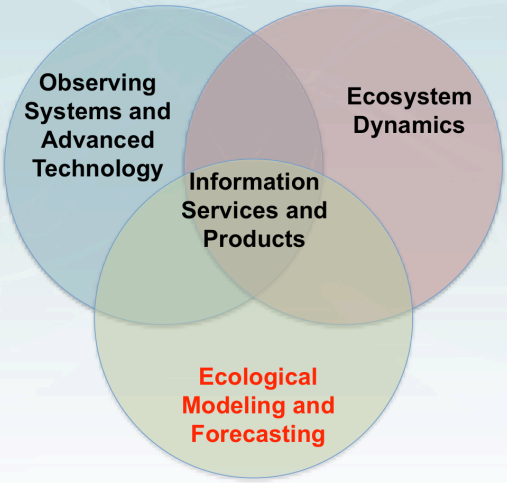
# Ecological Modeling and Forecasting

Dave Schwab



## GLERL Organizational Themes



## Ecological Modeling and Forecasting

Purpose is to develop, test, and implement ecological models on a variety of space and time scales to predict the impacts of physical, chemical, biological, and human induced change on ecosystems.

**NOAA Science Workshop 2010 - Overarching Grand Challenge*: Develop and apply holistic, integrated Earth system approaches to understand the processes that connect changes in the atmosphere, ocean, space, land surface, and cryosphere with ecosystems, organisms and humans over different scales*.**

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Purpose is to develop, test, and implement ecological models on a variety of space and time scales to predict the impacts of physical, chemical, biological, and human induced change on ecosystems and their components.



## NOAA 5-Year Strategic Plan Goals

- Protect, Restore, and Manage the Use of Coastal and Ocean Resources through an Ecosystem Approach to Management
- Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond
- Serve Society's Needs for Weather and Water Information
- Support the Nation's Commerce with Information for Safe, Efficient, and Environmentally Sound Transportation

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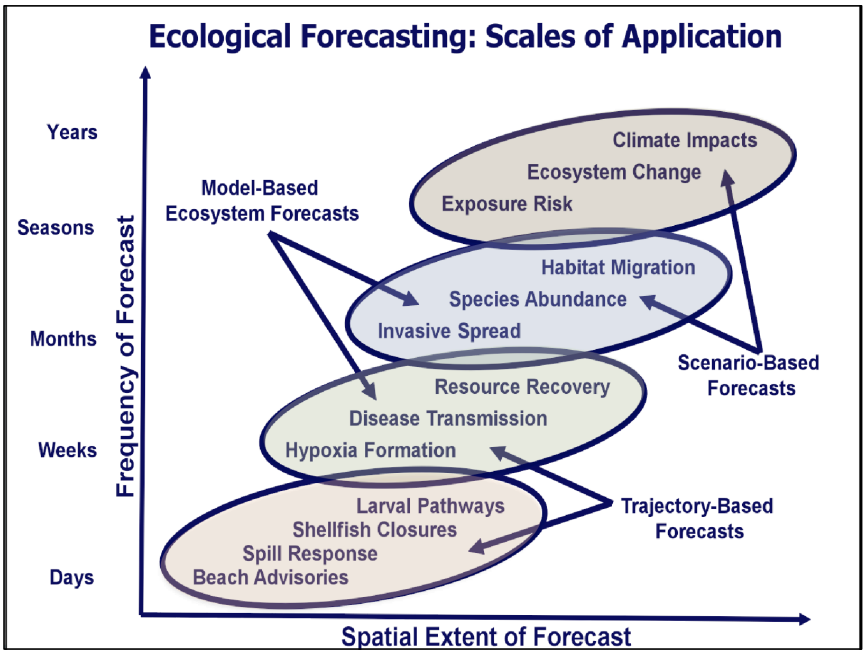
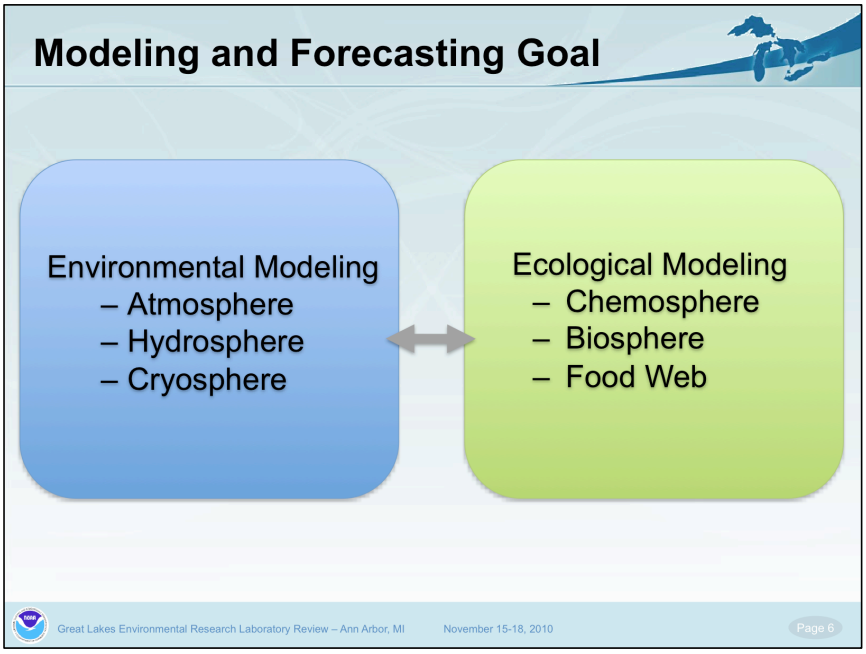



Time and space scales for ecological forecasting.






Goal: To create an integrated ecological modeling system for the Great Lakes which includes predictive and diagnostic models for regional climate (atmosphere), lake ice (cryosphere), ocean/lake circulation (oceanography/hydrodynamics), hydrology (land process), sediment/contaminant transport (beaches), and food webs (production, fish recruitment, invasive species impacts) as well as skill assessment, performance accuracy testing, and uncertainty analysis of these models

Integrated ecological modeling system for the Great Lakes
- predictive and diagnostic models for regional climate (atmosphere)
- lake ice (cryosphere)
- ocean/lake circulation (oceanography/hydrodynamics)
- hydrology (land process)
- sediment/contaminant transport (beaches)
- food webs (production, fish recruitment, invasive species impacts)

## Modeling and Forecasting Applications

Natural Resource Based Economy - Protect lives and property, enhance economic security, and meet stewardship mandates



## Great Lakes Regional Priorities

Great Lakes Regional Collaboration Strategy

To Restore and Protect the Great Lakes

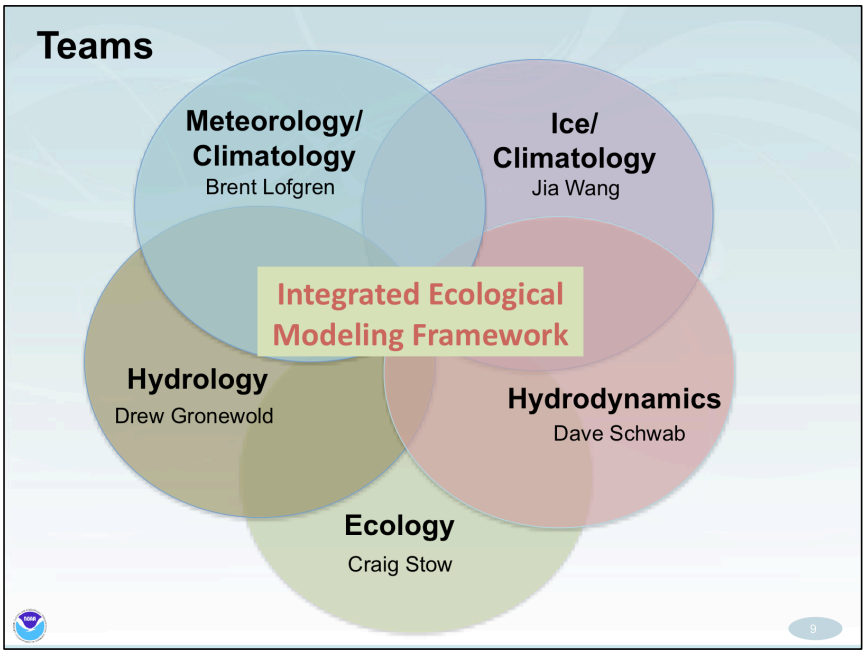
"focus must transition to an ecosystem approach with greater emphasis on predictive forecasting and adaptive management… Improvements in predictive capabilities are needed"

**Great Lakes community is unique**

- 1,500 people gathered from all sectors
- Developed research needs and priorities

"Research on the Great Lakes specifically provides the understanding necessary to make informed, scientifically-supportable decisions and actions, to assess the associated risks, expectations and timelines of management actions, to plan for effective observation and monitoring programs and to identify sensitive and meaningful indicators of ecosystem status."
"Research has traditionally been focused on single issues.This focus must transition to an ecosystem approach with greater emphasis on predictive forecasting and adaptive management. Research should be directed towards improving the understanding of natural fluctuations and interactions of ecosystem components. Improvements in predictive capabilities are needed, particularly regarding the impacts of chemical, biological and physical changes on ecosystem structure and function. Development of such capabilities requires a comprehensive research coordination strategy across partnering institutions."
Great Lakes Regional Collaboration partners include:

* Council of Great Lakes Governors
* Great Lakes and St. Lawrence Cities Initiative
* Great Lakes Congressional Task Force
* Great Lakes Indian Fish and Wildlife Commission
* U.S. Environmental Protection Agency, Great Lakes National Program Office

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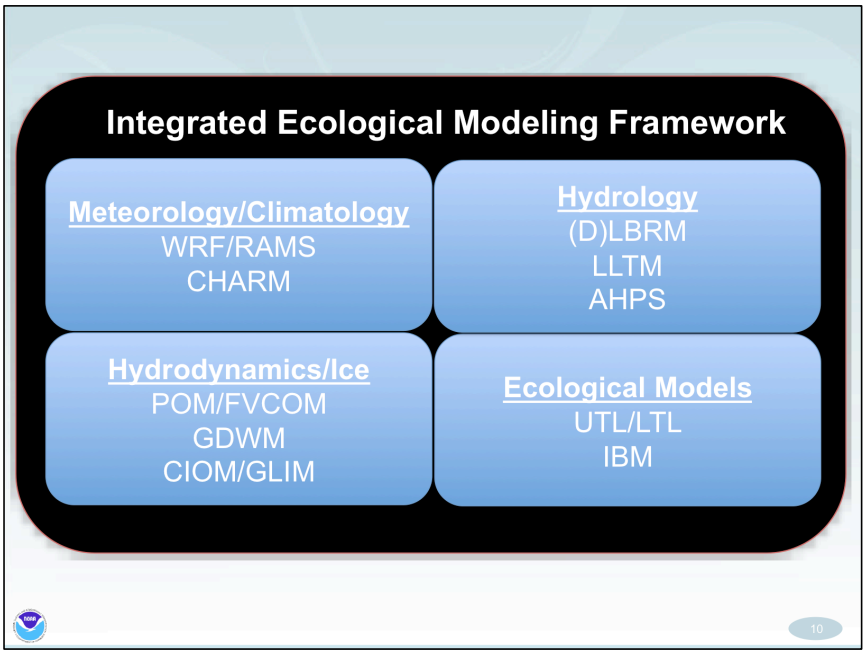


Different numerical model codes used by GLERL scientists illustrating the need for an integrated modeling framework.
WRF: Weather Research and Forecast / RAMS: Regional Atmospheric Modeling System
CHARM: Coupled Hydrosphere–Atmosphere Research Model
(D)LBRM: (Distributed) Large Basin Runoff Model
LLTM: Large Lake Thermal Model
AHPS: Advance Hydrologic Prediction System
POM/ FVCOM: Princeton Ocean Model/ Finite Volume Coastal Ocean Model
GDWM: GLERL D–Wave Model
CIOM: Community Ice Ocean Model
UTL/ LTL: Upper Trophic Level/ Lower Trophic Level
IBM: Individually Based Models

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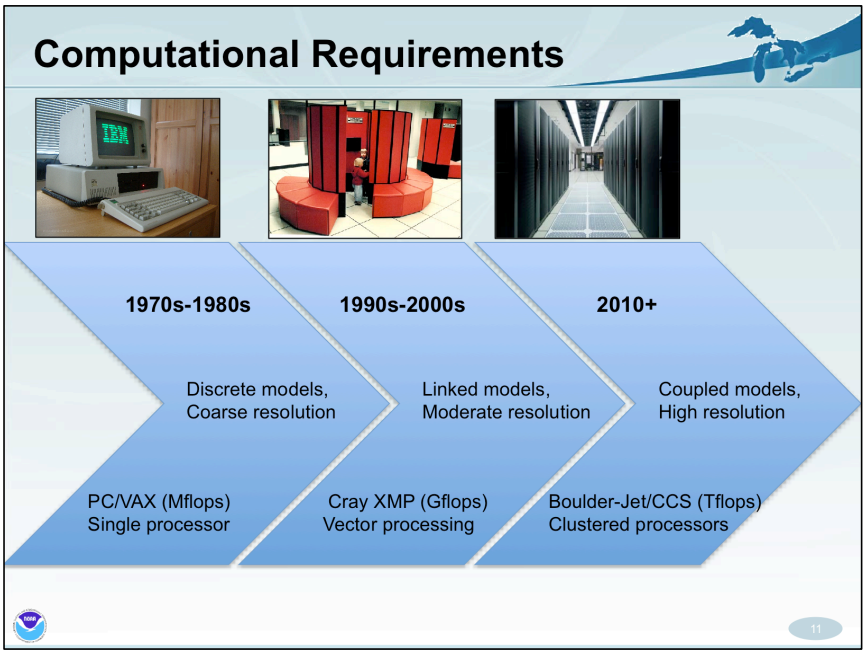
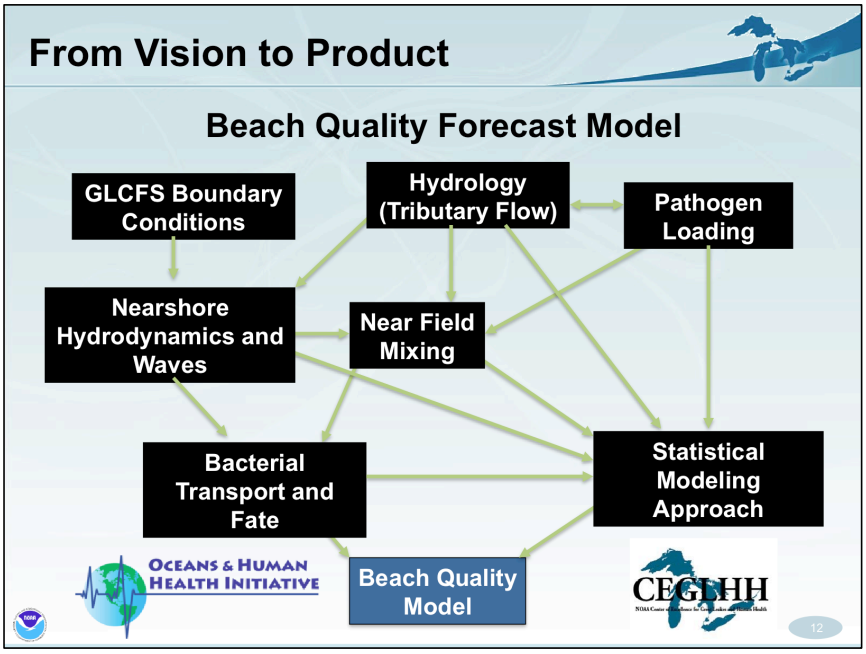



Flops: floating operations per second






An **example** from the NOAA Center of Excellence for Great Lakes and Human Health (housed at GLERL) of combining various modeling approaches to create a single end product– in this case: a beach water quality model.

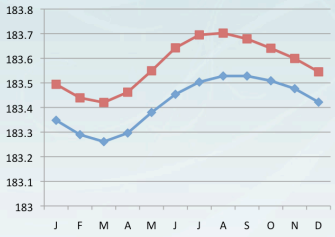
CEGLHH: http://www.glerl.noaa.gov/res/Centers/HumanHealth/

http://www.glerl.noaa.gov/res/glcfs/

## Lake Level Response to Climate

### Lake Level Changes 1982/2055

Lake Superior




Standard deviation increased from .23 m to .30 m.

Lake Michigan-Huron


Standard deviation increased from .62 m to .77 m.



Net basin supply is the difference between precipitation and evapotranspiration over both the land and lake portions of the basin. Increased net basin supply is a precursor to the illustrated rises in lake levels.

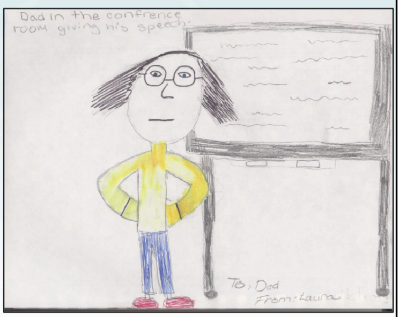
Work with International Joint Commission on Technical Committee



## Ecological Modeling and Forecasting Theme

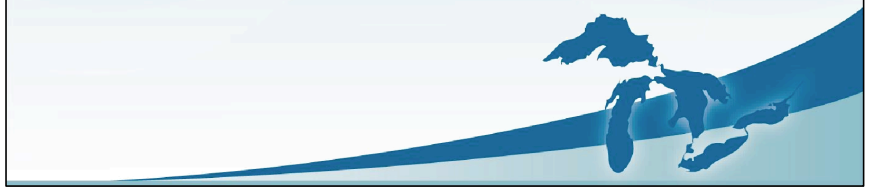
**Presentations:**

- Meteorology/Climatology: Brent Lofgren
- Hydrology: Drew Gronewold
- Hydrodynamics: Dave Schwab
- Ice/Climatology: Jia Wang
- Ecology: Craig Stow



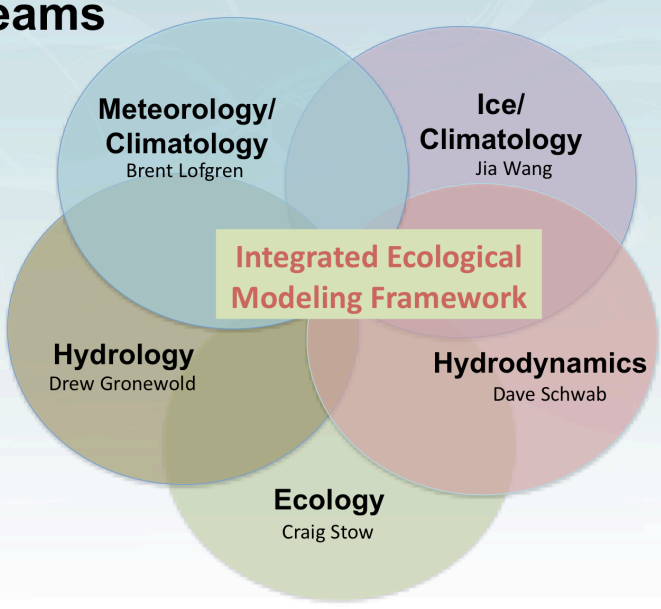
# Recap

The following slides are for the recap after the five team presentations





# Teams



## Ecological Modeling and Forecasting Highlights

**Lofgren:** Smaller increase in evaporation than previously thought is overbalanced by increased precipitation, leading to a rise in lake levels.

**Gronewold:** We are developing novel techniques to effectively quantify and communicate uncertainty and risk to water resource managers.

**Schwab**: Next generation of hydrodynamics models are being coupled with biology and water quality models to produce some of the first ecological forecasts in the Great Lakes.

**Wang:** Coupled hydrodynamics/ice model (GLIM) has been demonstrated for Lake Erie and an unstructured grid version is in the works.

**Stow:** Social-ecological systems are complex adaptive systems; understanding how their component parts function doesn't mean you can predict their overall behavior.





## Ecological Modeling and Forecasting

**Posters:**

**Drew Gronewold** - Hydrological Forecasting

**Drew Gronewold** – Sampling variability in Great Lakes beaches

**Dima Beletsky** - Modeling the transport of larval Yellow Perch in Lake Michigan

**Eric Anderson** - Operational Forecasts in the Huron-Erie Corridor

**Meng Xia** - Modeling nearshore wave current interaction with FVCOM

**Marjorie Perroud and Brent Lofgren** - Simulation of water temperature profiles over the Great Lakes region at a fine horizontal resolution

**Doran Mason** - Development of a bioenergetics model for Brown Shrimp

**Ed Rutherford** – Modeling of climate change and land use impacts on fish habitat

**David Rockwell, Sonia Joseph, and Dave Schwab** – Towards a 60 hour Beach Health Forecast Model for the Great Lakes

**Jia Wang** - Development of Great Lake Ice-circulation Model (GLIM)

**Jia Wang** - Severe ice cover in winter of 2008/09: contribution of AO and ENSO

**Hongyan Zhang** - Food web modeling in Lake Erie



Closed (Reviewers Only) Ecosystem Modeling and Forecasting Posters Session, Wednesday, November 17, 2:30 – 3:10 High Bay

# Regional Ecological Forecasting System

**Products and Services:**

- Ecological warnings, watches, advisories, and information bulletins
- Long-term scenarios and outlooks
- Interactive decision support, visualization aids, and maps
- Education and outreach

**Operating Principles:**

- Scalable to inform decisions for regional to local management
- Collaborative and community-based
- User-driven for mitigation, adaptation, restoration and recovery
- Effective, reliable and quality controlled with known uncertainties
- Directed to transition research results to validated applications
- Accessible and supportive operational infrastructure and feedback to drive new research





Regional Ecological Forecasting System

Products and Services:

**Expanding Environmental Prediction Capabilities for the Chesapeake Bay: Collaborative Development for Ecological Forecasting Applications**

*Louis W. Uccellini; Marie C. Colton; David S. Green and W. Douglas Wilson*
*NOAA National Weather Service, National Ocean Service & Chesapeake Bay Office*

2009 CRC Regional Conference

– Accessible and supportive operational infrastructure and feedback to drive new research

## Great Lakes Modeling and Assessment Center

**Partners**: National Centers for Environmental Prediction, CEP, National Weather Service, Great Lakes Environmental Research Laboratory, and Great Lakes Observing System Regional Association

**Capabilities:**

- Observation and Monitoring
- Data Assimilation and Modeling
- Dissemination
- Education & Outreach
- Research to Applications



GLOS: Great Lakes Observing System
http://glos.us/

NECP: NOAA NWS National Centers for Environmental Prediction
http://www.ncep.noaa.gov/