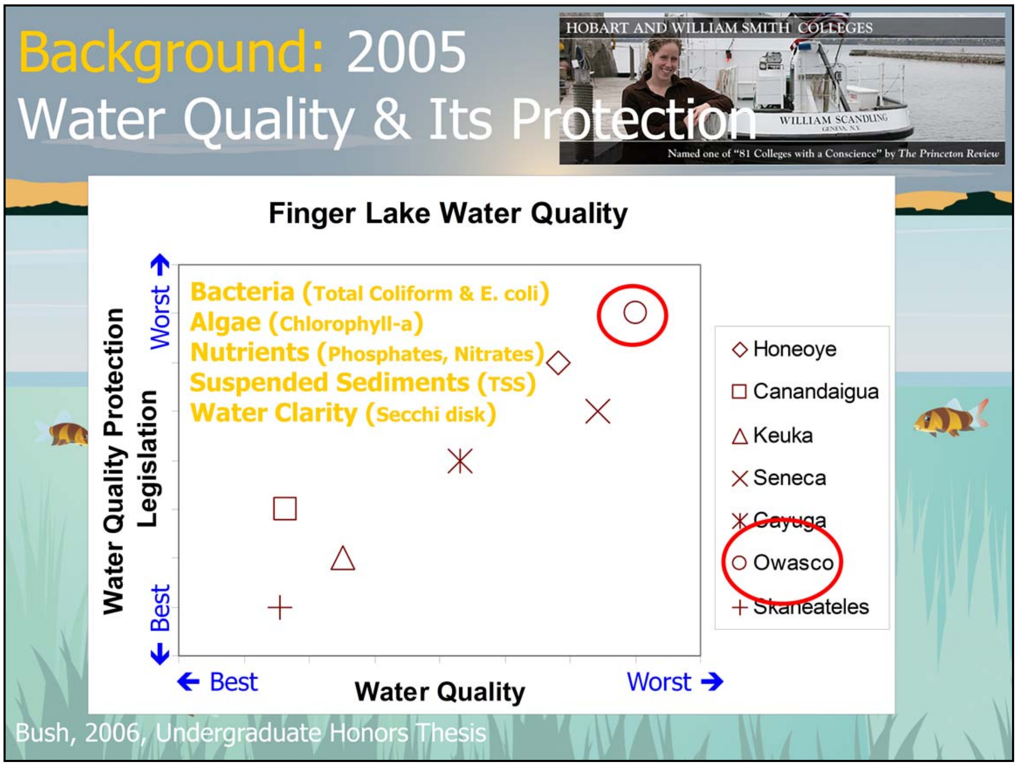
Introductions

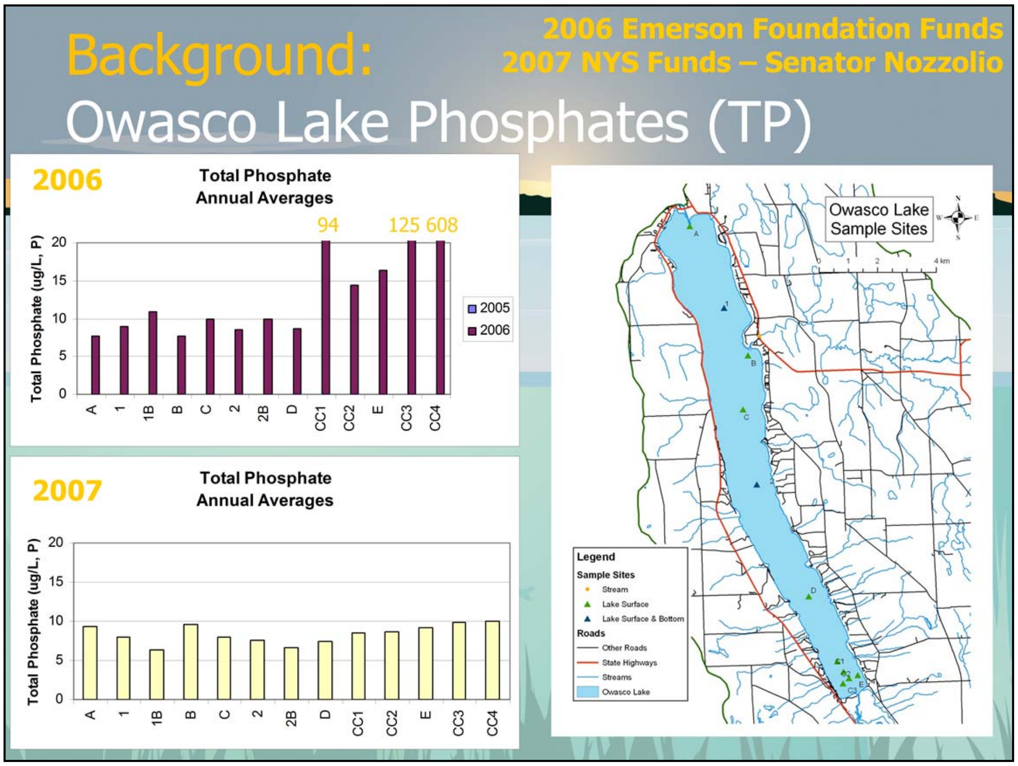
Halfman apologizes for not presenting this talk himself.

A family reunion took precedent.



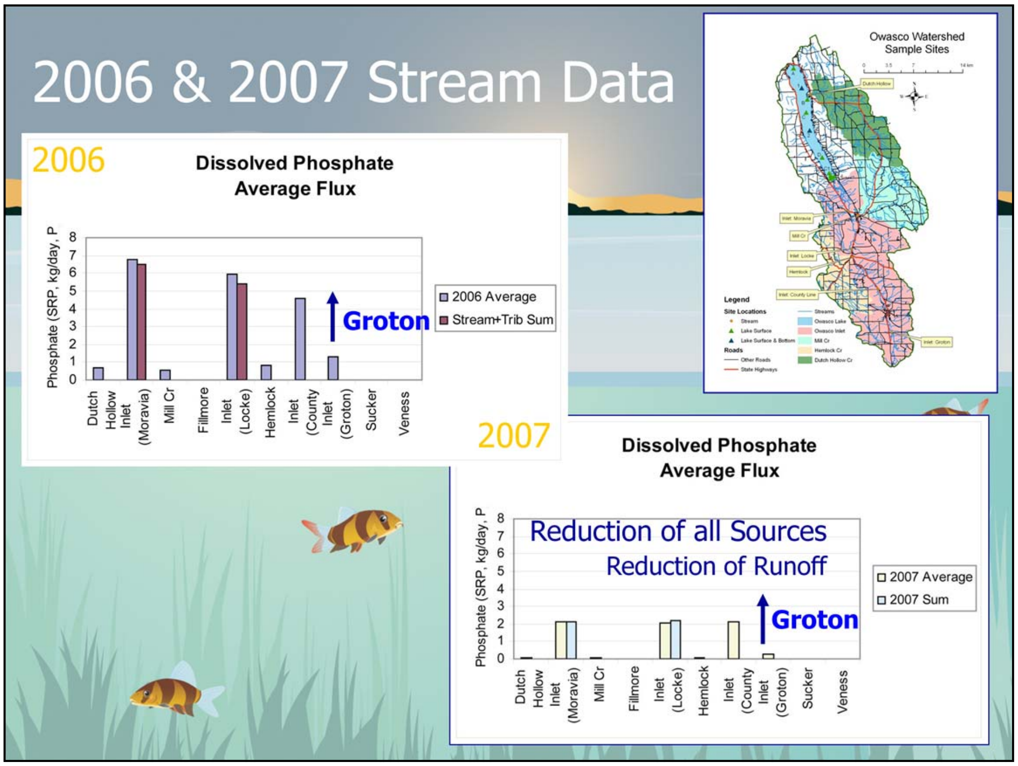
The beginnings

Preliminary water quality comparison of the Finger Lakes by Dr Bush (former student honor's thesis) indicated that Owasco Lake had one of the worst and Skaneateles, Canandaigua & Keuka had the best water quality among the seven easternmost Finger Lakes. Watershed management may play a role in this rank, as Skaneateles, Canandaigua and Keuka spend considerable time, energy and money to keep their lakes clean. Since 2005 bacteria analyses were discontinued due to limited funding.



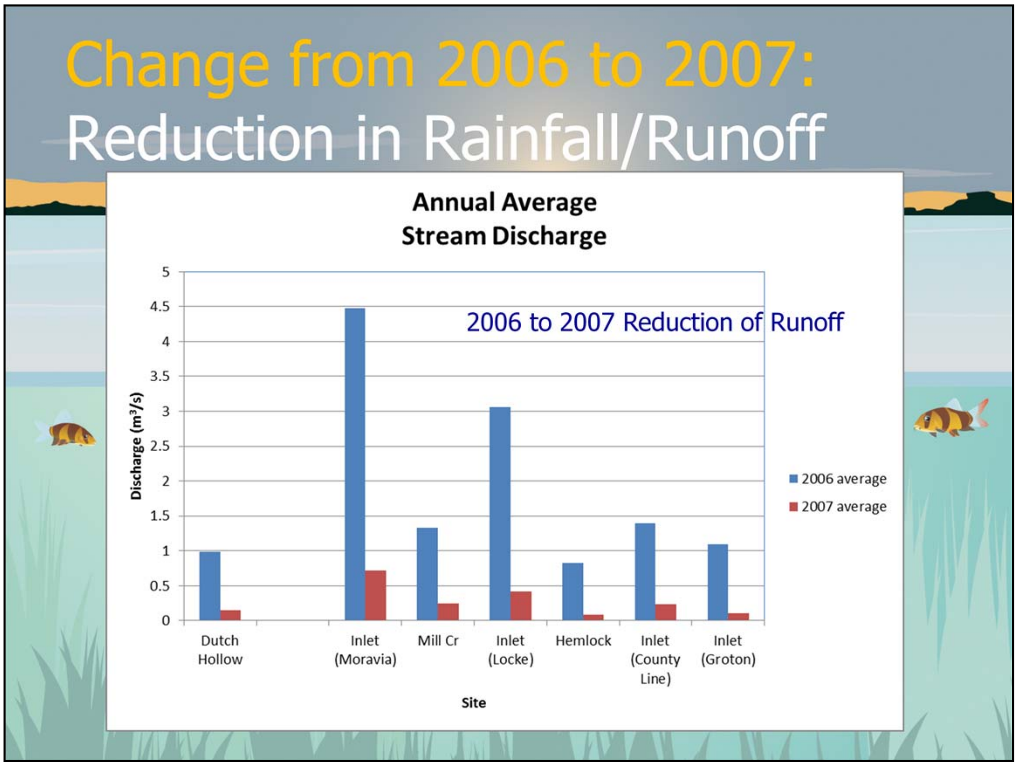
Lake data collected in 2006 showed phosphorous sources at southern end of the Lake – runoff from the Owasco Inlet – especially after heavy rainfall events.

These impairments were not detected in 2007. The difference between 2006 and 2007 was the amount of rainfall. More rain in 2006 generated more runoff of phosphorus in 2006 than in 2007.

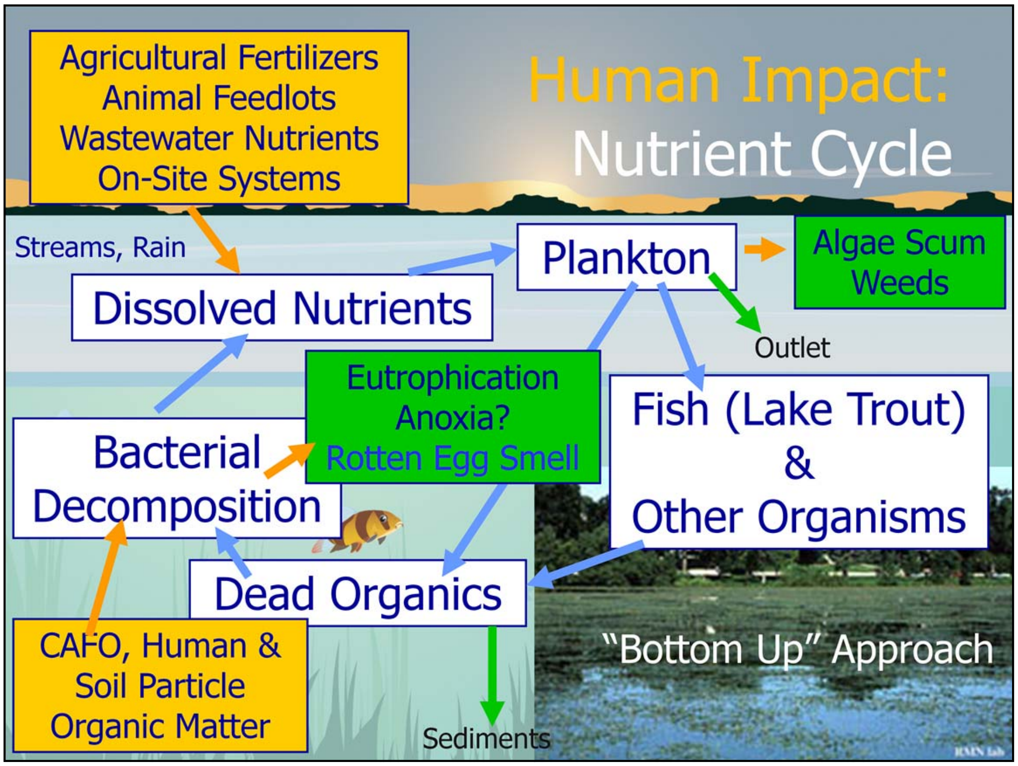


Stream data from 2006 & 2007 revealed following insights:

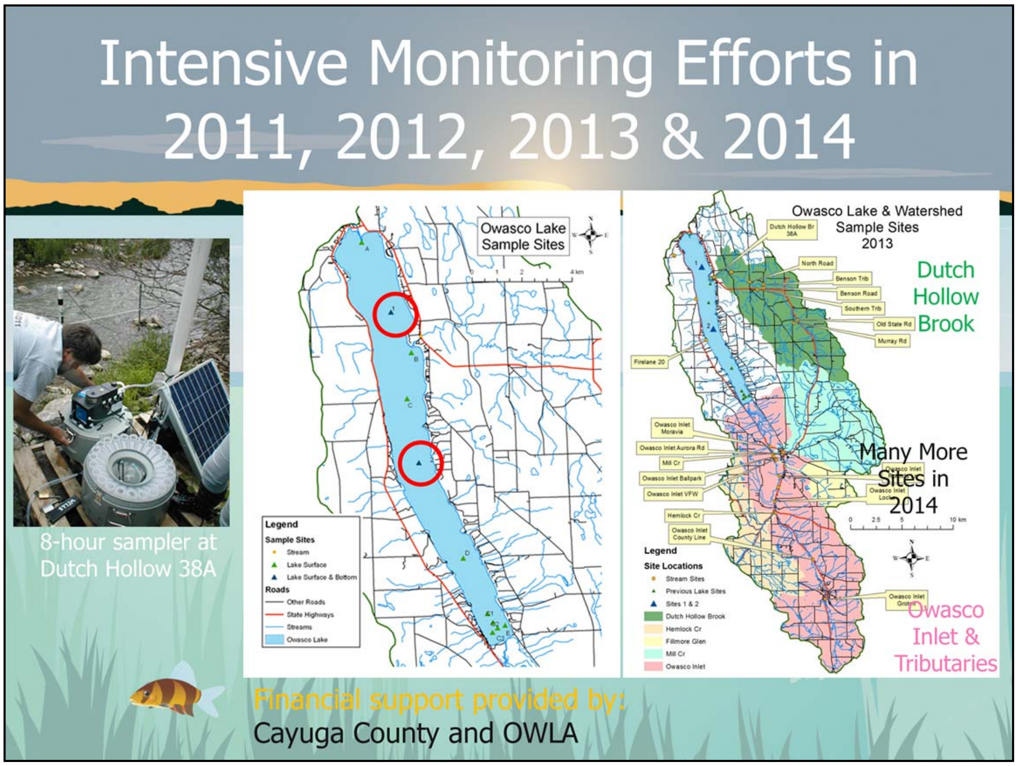
A point source of phosphorus between the Groton and County Line sites, the Groton wastewater treatment facility. Nonpoint sources from other areas, especially agricultural land. A marked decrease in phosphorus inputs at all sites from 2006 to 2007 was partly due to DEC mandated reductions in phosphorus release form Groton Facility. The decrease in phosphorus inputs from 2006 to 2007 was also a response to a reduction in rainfall, thus less runoff of phosphorus, from 2006 to 2007.



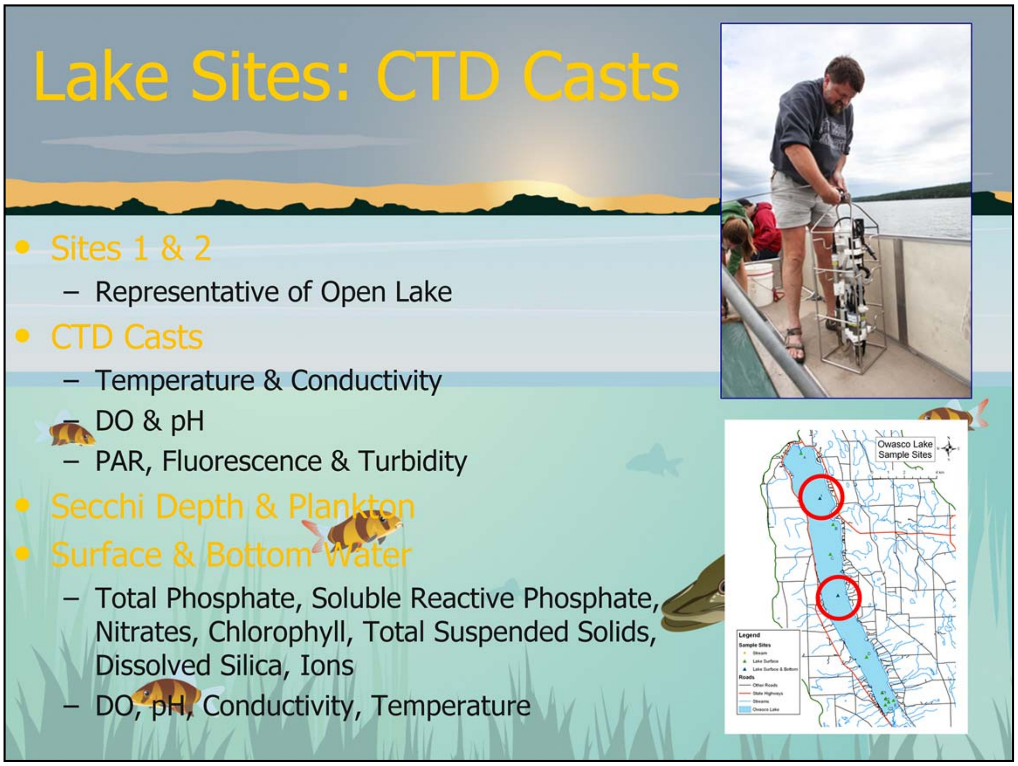
The reduction in rainfall from 2006 to 2007 is also reflected in and parallels a reduction of stream discharge from 2006 to 2007.



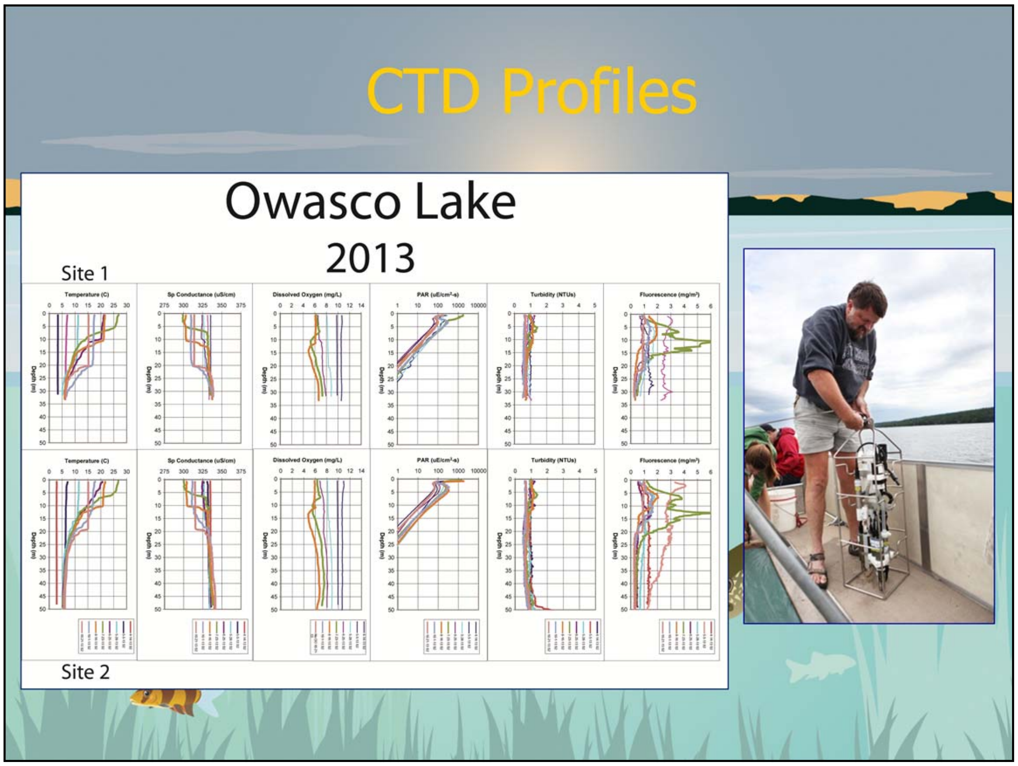
Phosphorus inputs to the lake are critical because this nutrient fuels growth of ecosystems by stimulating the growth of more plankton (algae). A simple nutrient cycle shows how nutrients enters the ecosystem, and once in the nutrient cycle typically stay and accumulate in the ecosystem (Owasco Lake) because nutrients are very efficiently recycled and remain within any aquatic ecosystem (e.g., Owasco Lake). The inputs also stimulate an increase in biomass in each step of the nutrient cycle, and if the inputs are intense enough, they can result in: eutrophication, bottom water anoxia, fish kills, excessive algal blooms, and proliferation of near shore weeds. Humans are important agents at releasing additional nutrients to aquatic ecosystems through, e.g., the runoff of fertilizers (both agricultural & lawn care), wastewater treatment facility effluent, septic systems, organic wastes, especially animal wastes from CAFO operations.



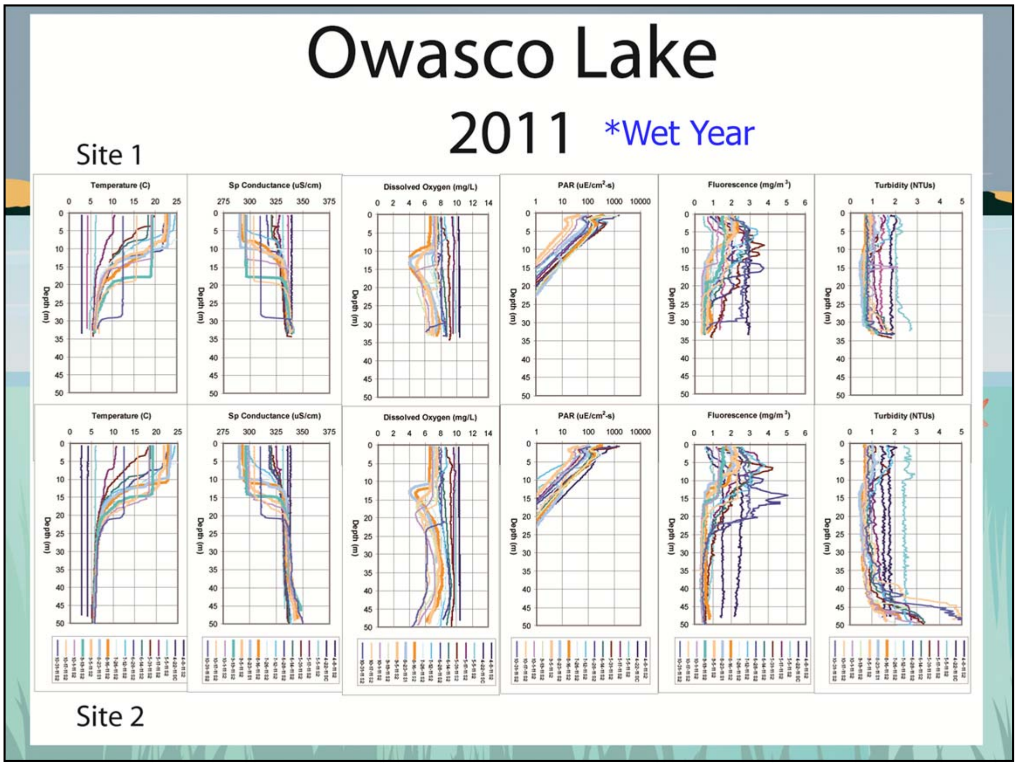
A multiyear investigation started in 2011 to (1) pinpoint sources of phosphorus, focusing on Dutch Hollow Brook and Owasco Inlet, and (2) monitor water quality trends in the lake over time. Financial support was from Cayuga County and other sources.



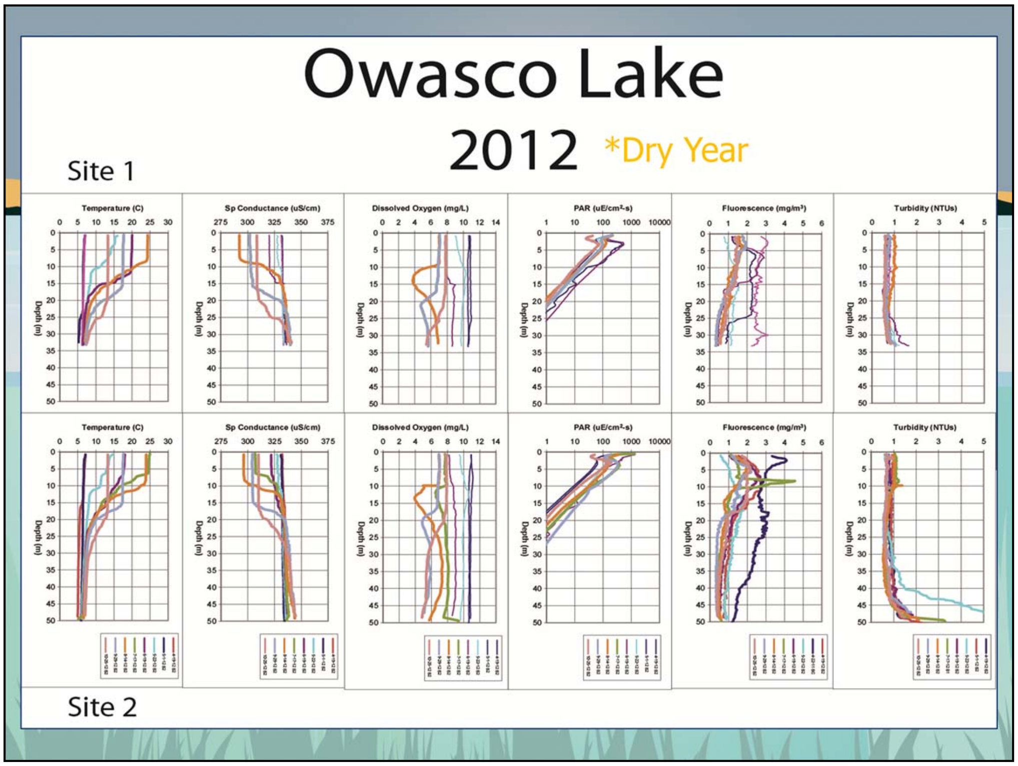
The specific lake analyses and sites to monitor water quality trends over time.



CTD casts depict water column profiles of temperature, salinity (specific conductance), dissolved oxygen, available light, turbidity and algal abundance, and their changes across the lake and over time. The 2013 monthly profiles depict the normal progression of water temperature, water salinity and availability of light, and the steady depletion of oxygen due to the decay/respiration of excess algae by bacterial in the water column through the stratified summer season. Dissolved oxygen concentrations approached those that are stressful for organisms living in the cold bottom waters of the lake, like lake trout.

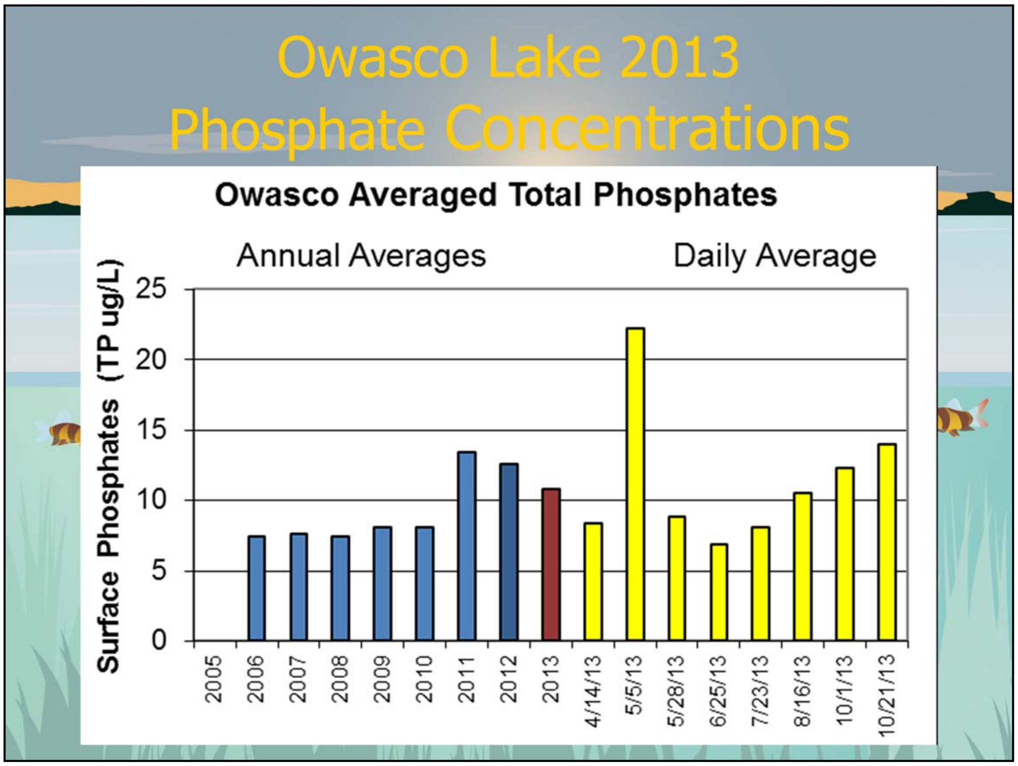


CTD profiles collected in 2001, a wet year, revealed a larger surface water dilution by the extra rainfall in 2011 than 2013, and increased algal and water column turbidity concentrations stimulated by the extra rainfall in 2011 than 2013.

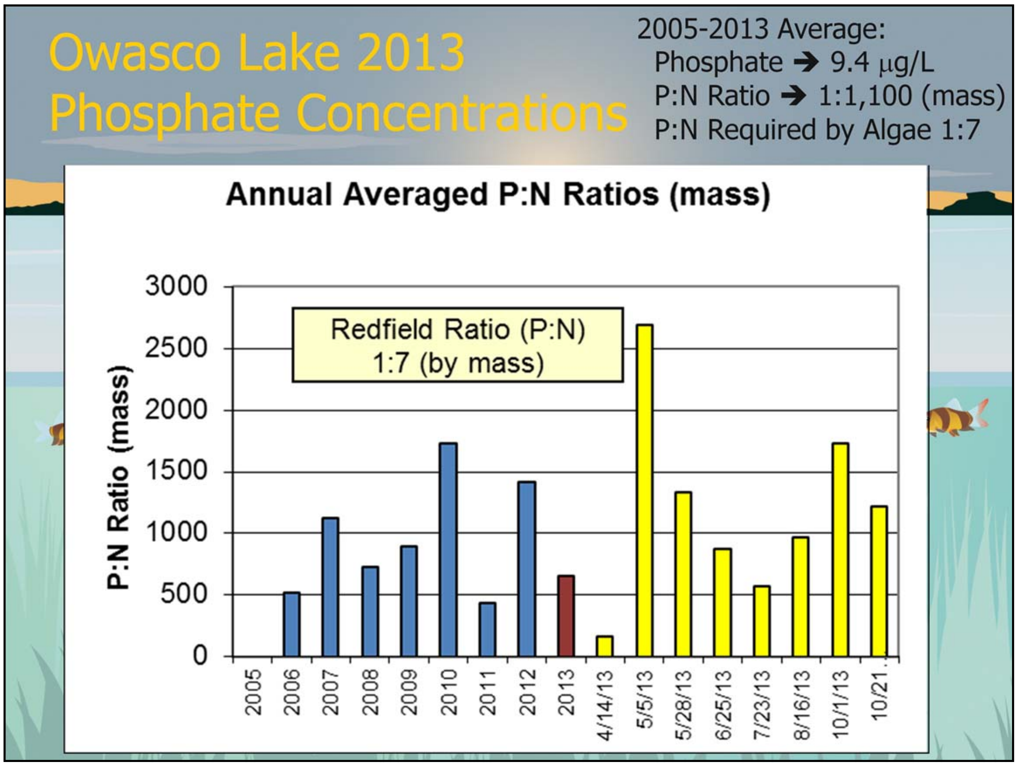


CTD profiles collected in 2012, a dry year, revealed lower dilution of the surface water, and less algae and turbidity in the water column in 2012 than 2013.

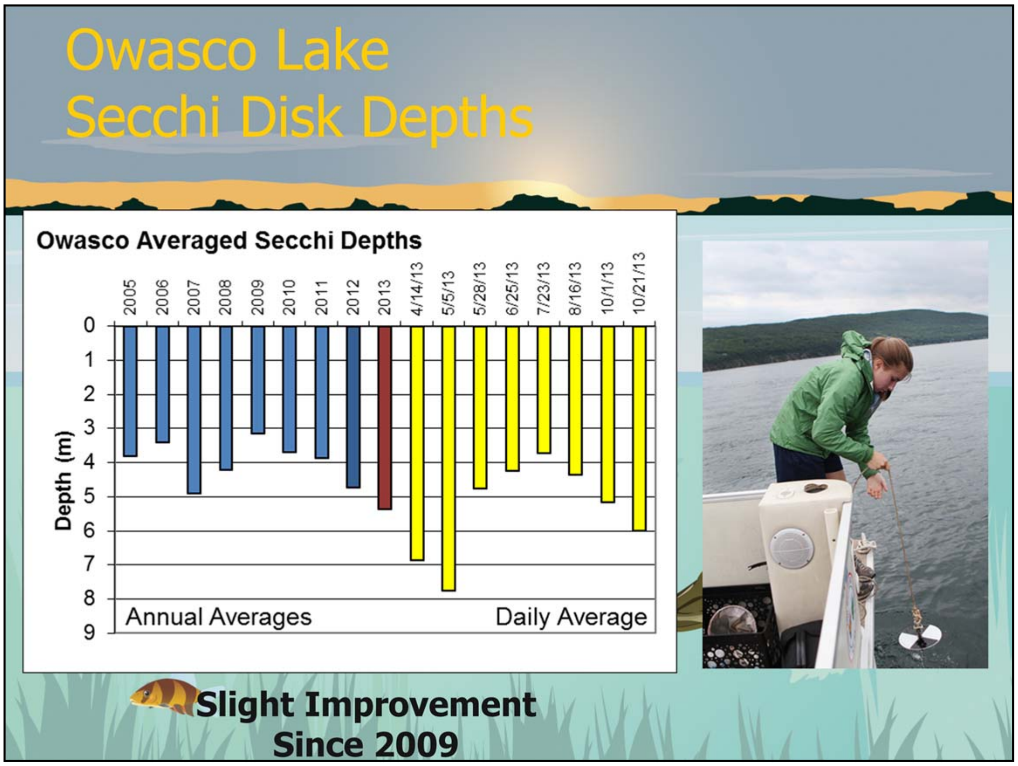
Rainfall and water column impacts during 2013 were in-between those in 2011 and 2012.



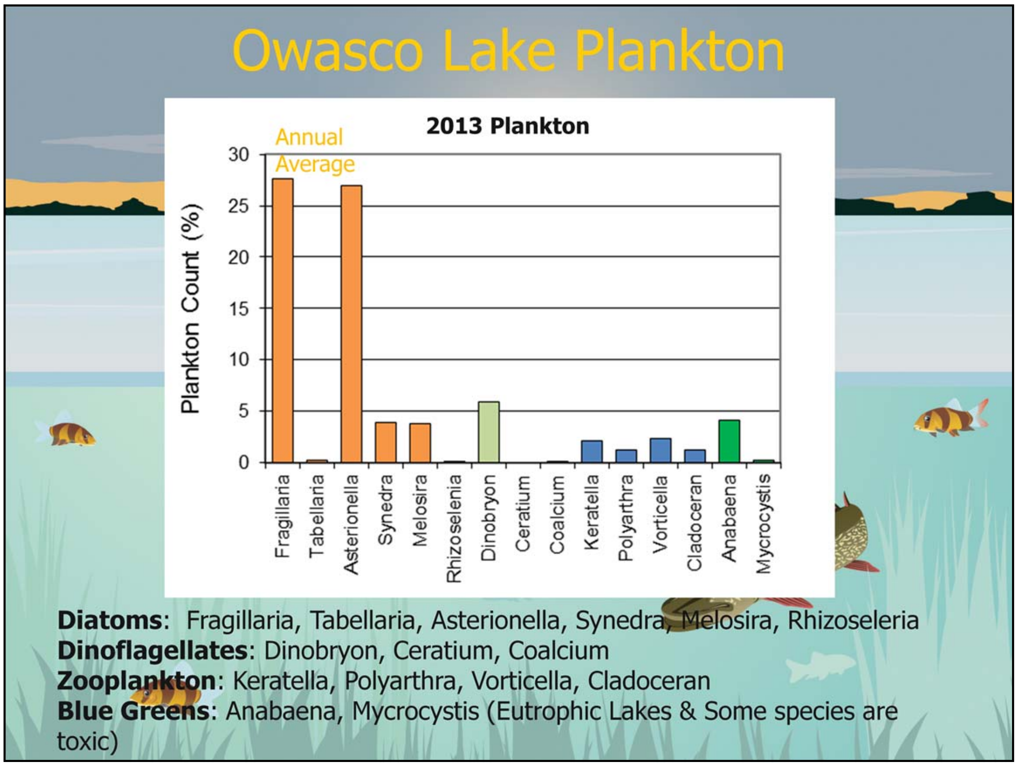
Total phosphorus annual average data (blue), and 2013 monthly (yellow) data. Annual averages suggest higher total phosphorus concentrations in 2011, a wet year. Annual averages suggest a slight improvement in water quality since 2011, the wet year. However the variability from month to month preclude a scientifically sound conclusion.



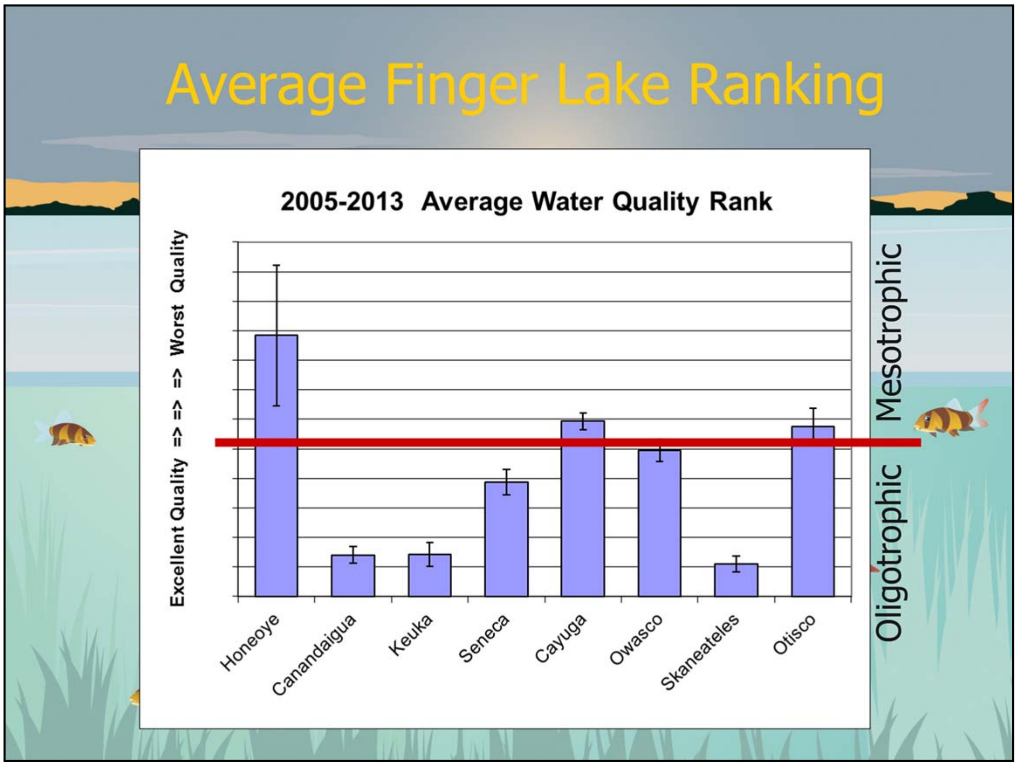
Phosphorus to Nitrogen (P:N) ratios in the water column reveal that phosphorus has always been the limiting nutrient in Owasco Lake. Both P and N are essential nutrients for algal growth, but P is much more scarce in Owasco than N, thus P limits algal growth in the lake. The implication, add more P to the lake, and the ecosystem will grow.



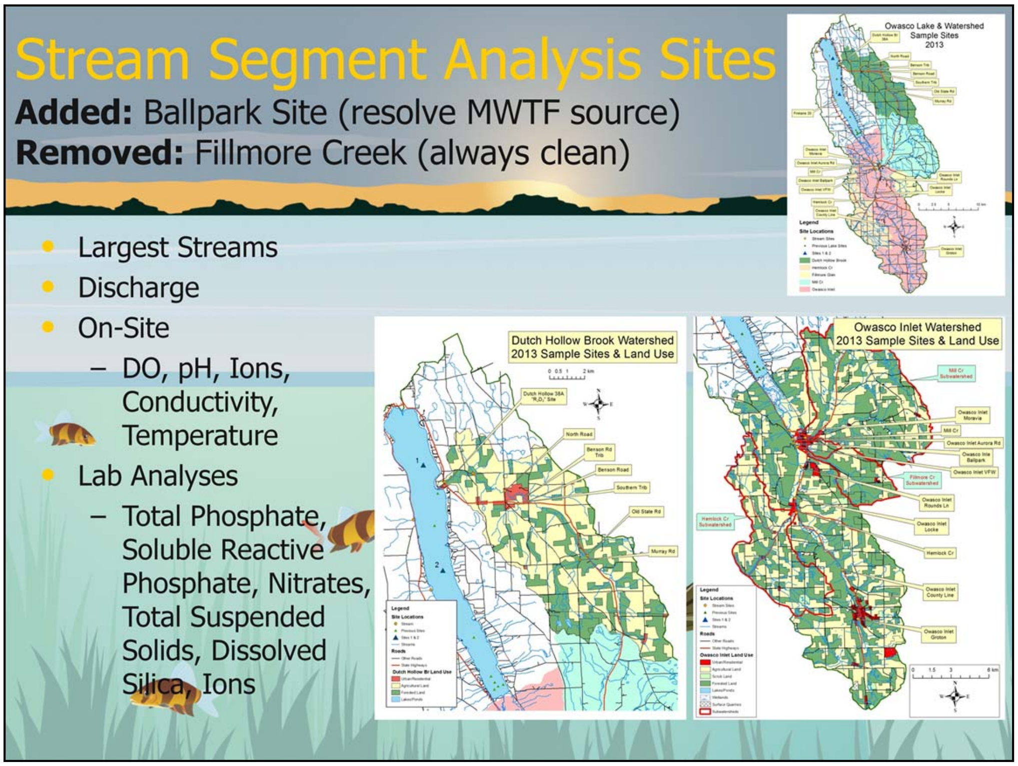
Secchi disk depths reveal water quality/clarity, in that, deeper Secchi depths reflect clearer water due to less algae and less suspended sediments. Annual average Secchi depths (blue), and monthly depths (yellow) are shown. Annual averages suggest a slight improvement in water quality since 2009. However the variability from month to month in any year preclude a scientifically sound conclusion.



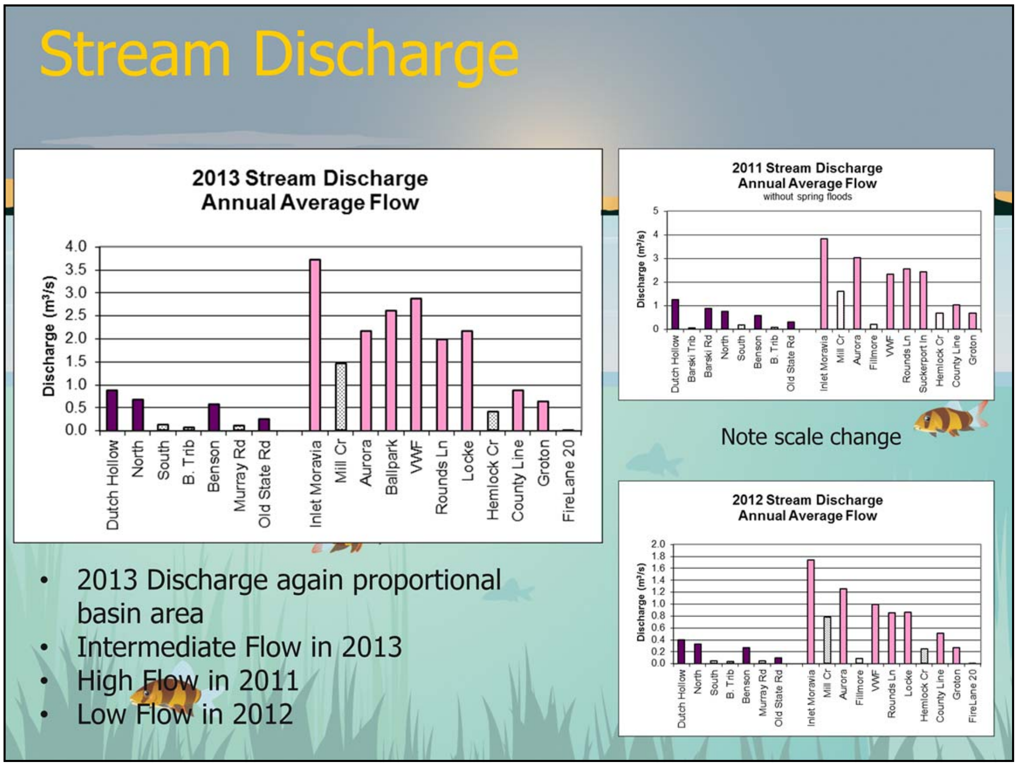
Plankton (both phytoplankton, i.e., algae, and zooplankton) annual mean concentrations. Most of the algae are diatoms, i.e., “good” algae. Some genera of bluegreen algae, aka “yucky algae”, are detected, especially in the late summer of each year. The occurrence of bluegreen algae are disturbing because they are typically found in eutrophic lakes, form algal surface water scums, and some strain of bluegreen algae are toxic to warm blooded animals like humans.



Owasco Lake still ranks as one of the worse Finger Lakes. The slight change in order from the initial ranking in 2005 is, in part, due to the discontinuance of measuring bacteria concentrations after the initial survey in 2005.

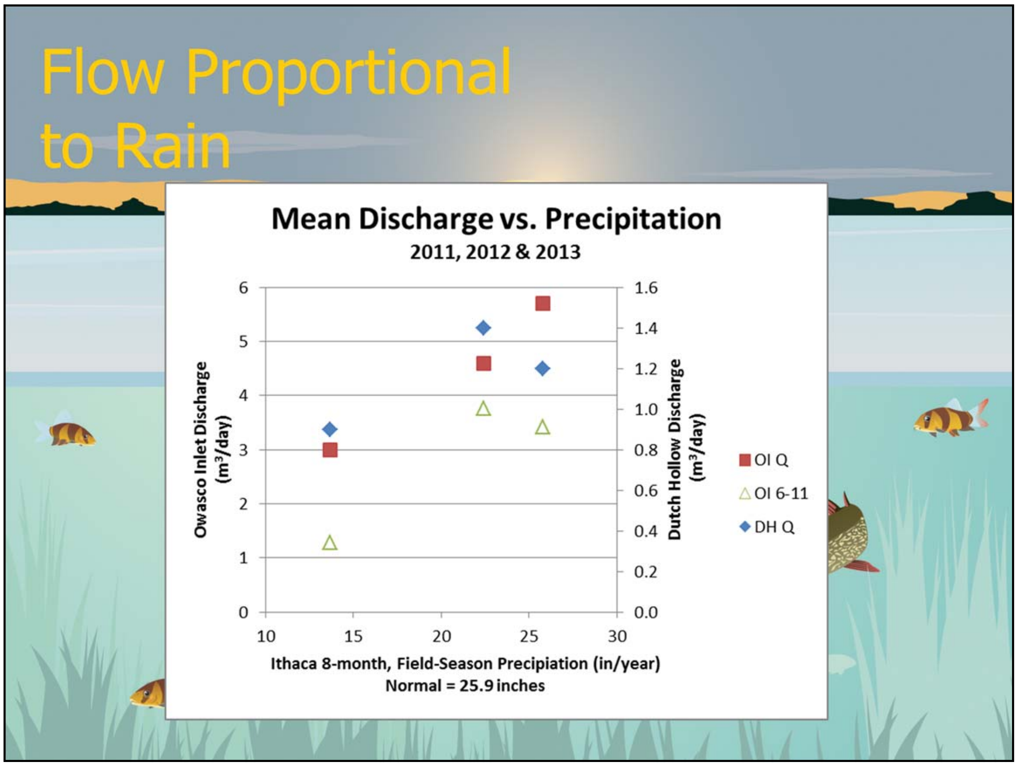


The specific stream analyses and site locations to find sources of phosphorus to the lake.

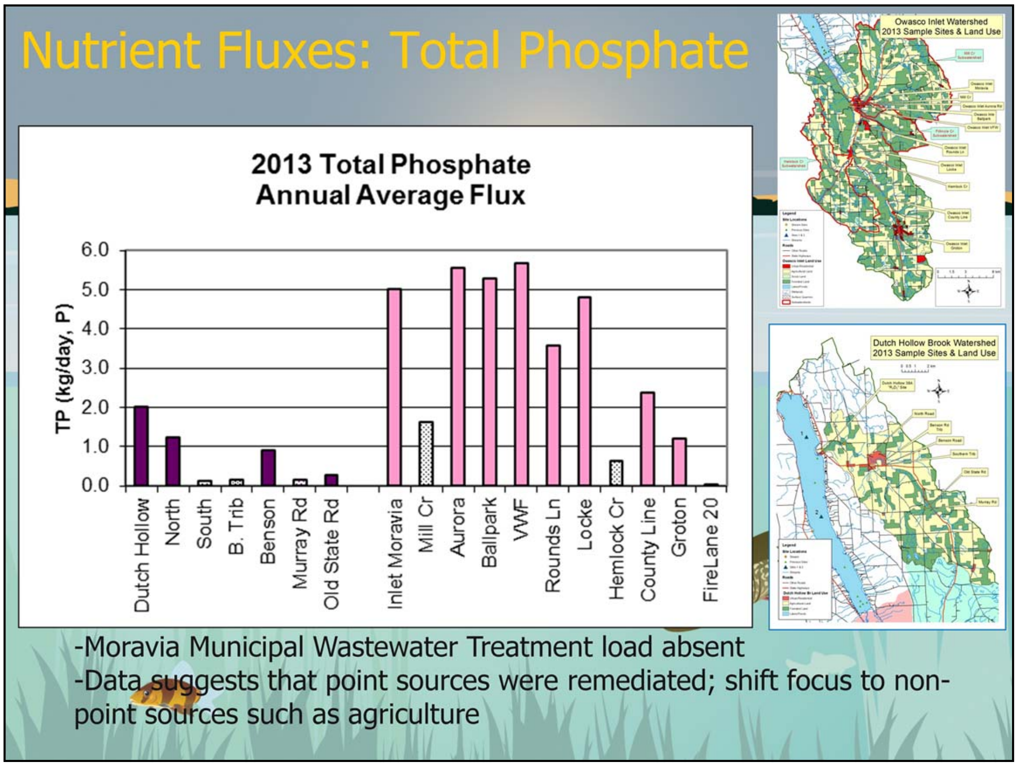


Annual average stream discharge at the stream sites in 2013 typically increases downstream as expected in both Dutch Hollow Brook (purple) and Owasco Inlet (pink). Tributaries to each stream are stippled.

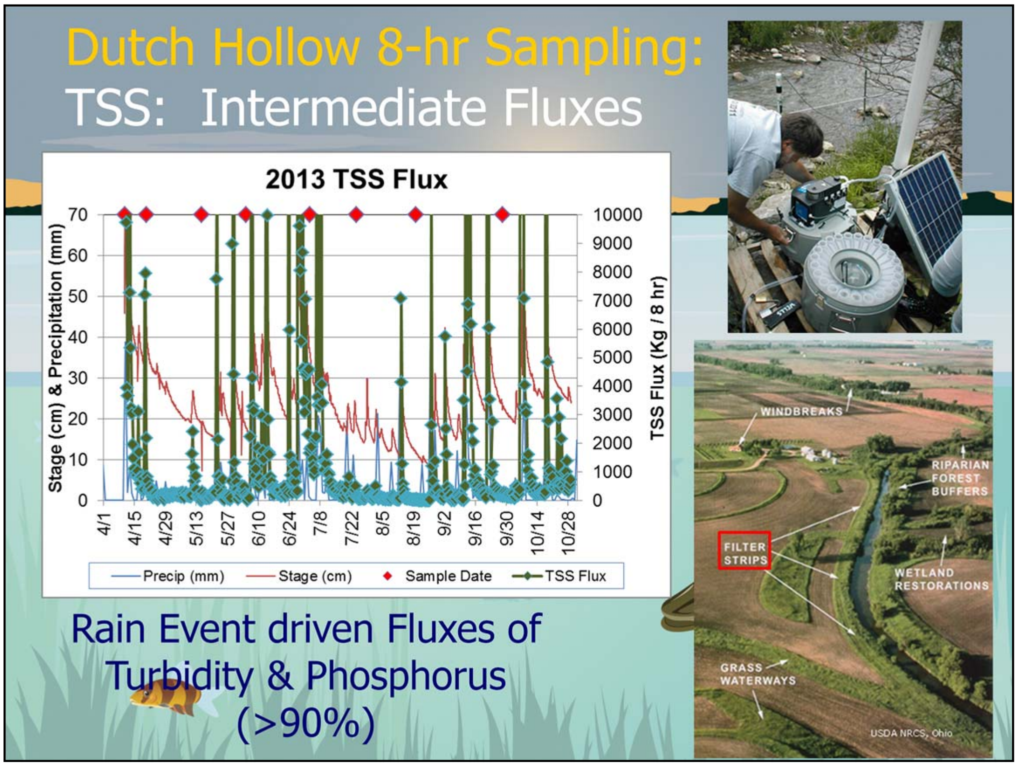
Two observations are apparent: (1) Discharge is largest in Owasco Inlet because discharges are proportional to basin areas, and (2) changes in discharge from 2011 through 2013 parallels changes in precipitation.



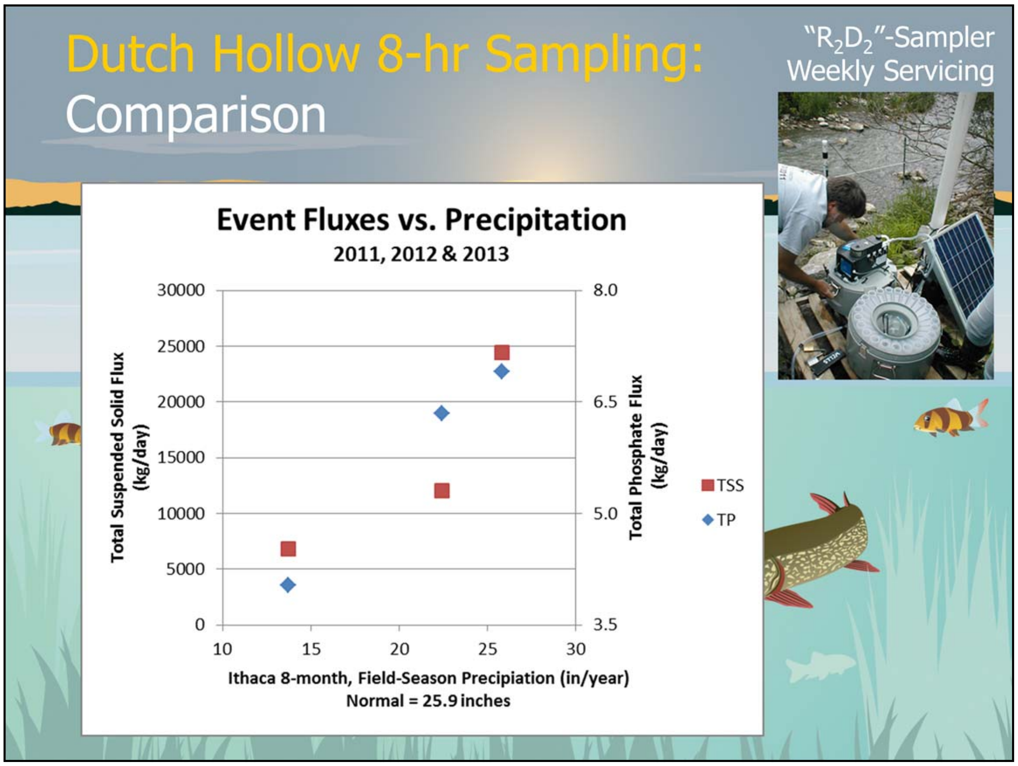
A positive correlation between discharge and precipitation (measured at the Ithaca Airport).



Annual average total phosphorus fluxes at the stream sites reveal small, if any, inputs form the Moravia and Groton wastewater treatment facilities in 2013, and additional unknown sources of phosphorus upstream of Locke along the Owasco Inlet. Agricultural land is a major nonpoint source of phosphorus. The Owasco Inlet is the largest source of phosphorus to the lake, followed by Dutch Hollow Brook. The tributary at Firelane 20 provides very little phosphorus, yet the data may reflect the timing of the sample collection and the relatively small size of the drainage.

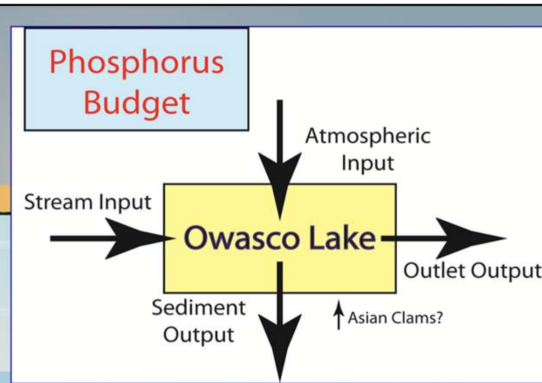


Samples collected every 8 hours a Dutch Hollow Brook by the autosampler reveal that the vast majority (over 90%) of the suspended sediments and phosphorus are delivered to the lake are, in turn, delivered to the stream by precipitation events. Thus, to reduce nutrient loading requires a reduction of the impact by storm water runoff over open fields and bare land through established BMPs (e.g., buffer strips, gully plugs, drainage ponds, wetland restorations). However, land owners can not be expected to pay o the entire cost to preserve water quality in Owasco Lake.



Variability in phosphorus and suspended loads between 2011, 2012 and 2013 parallels changes in rainfall. More rainfall, more nutrient loading.

Detailed Phosphorus Budget Past Three Years



Year	Total Inputs (tons/yr)	Total Output (tons/yr)	Net (tons/yr)
2011 wet	16.4	4.4	12
2012 dry	2.6	4.4	-1.8
2013 between	8.4	5.9	2.5

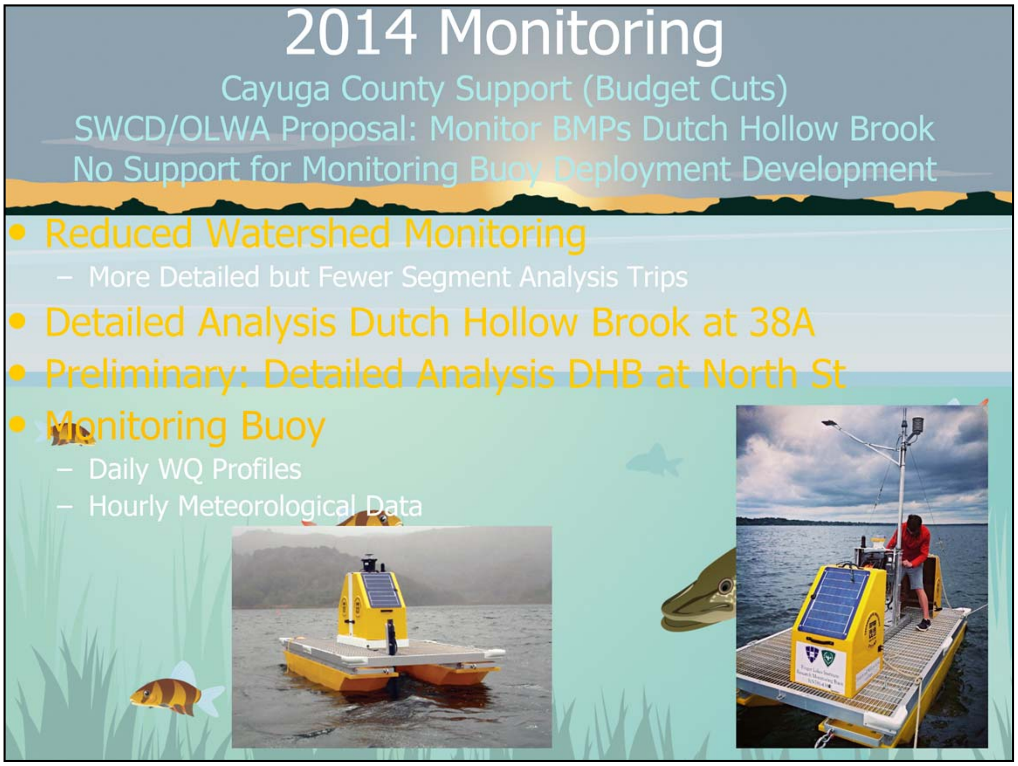
The lake's annual phosphorus budgets oscillates between more phosphorus entering the lake than being removed (in 2011 and 2013) to less phosphorus entering the lake than being removed (in 2012). The relationship indicates that effective reduction of phosphorus inputs during rainy years will place Owasco Lake in a negative nutrient balance, and the lake will "clean up" over time. The amount of phosphorus in the manure spills this past winter and spring are significant to the phosphorus budgets estimated here.

Summary:

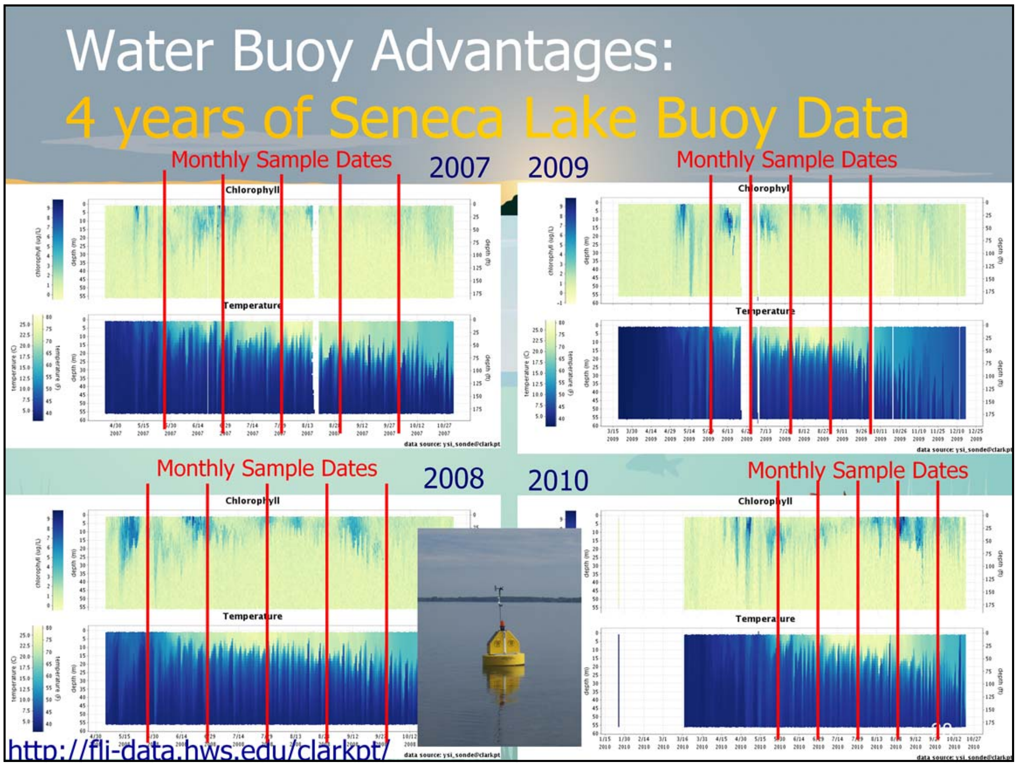
Rainfall intensity and amounts impact nutrient loading. To improve water quality in the lake, sources of phosphorus, like the specific examples listed above, must be curtailed.

Agriculture can be a significant source of phosphorus to the lake, especially when farms expand from a few cows / farm to Concentrated Animal Feedlot Operations (CAFOs). Great care must be used to spread the accumulating manure in a safe and environmentally sound manner. Spreading manure on snow covered fields is not wise, because the material is not as readily absorbed by the soil during the winter months, and instead will runoff into the lake during the next rainfall or snow melt event.

Many options exist to reduce inputs from CAFOs. As an analogue, humans must ship organic waste to municipal wastewater treatment facilities for proper disposal when their numbers/density exceed limits for alternative on-site disposal by septic systems or outhouses, i.e., when humans live in large towns, villages and cities. Should CAFO wastes, where the relative density of animals is also huge, be treated in a similar manner? However, it is an expensive option.



The monitoring effort in 2014 had to be curtailed due to cuts (20%) in the Cayuga County budget. State funding for BMP monitoring in Dutch Hollow Brook has yet to arrive. I'd also like to establish a monitoring buoy in the lake. It would provide two water column profiles a day, and mean hourly meteorological data.



Daily water column profiles would provide a detailed look at the lake. Like the 8-hour stream autosamplers, a buoy would not miss events potentially missed by monthly sampling strategies. Thus a buoy would more accurately reveal the annual change in water quality in the lake than monthly or bi-monthly monitoring. Shown here are 4 years of monitoring buoy data from Seneca Lake. Notice, the routine monthly sampling (red lines) missed the majority of the algal blooms in the lake detected by the buoy. FLI has already spent over $100,000 to purchase a buoy, and it is currently deployed in Owasco Lake. We are still looking for ongoing support for the required maintenance and calibration.

Please direct any questions to John Halfman, email: halfman@hws.edu, office: 315 781-3918.

Annual reports detailing the Owasco Lake monitoring effort are available at the bottom of Halfman's website: http://people.hws.edu/halfman/