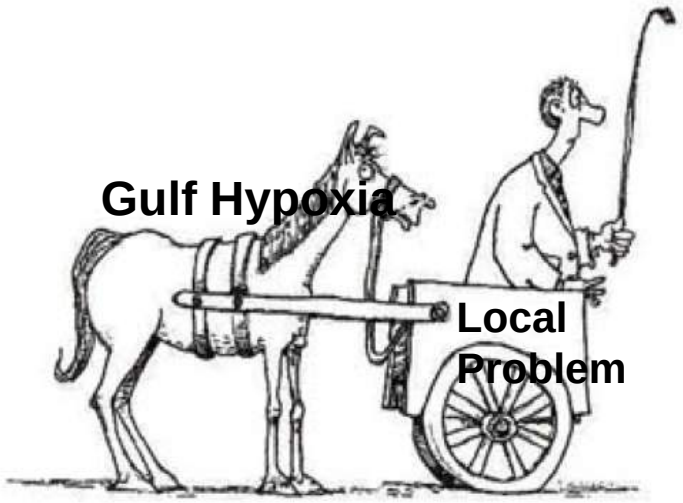
Interim Water Quality

Goals and Measures

So you have a Nutrient Problem…

- Goal of this talk:
  - How do you set a goals that the public understands
  - Do you a numeric target for nutrient reduction to protect/restore downstream uses that the public understan



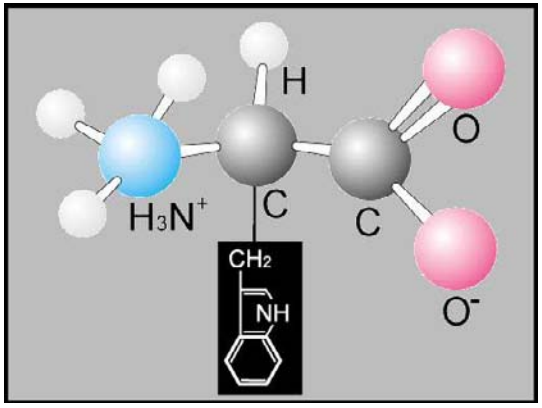
What are nutrients?

- Elements required for growth
- C, H, O, N, P, S – The Big Six Macronutrients
- 20 Other Micronutrients: B, F, Na, Mg, Si, Cl, K, Ca, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Se, Mo, Sn, I

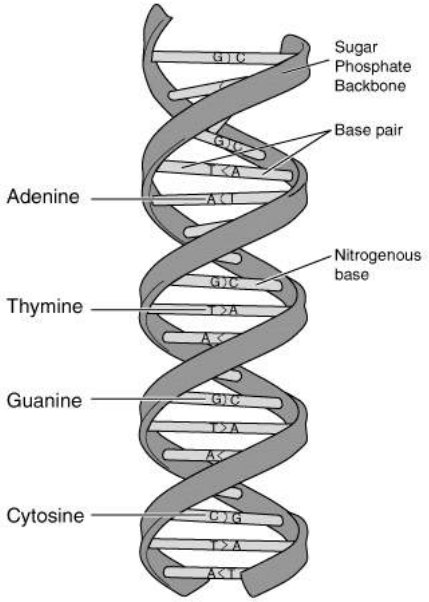
- Of the big six, C, H, O, and S are generally readily available and rarely limit growth
- Not so for N and P

Nitrogen and Phosphorus

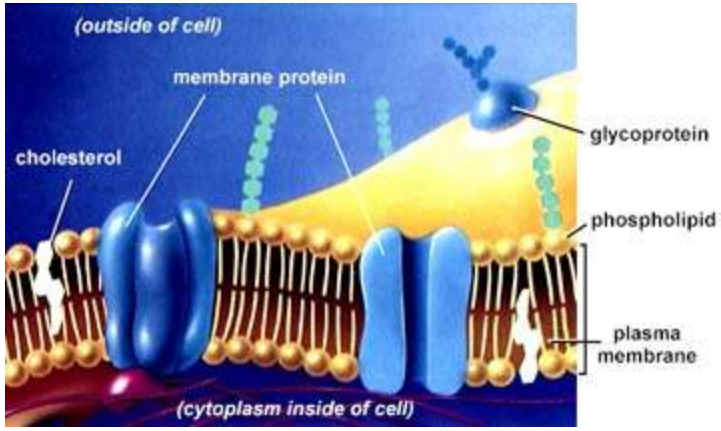
- Essential elements
  - Nitrogen: e.g., amino acids (all proteins), nucleic acids (DNA, RNA)
  - Phosphorus: e.g., nucleic acids, organelle walls (P-lipids), energy molecules (ADP/ATP/NADP)



A. Acid (Tryptophan)



DNA



Phospholipid Bilayer

Nitrogen – What is measured

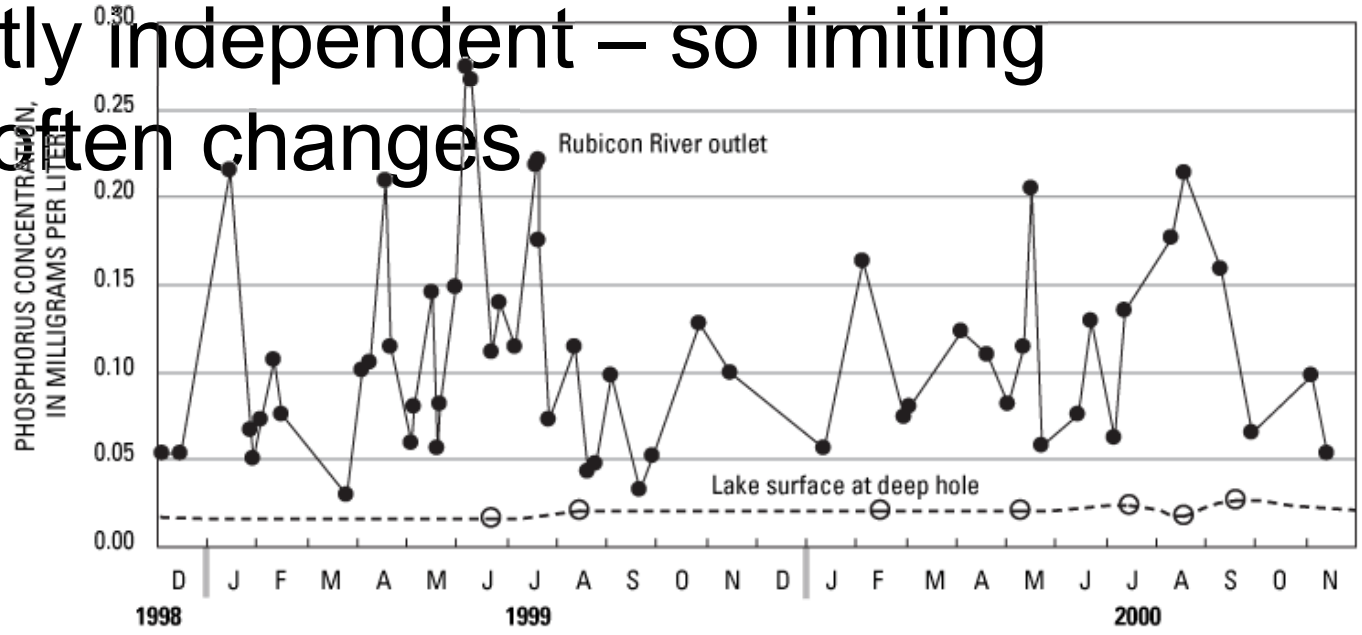
- Dissolved Forms (filtered – 0.45 μm)
  - NH_3-N (ammonia) and NH_4^+-N (ammonium)
  - NO_3/NO_2-N (nitrate/nitrite)
  - DIN = ammonia + nitrate/nitrite
  - Total Kjeldahl Nitrogen (TKN = DON-N + NH_3-N)
  - DON = TKN – (NH_3-N)
  - Total (TN) = TKN + NO_3/NO_2 (persulfate digestion)
- Total forms (unfiltered)
  - Same species as above including particulate forms
  - Particulate by subtraction

Phosphorus – what is measured

- Orthophosphate (PO_4-P) – form measured (as P)
  - Dissolved Forms (filtered – 0.45 μm)
  - Dissolved or Soluble Reactive P (SRP)
  - Dissolved Acid hydrolyzable P (condensed and some organic)
  - Total dissolved phosphorus (TP) – acid digestion
- Total forms (unfiltered) (particulate by difference)
  - Total reactive P
  - Total acid hydrolyzable P

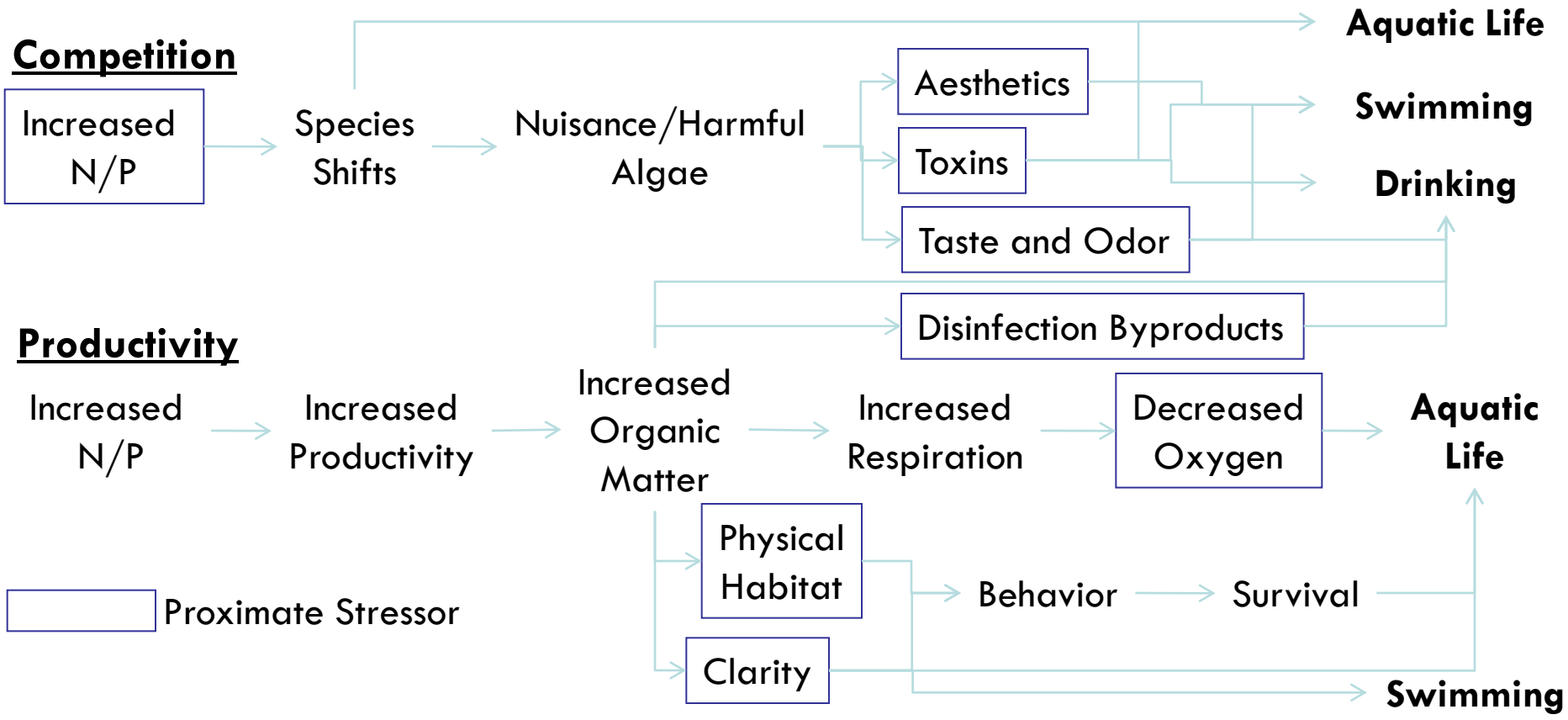
Nutrient Dynamics

- N and P vary, through time and space
- Lot of this is a function of climate and supply
- Frequently independent – so limiting nutrient often changes



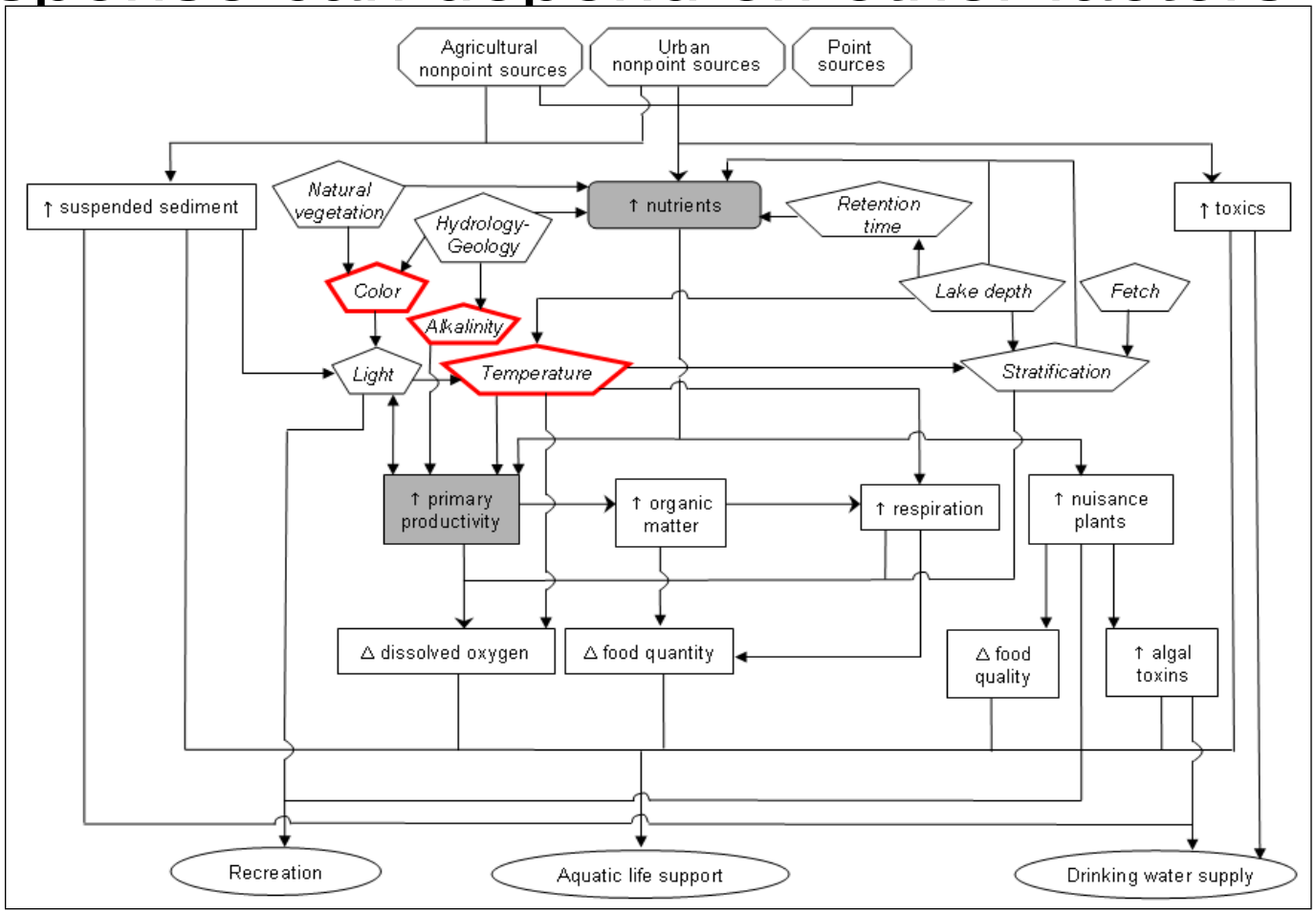
NUTRIENT EFFECTS ON AQUATIC ECOLOGY, RECREATION AND DRINKING WATER SUPPLY: NUTRIENT AND KEY RESPONSE INDICATORS

Uses


Competition
Increased N/P
Species Shifts
Nuisance/Harmful Algae
Aesthetics
Toxins
Taste and Odor
Aquatic Life
Swimming
Drinking
Disinfection Byproducts
Productivity
Increased N/P
Increased Productivity
Increased Organic Matter
Increased Respiration
Decreased Oxygen
Aquatic Life
Physical Habitat
Behavior
Survival
Clarity
Swimming
Proximate Stressor

General Approach: Stressor-response

- Response can depend on other factors



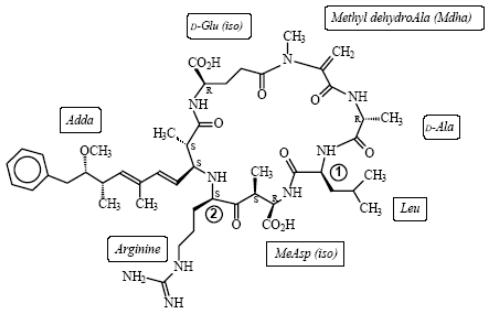
Nuisance Algae and Swimming

- Marine nuisance algae – harmful algae/red tides
  - Several species
    - *Karenia brevis, Pfiesteria piscicida, Pseudonitzchia*, *Protoperidinium crassipes, Gambierdiscus toxicus, Dinophysis, Prorocentrum, Alexandrium, Pyrodinium, Gymnodinium, Lyngbya*
  - Evidence suggests linkage to nutrient inputs to bloom frequencies of many species
  - Still an area of much research

Nuisance Algae and Swimming

- Nuisance Algae/Plants
  - Many are poor competitors for low nutrients
  - In blooms, they look (and smell) bad
  - Decomposition and chemicals produced by senescing algae

Nuisance Algae and Swimming/Drinking



- Many produce toxins
  - Cyanotoxins (70 kinds):
    - Hepatotoxins: Microcystins, Nodularin
      - Liver damage; tumor promotion
      - *Microcystis, Anabaena, Oscillatoria, Nostoc, Anabaenopsis*
    - Neurotoxins: Anatoxins, saxitoxins
      - Block neurotransmission - paralysis
      - *Anabaena, Aphanizomenon, Microcystis, Oscillatoria,*
    - Cylindrospermopsin
      - Blocks protein synthesis –liver and kidney damage
      - *Cylindrospermopsis*
    - Lyngbyatoxin, debromoaplysiatoxin
      - Dermatitis
      - *Lyngbya*

Increased N/P → Species Shifts → Nuisance/Harmful Algae → Toxins → **Swimming**, **Drinking**

SDWA Violations Assumptions

- There were no operator errors
- No treatment equipment problems
- Treatment plant was properly designed to handle nutrients in the first place

Need a detailed investigation of the PWS and its operation on the day a specific violation occurred..

If it’s a source water problem

Organic Matter and Drinking

- Filtration costs
  - Excess organic matter in suspension or on intake structures can increase operating costs
  - Clog intake screens, Increase coagulant demand, Shorten filter runs, Increase filter backwash water

Increased N/P → Increased Productivity → Increased Organic Matter → **Drinking**

In general the higher the quality of the source water

Less treatment is required and thus easier/less costly

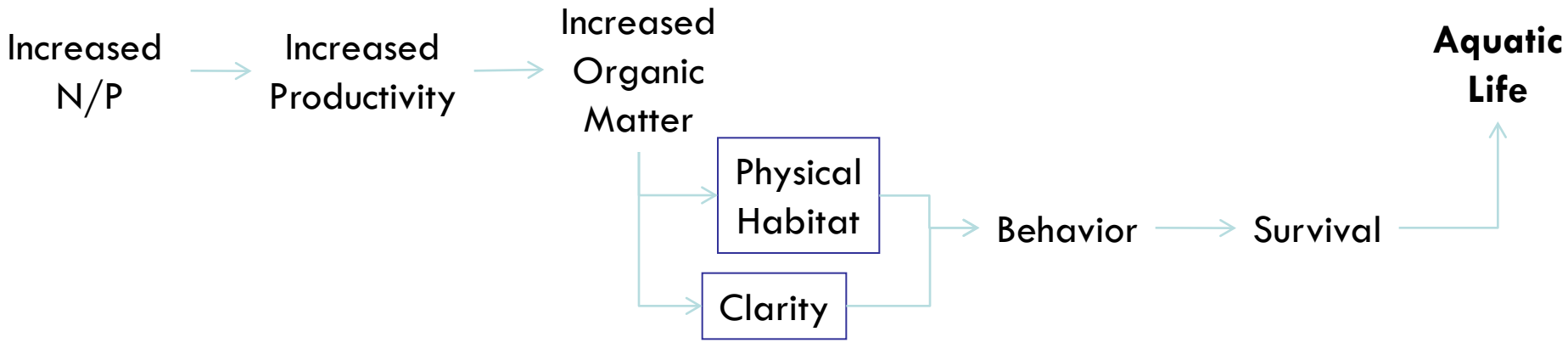
Organic Matter and Aquatic Life

- Respiration drives down dissolved oxygen
  - Hypoxia (<2 mg/L) and Anoxia (0 mg/L)
  - Organisms that need oxygen must either move, die, or both
    - Hypoxia/Anoxia can make other pollutants more "available" and this synergy may increase their toxicity

Increased N/P → Increased Productivity → Increased Organic Matter → Increased Respiration → **Decreased Oxygen** → **Aquatic Life**

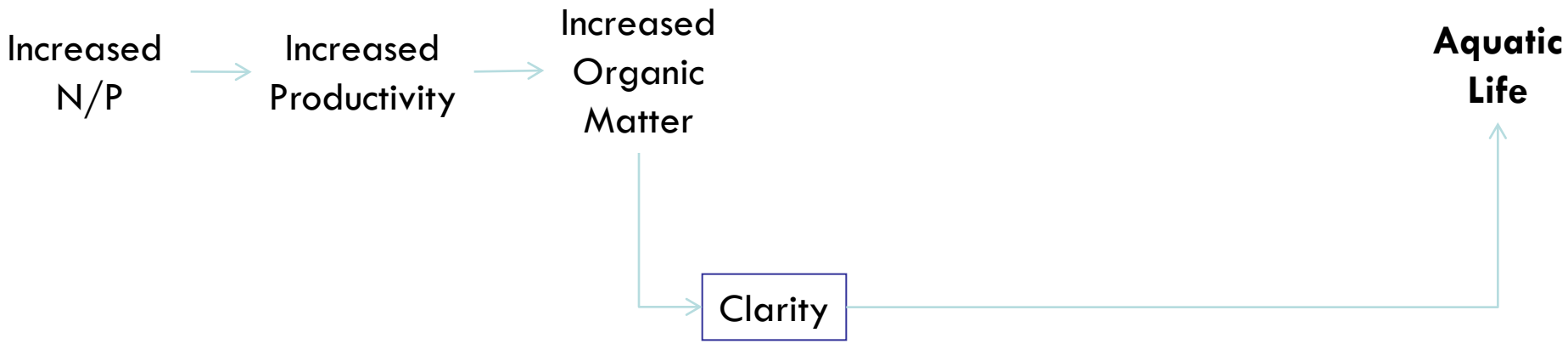
Organic Matter and Aquatic Life

- Habit change is another way eutrophication affects aquatic life
  - Feeding and reproductive habitats are altered by excess plant growth
  - This influences survival/growth and affects species survival



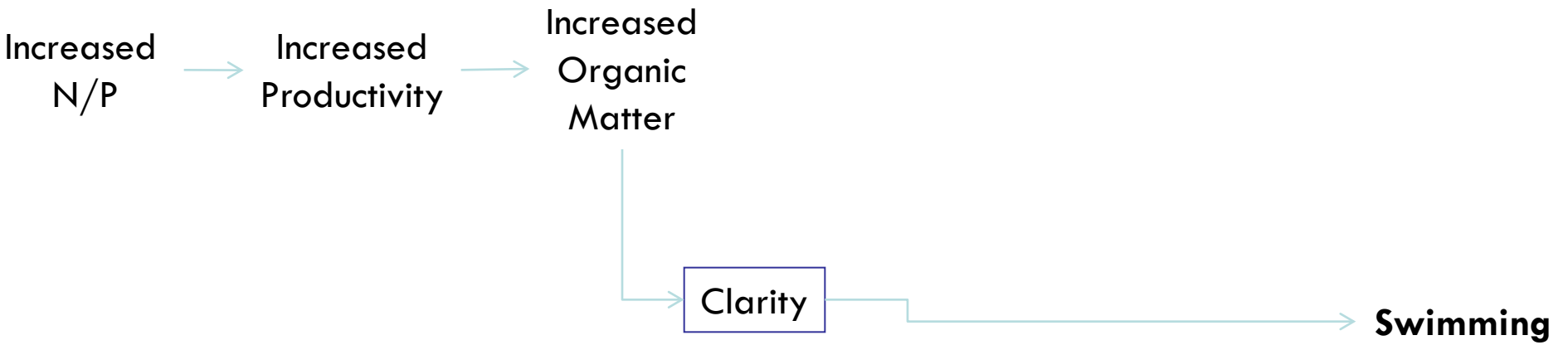
Organic Matter and Aquatic Life

- Reduced clarity caused by excess phytoplankton reduces light for other plants
  - Native macrophytes/seagrasses
  - Restoration of native macrophytes often includes nutrient reduction to improve clarity

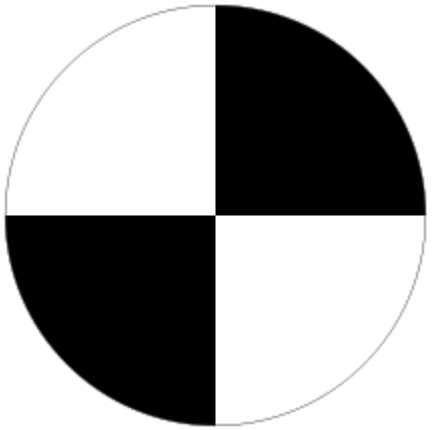


Organic Matter and Swimming

- Perhaps redundant with aesthetics
  - But safety is influenced by clarity when phytoplankton densities increase
  - BSA Safe Swim Defense: "Visibility: Underwater swimming and diving are prohibited in turbid water. Turbid water exists when a swimmer treading water cannot see his feet. Swimming at night is allowed only in areas with water clarity and lighting sufficient for good visibility both above and below the surface."



Clarity



- Secchi depth
  - Fr. Pietro Angelo Secchi (1818-1878)
    - Astronomer
    - Also oceanography, meteorology, and physics
    - Published 730 papers and several books
- Also measure photosynthetically active radiation and light attenuation
- Turbidity

What we are we looking at:

- Algal blooms: Occurrence and composition (HABs)
- Drinking water: Decrease in treatment costs at key PWS
- Aquatic life: decreased winter fish kills
- Aquatic life: changes in benthic community and aquatic habitat (restoration goal)
- Clarity goals (swimming beach:) closures related to organic matter.
- Still a lot of science to be done