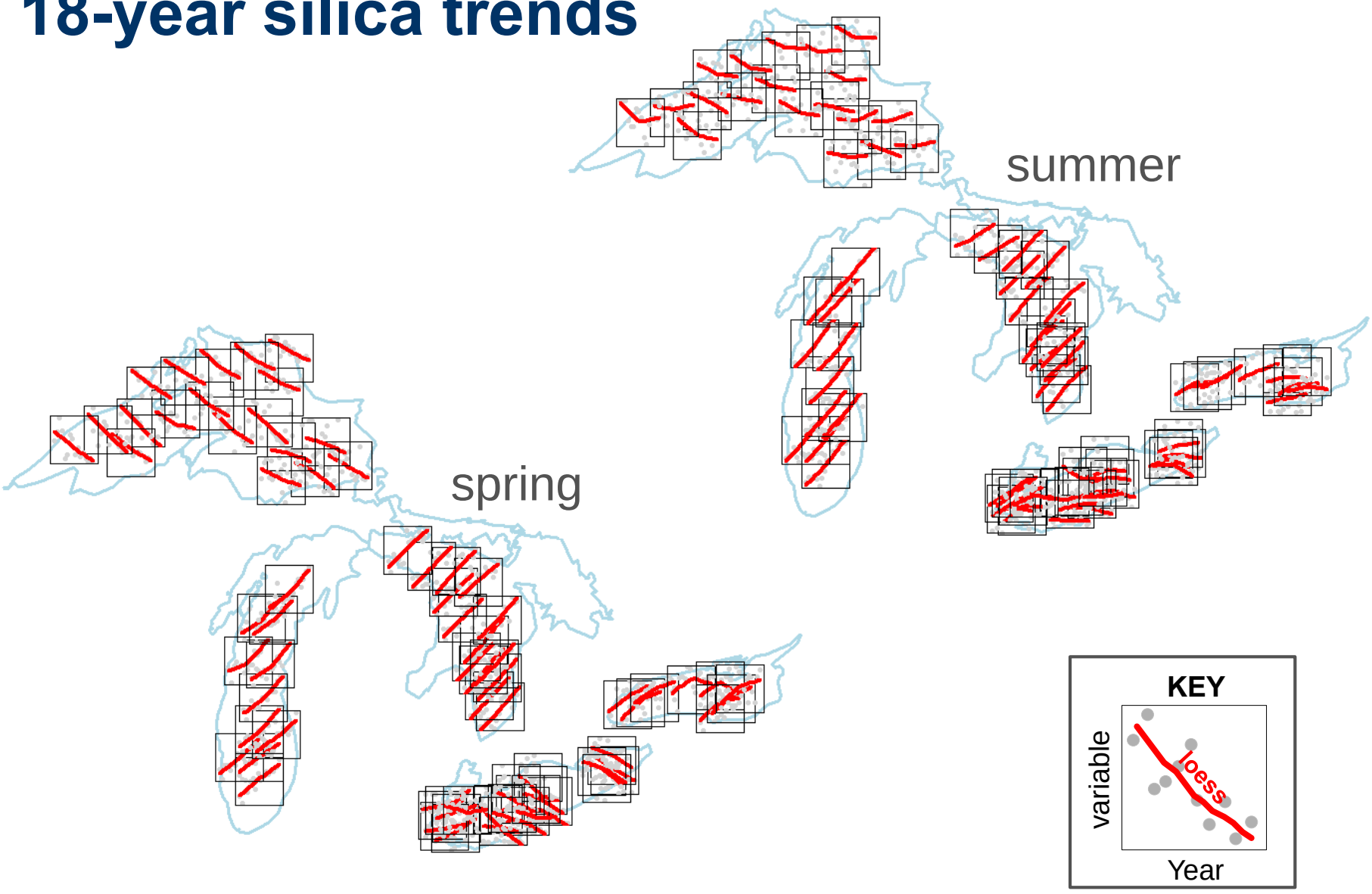
Physical variables
Temperature
Secchi depth
Transparency
Color
Latitude
Longitude
Depth
Lake
Habitat



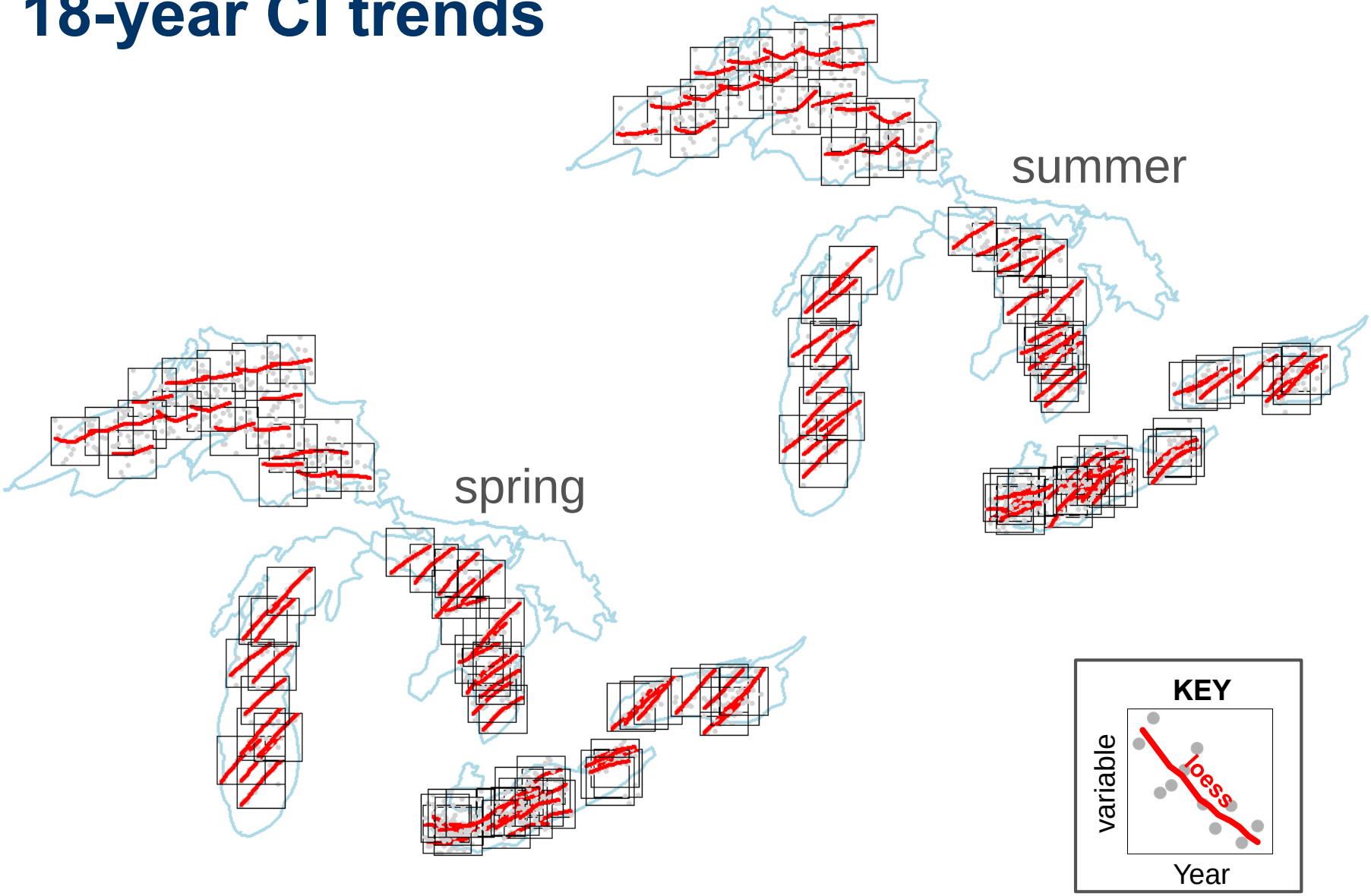
18-year NO_x trends



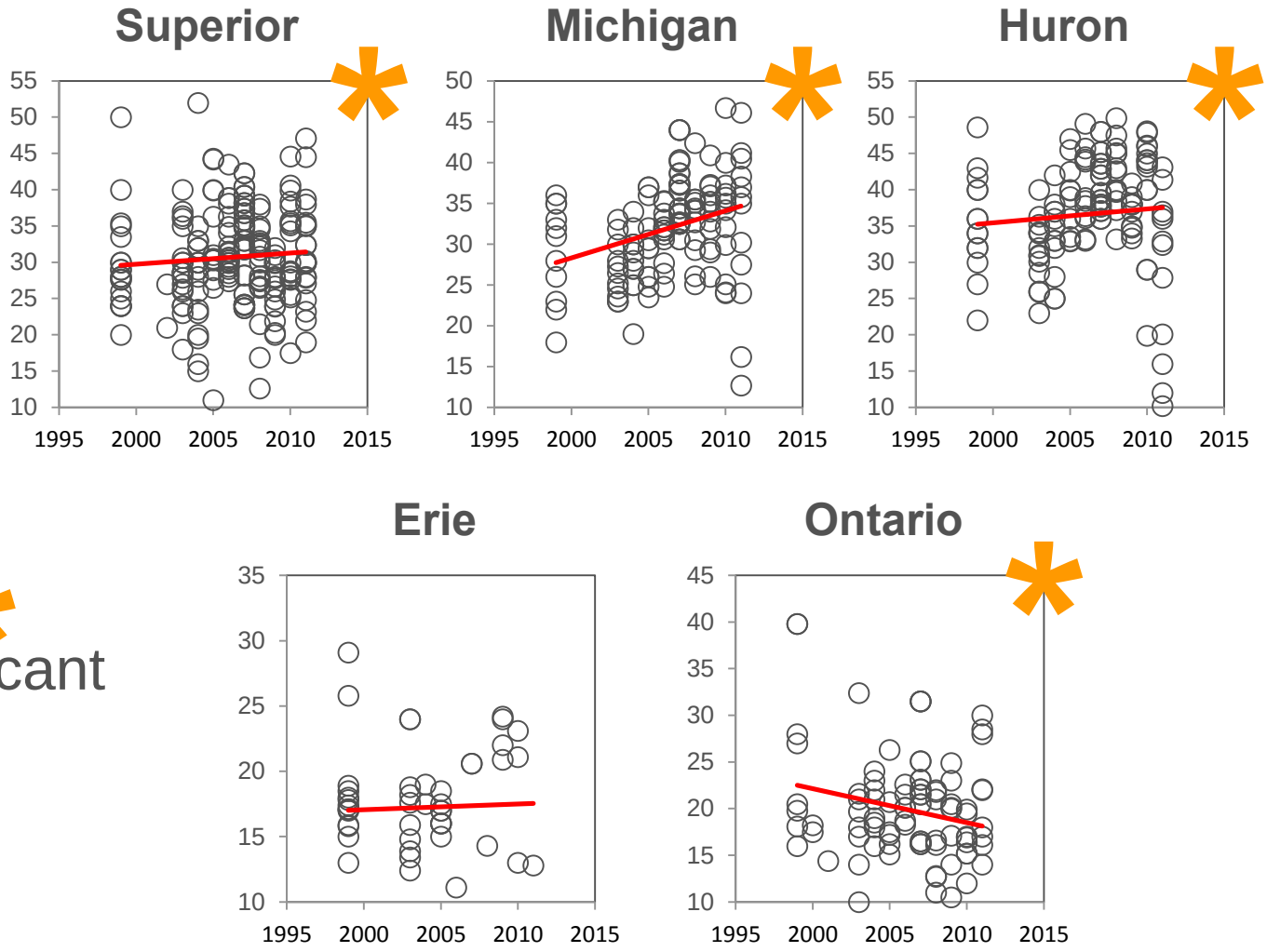
18-year silica trends



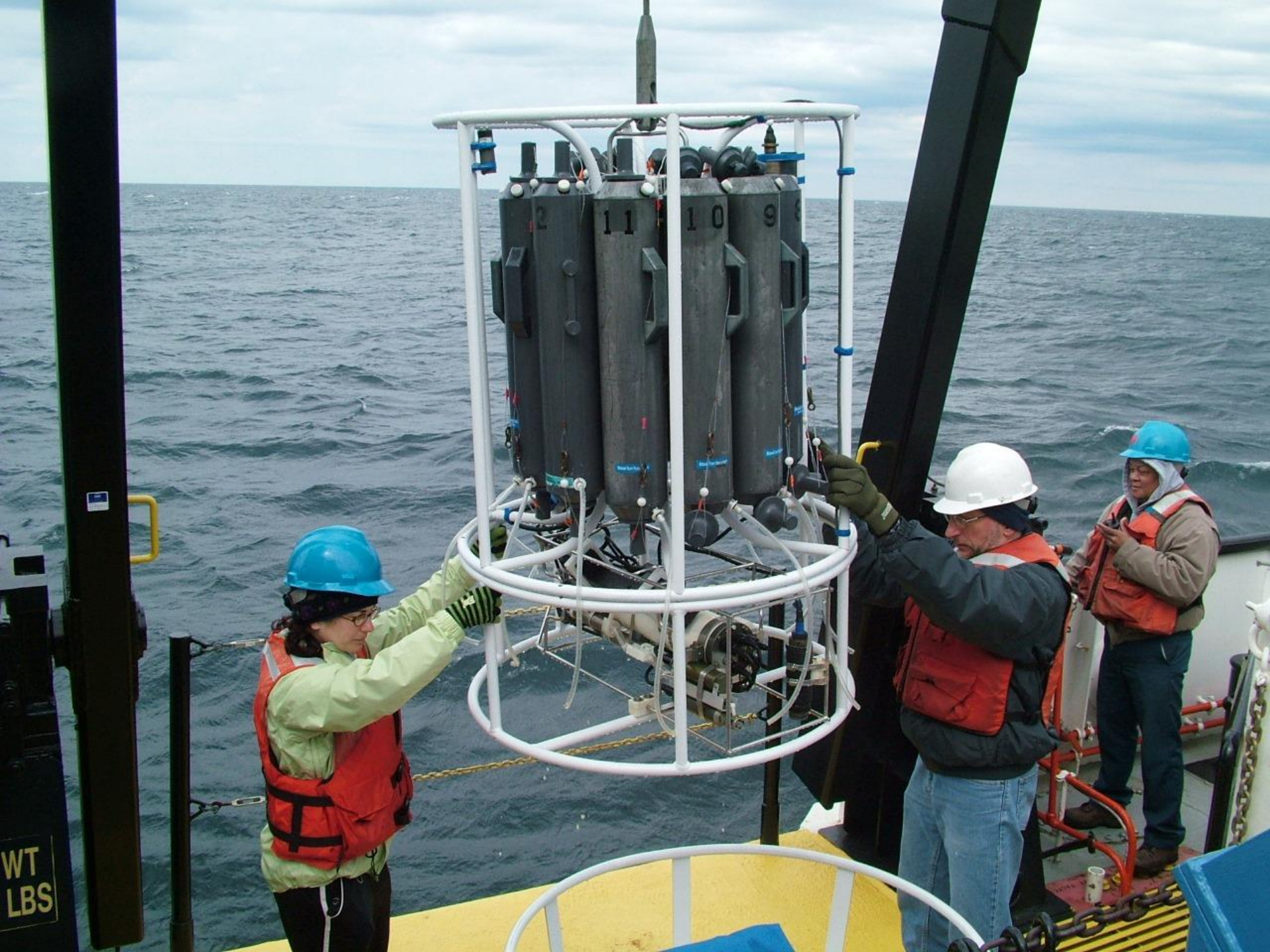
18-year CI trends

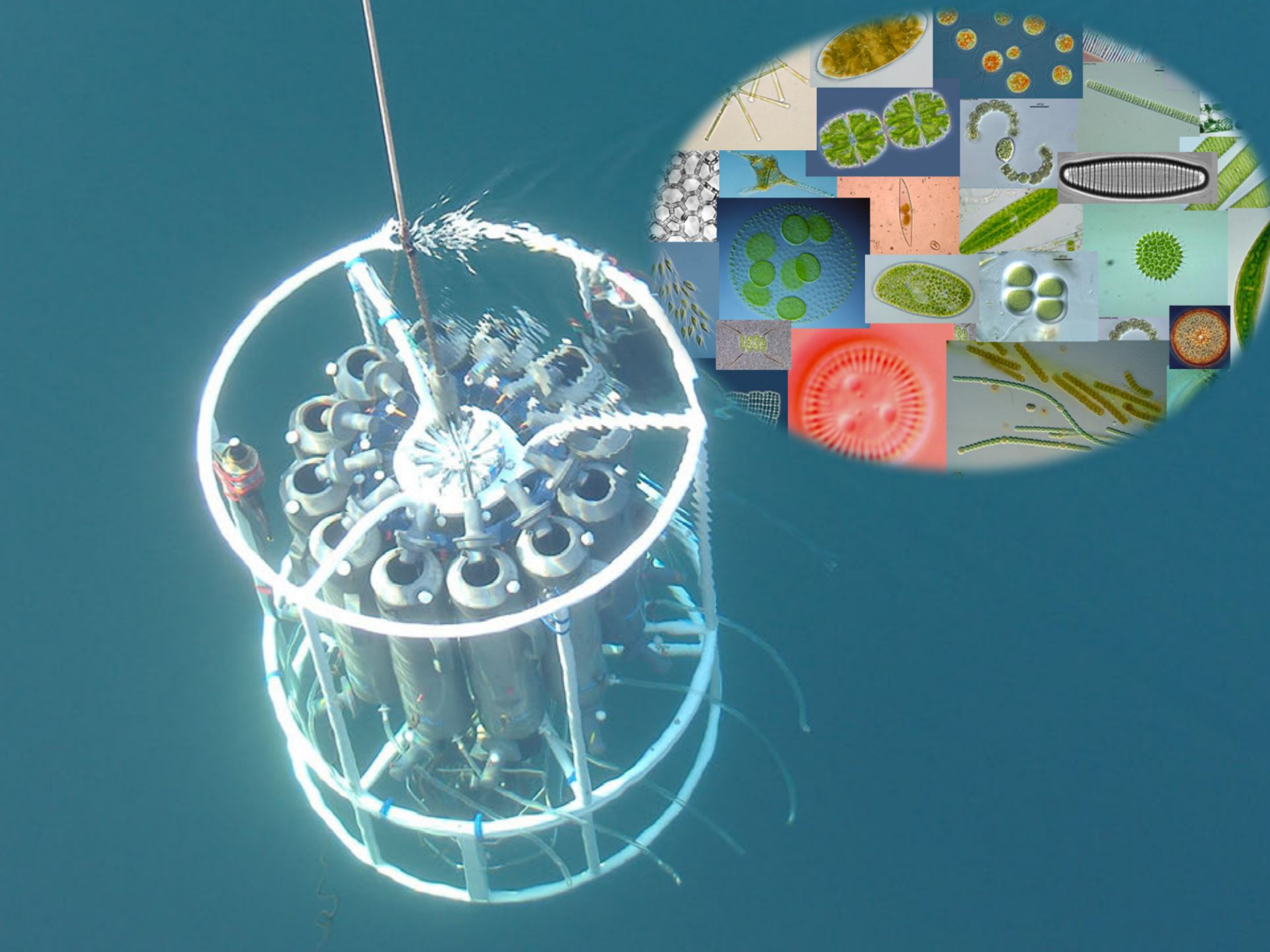


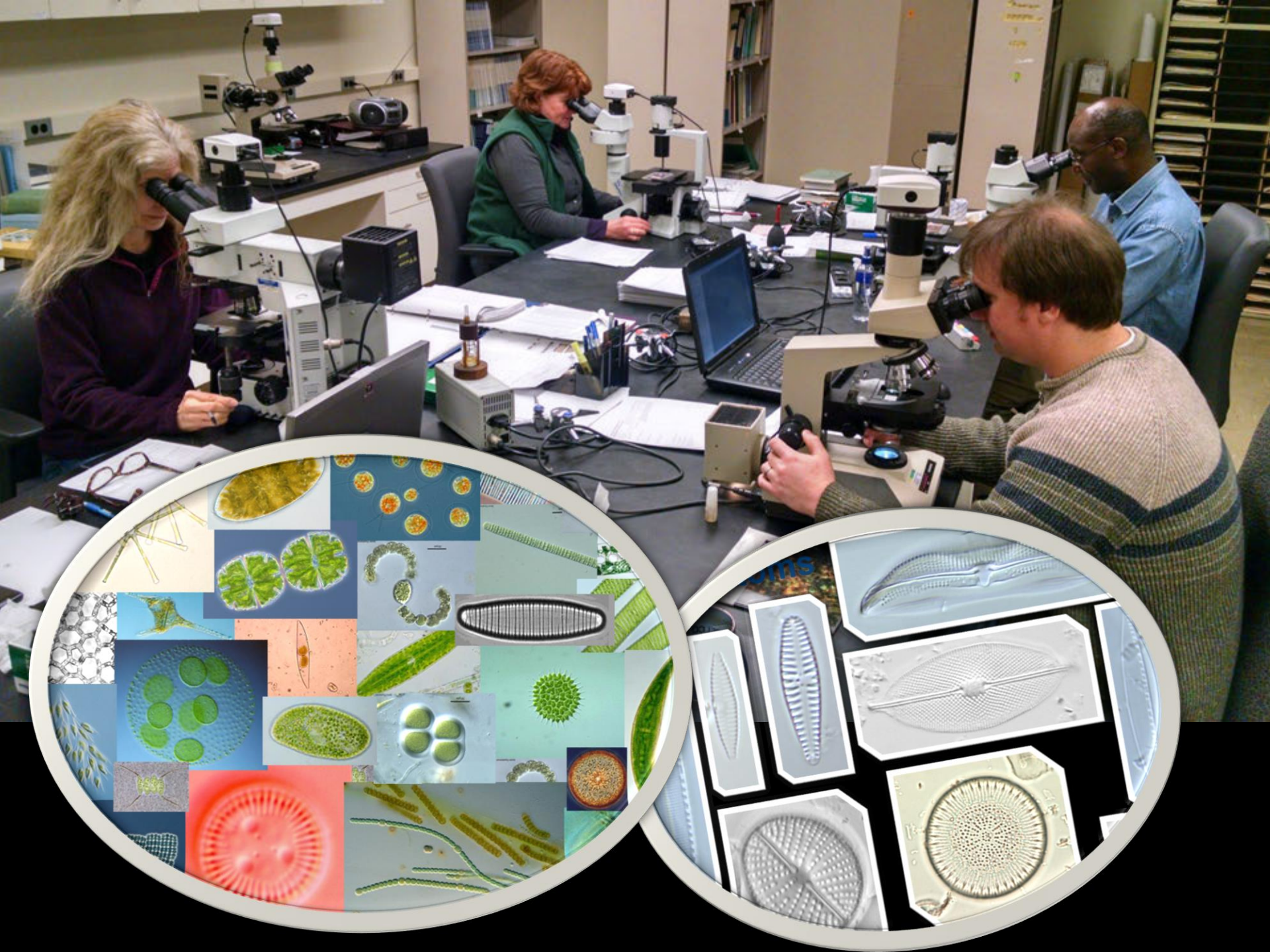
Epilimnion thickness? (DCL depth [m])



* significant

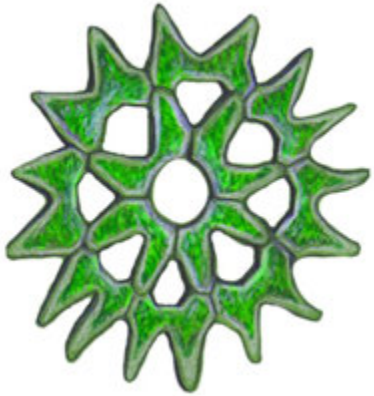

12
11
10
9
WT
LBS

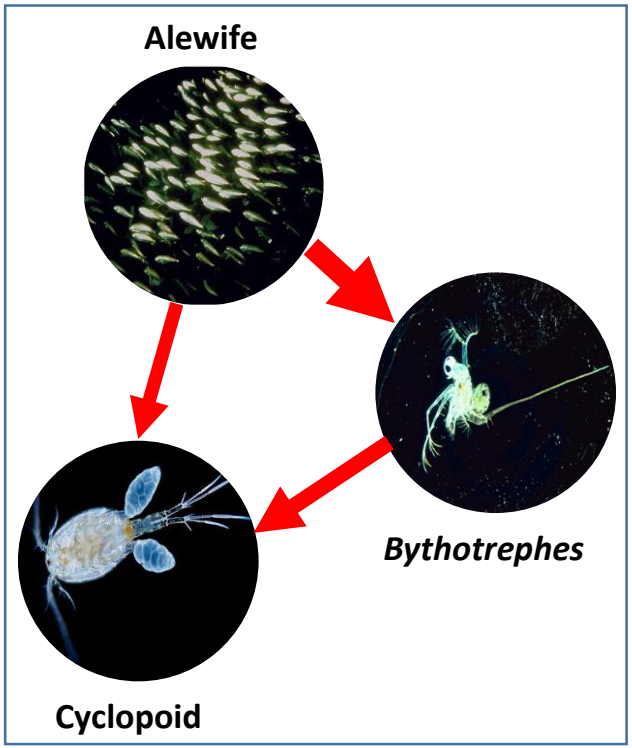


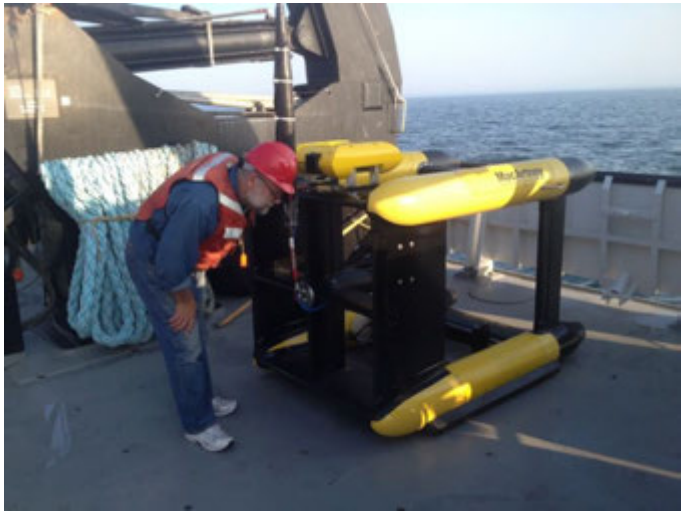


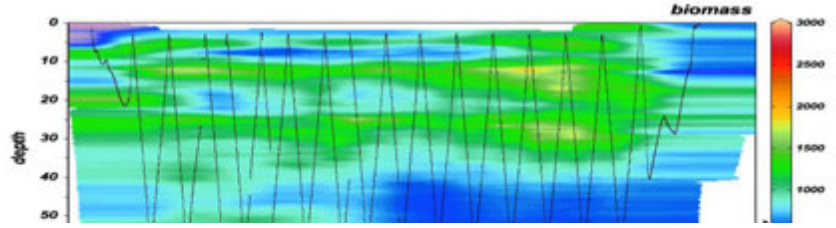
Why do we monitor algae?

- First responders to water quality changes
- An important component of the food web
- Integrating indicators of quality, including long-term retrospection
- They can be a problem
- Invasive species (and their effects)

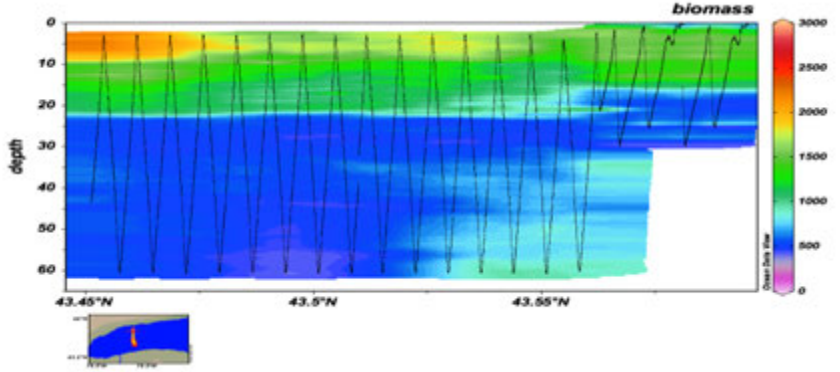








Zooplankton Day

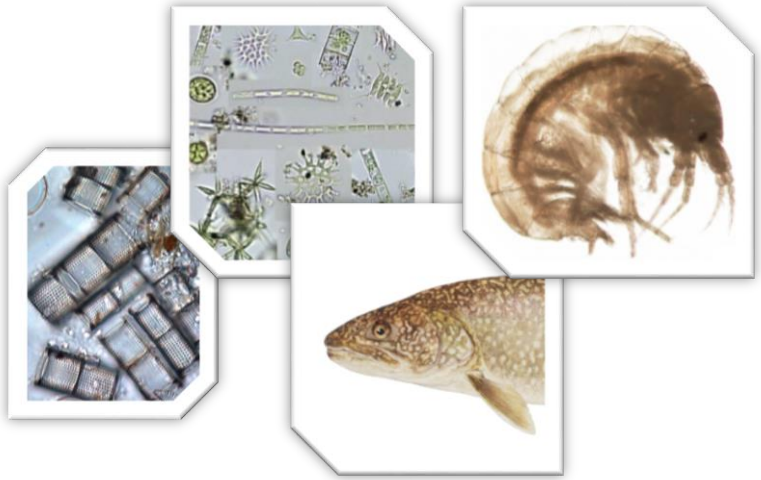


Zooplankton Night

Corresponding Zooplankton collections

What's this all telling us?

- **Phytoplankton, zooplankton and water quality are changing due to anthropogenic drivers.**
- **Monitoring activities under the GLWQA are accomplishing exactly what they're meant to.**
  - Long-term changes (good and bad)
  - Ecological trajectories
  - Food web shifts

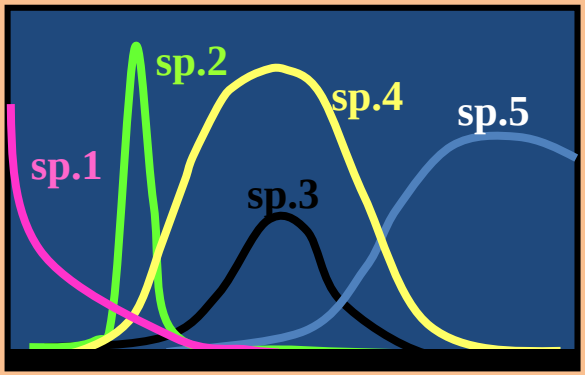


Construction of a diatom-based model

Diatom assemblages

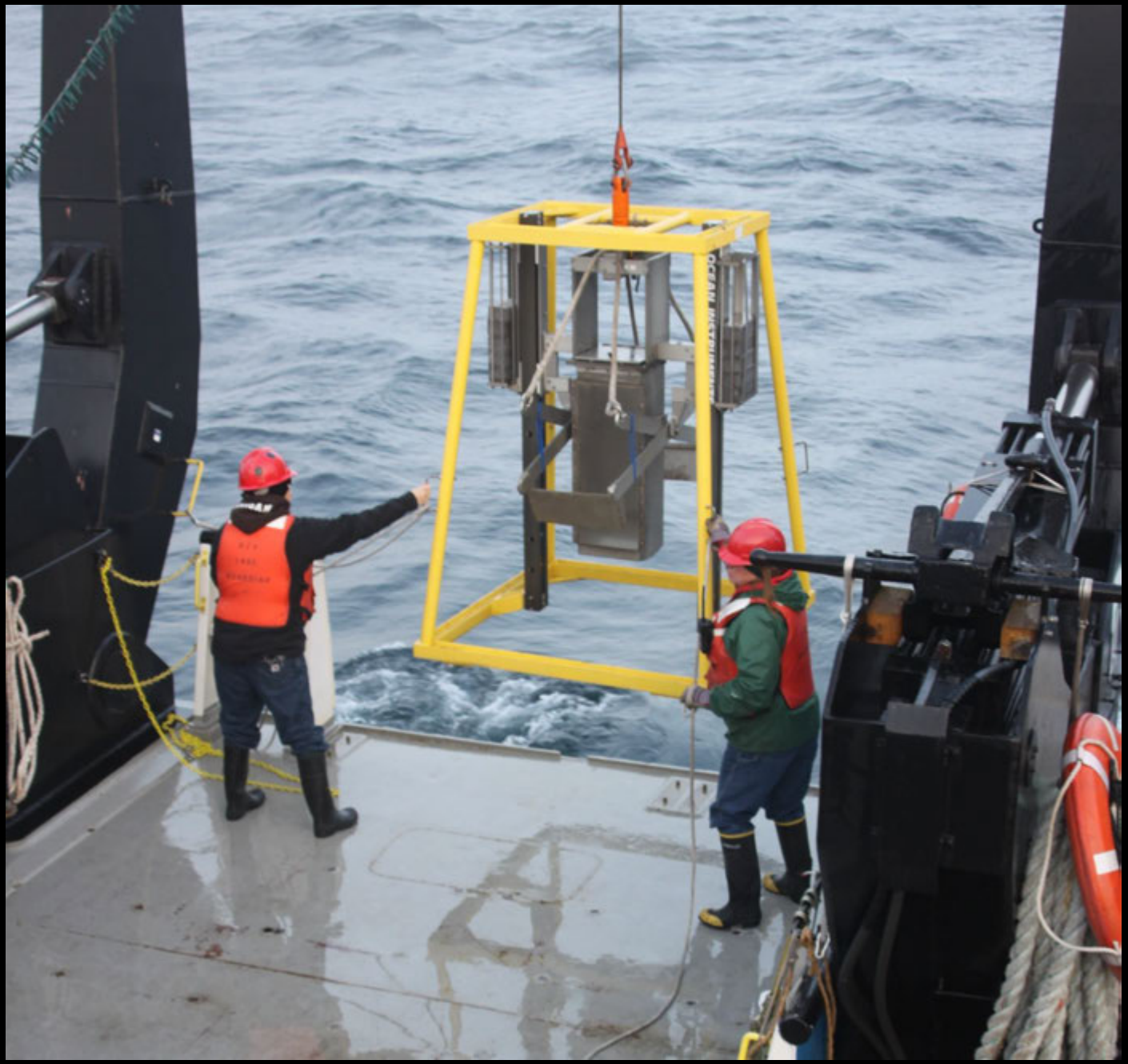
Phosphorus measurements

Diatom Responses

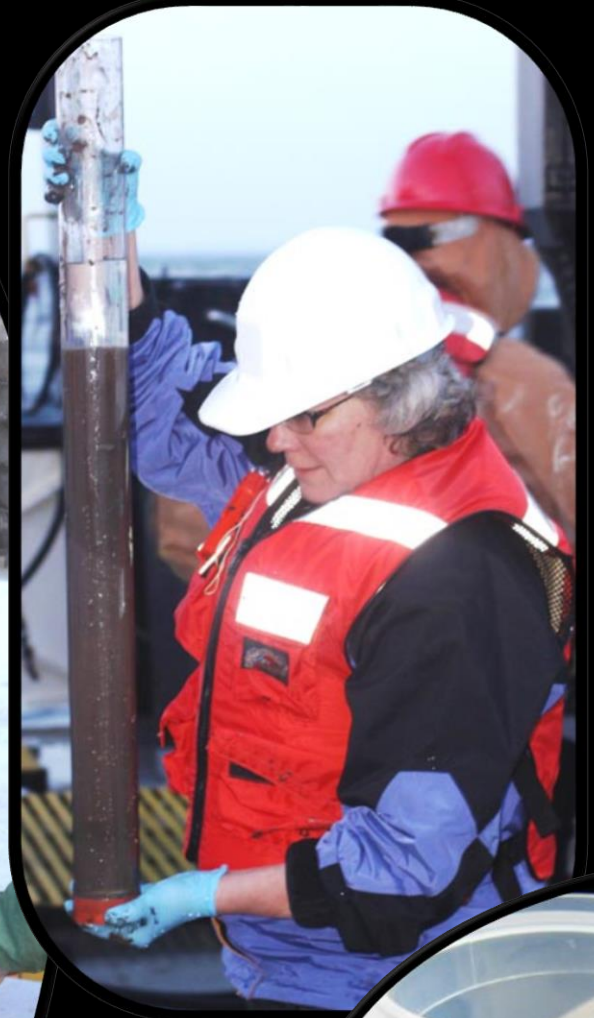


Reavie et al. 2014. PLoS ONE 9(8): e104705

Great Lakes cores



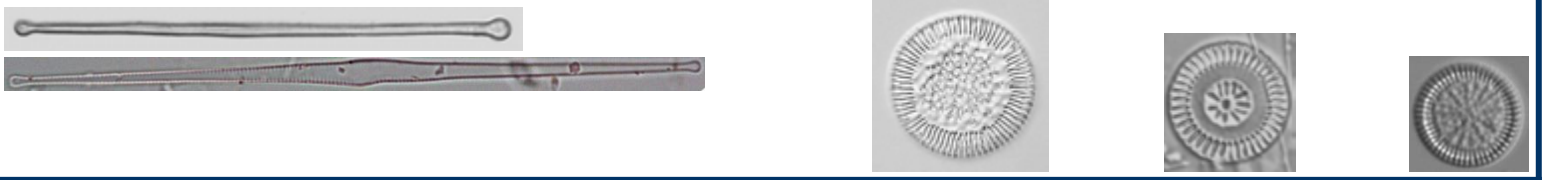
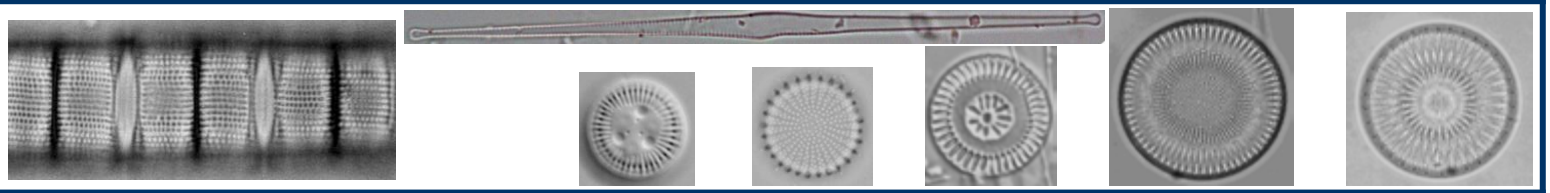
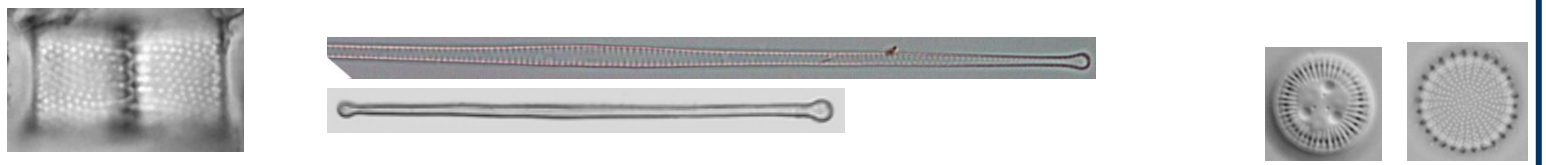

STN4



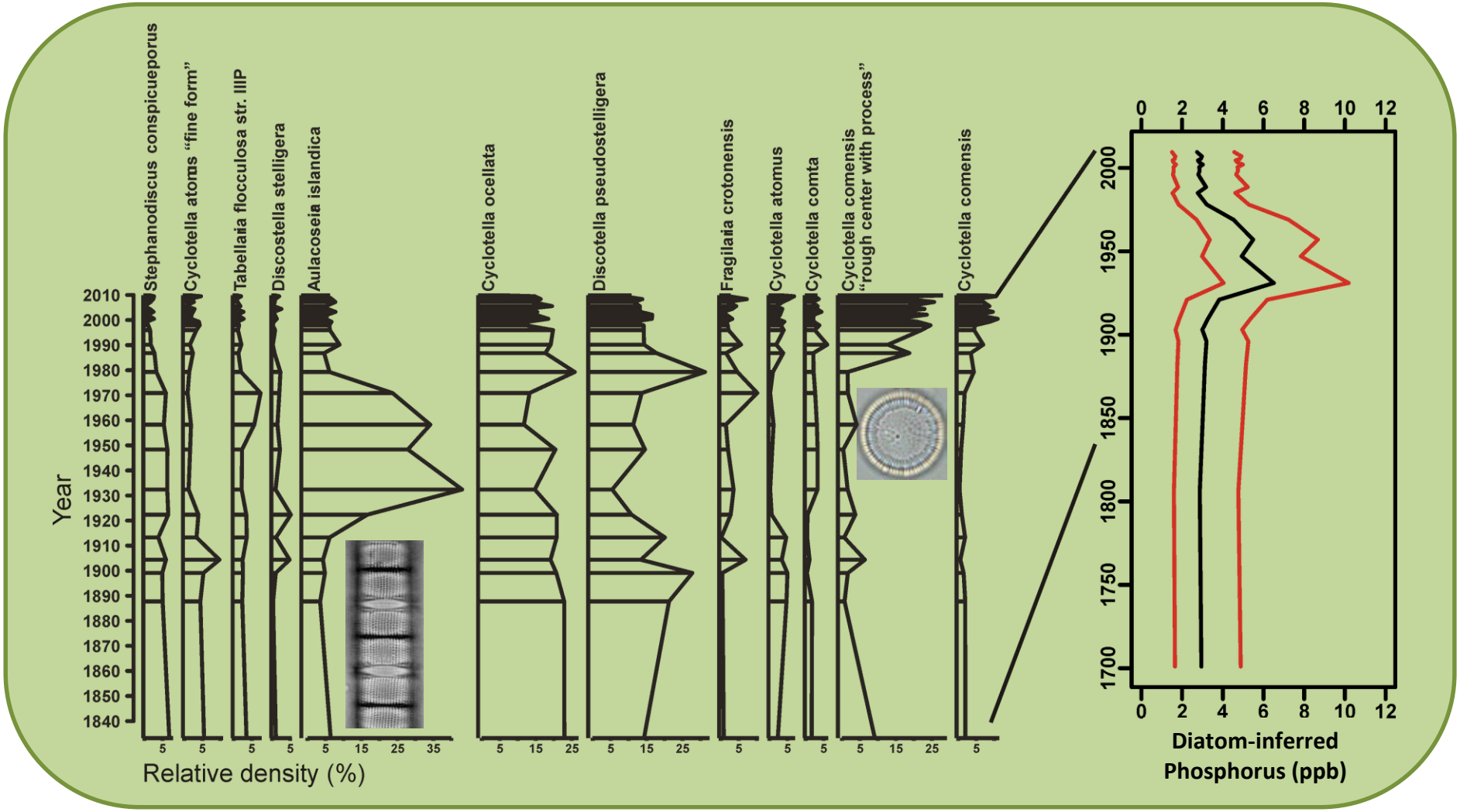
April 2010

How have the diatoms changed?

(e.g., Superior)

2000s	
1990s	
1980s	
1950-1980	
1900-1950	
Pre-European	

Lake Superior nutrient history



Shaw Chraïbi et al. 2014. J. Great Lakes Res. 40(4)

Multiple paleoindicators used… e.g…

- Geochemistry
  - Isotopes (^{210}Pb)
  - Organics & inorganics
  - Metals (incl. Hg) & oxides
  - Contaminants
- Biology
  - Diatoms
  - Pollen & Phytoliths
  - Pigments
  - Chrysophytes

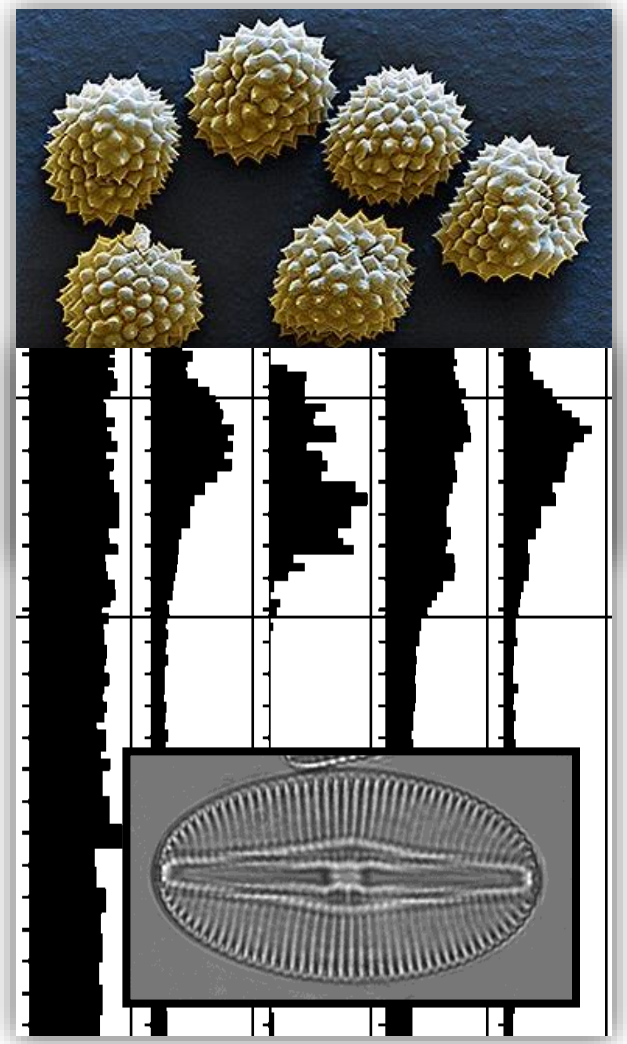
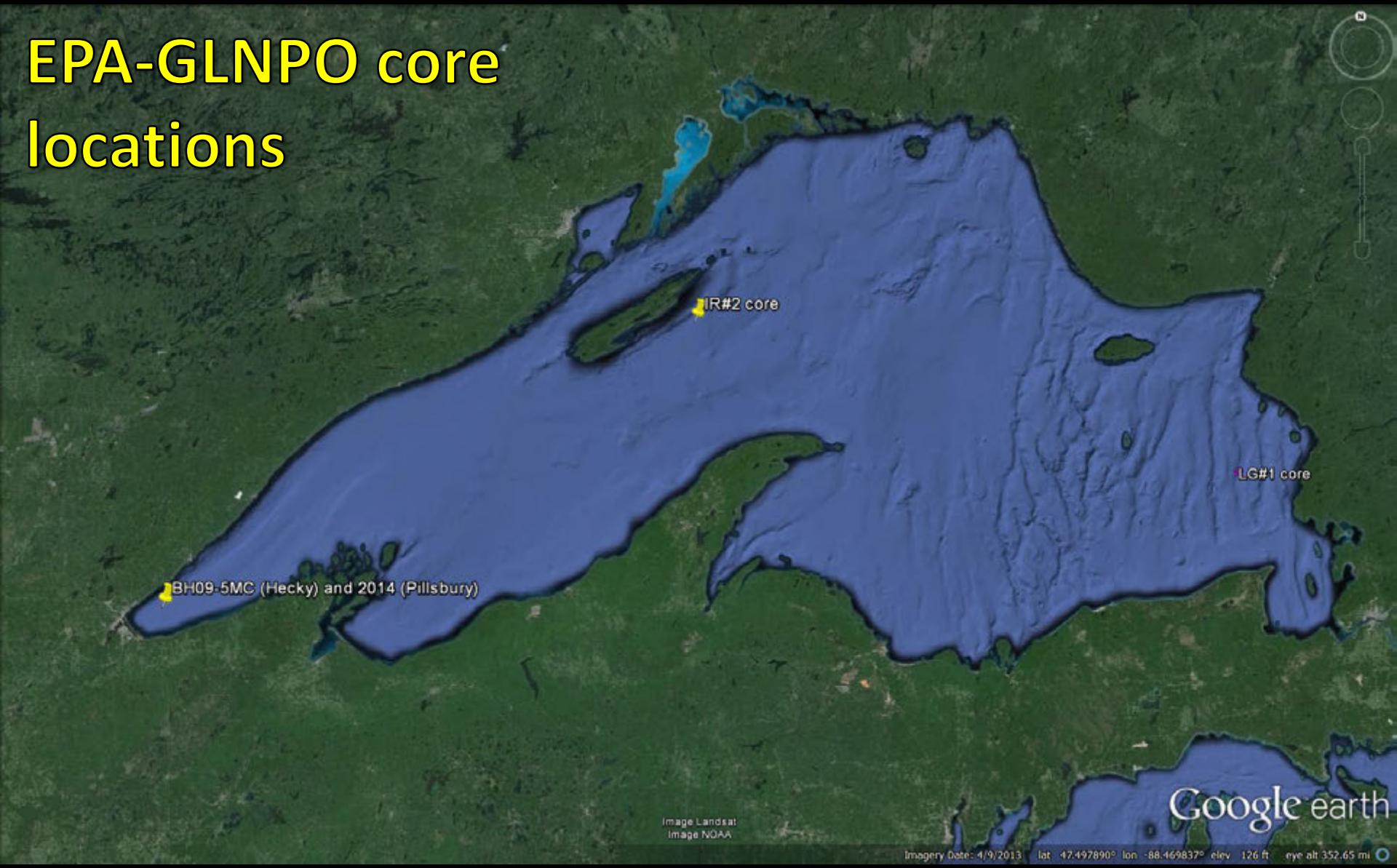
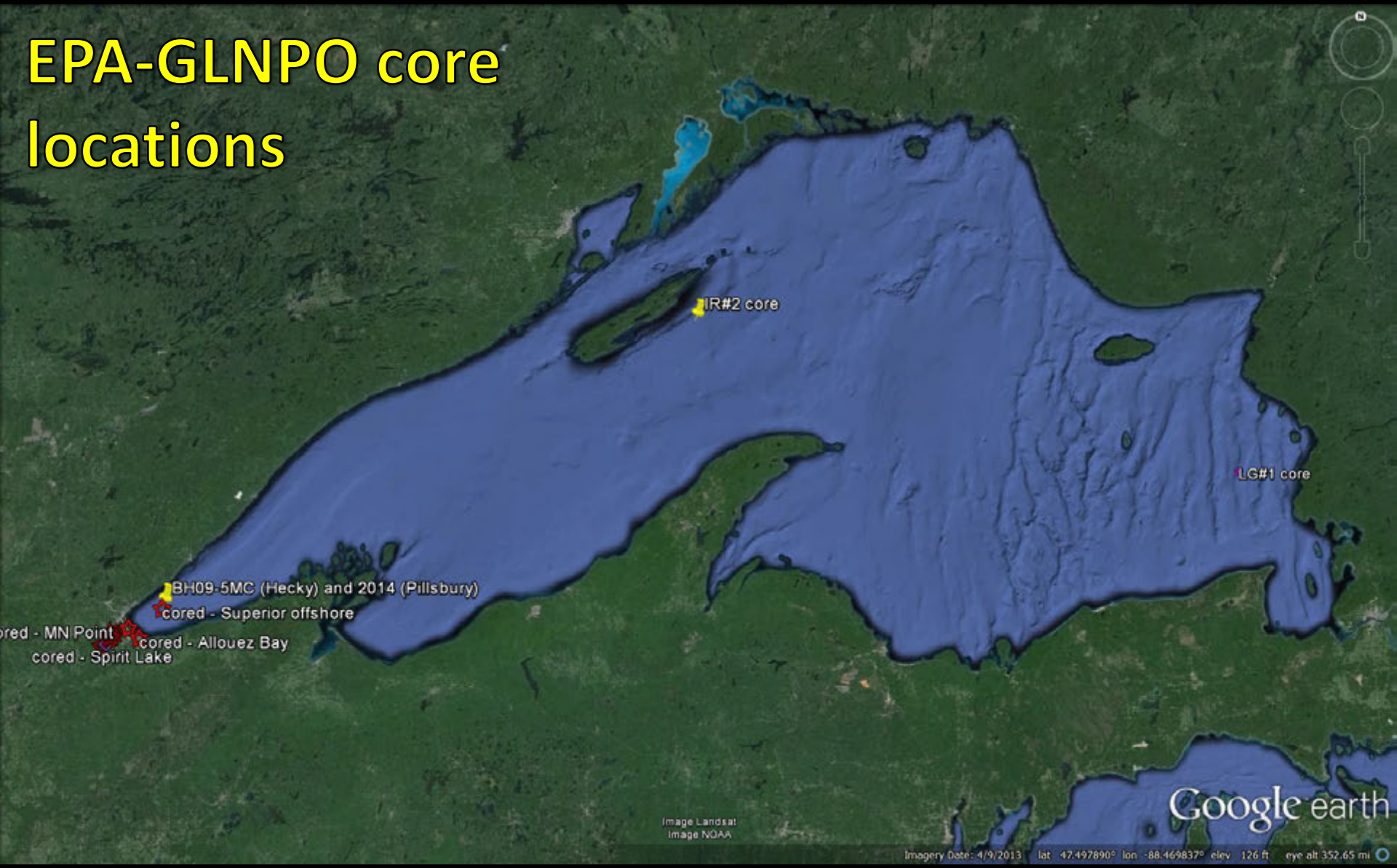
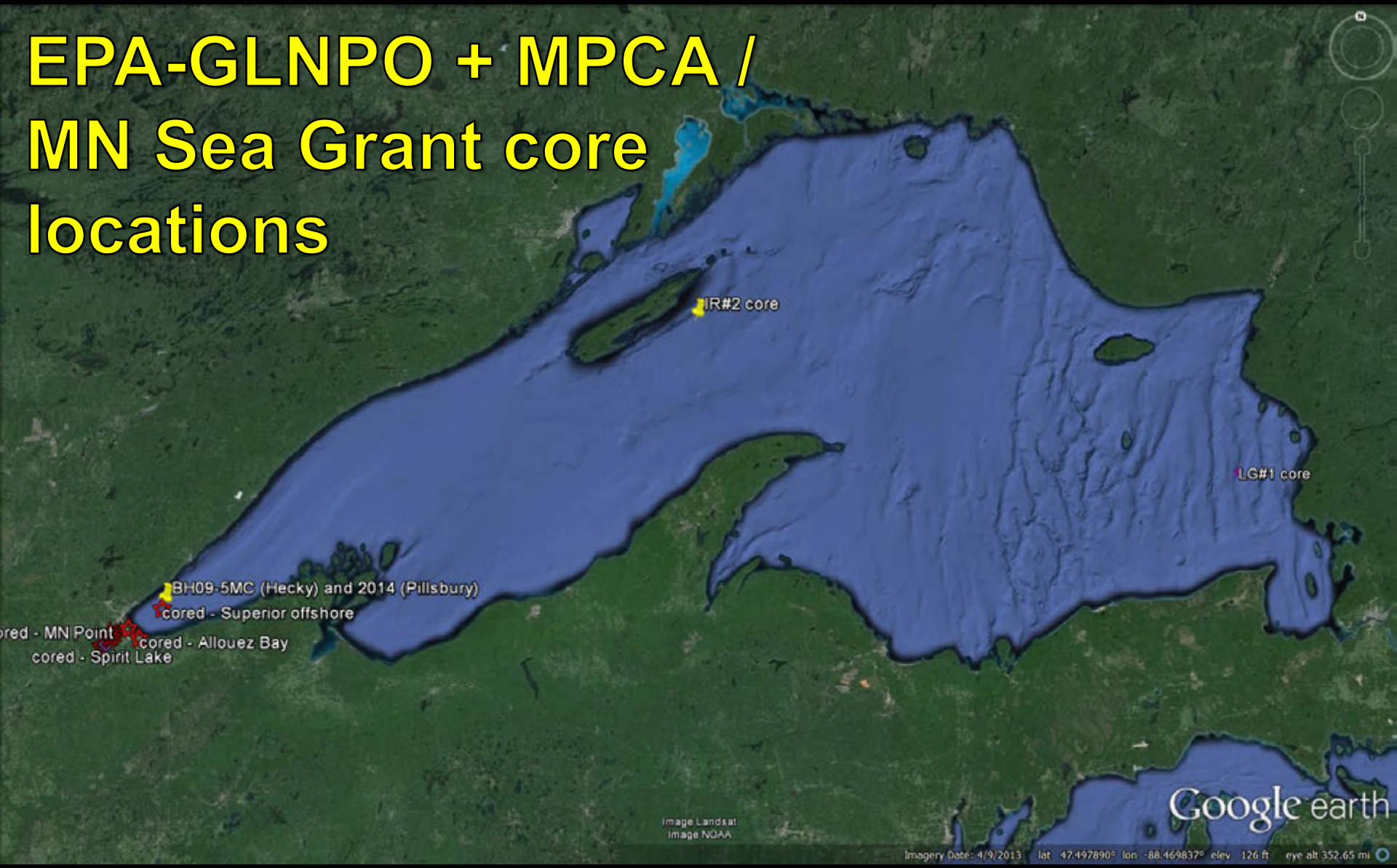


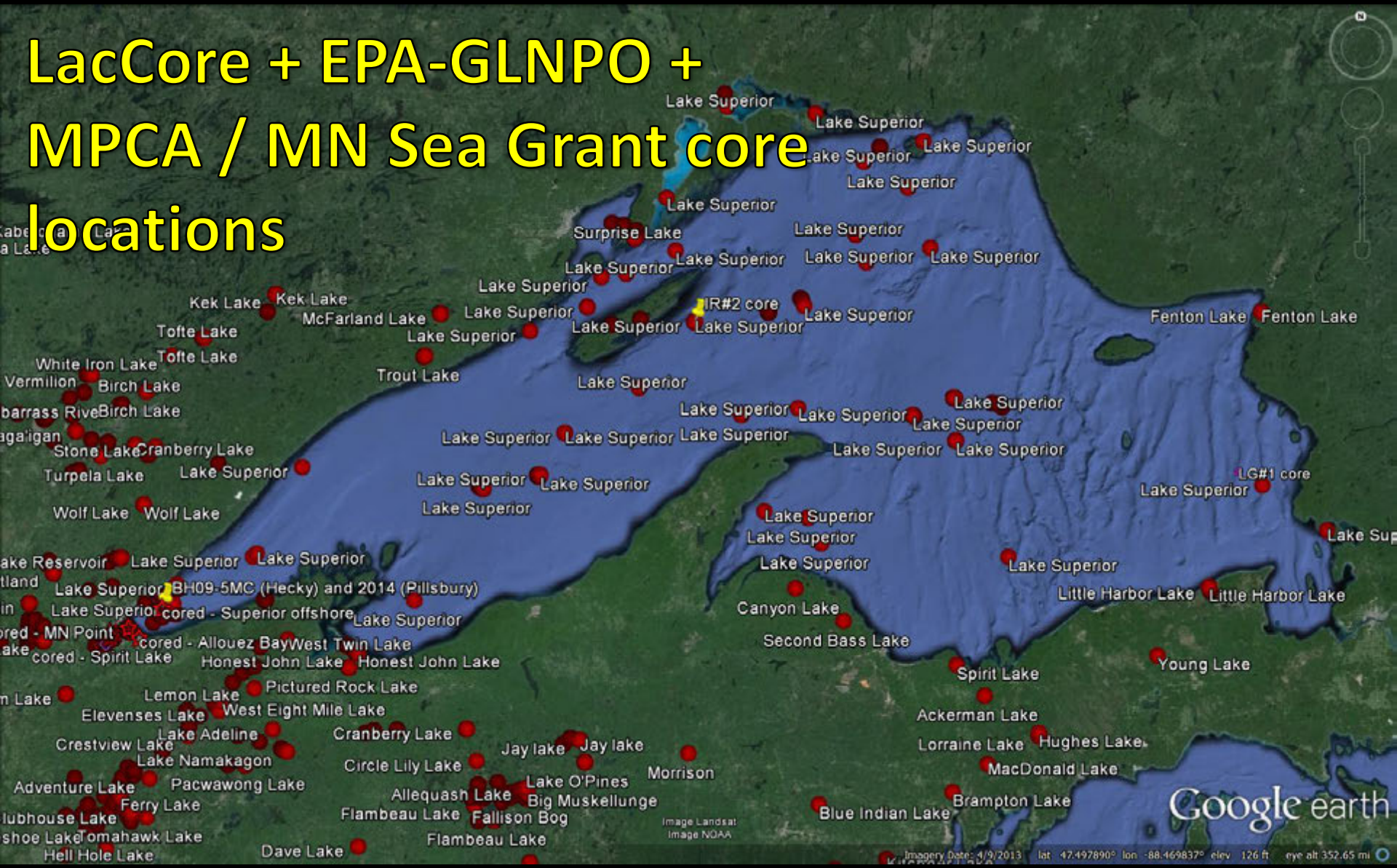

Image Landsat
Image NOAA
Google earth
Imagery Date: 4/9/2013 lat 47.497890° lon -88.469837° elev 126 ft eye alt 352.65 mi


EPA-GLNPO core locations
IR#2 core
LG#1 core
BH09-5MC (Hecky) and 2014 (Pillsbury)
Image Landsat
Image NOAA
Google earth
Imagery Date: 4/9/2013 lat 47.497890° lon -88.469837° elev 126 ft eye alt 352.65 mi


EPA-GLNPO core locations
IR#2 core
LG#1 core
BH09-5MC (Hecky) and 2014 (Pillsbury)
cored - Superior offshore
cored - Allouez Bay
cored - Spirit Lake
Image Landsat
Image NOAA
Google earth


MPCA / MN Sea Grant
core locations
cored - MN Point
cored - Clough
cored - Billings Park
cored - Pokegama Bay
cored - Spirit Lake
cored - Allouez Bay
cored - Fond du Lac
Image NOAA
Image © 2014 TerraMetrics
Imagery Date: 8/28/2010 46° 42.307' N 92° 7.172' W elev 201 m


EPA-GLNPO + MPCA / MN Sea Grant core locations
IR#2 core
LG#1 core
BH09-5MC (Hecky) and 2014 (Pillsbury)
cored - Superior offshore
cored - Allouez Bay
cored - Spirit Lake
Image Landsat
Image NOAA
Google earth


LacCore + EPA-GLNPO +
MPCA / MN Sea Grant core
locations
Lake Superior
Surprise Lake
IR#2 core
Fenton Lake
Kek Lake
McFarland Lake
Tofte Lake
White Iron Lake
Vermilion
Birch Lake
Trout Lake
Stone Lake
Cranberry Lake
Turpela Lake
Wolf Lake
LG#1 core
BH09-5MC (Hecky) and 2014 (Pillsbury)
cored - Superior offshore
cored - Allouez Bay
cored - Spirit Lake
cored - MN Point
West Twin Lake
Honest John Lake
Pictured Rock Lake
Lemon Lake
Elevenses Lake
West Eight Mile Lake
Lake Adeline
Crestview Lake
Lake Namakagon
Adventure Lake
Pacwawong Lake
Ferry Lake
Tomahawk Lake
Hell Hole Lake
Dave Lake
Cranberry Lake
Jay lake
Circle Lily Lake
Morrison
Lake O'Pines
Allequash Lake
Big Muskellunge
Flambeau Lake
Fallison Bog
Canyon Lake
Second Bass Lake
Little Harbor Lake
Spirit Lake
Young Lake
Ackerman Lake
Lorraine Lake
Hughes Lake
MacDonald Lake
Brampton Lake
Blue Indian Lake
Google earth

UMD

Natural Resources Research Institute

University of Minnesota Duluth

Driven to Discover

Minnesota Pollution Control Agency

United States Environmental Protection Agency

Sea Grant

Lake Ontario, Lake Guardian, April 2013