

How the Delaware Estuary Works

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Prepared for Processes Workgroup

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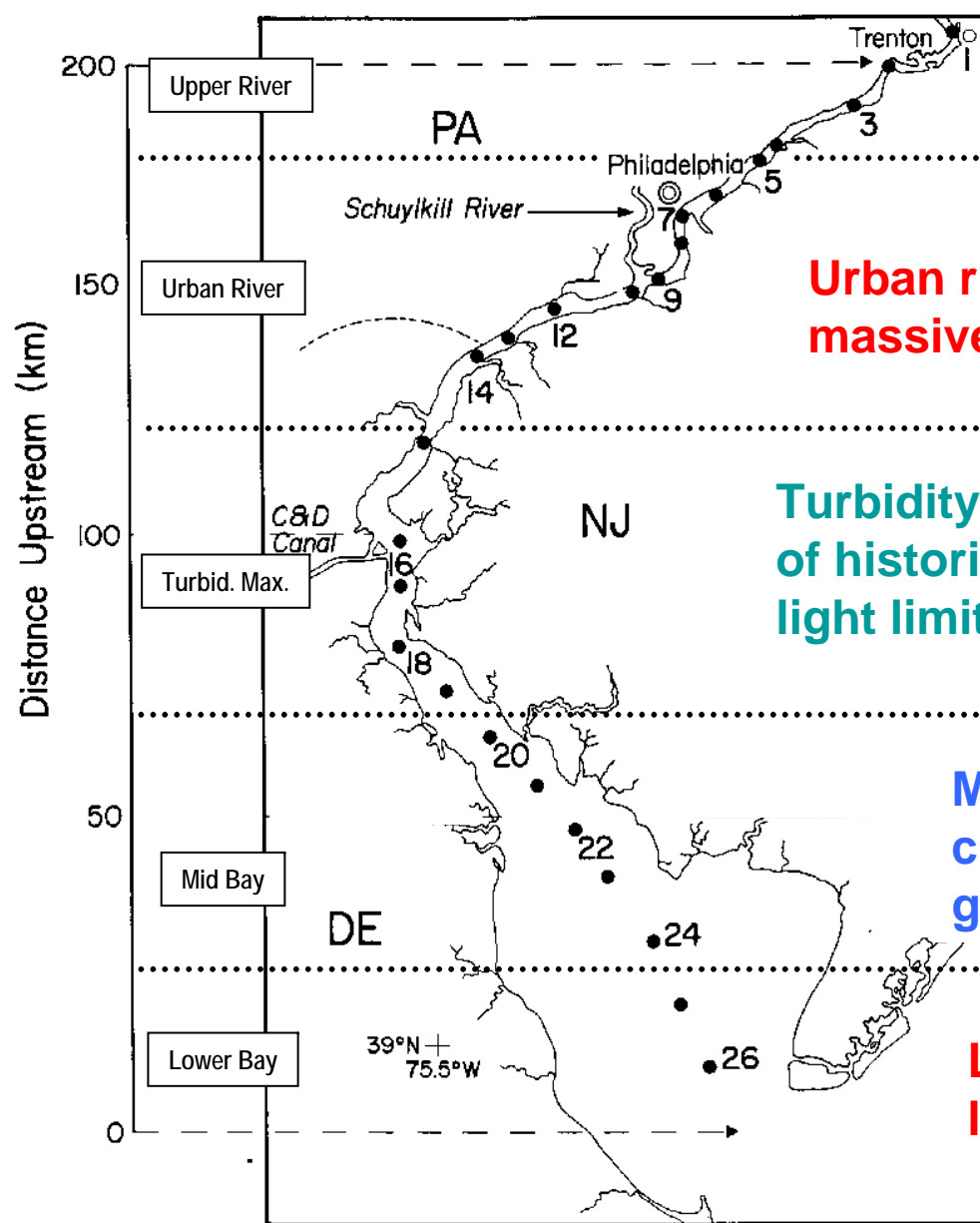
The Delaware Estuary

Tidal Delaware River – about 80 km length of fresh water from head of tide through Philadelphia urban area.

Saline river and bay – about 140 km length with salinity from about 0.2 to 30. Broad mid and lower bay (generally 10-30 salinity) makes up most of surface area and volume of estuary.

Very high nutrient inputs from upper drainage basin and inputs in urban region; diluted going down salinity gradient to low near mouth of Delaware Bay.

We have divided into 5 regions (along distance axis) that can be individually characterized.



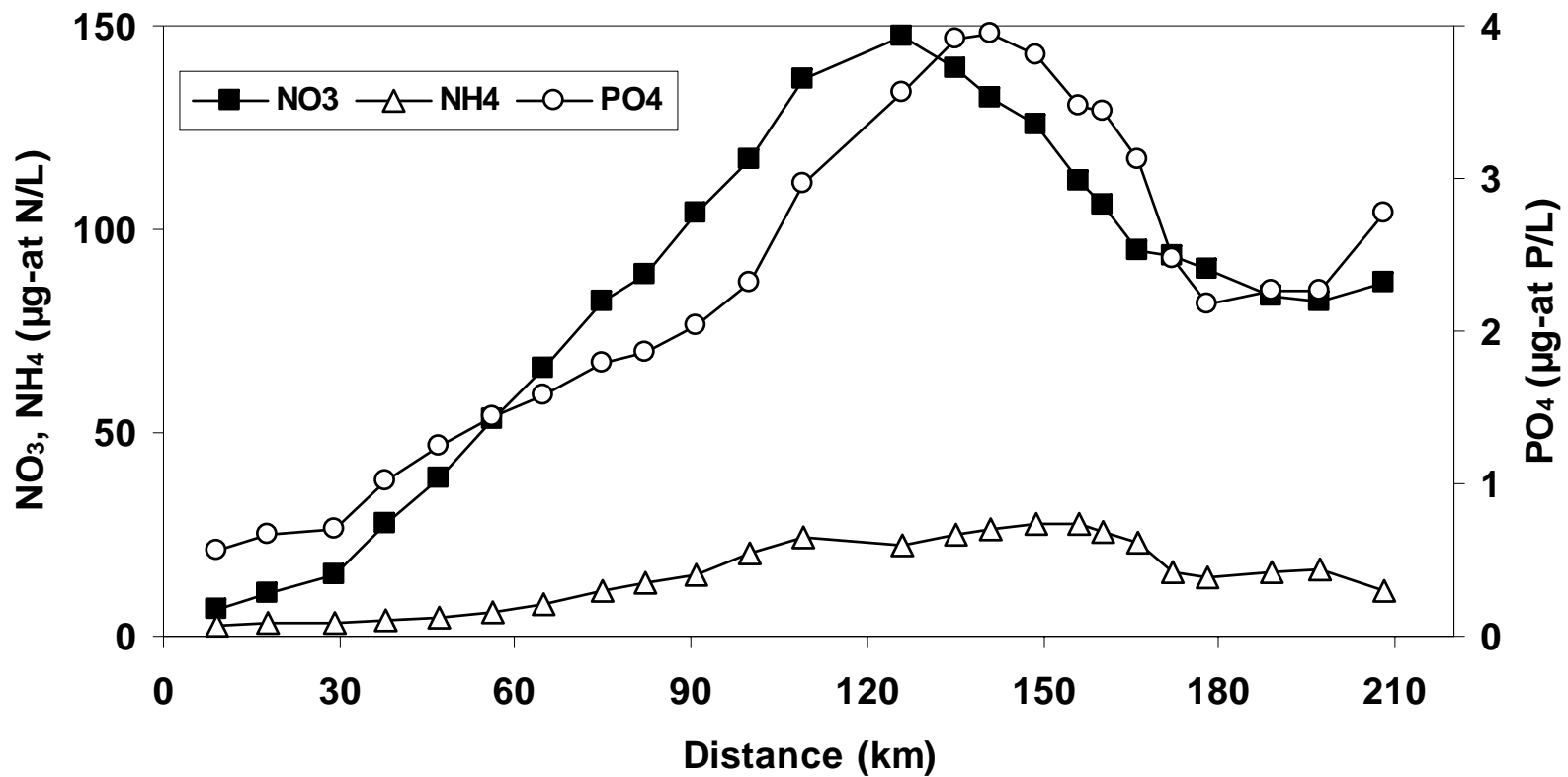
Upper tidal river – clear, composite agricultural and municipal inputs from fall line

Urban river – relatively clear, local massive municipal inputs

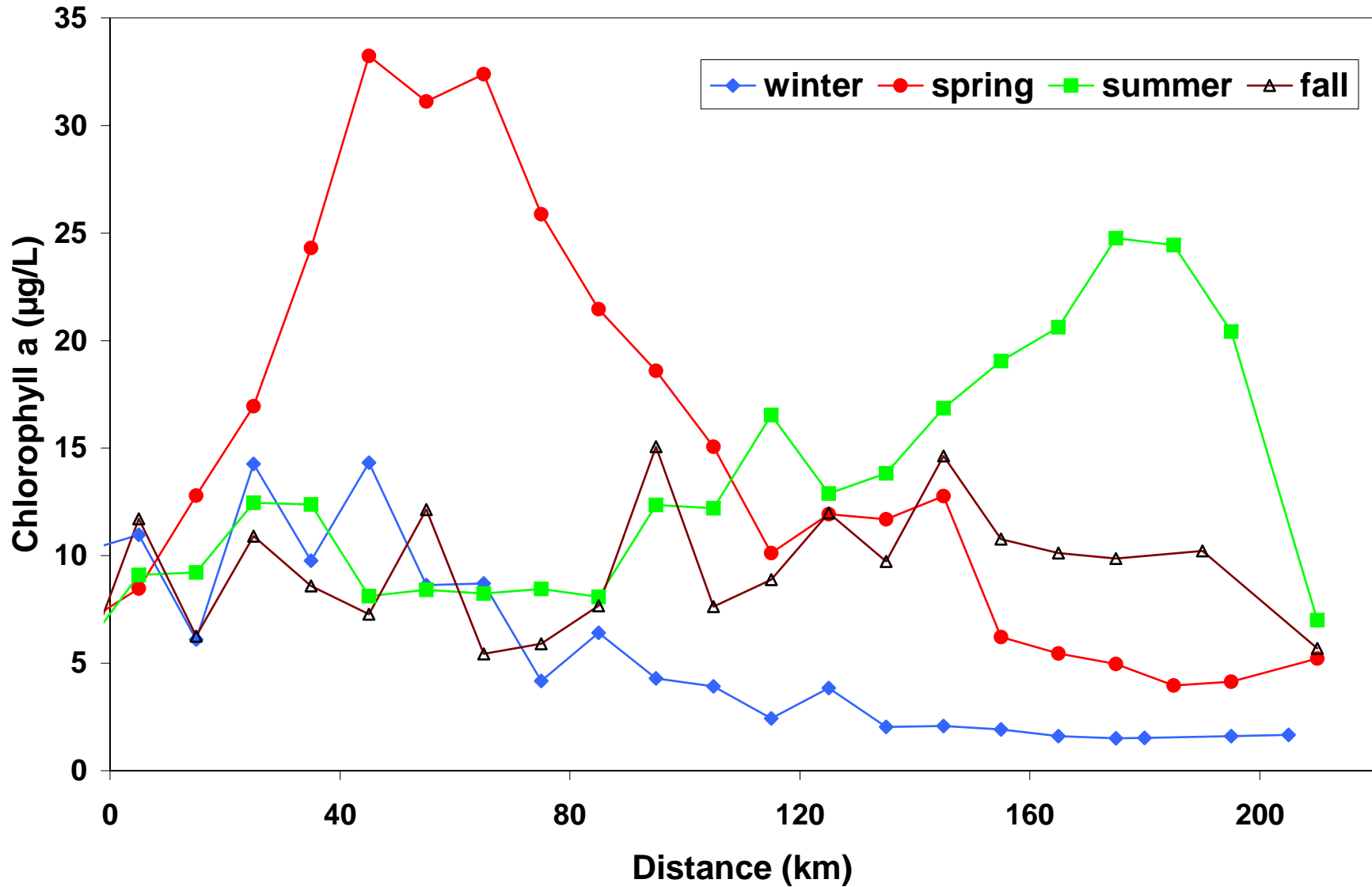
Turbidity maximum – resuspension of historical TSS inputs – strong light limitation

Mid-bay – grading from turbid to clear, relatively high nutrients grading to limitation

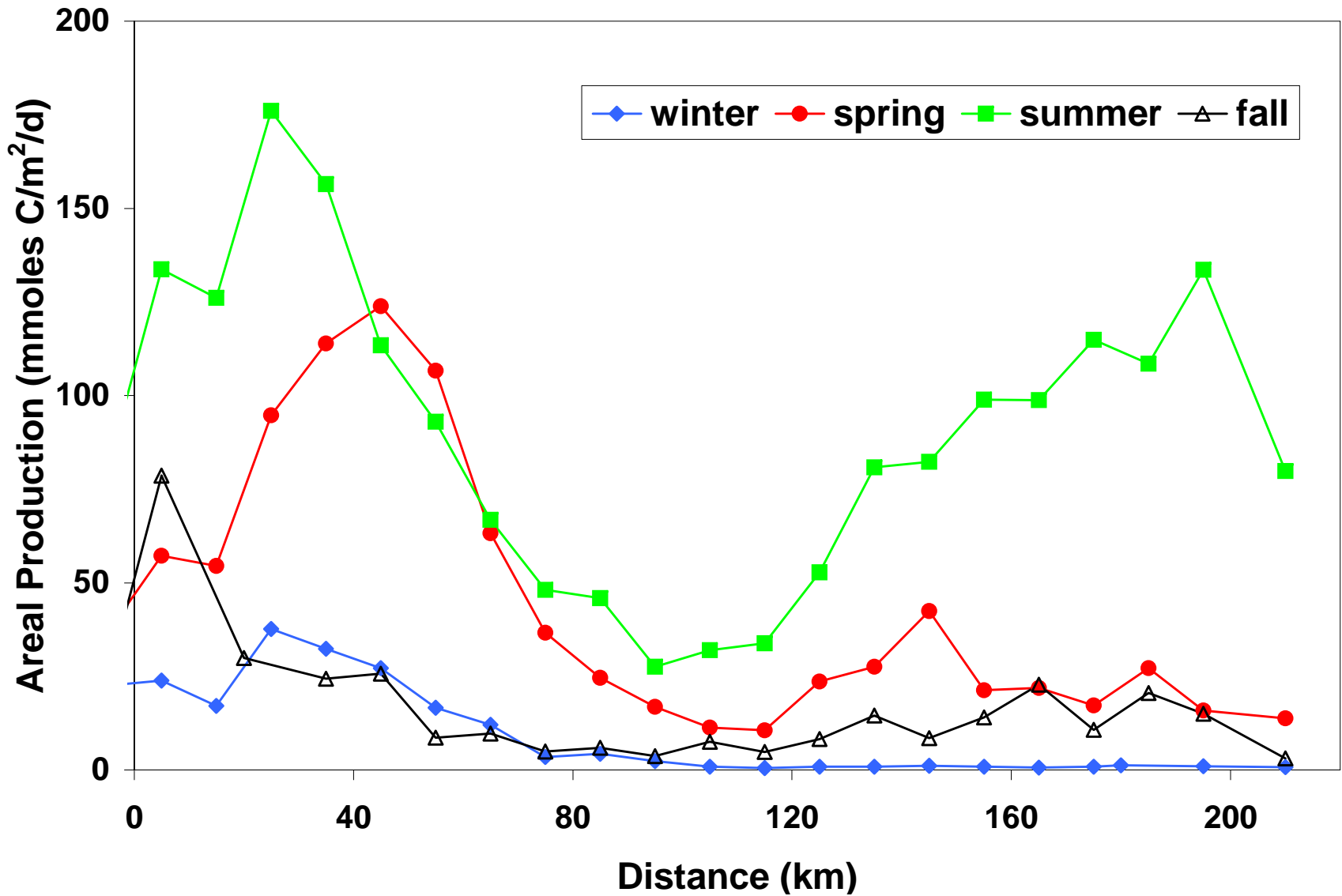
Lower bay – very clear, nutrient-limited



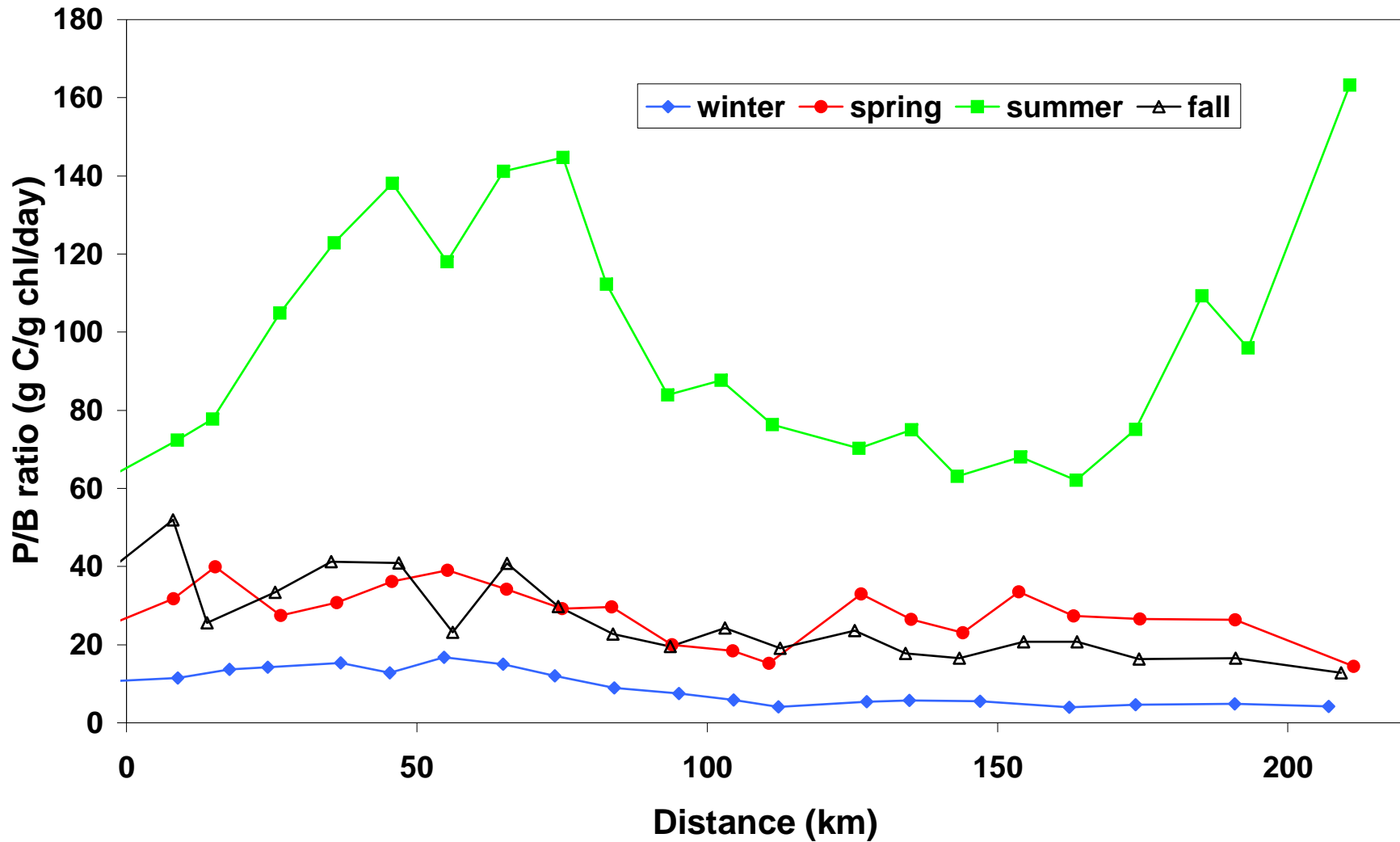
Monthly-weighted annual average nutrient concentrations in Delaware Estuary – large seasonal variations. The very high concentrations in the urban river region grade to low by mouth of bay.



Chlorophyll biomass in the Delaware Estuary – seasonal averages for 1978 -2003. Spring bloom biomass peak in mid-bay; high in upper river only in summer.



Depth-integrated 24 hr ^{14}C “simulated” *in-situ* areal primary production in Delaware Estuary. Peak associated with spring bloom but higher peak nearer mouth of bay in summer.

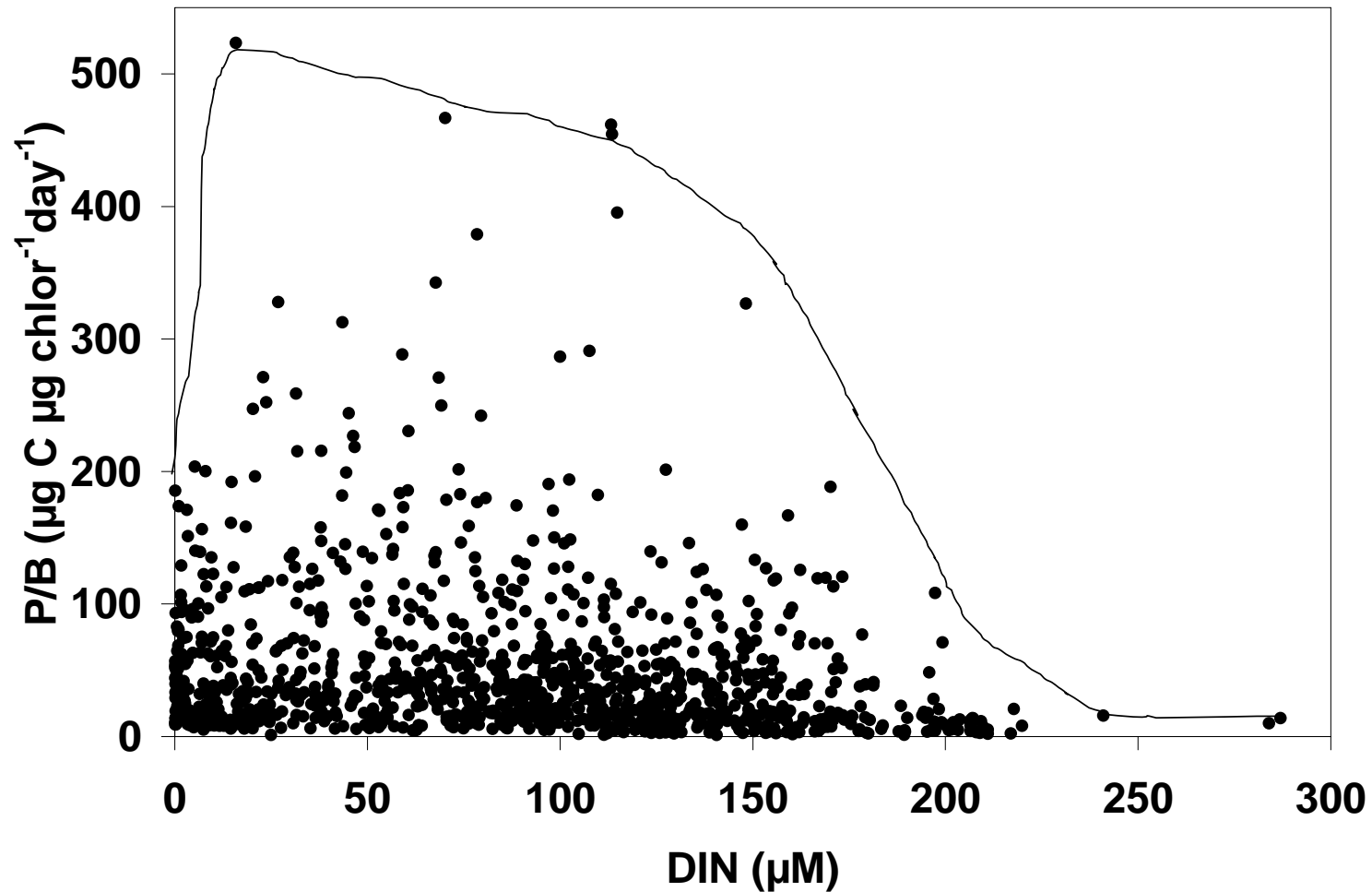


Normalizing 24-hr production to chlorophyll biomass – indicator of phytoplankton physiology. Highest in mid-bay in summer; also, peak in upper river in summer.

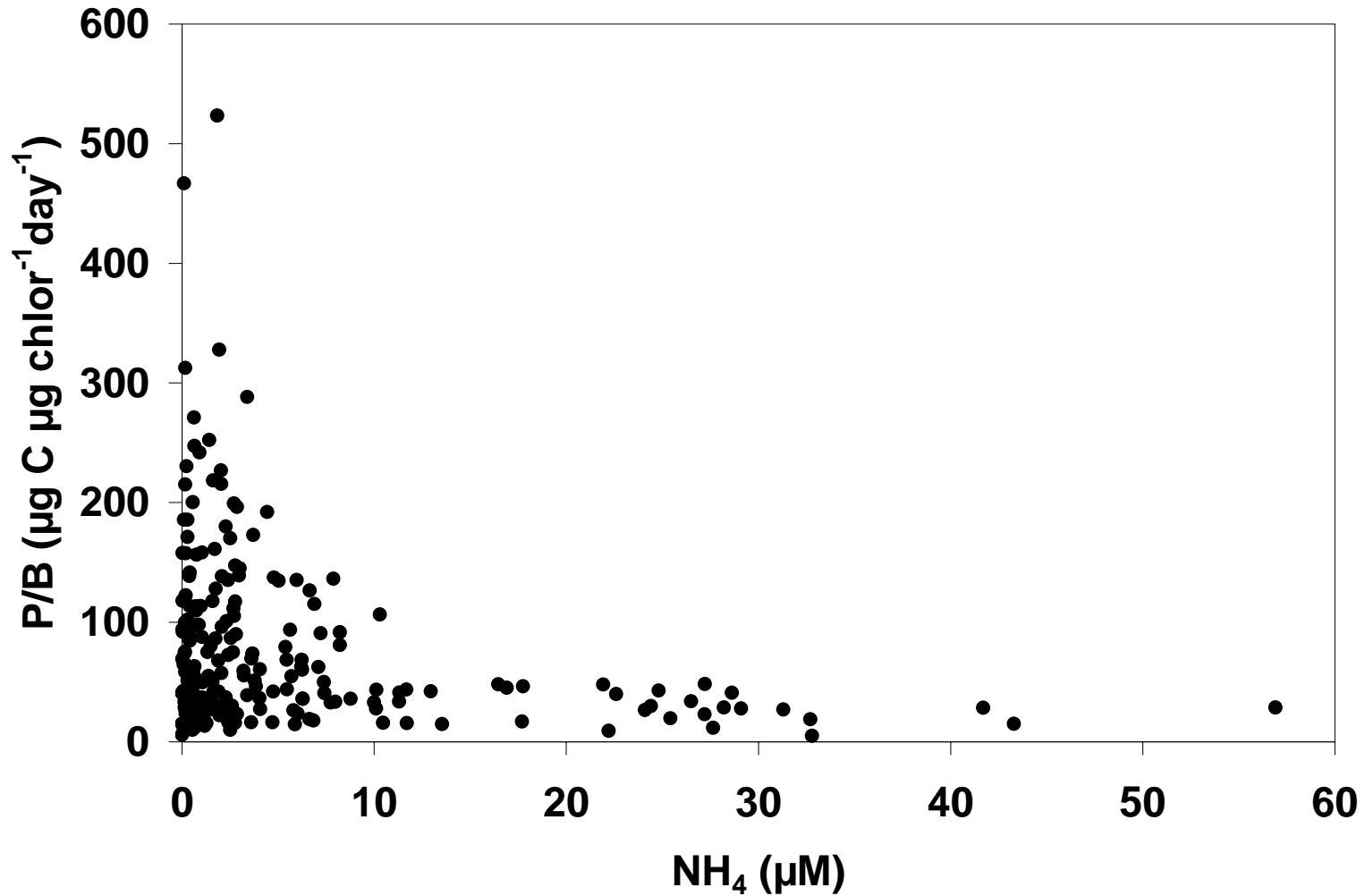
Lack of Response

Looking at the summer P/B plot in the last slide, production is low at the mouth of the bay (probably due to nutrient limitation), it is low in the region of the turbidity maximum around 100 km (strong light limitation) and is low in the urban river region around 120-150 km (presumably due to contaminant inhibition).

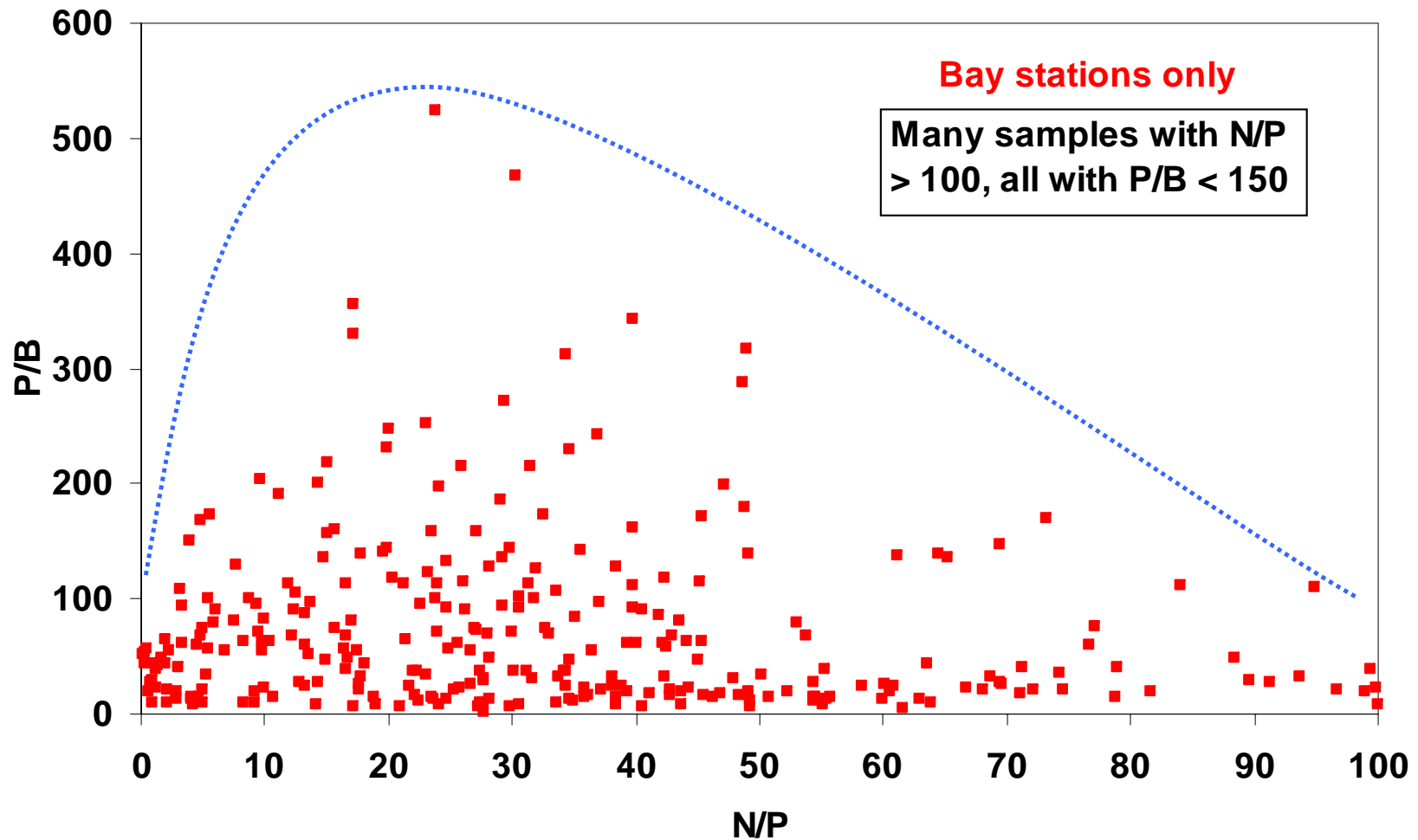
Overall, there does not appear to be a strong response of primary production to nutrient concentration. This can be seen by plotting P/B against nutrient concentration.



Production in the Delaware Estuary for all regions of the estuary for all seasons versus ambient total dissolved inorganic nitrogen (DIN) concentration. A threshold is reached and there is lower production at very high DIN concentrations.



Production in the Delaware Estuary versus ammonium nitrogen concentration for mid and lower bay for spring and summer. A threshold for this specific N-species is very low (around 4 μM N).



Plot P/B versus N/P ratio of ambient nutrient pool. Highest production with N/P close to Redfield ratio. There is some P-limitation at moderate to high N concentrations.

Production from Chlorophyll

To use chlorophyll biomass as an indicator or algal response or to model production from ambient chlorophyll.

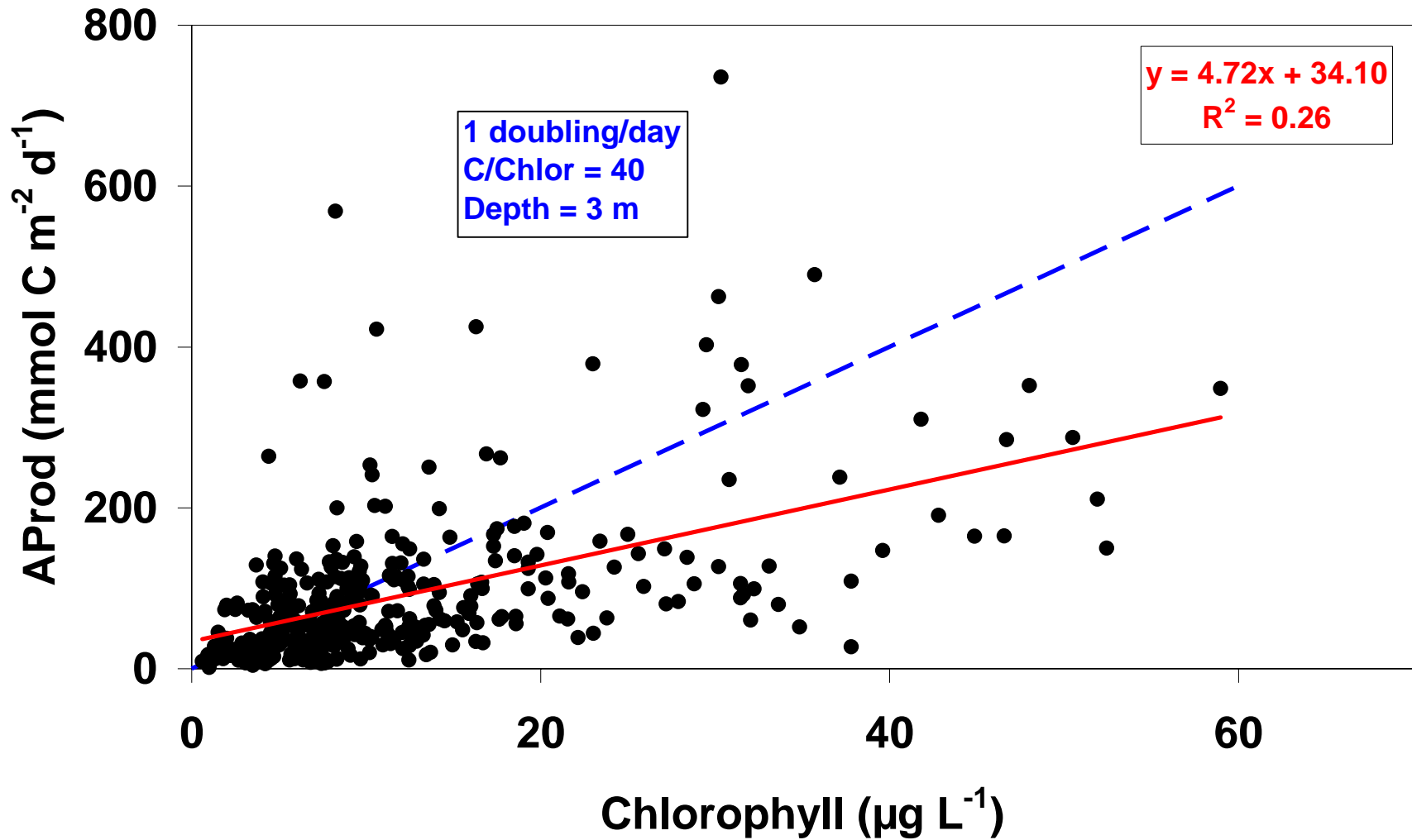
Measured chlorophyll from single surface depth.

Production measured as depth-integrated areal value from single surface sample and light levels simulating depths to bottom of photic zone.

Look at fit of regression trend line.

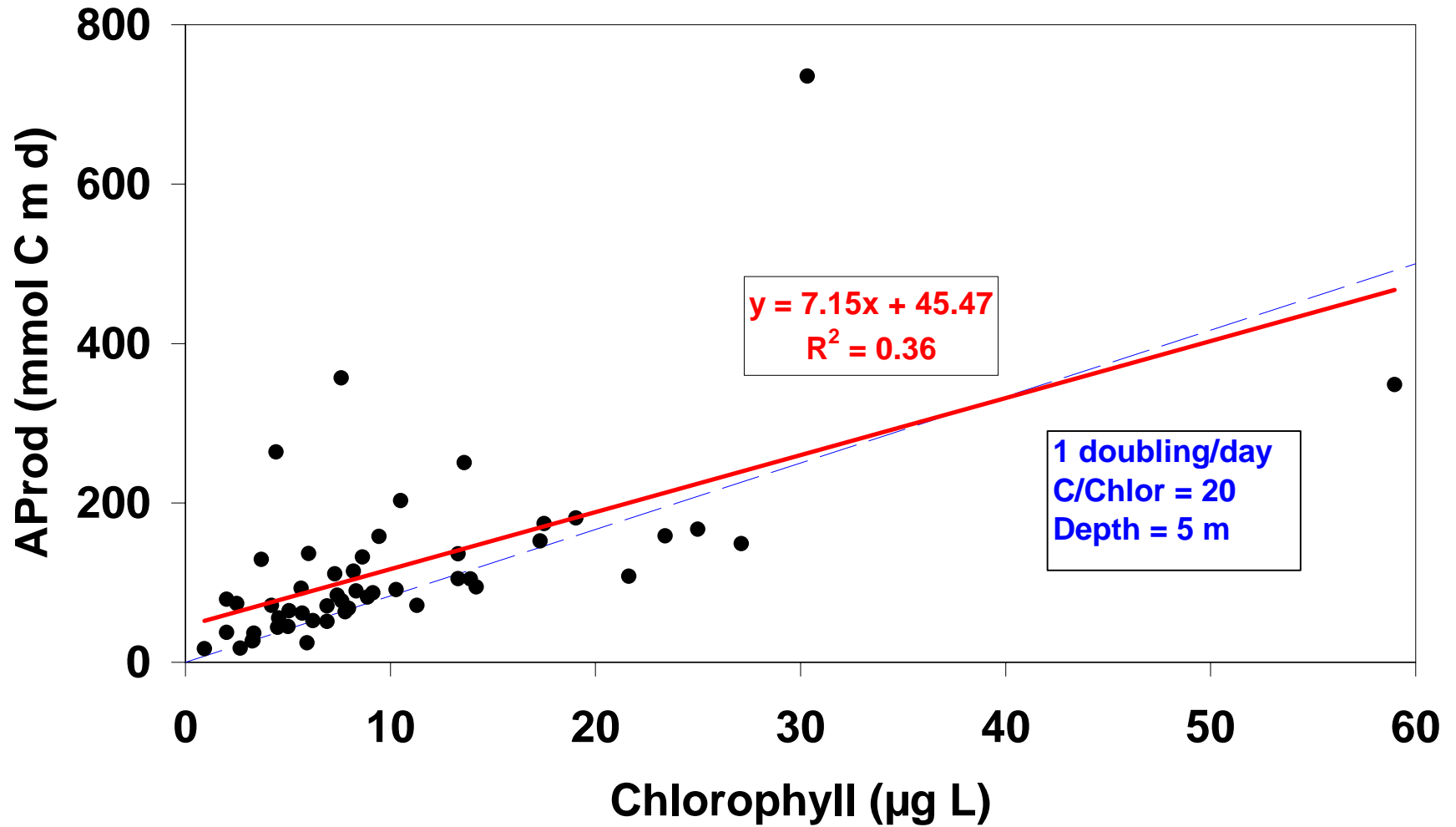
Compare to modeled value by using C/Chlorophyll ratio and depth for photic zone.

Summer - All Regions



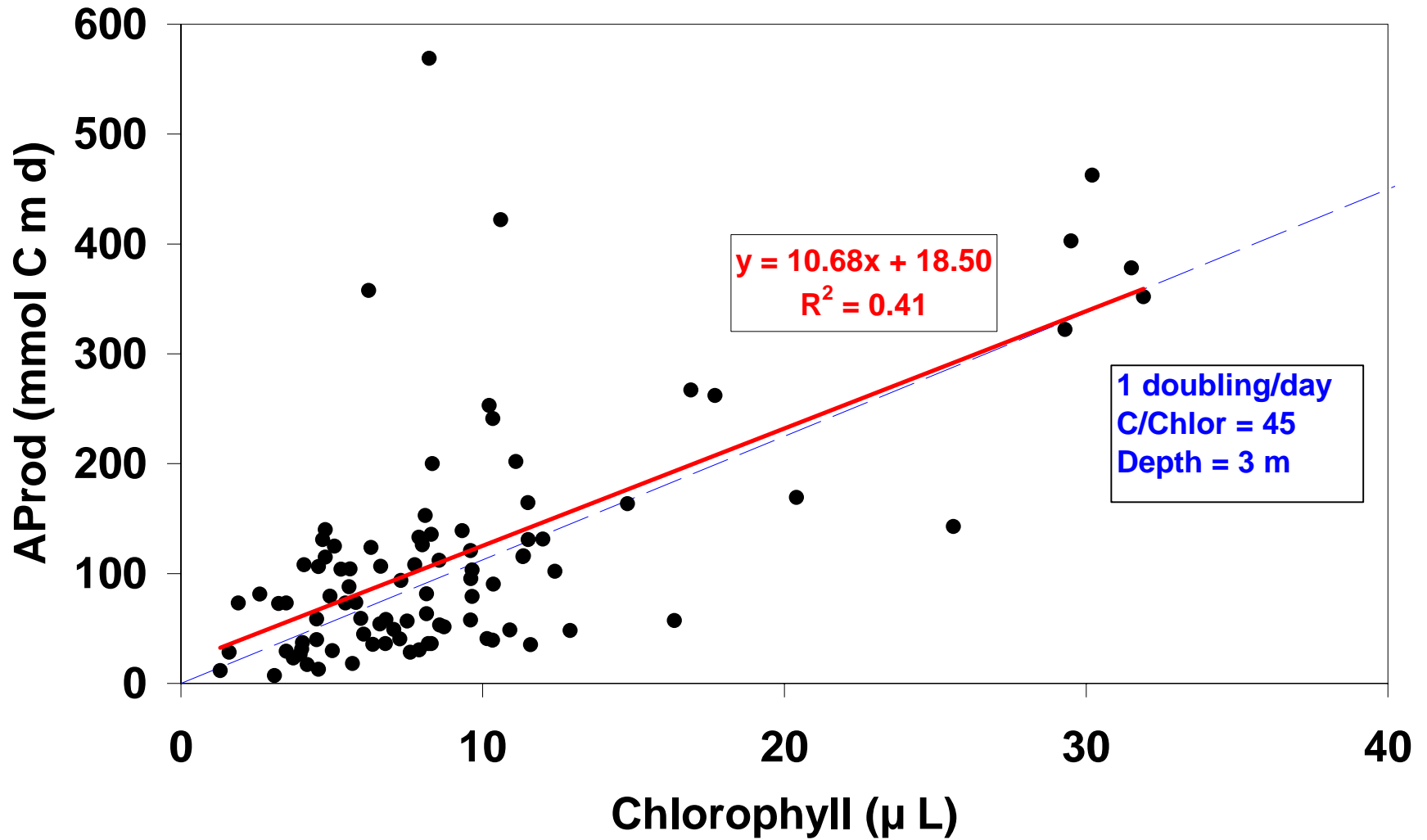
Poor fit – too much variability in 1% light depth and C/chlor ratio.

Summer - Lower Bay



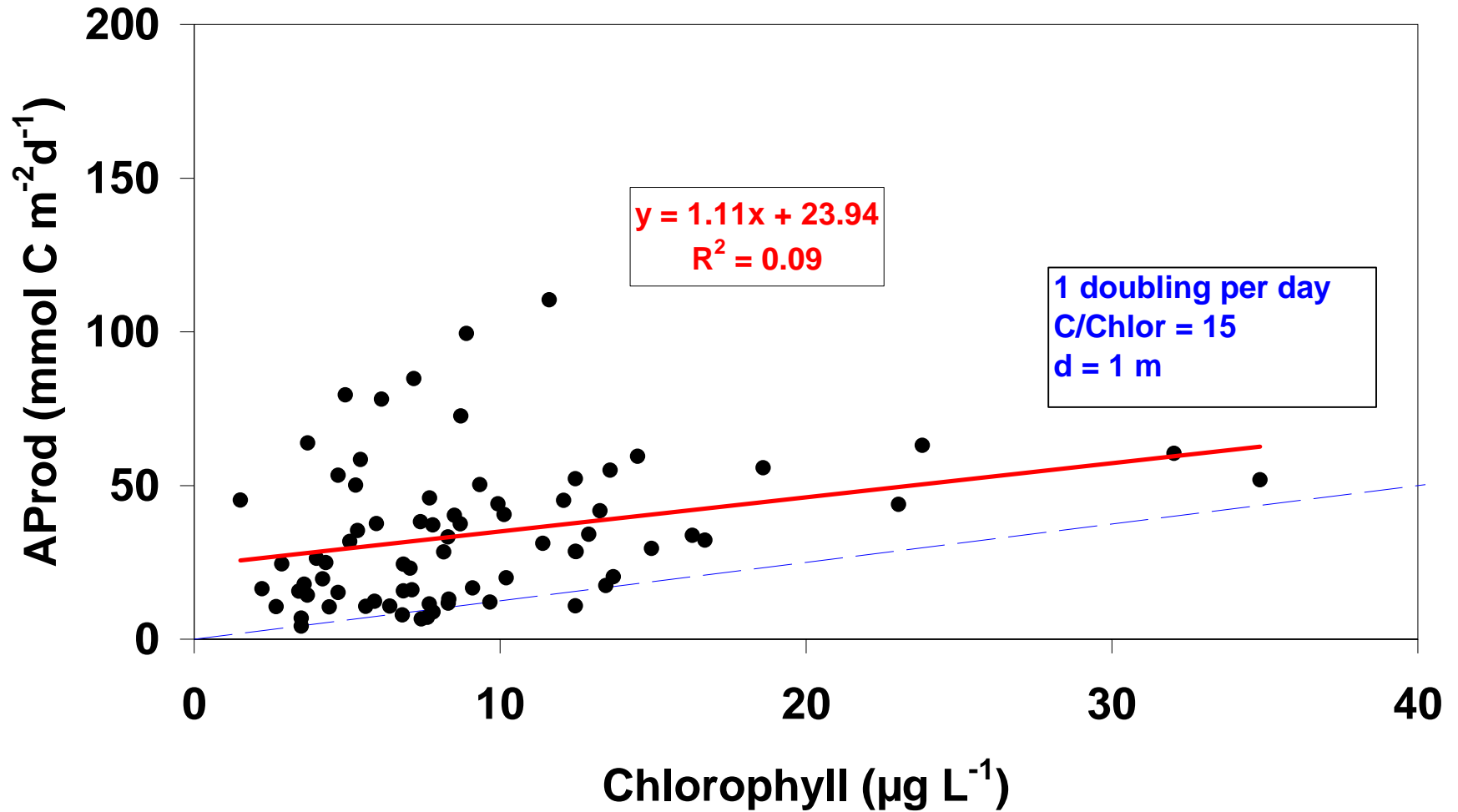
Measured 1% light level at 4-6 m. Nutrient limitation, lower C/Chlor.

Summer - Mid Bay



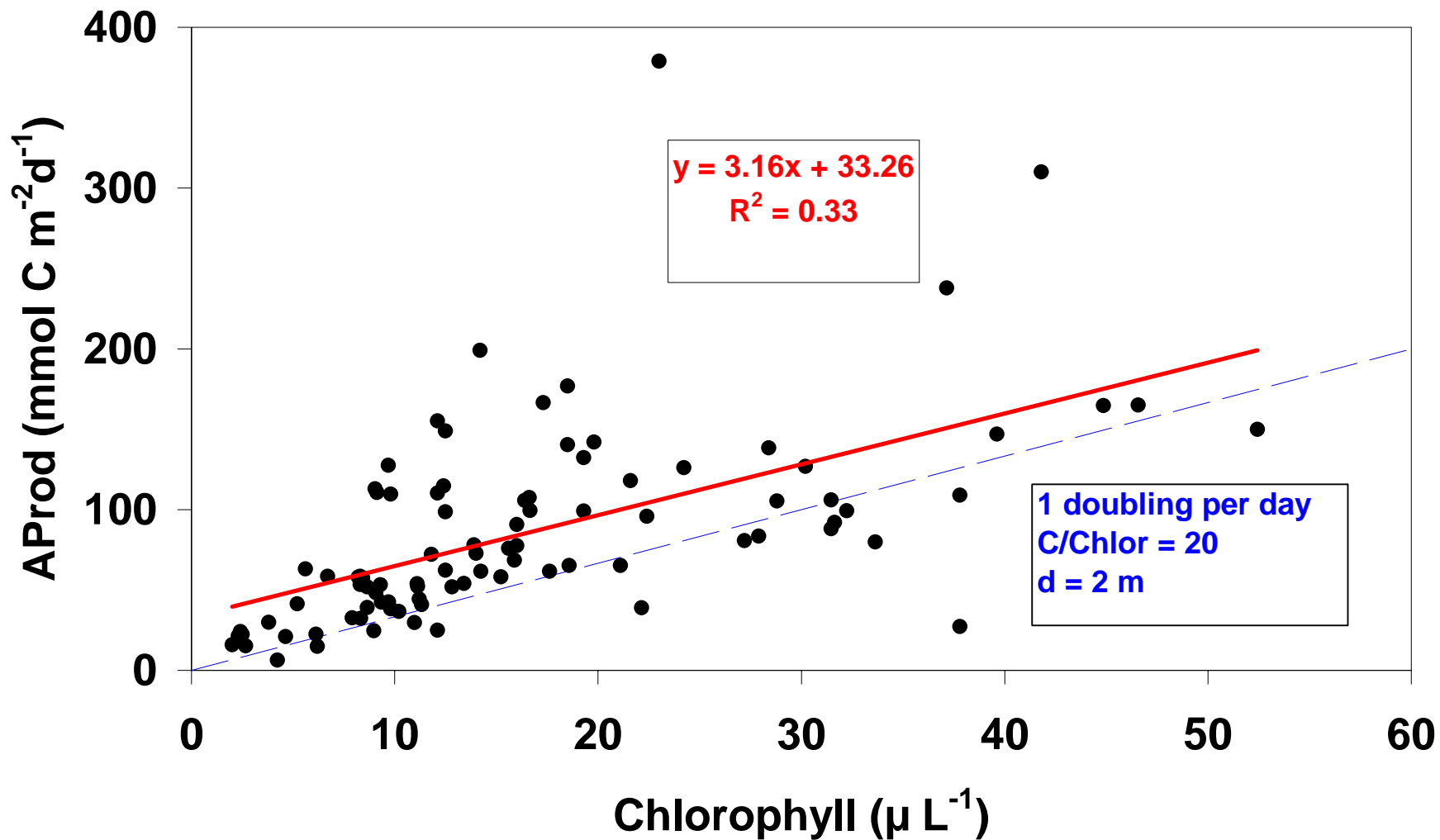
Measured 1% light level usually around 3 m. Very good fit, high C/Chlor

Summer - Turbidity Max



Measured 1% light level of 0.6 – 1 m. Strong light limitation – very low C/Chlor.

Summer - Urban River



Measured 1% light level of 2-4 m. Contaminant inhibition – low C/Chlor.

How the Delaware Estuary Works

In regions of very high nutrient concentrations, primary production is not high. At time of highest biomass, production is not high. Production per biomass is highest in mid-bay in summer with modest chlorophyll.

With P/B, thresholds so that production lower at highest nutrient concentrations. P/B highest at N/P in range of 10-50.

Production vs chlorophyll poor correlation for entire system and all seasons. Can get better correlation with temporal and spatial segregation.