Currents and Temperature in Lake Erie

2004 Experiment:

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Environment Canada Environnement Canada

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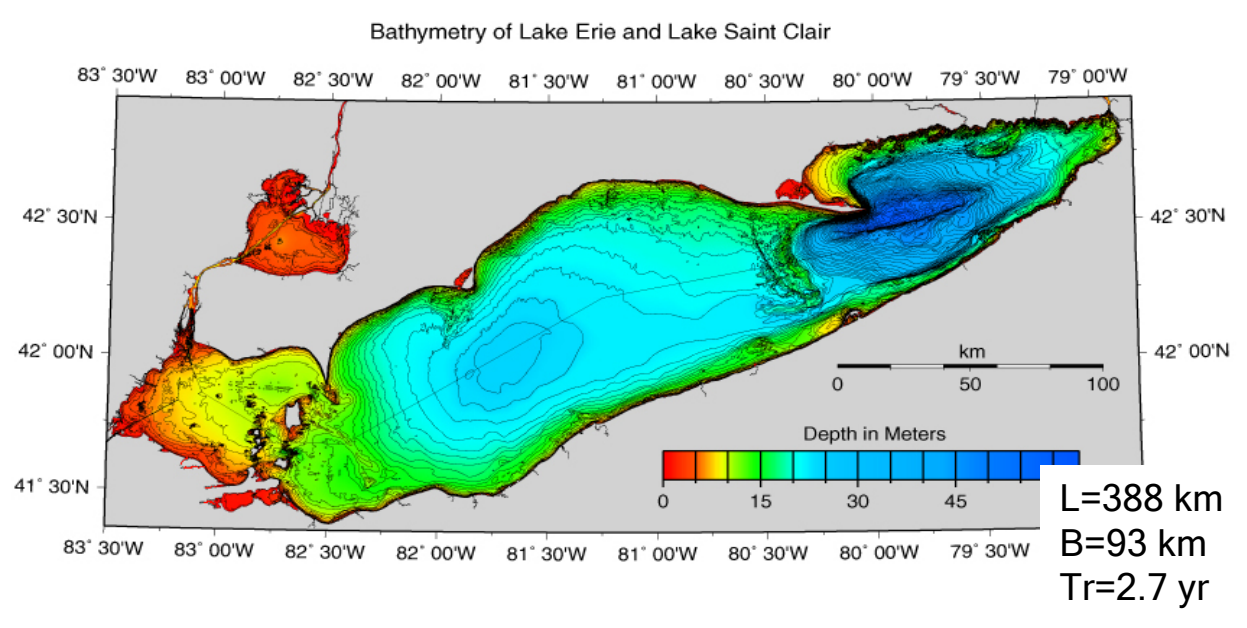
INSTITUT NATIONAL DE RECHERCHE SUR LES EAUX



Background

Nutrient management plans started in 70s reduced

- Eutrophication, Hypoxia & TP in the central basin

90s Issues

- Warmer temperatures, alteration in the ecosystem due to zebra mussel invasion etc.
- Re-emergence of some 70s issues (Cladophora, Increased TP, Low DO levels never went away in the CB)

Need to revisit nutrient management plans of the lake?

Recent Model Simulations

Water Quality Simulations (Lam et al. 2002)

Lake Erie water quality model simulations (post zebra mussel scenarios) indicated that

- Mussels can affect the phosphorous concentrations in the Lake
- Simulations have not shown any affect of Mussels on the DO in the central basin
- DO variability is related to the interannual variability of the meteorological conditions.

Limitations and future needs (gaps) of these simulations

•Substantial experimental data such as circulations, thermal structure, horizontal and vertical exchanges and biochemical data need to be incorporated in models to improve the predictions.

•Increased understanding of nearshore-offshore exchanges is needed & incorporate these effects in models

•Recalibration of water quality model parameters (for eg. sedimentation and resuspension) in the present conditions

•The models require better tributary loading estimates

Previous experiments

Project Hypo (1970) & Bi-National Program (1979-80)

Objective

To conduct intensive measurements in Lake Erie for providing hydrodynamic and thermal observations required to assess/predict changes in water quality and aquatic ecosystem components concurrently with the cooperative monitoring in 2004.

Sub-objectives

- Develop a data base for calibration and verification of hydrodynamic model and 9 Box Model.

- Estimate Water residence times
- Estimate Inter basin transports on daily scale for model input
- Study bottom currents and dissolved oxygen in the hypolimnion of the central basin
- Estimate onshore-offshore exchanges during summer episodic events (upwelling) along the north shore of the central basin

Great Lakes Surveillance Program

- 8 CCGS LIMNOS surveys
- Spring sampling = surface
- Summer sampling
  - a. 1 m below water surface, plus
  - b. 1 m above the thermocline, plus
  - c. mid-thermocline, plus
  - d. 1 m below the thermocline, plus
  - e. bottom minus 10 and 2 meters.

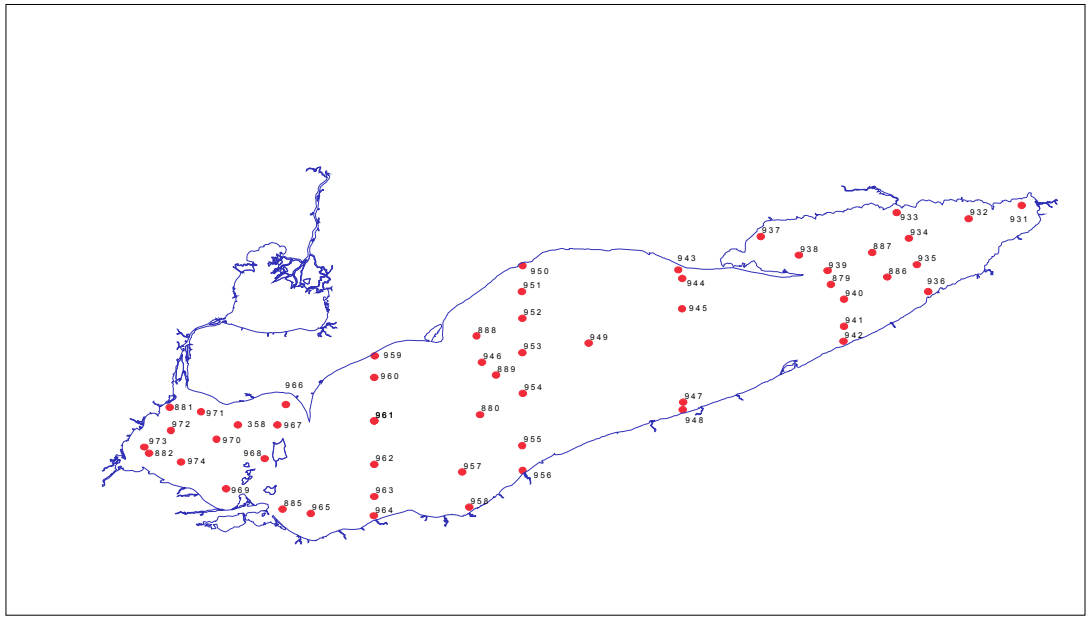
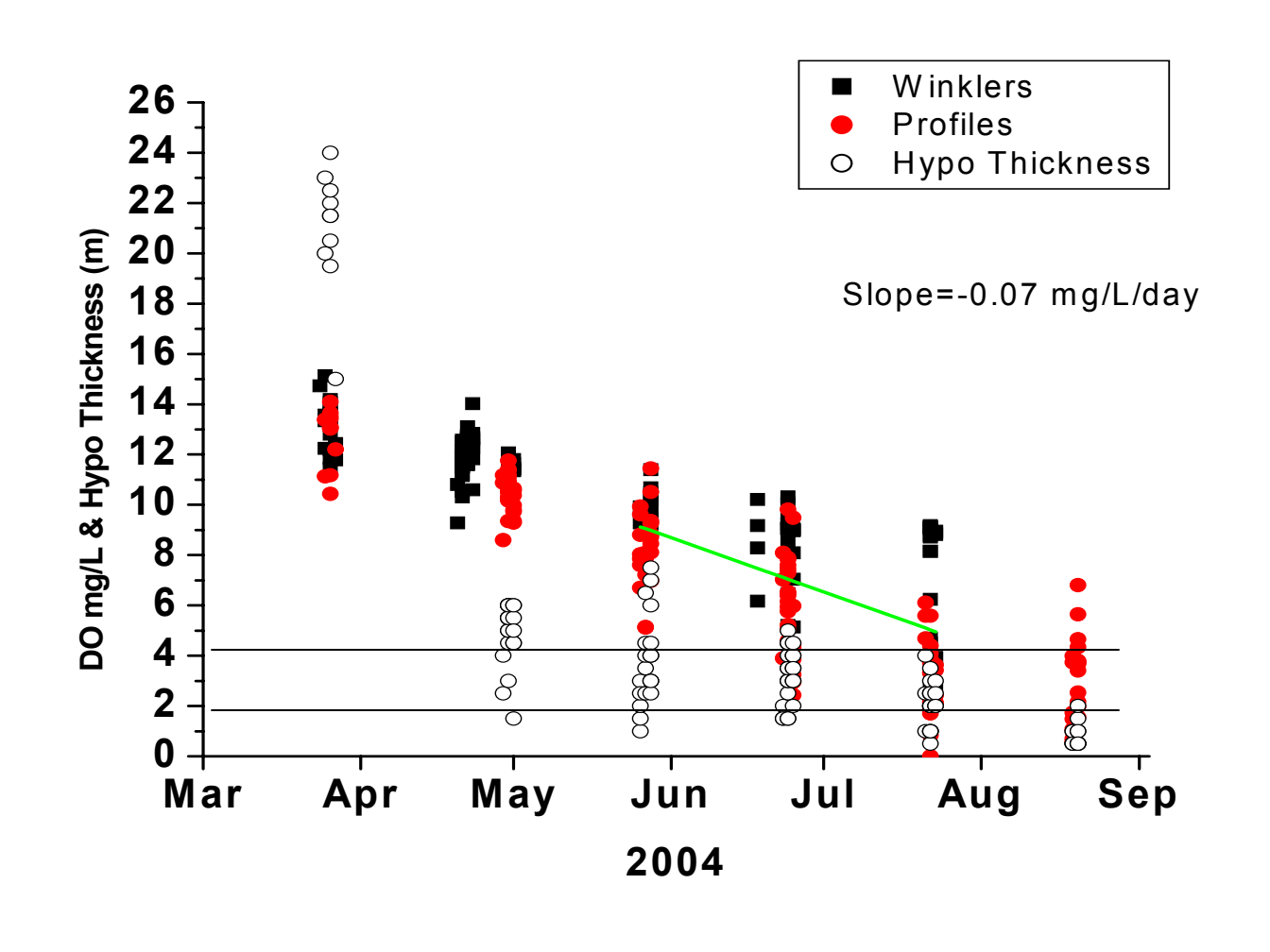
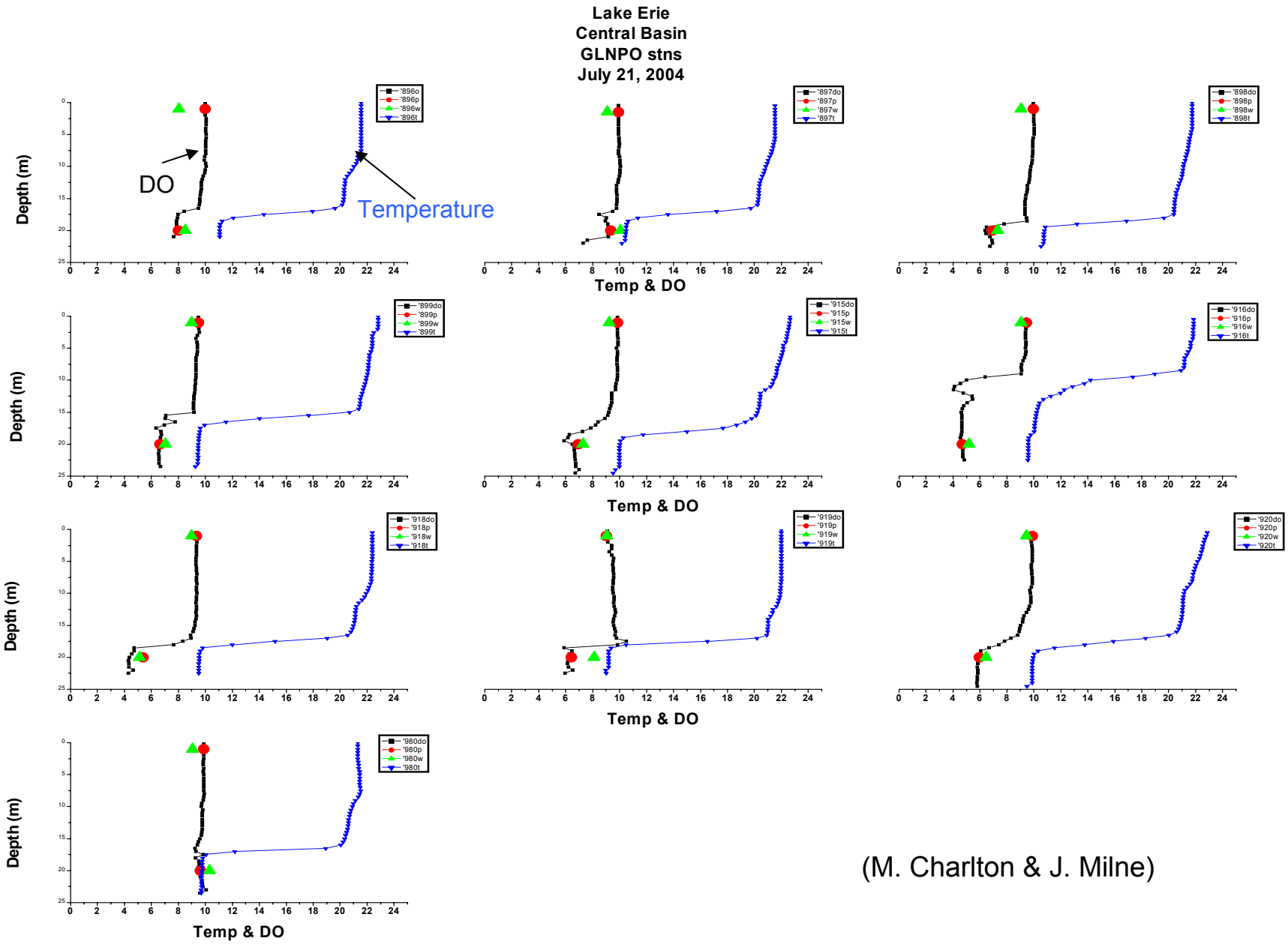


Figure 2. Station locations for the Lake Erie surveillance program 1994-1998.



1. The linear slope shows a depletion of 0.07 mg/L/d.
2. Some stations show anoxic conditions from mid-July to the middle of August.

(M. Charlton & J. Milne)


Lake Erie
Central Basin
GLNPO stns
July 21, 2004
Depth (m)
DO
Temperature
Temp & DO
'896o
'896p
'896w
'896t
'897do
'897p
'897w
'897t
'898do
'898p
'898w
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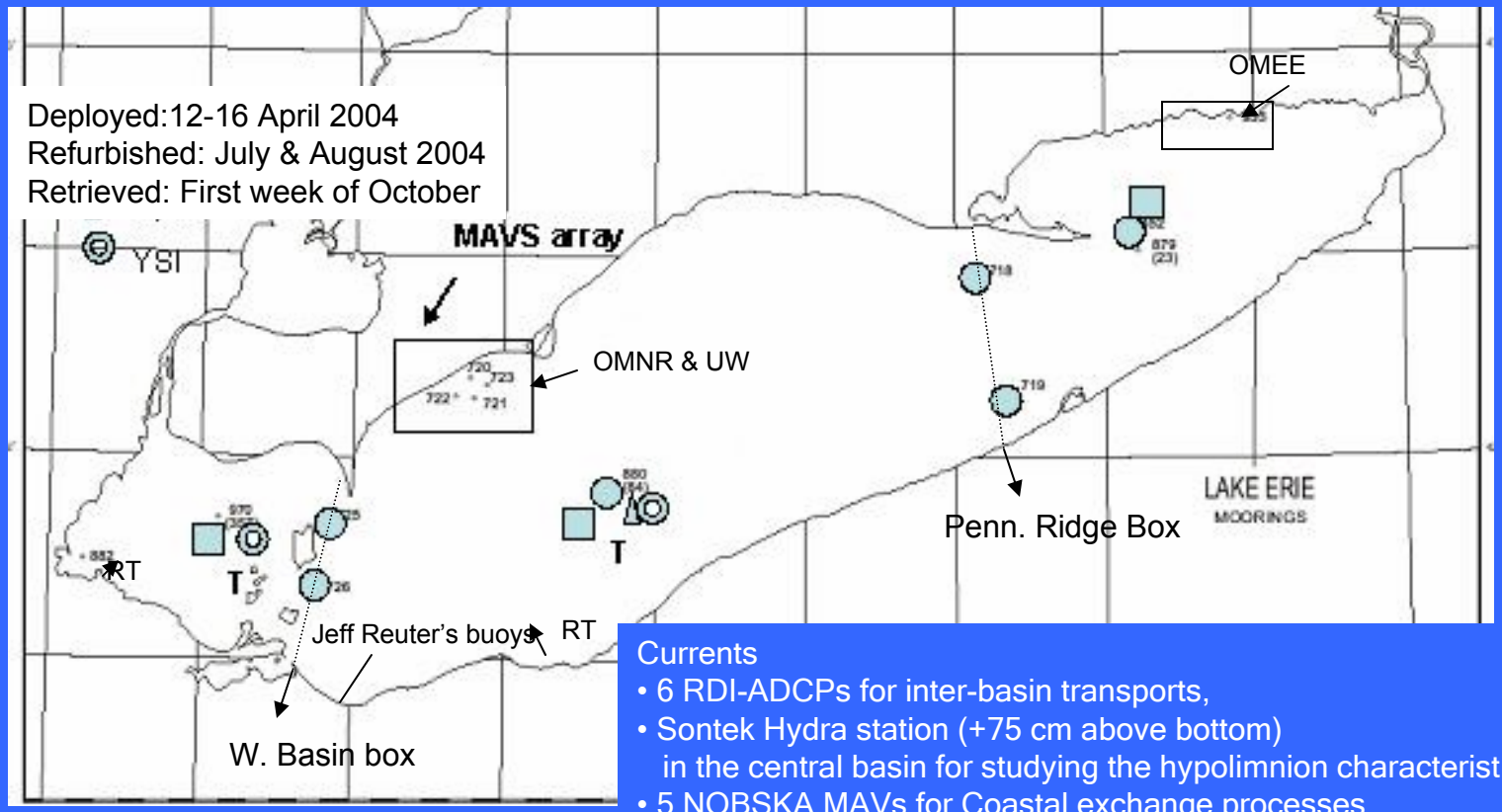
(M. Charlton & J. Milne)

Experimental Set-up (Physical measurements)



Currents
- 6 RDI-ADCPs for inter-basin transports,
- Sontek Hydra station (+75 cm above bottom) in the central basin for studying the hypolimnion characteristics.
- 5 NOBSKA MAVs for Coastal exchange processes

Temperature

Thermistor chain moorings near all ADCP and Met stations.

Meteorology

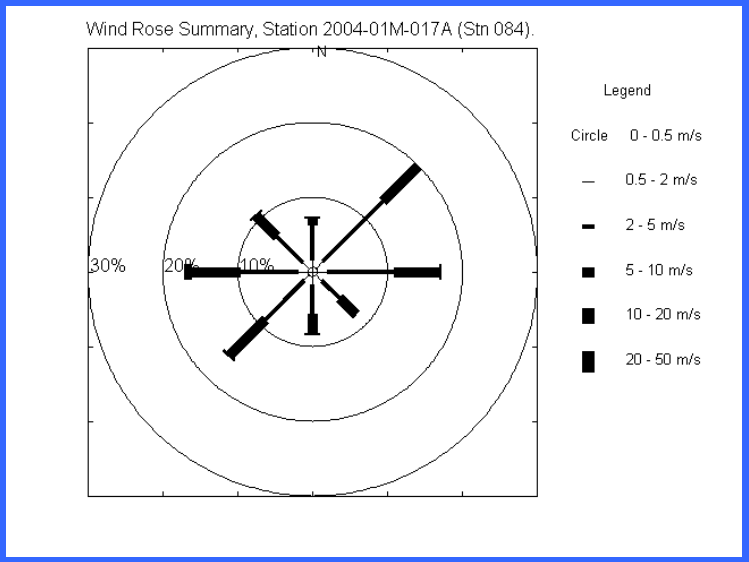
3 Meteorological buoys in three basins with Radiation sensors

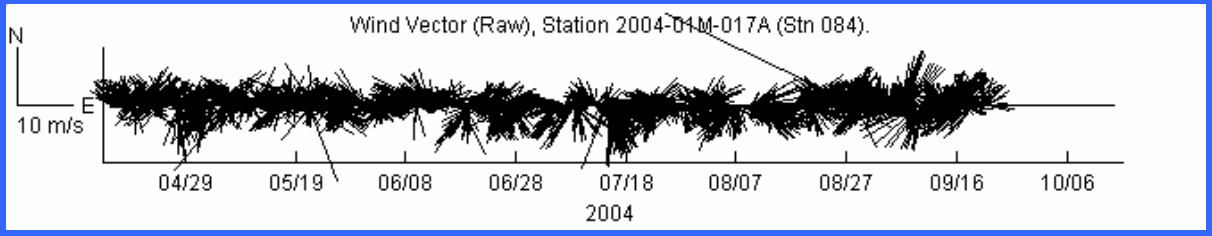
Water Quality

2 Stations with transmissometers at two depths
3 YSI 6600 (2 in the central basin)
Hydrolab stations in the western basin

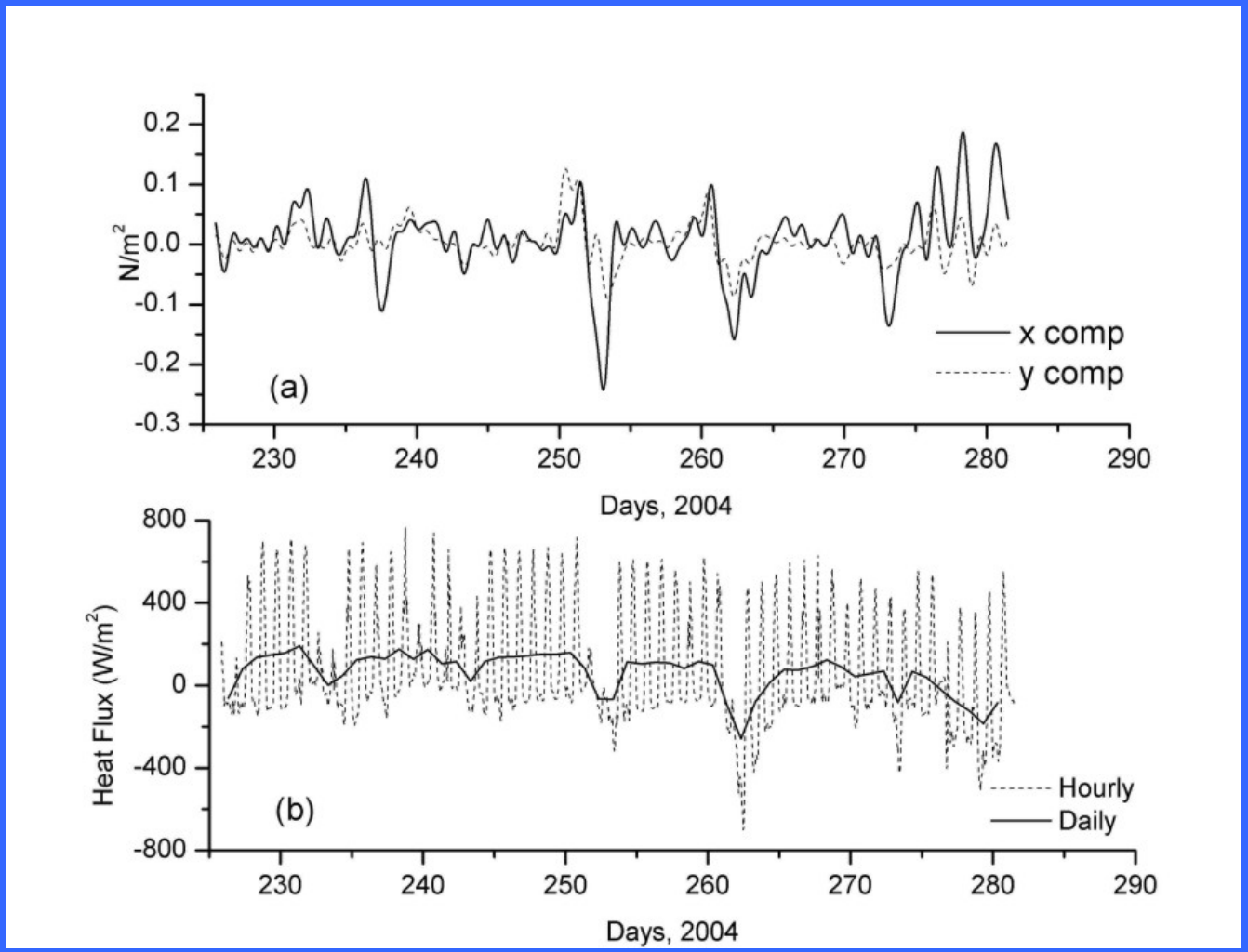
Meteorology

Central basin buoy

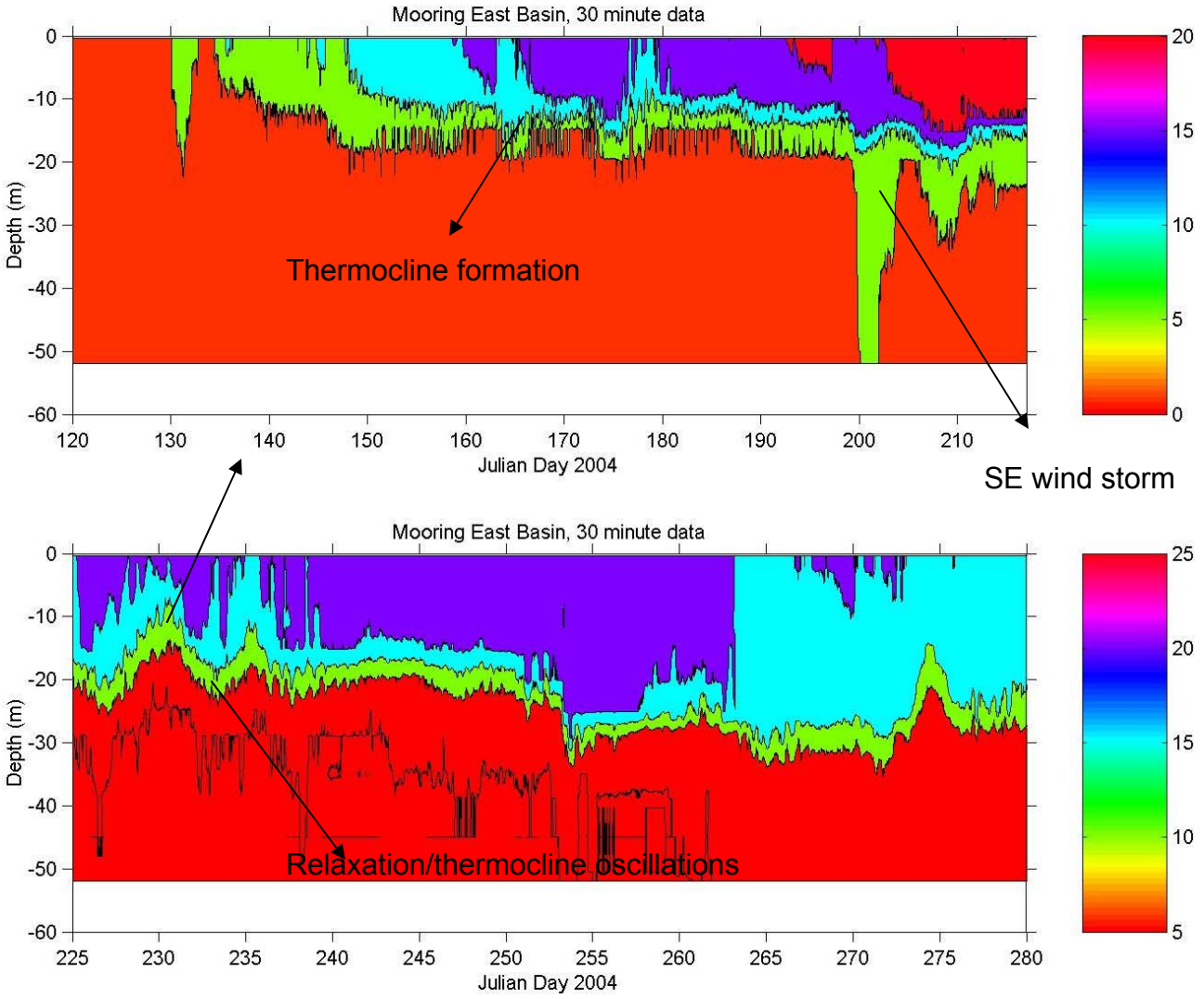




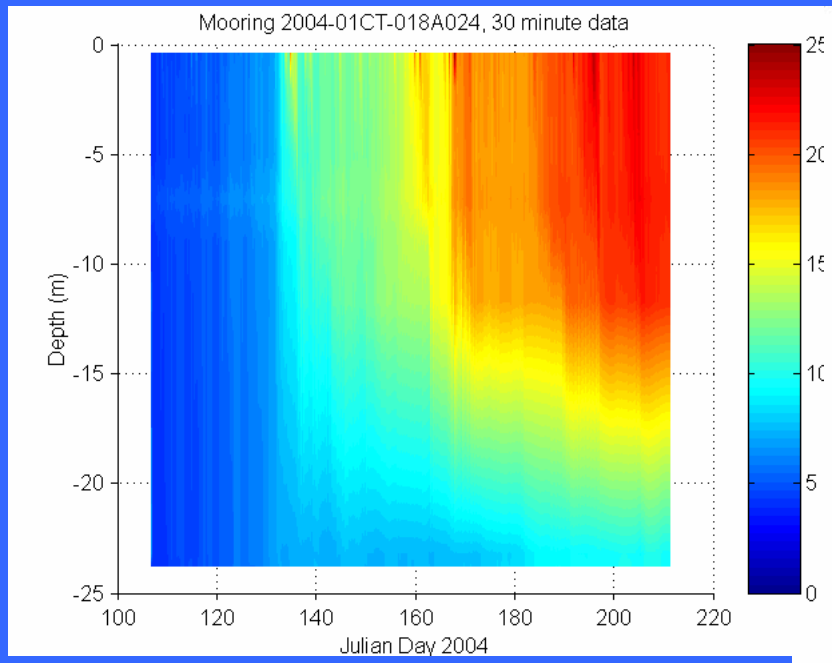
Wind stress and Heat flux in the east basin

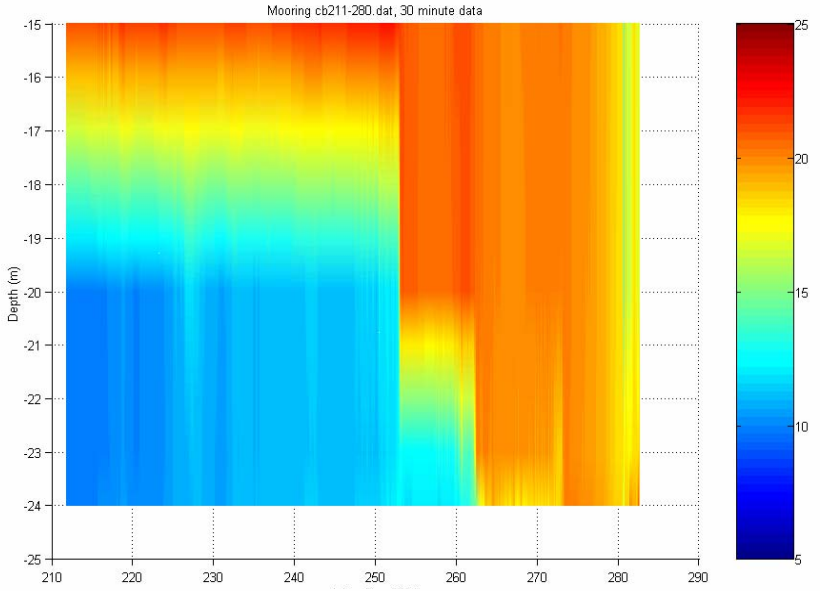


Thermal structure in the east basin

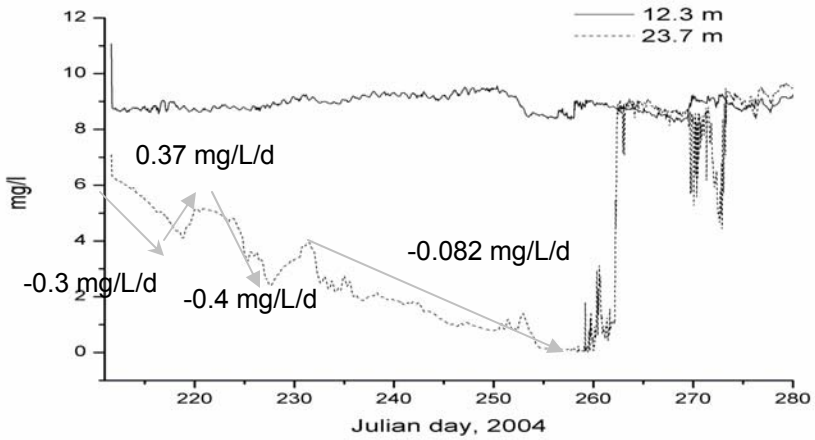


Temperature and DO in the central Basin

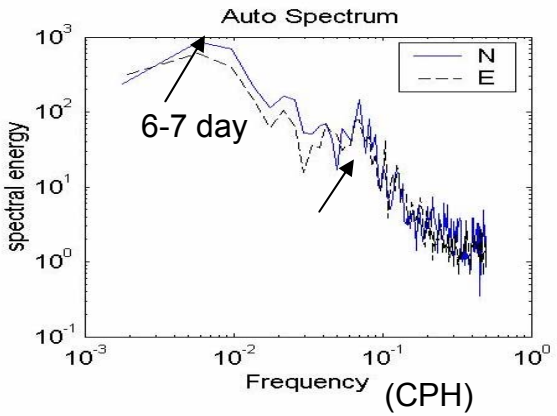




1. Stratification started from middle of June
2. Hypo depth & Low DO
3. Effects of physical processes on DO

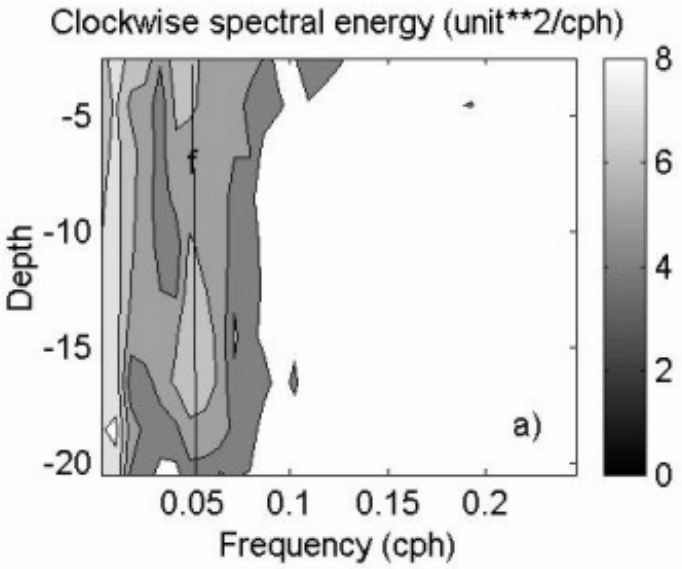


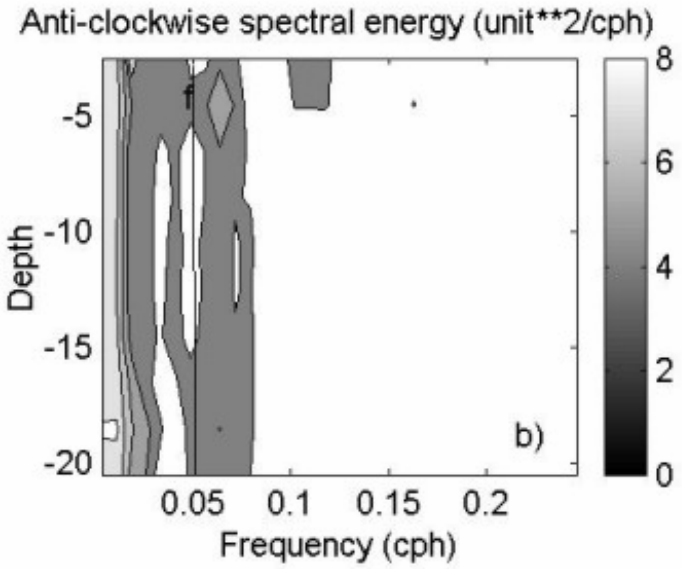
Currents: Spectral Characteristics



1. 6-7 day period
2. Near-inertial

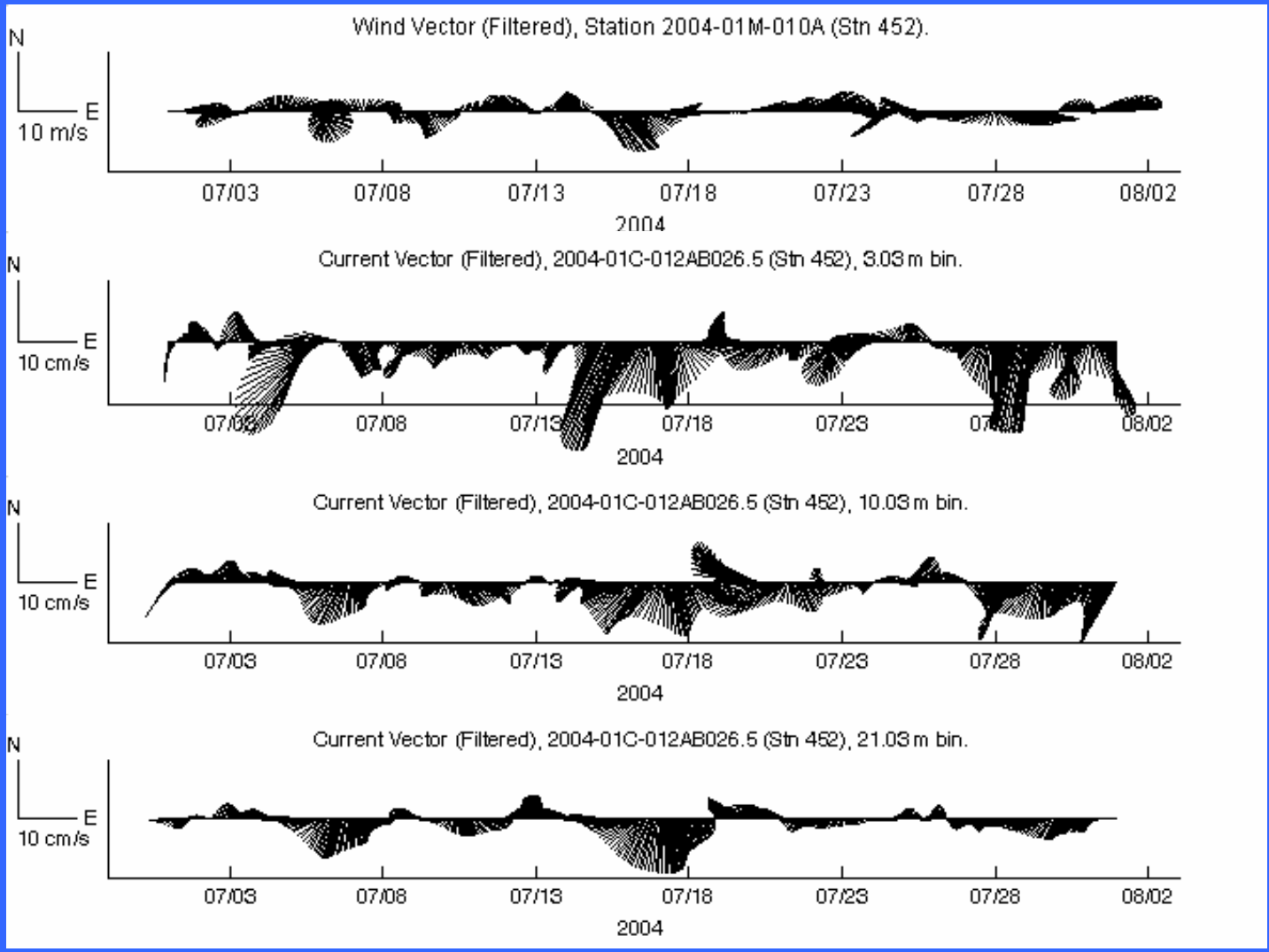
Rotary Spectra



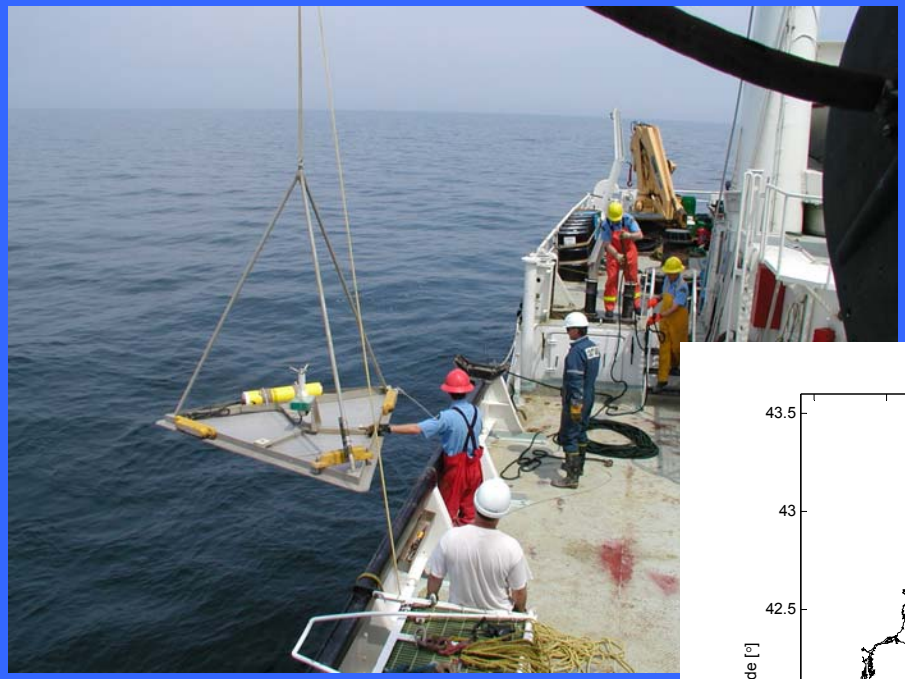


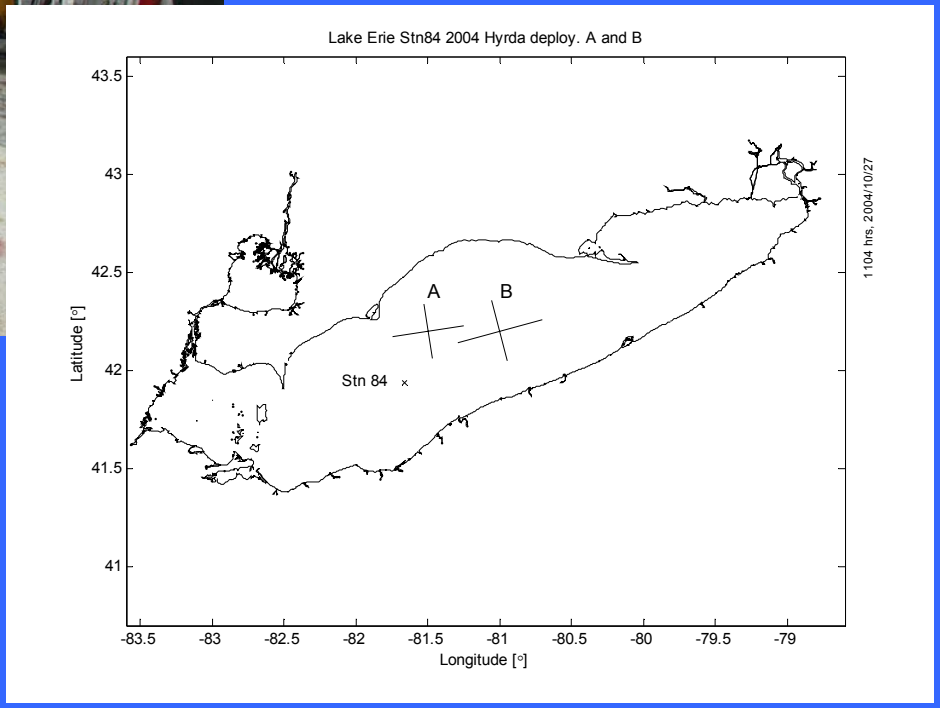
Stn: Penn Channel

Wind and current vectors (low-pass filtered in EB)



Near Bottom Currents





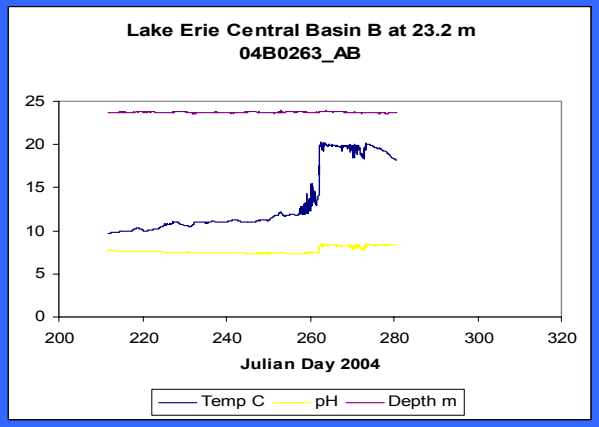
A: major: 3.3 cm/s, 80.8°T; minor: 2.6 cm/s. For B: major: 4.1 cm/s, 85.4°T, minor: 2.9 cm/s

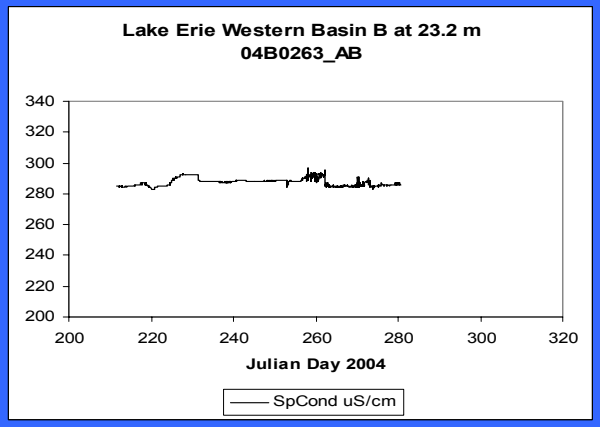
Currents are not very weak as typical parameterizations assume
current fluctuations were some times as high as 8 -10 cm/s
BBL processes- resuspension processes needs more data and analysis

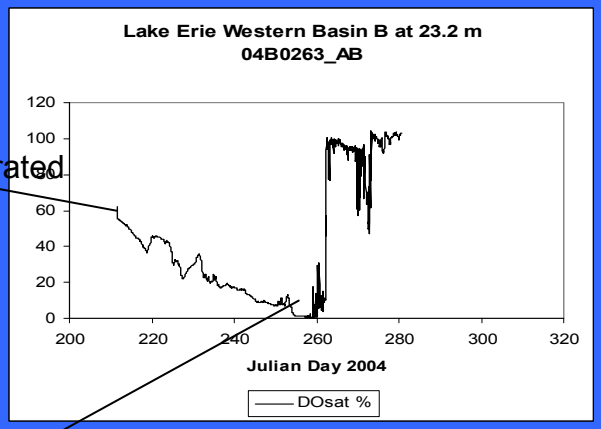
Water Quality time series

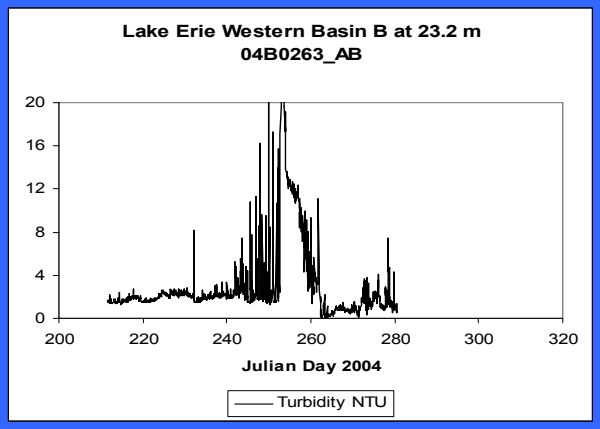
Deployed in the central and west basins

Cross-validation of DO and temperature data is being carried out in Hamilton Harbour





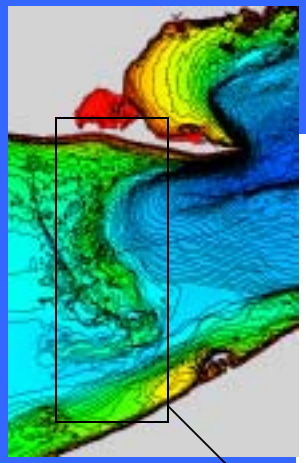


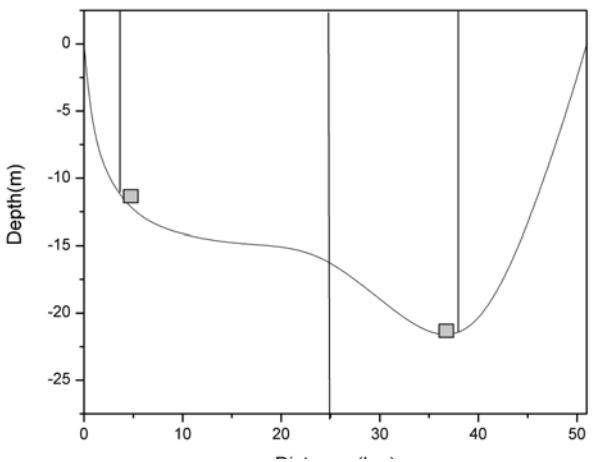


recalibrated

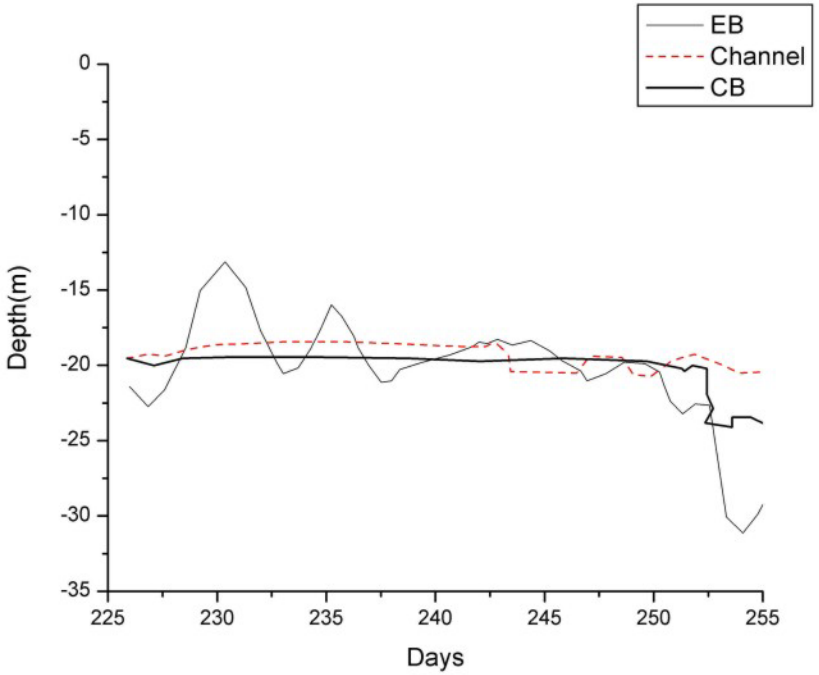
DO is practically zero?, and sudden recovery due to easterly storm

Inter-basin Exchanges

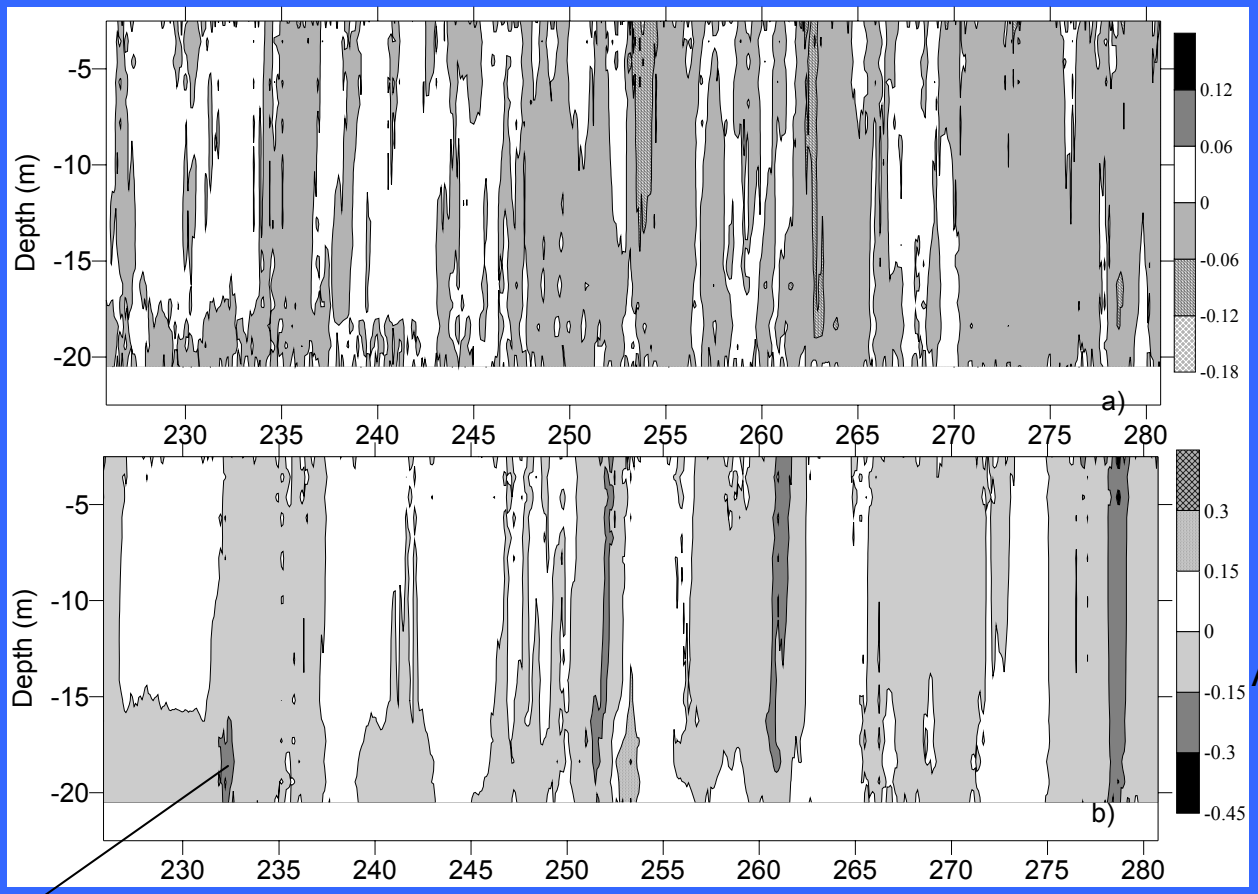




1. Correlation with along-the-lake wind
2. Return flow
3. Thermocline depth



Low-pass filtered Penn. Channel ADCP currents



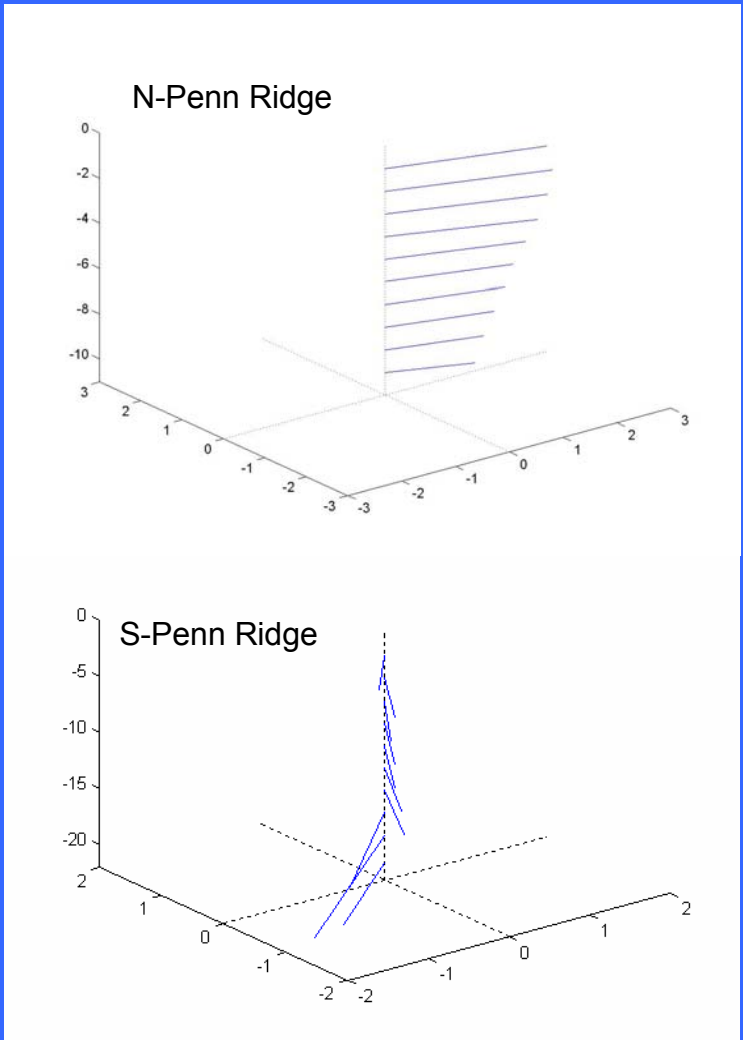
Cross-lake

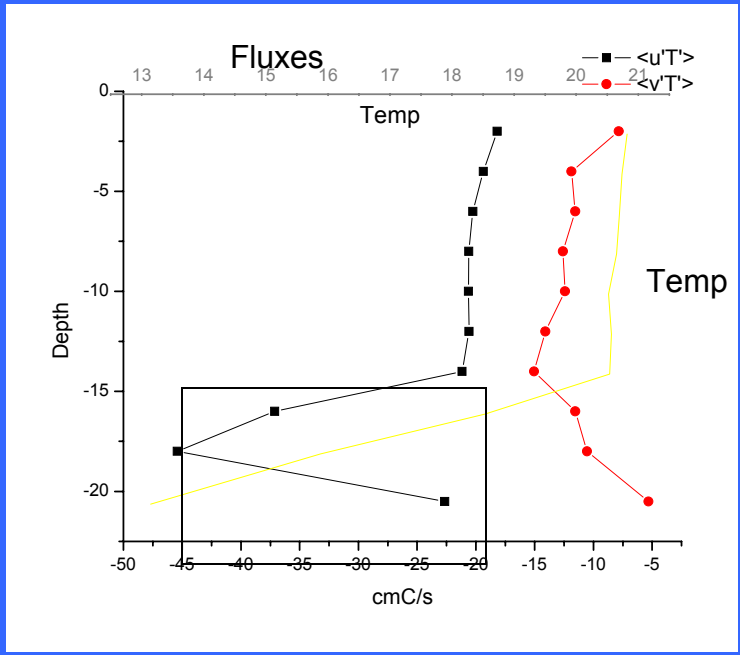
Along-lake

+ towards the east

Towards the CB

Currents in Penn. Ridge

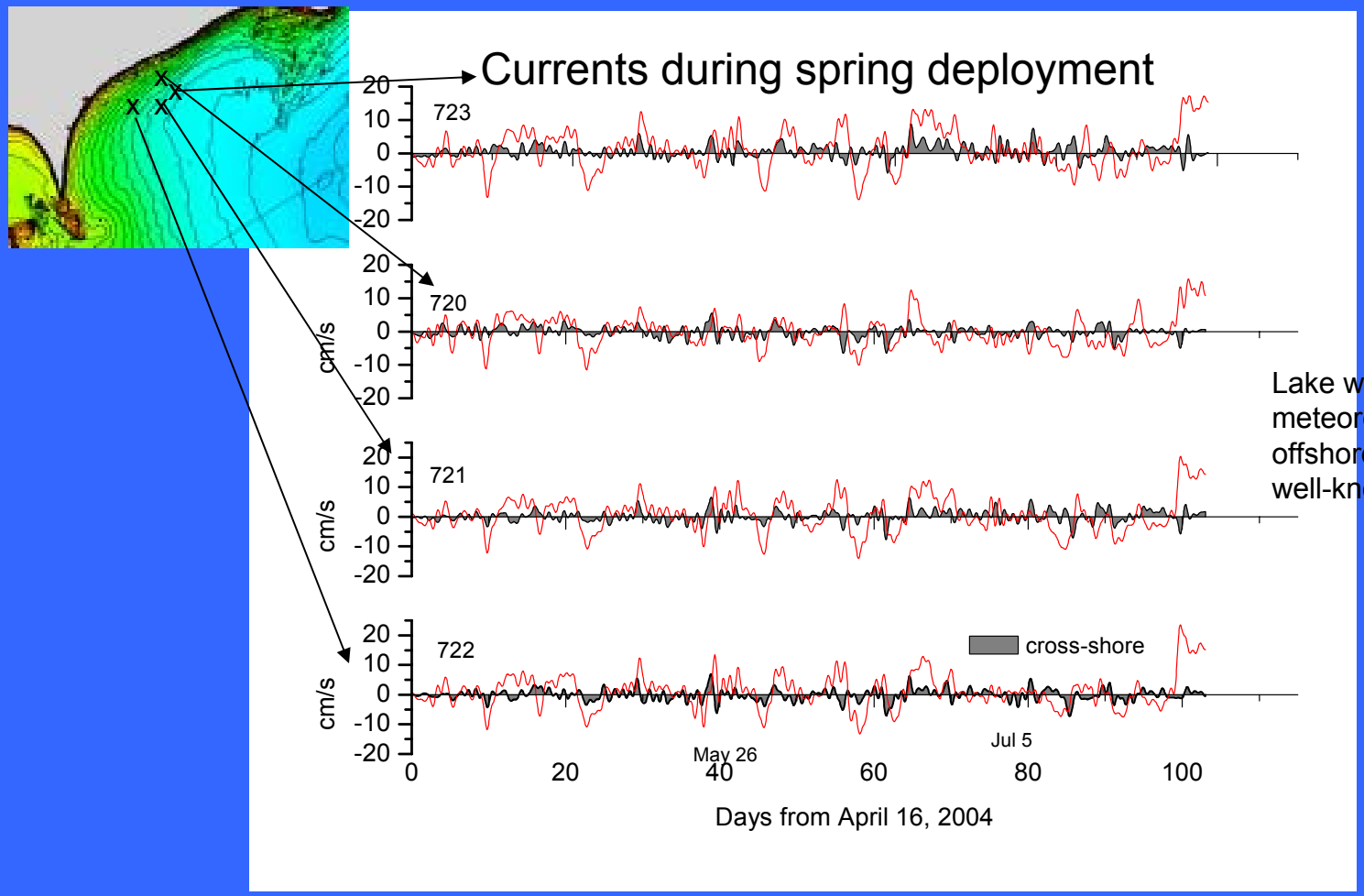




Mean heat fluxes are towards the CB

Transports & exchanges are being calculated
Hydrodynamic modeling work in progress

Horizontal exchanges in the coastal zone



Lake wide forcings; meteorology- nearshore/ offshore accelerations- well-known

Both alongshore & Crosshore exchanges are episodic

Summary

2004 Measurements:

- Large experiment after 20 years in the lake
- Physical limnology and surface meteorology parameters
- Extensive lake-wide surveys
- Data analysis & Hydrodynamic and water quality modeling (In progress)

2005 Measurements with IFYLE:

- ADCP, Temp, Met moorings
- Higher resolution in the thermocline and BBL
- Long-term deployments of YSI at four stations in the central basin

International Field Year on Lake Erie