Phosphorus and Sediment Change in Lake Okeechobee, FL

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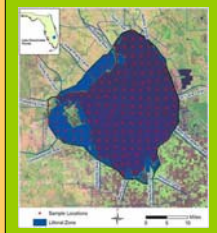
Introduction

Lake Okeechobee is a large, shallow lake located in South Florida. It has been subject to high external loads of P from its watershed for decades, resulting in its eutrophication. P has accumulated in the lake's sediments, and internal loading from this source has become a significant component of the nutrient budget of the lake.

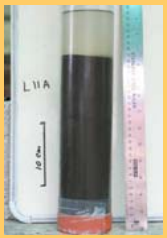
The flocculent nature of the mud, combined with the large fetch and shallowness of the lake, make sediment resuspension and the resulting P load to lake waters an issue of concern. Distribution of the mud sediment, as well as distribution of P throughout all substrate types, remains an important component of lake monitoring efforts.

Methods



174 sites were visited by boat or airboat. Sediment cores were taken using a piston corer or by hand, and were analyzed for total P, N, C, bulk density, TKN, NH_4-N, and HCl-extractable Fe, Ca, Mg, and Al. Porewater was analyzed for total P, N, C, pH, conductivity, TKN, NH_4-N, and HCl-extractable Fe, Ca, Mg, and Al.

t-tests for dependent samples were used to test for changes between sampling years (1988, 1998, and 2006). t-tests were performed both on the entire population, and separately on the subset of sites whose substrate went unchanged between each pair of surveys. ArcGIS (ESRI) was used to create interpolative maps to show the spatial distribution of sediment characteristics and mud depth.



Results

Sediment P concentration increased between 1988 and 1998, then decreased between 1998 and 2006. Statistically significant change was associated with sites whose substrate type did not change between surveys. There was no significant difference between 1988 and 2006 levels.

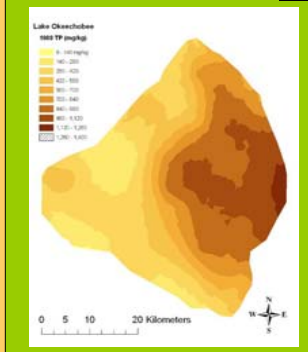
Mud depth decreased significantly between each survey since 1988.

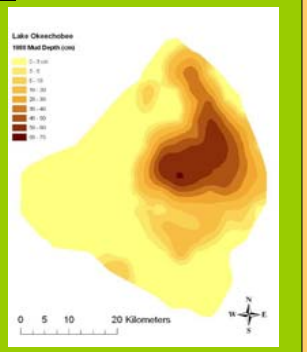
Table of p values	88-98	98-06	88-06
TP (all sites)	0.2010	0.1536	0.4817
Mud Depth (all sites)	0.0073	0.0017	0.0000
TP (unchanged substrate only)	0.0465	0.0270	0.5568

Values < .05 are significant

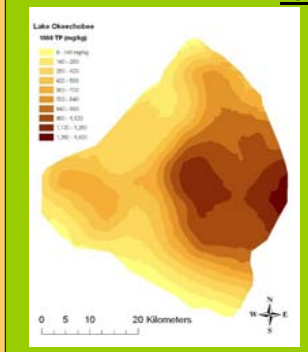
The extent of the mud zone remained unchanged between 1988 (~80,000 ha) and 1998 (~79,000 ha). However, between 1998 and 2006, it increased to an area of ~93,000 ha.

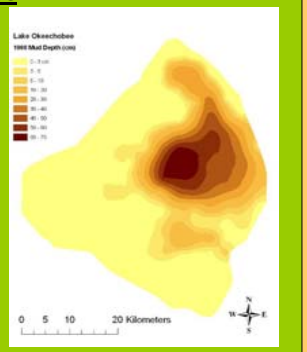
1988



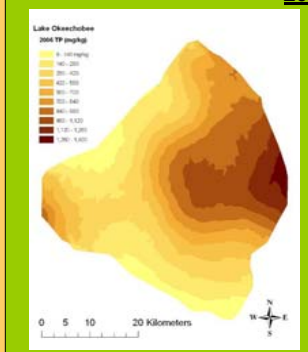


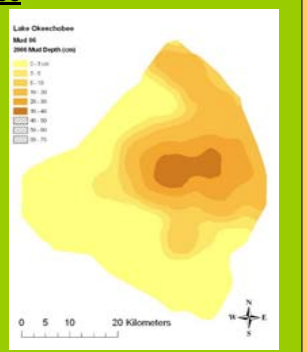
1998





2006





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1998 Substrate

1988 Substrate	Count	Marl	Mud	Peat	Rock	Sand	Total	%Unchanged
	Marl	4	6	1	1	6	18	22.2%
	Mud	1	52		4	3	60	86.7%
	Peat		1	28	1	2	32	87.5%
	Rock	1	1		10	1	13	76.9%
	Sand	1	4	9	4	28	46	60.9%
	Total	7	64	38	20	40	169	72.2%

2006 Substrate

1988 Substrate	Count	Marl	Mud	Peat	Rock	Sand	Total	%Unchanged
	Marl	2	7	1	4	4	18	11.1%
	Mud	1	48	1	7	3	60	80.0%
	Peat			22		9	31	71.0
	Rock	1	1		10	1	13	76.9%
	Sand	2	9	9	2	24	46	52.2%
	Total	6	65	33	23	41	168	63.1%

2006 Substrate

1998 Substrate	Count	Marl	Mud	Peat	Rock	Sand	Total	%Unchanged
	Marl	1	1		2	3	7	14.3%
	Mud	2	50	1	7	4	64	78.1%
	Peat		1	28		9	38	73.7%
	Rock	1	4		13	2	20	65.0%
	Sand	2	9	4	2	23	40	57.5%
	Total	6	65	33	24	41	169	68.0%

Pivot tables showing changes in substrate type. The tables are read such that each intersection in the table represents changes between years from one type to another; total counts of each type are given at the end of each row/column. For instance, between 1988 and 1998, 6 marl sites became mud sites, while 4 remained classified as marl.

Discussion

Changes in substrate type were shown to be important when monitoring for changes in the sediment P pool. P levels have changed significantly between surveys, but not in a unidirectional fashion; there may be some kind of decadal variation at work.

The mud zone appears to have experienced an increase in area between 1998 and 2006, and a reduction in its average and maximum depth. A possible explanation is the effect of hurricanes and strong storms that impacted the lake in that time period.

In 2002 Reddy et al. reported that the area of the lakebed covered by mud was in excess of 80,000 hectares, with a total volume of ~200 million m^3 of material in the lake; our calculations indicate that, as of 2006, there were ~134 million m^3 of mud in the lake, suggesting a large reduction in volume.

While the average P concentration decreased between 1998 an 2006, the total mass of P in the top 10 cm actually increased from 41.8 million kg (1998) to 46.3 million kg (2006). Increased bulk density of lake sediments could potentially explain this.

Conclusions

P concentrations in the upper sediments of Lake Okeechobee have changed in magnitude between surveys, increasing between 1988 and 1998 and then decreasing between 1998 and 2006.

Mud sediments, which have been positively associated with increased P concentrations, have been decreasing in depth since 1988, though have increased in areal extent between 1998 and 2006. Due to apparent large changes in mud volume, along with mud being manually removed during the recent historic drought, continued research and monitoring is required to understand changes occurring in this substrate in Lake Okeechobee.

Acknowledgements

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Works Cited

Reddy, K. R. W., J. R.; Fisher, M. M.; Pant, H. K.; Wang, Y.; Grace, K.; Harris, W. G. (2002). Potential Impacts of Sediment Dredging on Internal Phosphorus Load in Lake Okeechobee, South Florida Water Management District: 14.