

### **Indicator 2.3 - Lake Okeechobee Algal Blooms**

#### **What is the desired restoration condition?**

The desired restoration condition for Lake Okeechobee algal blooms is to substantially reduce the frequency of blue-green algal blooms in the pelagic (open water) region of the lake. Algal blooms are defined as chlorophyll *a* concentrations in excess of 40 parts per billion (ppb), and the numeric goal is to reduce the occurrence of such concentrations to less than 5 percent of water samples collected in the pelagic zone (as a five-year running average). Chlorophyll *a* is the green pigment found in algal cells that allows them to carry out photosynthesis. It is a reliable measure of the biomass of algae in the water. A concentration of 40 ppb is used by the State of Florida and other states as an indicator of a bloom. When water has 40 ppb of chlorophyll *a*, it is visibly green. The scientific basis for the 5 percent goal is provided in Havens and Walker (2002).

#### **Why is this indicator important and why is it a good indicator of CERP restoration?**

This indicator is important for the following reasons:

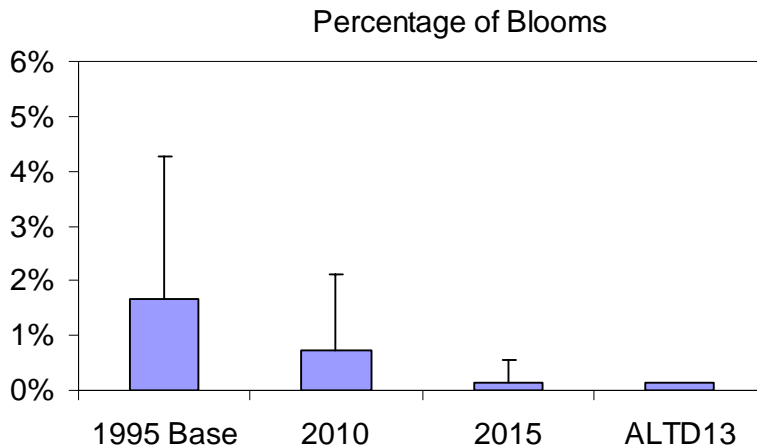
- Algal blooms in Lake Okeechobee have been associated with deteriorated aesthetic values, taste and odor problems in drinking water, death of shoreline macroinvertebrates, and other adverse ecosystem effects (Havens et al. 1996).
- The frequency of algal blooms is expected to decline when concentrations of phosphorus are reduced (see Indicator 2.1).
- The current state is one where a high frequency of blooms adversely impacts the lake's flora and fauna (Havens et al. 1996, Havens and Schelske 2001).

#### **How is the interim goal for this indicator predicted?**

Three attributes related to algal blooms are modeled by the Lake Okeechobee Water Quality Model (LOWQM) (James et al. 1997). Assumptions and uncertainty analyses are identical to those described for Indicator 2.1. Algal bloom frequency is predicted, as described above. The model also predicts the ratio of diatoms to blue-green algae, an important indicator because the lake historically was diatom-dominated and now is dominated by blue-greens, which cause the blooms (Havens et al. 1996). The lake water nitrogen to phosphorus ratio also is predicted, because low nitrogen to phosphorus ratios in the lake, caused by a long history of excessive phosphorus loading, are the main reason that the lake has dominance by bloom-forming blue-green algae (Havens et al. 2003).

### What are the predictions for five-year increments?

The model output (Figure 2.3.1) shows predicted frequency of algal blooms as defined above. The results are means from the last five years of long-term model runs, with inflow total phosphorus concentrations initialized to values expected to occur in the base year 1995 (1995 Base), 2010, 2015, and after full CERP implementation (ALTD13) (see Indicator 2.1 for more details).

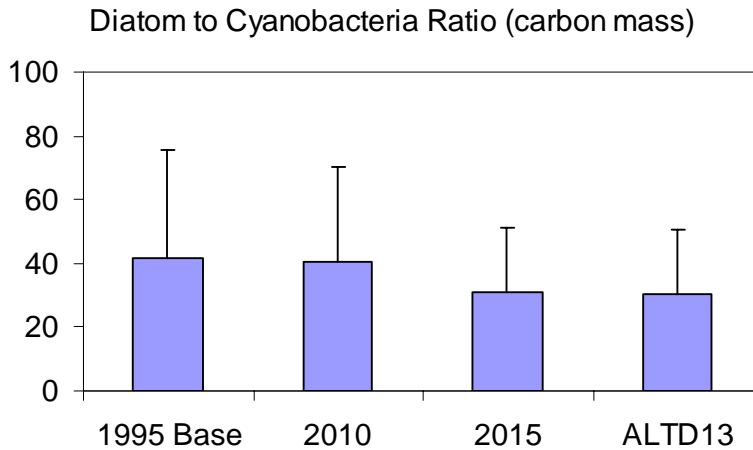


**Figure 2.3.1.** Predicted frequency of algal blooms

All of these frequencies are lower than we consider reasonable, and likely reflect the inability of the LOWQM to model important factors influencing blooms, such as stratification of the lake's water column. More reliable and also spatially-explicit predictions of bloom frequencies will be possible in the future using the Lake Okeechobee Environment Model (LOEM) currently under development. At this time, it is recommended that these results be considered only in a relative context. They indicate a progressive decline in bloom frequencies in the lake over time – a desired outcome of the CERP.

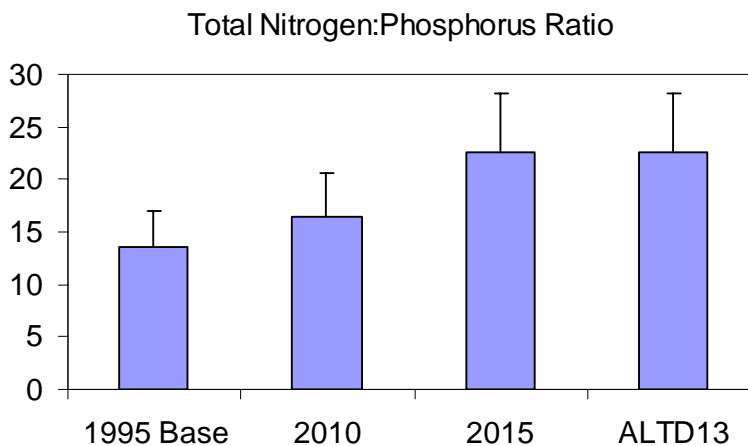
Figure 2.3.2 shows the LOWQM predictions for ratios of diatoms to cyanobacteria, based on model runs initialized as indicated above. In this case, the model output indicates that little change will occur in this attribute.

We know that the relative availability of nitrogen and phosphorus is very important in determining which types of algae are dominant in this lake. Given that the model assumes no reductions in external nitrogen loading with the CERP (given a lack of information about how CERP projects will affect nitrogen loads), there is little or no certainty that this graph reflects what actually will occur in the lake.



**Figure 2.3.2.** Predictions for ratios of diatoms to cyanobacteria

Figure 2.3.3 shows the LOWQM predictions for ratios of total nitrogen to phosphorus in the lake, based on model runs initialized as indicated above. In this case, the model output indicates that the ratios will increase over time with implementation of CERP projects. However, this may simply be an artifact of the model assumption that nitrogen loads remain constant (see Indicator 2.1), a result of lack of information on how CERP projects will affect nitrogen. As a result, there is little or no certainty that this graph reflects what will actually occur in the lake.



**Figure 2.3.3** Predictions for ratios of total nitrogen to phosphorus

**How will we track whether the interim goals established for the indicator have been achieved?**

The South Florida Water Management District conducts in-lake monitoring at 33 sites within Lake Okeechobee. The in-lake monitoring is designed to provide data necessary to quantify,

among other things, diatom:cyanobacteria ratio and algal bloom frequency. Algal bloom frequency is based on chlorophyll *a* concentrations in excess of 40 ppb. The monitoring protocols are discussed in more detail in the *CERP Monitoring and Assessment Plan: Part 1, Monitoring and Supporting Research* (RECOVER 2004).

### **What additional work is needed to improve this interim goal?**

The simulations for the interim goal exercise assume that reductions of nitrogen loads will be equivalent with reductions of phosphorus loads. This simple assumption is made because no data support a more complex relationship. Therefore, this indicator, which is related to both phosphorus and nitrogen availability and its influence on algae in the lake, is uncertain. Additional research and model development is needed to better predict how the watershed, projects constructed in the watershed, and the lake itself, processes phosphorus relative to nitrogen.

It should also be noted that this modeling approach described above will provide a conservative estimate of lake benefits from phosphorus load reduction, in that algal blooms in the pelagic region are largely controlled by high turbidity in the water, which in turn is driven by wind resuspension of bottom sediments. The LOWQM does not consider algal bloom frequency in the lake's shoreline region, which is the area of greatest use by wildlife and society, and the area where blooms are most sensitive to changes in phosphorus concentration. When the LOEM, a coupled hydrodynamic, sediment transport, water quality model, is completed, South Florida Water Management District staff will switch to using that model for evaluating interim goals related to algal bloom indicators, because unlike the LOWQM, which treats the lake as one mixed unit, the LOEM allows for prediction of trends in blooms in specific regions of the lake.

### **References**

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- Havens, K.E., R.T. James, V.H. Smith, and T.L. East. 2003. N:P ratios, light limitation, and cyanobacteria dominance in a subtropical lake impacted by non-point source nutrient pollution. *Environmental Pollution* 122: 379-390.
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- Havens, K.E. and W.W. Walker. 2002. Development of a total phosphorus concentration goal in the TMDL process for Lake Okeechobee, Florida (USA). *Lake and Reservoir Management* 18: 227-238.

James, R.T., J. Martin, T. Wool, and P.F. Wang. 1997. A sediment resuspension and water quality model of Lake Okeechobee. *Journal of the American Water Resources Association* 33: 661-680.

RECOVER. 2004. CERP Monitoring and Assessment Plan: Part 1, Monitoring and Supporting Research. Restoration Coordination and Verification Team, c/o United States Army Corps of Engineers, Jacksonville District, Jacksonville, FL, and South Florida Water Management District, West Palm Beach, FL.

