Developing a Hypoxia Forecast Model for the Central Basin of Lake Erie

Mark D. Rowe[1], E. J. Anderson[2], S. A. Ruberg[2], S. Moegling[3], E. M. Verhamme[4], D. Beletsky[1], H. Zhang[1],T. H. Johengen[1], C. A. Stow[2]

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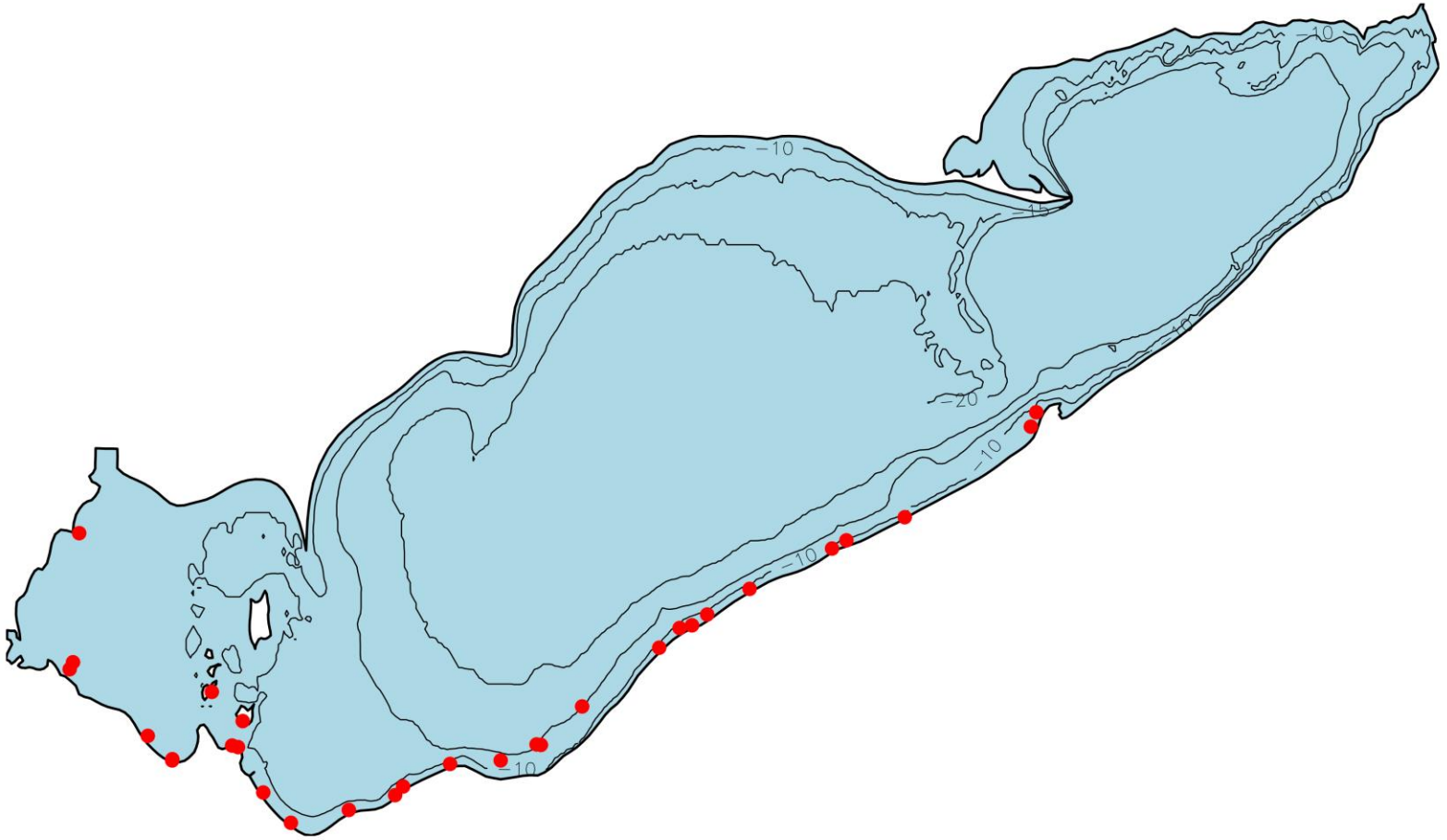
[3]Cleveland Division of Water

[4]LimnoTech

Photo: Gus Chan, The Plain Dealer

Lake Erie provides drinking water to 11 million people through > 30 public water systems



Operational Lake Erie Hypoxia Forecasting for Public Water Systems Decision Support

CIGLR – Great Lakes Science for Society

Mark Rowe
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Devin Gill
Dmitry Beletsky
Tom Johengen

GLERL – Great Lakes Environmental Research Laboratory

Craig Stowe
Steve Ruberg
Eric Anderson
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Partners

City of Cleveland Water – At Your Service

Scott Moegling

USGS – science for a changing world

Richard Krause

LimnoTech – Water | Environment | Scientists | Engineers

Ed Verhamme

Purdue University

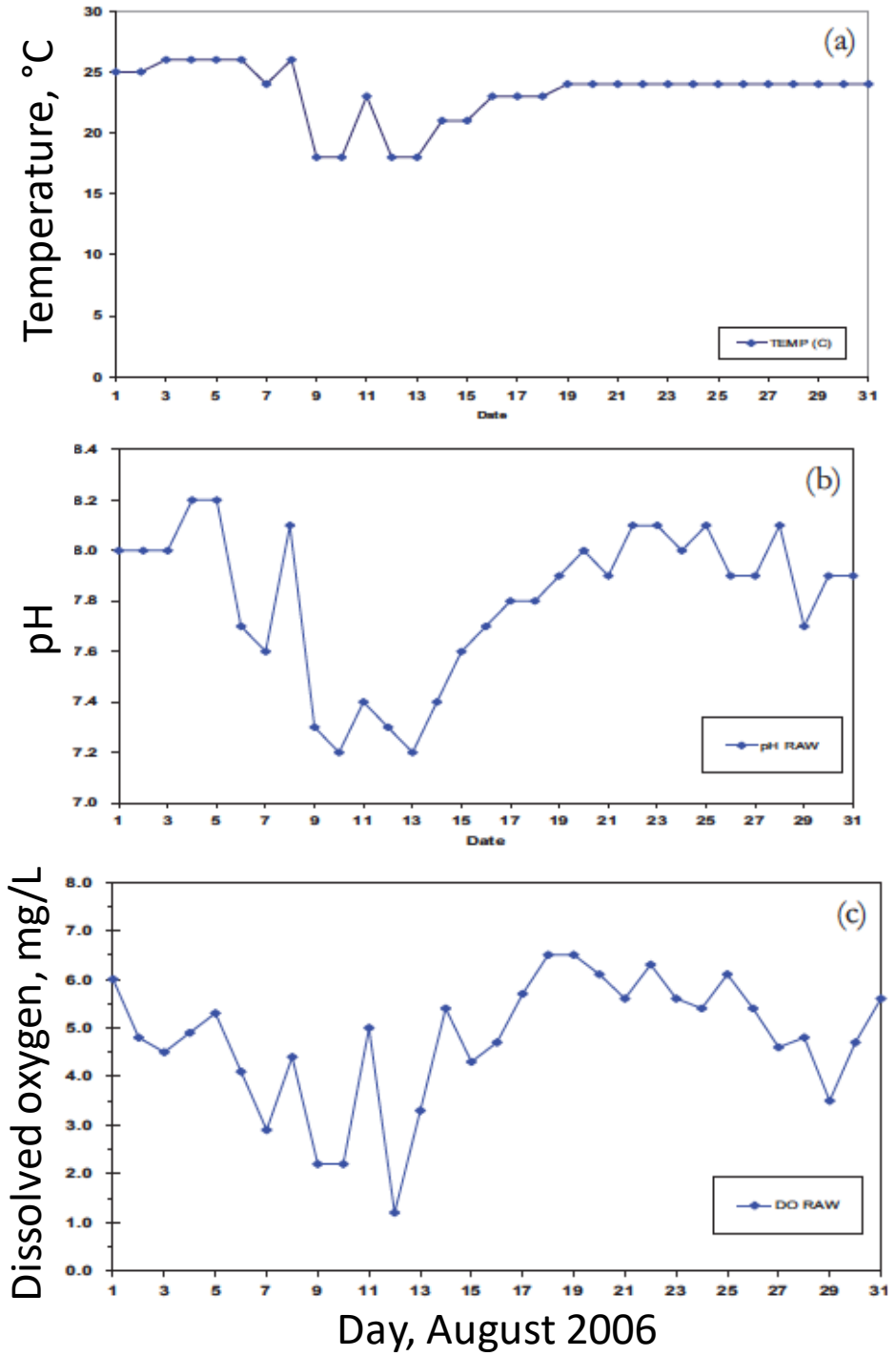
Paris Collingsworth

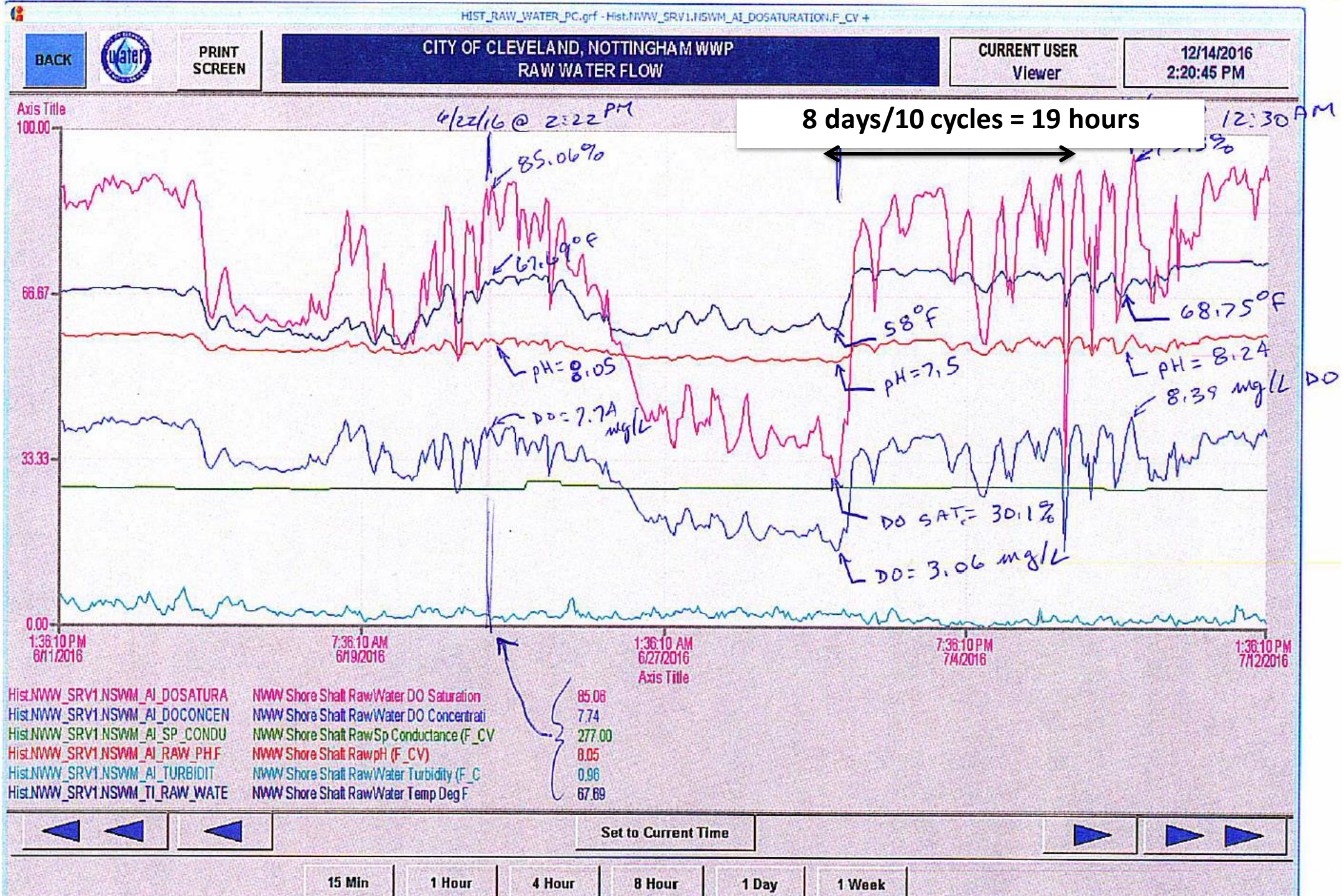
Project goal

Develop a model that can forecast episodes of hypoxia at water intakes on Lake Erie that is suitable for transition to operational use at NOAA

Intake water quality at Cleveland Ohio

Ruberg et al. 2008. Marine Techology Society Journal, 42(3): 103-109




HIST_RAW_WATER_PC.grf - Hist.NWW_SRV1.NSWM_AI_DOSATURATION.F_CV +
BACK
PRINT SCREEN
CITY OF CLEVELAND, NOTTINGHAM WWP
RAW WATER FLOW
CURRENT USER
Viewer
12/14/2016
2:20:45 PM
8 days/10 cycles = 19 hours
4/22/16 @ 2:22 PM
12:30 AM
85.06%
67.69°F
58°F
68.75°F
pH=8.05
pH=7.5
pH=8.24
DO=7.74 mg/L
8.39 mg/L DO
DO SAT=30.1%
DO=3.06 mg/L
Axis Title
100.00
66.67
33.33
0.00
1:36:10 PM 6/11/2016
7:36:10 AM 6/19/2016
1:36:10 AM 6/27/2016
7:36:10 PM 7/4/2016
1:36:10 PM 7/12/2016
Axis Title
Hist.NWW_SRV1.NSWM_AI_DOSATURA NWW Shore Shaft RawWater DO Saturation 85.06
Hist.NWW_SRV1.NSWM_AI_DOCONCEN NWW Shore Shaft RawWater DO Concentrati 7.74
Hist.NWW_SRV1.NSWM_AI_SP_CONDU NWW Shore Shaft RawSp Conductance (F_CV 277.00
Hist.NWW_SRV1.NSWM_AI_RAW_PH F NWW Shore Shaft RawpH (F_CV) 8.05
Hist.NWW_SRV1.NSWM_AI_TURBIDIT NWW Shore Shaft RawWater Turbidity (F_C 0.96
Hist.NWW_SRV1.NSWM_TI_RAW_WATE NWW Shore Shaft RawWater Temp Deg F 67.69
Set to Current Time
15 Min
1 Hour
4 Hour
8 Hour
1 Day
1 Week

GLERL

NOAA - Great Lakes Environmental Research Laboratory

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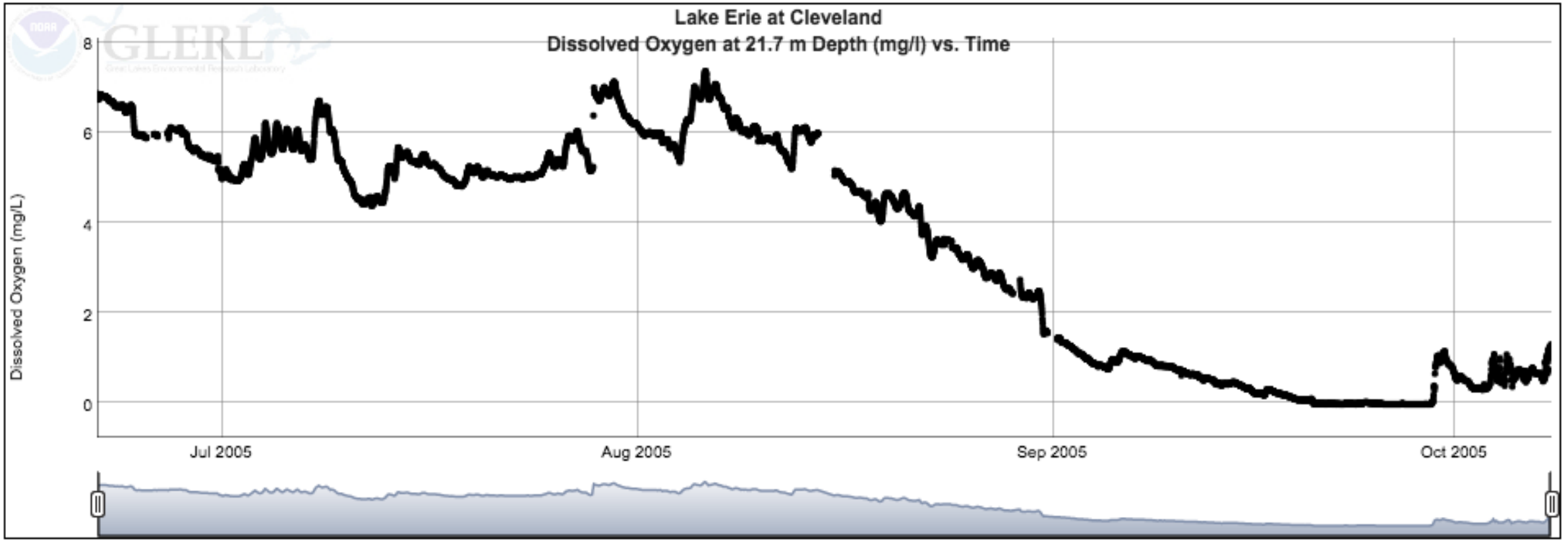
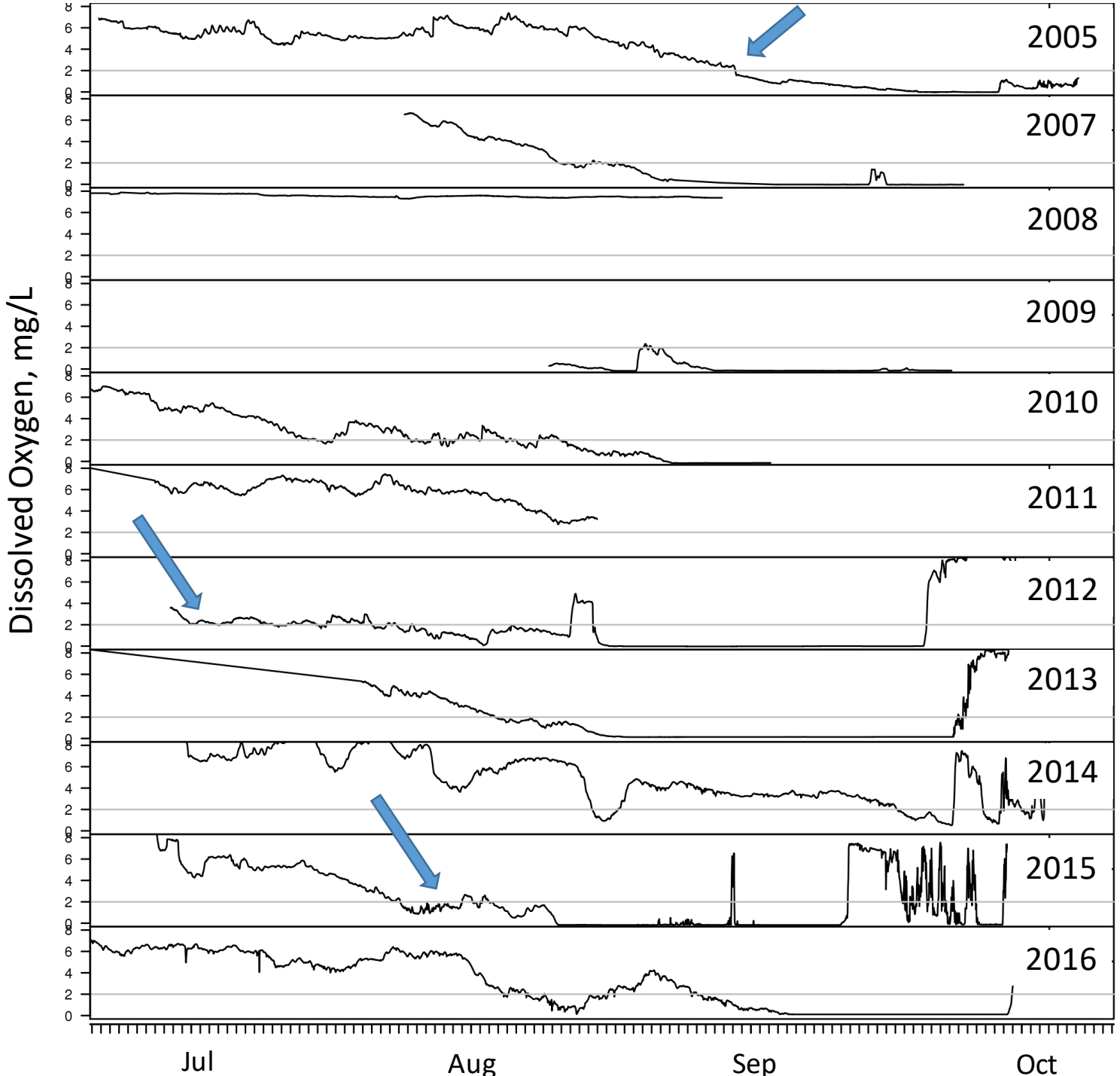
Hypoxia Warning System - Lake Erie at Cleveland, OH

*** *EXPERIMENTAL* ***

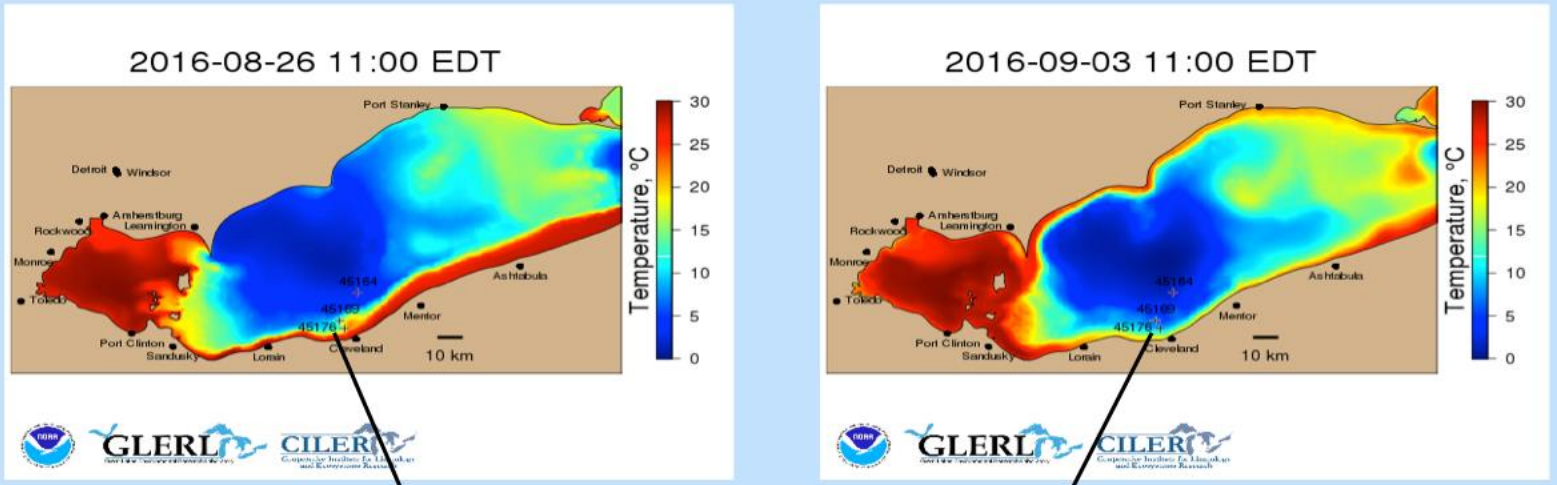


https://www.glerl.noaa.gov/res/HABs_and_Hypoxia/hypoxiaWarningSystem.html

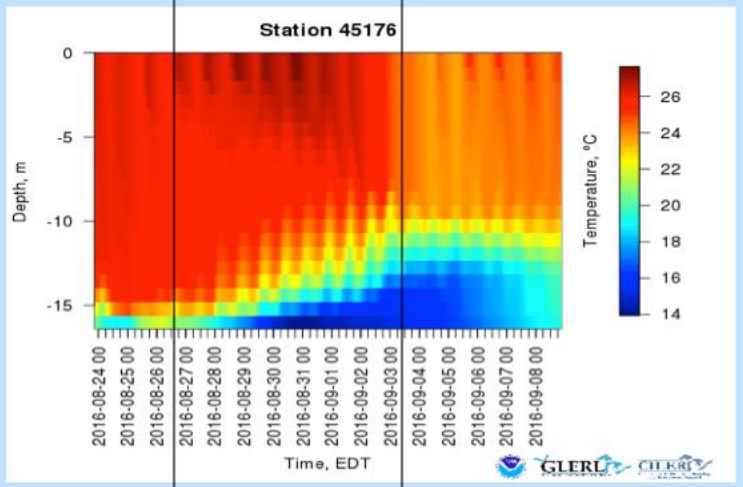
Hypoxia Warning System
Buoy 45164
2005 - 2016



Hypoxia Warning System - Lake Erie at Cleveland, OH



Bottom water temperature forecast predicted upwelling near Cleveland, Aug 26 – Sep 3, 2016



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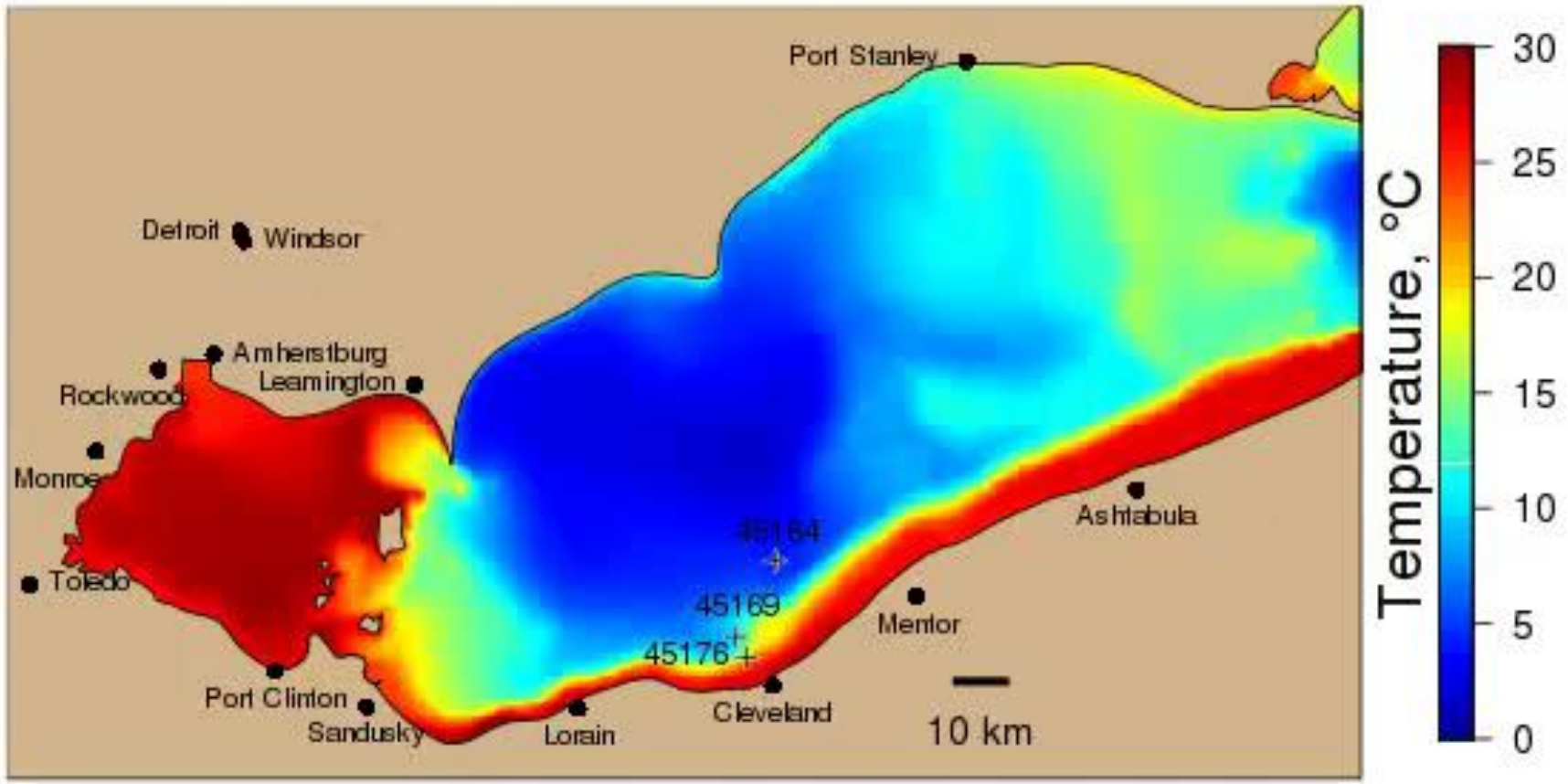
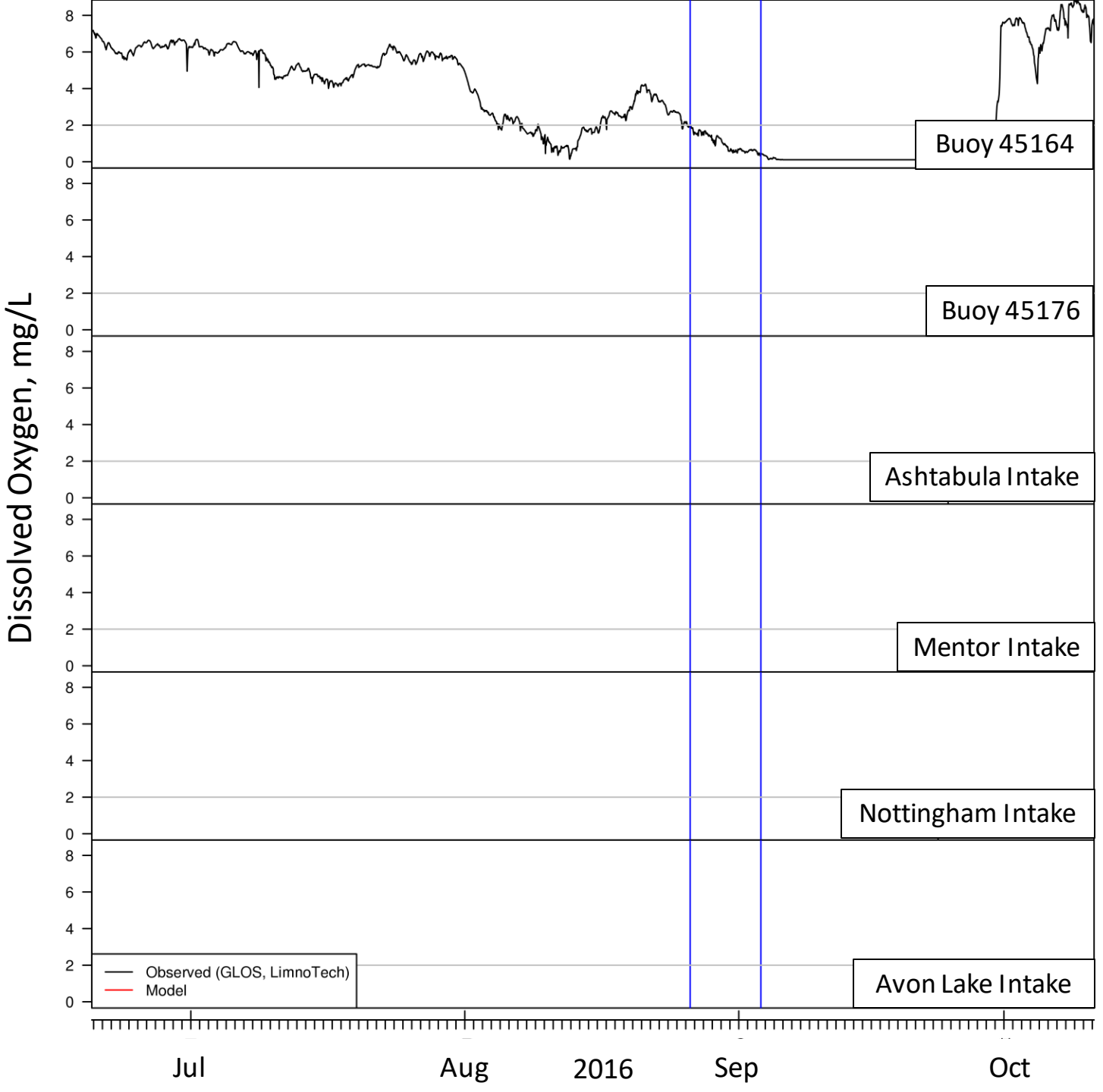
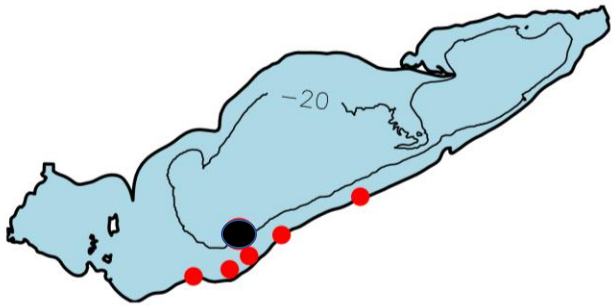



Dissolved Oxygen, mg/L
Buoy 45164
Buoy 45176
Ashtabula Intake
Mentor Intake
Nottingham Intake
Avon Lake Intake
Observed (GLOS, LimnoTech)
Model
Jul
Aug
2016
Sep
Oct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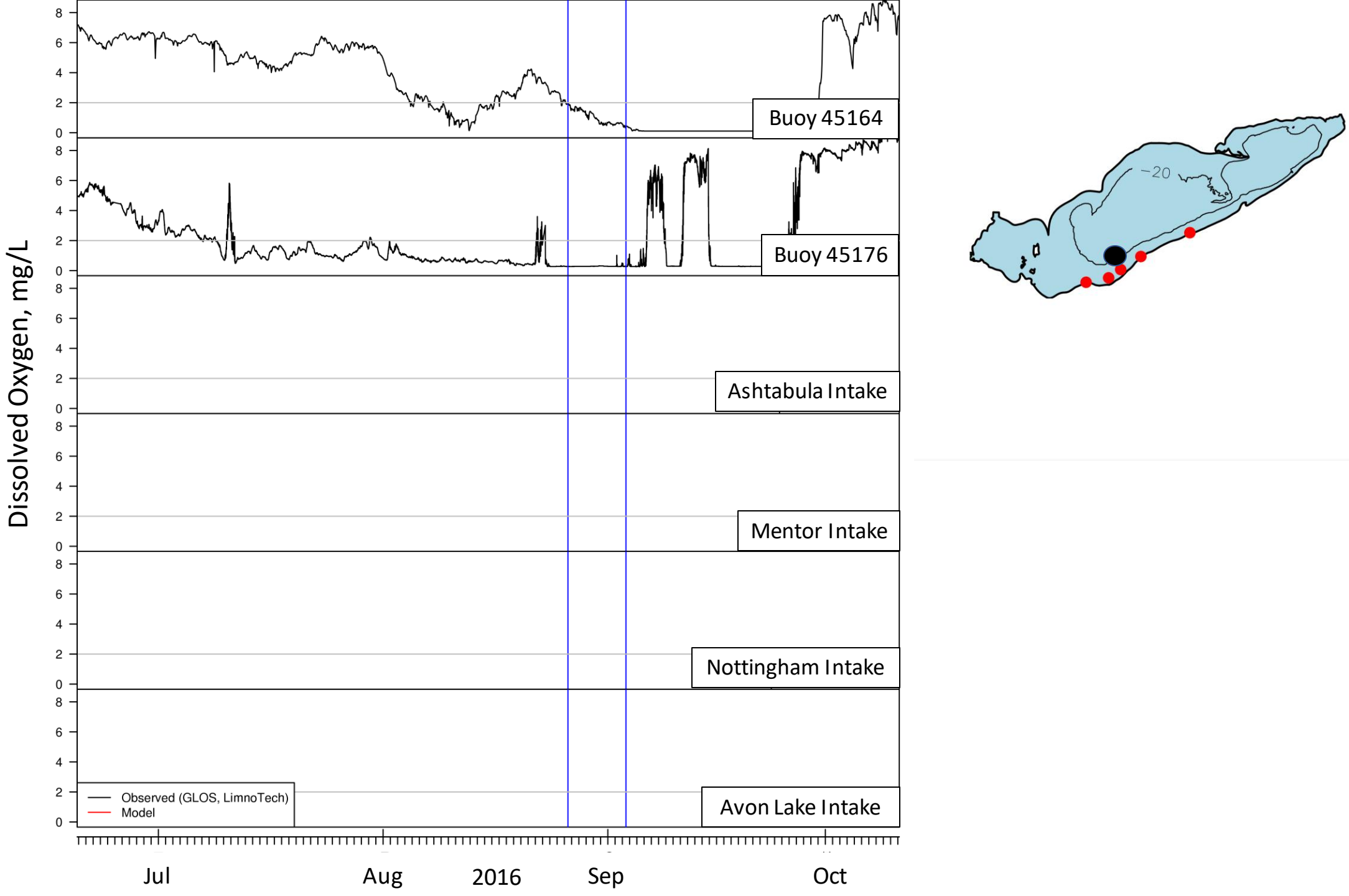
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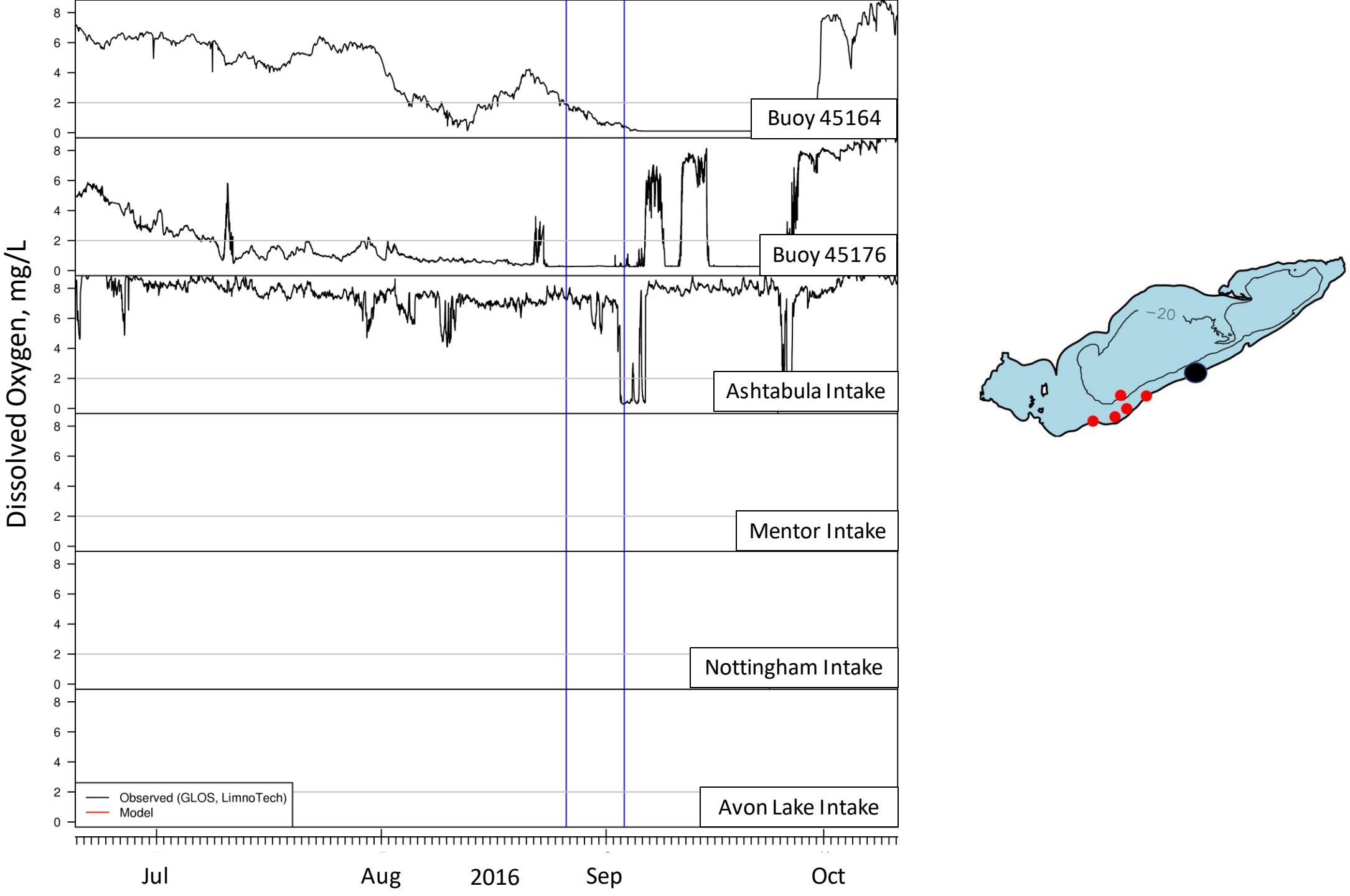
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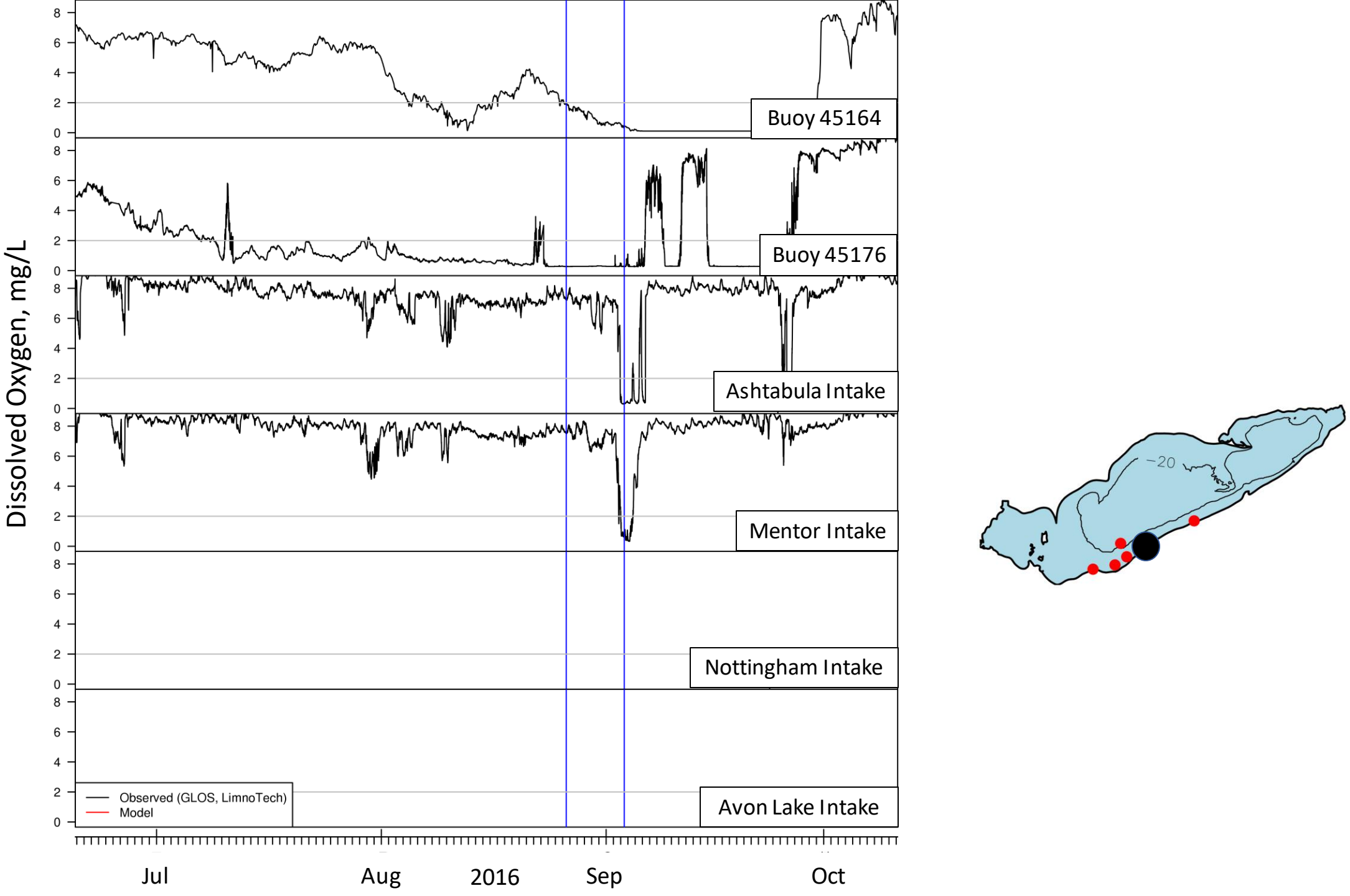
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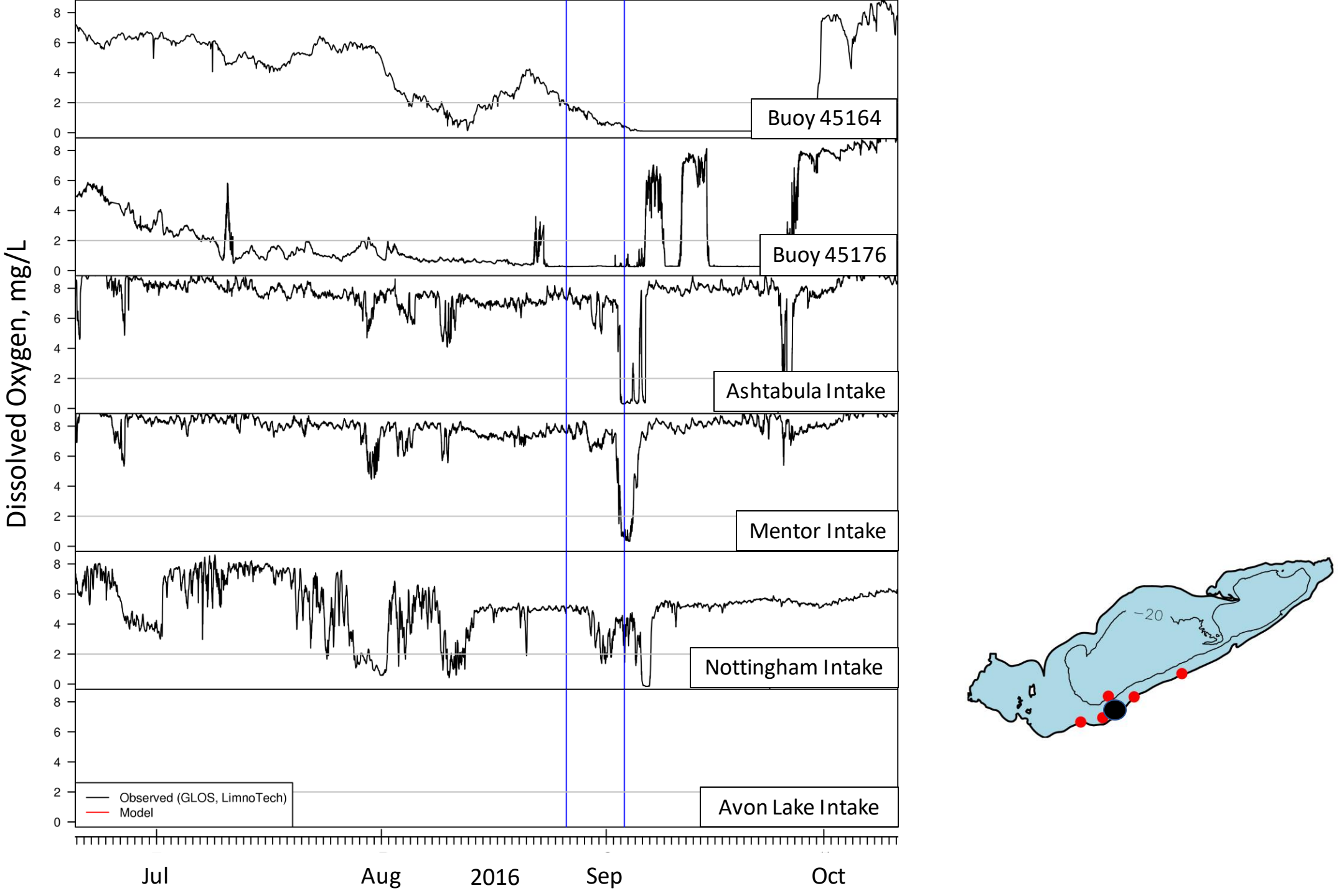
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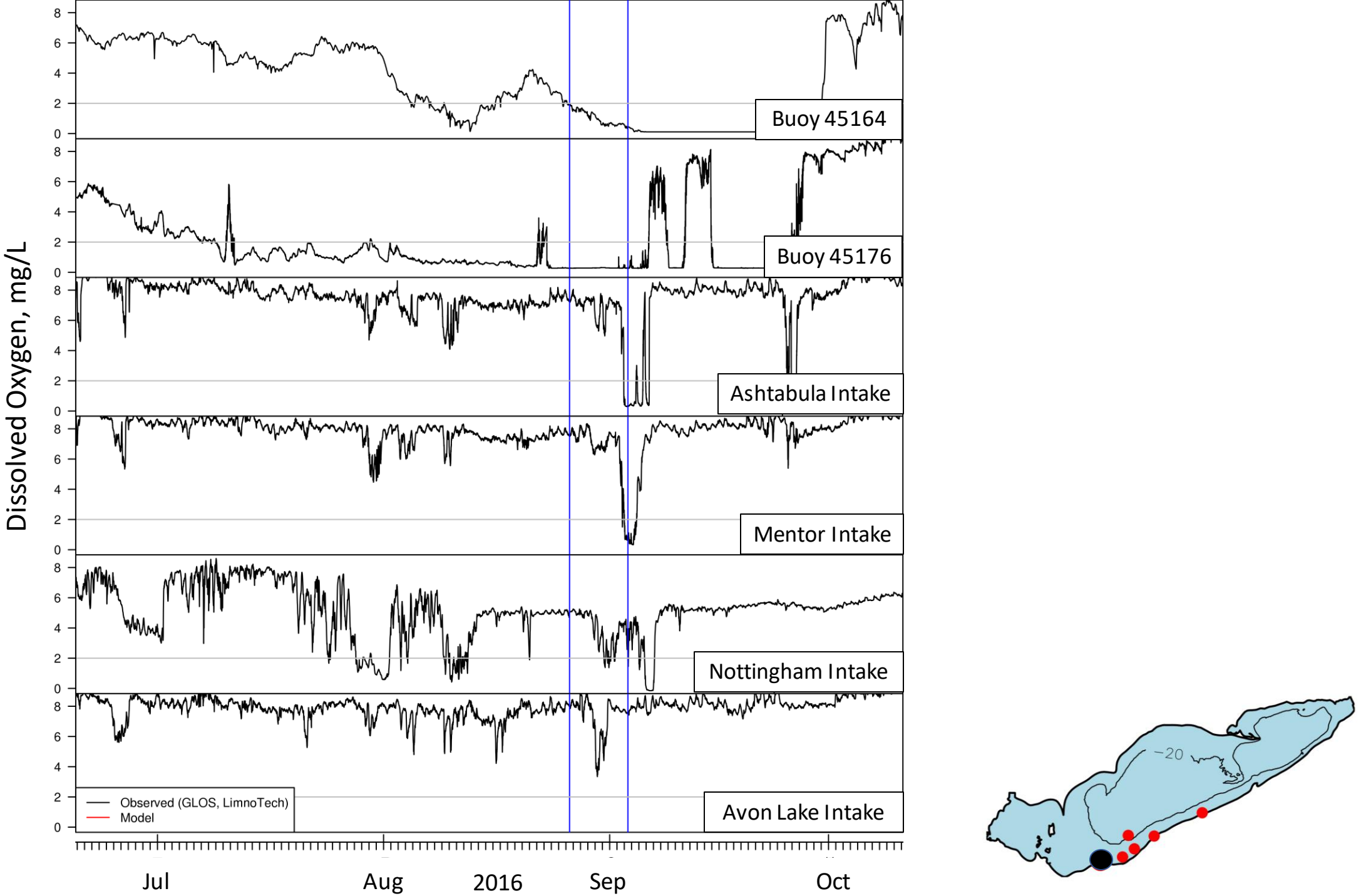
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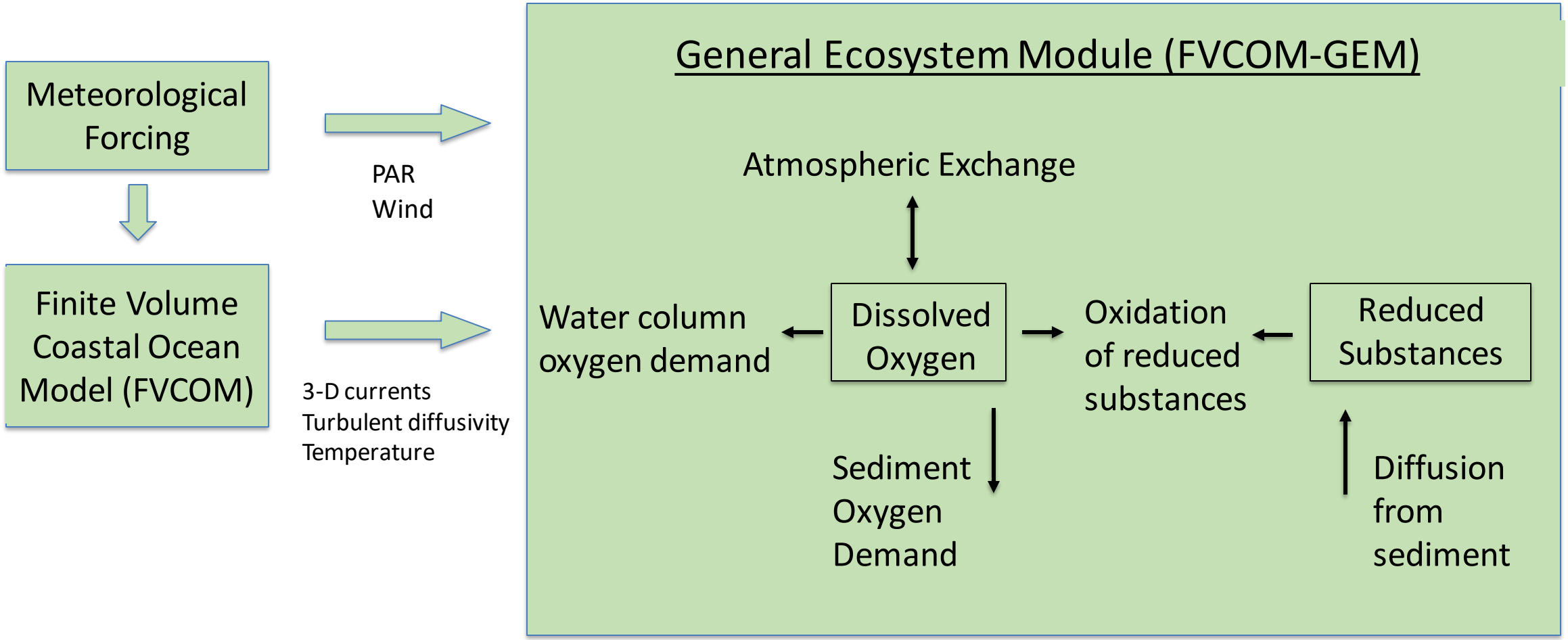
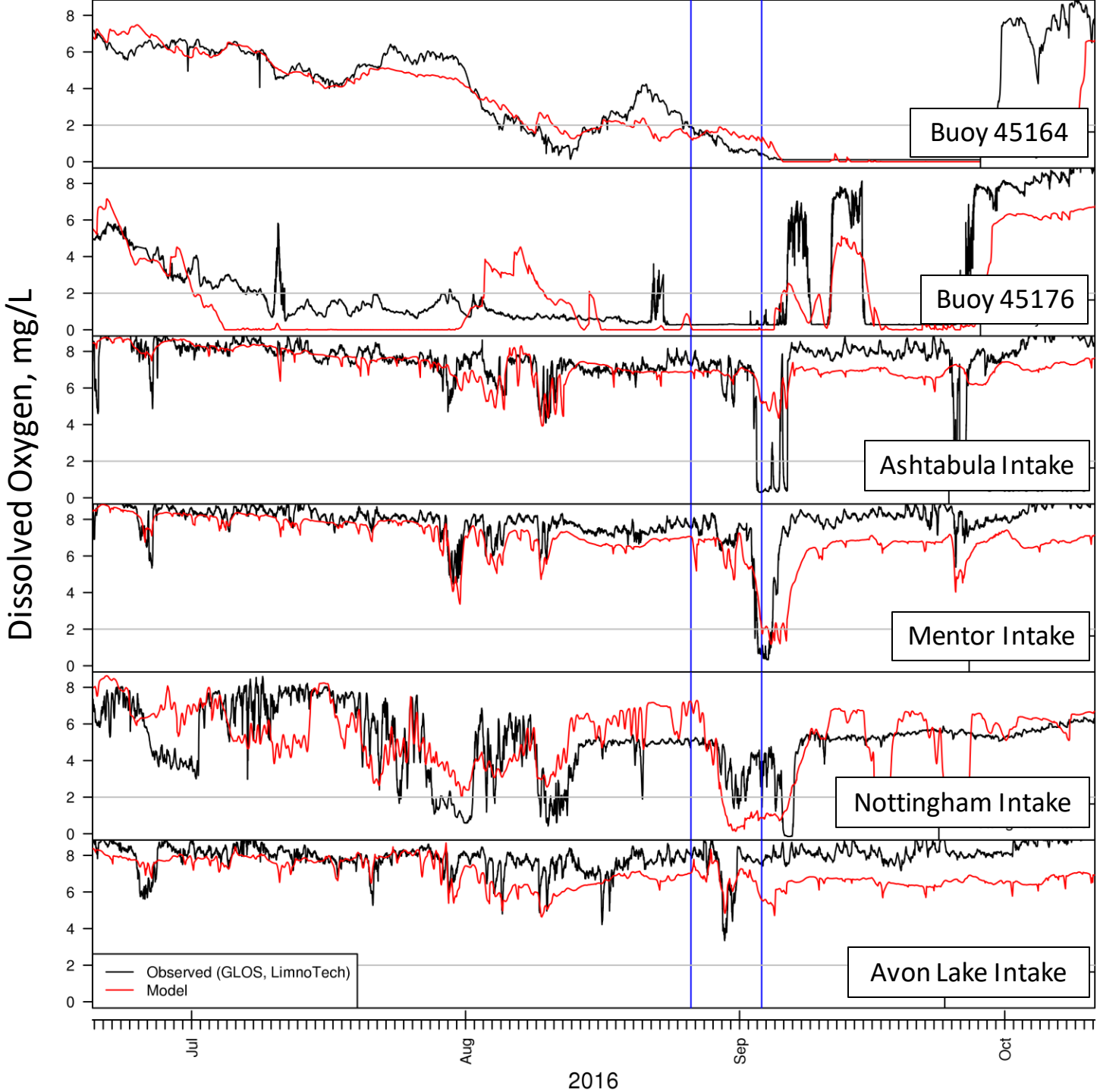
Physical dissolved oxygen model

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Ashtabula Intake
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Nottingham Intake
Avon Lake Intake
Observed (GLOS, LimnoTech)
Model
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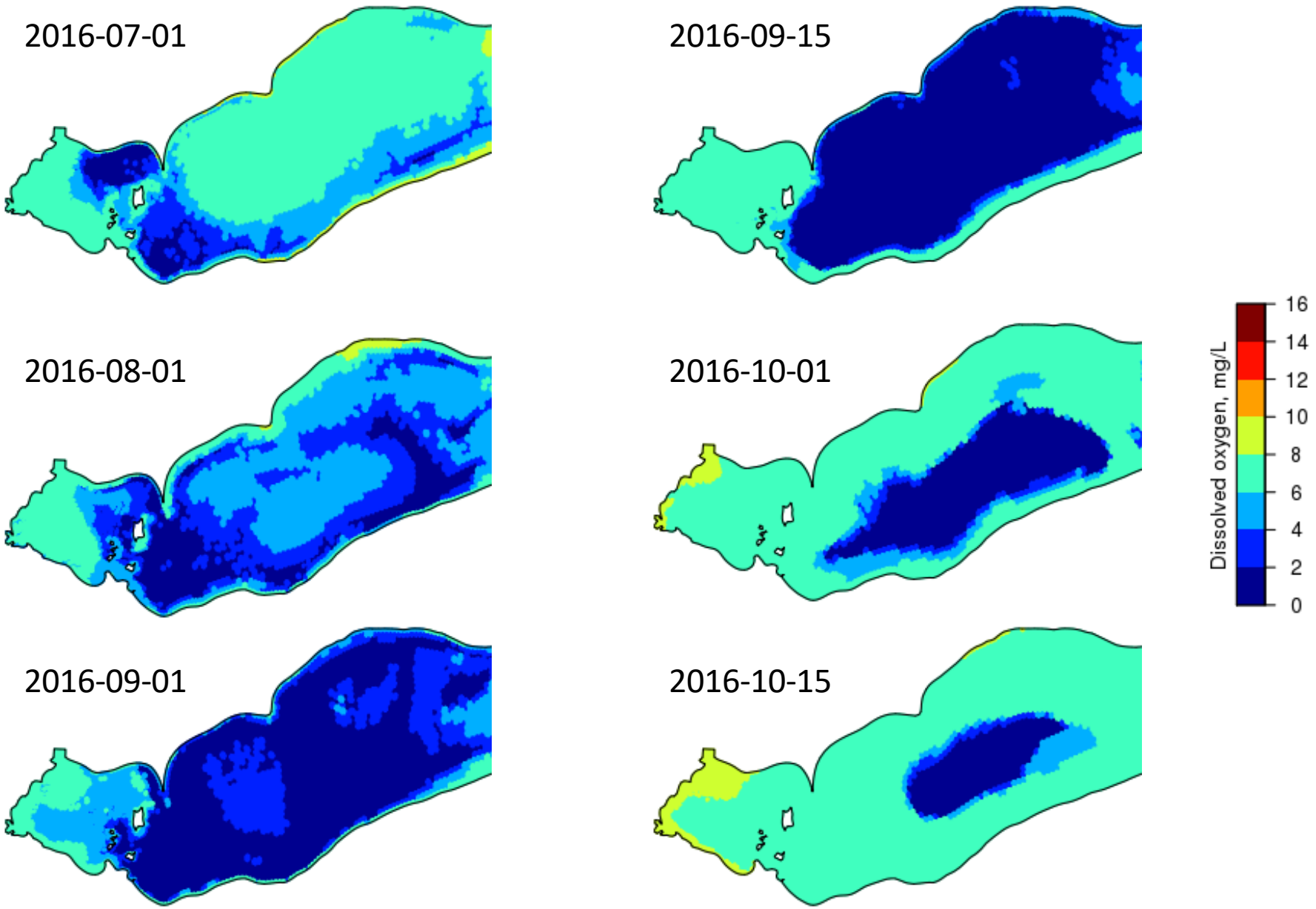
2016

Simulated bottom water dissolved oxygen



Water Resources Research

RESEARCH ARTICLE
10.1002/2015WR018170

Temporal and spatial dynamics of large lake hypoxia: Integrating statistical and three-dimensional dynamic models to enhance lake management criteria

Key Points:
- We modeled seasonal and spatial dynamics of Lake Erie hypoxia
- We showed hypoxia starts nearshore and can persist after traditional monitoring programs end

Serghei A. Bocaniov[1] and Donald Scavia[1]

[1]Graham Sustainability Institute, University of Michigan, Ann Arbor, Michigan, USA

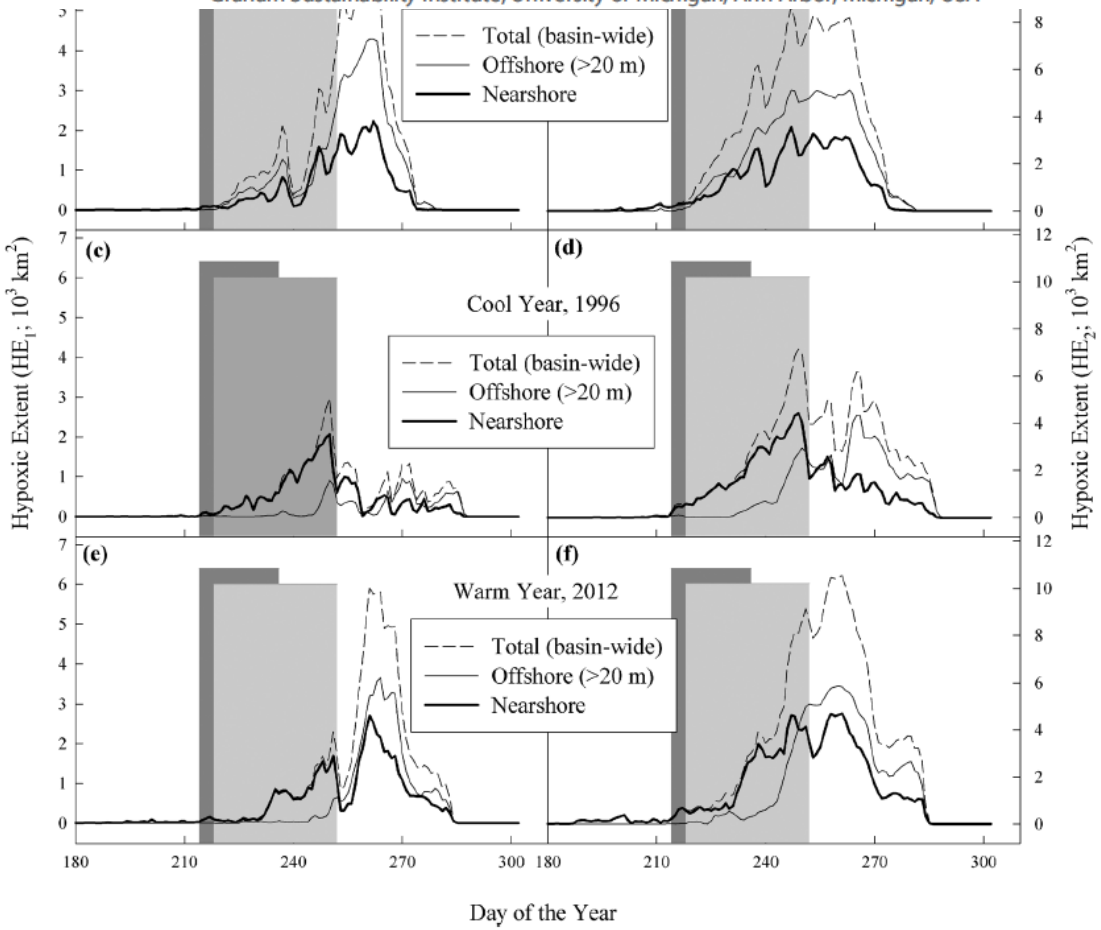
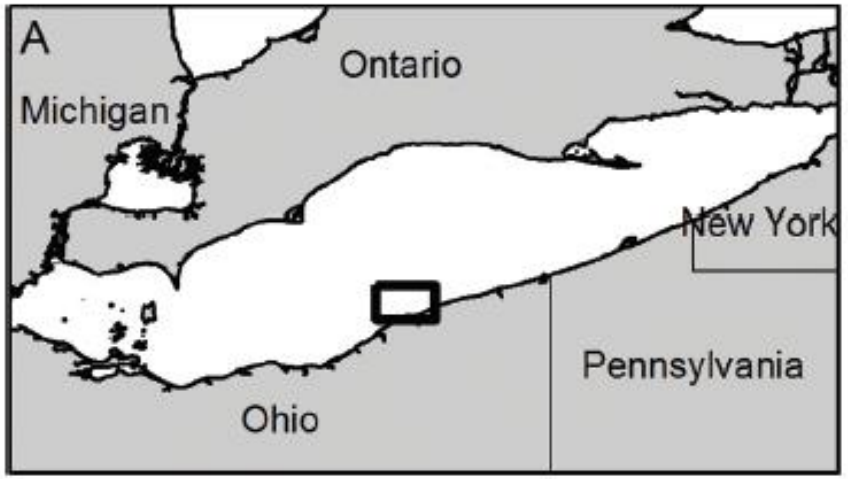


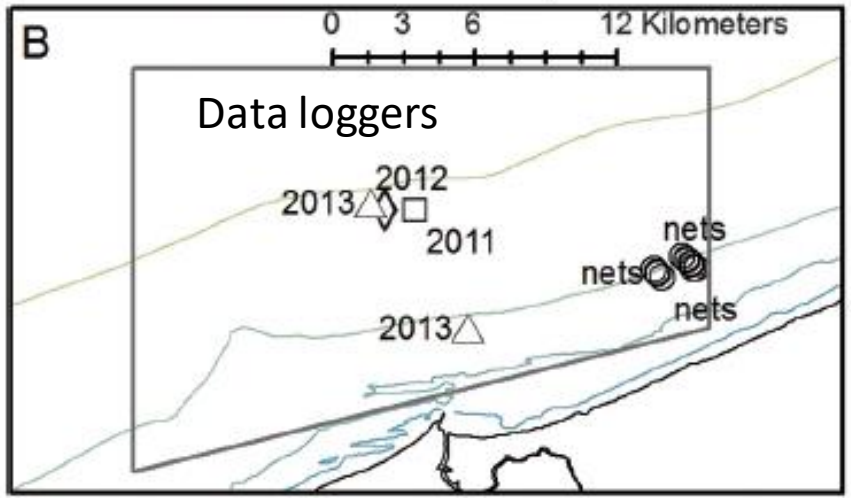
Figure 9. Simulated seasonal dynamics of HE_1 (a, c, e) and HE_2 (b, d, f) for basin-wide, nearshore and offshore zones in 2008 ("normal" year; a-b) and using meteorological conditions for 1996 (c–d) and 2012 (e–f) accounting for the meteorological conditions of the 'cool' and "warm" years, respectively. The vertical light and dark grey bars indicate timing in days (mean ± SD) of all central basin DO monitoring cruises from 1987 to 2007 for all agencies (CLNPO, GLERL, and NWRI; $N = 75$) and some selected agencies (GLNPO and GLERL; $N = 26$), respectively, based on data provided in supporting information Table S1 in *Zhou et al.* [2013].

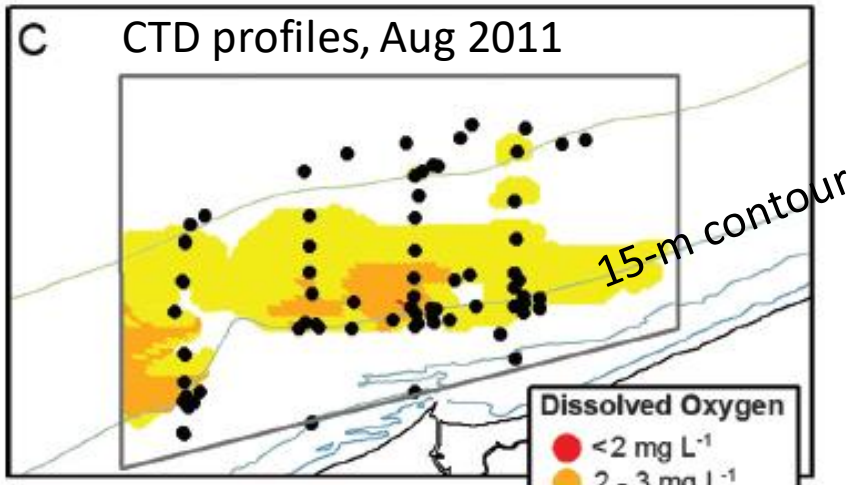
Dynamic hypoxic zones in Lake Erie compress fish habitat, altering vulnerability to fishing gears[1]

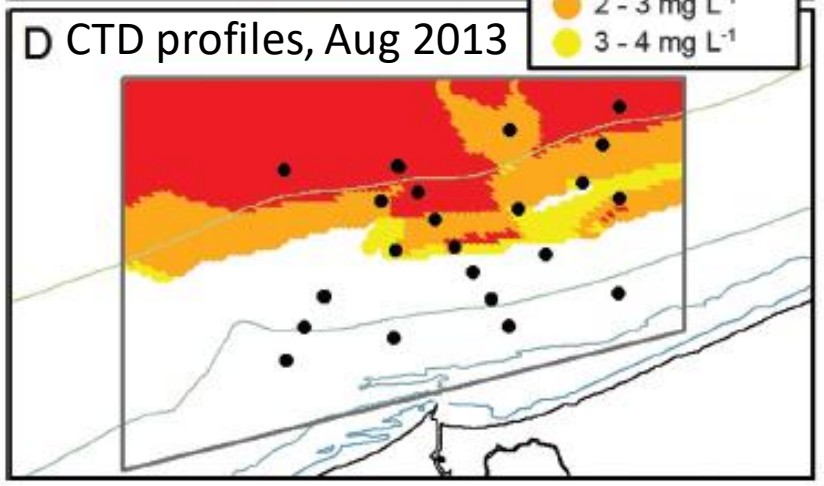
Richard T. Kraus, Carey T. Knight, Troy M. Farmer, Ann Marie Gorman, Paris D. Collingsworth, Glenn J. Warren, Patrick M. Kocovsky, and Joseph D. Conroy

Can. J. Fish. Aquat. Sci. 72: 797–806 (2015) dx.doi.org/10.1139/cjfas-2014-0517









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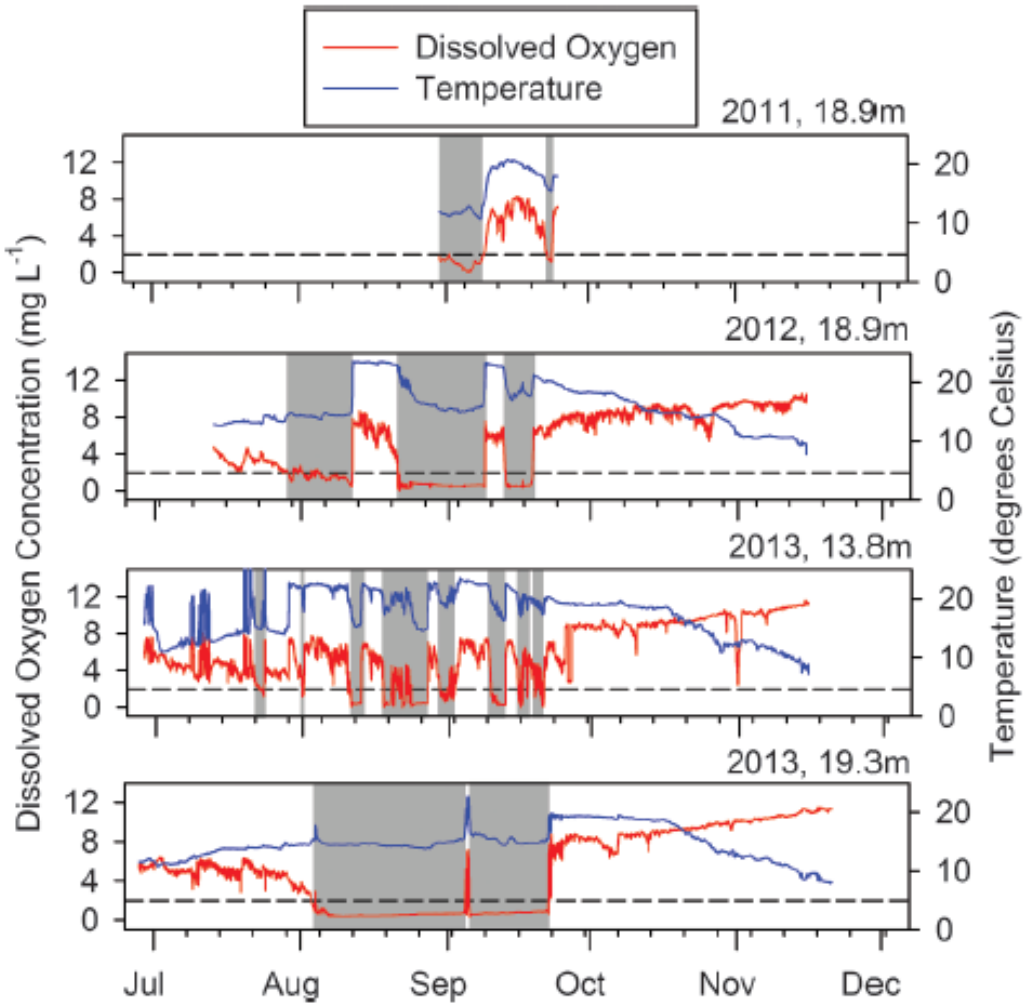
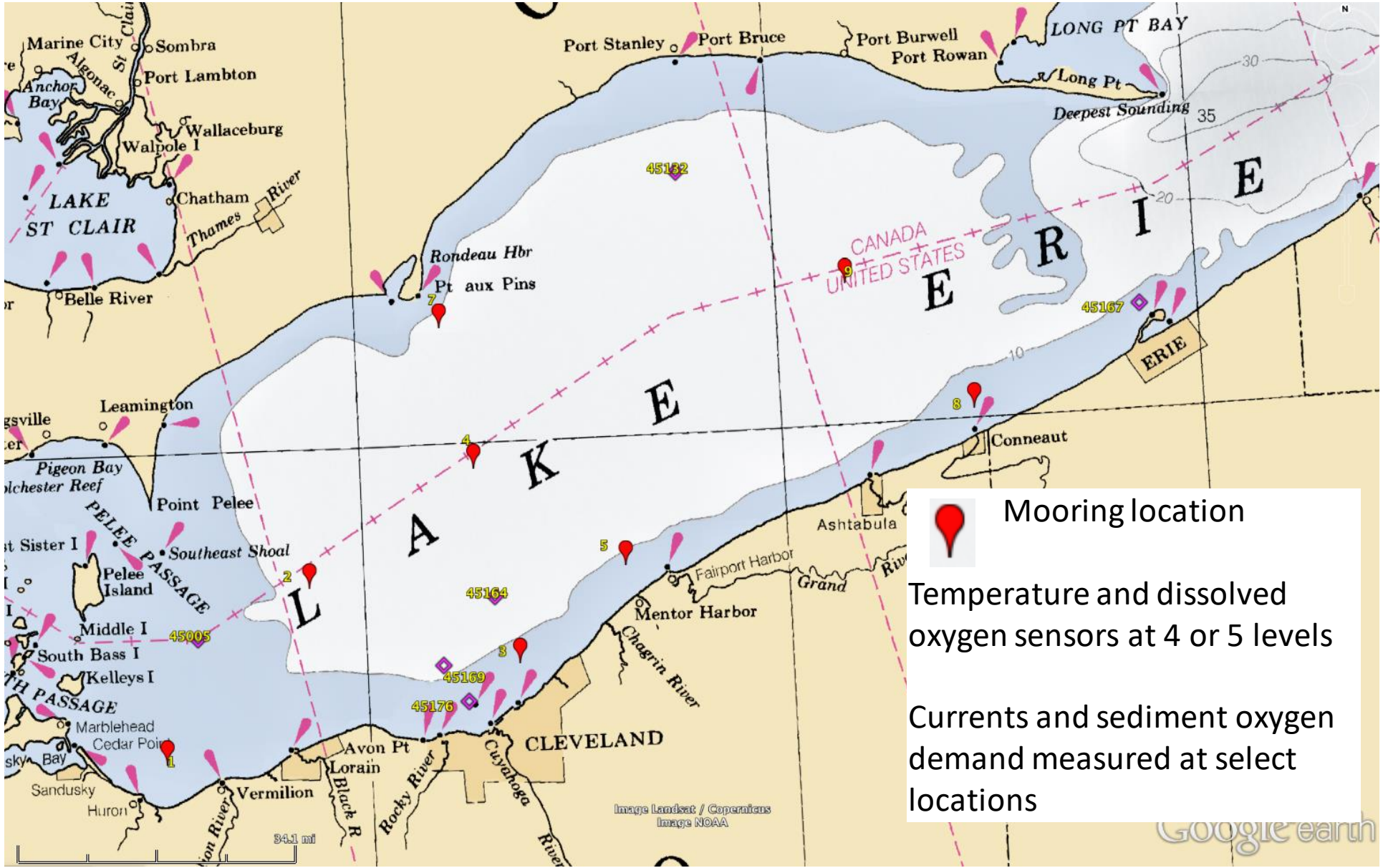


13.8 m station

Proposed mooring array



Summary

- Spatial and temporal extent of hypoxia is variable and not well known
- Physical variables influence episodes of nearshore hypoxia
  - Hypolimnion thickness
  - Meteorological forcing
  - Circulation patterns
- Spatial and temporal variability of biochemical oxygen demand may also be important, but relatively few observations
- Improved models and increased monitoring of nearshore hypoxia will improve our understanding and predictive ability, which is of interest to public water systems