Water quality research for Lake Granbury, TX

Support from
2006/07 congressional earmark

Championed by
Rep. Chet Edwards

Leading Institutions
Texas A&M University
University of Texas at Arlington
Baylor University

Collaborators
Texas Water Research Institute
Brazos River Authority
Texas Parks and Wildlife

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Prymnesium parvum blooms (golden algae)

TAMU, UTA, BU

Prymnesium parvum blooms (golden algae)

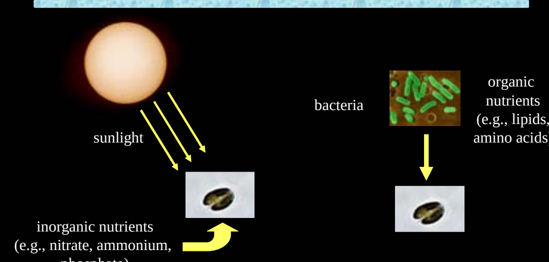
TAMU, UTA, BU

Fish are dying in Lake Granbury - now

Pat and Dan Loomis

Prymnesium parvum: life as a mixotroph

TAMU, UTA, BU



life as a plant

life as a animal

Lake Granbury, TX: Water quality questions

TAMU, UTA, BU

- What causes golden algae blooms?
- Are golden algae and *E. coli* problems linked?
- Might “leaky” septic systems play a role?
- What can we do about it?

Research approach

TAMU, UTA, BU

1. In-lake monitoring
   fixed-station sampling
   high-resolution spatial mapping
2. Direct measurements of toxicity
   bioassays using a fish
   bioassays using a crustacean
3. Predictive modeling
   laboratory studies
   mathematical equations
   validation and scenario testing

1. In-lake monitoring: Fixed-stations

TAMU, UTA, BU

Ten locations

#1 Head of reservoir

#2, 3
#4, 5
#6, 7
#8, 9
} Paired-stations (shallow and deep)

#10 Dam

1. In-lake monitoring: Fixed-stations

TAMU, UTA, BU

Parameters sampled

P. parvum
E. coli
Fecal coliform
Dissolved org.-carbon
Toxicity

Chlorophyll *a*
Phytoplankton composition
Zooplankton composition
Total bacteria

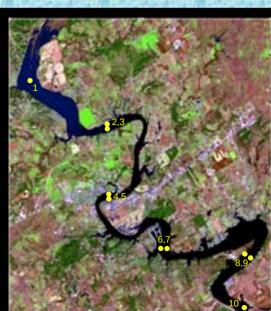
1. In-lake monitoring: Fixed-stations

TAMU, UTA, BU

Parameters sampled

Nutrients
- Nitrate/nitrite
- Ammonium
- Phosphate
- Total nitrogen
- Total phosphorus

Light
- Transmission
- Secchi depth

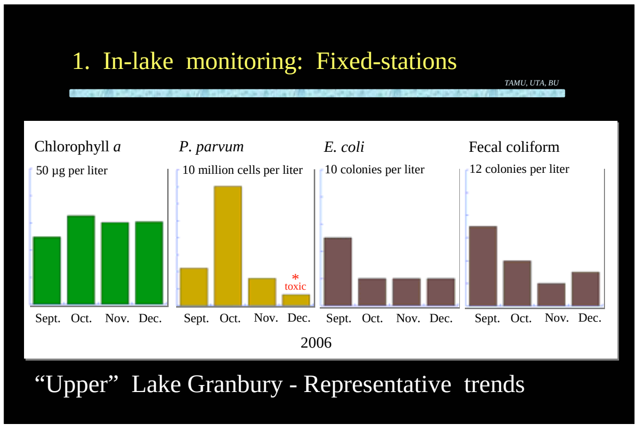


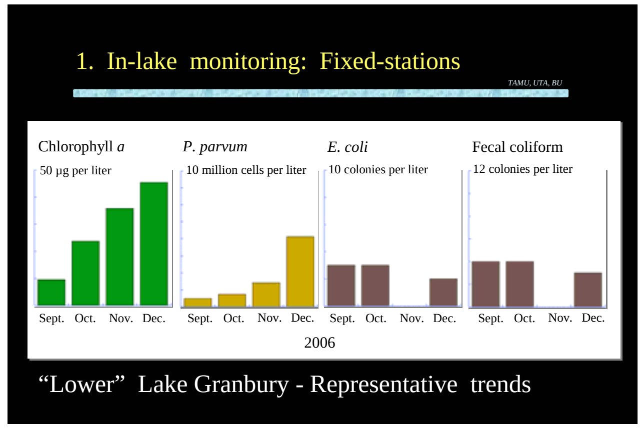
1. In-lake monitoring: Fixed-stations

TAMU, UTA, BU

Parameters sampled

Temperature
Salinity
Dissolved oxygen
pH
Total suspended solids
Oxidation-Reduction Potential


1. In-lake monitoring: Fixed-stations
TAMU, UTA, BU
Chlorophyll a
50 µg per liter
P. parvum
10 million cells per liter
E. coli
10 colonies per liter
Fecal coliform
12 colonies per liter
* toxic
Sept. Oct. Nov. Dec.
2006
"Upper" Lake Granbury - Representative trends


1. In-lake monitoring: Fixed-stations
TAMU, UTA, BU
Chlorophyll a
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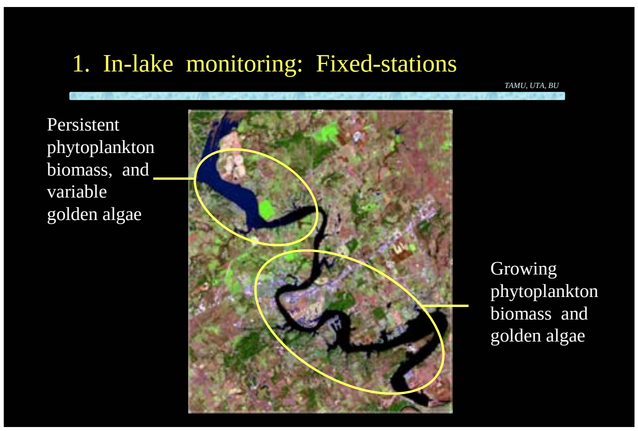
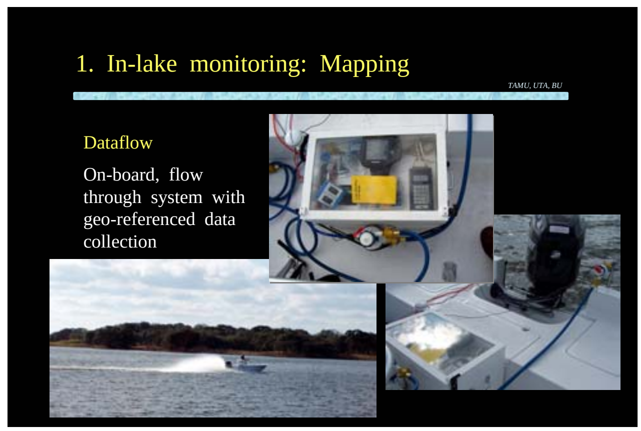
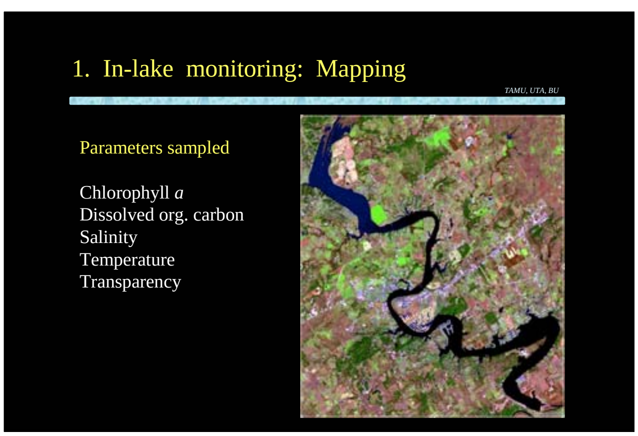
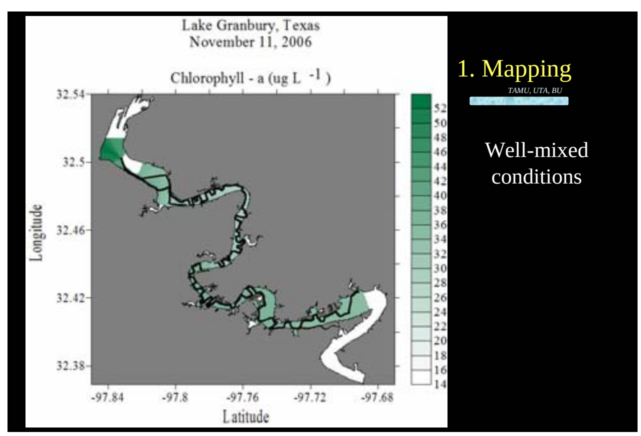
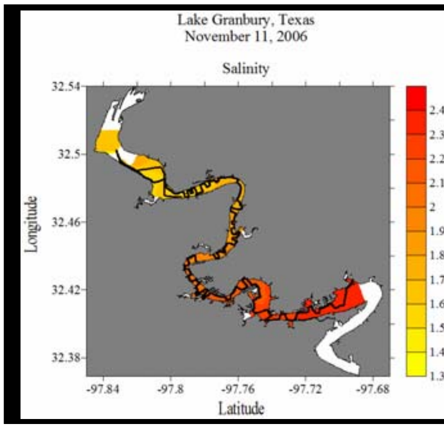
"Lower" Lake Granbury - Representative trends


1. In-lake monitoring: Fixed-stations
TAMU, UTA, BU
Persistent phytoplankton biomass, and variable golden algae
Growing phytoplankton biomass and golden algae


1. In-lake monitoring: Mapping
TAMU, UTA, BU
Dataflow
On-board, flow through system with geo-referenced data collection


1. In-lake monitoring: Mapping
TAMU, UTA, BU
Parameters sampled
Chlorophyll a
Dissolved org. carbon
Salinity
Temperature
Transparency

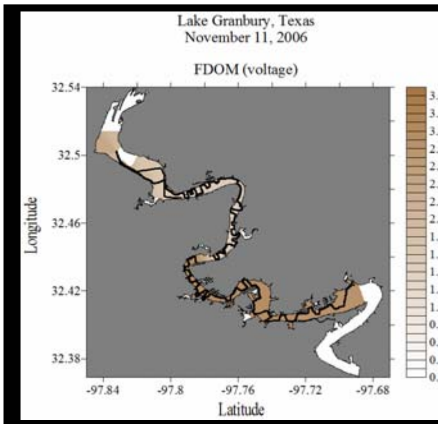

Lake Granbury, Texas
November 11, 2006
Chlorophyll - a (ug L -1)
32.54
32.5
32.46
32.42
32.38
Longitude
-97.84
-97.8
-97.76
-97.72
-97.68
Latitude
52 50 48 46 44 42 40 38 36 34 32 30 28 26 24 22 20 18 16 14
1. Mapping
TAMU, UTA, BU
Well-mixed conditions



1. Mapping

TAMU, UTA, BU

Well-mixed conditions



1. Mapping

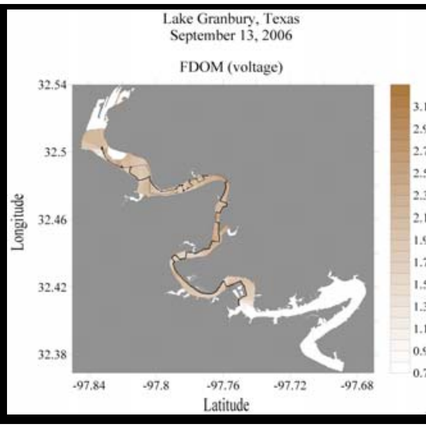
TAMU, UTA, BU

Well-mixed conditions

1. Mapping

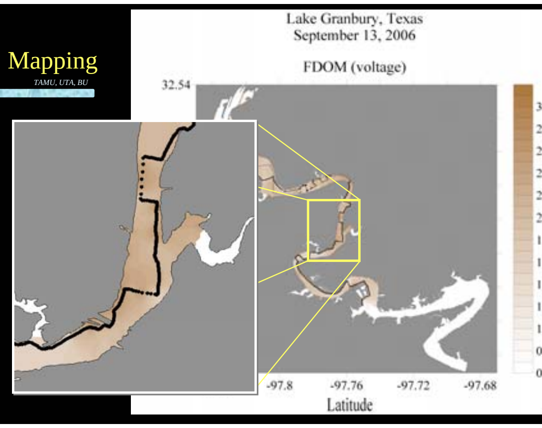
TAMU, UTA, BU

Spatial heterogeneity



1. Mapping

TAMU, UTA, BU

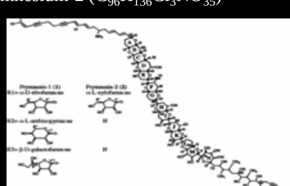


2. Direct measurements of toxicity

TAMU, UTA, BU

Prymnesium parvum

Fish kills believed to result from exposure to prymnesium-1 ($C_{107}H_{154}Cl_3NO_{44}$) and/or prymnesium-2 ($C_{96}H_{136}Cl_3NO_{35}$)



From Igarashi et al. 1999



J La Claire, UT Austin

2. Direct measurements of toxicity

TAMU, UTA, BU

Coal miners used canaries to signal if there was a problem in the mine shaft

Similarly, we use sensitive organisms to signal if toxic *P. parvum* blooms occur

Daphnia magna
- A "water flea"

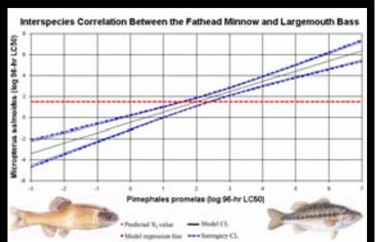
Pimephales promelas
- A common minnow

2. Direct measurements of toxicity

TAMU, UTA, BU

Even though a minnow…

is not a largemouth…



the minnow can be protective of other fish.

2. Direct measurements of toxicity

TAMU, UTA, BU

Prymnesium parvum Toxicity

Why Use Aquatic Biosensors?

1. Sensitivity - excellent “sentinels”
2. Ecological Relevance - representative of other cladocerans and fish
3. Availability - species widely used for monitoring water quality
4. Precision - reproducibility of responses within and between labs

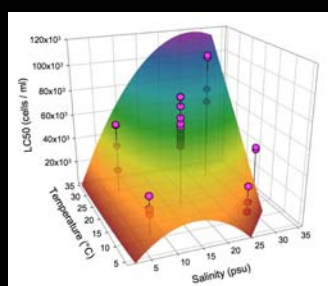
2. Direct measurements of toxicity

TAMU, UTA, BU

P. parvum toxicity to fish affected by temperature and salinity

Most pronounced at lower salinity and temperatures similar to those experienced during winter blooms in Texas reservoirs (e.g., Granbury, Possum Kingdom, Whitney)

Perhaps a recipe for fish kills?

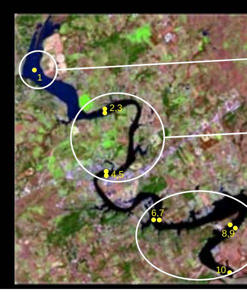


2. Direct measurements of toxicity

TAMU, UTA, BU

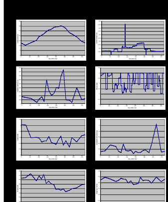
Fish Biosensor Responses to the January 2007 Toxic Bloom

Site Number	Percent Mortality
1	27%
2	93%
3	87%
4	93%
5	73%
6	0
7	0
8	0
9	0
10	0

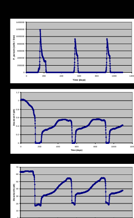


3. Predictive modeling - overview

TAMU, UTA, BU



Input Data → Equations & Calculations → Output Data



Based on lake characteristics

Based on knowledge and guesswork

Predicted *P. parvum* density, dissolved nitrate and phosphate

3. Predictive modeling – Knowledge & guesswork

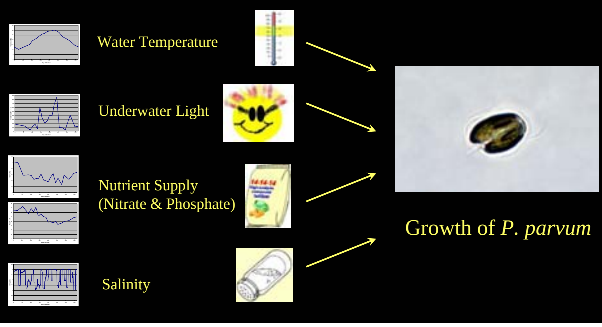
TAMU, UTA, BU

Equations & Calculations

Population Change = Growth (Reproduction) - Mortality

3. Predictive modeling – Growth

TAMU, UTA, BU

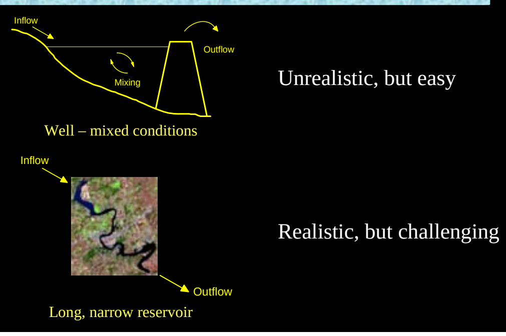


3. Predictive modeling – Mortality

TAMU, UTA, BU

3. Predictive modeling – Physical settings

TAMU, UTA, BU



3. Predictive modeling – More complications

TAMU, UTA, BU

Other algae live in the lake and compete with *P. parvum*, what is their effect?

Toxicity of *P. parvum* is not in the current version.

"Life as an animal" is not in the current version.

All processes in the model are highly simplified and could be more realistic.

3. Predictive modeling – Uses

TAMU, UTA, BU

Summarizes knowledge systematically, identifies gaps.

"What if" questions and management scenarios can be explored.

Forecasting and prediction…

Timeline and What's next?

TAMU, UTA, BU

Monthly sampling, and increased scope

- on-going lake sampling (as described)
- correlations between golden algae, bacteria and DOM
- add anthropogenic tracers (e.g., nicotine, caffeine, etc.)
- expand to regional studies (multiple lakes, historical analysis)

Predictive modeling

- develop model of golden algae with competitors
- extend model to long, narrow reservoir setting
- compare model to field data
- extend realism of model (toxicity, life as an animal)