Water quality in stormwater detention ponds and the impacts of pond discharges on ecosystem processes within tidal creek receiving waters:

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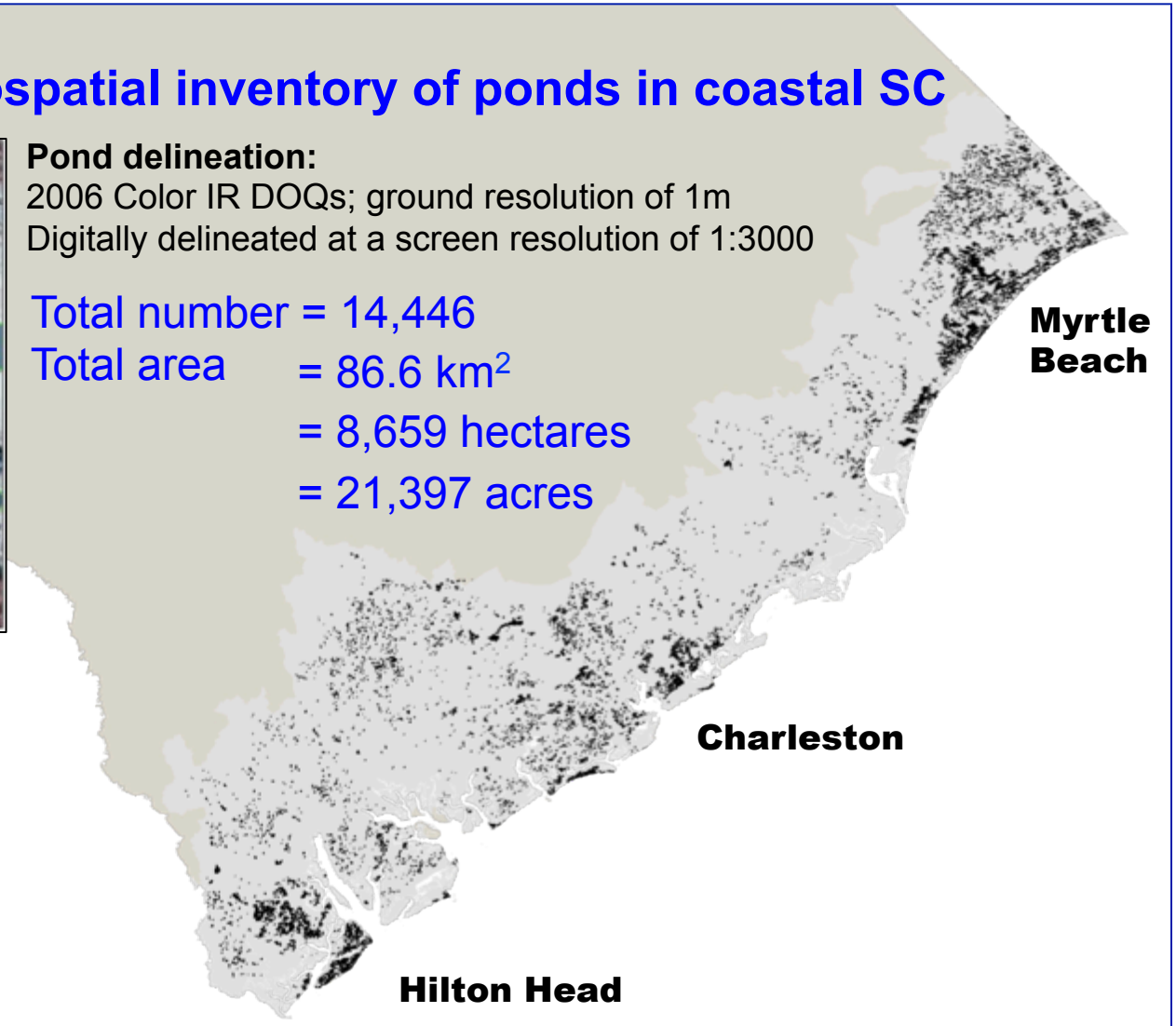
Created ponds have become a major feature of the coastal landscape

Geospatial inventory of ponds in coastal SC

Pond delineation:
2006 Color IR DOQs; ground resolution of 1m
Digitally delineated at a screen resolution of 1:3000

Total number = 14,446
Total area = 86.6 km^2
= 8,659 hectares
= 21,397 acres

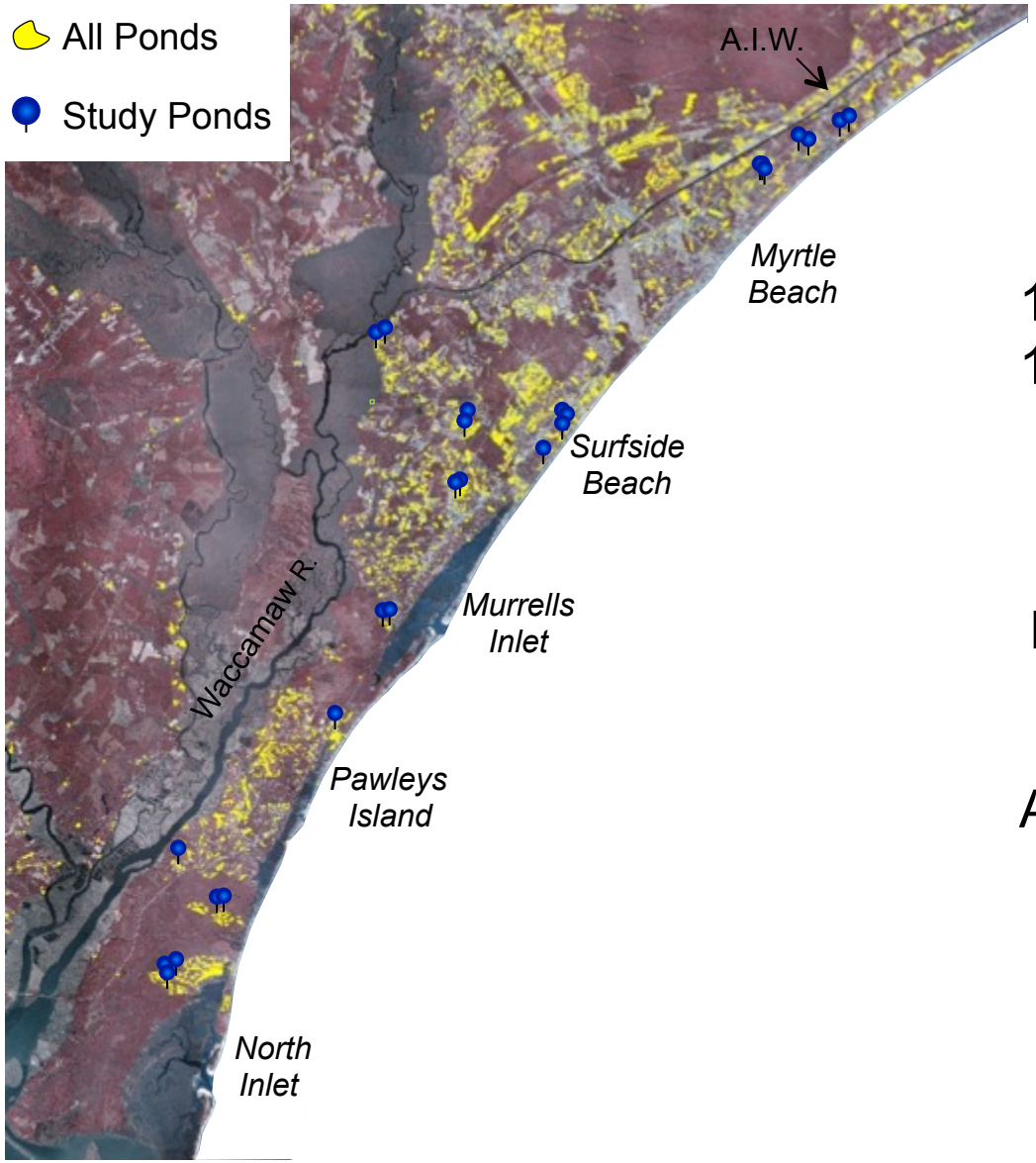


Most stormwater ponds are **detention** ponds

- Designed to capture “first flush” (typically 1st 0.5” of runoff)
- Outlet structure discharges to adjacent surface water
- Ultimately drain to coastal receiving waters.

How do water quality impacts in these (freshwater) ponds affect water quality conditions and ecosystem function in (marine) tidal receiving water?

Comparative study of 26 stormwater ponds spanning a range of development density



26 residential ponds

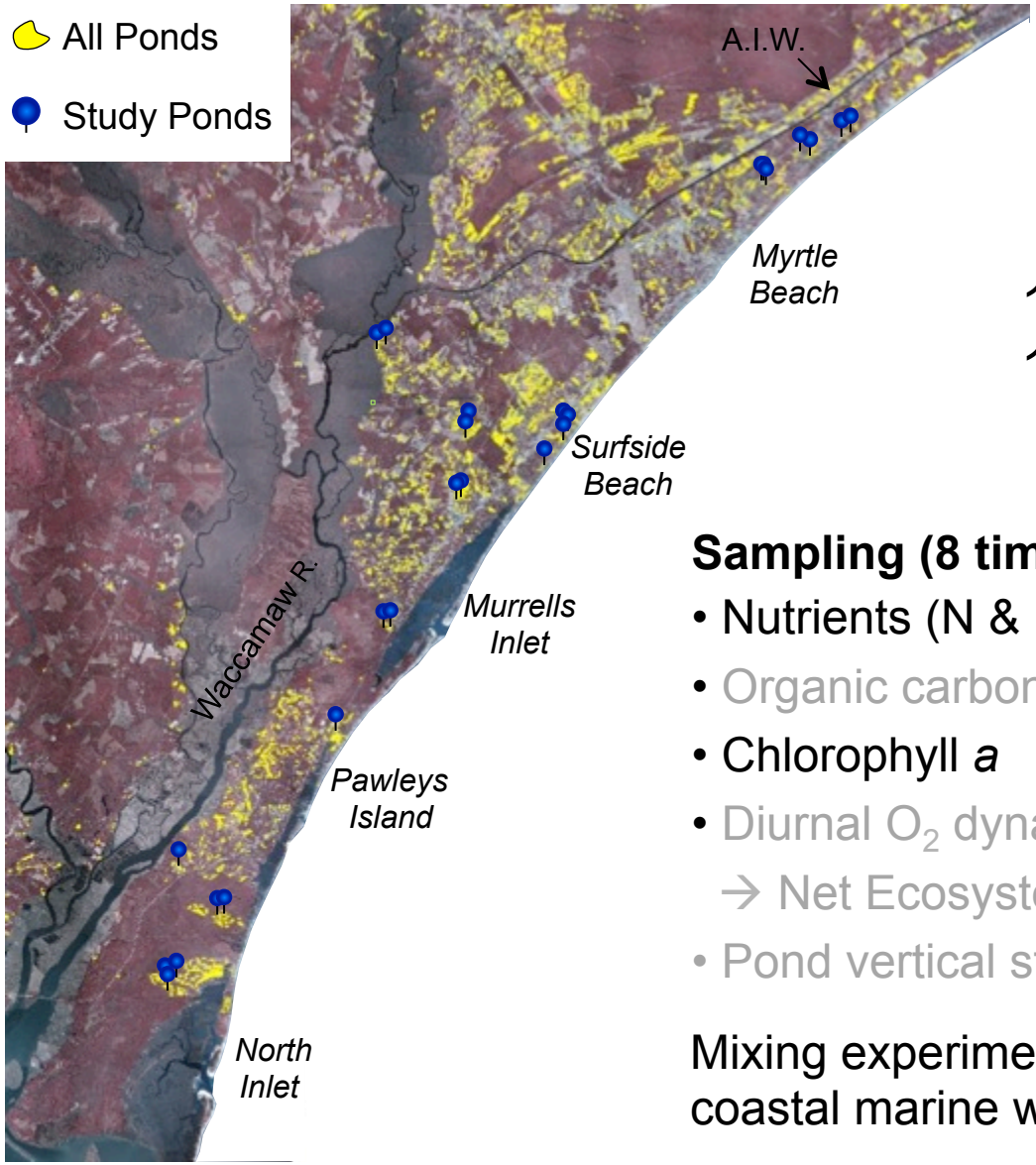
2 Undeveloped
7 Low density development
10 Medium density development
10 High density development

Pond size : 0.25 – 13.6 acre
mean = 4.3 acre

Pond depth : 1.0 – 5.0 m
mean = 2.0 m

All sampled ponds are *freshwater.*

Comparative study of 26 stormwater ponds spanning a range of development density



26 residential ponds

2 Undeveloped
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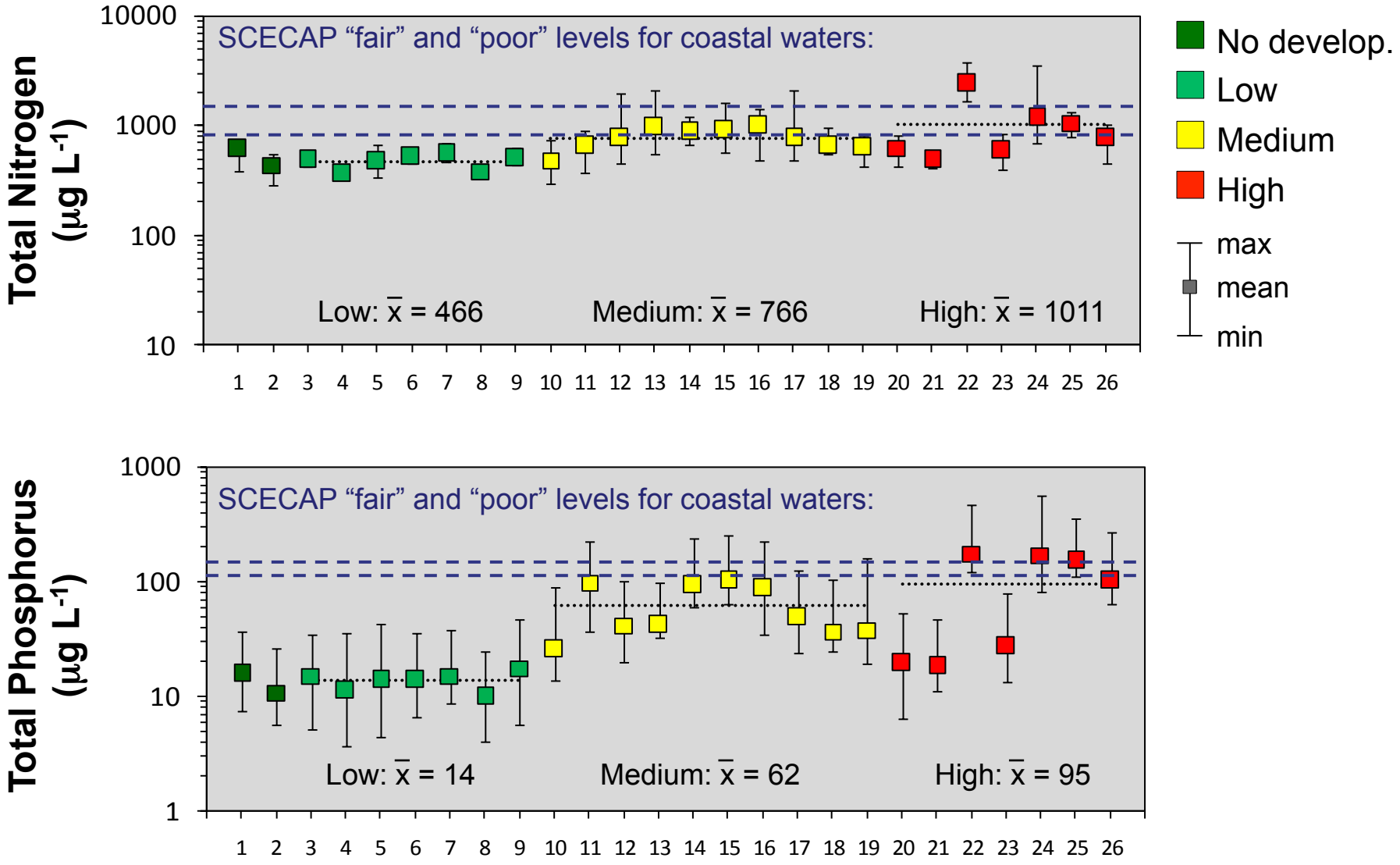
Sampling (8 times from June – September):

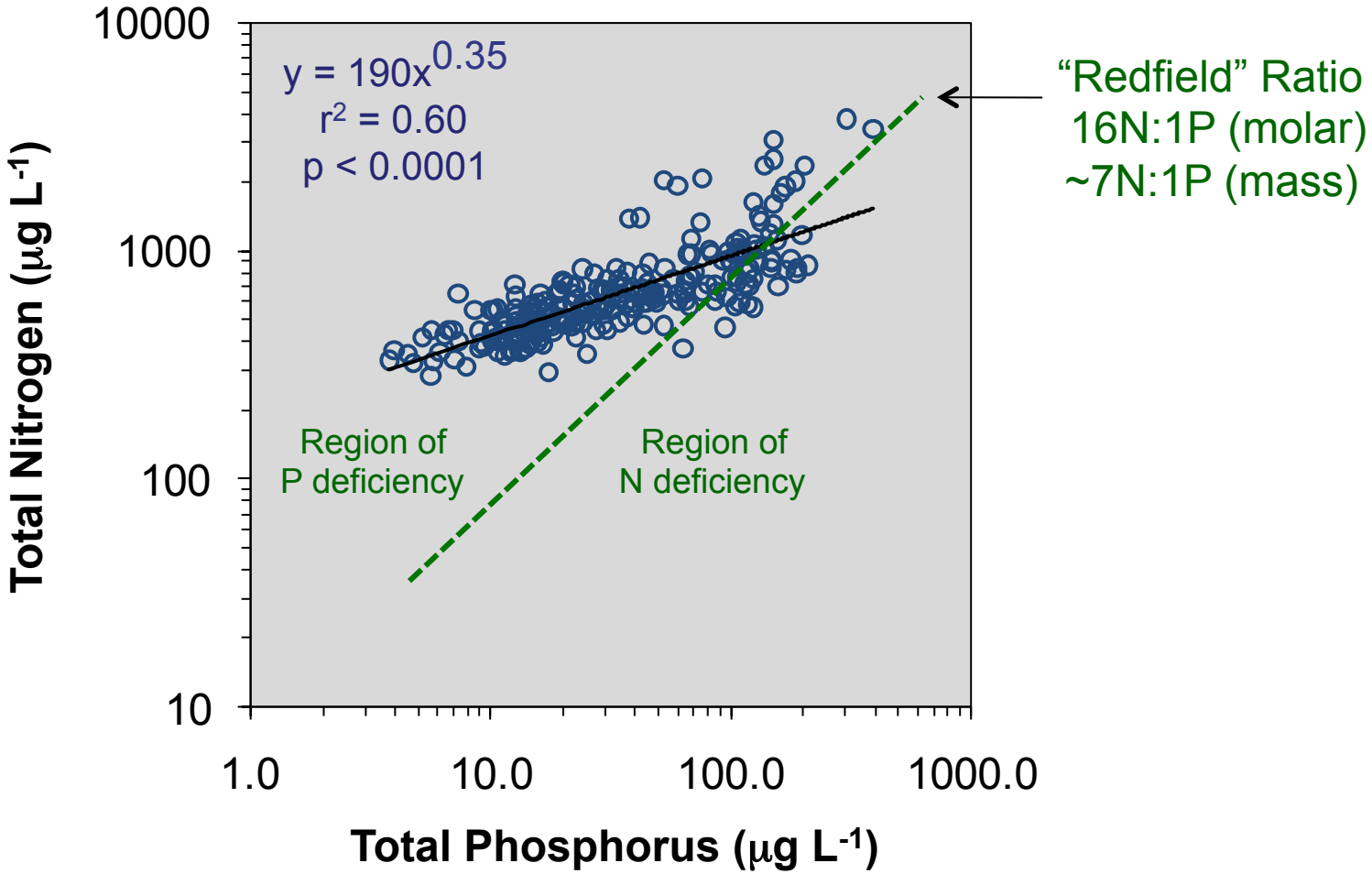
- Nutrients (N & P in all forms, particulate & dissolved)
- Organic carbon (particulate & dissolved, % labile)
- Chlorophyll *a*
- Diurnal O_2 dynamics in surface & bottom waters
  → Net Ecosystem Production
- Pond vertical structure and light attenuation

Mixing experiments: Effects of pond discharges on coastal marine waters

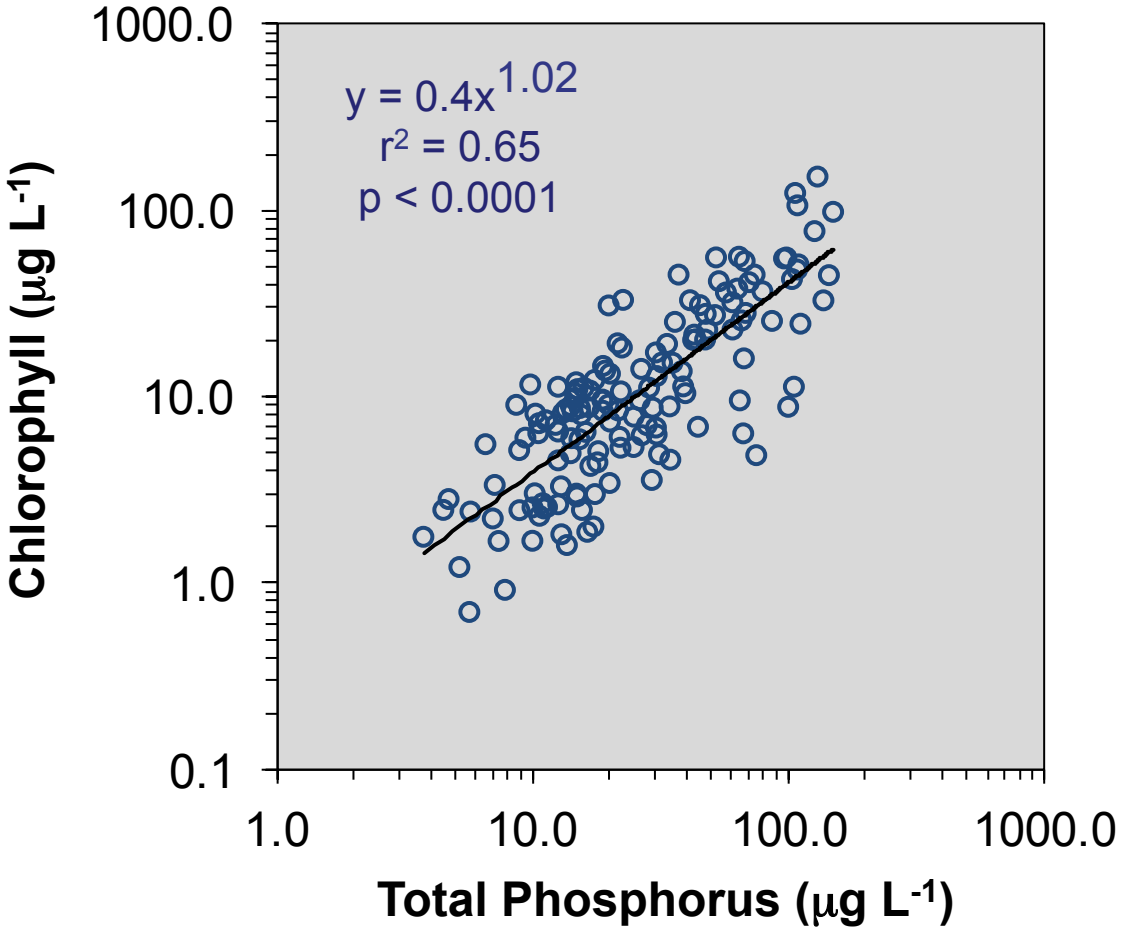
Total nutrient concentration variability across all ponds:



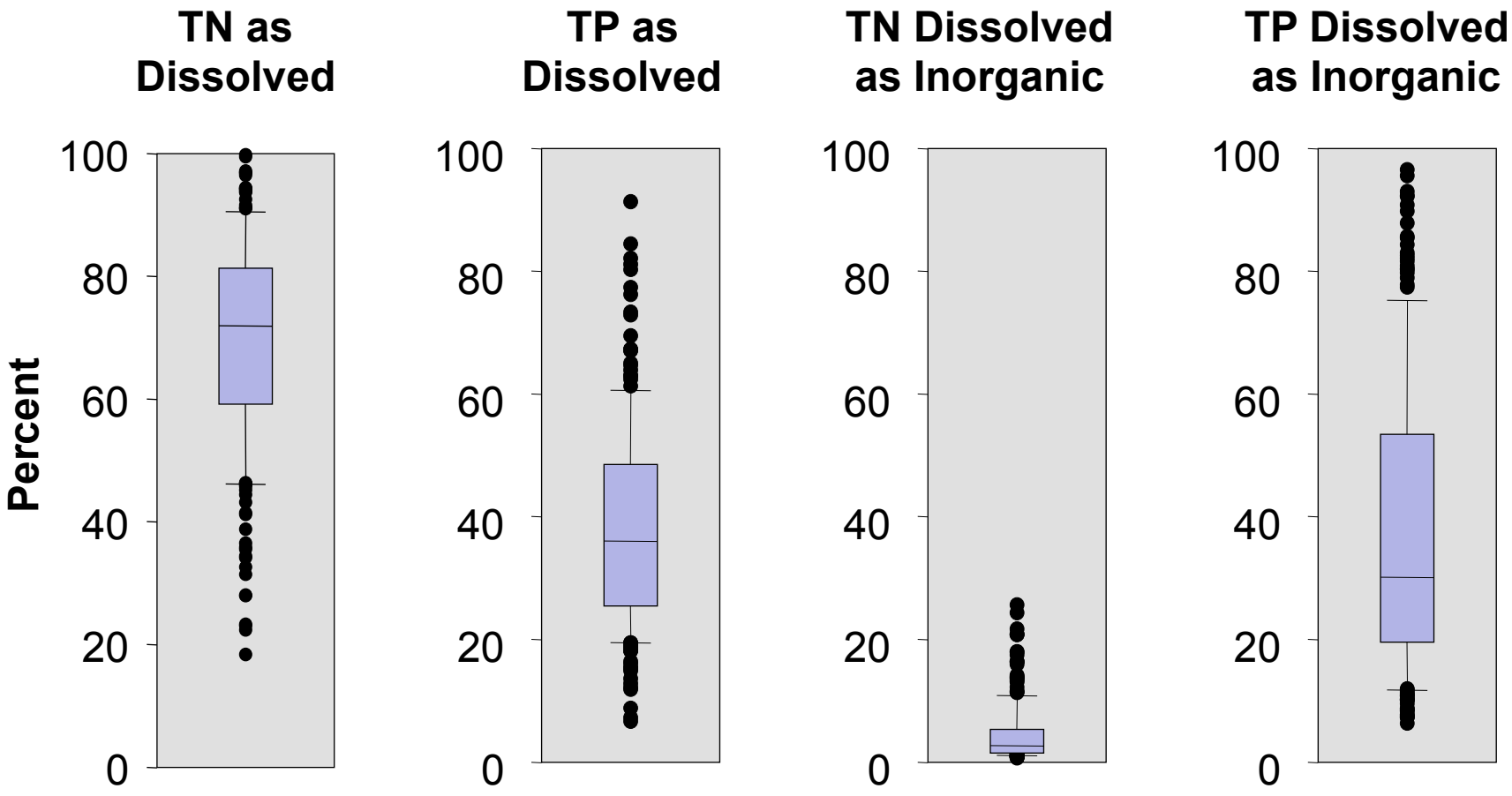
Strong Relationship Between
Total Nitrogen and Total Phosphorus
(all ponds, all sampling events)



Total phosphorus is a strong predictor of Chlorophyll across all ponds

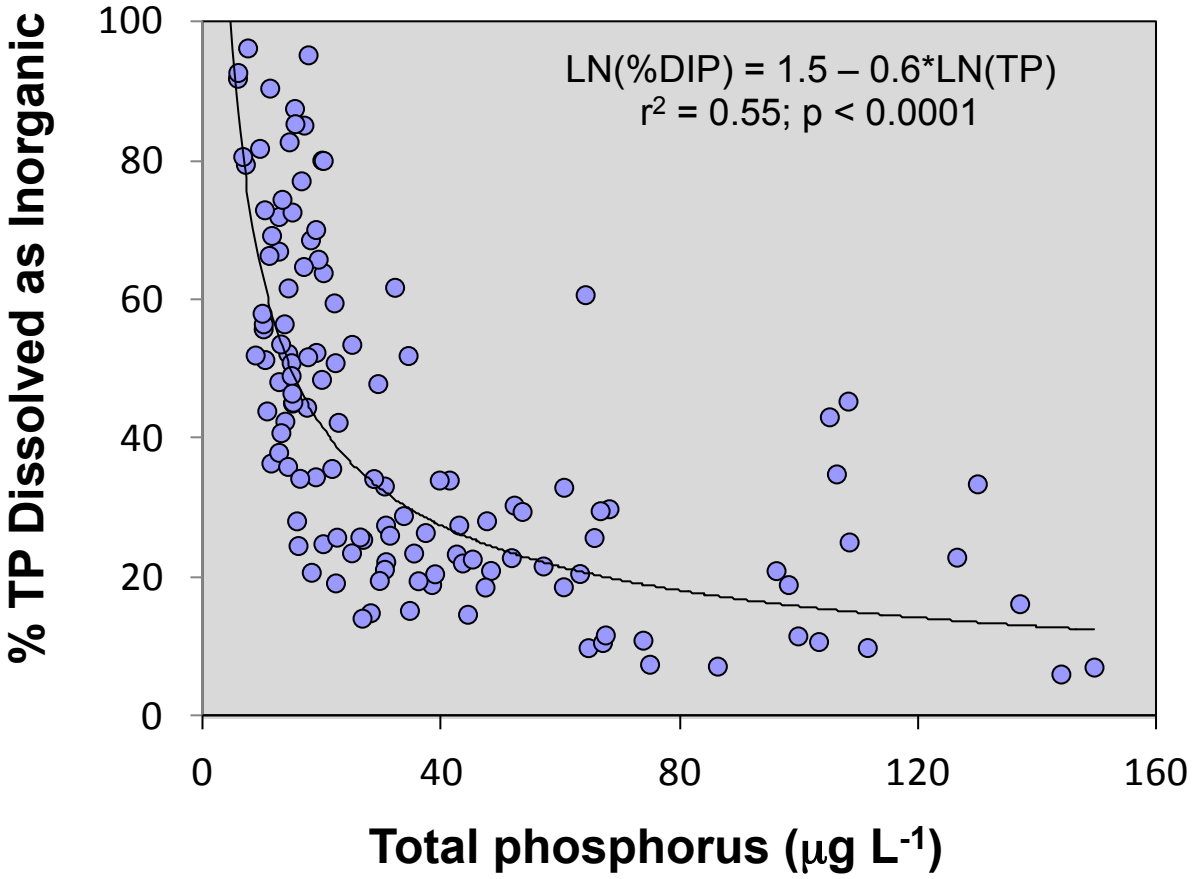


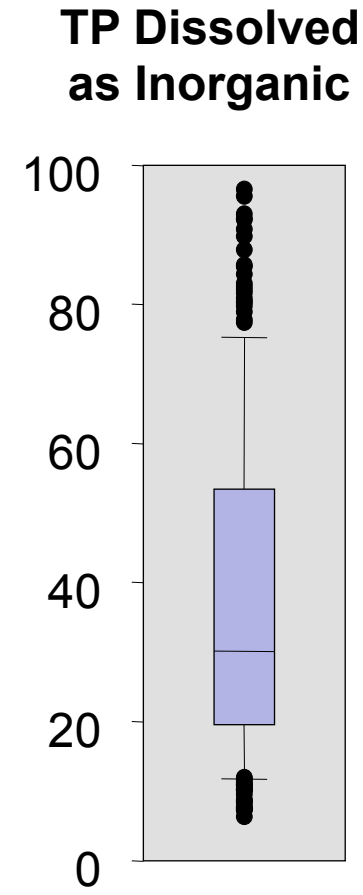
Nutrient Distributions: Particulate vs. Dissolved & Organic vs. Inorganic



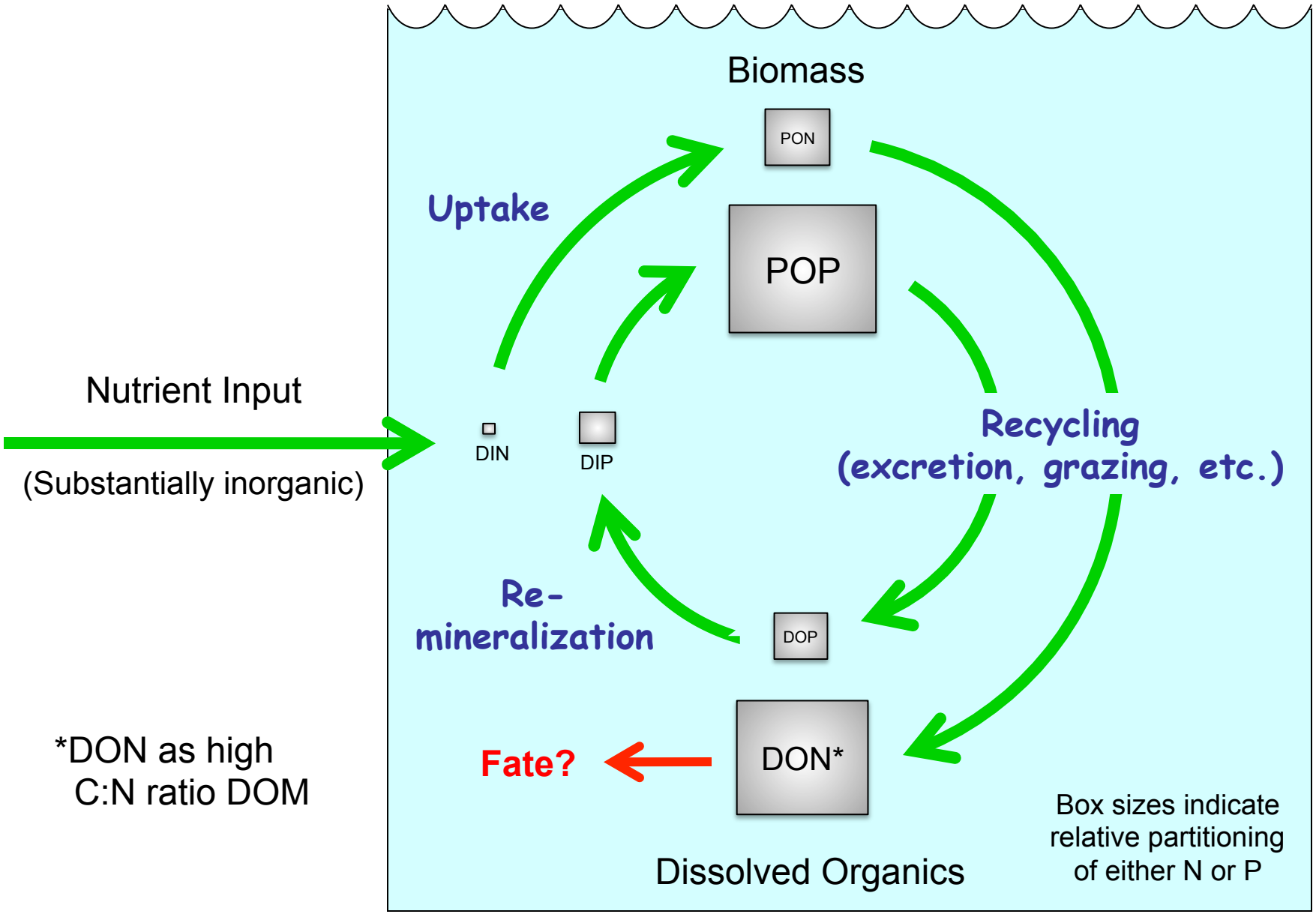
- TN dominated by DISSOLVED N.
- TP dominated by PARTICULATE P.
- $TN_{dissolved}$ dominated by DON.
- $TP_{dissolved}$ much more variable.

Nutrient Distributions:
Particulate vs. Dissolved & Organic vs. Inorganic





Conceptual Model of Nutrient Dynamics in Ponds



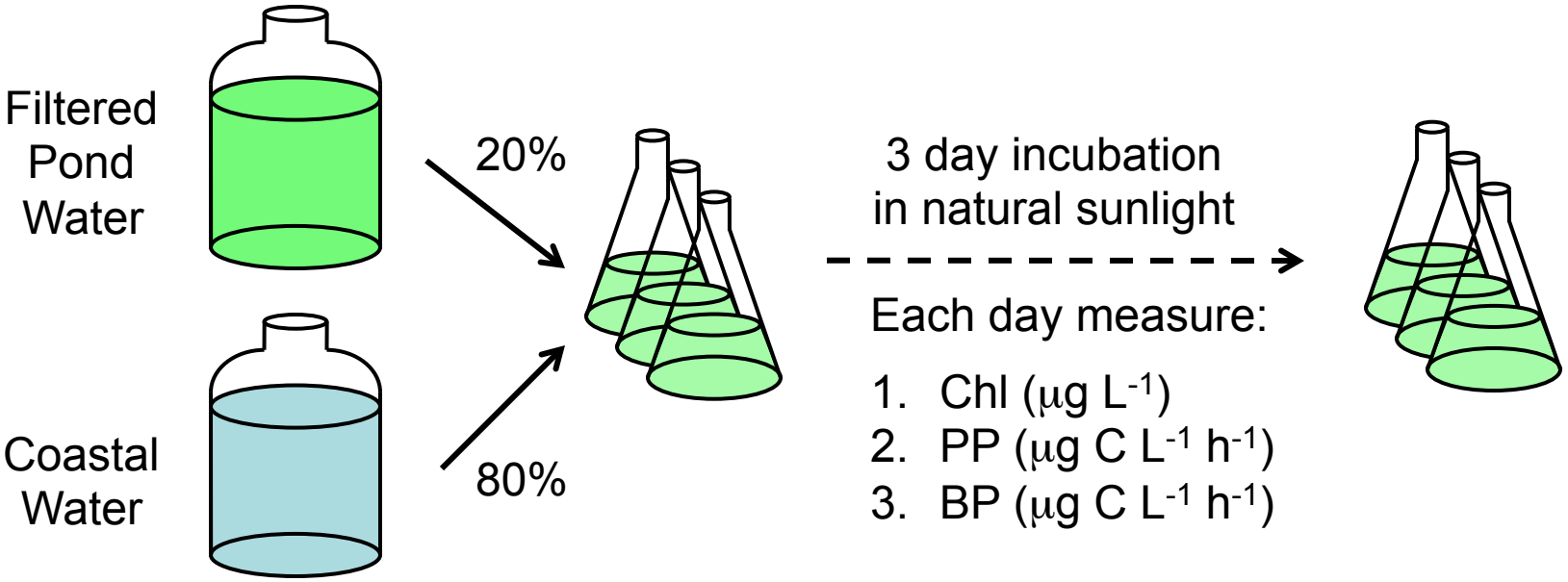
What happens when this DON enters (N-limited) coastal marine waters?

Approach: Mix: 20 % filtered pond water with 80 % North Inlet water

Response Variables:

- Chlorophyll concentration
- Phytoplankton primary production rate (^{14}C method)
- Bacterioplankton production rate (^{3}H-Leucine method)

Quantify over 3 days of incubation under natural sunlight



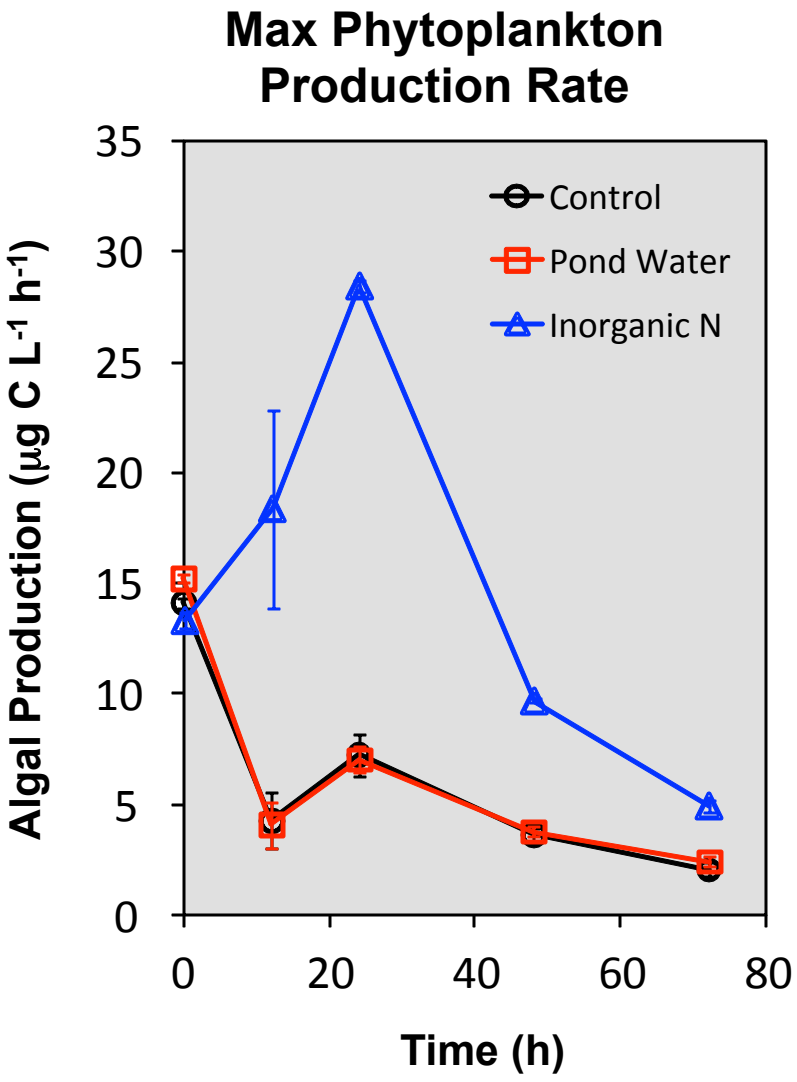
What happens when this DON enters (N-limited) coastal marine waters?

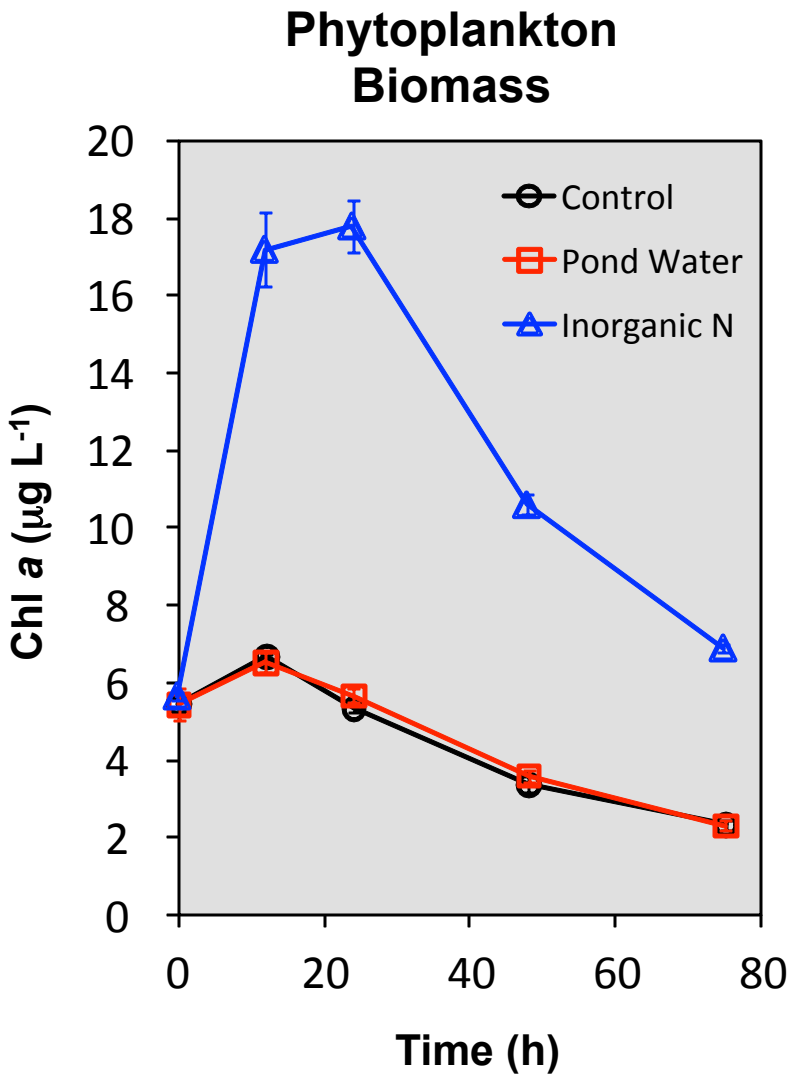
Approach: Mix: 20 % filtered pond water with 80 % North Inlet water

Treatments (triplicate incubations):

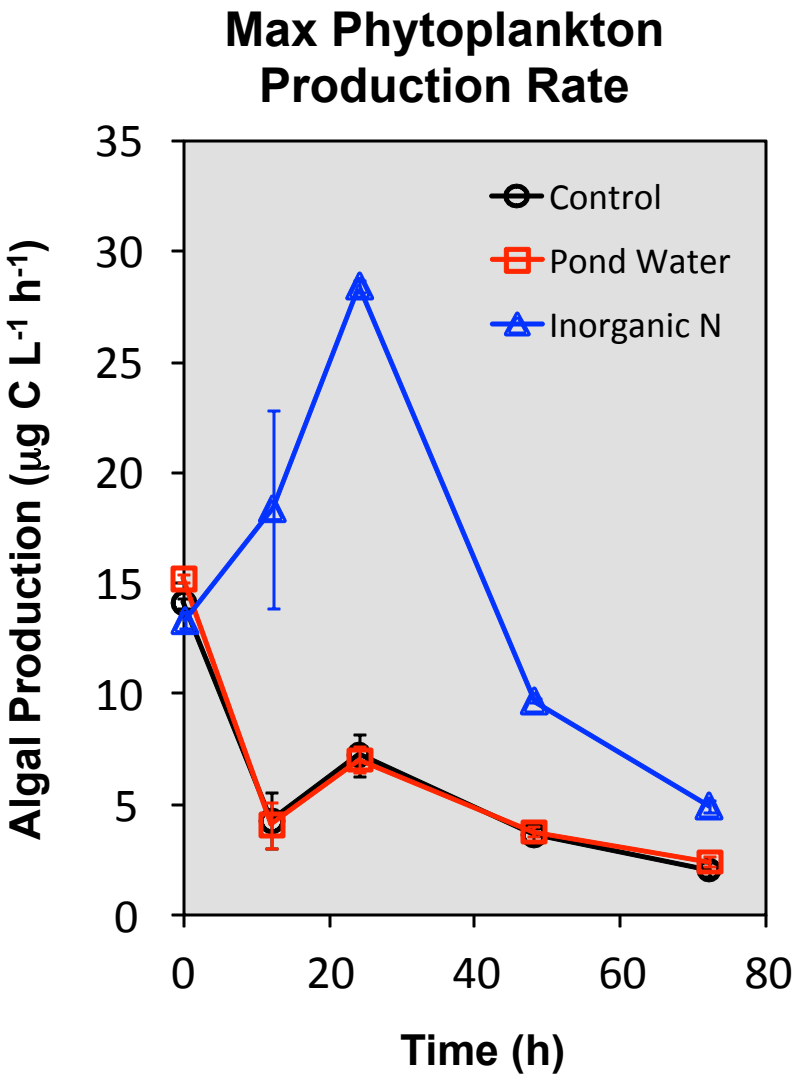
- 0.2 μm filtered pond water
- D.I. water (control for dilution effects)
- D.I. water with equivalent concentration of N as DIN (50:50 NH_4:NO_3)

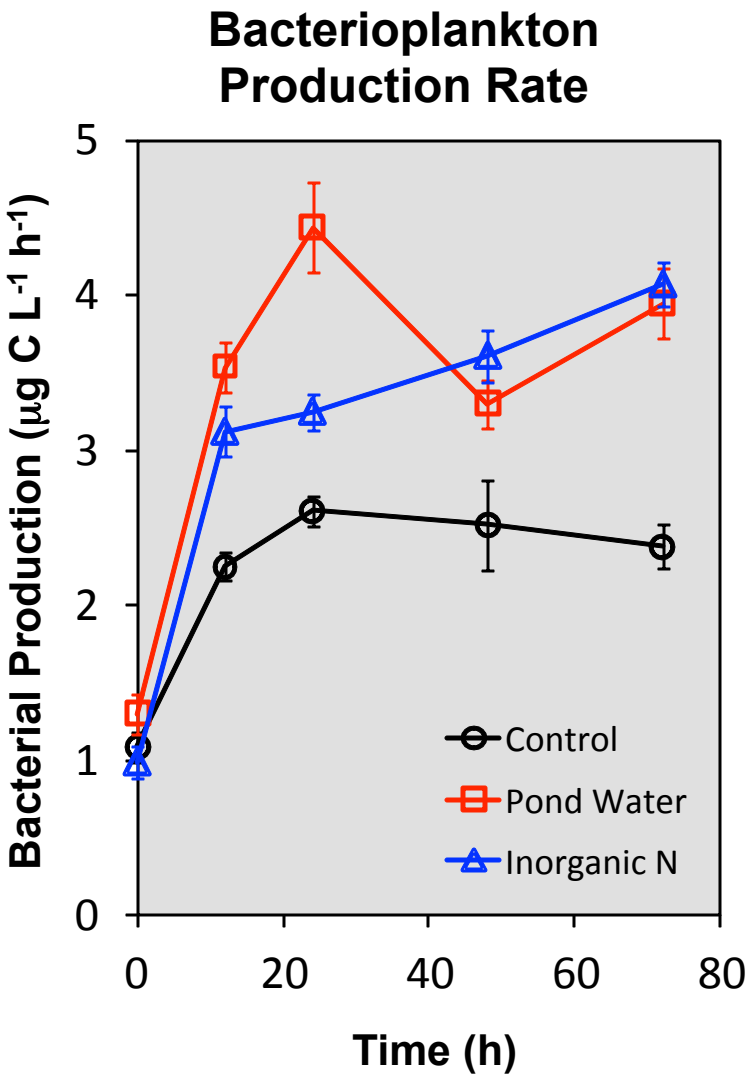
Autotrophic response:





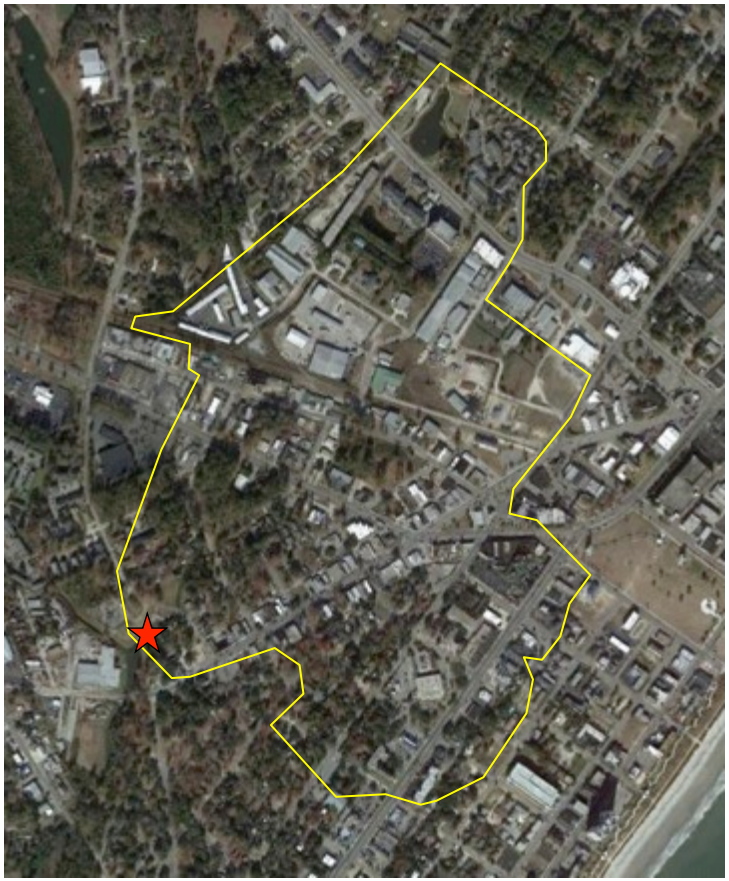
Autotrophic vs. heterotrophic responses:



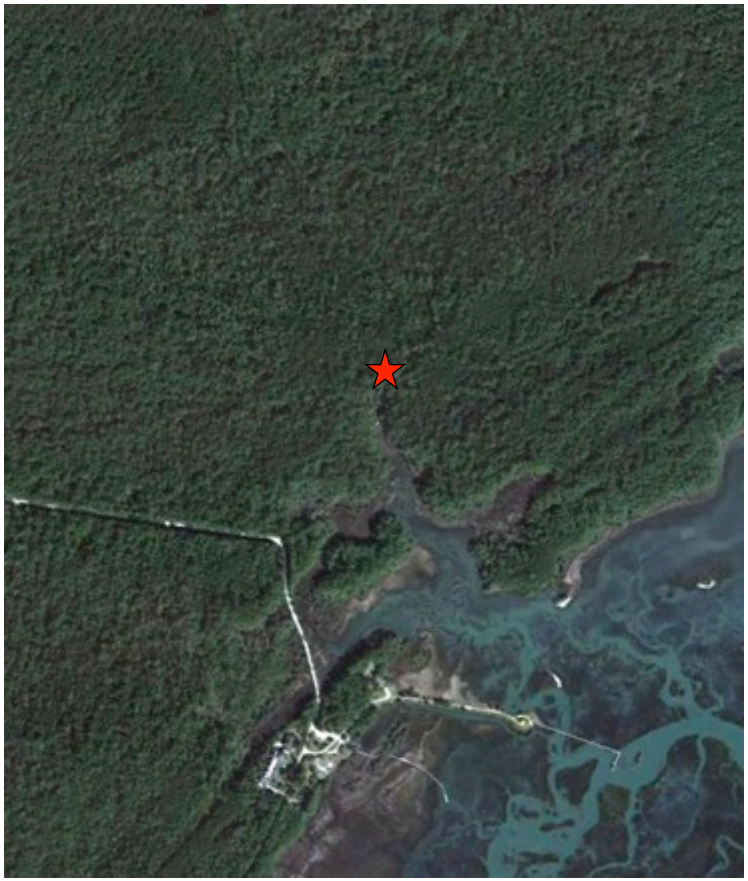


Pond discharge effects relative to those from other sources

Urban stormwater runoff

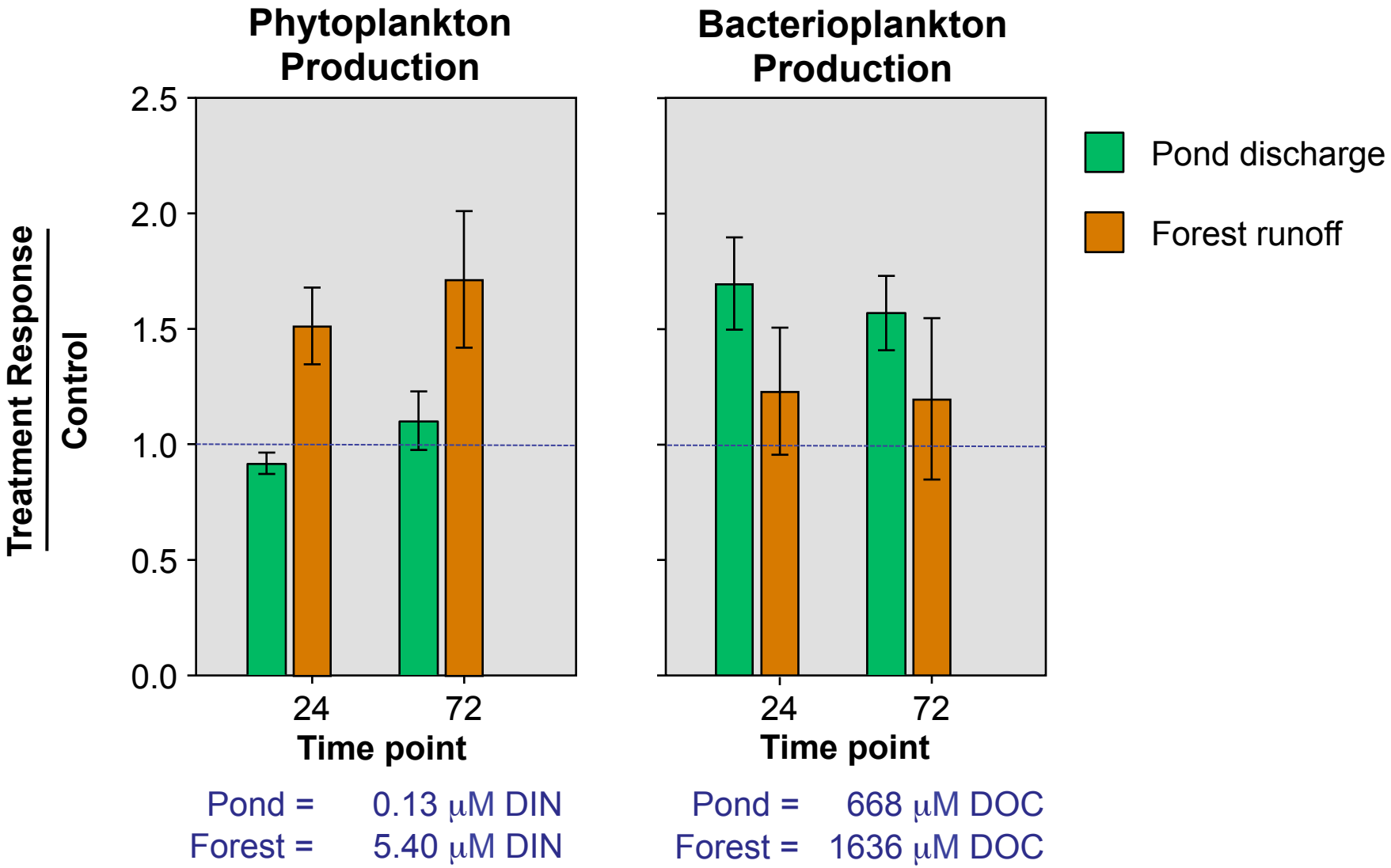


Forest drainage



Hutchins PR, EM Smith, ET Koepfler, RF Viso, RN Peterson (2013) Metabolic responses of estuarine microbial communities to discharge of surface runoff and groundwater from contrasting landscapes. Estuaries and Coasts, in press.

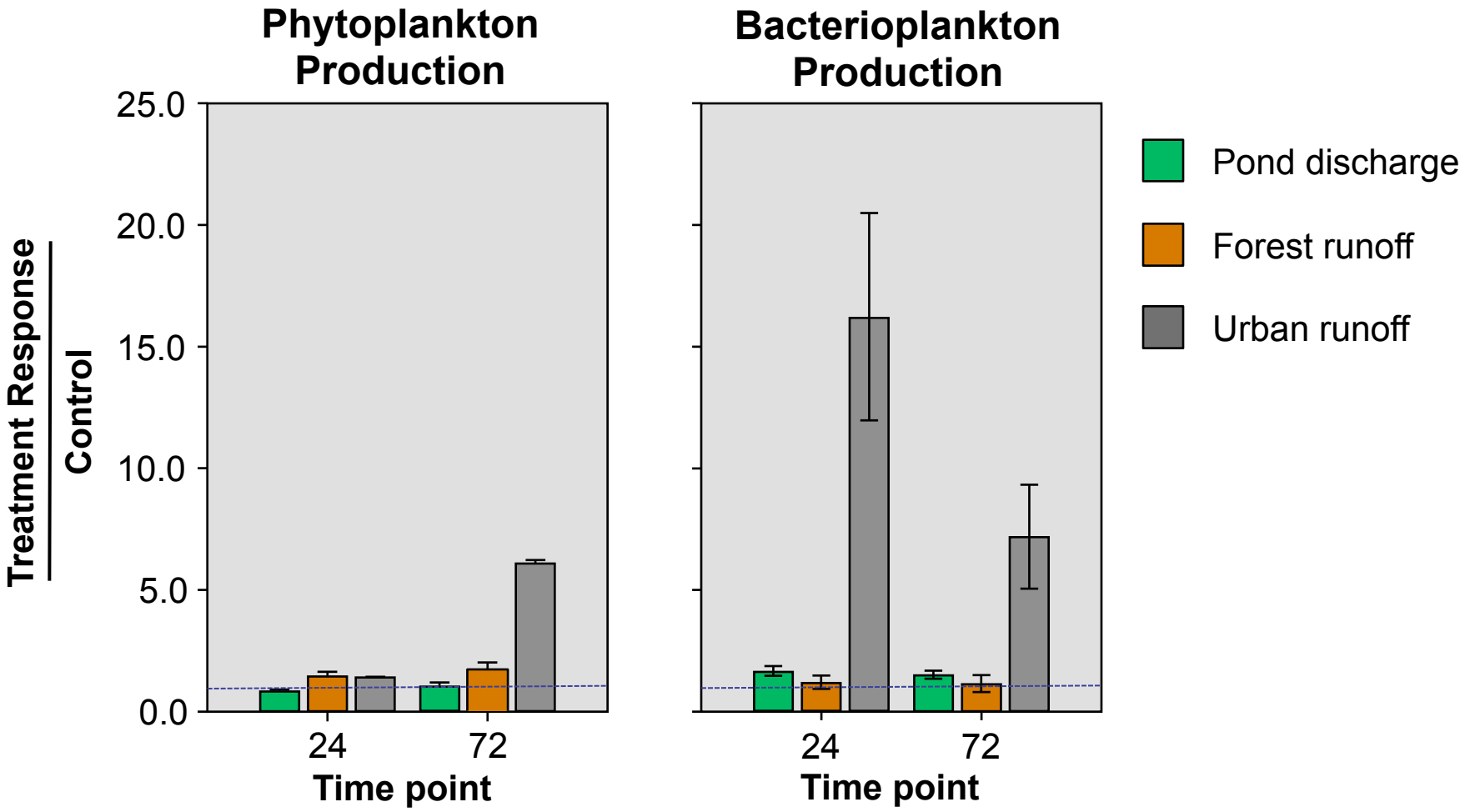
Pond discharge effects relative to those from other sources



Pond = 0.13 μM DIN
Forest = 5.40 μM DIN

Pond = 668 μM DOC
Forest = 1636 μM DOC

Pond discharge effects relative to those from other sources



Pond = 0.13 μM DIN
Forest = 5.40 μM DIN
Urban = 203.22 μM DIN

Pond = 668 μM DOC
Forest = 1636 μM DOC
Urban = 2628 μM DOC

Summary

- Stormwater detention ponds have become a major feature of the landscape in coastal South Carolina.
  ~ 14,000 ponds within coastal zone, covering ~ 85 Km^2 (~ 21,000 acres)

- Ponds exhibit a large range in nutrient and chlorophyll concentrations.
  - Development appears to increase TP more so than TN concentrations
    - Relatively little variation in nitrogen within and across ponds
    - Substantial variation in phosphorus within and across ponds

- Chl concentrations more a function of TP variability, than TN variability

- Pond organic matter dominated by dissolved materials & ponds effectively convert DIN inputs to DON, which accumulates as high C:N DOM.

- Pond exports have little to no direct effect on marine autotrophic processes, but significantly stimulate heterotrophic processes.

  → Responses to pond discharges much smaller than response to direct urban stormwater runoff