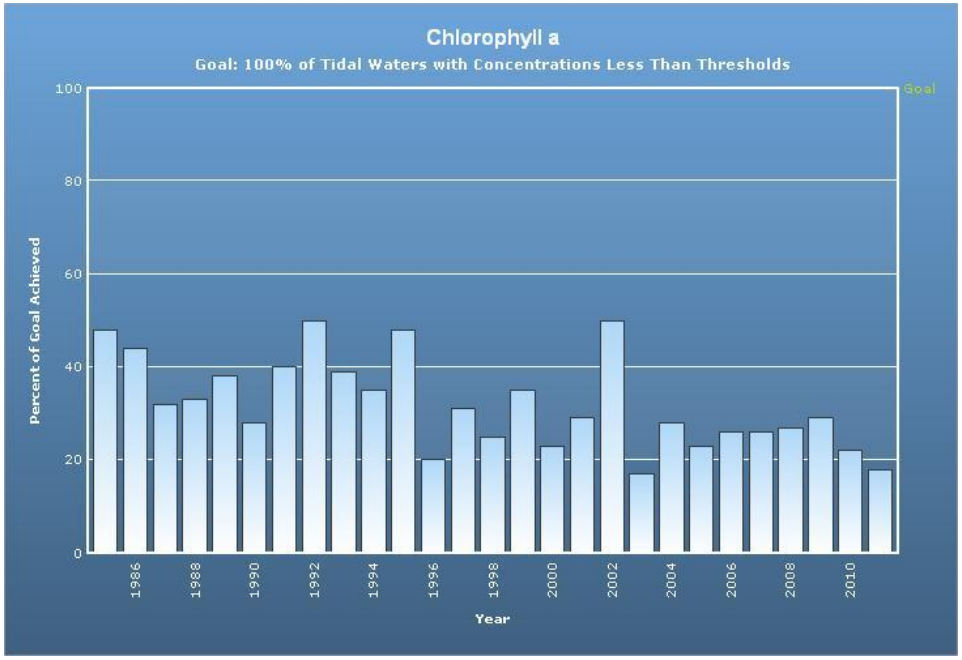
Re-Evaluating the Chlorophyll a Trend Explanation

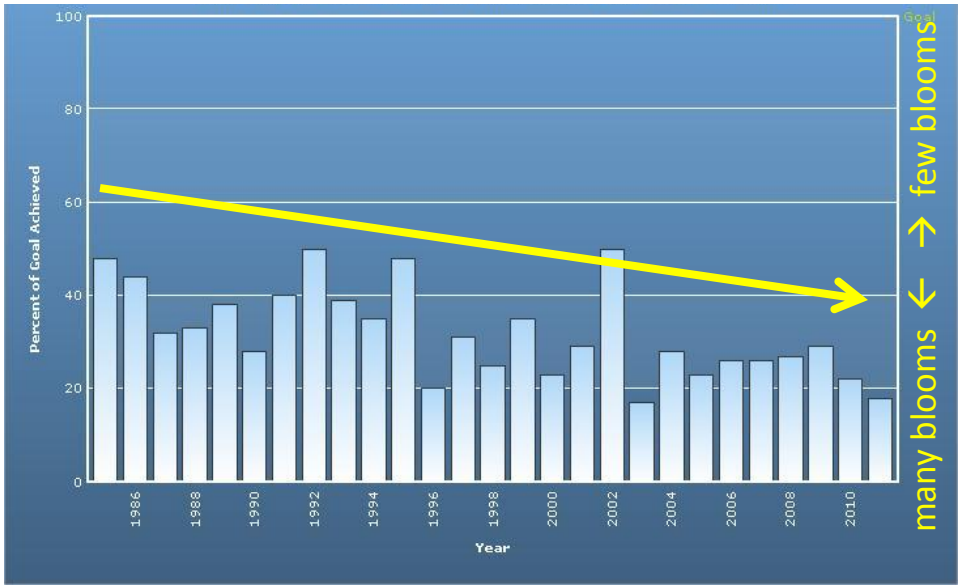
March 27, 2013
Joint TMAW/NTWQ workgroup meeting

% Attainment of Chl a Goal



GOAL: 100% of Chesapeake Bay tidal waters below certain threshold concentrations of chlorophyll *a* that are acceptable to underwater bay grasses.

% Attainment of Chl a Goal



% Attainment of Phytoplankton Goal

Why re-evaluate Chl a trend explanation?

It doesn't agree with trend in phytoplankton.

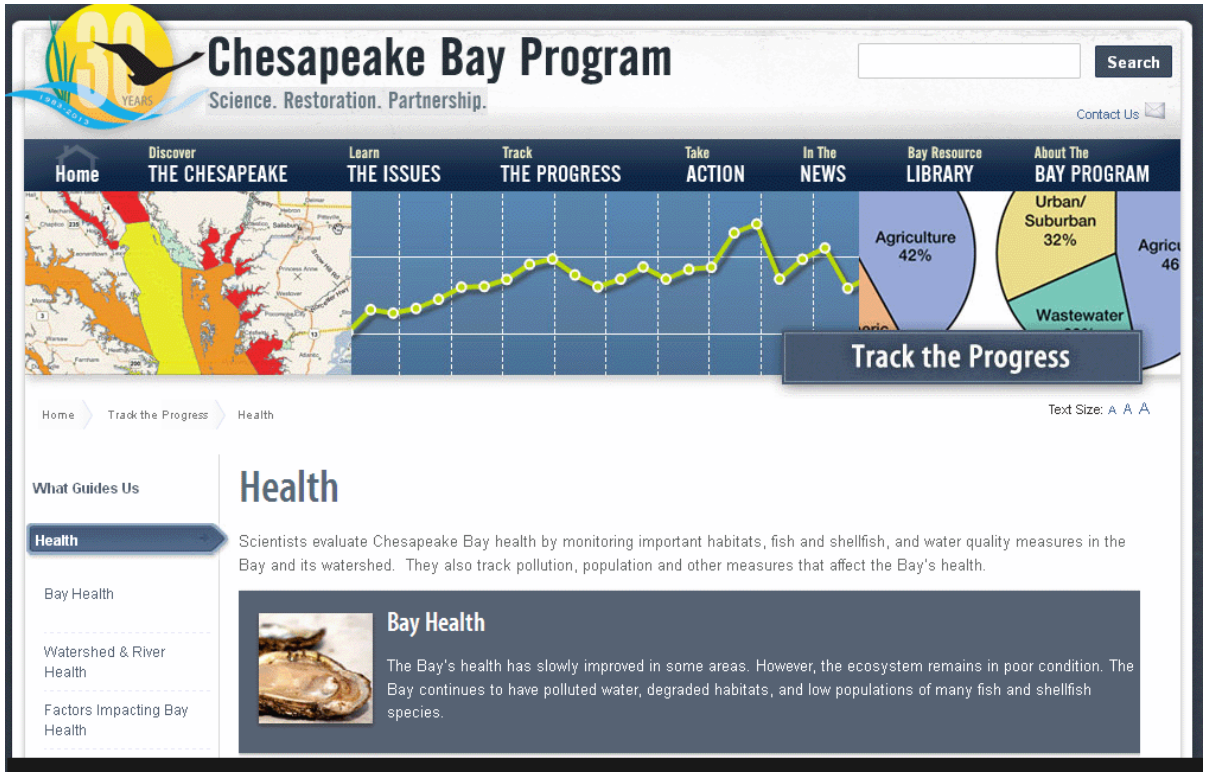
Phytoplankton Index of Biotic Integrity

Goal: 100% of sites with PIBI score ≥ 3 on a scale of 1-5

- multi-metric index

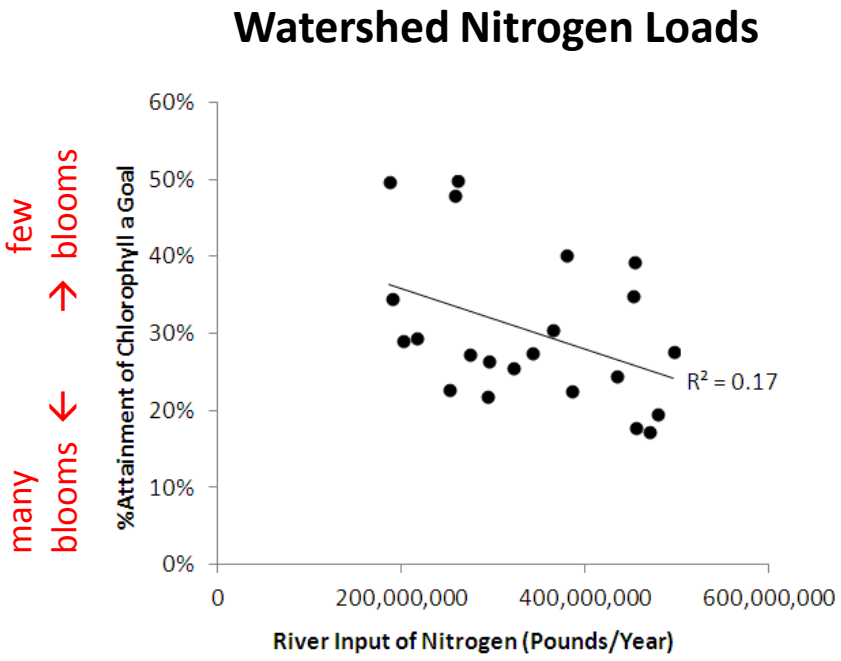
  Chl a pheophytin DOC C:Chla
  taxa biomasses taxa abundances

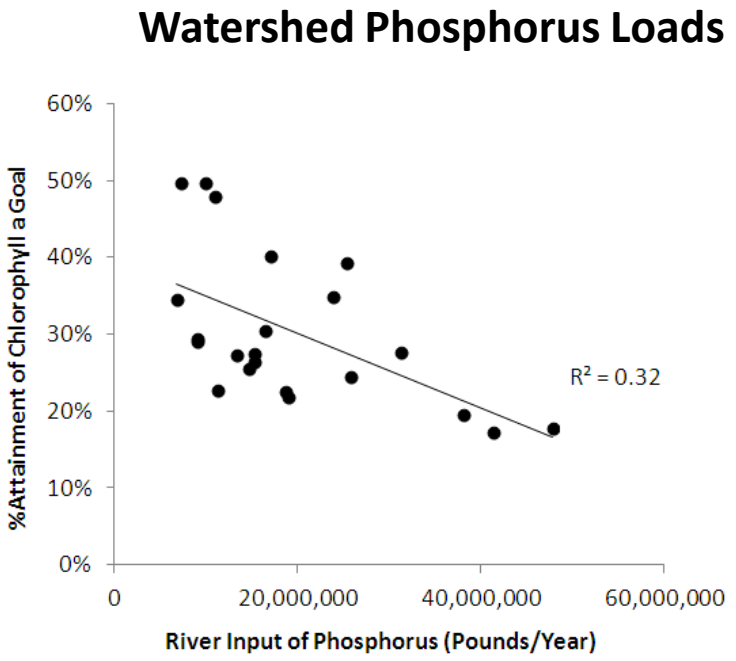
- biomasses determined from phyto counts
- sensitive to changes in water quality
- re-validation confirms Lacouture *et al.* 2006 in Estuaries
- a better all-around indicator of phytoplankton community status than Chl a



- "The goal is for 100 percent of Chesapeake Bay tidal waters to be below certain threshold concentrations of chlorophyll *a* that are acceptable to underwater bay grasses.

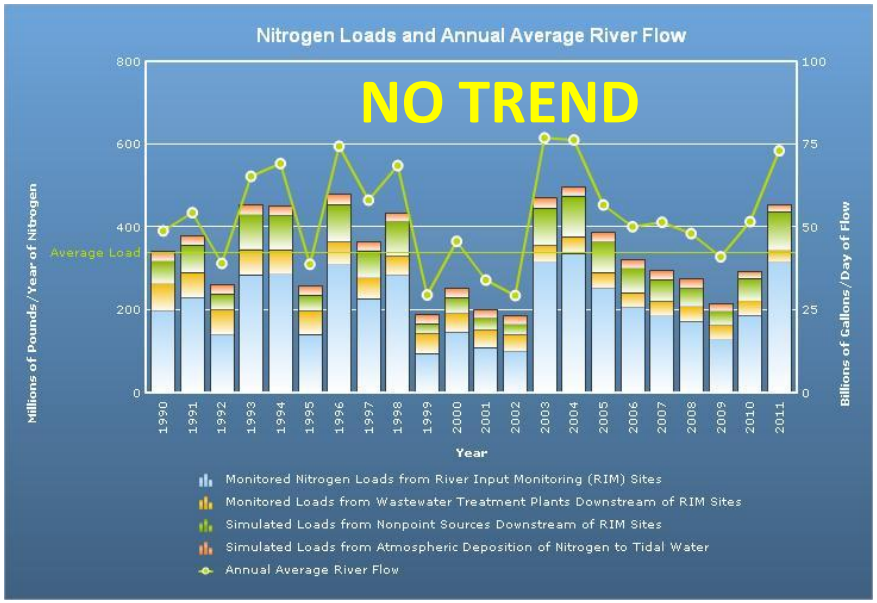
- "The goal is for 100 percent of Chesapeake Bay tidal waters to be below certain threshold concentrations of chlorophyll *a* that are characteristic of healthy phytoplankton, the base of open-water food webs. These levels are also acceptable to the Bay's underwater grasses.



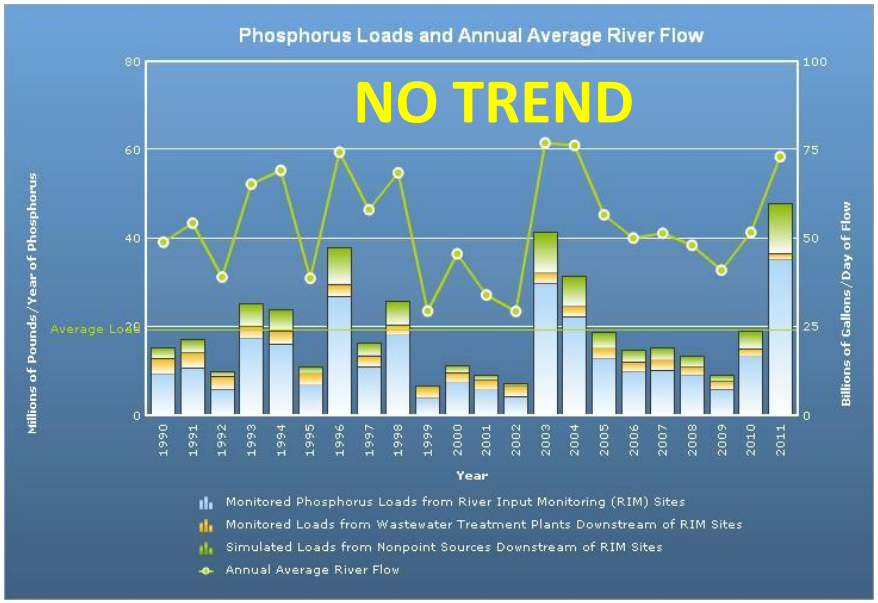


• "High chlorophyll *a* concentrations are generally a response to <u>increased nutrient inputs</u> to the Bay

Watershed Nitrogen Loads



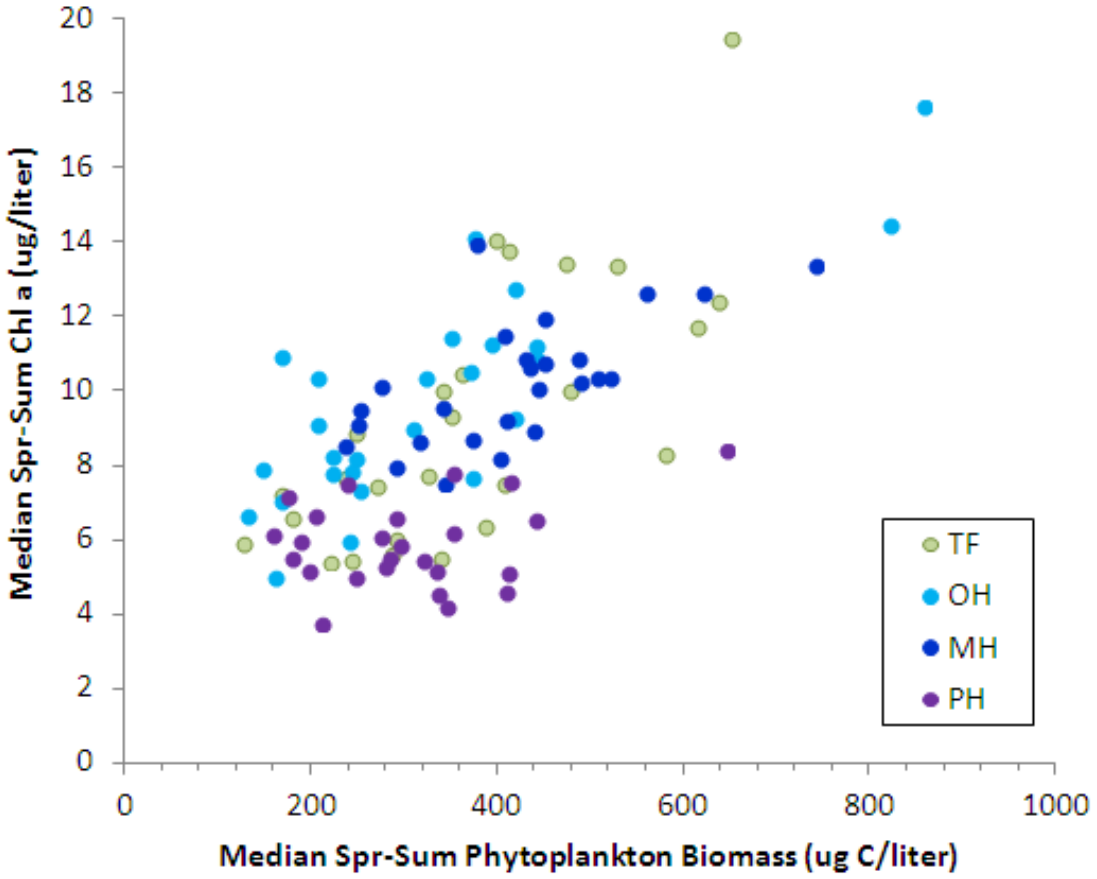
Watershed Phosphorus Loads



• "High chlorophyll *a* concentrations are generally a response to increased nutrient inputs to the Bay

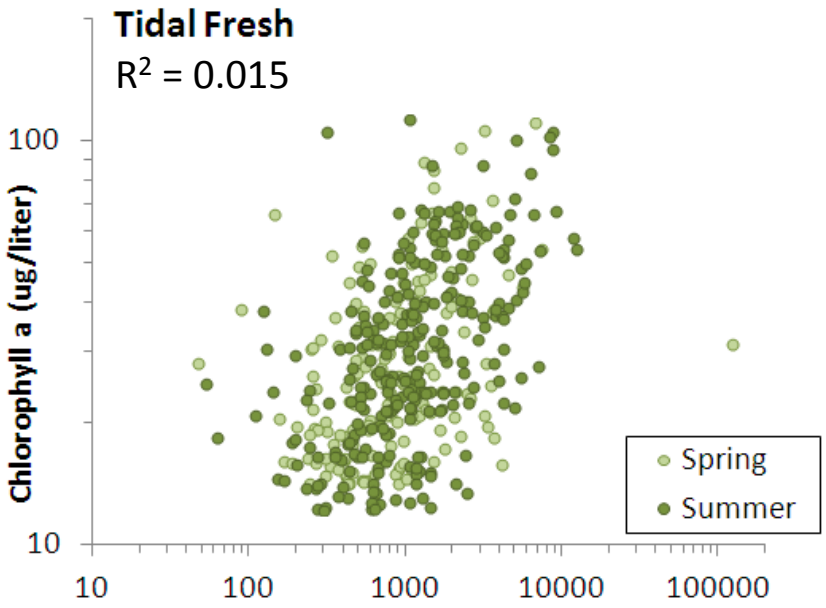
• High chlorophyll *a* concentrations are a response to many factors in Bay waters, especially excess nutrient concentrations, poor water transparency (clarity), weather, and a lack of grazers.

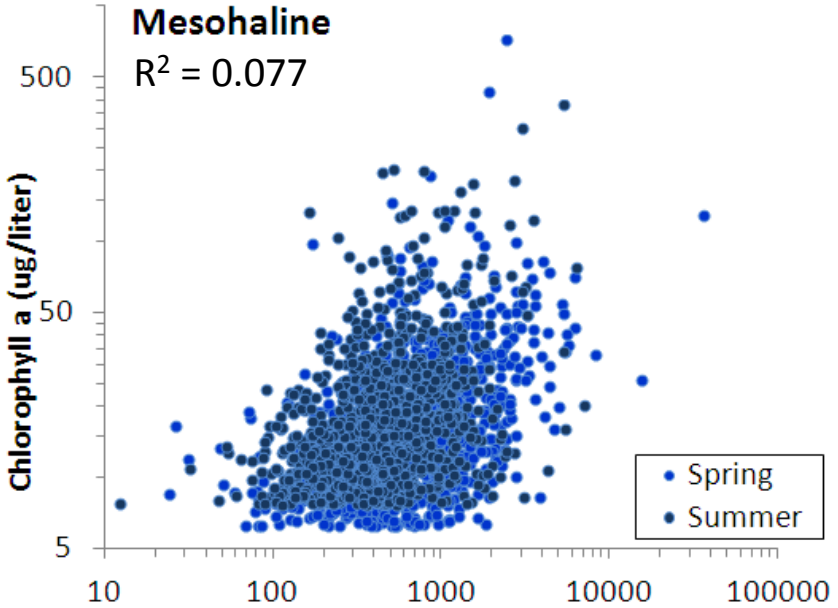
Seasonal Chl a vs Seasonal Phytoplankton Biomass

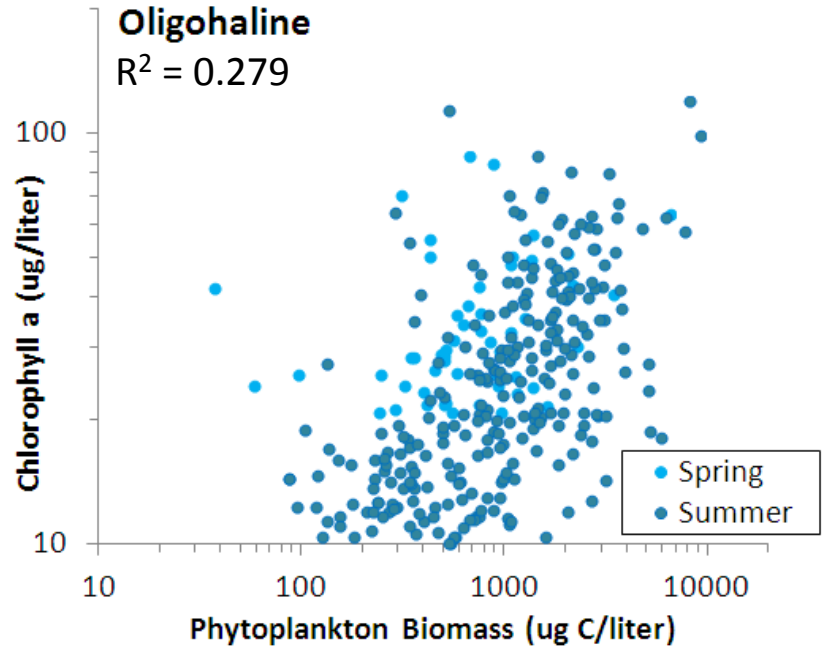


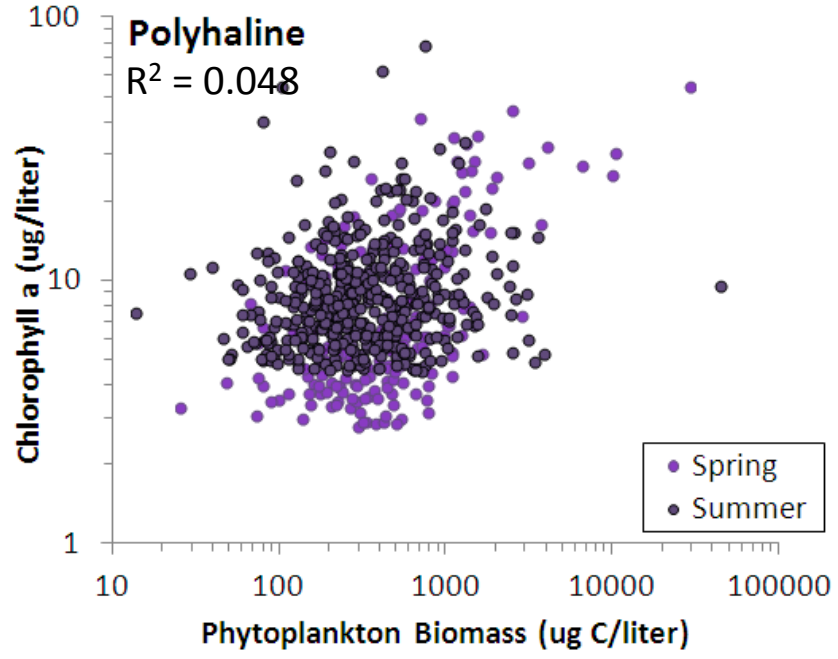
$R^2 = 0.44$

• "High chlorophyll *a* concentrations are … indicative of high algal biomass in the water column."



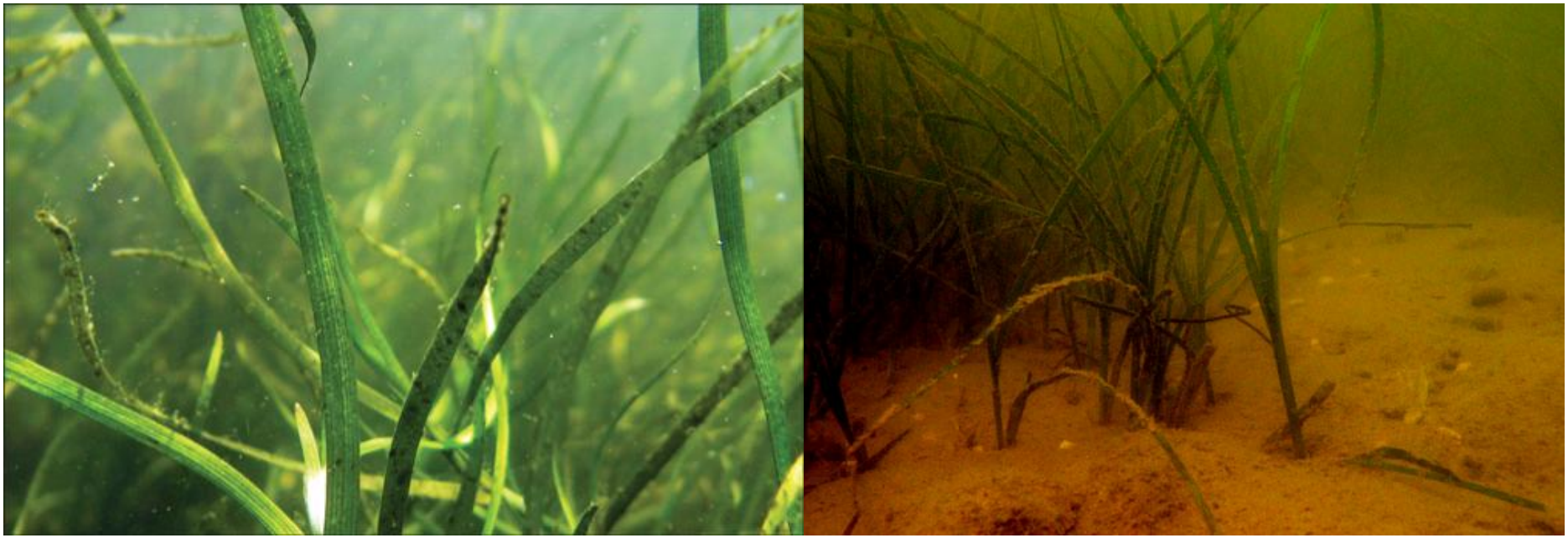






SHOWN: Only “bloom” records (where Chl a exceeds thresholds)

Why can Chl *a* be a weak indicator of phytoplankton biomass?



Chesapeake Quarterly photo gallery

Just like SAV, phytoplankton capture energy from the sun through photosynthesis. Inadequate underwater light stresses phytoplankton cells.

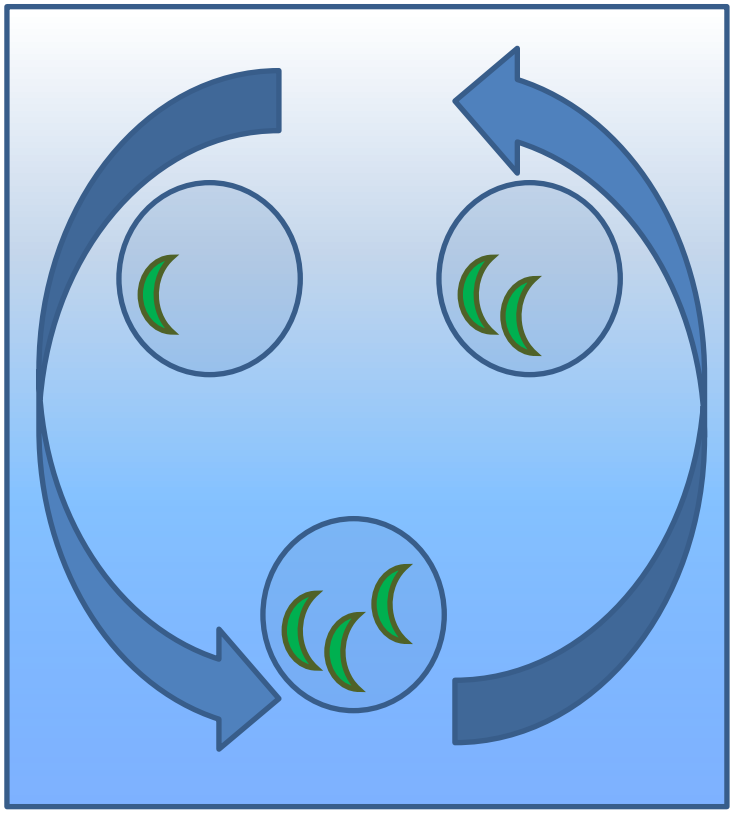
Light-stressed cells increase their chances of capturing the fewer light photons by creating more chlorophyll *a*.

High chlorophyll a levels can indicate

1) a few cells with lots of Chl a per cell
2) lots of cells with little Chl a per cell

Above Pycnocline Layer

Adequate Water Clarity

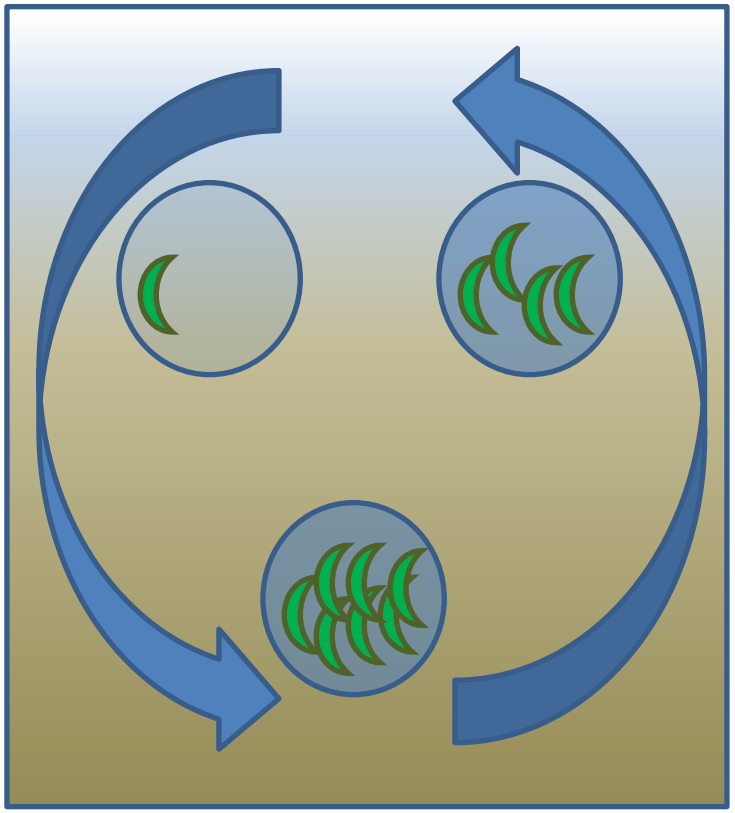


Adequate light for survival

Cells don't need to build up Chl a

Popns. less likely to "bloom" in surface waters

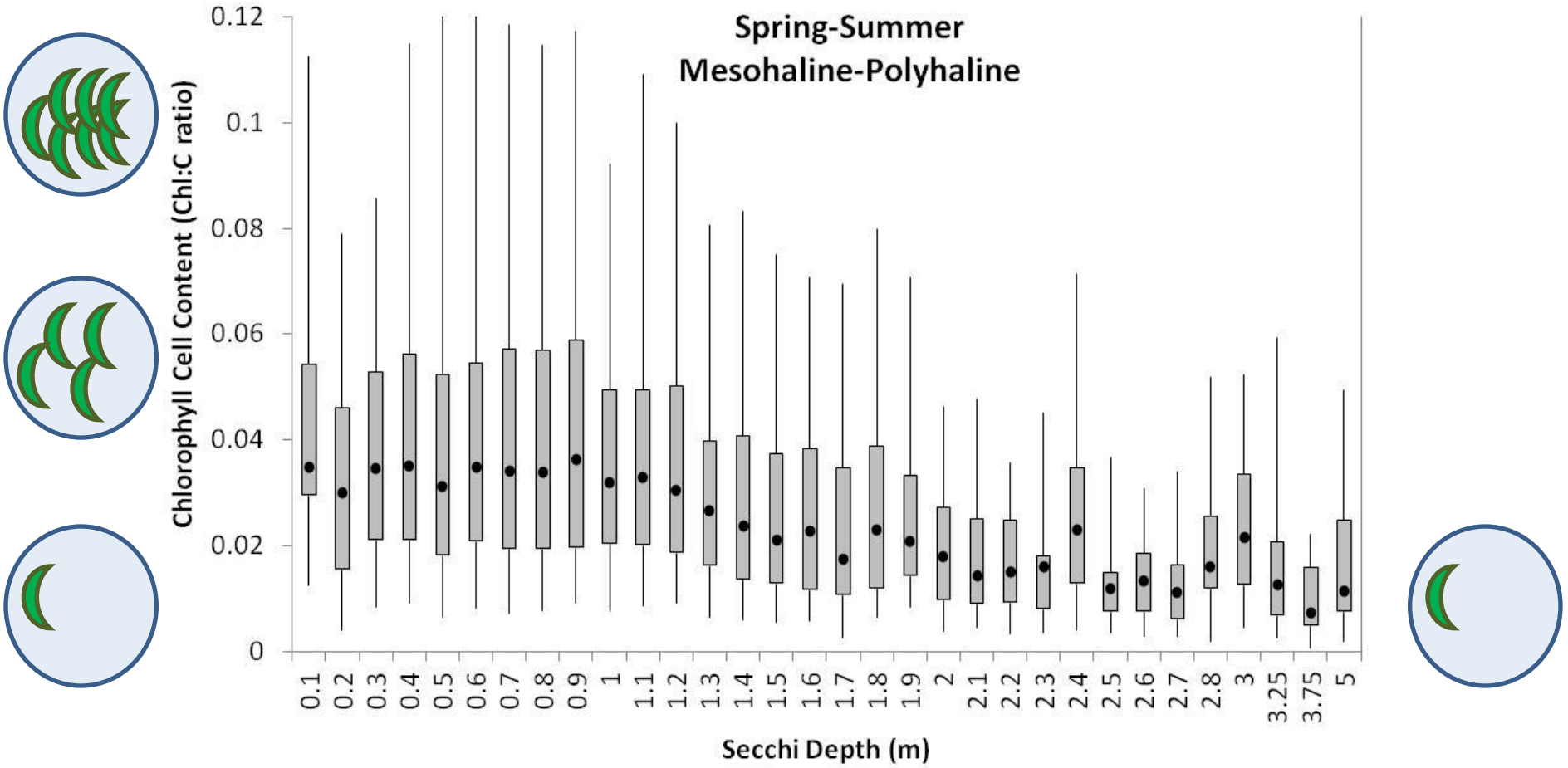
Sediment-Laden Water



Inadequate light for survival

Cells build up Chl a to survive in dim light

Popns. prone to forming nuisance blooms in surface waters, ***especially nutrient-rich waters***



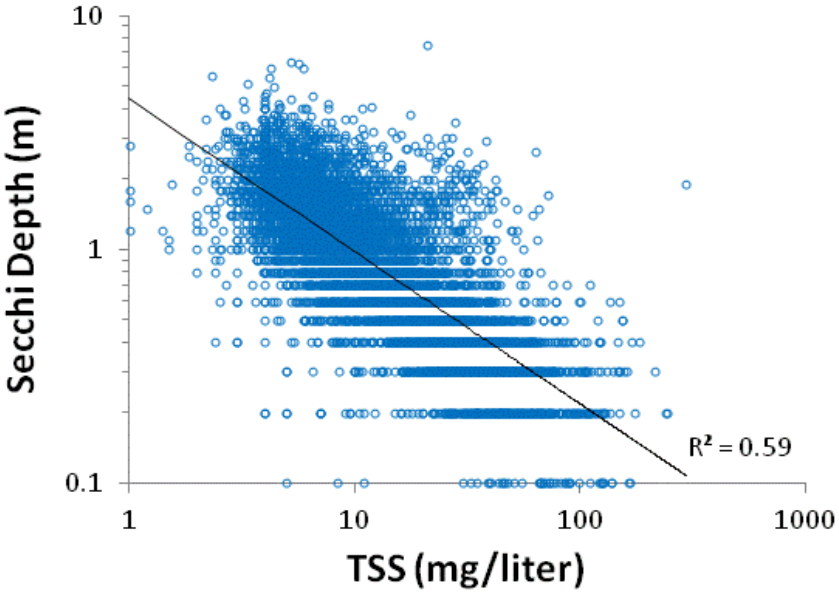
• "High chlorophyll *a* concentrations are … indicative of high algal biomass in the water column."

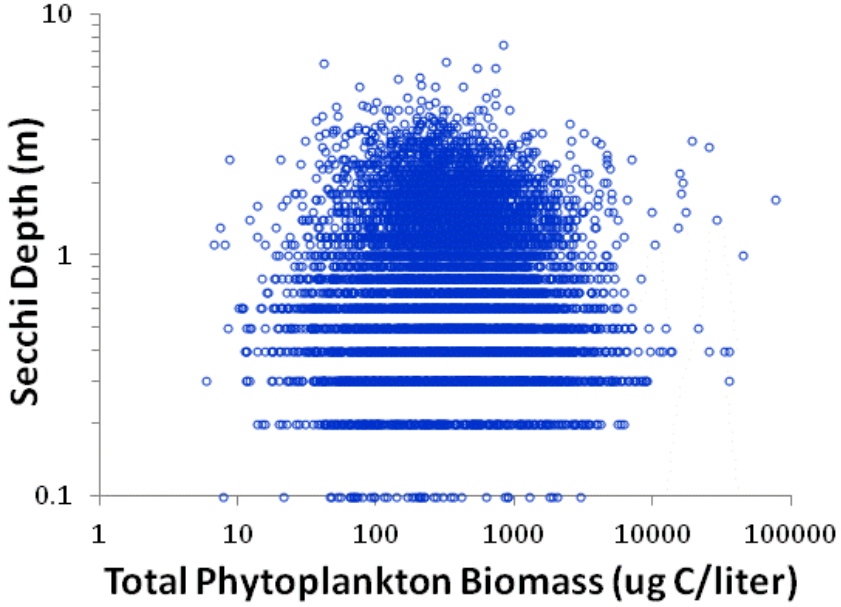
• "High chlorophyll *a* concentrations relative to total phytoplankton biomass are indicative of physiological stress due to poor light conditions in the water column.

- "Too much algae can block sunlight …."

  Multiple studies show that light attenuation and scattering in Bay waters is due mostly to water, abiotic TSS, and CDOM (e.g. Xu et al. 2005 Estuaries) and flocculation of fine particles (Sanford, Gallegos)

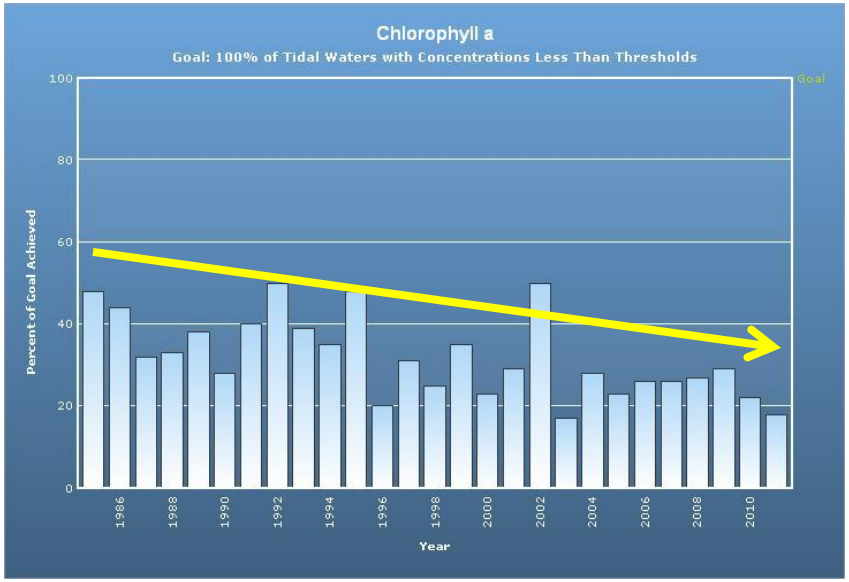
  Monitoring data also indicate abiotic particles attenuate more light than phytoplankton biomass



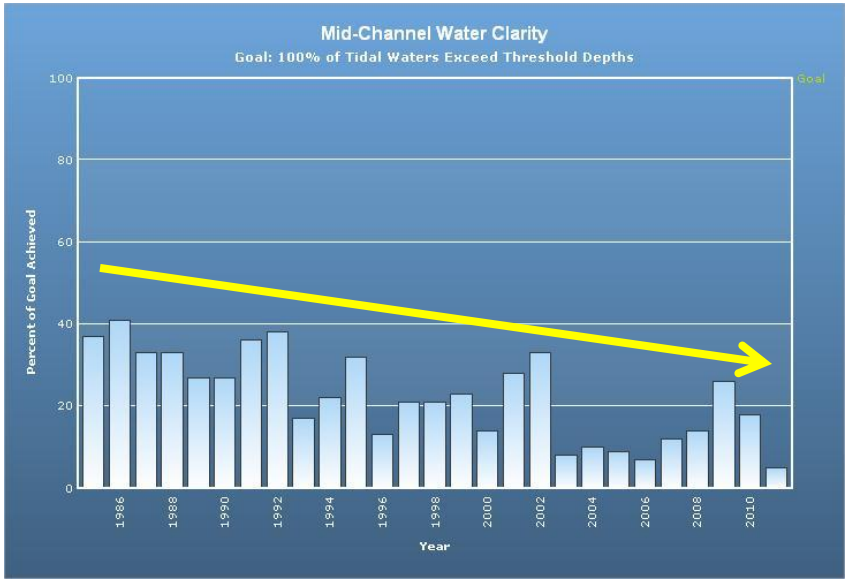


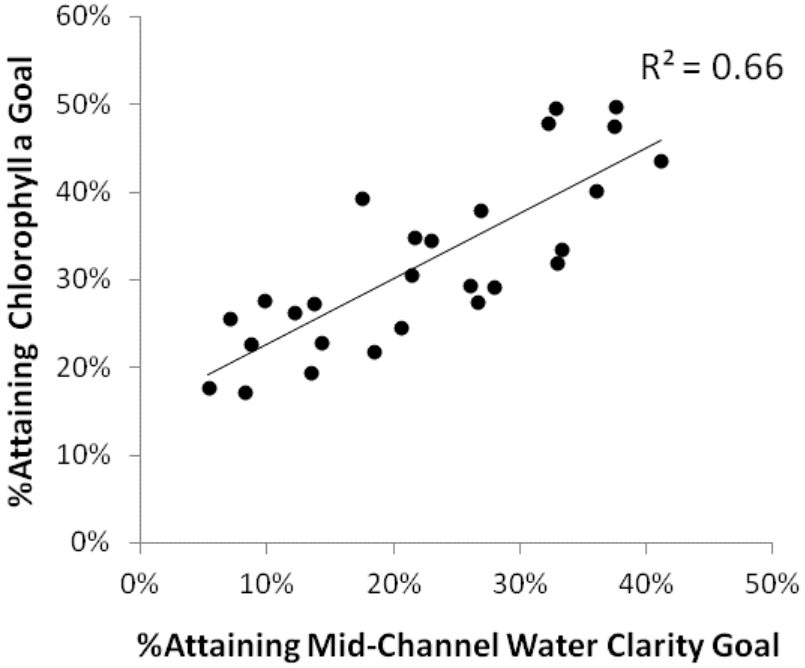
- "Too much algae attached to or settled on leaves of underwater grasses can block sunlight from reaching grasses.

% Attainment of Chl a Goal



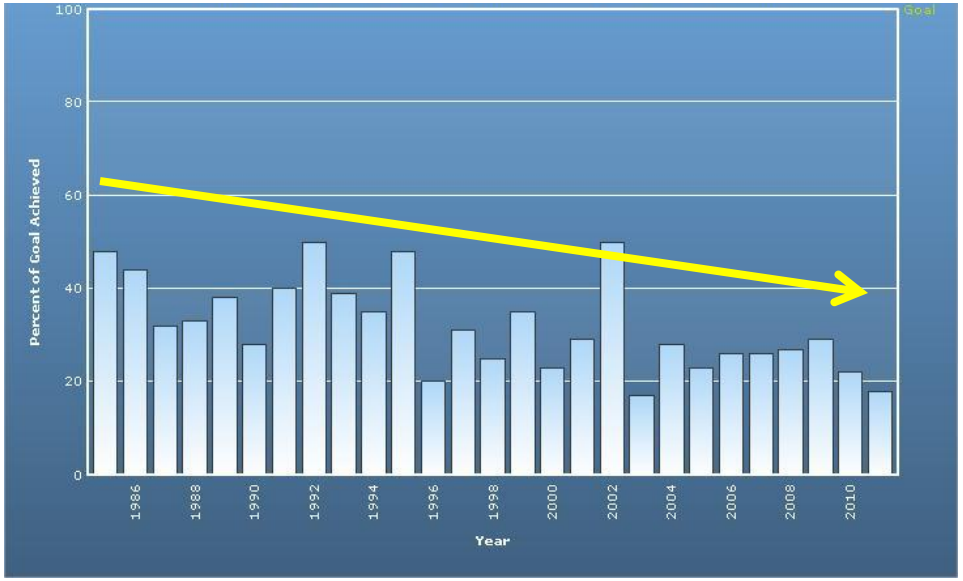
Attainment of Water Clarity Goal



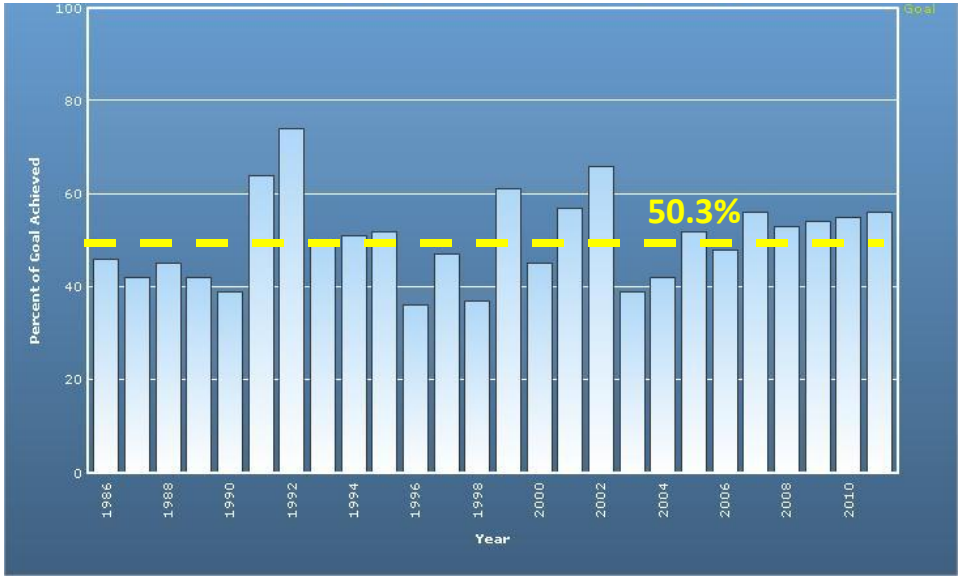


Very good agreement

% Attainment of Chlorophyll a Goal



% Attainment of PIBI Goal



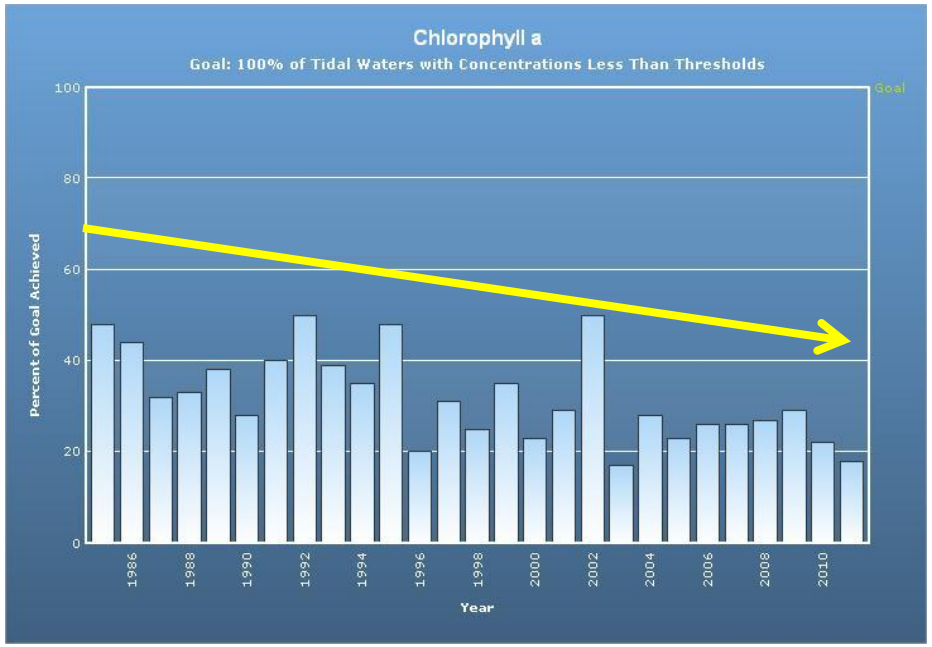
Nuanced interpretation:

The effect of declining water clarity on the Chl a content of phytoplankton cells is one reason…

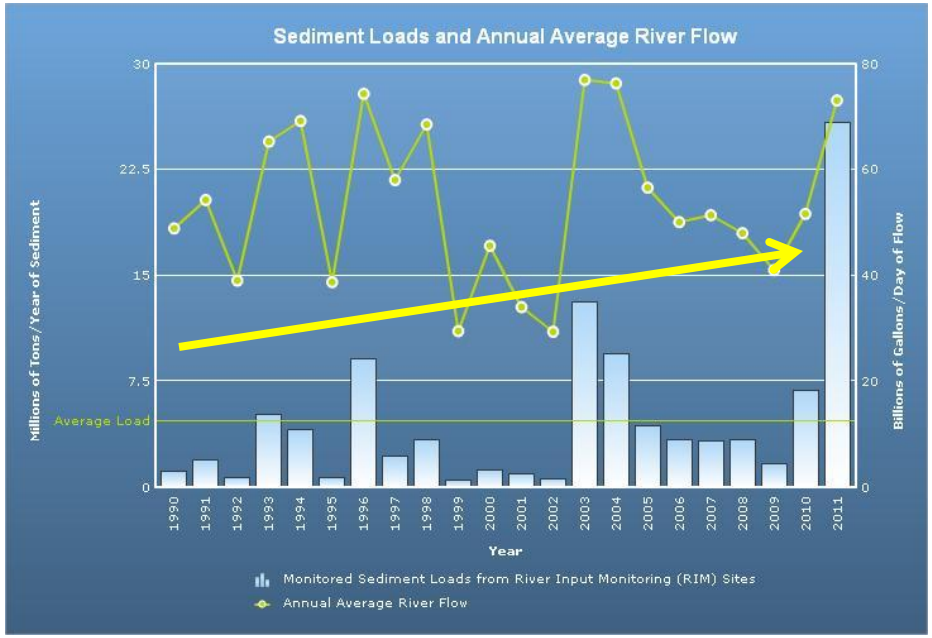
the frequency of algal blooms as measured by Chl a is increasing…

while the PIBI score of the phytoplankton community as measured by several metrics is not changing.

% Attainment of Chl a Goal



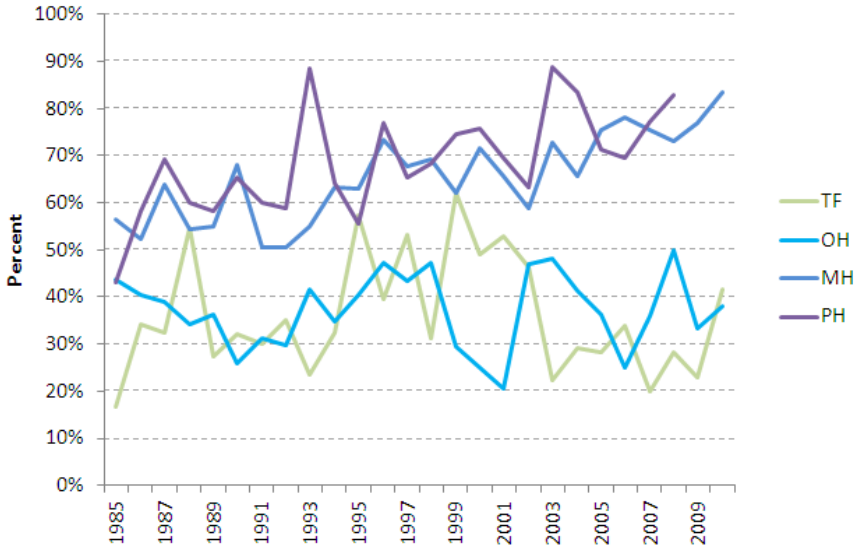
Watershed Sediment Loads to Bay



Tempting to related Chl a trend to increasing sediment loads to Bay

Increasing Chl a concentrations are in mesohaline and polyhaline segments – not close to major (river) sediment loads….

% Chl a *Failing* Thresholds

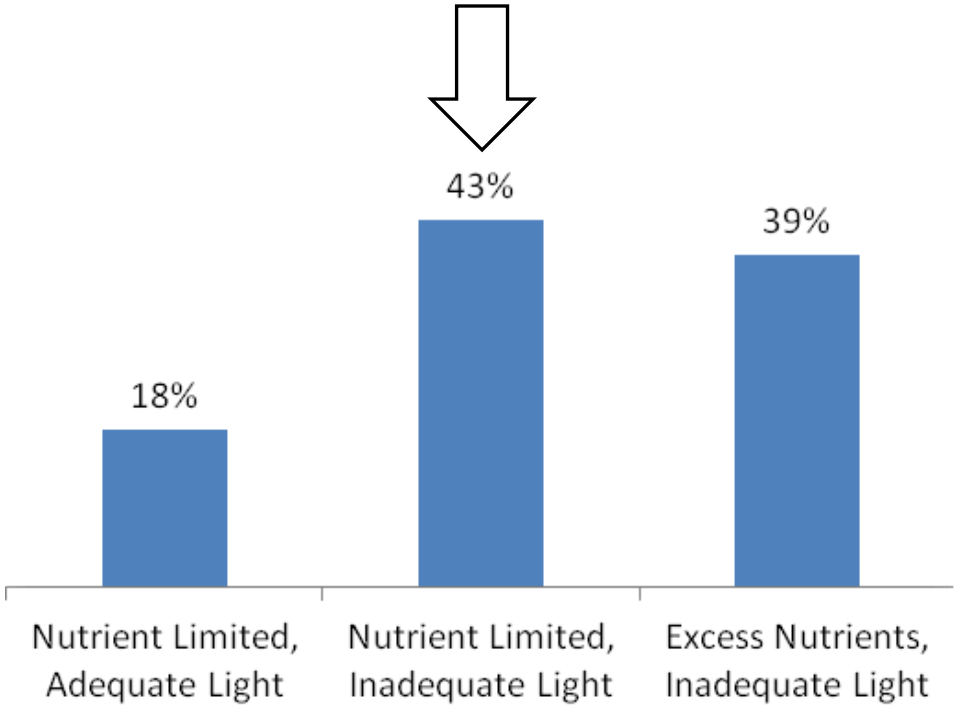


Long-distance transport of fine particles and organics from watershed sources?

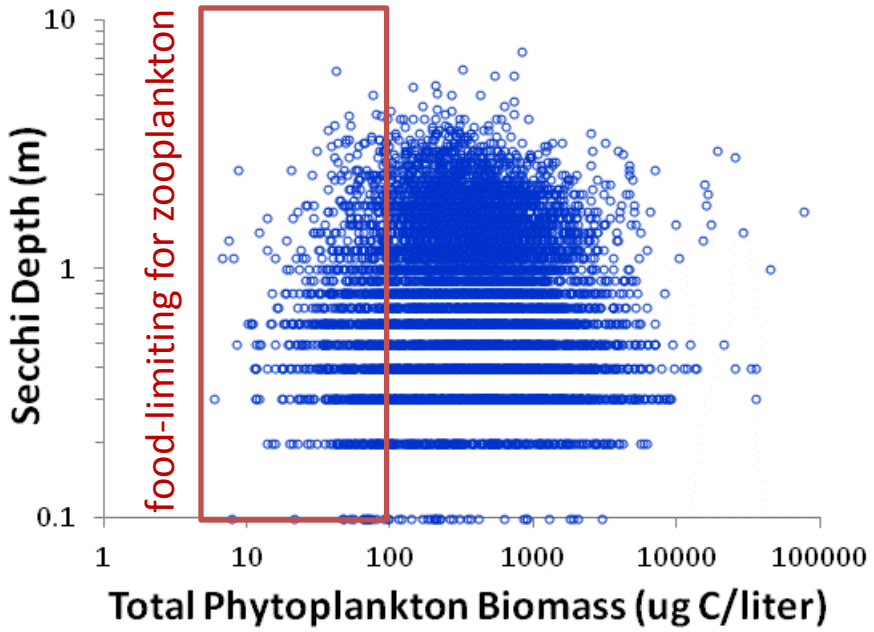
Some possible new statements

- "Attaining the water clarity goal in Bay open waters through reduction in sediments and dissolved compounds that color the water will promote attainment of the chlorophyll *a* goal…."

"…and may stabilize and even improve phytoplankton food levels for grazers."

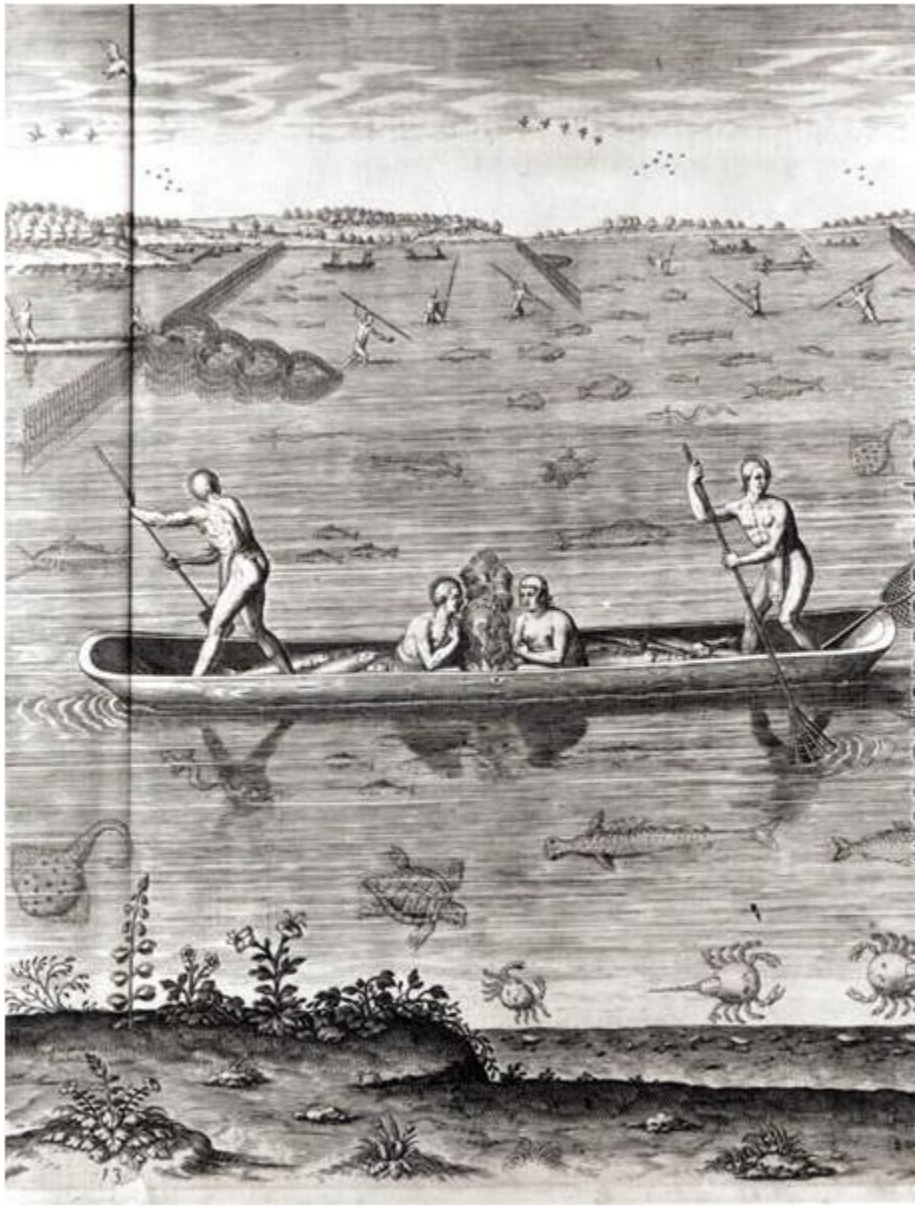


Phytoplankton Habitat Conditions*



* based on Spring-Summer phytoplankton station data, not area-weighted

“….but estuaries are naturally turbid!!”

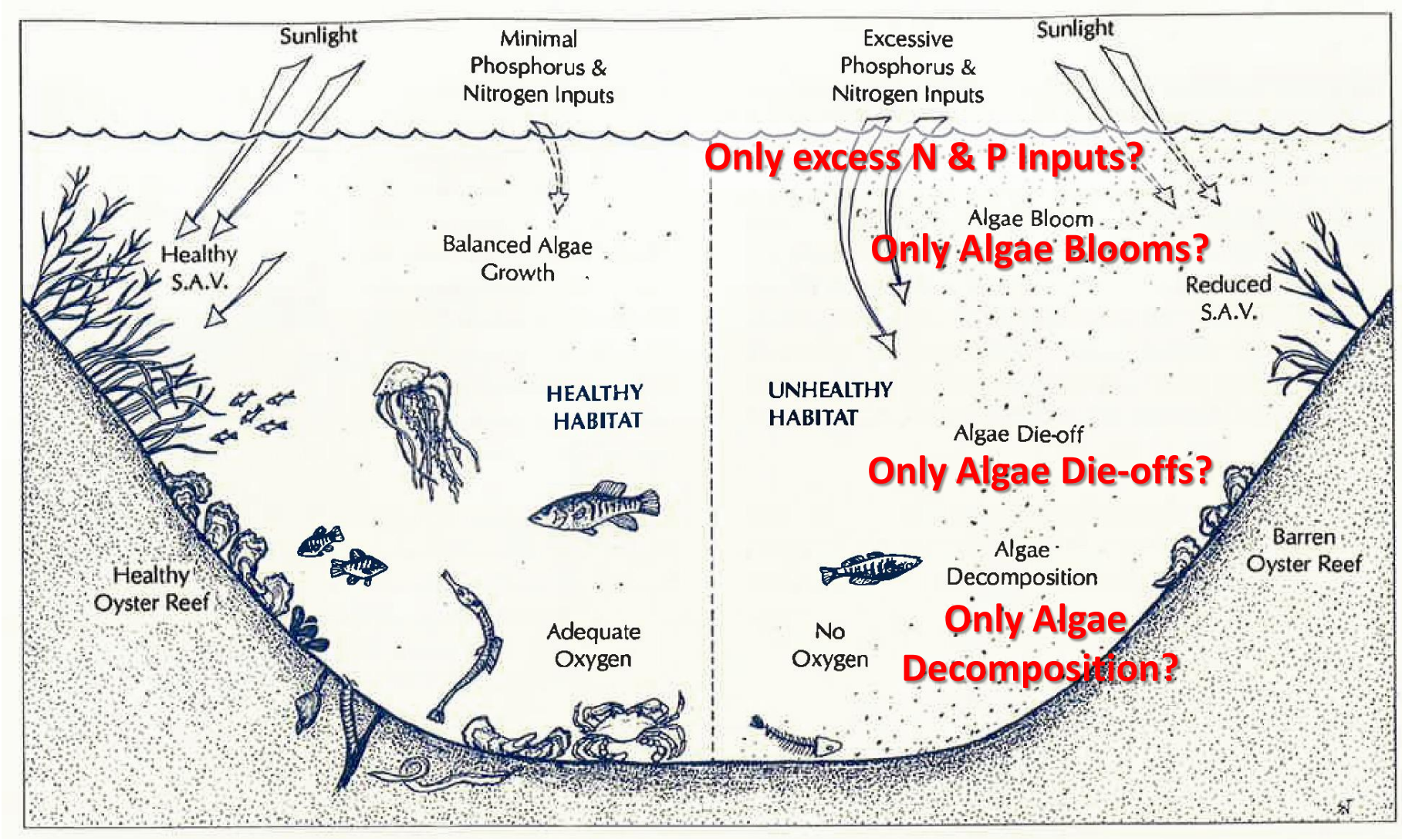


De Bry engraving (1585) of John White painting
“Methods of fishing of the North Carolina Algonquins.”

Time to Rethink the Algae Explanation?

CBP's "Healthy Habitat"

CBP's "Unhealthy Habitat"



Change in Phytoplankton Habitat Types from Base (1984-2002) to Recent (2003-2010) Periods

TYPE:	REFERENCE+		Mixed-PoorLight		DEGRADED	
	"better" or "best" light bloom-limiting N and P		"poor" or "worst" light relatively low N & P		"poor" or "worst" light excess N + excess P	
Salinity	Spr	Sum	Spr	Sum	Spr	Sum
TF	-3.4% •	-18.0% ▼	-0.3% •	15.1% ▲	6.4% •	12.1% ▲
OH	-1.9% •	-13.0% ▼	9.9% •	3.4% •	-6.8% •	-7.7% •
MH	-11.5% ▼	-10.8% ▼	20.7% ▲	22.8% ▲	-6.0% •	12.3% ▲
PH	-19.1% ▼	-18.1% ▼	21.8% ▲	15.1% ▲	-1.5% •	4.3% •