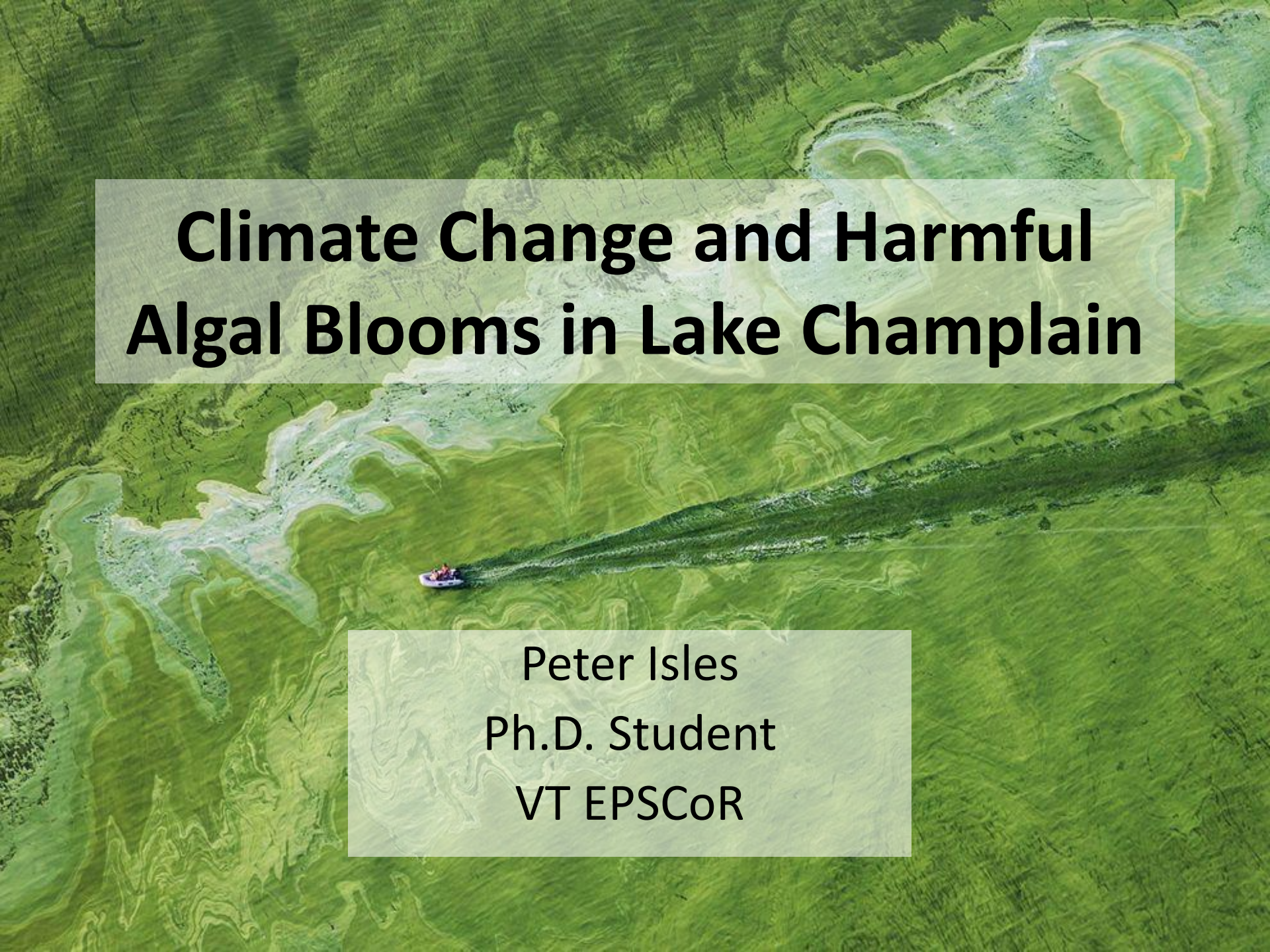
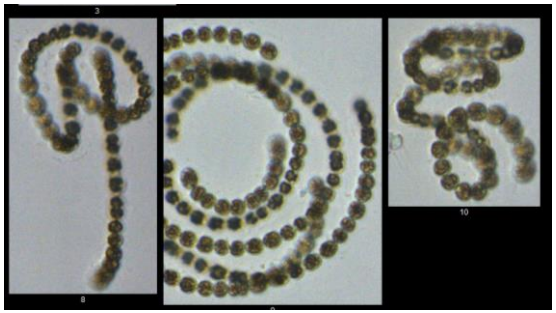


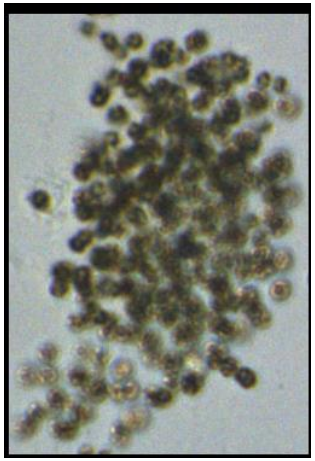
Climate Change and Harmful Algal Blooms in Lake Champlain

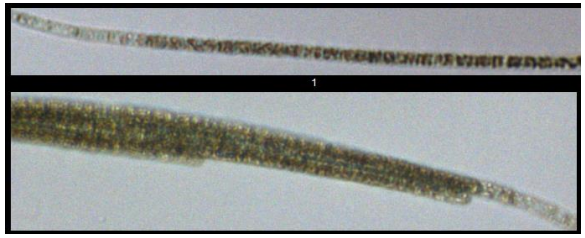
Peter Isles
Ph.D. Student
VT EPSCoR

Harmful Algal Blooms (HABs) in Context

- Increasing problem worldwide
  - Fresh and salt water
- In freshwaters, usually cyanobacteria
  - Toxic, nuisance, economic, and ecological effects
- Increases caused by changes in land use, nutrient loading and **climate**







Global Change Biology (2011) **17**, 1809–1820, doi: 10.1111/j.1365-2486.2010.02332.x

Increases in lake phytoplankton biomass caused by future climate-driven changes to seasonal river flow

IAN D. JONES*, TREVOR PAGE†, J. ALEX ELLIOTT*, STEPHEN J. THACKERAY* and A. LOUISE HEATHWAITE†

*Centre for Ecology and Hydrology, Lancaster Environment Centre, Library Avenue, Bailrigg, Lancaster LA1 4AP, UK, †Centre for Sustainable Water Management, Lancaster Environment Centre, Lancaster University, Bailrigg, Lancaster LA1 4YQ, UK

Global Change Biology (2008) **14**, 495–512, doi: 10.1111/j.1365-2486.2007.01510.x

Summer heatwaves promote blooms of harmful cyanobacteria

KLAUS D. JÖHNK*,1,2, JEF HUISMAN*,2, JONATHAN SHARPLES†, BEN SOMMEIJE PETRA M. VISSER* and JASPER M. STROOM§

*Aquatic Microbiology, Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, Nieuwe Achterg 1018 WS Amsterdam, The Netherlands, †Proudman Oceanographic Laboratory, University of Liverpool, 6 Brownlow S Liverpool, L3 5DA, UK, ‡Center for Mathematics and Computer Science, Postbus 94079, 1090 GB Amsterdam, The N §Water Board Rijnland, PO Box 156, 2300 AD Leiden, The Netherlands

Limnol. Oceanogr., 54(6, part 2), 2009, 2283–2297

Lakes as sentinels of climate change

Rita Adrian,[a,*] Catherine M. O'Reilly,[b] Horacio Zagarese,[c] Stephan B. Baines,[d] Dietmar Hessen,[e] Wendel Keller,[f] David M. Livingstone,[g] Ruben Sommaruga,[h] Dietmar Straile,[i] Eddy Van Donk,[j] Gesa A. Weyhenmeyer,[k] and Monika Winder[l]

Ecology, 85(8), 2004, pp. 2100–2106

CLIMATE CHANGE UNCOUPLES TROPHIC INTERACTIONS IN AN AQUATIC ECOSYSTEM

Monika Winder[1,3] and Daniel E. Schindler[1,2]

Global Change Biology (2012) **18**, 118–126, doi: 10.1111/j.1365-2486.2011.02488.x

Warmer climates boost cyanobacterial dominance in shallow lakes

SARIAN KOSTEN*‡‡‡, VERA L. M. HUSZAR†, ELOY BÉCARES‡, LUCIANA S. COSTA†, ELLEN VAN DONK§, LARS-ANDERS HANSSON¶, ERIK JEPPESEN‖**††††, CARLA KRUK**, GISSELL LACEROT**, NÉSTOR MAZZEO††, LUC DE MEESTER‡‡, BRIAN MOSS§§, MIQUEL LÜRLING*, TIINA NÕGES¶¶§§§, SUSANA ROMO‖‖ and MARTEN SCHEFFER*

Climate-driven changes in spring plankton dynamics and the sensitivity of polymictic lakes to the North Atlantic Oscillation

Dieter Gerten[1] *and Rita Adrian*
Institut für Gewässerökologie und Binnenfischerei, Müggelseedamm 260, D-12562 Berlin

CLIMATE

Blooms Like It Hot

Hans W. Paerl[1] and Jef Huisman[2]

Nutrient overenrichment of waters by lak

Climate Change Impacts

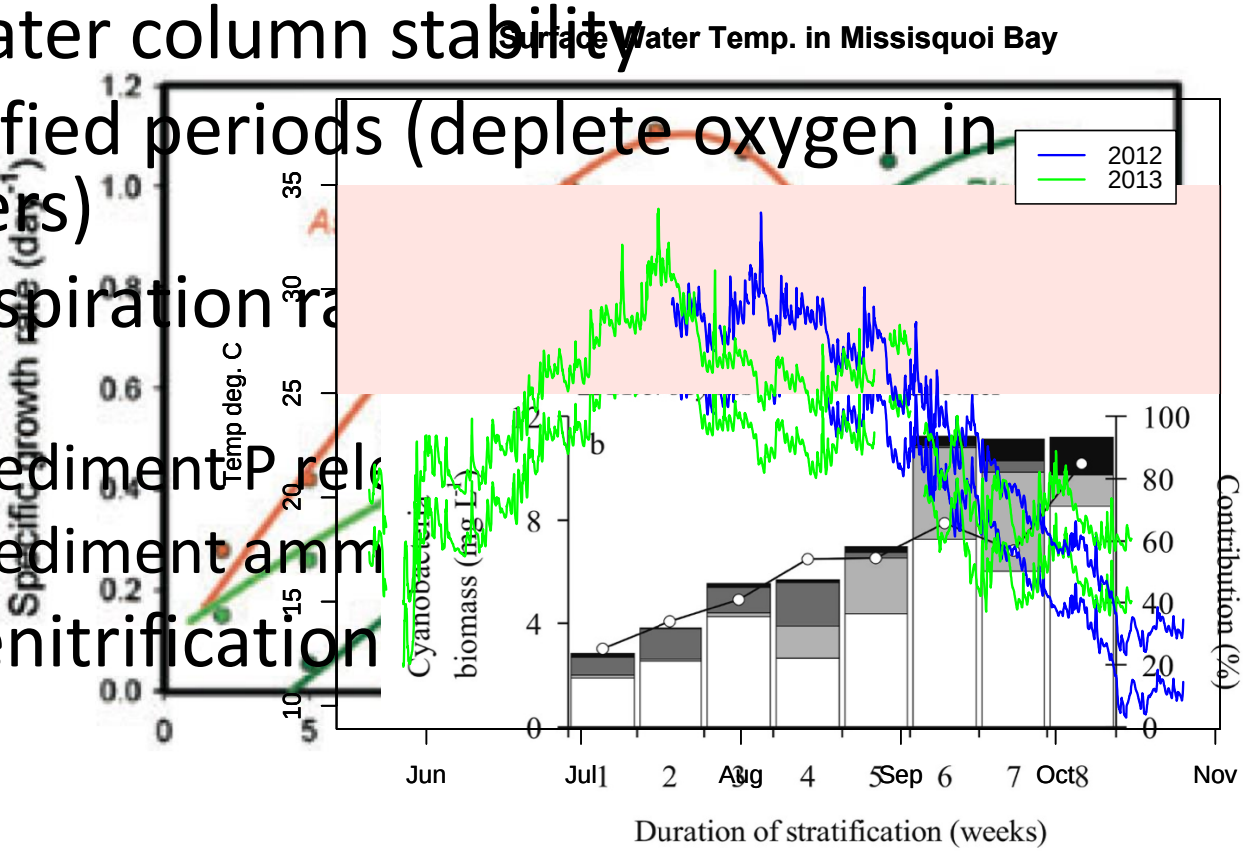
To-Lake Effects

- Increased Storm Intensity
  - Sediment and nutrient loading rises exponentially with discharge
- Longer drought periods?
  - Increase residence times
  - Reduced Mixing
- Changes in snowmelt, seasonality

Climate Change Impacts

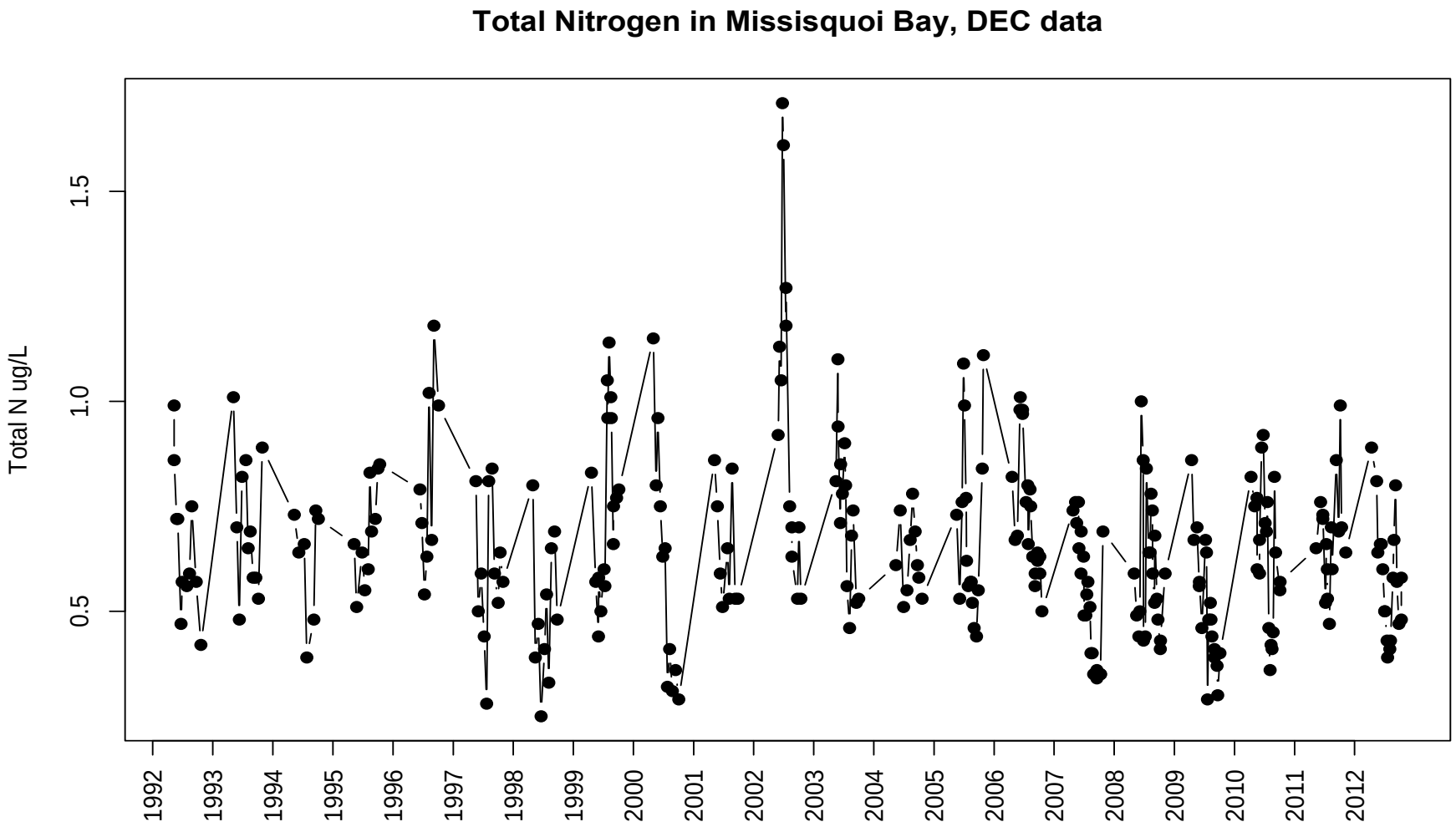
In-Lake Effects

- Direct effects of temperature on phytoplankton growth rates (especially cyanobacteria)
- Increased water column stability
- Longer stratified periods (deplete oxygen in bottom waters)
- Increased respiration ra
  sediments)
  - Increased sediment P rel
  - Increased sediment amm
- Increased denitrification



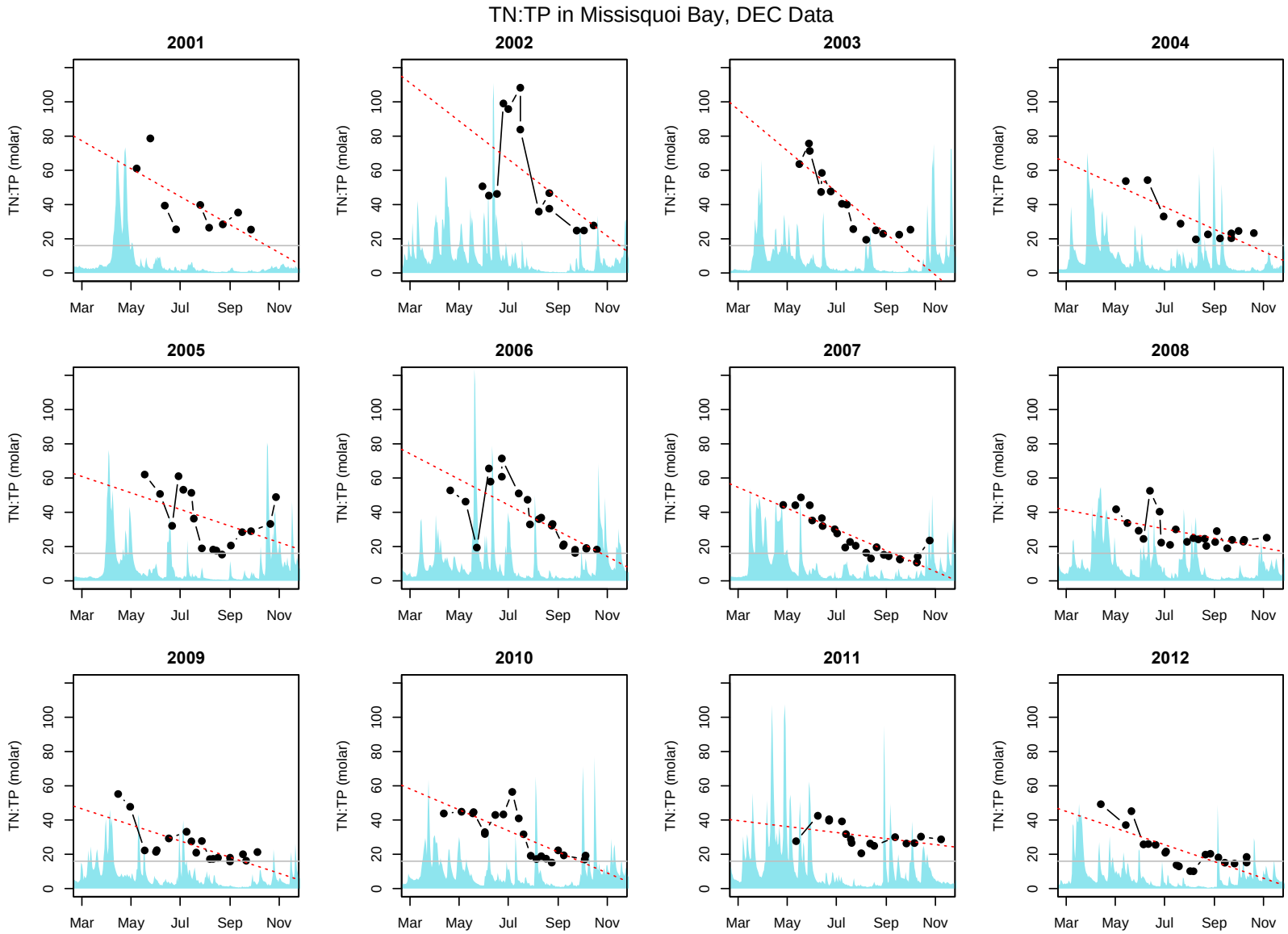
Wagner and Adrian 2009

Decadal trends in Missisquoi Bay



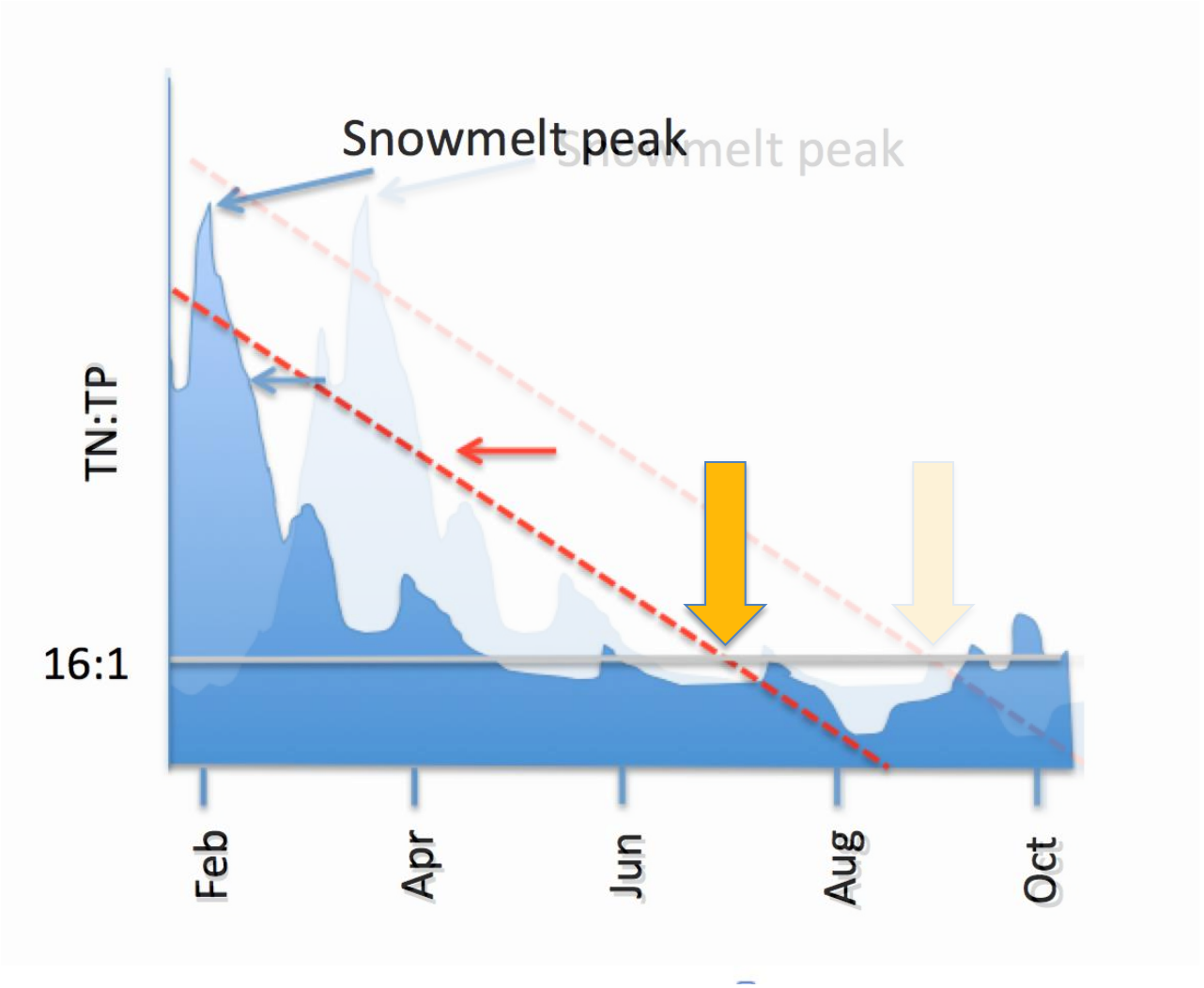
Missisquoi Bay

Temporal dynamics of phytoplankton resource limitation



Climate Change

Temporal dynamics of phytoplankton resource limitation



Recap: Effects of Climate Change

In-Lake Processes → More Cyanobacteria Dominance

- Direct effects of temperature on phytoplankton growth rates
- Longer stratified periods
- Increased Internal Loading
  - sediment P and ammonium release
- Increases in N-limitation
  - Increased denitrification
- Increased water column stability

Sources of Uncertainty

In-Lake Processes

- What changes will there be in wind mixing, and how will this affect blooms?
- What changes will there be in cloud cover and periods of drought, and what effects will these have?
- What other climate-related stressors might affect blooms (e.g. species introductions)?
- How will these changes affect the long-term trajectory of lake recovery?