GLEON 7 Working Group Notes

Contents

Lake Metabolism

Leaders: Paul Hanson, Kathie Weathers

Participant List

- This is a list of people who attended the metabolism working group discussions
- This is ***not*** an exhaustive list of everyone who may be interested in participating

First	Last	Email
Ami	Nishri	nishri@ocean.org.il
Carol	Brewer	carol.brewer@umontana.edu
Chris	Solomon	ctsolomon@wisc.edu
David	Motta-Marques	dmm@iph.ufrgs.br
Emil	Rydin	emil.rydin@ebc.uu.se
Gesa	Weyhenmeyer	Gesa.Weyhenmeyer@ma.slu.se
Greg	Koch	Gkoch001@fiu.edu
Ina	Bloch	ina.bloch@ma.slu.se
Jeng-Wei (David)	Tsai	tsaijw@mail.cmu.edu.tw
Jim	Coloso	jjc9r@virginia.edu
Julita	Dunalska	julitad@uwm.edu.pl
Kane	Aldridge	Kane.aldridge@adelaide.edu.au
Kathie	Weathers	weathersk@ecostudies.org
Kevin	Rose	RoseKC@muohio.edu
Lars	Tranvik	
Lauri	Arvola	lauri.arvola@helsinki.fi
Matt	Cooper	coopmat@gvsu.edu
Matt	Van de Bogert	mcvandeb@wisc.edu
Nathaniel	Ostrom	ostromn@msu.edu
Paul	Hanson	pchanson@wisc.edu
Peter	Staehr	pastahr@bio.ku.dk
Samuel	Kibichii	Samuel.Kibichii@ucd.ie
Stuart	Jones	stujones@msu.edu
Susan	Hendricks	susan.hendricks@murraystate.edu
Tiina	Noges	tiina.noges@emu.se
Zhengwen	Liu	zliu@niglas.ac.cn

Notes from large-group discussion
(Notetakers: Kevin Rose, Matt Van de Bogert, Kathie Weathers)

Goal of our discussions over the next two days:
Describe path(s) forward toward product(s).

What are possible products that can come from this group?

- Publications
- Web tools and/or stand-alone software tools
- Grant proposals
- Ideas for experiments
- Analyses of currently available data
- List of our next steps: timeline, goals, things to do

Discussion on working definition of "metabolism" for our purposes…
"Metabolism" can be defined by the metabolic processes that occur in the ecosystem, namely production and respiration. In the broadest sense, this can mean the production and respiration of the entire lake ecosystem. It can also be grouped into categories by the source organisms (e.g. aerobic vs anaerobic), the source of the carbon that is either respired or produced (e.g. autotrophic vs. heterotrophic, allocthonous vs autochthonous), or the habitats where the metabolism originates (e.g. pelagic vs. littoral, planktonic vs. benthic, epilimnetic vs. hypolimnetic).

What we view as metabolism can be shaped by our *research questions* (e.g. how does pelagic metabolism differ from littoral?), by the practicalities of our *methods* (i.e. by what we are able to directly measure), or by the temporal scale of interest (e.g. daily, seasonally, annually, etc.). What we actually measure (in dissolved oxygen time series, for example) may be influenced by physical, biological, and chemical processes unrelated to metabolism.

Different methods for measuring metabolism may be more or less influenced by these various non-metabolic processes. Thus, from a practical standpoint, our definition of lake metabolism depends on our measurement techniques: Do we measure carbon or oxygen? Do we include measurements of stable isotopes (e.g. ^{16}O, ^{17}O, ^{18}O)? Do we use radio isotopes for production estimates (^{14}C)? Do we measure these only in the epilimnia of stratified lakes or do we also measure at various depths? Do we use free-water measurements or containers (bottles, chambers, etc.)?

Perhaps there would be some utility in creating a table which includes the ecological and biogeochemical drivers/mechanisms which account for the expected differences in metabolism estimates based on the different methods one could use.

A potential project for this working group might be to compare estimates of lake metabolism based on different methods.

In order to prevent methodological questions from stalling the group's progress, we decided to focus our future discussion on metabolism estimates made using the method that is common among most GLEON sites: **free-water dissolved oxygen measurements from automated sensors.**

Now that I have metabolism estimates, what can we use them for?

Idea generating discussion: Name indicates who started the discussion, but doesn't indicate they were necessarily the only contributor. Ideas for each of these topics were often fleshed out by the entire group.

S.Jones: DOC is an ecosystem subsidy and theory suggests that subsidies are stabilizing forces, up to a certain point. Stuart is currently investigating variability in GPP and R across several lakes to determine if DOC relates to the variability in metabolism to investigate if DOC is a stabilizing force.

J.Dunalska: How do temperature and biological shifts affect lake metabolism? What if spring comes earlier? Effect on plankton and thus metabolism?

P. Stæhr: Connecting metabolism to underlying physiological mechanisms over lake types, temporal scales (weeks, seasons, years), etc. Normalize GPP to pigment concentrations, underlying biogeochemistry, light-use efficiency. i.e. getting back to the theoretical basis of metabolism.

M. Cooper: Calculate metabolism across GLEON lakes using consistent methods. Potentially offering GPP/R/NEP as derived variables that could be downloaded.

K. Rose & Others: Comparing GPP and R across lakes. Is GPP more/less variable than R?

K. Weathers, D. Motta Marques, P. Hanson: Influence of watershed characteristics on metabolism. Allochthonous vs. autochthonous C sources, hydrology, land use/land cover, watershed area: lake area ratios, meteorological characteristics, geology, geographical location, climate. Satellite imagery: maybe there are good connections within GLEON to obtain this imagery. Check with Fang Pang?

T. Nõges: Can we use metabolism estimates to help construct carbon budgets for lakes in the network? How do carbon budgets compare across GLEON lakes? Must measure inputs, outflows, gas flux, transformations, internal production/consumption, sedimentation.

J. Dunalska: Can we use metabolism as a lake quality/condition indicator? Have watershed drivers influenced the lake condition?

E. Rydin, K. Weathers, N. Ostrom: How to connect paleoecological perspective to "modern" biogeochemistry. Catchment changes should leave footprint in sediment record. Which GLEON lakes have sediment cores? Can we look for relationships between past and current biogeochemical processes? How might we marry information from such different temporal scales: sediment at decadal scales, metabolism at much finer resolution?

P. Stæhr: Conceptual framework for what defines lake metabolism. What defines lake metabolism? What are the processes and regulators of variability? Conceptual framework development. Relate to the processes we can and cannot measure. Read/review current literature, develop framework, fit current knowledge to arrows (where we know), and suggest future research directions.

:Metabolism across the globe, compare metabolism across biomes, temperature gradients, precip, etc. Relate to terrestrial NEP across major biomes.

Where do we go from here?

We decided to gauge interest in each of the topics mentioned above with the idea that we'd split into sub-groups for discussion of the top 3 or 4 topics. The remainder of the metabolism working group's time was spent split into sub-groups centered around the three topics with the most interest:

- Conceptual Framework development (Contact: Matt Cooper)
- Drivers of variability in metabolism among GLEON lakes (Contact: Kevin Rose)
- Watershed drivers of metabolism (Contact: Matt Van de Bogert)

Summary slides from metabolism working group to GLEON 7 plenary
30 September 2008

Possible Products:
- Manuscripts,
- communication tools within working group,
- funding proposals,
- software development and web tools

What is Metabolism?:
- Generally: production and respiration
- Con get more complex: partitioning among sources
- Different methodologies: free water, oxygen vs. carbon, isotopes, eddy covariance, etc
- Focus on methodology of free-water, automated, dissolved oxygen measurements.

Current Top 3 Ideas:
- Conceptual Framework development
- Drivers of variability in metabolism among GLEON lakes
- Watershed drivers of metabolism

Domains of Control

Leaders: Eleanor Jennings, Thorsten Blenckner (first draft notes by Don Pierson)

Larger Questions

There were a number of overreaching questions that were discussed by the group. These can be characterized as questions that will define the long term activities of the group and influence the direction of research carried out by the group, but at the same time are too large to be answered by any single research project.

1. How can the highly detailed temporal data collected by GLEON sensors be extrapolated beyond the network using Remote Sensing and other data?
2. How can Sensor data be used to detect changes in ecosystem state? At what scale can state changes be detected? What are the Thresholds of Detection and how can these be determined?
3. What are the number and nature of domains that control lake ecosystems?

Areas of Research

Three general areas of research were identified that could be addressed by the domains of control group. In our initial discussions there was a strong emphasis on testing different methods (i.e. spectrum analysis, wavelet analysis) as means of identifying the frequency of variation in key (measurable) ecosystem properties that can be linked to variations in controlling variables acting on the ecosystem.

1. Pattern and Trend Detection
    a. Are there patterns in sensed variables that are a result of specific abiotic or biotic processes?
    b. What are the governing processes that can be detected using high frequency sensor data?
2. Instrument Properties - guidance on frequency of measurements.
3. Network wide Questions
    a. How Representative is a single Buoy?
    b. What is the role of GLEON within the larger world of sensing Systems?
    c. What the common driving variables across GLEON sites?

Proposed Experiments

A number of experiments were identified by the group that could be started in the next few months, be carried out using data from multiple sites within the GLEON network, and which hopefully would lead to manuscripts within the next 12-18 months.

1. Analysis of ice cover dynamics using water temperature measurements - **Don Pierson**
   Progress since GLEON6:
   Six or seven sites provided data for this analyses. This data is being analysed by Don Pierson – on-going

2. Wavelet analysis - **Thorsten Blenckner**
   Progress since GLEON 6:

The first wavelet analyses have been carried out by Luke Winslow. Luke is preparing a document with an example of this procedure (using Matlab) and will be circulating this to the wider group.

3. Testing of senor measurement frequency - **Who is in charge???**

a. Goals

i. Provide guidance on the frequency of measurement for the GLEON Network

Since GLEON 6 a discussion had taken place using the DoM listserver and six or seven sites have indicated that they would like to be involved in this exercise. A subcommittee was formed to create a draft protocol for testing differing measurement frequencies – Eleanor Jennings, Heidrun Feuchtmeyr , Francesco Pomati and Hampus Markensten. The first steps in this exercise are

to collate metadata from different sites

perform preliminary analysis on sample datasets from some sites with different statistical methods (e.g. analysis of autocorrelated variance)

The protocol will take into account aliasing? artefacts.
The timeline for this excersise is 6 months.

ii. Can processes of characteristic frequecy be identified that act across lakes within GLEON Network – depends on outcome of previous task.

4. System Identification **-Fang-Pang Lin - on-going**
5. Analysis of onset and offset of stratification at a range of sites and how the potential impacts of projected climate change

Microbes: cross-site experiment

Leaders: Trina McMahon, Ashley Shade

Notes from Cross-site experiment working group, GLEON 7 in Sweden and the Microbial Community Dynamics workshop

30 Sept 2008

Working group participants

Bas Ibelings, EAWAG, Switzerland. Email: bas.ibelings@eawag.ch

- Works in Lakes Zurich and Isselmeer
- Phytoplankton ecology, particularly co-evolution
  - Predator-prey dynamics (e.g. diatoms and fungi)
  - Experimental evolution in the lab, but want to take this to the field especially to study biogeography
  - Phylogenetic ecology and community assembly, relating traits and evolution
- Phytoplankton sensors using flow cytometry to measure size, shape, pigments
- Harmful algal blooms

Michael Zeder, PhD student with Pernthaler in Switzerland

- FISH image analysis, heavy technology focused
- Interested in Flavobacteria

Albert Babera, PhD student with Casamayor in Spain

- Community ecology
- Assembly and phylogeny
- Ecological theory applied to microbes
- Using 16S genes from other studies to study:
  - Community scale
  - Marine versus fresh
  - Stratified lakes

Friedrike Heinrich, PhD student with Bertilsson at Uppsala University, Sweden

- Works in Lake Erken and others
- Vertical stratification (fine scale) and population distributions
- Activity of LD12 (alpha proteo)

Charles Chiu, Academia Sinica, Taiwan. Email: bochiu@sinica.edu.tw

- Works in Yuan Yang Lake
- Soil scientist interested in fate of organic matter
- Became interested in lakes because of YYL and GLEON

Niels-Ulrik Frigaard, Univ of Copenhagen, Denmark. Email: nuf@bio.ku.dk

- Works in Lake Cadagno
- Sulfur oxidation metabolism and associated genes involved
- Proteorhodopsin
- Especially interested in RNA to monitor expression

Jakob Pernthaler, Univ of Zurich, Switzerland. Email: pernthaler@limnol.uzh.ch

- Works in Lake Zurich and others
- Limnologist/marine biologist interested in plankton
- Population ecology, with focus on Flavobacteria (CFB)
- FISH techniques and automation
- Roles and trains related to substrate uptake (microautoradiography)
- Populations that respond strongly to perturbations
- Food web interactions (predation)
- In lake Zurich focusing on spring blooms
- Detecting events

Karl Simek, Institute of Hydrobiology, Czech Republic. Email: ksimek@hbu.cas.cz

- Works in Lake Rimoff and others
- Interactions between bacteria and algae
- Population ecology of R-BT (beta Proteo) and its response to algae
- Success of betas related to phosphorus availability
- Epibionts

Ashley Shade, PhD student, U of Wisconsin, USA

- Disturbance and community ecology
- Worked in YYL and now in N. Wisconsin bog lakes
- Whole lake experiments

Trina McMahon, U of Wisconsin, USA

- Works in Wisconsin lakes (Mendota, bogs, etc) and others
- Community ecology
- Phylogenetic ecology and community assembly patterns/rules
- Disturbance and population response to perturbations
- Sensors to guide adaptive sampling and for ancillary environmental data

Emerging themes we are all interested in:

- Biogeography
- Community ecology (succession, assembly,
- Variability and response to perturbations
- Interaction of physics and biology (stratification and temperature as drivers)

1 October 2008

Participants: Frigaard, Chou, Heinrich, Ibelings, Pernthaler, Simek, McMahon

Cross-cutting topics that could lead to fruitful collaborations

- High vertical/temporal variability
- Episodic events
- Dynamic seasonal period

(note all three of these could make great use of buoy or at least in-situ sensor data, particularly for thermal structure)

We are focusing in on **spring blooms** as a topic that we can all get excited about, from our various angles of interest in community and population ecology.

- The spring warm-up is very dynamic
- Good candidate for short-term high-intensity sampling
- Interesting because of both phytos and bacteria, as well as individual populations (e.g. Flavos, Actinos, RB-T, LD12)

Science questions that could guide our experimental design

Ibelings

- What triggers phyto blooms across different lakes?
- Can we model succession within a bloom considering r versus K strategies
- What is the inoculum?
- What is the effect of vertical structure?
- How doe genetic structure vary within and across lakes?
- What causes the termination of spring bloom and when does it happen in different lakes?

Pernthaler

- Why are some populations stable and others dynamic?
- What fraction of the community is active?
  Are certain genotypes associated with phytos?
- How does competition shape community?

Heinrich

- How does pre-bloom state affect the bloom development and outcome?
- How does verticle spatial structure influence community structure?
- How do alpha-Proteos change in time and space (especially activity)

Simek

- How do RB-T respond to phyto succession?
- How does P-availability influence community assembly/succession

McMahon

- How do the trajectory and pace of community change compare across lakes?
- Why do certain populations of Acintobacteria bloom primarily in spring?
- How are Actinobacterial populations structured across lakes and through time within a lake?
- How do spring bloom dynamics influence subsequent community/population dynamics (succession) that occur throughout summer?

Moving Forward

-- DRAFT 6 November 2008 --

(based on notes generated during our third meeting, with Bertilsson, McMahon, Pernthaler, Simek present, 4 October 2008)

Timeline

November 1 – protocols circulated
November 15 – white paper describing experiment
Spring 2009 – field work conducted
Spring 2010??– re-unite at Lake Erken to analyze data and write papers!

Experimental Design

Collect samples three times per week for five weeks during the spring bloom in SIX (?) lakes, at two depths (chl-a maximum and 1% PAR).

Response Variables

- Phytoplankton community composition – Ibelings
- Bacterial community composition by ARISA – McMahon
- Bacterial community composition by FISH – Pernthaler
- Viral counts – Simek
- Beta-proteobacterial population dynamics – Simek
- Actinobacterial population dynamics – McMahon (qPCR) and Pernthaler (FISH)
- Alpha-proteobacterial population dynamics – Bertilsson
- Flavobacteria population dynamics – Pernthaler (FISH)
- Bacterial numbers and biomass
- Zooplankton
- Heterotrophic nanoflagellates
- (Others??)

Lakes

Lakes	buoy	troph	size	depth	defining characteristics
Mendota, WI, USA	Y	eu	large, medium	24 m	freezes urban, agricultural 5 yrs HRT (retention time) buoy!
Zurich, Switzerland	n/?	meso	large, deep	136 m	urban 1.2 y HRT
Rimov, Czech Republic	N	meso/eu	medium, deep	44 m	reservoir
Erken, Sweden	Y	meso	medium, medium	21 m	Sometimes freezes. Buoy! With electronic tongue!
Isselmeer/Maarsseveen, Netherlands	y/n	eu	large, shallow	4 m	3 months retention time
Trout bog or NSB, WI, USA	Y	humic	small	8 m	NSB was artificially mixed in summer 2008
Yuan Yang Lake, Taiwan	Y	humic	small, shallow	4 m	mountain, typhoons, subtropical

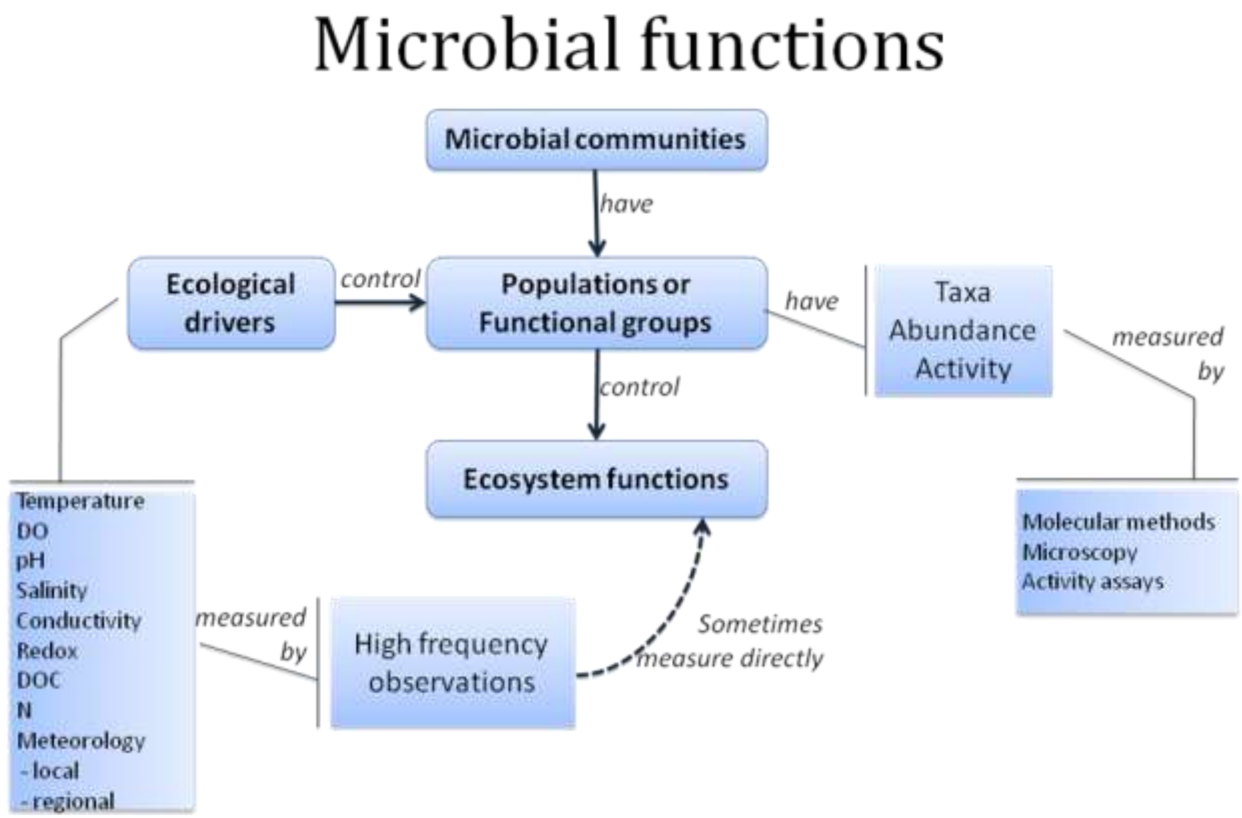
(not sure about including the two humic lakes or not because they are so different)

	all lakes	all samples	site specific	#	go to	Protocol
Samples to be collected						
DNA filters, 0.2 um, 47mm, min 100 ml/filter	x	x		4	T, S, J	T
Phytoplankton preserved in lugols	x	x			B	B
FISH filters, 5 ml	x	x		2	K, J	J (+BrdU!)
bacterial numbers	x	x				J (T's samples)
bacterial biomass	x	x				
bacterial production			x			
Viruses	x	x			?	K
Zooplankton			x			
heterotrophic flagellates			x			
Contextual Environmental Data						
DO, temp, TP, DRP, Si, (NH4, NO3)	x	x				
DOC	x					
PAR	x	x				
Secchi	x	x				
Chla	x	x				

T = Trina, S = Stefan, J= Jakob, K = Karl, B = Bas

Microbes: function

Leaders: Stefan Bertilsson, Angela Kent



Coordinating with HF observations

<u>Iterative process</u>:

- Does the suite of available HF observations adequately explain microbial dynamics?
- Do microbial community dynamics allow prediction of ecosystem functions?
- What additional information is needed?
  - More/different HF data?
  - More/different microbial data?
  - Something else?
    - More data analysis? Better modeling?

Food for thought

- Does the suite of available HF observations adequately explain microbial dynamics?
  - Is focusing on microbial dynamics a good plan?Is function or process a better focus?
  - Can we study microbial structure and function relationships in the context of HF data?
  - Do microbial community dynamics allow prediction of ecosystem functions?

Additional discussion points

- Is combining HF data and microbial data a useful approach?

    - Possible approaches?
    - Will we generate new research questions?
    - What are the research questions that could be addressed with this approach?
    - Are there other research questions that could not be addressed this way?
        - Different ideas for approaching research questions with GLEON data?

Microbes + GLEON: approaches

- In situ sensors to place on GLEON buoys
    - MEON?
- Correlate environmental data from sensors with microbial data
- Use GLEON HF data to fine-tune models that predict dynamics of microbial communities
    - Structure or function
- Use GLEON data to predict/identify appropriate sampling times

Research questions

- What is the lag time of microbial community response to environmental changes?
- What is the response of microbes to episodic events?
- Does microbial community structure *matter* for function?
    - At what time scales?
    - Does microbial community structure explain the lag of function in response to environmental change?
    - Are specific populations influential?

Research questions

- When we observe functions changing rapidly or in response to disturbance:
    - What populations are changing?
    - Does knowing which populations are changing improve our understanding of microbial functions?
        - Allow us to use previously measured parameters to predict microbial activity?
        - Guide management or sampling?
- What temporal scale matters for predicting microbial functions?
    - Modeling to guide sampling frequency or identify sampling conditions
    - Adaptive sampling to take advantage of GLEON's HF data

Research questions

- Global climate change is predicted to increase the frequency of episodic events:
    - What is the ecosystem response (mediated by microbes)? How does C and N cycling change in response to episodic events?
    - Collection of background data now will allow us to recognize:
        - Natural vs. anthropogenic change in microbial community structure and function
        - Short-term vs. long-term change
        - Predict response of microbial communities to global change

Research outcomes

- Use GLEON HF data to predict microbial function
- Predict drivers of microbial community structure and function
- Does microbial community structure and function drive GLEON observations?

Additional discussion points

- What are some improvements we need to our methods?
    - *In general terms*
    - Come up with a list of properties that our data should have to interface with GLEON data
    - What functions do we want to predict?
    - How to calibrate and validate microbial data collected with GLEON data?

Microbes + GLEON: data properties

- Dynamic data
    - Seasonal, diurnal, etc.
    - Multiple time points!
- Observation in extremely dynamic environments
    - Episodic events = high contrast
    - GLEON data may predict episodic events too
- Metadata / catalog of data
    - Identify microbe + GLEON datasets that can be integrated

Microbes + GLEON: wish list

- Metadata
    - Links to all datasets (microbial + sensor data) available for a given time or site
- Sample catalog
    - List of archived samples that are available for a dataset
        - Sample exchange program
    - Coordinate with cross-site expt group, identify common samples to collect?

Microbes + GLEON: wish list

- Data sharing
    - On-line availability of microbial data
        - Who to organize?
        - How to fund?
- Investigate new approaches for linking and analyzing microbe + GLEON datasets
    - Facilitate collaboration between modelers and microbial ecologists
    - Modeling tools for linking microbial and GLEON datasets
        - Neural networks, AI, Bayesian, new analysis techniques

Microbes + GLEON: wish list

- Collaborate or integrate with other observing systems
    - Ideas, approaches, integration
- Links to outside datasets
    - GLEON data as metadata for on-line microbial molecular data
        - e.g., GenBank sequences
    - Link GLEON met data to regional/national/international met data
        - NOAA data
        - Other regional met data

Microbes: MiniReview

Present:
S. Bertlisson
C. Carey
E. Kara
A. Shade

We decided to pursue a mini-review/opinion manuscript on how aquatic microbial ecology can be augmented with high resolution sensor data. We first brainstormed with a draft of a manuscript that A. Shade had been working on. We identified eight sub-disciplines of microbial ecology that could specifically benefit from high res data. We then addressed the take home point of the paper: **High resolution, automated sensing observations have potential to link microbial composition and function by providing observations previously impossible to collect at the same spatial or temporal resolution.**

We then decided on two applications of high resolution data, which are adaptive sampling and adaptive management. We decided to divide our 8 chosen sub-disciplines into these two main applications for a conceptual table.

We made a timeline for submitting the manuscript before Christmas. We plan to continue work on the manuscript (re-structuring, writing assignments) during time in the co-occurring microbial dynamics workshop Thursday.

Information Technology – Cyberinfrastructure-enabled development

Leaders: Fang-Pang Lin, Hsiu-Mei Chou

Luke Winslow, Sameer Tilak, Hsui-Mei Chou, Tim Kratz, Sally Holbrooks, Russ Schmitt, Mark Honti, Patricia Garcia, Fang-Pang Lin

- Low hanging fruits
  - Data stream filtered to/from dbadger from different sites
  - Sites ready, waiting for plugin.
  - Documentation
    - Tools, Techology
    - Specific Requiremenets
    - Minimum Must - Rules & Procedures (tricky part)
    - Metadata standard
- Prototype by Example NOW
    - Sameer, Luke, Hsiumei, Mark, Patricia
    - Control Vocabulary
- User feedback & Tap to talents
- Feedback from task force home assignment
- XML format (Data model) -> exposure
  - Webservice for data exposure.
  - Schema mapping (opt)
- Responsibility: (IT steering committee oversee the development and bringing outside expertise.)
  - **Hungary/YYL**
    - Implement webservice (e.g. experiences from online charts publication)
    - Assemble local schema to achieve this.
    - Document the process
  - **Wisconsin**
    - Harvester (easy to implement): pull data from the site , test the implementation
    - Provide XML standard (webservice interface) (existing)
  - **UCSD**
    - Work with Wisconsin on interface design
- Milestones:
  - Mailing list done and report back IT steering committee by 3 Oct, 2008
  - Having data available in dbBadger by 1 November, 2008
  - Possible involvement from different sites
- Israel, Ireland, UK shows interests and are willing to join the test.
  - Israel provides EXCEL files and uses Access database
  - UK uses Oracle database & flat files
  - Ireland uses flat files.
  - No IM support from the 3 sites.
- Suggest the IT team includes 3 sites before New Zealand.

Climate and Lake Physics

Leaders: Evelyn Gaiser, David Hamilton

This group identified three main areas for pursuing further discussion and developing outputs from this group. The three areas included episodic events, long-term temperature profile data, and the use of climate-coupled lake models.

Long-term temperature profile data

This work stems from discussions at a recent AGU meeting on climate effects on lakes, in which David Livingstone agreed to put together a figure showing how temperature profiles in lakes had changed in recent years as a result of climate change. It was suggested that David could extend this work to include data sets from within the Climate and Lake Physics group but also including the wider GLEON community. A recommendation arising from this discussion was that the requirements for a metadataset would be useful; David could define the sort of data he requires and the long-term data sets could be contributed by GLEON members, as a complement to the high frequency datasets.

Coupled climate–lake models

This discussion focused around the use of Regional Climate Models (RCMs) that could be coupled to lake hydrodynamic models. Two different types of applications were identified here:

- One would have a focus on ‘processes’. These lake models are more likely to be highly spatially and temporally resolved. The applications of these models may be system-specific and therefore may be less applicable to the sort of comparative assessment relevant to the GLEON community;
- The other focus may be on ‘phenomena’. These models would run over longer time scales for the purpose of examinations at a variety of scales such as long–term climate change and El Niño Southern Oscillation (ENSO). These models would mostly likely be one-dimensional, reducing the spatial resolution as a balance for the computational requirements to run long-term simulations.

Episodic Events

Examples of episodic events might include El Niño Southern Oscillation (ENSO), hurricanes, typhoons, storms etc. Interest was in how these events might affect stratification/mixing, organic carbon and metabolism, and phytoplankton dynamics. Several overarching questions were initially posed by the group concerning episodic events:

- **What is the definition of an event?**

Several definitions were posed to answer this question. Specifically, two distinct types of episodic events were described: inflow events and mixing events, alternatively described as external and internal events. Elenor Jennings is currently writing a manuscript dealing with this issue.

- **What is the frequency and intensity of these events?**

- **What variables can we pull together to understand the magnitude or variability of change?**
- **Do these characteristics vary across regions?**
-

These questions led to discussion of a potential paper analyzing stability across a large range of lakes in the presence of episodic events. The core of this analysis involves generating stability time series and identifying what an "event" is within the context of our analysis. In addition, various metadata associated with the lakes will be incorporated into the analysis with the ultimate goal of explaining variability in the responses of lakes to the events. This variability could take the form of changes in the magnitude of the response, the duration of the response, or the frequency of observed events. The metadata and data needed for this analysis were enumerated (Table 1).

Metadata Needs	High Frequency Data Needs
Latitude / Longitude	Wind speed
Lake area	PPT
Mean and max depth	Thermal Profile
Annual Precipitation	Surface oxygen
Mean annual air temp.	Transparency
Climate regime	CDOM
Discharge	Chl-a
Mixing type	Turbidity
Other (biogeochem/biotic)	Air temperature
	Flow / Discharge

Table 1: Data needs for episodic event analysis

The breadth of lakes available within GLEON covers a large degree of variability within the various regimes of stability we identified. Several lakes with the required data have been identified as potential candidates for inclusion in the analysis (Table 2). A thought exercise was performed to help the group identify potential types of stability we see within the GLEON lakes (Figure 1).

Candidate Lake	Mixing
Esthwaite	Monomictic
Mendota	Dimictic
Annie	Monomictic
Rotorua	Polymictic
Feeagh	Polymictic
Taihu	Mictic (mixed most of year)
Alexandria	Dimictic
Erken	Polymictic
Galten	Mictic (mixed most of year)
Tangeneka	Meromictic
Ekoim	Dimictic

Table 2: Potential lakes for paper figure. Figure would consist of a plot of lake stability (log(stability) vs date)

With respect to the frequency aspect of the disturbances, several hypotheses were put forward. A frequent disturbance might have less of an effect due to the lake regularly encountering the disturbance and a very infrequent event may affect the lake strongly on a local temporal scale. With this in mind, the intermediately-occurring disturbances might have the most effect on overall stability. In addition, the degree of stability of the lake will determine how much mixing will affect the lake. Highly stratified and stable lakes would be greatly affected by mixing, and weakly stratified lakes would be affected less. The amount of the water column that was mixed will also be important. A few 'interesting' lakes were discussed in more detail, for example, Lake Taihu was discussed due to its 'opposite' disturbance regime in which it has a normally mixed water column, punctuated by periods of stratification.

The discussion of the data needed for this project led to a few specific problems that the group will need to overcome. The data needed for the detailed analyses may not be available. In addition, different sampling rates may be present at different sites and this problem is somewhat exacerbated for non-autonomous samples.

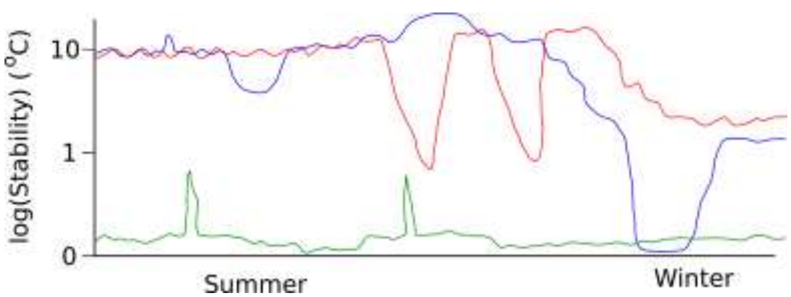


Figure 1: Examples of potential stability patterns from late summer to winter. Blue is a hypothetical pattern generated by Lake Mendota, green is Lake Taihu, and red is Lake Annie.

The last few hours of the working group were devoted to determining the specific questions, hypotheses, timeline, and introduction of the manuscript. In the process of developing these pieces of the project, a few ideas for analysis were presented (Figure 2).

Questions

- Q1: What lake characteristics control sensitivity to event metrics? (relative frequency, relative magnitude, and duration of the events)
- Q2: What proportion of the variance of these event metrics is explained by identified controls?
- Q3: What is the relationship among event metrics across lake types? Can it be used to predict response to climate change?

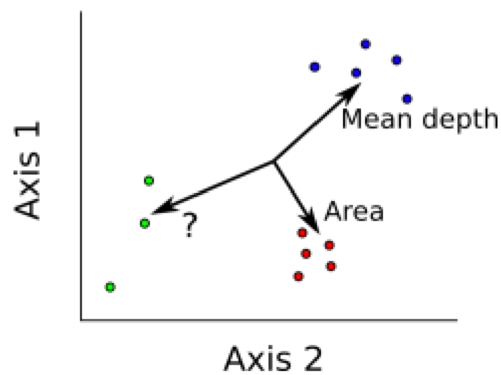


Figure 2: One potential method of analysis. An ordination-based approach could allow important lake characteristics to be identified. The direction and magnitude of the movement within the axes would provide information about the relationship of lake characteristics and response to episodic events.

Possible title
Episodic event phenology across lake types

Timeline

- 3 weeks: email list, everyone communicating and working on getting the data
- 1 month: data gathered and ready for analysis
- 2 months: analysis underway and draft started

Participants, Areas of Interest, and Tentative Responsibilities:

Name	Area of Interest (sub-working group)	Responsibility at GLEON 7
Thorsten Blenckner	Long-term/Episodic	
Justin Brookes	Modelling (bio/phys), episodic	
Evelyn Gaiser	Long-term/Episodic	WG Co-Lead
David Hamilton	Episodic (phys/bio), Modelling	WG Lead
Kata Hubai	Long-term (large lakes)	
Timo Huttula	Modelling (bio/phys), long-term	
Eleanor Jennings	Episodic (phys/bio)	
Ian Jones	Episodic (phys)	WG Reporter
Owen Langman	Episodic	

Antti Lindfors		
David Livingston	Long-term change (phys)	
Hampus Markensten	Modelling (bio/phys)	
Catherine O'Reilly	Long-term/Episodic	
Liz Ryder	Episodic (bio)	WG Reporter
Chris Soloman	Modelling (climate~phys)	
Niklas Strombeck	Long-term change (remote sensing)	
Carola Wagner	Episodic (bio)	
Guangwei Zhu	Episodic (eutrophic lakes, Taihu)	

<u>Tentative responsibilities in sub-working groups:</u>

Long-term temperature profile data– David Livingston is taking the lead on this with data input from GLEON members and participants of the special AGU session

Coupled climate–lake models – David H. led this discussion and was joined by Justin Brookes, Timo Huttula, Hampus Markensten and Chris Soloman

Episodic events –David H. will be collecting information on participation and datasets from the working group and providing assistance (and program) for calculating derived thermal data. Ian Jones will be collecting and disseminating metadata for participating lakes and take the lead on the data screening for event detection and evaluation. Evelyn, David H., Catherine and Owen L. worked on the hypotheses and offered to continue to help lay out the conceptual framework. Eleanor Jennings offered to write an introductory paragraph on episodic events and Hampus Markensten can write a paragraph on event drivers. A call for metadata will go out to working group members just after the meeting and will be open to the rest of GLEON as the project evolves. Authorship will follow GLEON guidelines and order will be determined organically as manuscript responsibilities become better defined. David H. and Ian J. are currently leading information collection efforts.