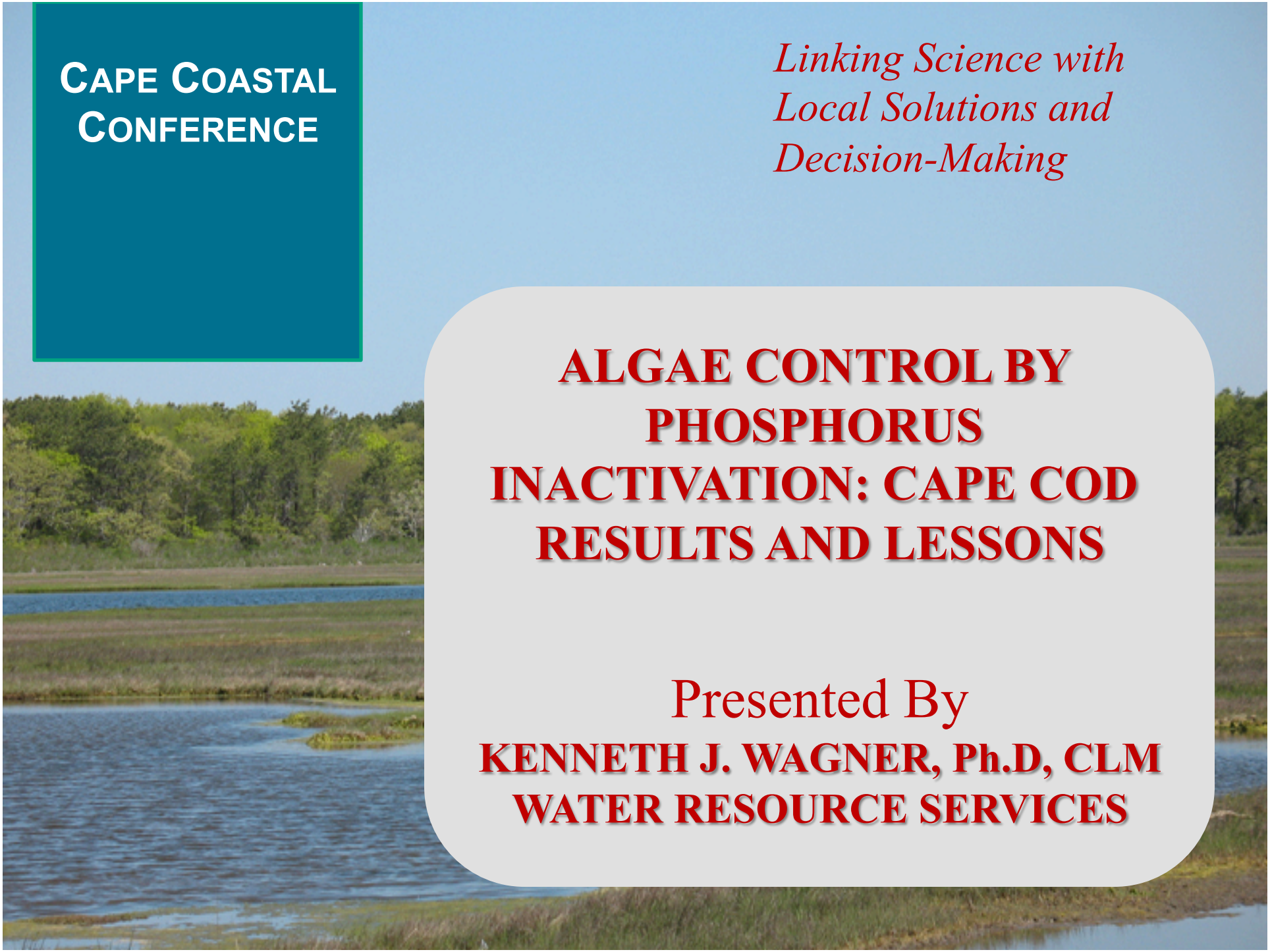

CAPE COASTAL CONFERENCE

Linking Science with Local Solutions and Decision-Making

ALGAE CONTROL BY PHOSPHORUS INACTIVATION: CAPE COD RESULTS AND LESSONS

Presented By

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WATER RESOURCE SERVICES

Generation of Internal Load

- **Some portion of the phosphorus (P) that enters a lake winds up in the sediment**
- **Some fraction of the sediment P can be released back into the water**
- **Different fractions react to different processes**

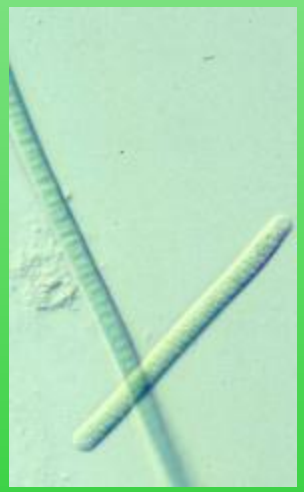
Key processes in internal loading

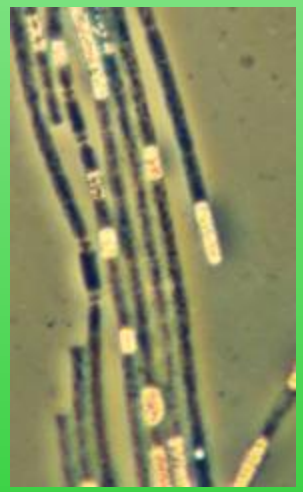
- **P bound as organic matter may be released upon decay**
- **P bound as calcium may be released under low pH**
- **P bound as iron may be released under low oxygen**
- **P bound as aluminum tends not to be released**
- **Rooted plants can extract P from most sediment forms, and may release some of it into the water column**



Algal Response to Internal Load

- **Bottom mats take up P as quickly as it is released**
- **Algae may thrive on the edge of light and nutrient limitation, at an intermediate summer depth**
- **Some algae move down to get nutrients and up to get light**
- **Some algal resting stages take up enough P from sediment to support substantial growth when they "hatch"**
- **Proportionally more P than N is recycled, leading to reduced N:P ratio and favoring cyanobacteria**



Evaluating Internal Load

- **Measure P near the bottom and top, and preferably in between, to look for gradients**
- **Measure P over time to detect accumulation in bottom or surface waters**
- **Measure forms of P in the sediments; evaluate potential releases**

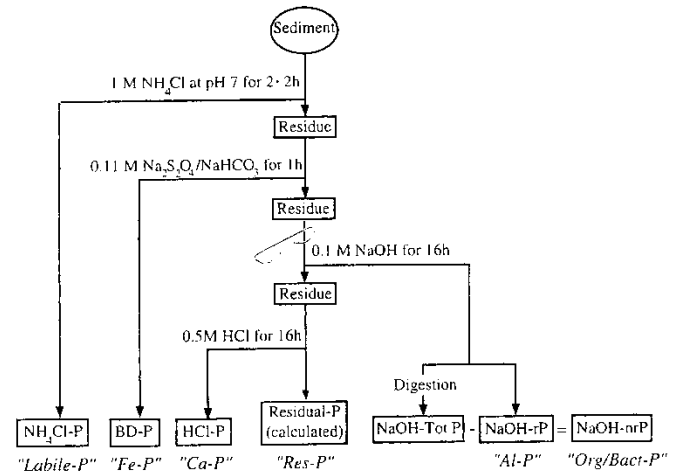


Fig. 2. The modified Hieltjes and Lijklema (1980) scheme used for phosphorus fractionation, including a dithionite/bicarbonate step to separate BD–P and also including a digestion step to distinguish reactive P (rP) from non-reactive P (nrP) in the NaOH extracted P.

Binder Options

- **Iron is the most common natural binder, but does not hold P under anoxia**
- **Aluminum is the most common applied binder, multiple forms, permanent results, toxicity issues**
- **Calcium used in some high pH systems**
- **Binders used for water column or sediment P**

When to use Aluminum

- **Internal P load is high relative to external load, or external load is pulsed such that limited treatment covers much of the annual load**
- **Detention time is high; short term loading won't drastically change conditions**
- **pH is 6-8; prefer alkalinity (buffer capacity) >20 ppm during treatment, but not essential**
- **Potentially sensitive receptors are few, or avoidable, or impacts are acceptable**
- **Rooted plant density in the targeted area at the time of treatment is low**

Factors in Planning Treatments

- **Problem to be solved: algal blooms due to high P**
- **Existing P load, internal vs external**
- **P sources and inactivation needs – field/lab tests**
- **System bathymetry (depth) and hydrology (flow)**
- **Potential water chemistry alteration - pH, metals levels, oxygen concentration**
- **Potentially sensitive receptors - fish, zooplankton, macroinvertebrates, reptiles, amphibians, waterfowl**
- **Accumulated residues - quantity and quality**

Phosphorus Inactivation by Aluminum

Lake Water Column Treatment:

- Doses vary – prefer 20+ times TP conc.
- Can achieve >90% P removal, 60-80% more common, can be lower (inefficient at lower P)
- Effects diminish over 3-5 flushings of the lake (time it takes to replace P externally)

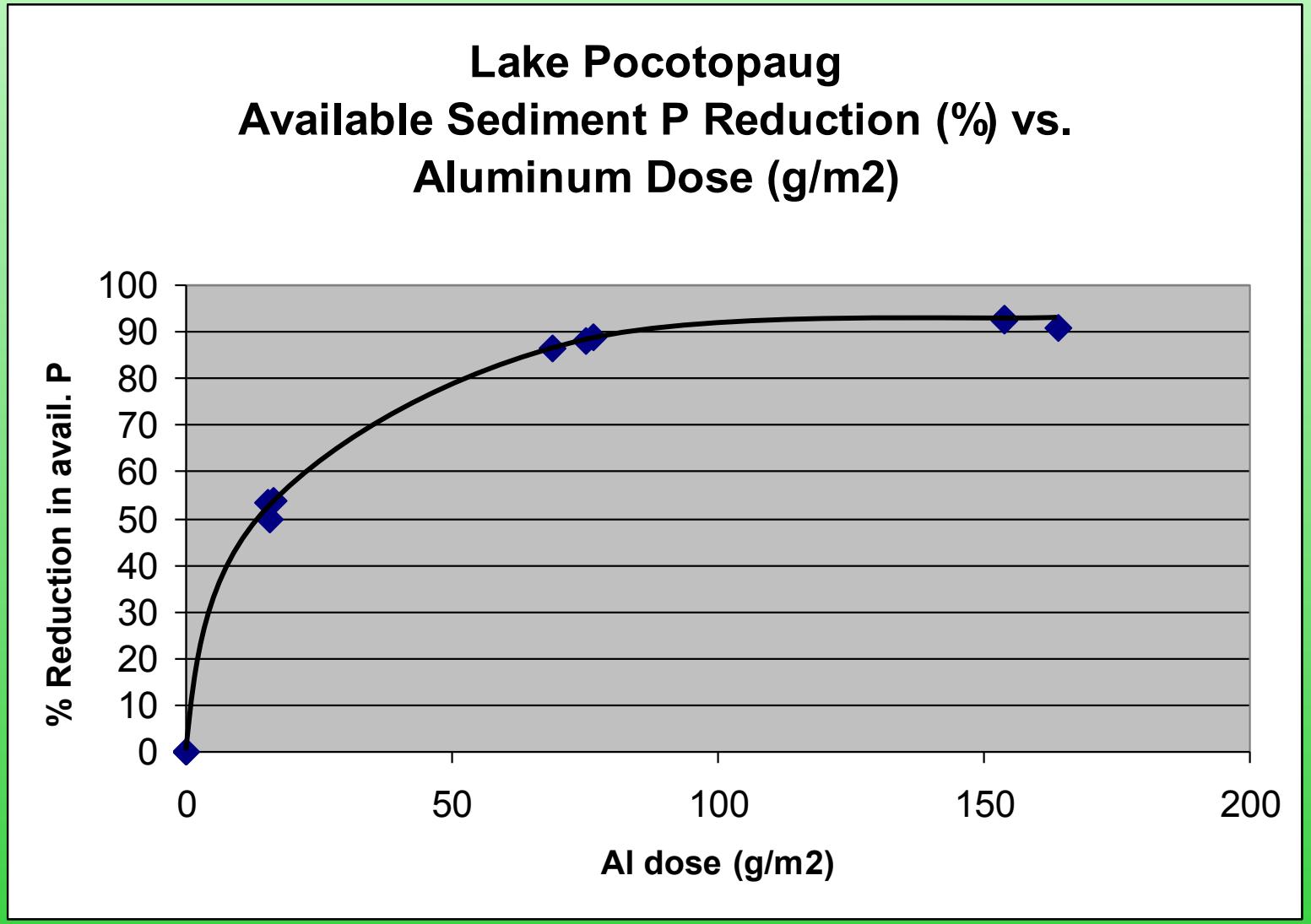
Phosphorus Inactivation by Aluminum

Lake Sediment Treatment:

- Can reduce longer-term P release
- Normally reacts with upper 2-4 inches of sediment
- Dose usually 25-100 g/m2 - should depend upon form in which P is bound in sediment

Sediment Dose Calculation

Sediment P response curve, based on aluminum dosing

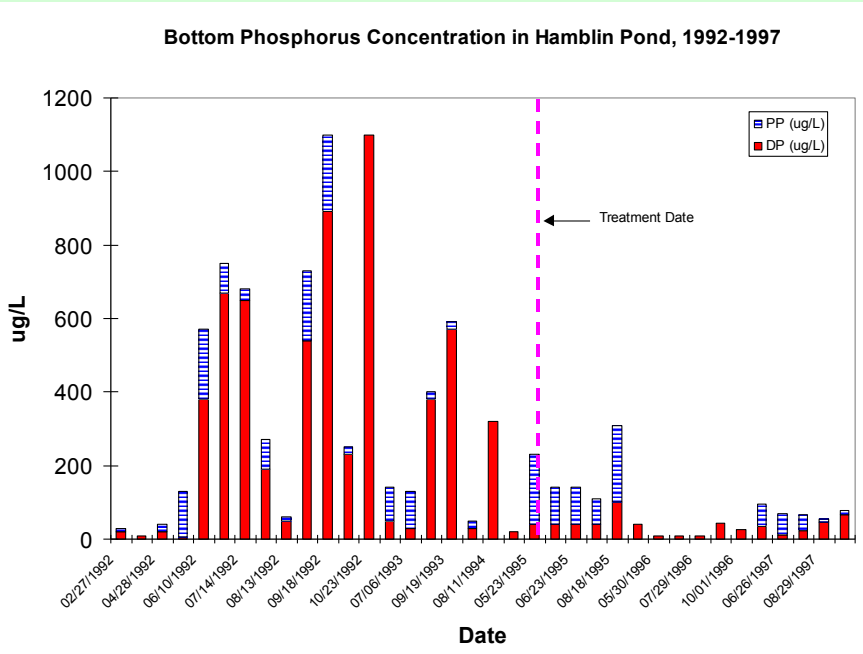


Methods for Minimizing Aluminum Toxicity

- **Aluminum dose at any one time should be <10 mg/L, preferably <5 mg/L**
- **When buffering alum with aluminate, use a 2:1 ratio of alum to aluminate, by volume, to avoid pH change (can be adjusted – 1.8 to 2.1 common)**
- **Treat defined areas of the lake in a pattern that minimizes contiguous area treated at once (patchwork with adjacent blocks not treated sequentially)**
- **Apply aluminum at enough depth to create a surface refuge (can even treat below thermocline), but limits stripping of P from water column**

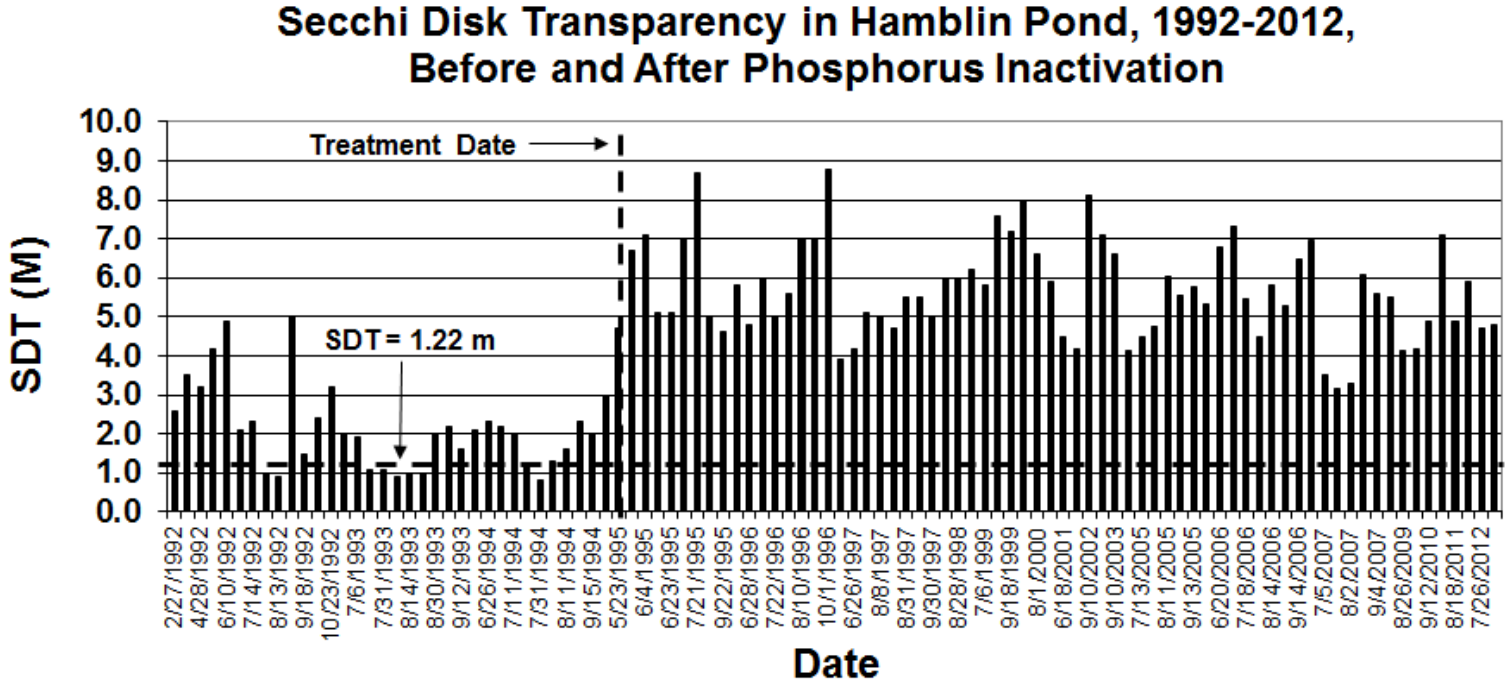
Hamblin Pond Example
Cape Cod, MA

- P levels related to old duck farm, could not use multi-million $ beach
- Poor ratio of chemicals caused fish kill in 1995

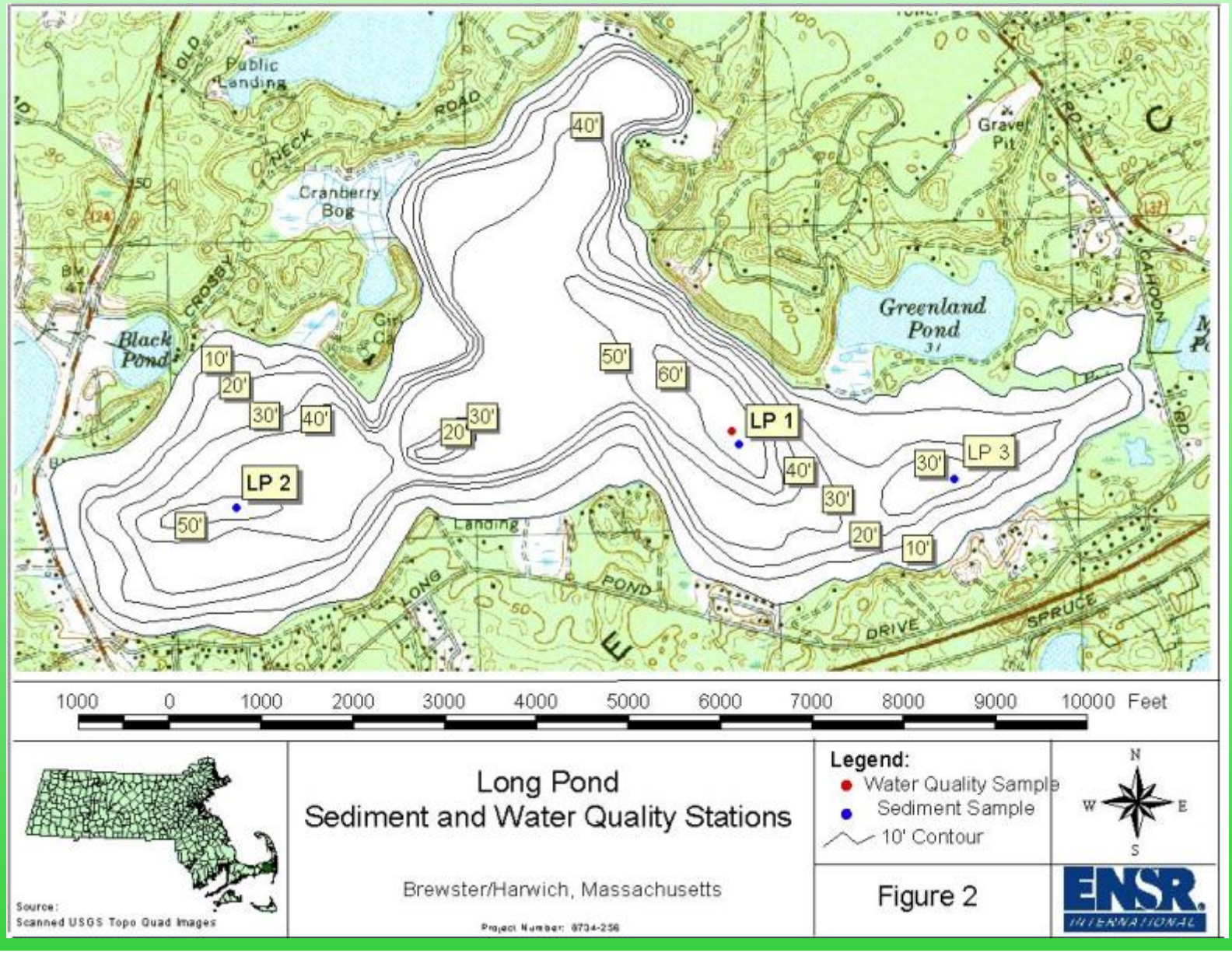


Hamblin Pond Example Cape Cod, MA

- P levels dramatically reduced, water clarity substantially increased for 17 years so far
- Fishery seems recovered



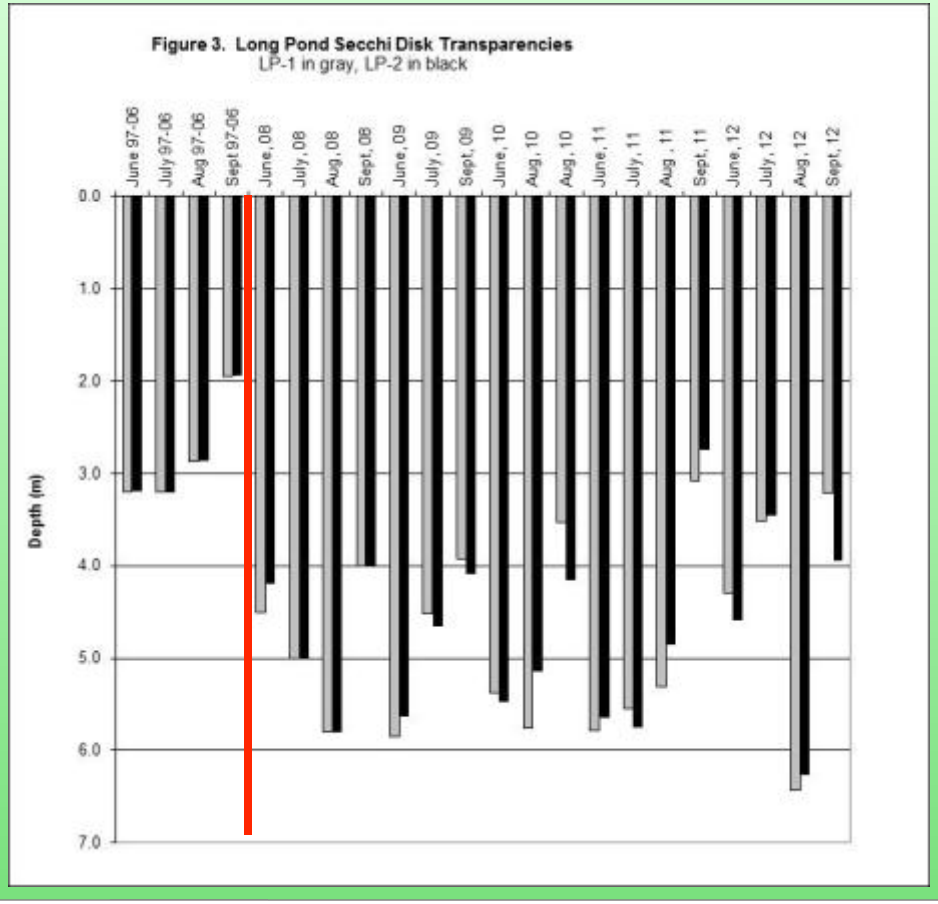
Long Pond Example, Cape Cod, MA
370 acres of a 740 ac lake treated; everywhere >30 ft deep



Long Pond Example
Cape Cod, MA

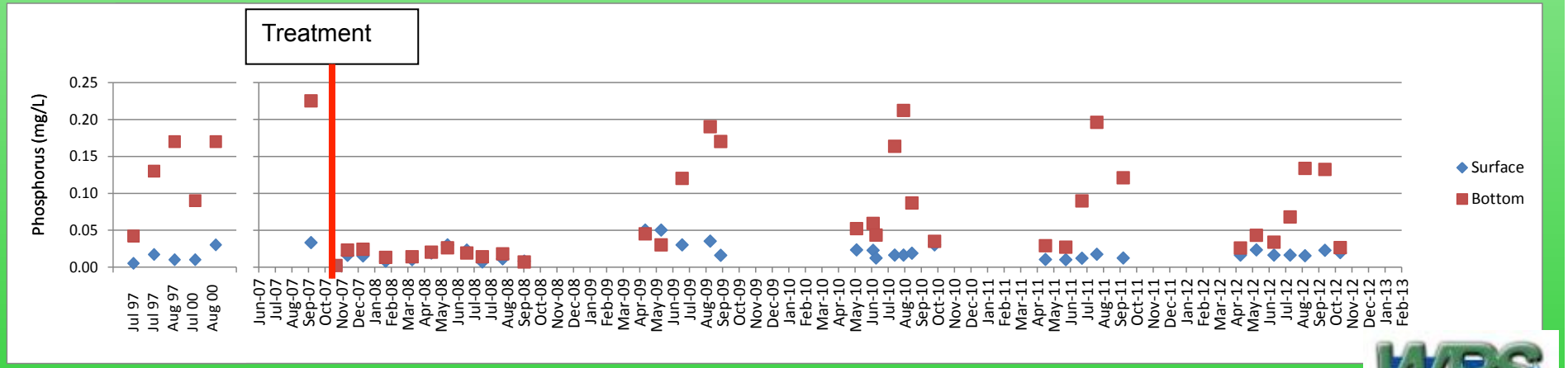
Aluminum sulfate and sodium aluminate distribution

Not a large dose; 10-30 g/m2, done in fall after internal load maximized



Long Pond Example
Cape Cod, MA

- **Clarity remains high through 5 years**
- **Deep water TP levels dramatically reduced, but only for a year**
- **Still have pattern of Sept clarity decline, but all values are higher now**



Mystic Lake Example
Cape Cod, MA

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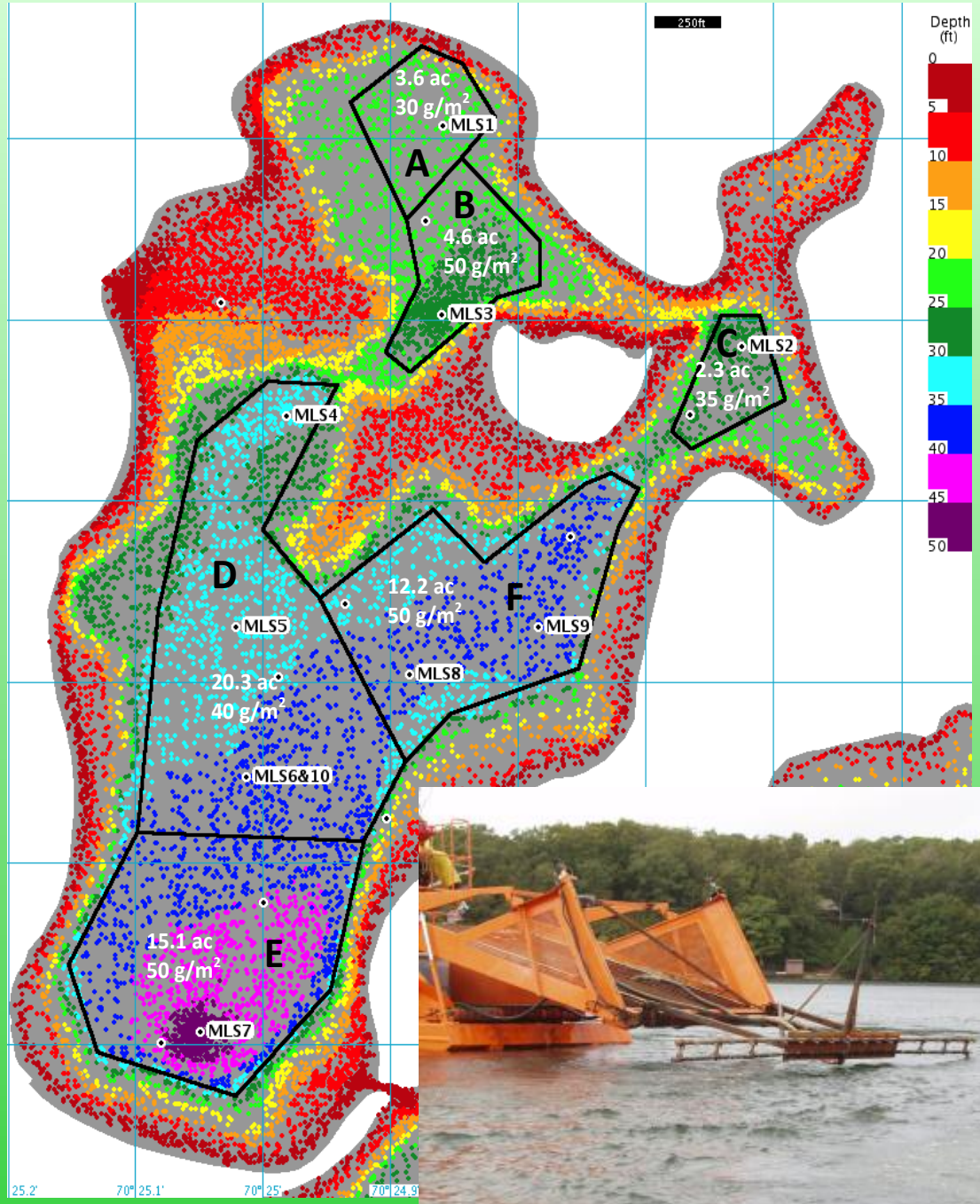
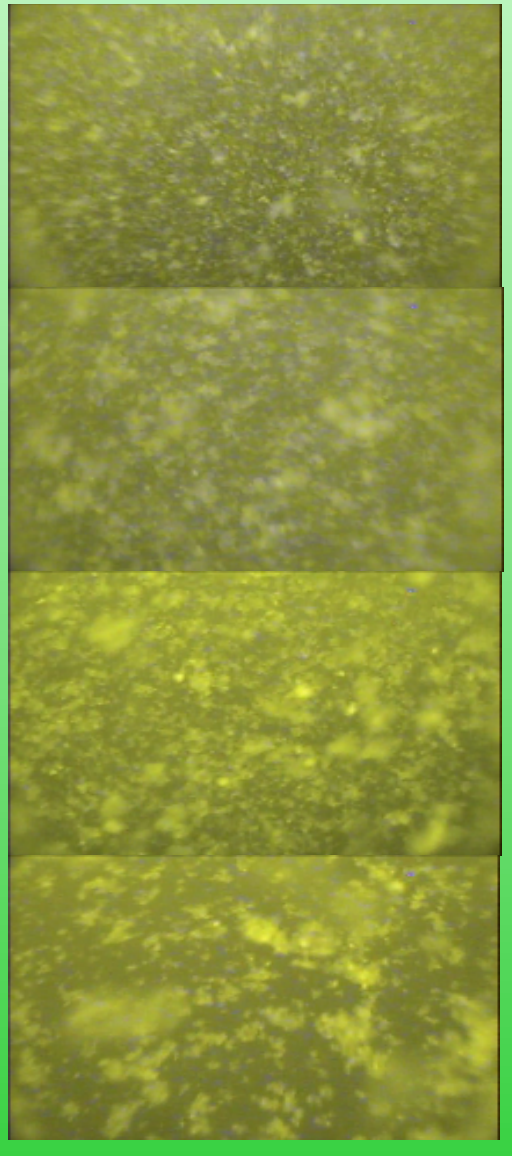
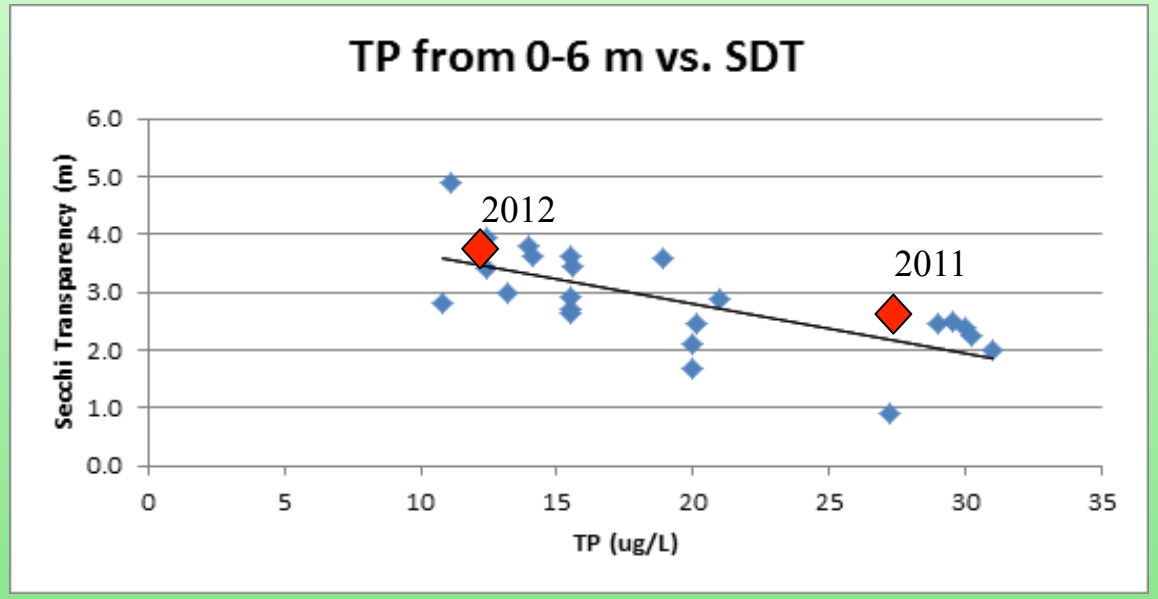
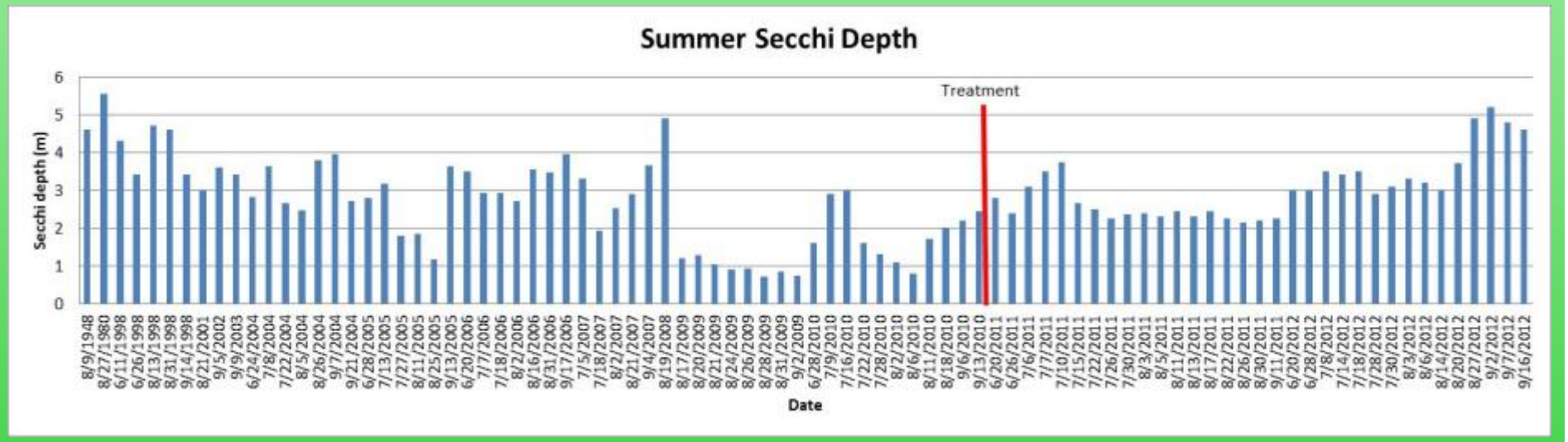
Cape Cod, MA





Mystic Lake Example, Cape Cod, MA





Ashumet, Stillwater, Lovers and Herring Ponds treated more recently

Conclusions

- Where internal loading represents the majority of phosphorus inputs and depresses the N:P ratio in lakes with relatively long detention times, cyanobacteria blooms are common and P inactivation can be a great aid to reducing the symptoms of eutrophication
- Many Cape Cod lakes possess the features that make P inactivation a logical approach to algae control
- Many factors affect aluminum treatment success and impacts; study prior to treatment is needed and may not address the same issues for all lakes at the same level
- Fall treatments appear less immediately effective than spring treatments, but can result in improved water clarity
- Aluminum treatments do not make the system completely infertile; rather, there tends to be a shift in algae types and improved food web processing of algae

The End


SANDWICHES
Ouvert Jour
One more and I think this will all make sense…
QUESTIONS?