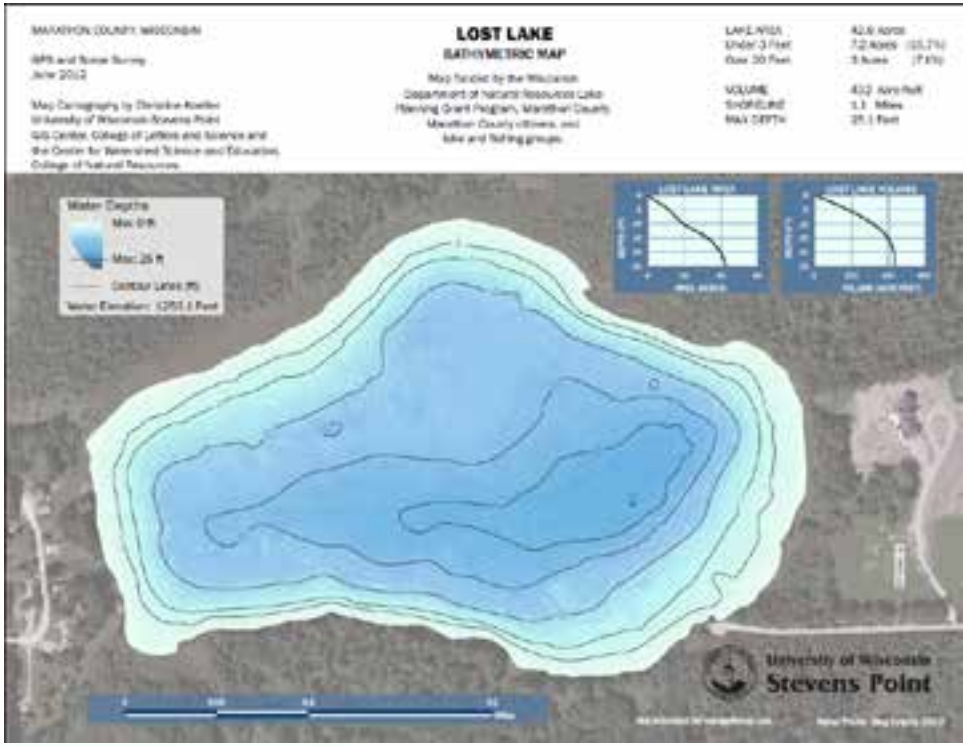
University of Wisconsin
Stevens Point

Documenting Changes in Lake Morphology of Six Inland Wisconsin Lakes

By: Christine Koeller[1] and Ron Crunkilton[2]

[1]Graduate Research Assistant – UW-Stevens point

[2]Professor – UW-Stevens Point



Overview

- Terms/History/Significance
- Objectives
- Methodology
- Results
- Discussion/Future Studies

Terms

Bathymetric Map: Contoured depths of a water body to give 3-dimensional information in 2D.

Sonar xyz Data:

x = Longitude

y = Latitude

z = Depth (feet)

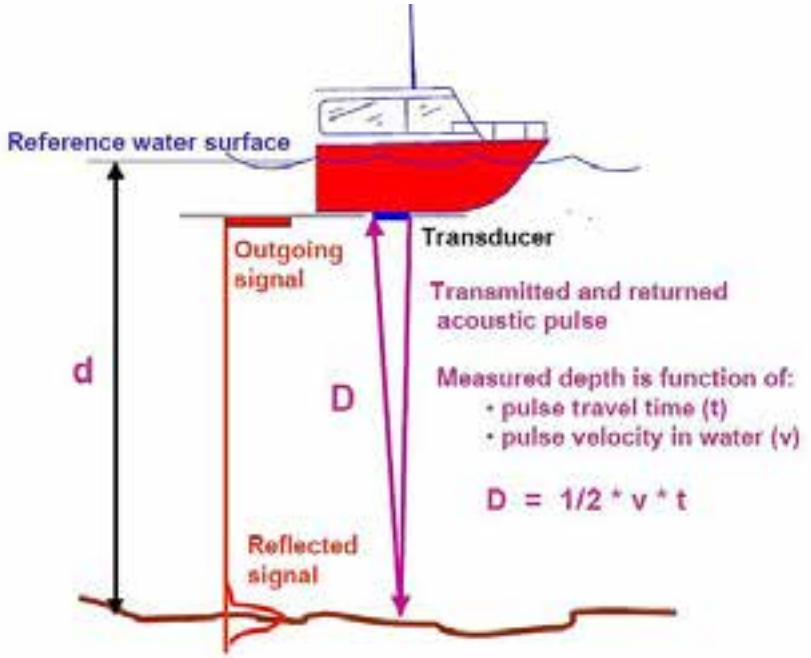


Figure 9-1. Acoustic depth measurement

Accessed at http://upload.wikimedia.org/wi...

Bathymetric Mapping Uses

- Calculate Lake Volume (water storage/retention time)
- Chemical Application Rates (i.e. aquatic plant control)
- Locate Sampling Locations
  - Water Quality Sampling
  - Lake Depth Profiles
    - Lake Stratification

Historic Bathymetric Mapping

Timeframe	Method
Prior to 1960	ò Ice Grid Point Data
1960-1992	ò Graphing sounder depth recorded plotted on air photo
1992-1996	ò GPS used to locate transects for graphing sounder
1997-Present	ò Free-form survey with GPS point capability on sonar

Accessed at http://www.uwec.edu/hartnesg/hartnett/SeanWeb/BTsur.html (verified March, 2011).

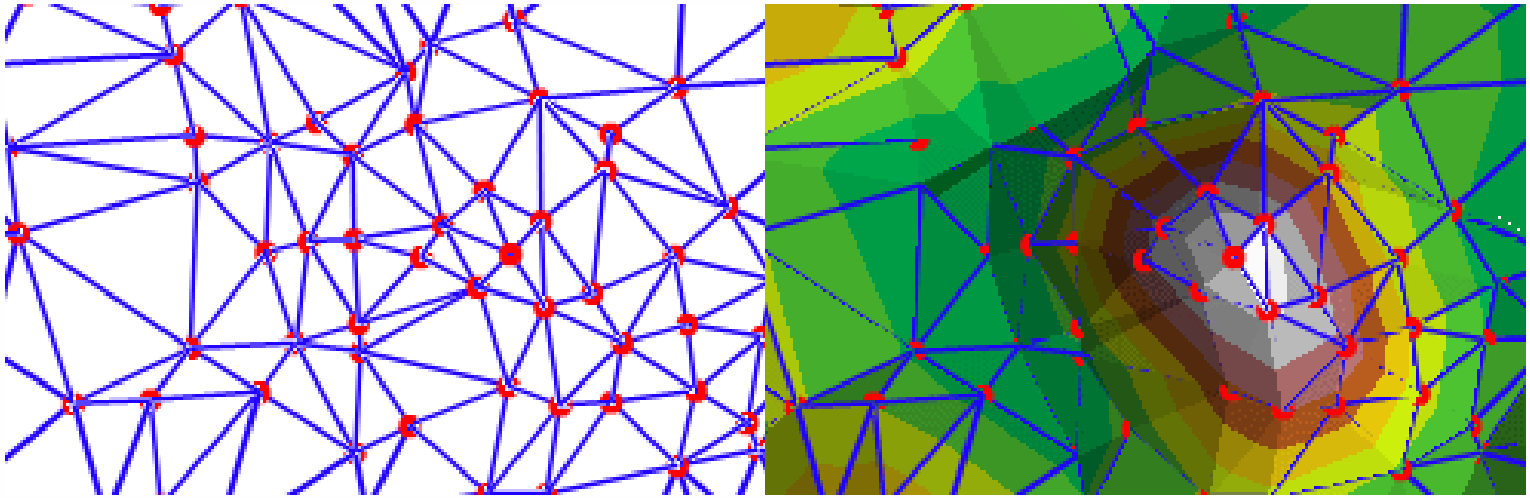
TIN Models

XYZ Data used to create the Lake Model

(Triangulated Irregular Network)

How it Works:

Points are connected to create a series of triangles

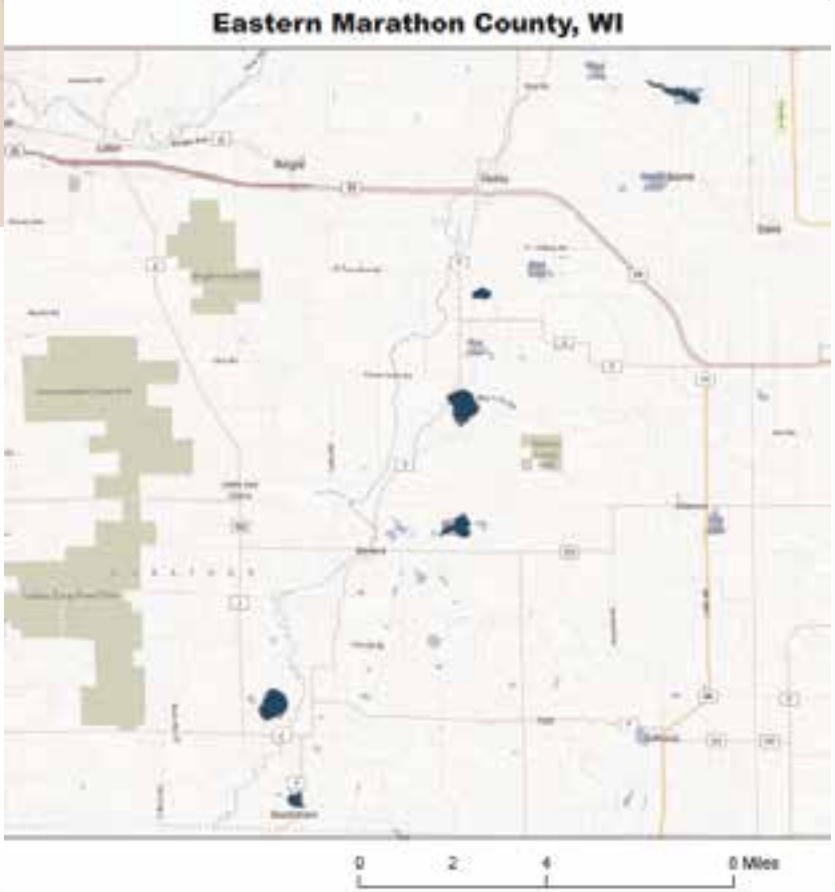


Accessed at:
http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#/What_is_a_TIN_surface/006000000001000000/.

Objective 1

To determine if lake morphology has changed over time. (H_o: $X_1 - X_2 = 0$)

Study Area



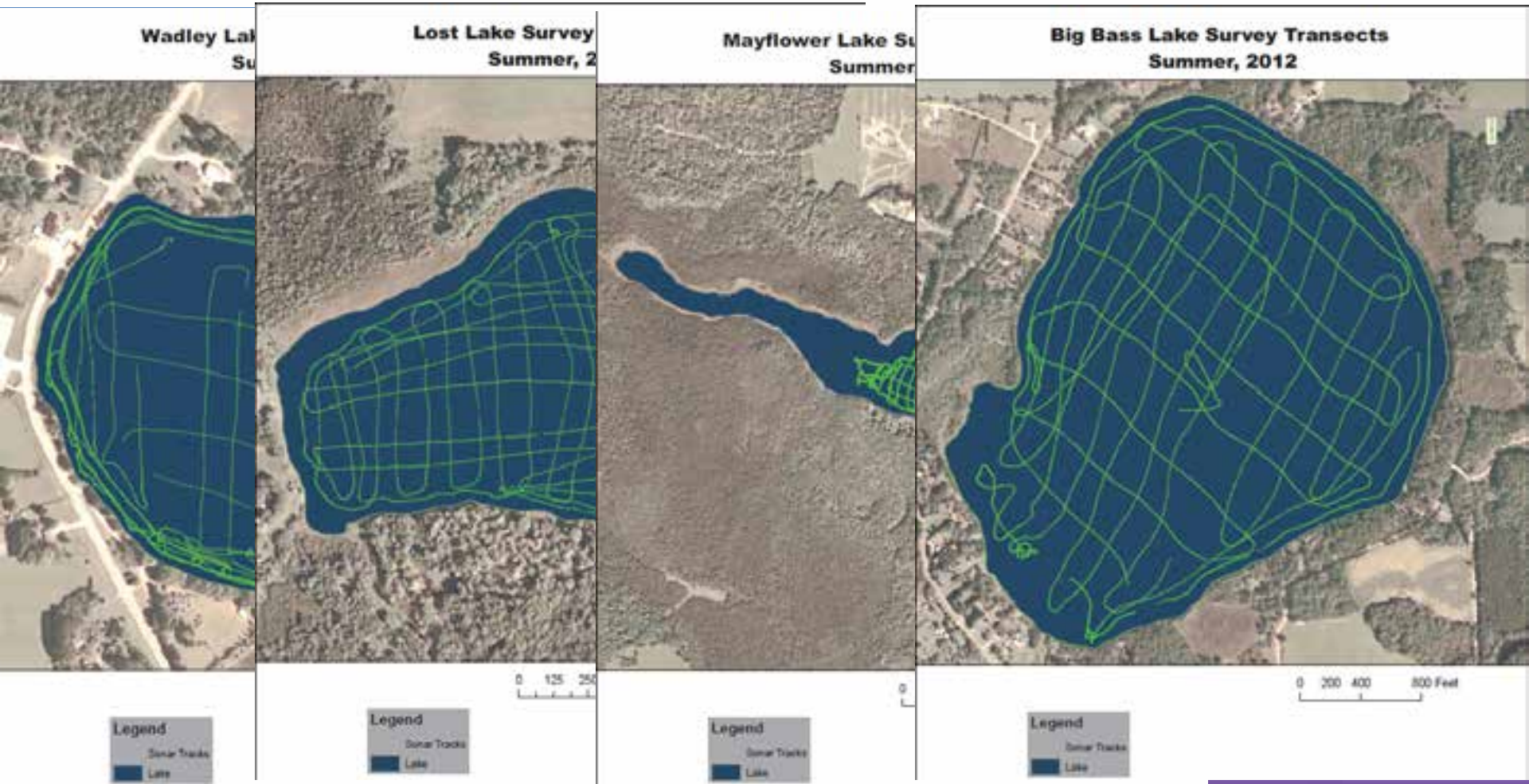
Lake	2012 Area (ac)
Lost	42.6
Wadley	47.2
Mayflower	96.3
Mission	108.7
Big Bass	179.9
Pike	206.4

Methods: Equipment

- XYZ positioning data collected with:
  - Trimble R6 GPS receiver
  - Sonarmite Depth finder
  - WISCORS instantaneous positioning correction
  - Accuracy
    - Horizontal (<1cm)
    - Vertical (± 3cm)

Lowrance Depths also collected

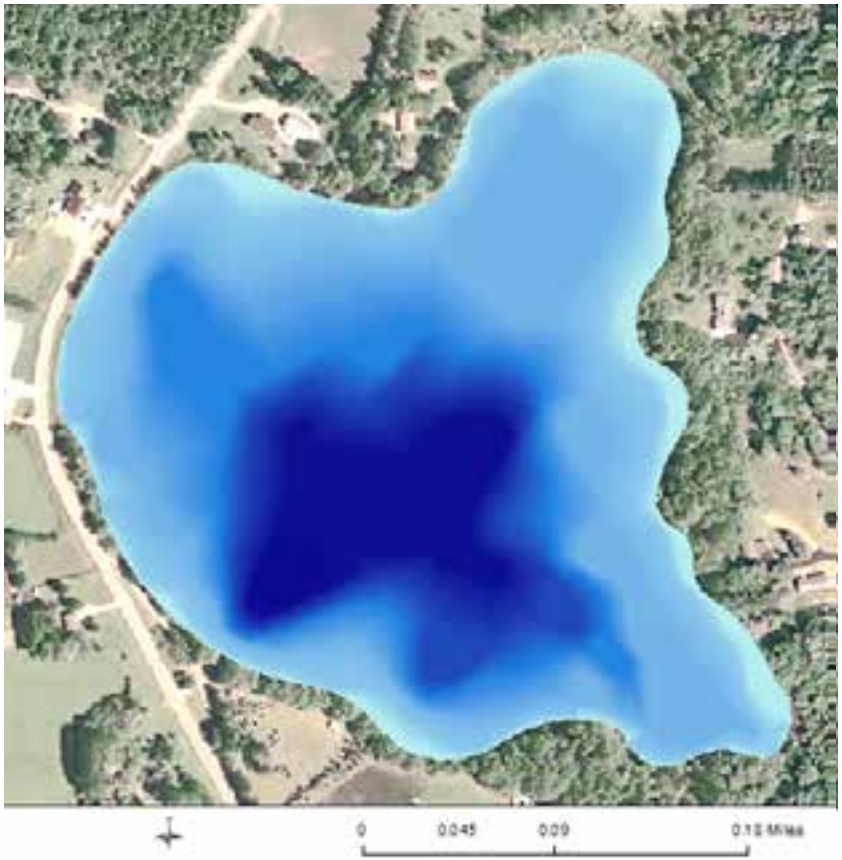
- Transects spaced 100-200 feet.
- Near-shore surveyed between 2-3 ft. depth.
- XYZ positions collected every second.



Methods

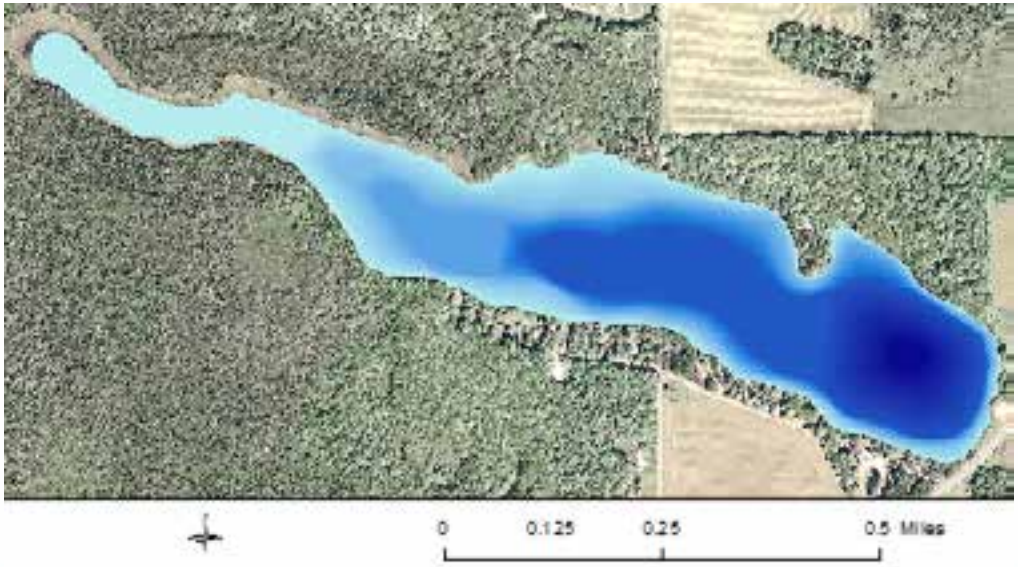
- Model built with Survey points *and* Shoreline points (depth= 0 feet) (TIN with ArcMap 10.0)

- TIN converted to 1-meter grid.

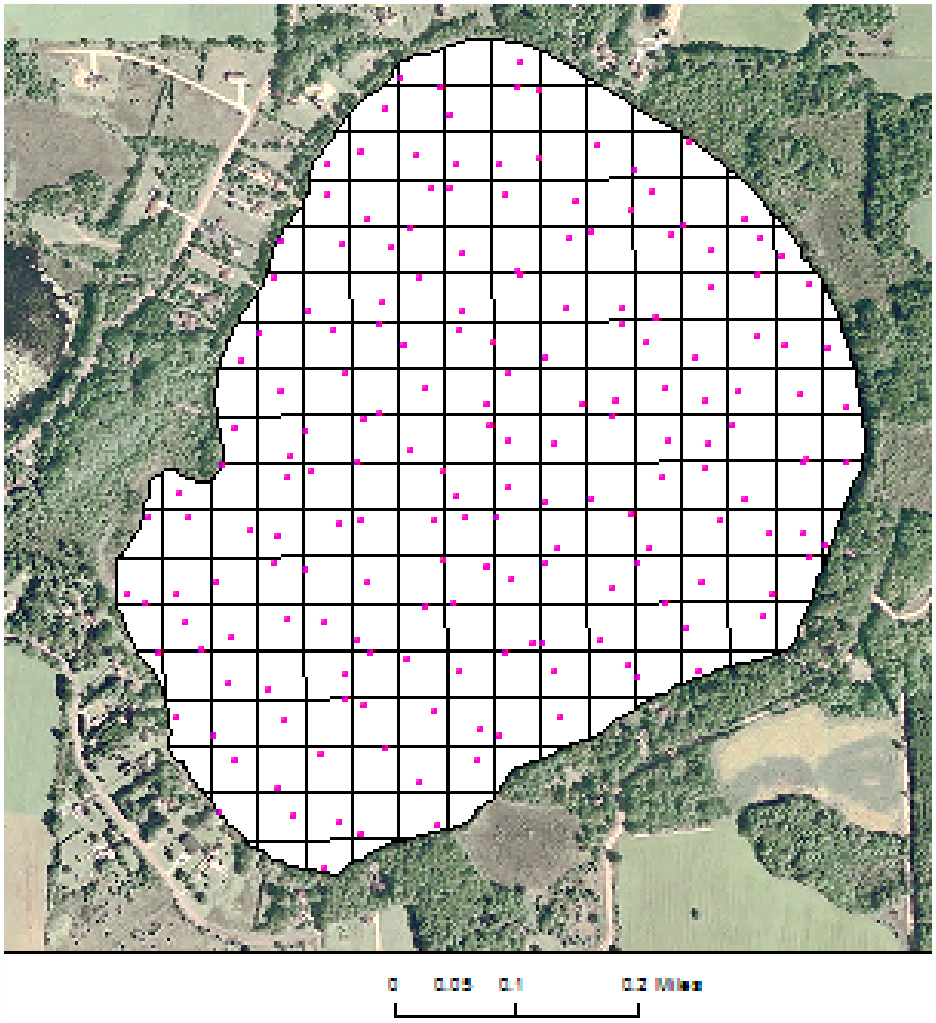


Methods

- Historic Imagery rectified using Georeferencing tools in ArcMap 10.0.
- Historic Contours digitized into lines/polygons.
- Converted to TIN, then 1m grid.



Results



Stratified Random Points

(GME, Beyer, 2012)

- 1-acre grids.
- 1 random point/acre.
- Depth compared at points: *Historic vs. Present*
- Models compared using paired T-test (two-tail, P=0.05)

Results

Paired T-Test ($\alpha = 0.05$)	Lake	P-value
$t_{0.05(\text{two-tail}),223}$	Pike	<.0001
$t_{0.05(\text{two-tail}),53}$	Lost	0.0018
$t_{0.05(\text{two-tail}),103}$	Mayflower	0.0004
$t_{0.05(\text{two-tail}),58}$	Wadley	<.0001
$t_{0.05(\text{two-tail}),180}$	Big Bass	0.0001
$t_{0.05(\text{two-tail}),121}$	Mission	<.0001

Significant differences exist between the models.

Spatially Viewing Depth Change

- Determined grid change spatially using subtraction

Historic depths

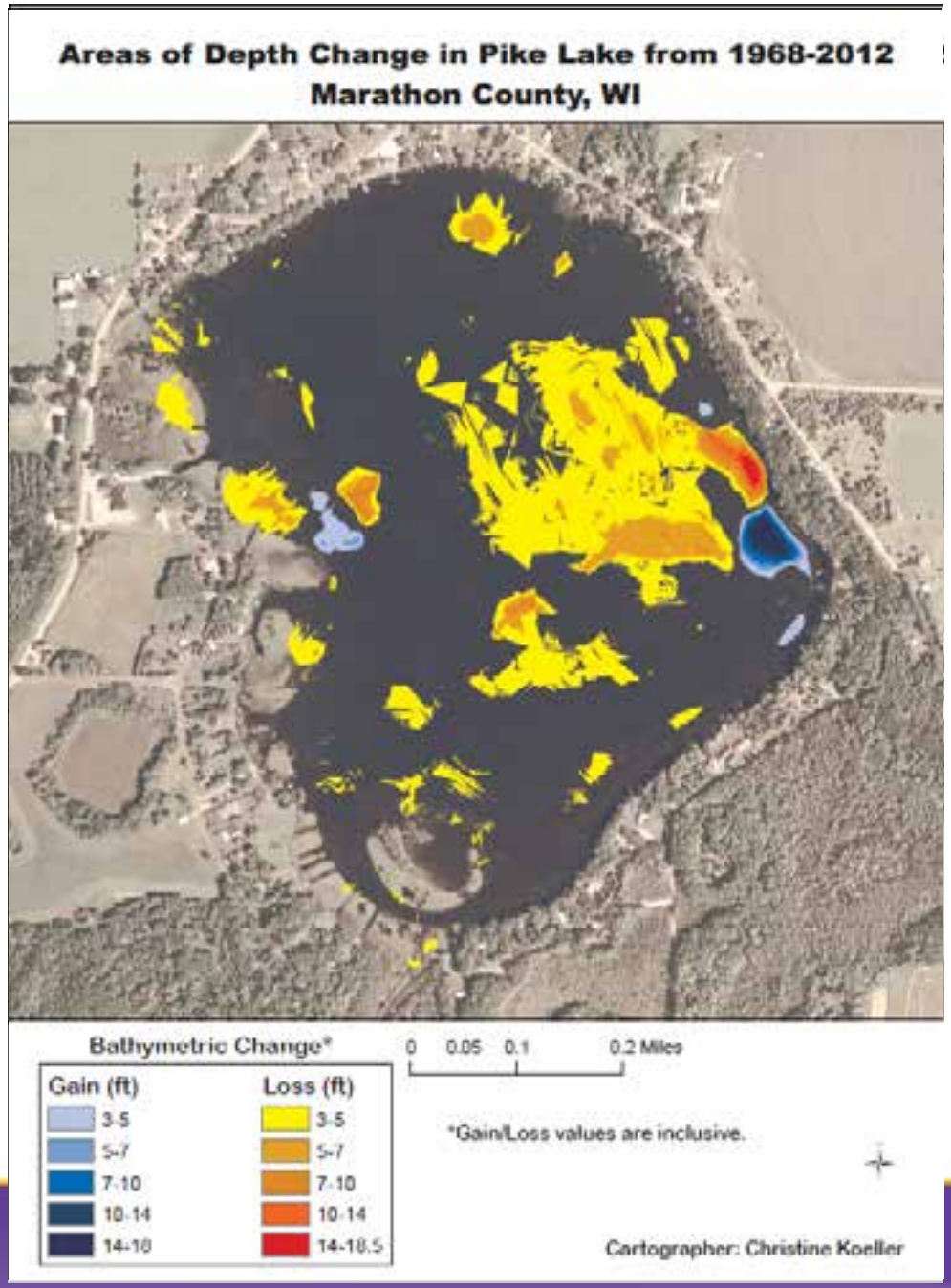
\- Current depths

Change

1975

2012

(3x exaggeration)



Spatial Depth Change

Change <3ft ignored

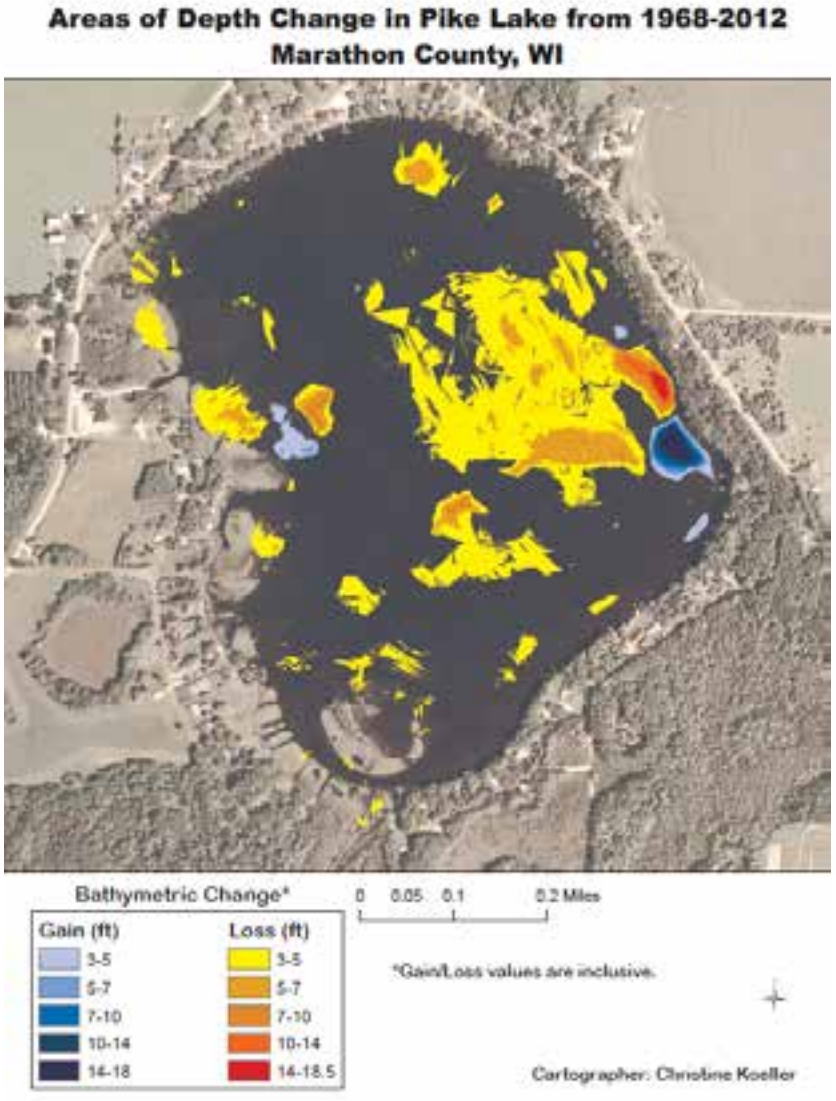
A Closer Look

Pike Lake Case Study

0.1 ft. difference in Elevation

- 1967 Volume
  - 2337 Acre-Feet
  - Max Depth 34 Feet
- 2012 Volume
  - 2005 Acre-Feet
  - Max Depth 31 Feet

15% loss in total lake volume

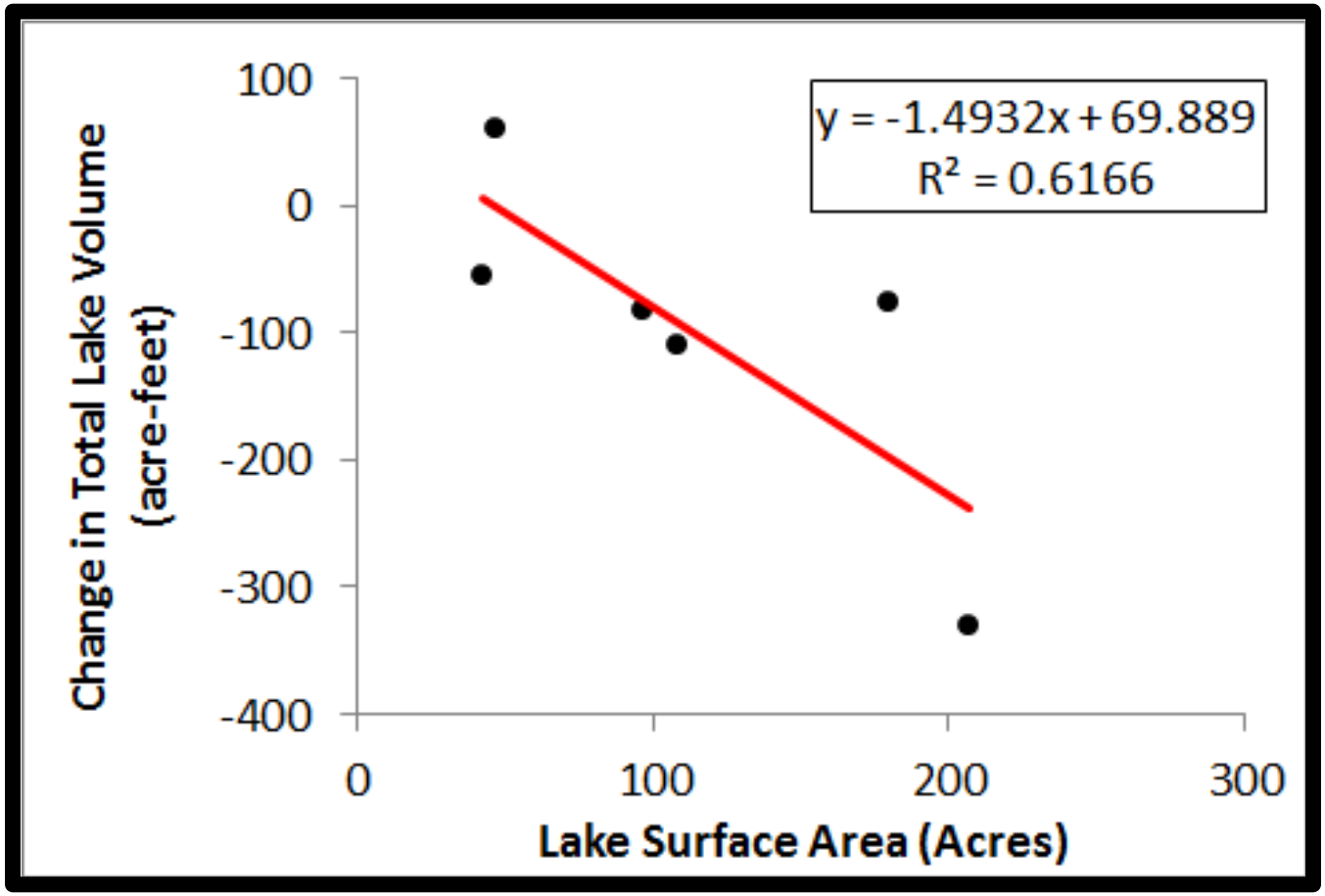


Results

Lake	Present (ac-ft)	Historic (ac-ft)	% Difference
Pike	2005.93	2337.75	15.28%
Mission	1172.88	1283.23	8.99%
Lost	432.04	488.01	12.17%
Wadley	456.27	395.73	14.21%
Mayflower	610.42	693.5	12.74%
Big Bass	705.14	782.15	10.36%

Total lake volumes calculated in ArcMap 10.0

Results



Is there a Relationship between:

1) ***lake size***

and

2) ***Volume change***

Discussion

Possible Reasons for Depth Change

1) Sedimentation
2) Poor positional accuracy during historic survey

Future Research:
Determine relationship between depth change and dated sediment material.

Objective 2

To determine if Trimble equipment builds significantly different models than Lowrance equipment.

(Methods same as objective 1)

Advantages/Disadvantages

	Trimble	Lowrance
Horizontal deviation	± 1cm	± 30m
Vertical Deviation	± 3cm	unk
Cost	$32,000	$600-1200
Water Elevation	Yes	No
Differential correction	WISCORS	none
Additional Equipment	mobile wifi	none
Ease of use	difficult	easy

Trimble models vs. Lowrance models

Paired T-Test ($\alpha = 0.05$)	Lake	P-value
$t_{0.05(two\text{-}tail),223}$	Pike	<.0001
$t_{0.05(two\text{-}tail),53}$	Lost	0.1360
$t_{0.05(two\text{-}tail),103}$	Mayflower	0.0005
$t_{0.05(two\text{-}tail),58}$	Wadley	<.0001
$t_{0.05(two\text{-}tail),180}$	Big Bass	<.0001
$t_{0.05(two\text{-}tail),121}$	Mission	<.0001

Most Trimble models are significantly different from Lowrance models.

Lowrance consistently understimated lake volumes calculated with Trimble.

Lake	Trimble Volume (acre-feet)	Lowrance Volume (acre-feet)	Percent Difference
Big Bass	705.1	622.1	6.2%
Wadley	456.3	420.6	4.1%
Mission	1172.9	1090.3	3.6%
Pike	2005.9	1918.4	2.2%
Mayflower	610.4	596.0	1.2%
Lost	432.0	455.2	-2.6%

Trimble vs. Lowrance: What to use?

Depends on Goals and Objectives of the lake mapping project.

	Trimble	Lowrance
Horizontal deviation	± 1cm	± 30m
Vertical Deviation	± 3cm	unk
Cost	$32,000	$600-1200
Water Elevation	Yes	No
Differential correction	WISCORS	none
Additional Equipment	mobile wifi	none
Ease of use	difficult	easy

Future Work

Use Trimble technology to monitor lake bottom changes over time.

Can we determine where solids are settling out with this equipment?

Can't be done with other forms of data collection.

PIKE LAKE

BATHYMETRIC MAP

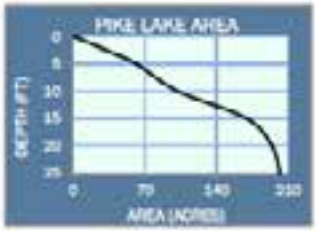
Map funded by the Wisconsin Department of Natural Resources Lake Planning Grant Program, Marathon County, Marathon County citizens, and lake and fishing groups.

MARATHON COUNTY, WISCONSIN

GPS and Sonar Survey
June 2012

Map Cartography by Christine Koeller
University of Wisconsin-Stevens Point
GIS Center, College of Letters and Science
and the Center for Watershed Science and Education, College of Natural Resources.

LAKE AREA	207	Acres
Under 3 Feet	38.6	Acres (18.7%)
Over 20 Feet	12.7	Acres (6.1%)
VOLUME	2009	Acre-feet
SHORELINE	2.6	Miles
MAX DEPTH	31.0	Feet



Water Depths
Min: 0 ft
Max: 31 ft
Contour Lines (ft)
Water Elevation: 1230.7 Feet

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0 0.05 0.1 0.2 0.3
Miles

Not intended for navigational use. Aerial Photo: Bing Hybrid, 2010

Acknowledgements

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- UWSP Center for Watershed Science and Education.
- Geospatial Modelling Environment Version 0.7.2 (Hawthorne L. Beyer).

GIS Center
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University of Wisconsin-Stevens Point