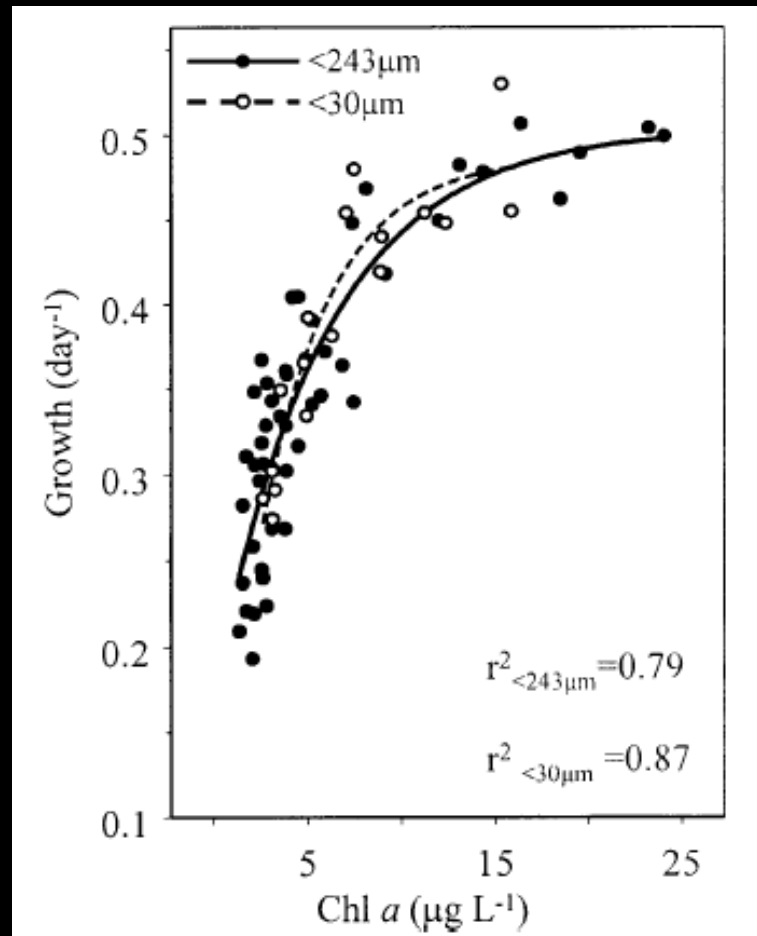


# Response of chlorophyll to reduced phosphorus concentration in the Delta and the Rhine River

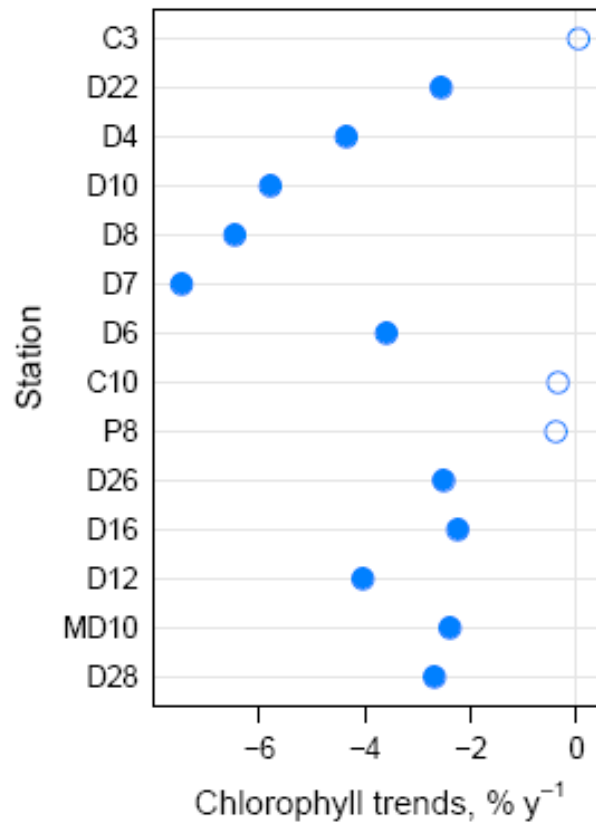
Erwin Van Nieuwenhuysse, Ph.D.  
Bureau of Reclamation

CWEMF Technical Workshop  
March 25, 2008  
Secretary of State Bldg Auditorium, Sacramento, CA



Source: Mueller-Solger et al 2002, Limnol. Oeanogr. 47(5): 1468-1476

Note: Test organism = juvenile *Daphnia magna*



**Figure 4.** Long-term trends in Chl-*a* for 1975–2005. Trends are expressed as the Theil-Sen slope divided by the long-term median for the station. Trends are adjusted for river inflow, and *p*-values are corrected for seasonal serial correlation. Stations are arranged as in Figure 5 but with the left-column stations stacked on top of the right-column stations. *Solid circles*, *p* < 0.05 level according to the Seasonal Kendall test.

Alan Jassby. Phytoplankton in the Upper San Francisco Estuary:  
 Recent Biomass Trends, Their Causes and Their Trophic Significance.  
 San Francisco Estuary and Watershed Science, Vol. 6, Issue 1 (February 2008), Article 2.



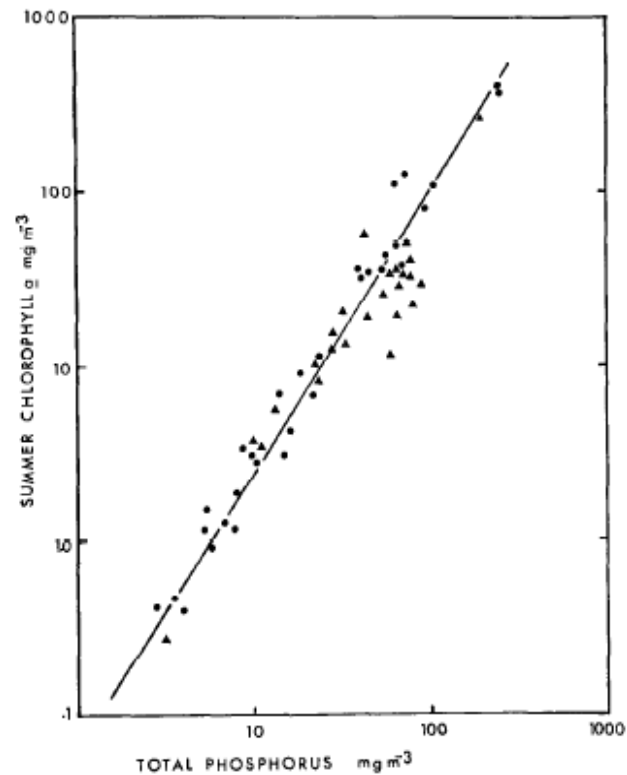
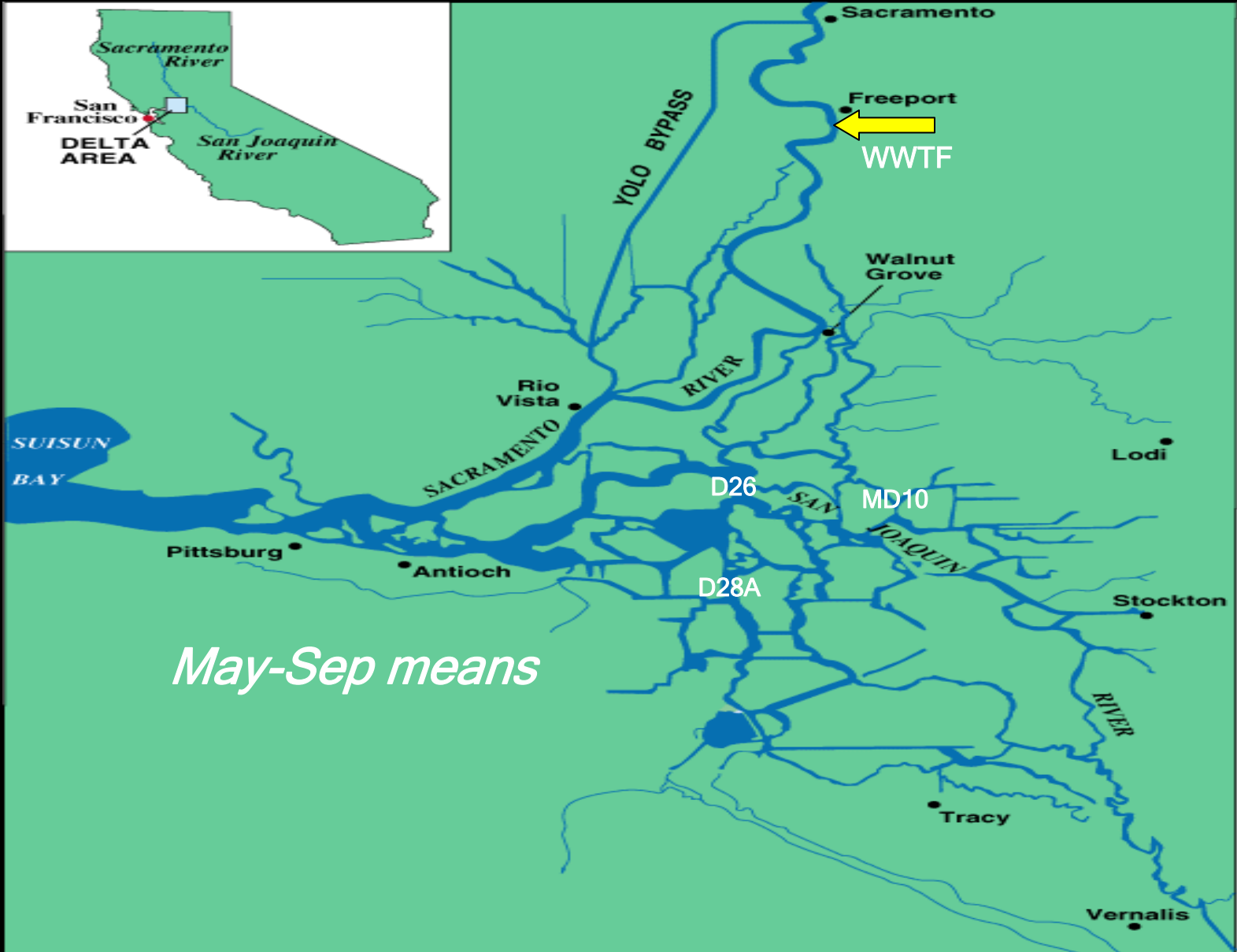
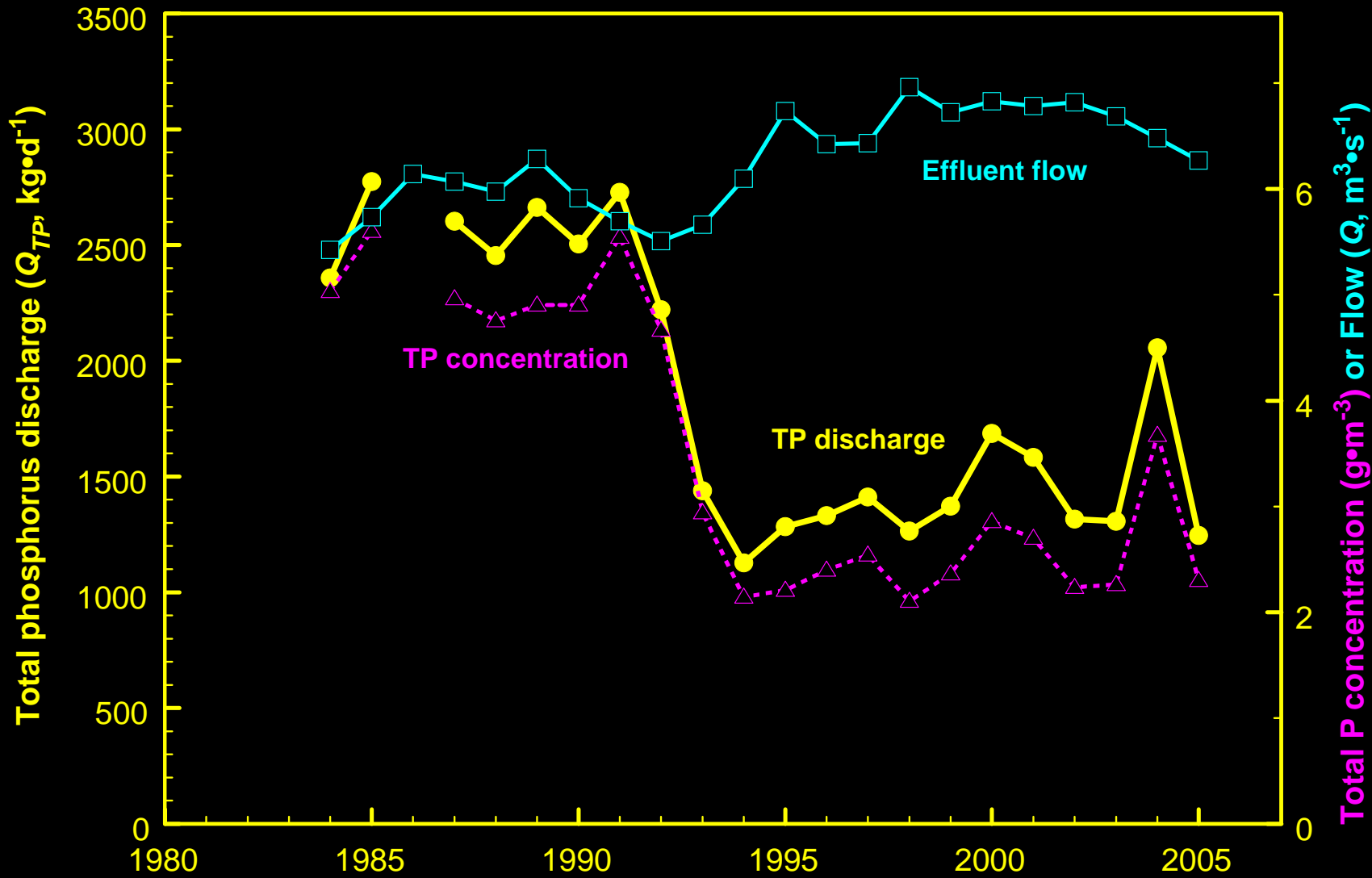


Fig. 1. Summer average chlorophyll concentration vs. total phosphorus concentration at spring overturn. Circles—data from Sakamoto (1966), chlorophyll measured by the method of Hogetsu and Ichimura (1954) and Ichimura (1956); triangles—data for other lakes reported in the literature, chlorophyll measured as chlorophyll *a*. The line shown is the regression line for Sakamoto's data.

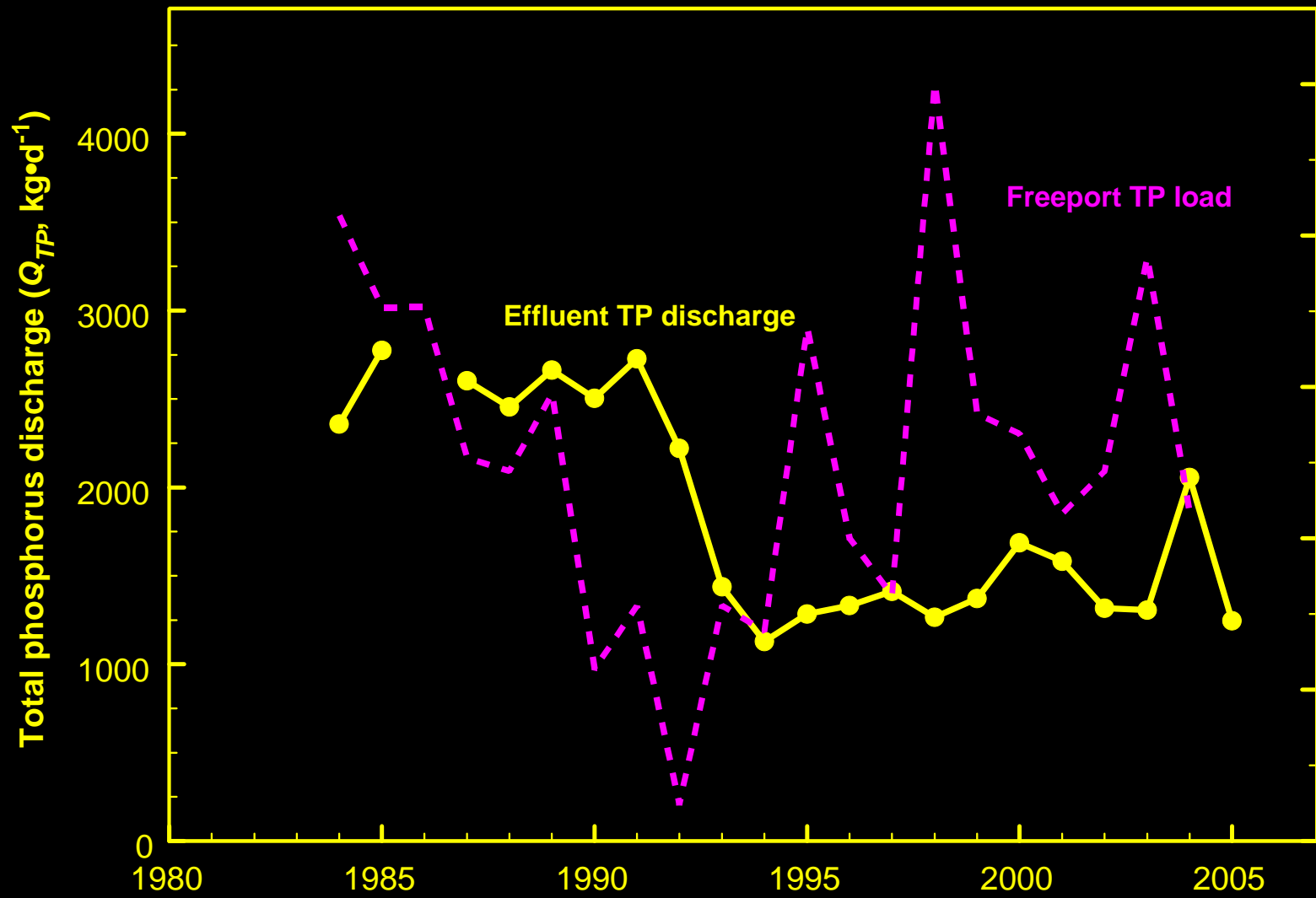
# Outline

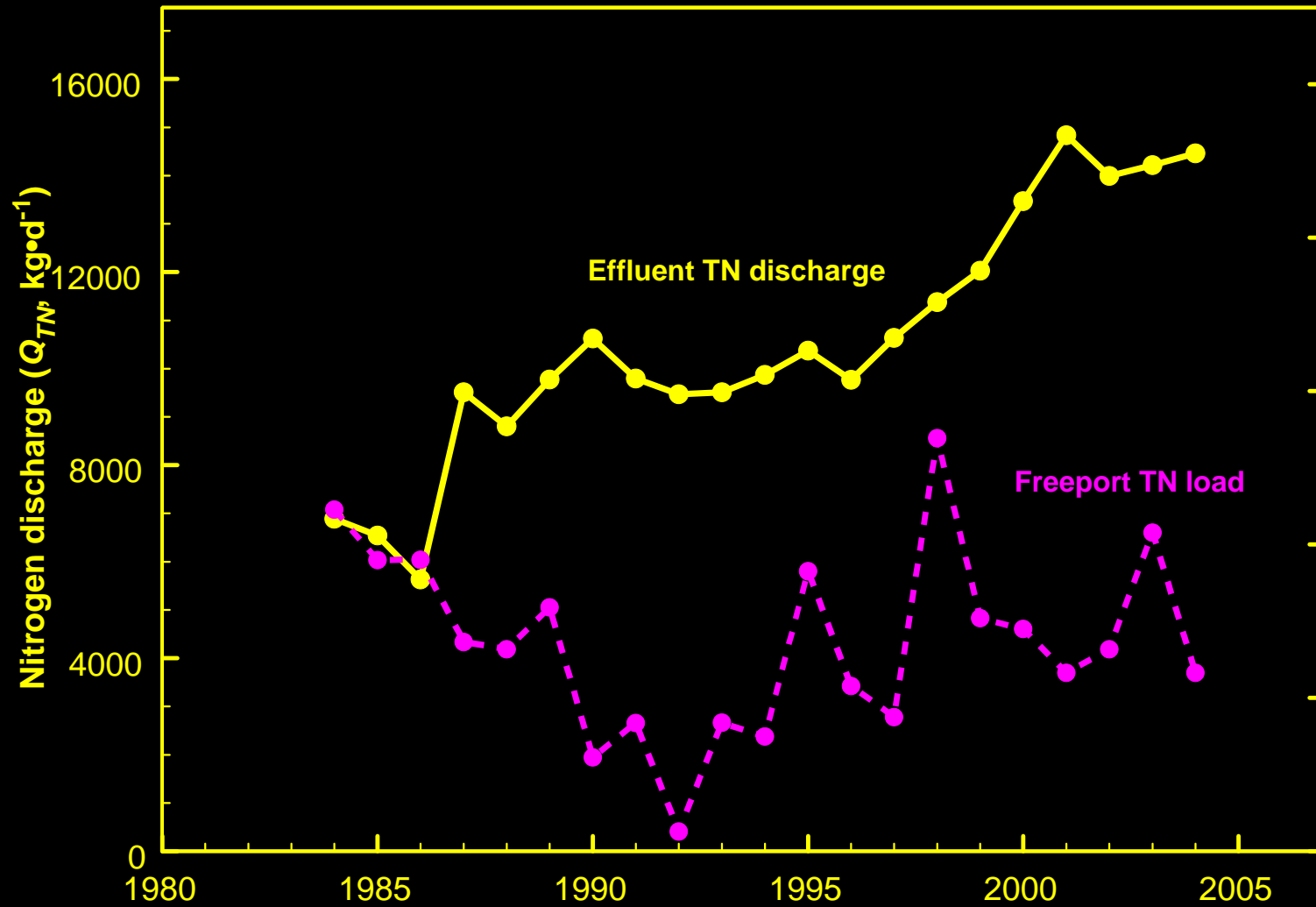
- Document Delta's chlorophyll response to phosphorus reduction
- Compare to the Rhine River's response
- Compare to an empirical model for flowing waters

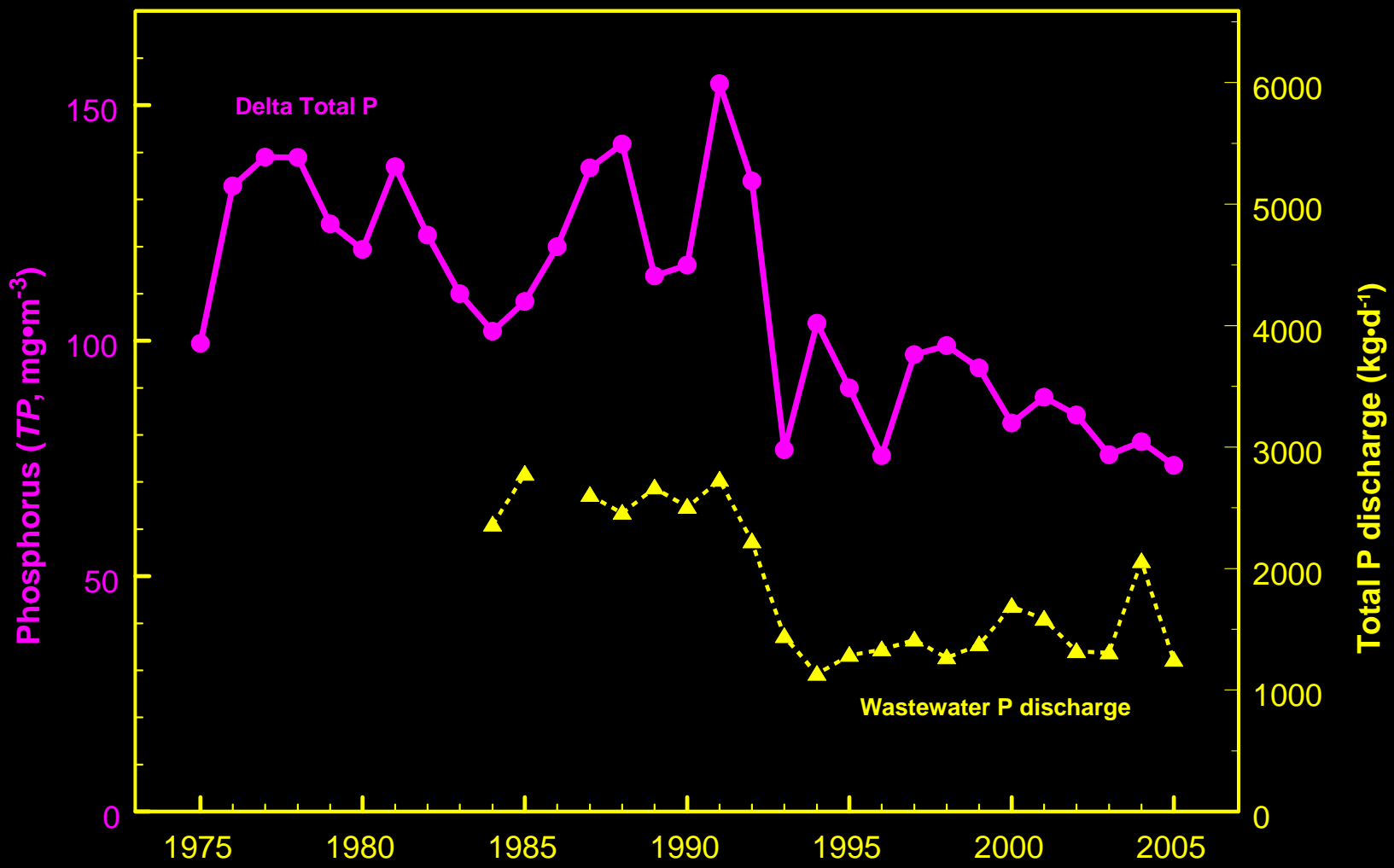


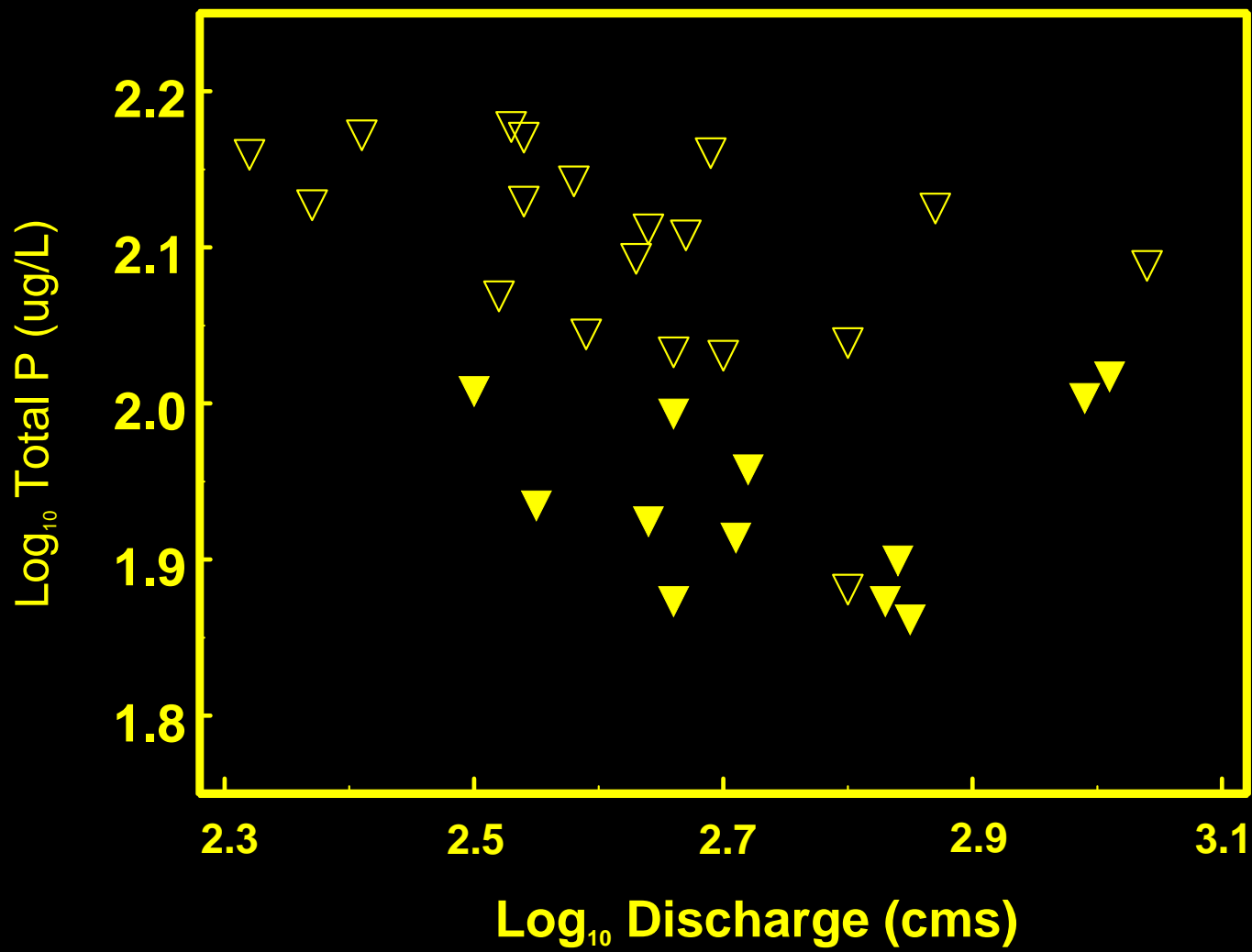


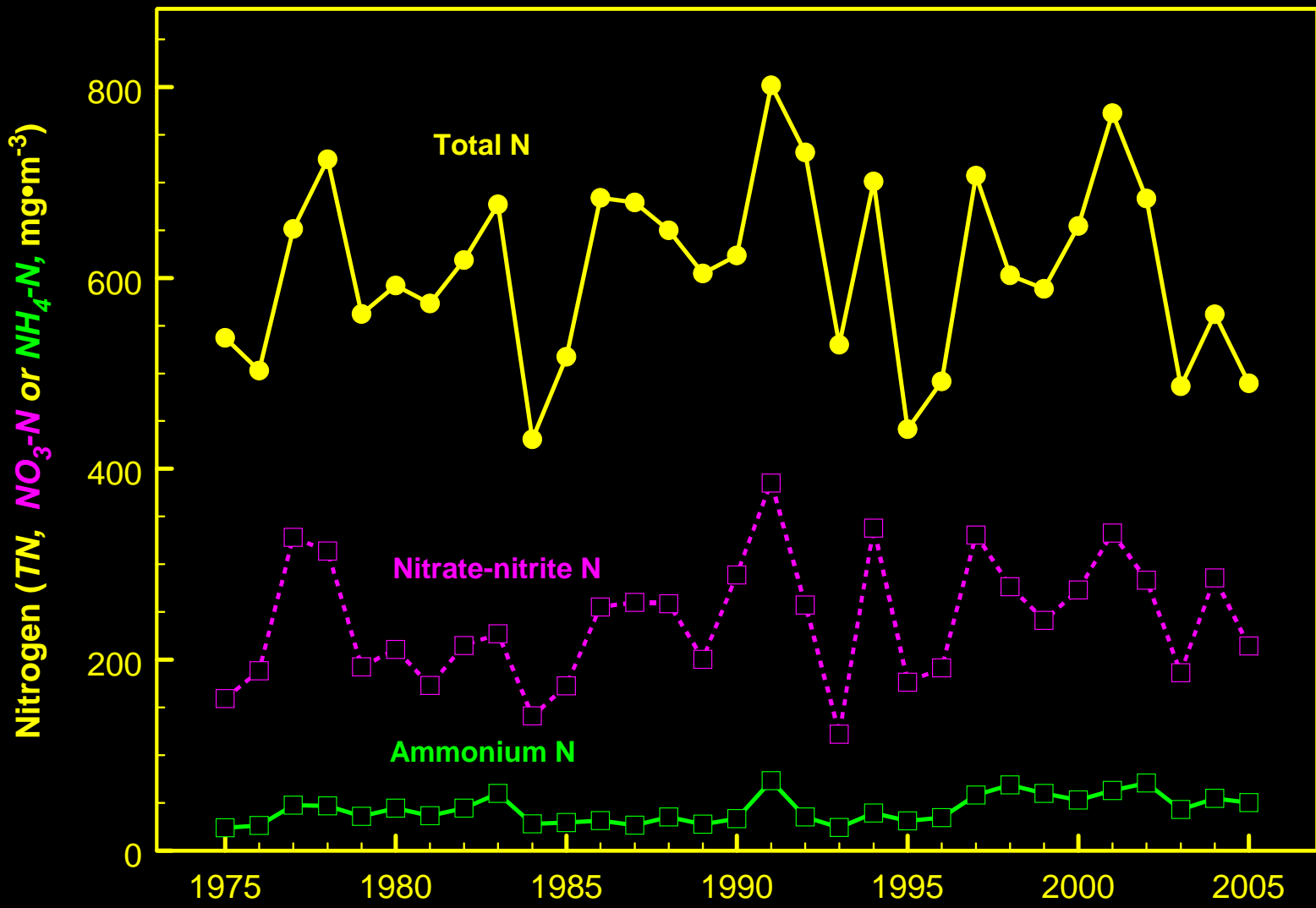


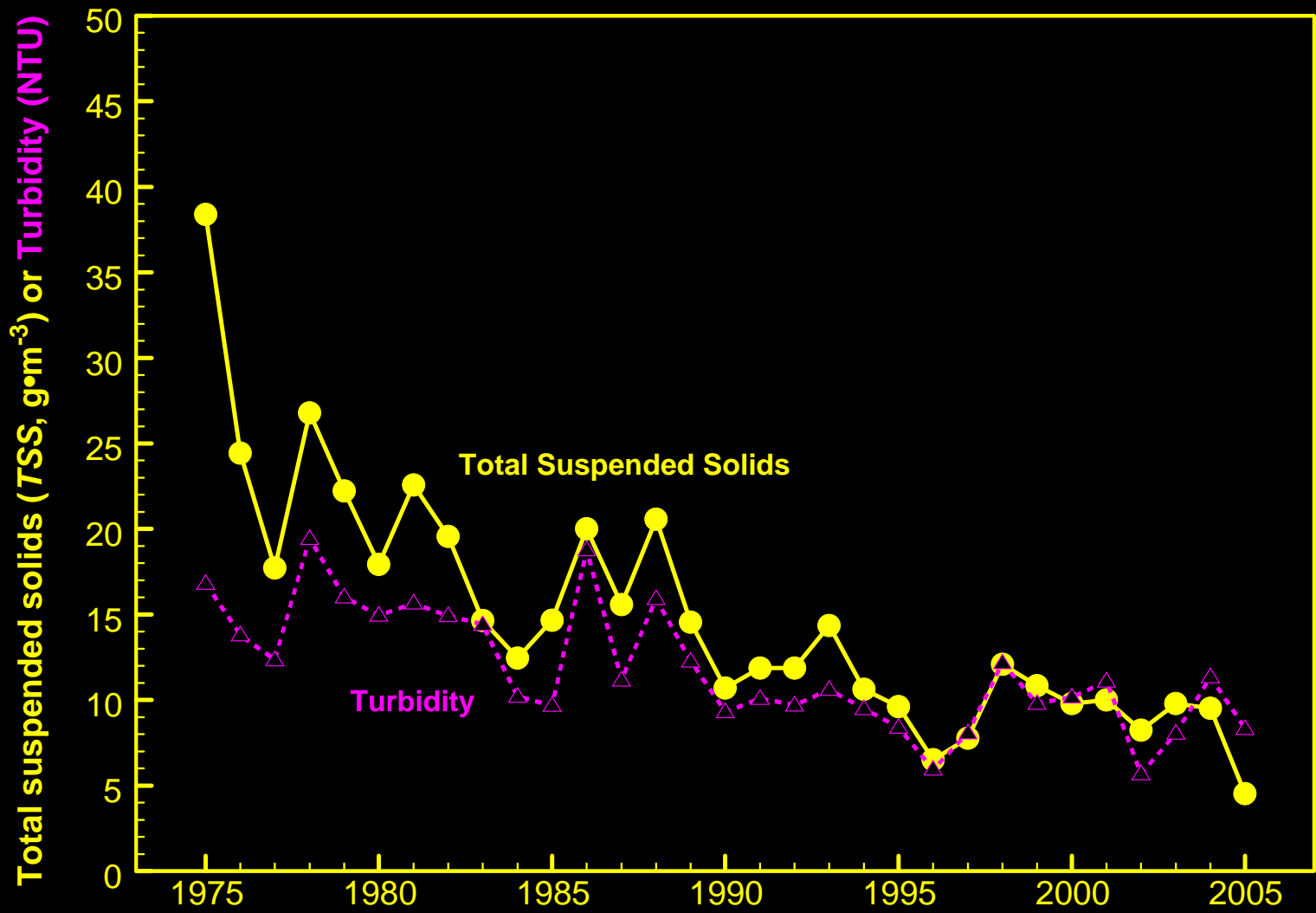


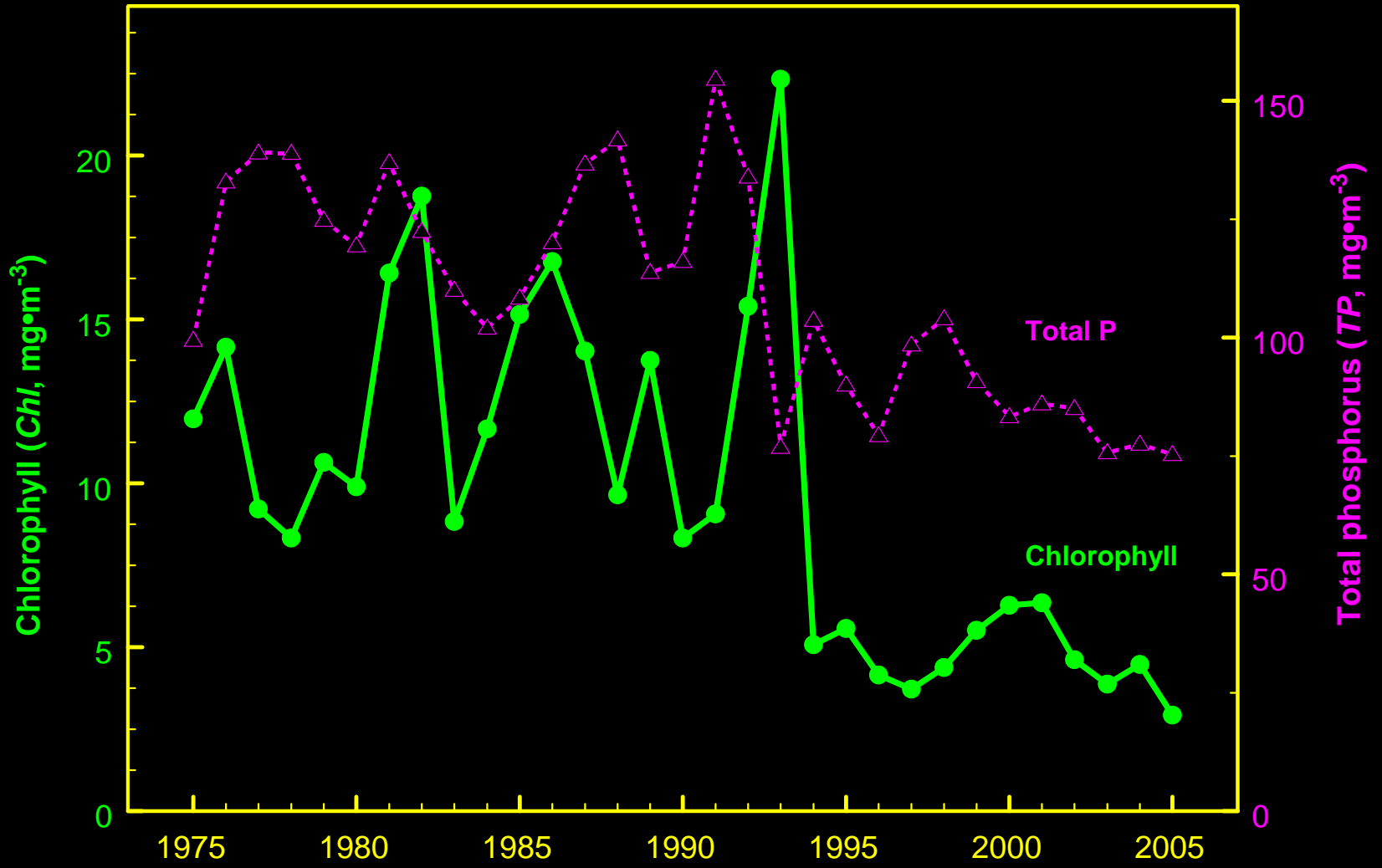


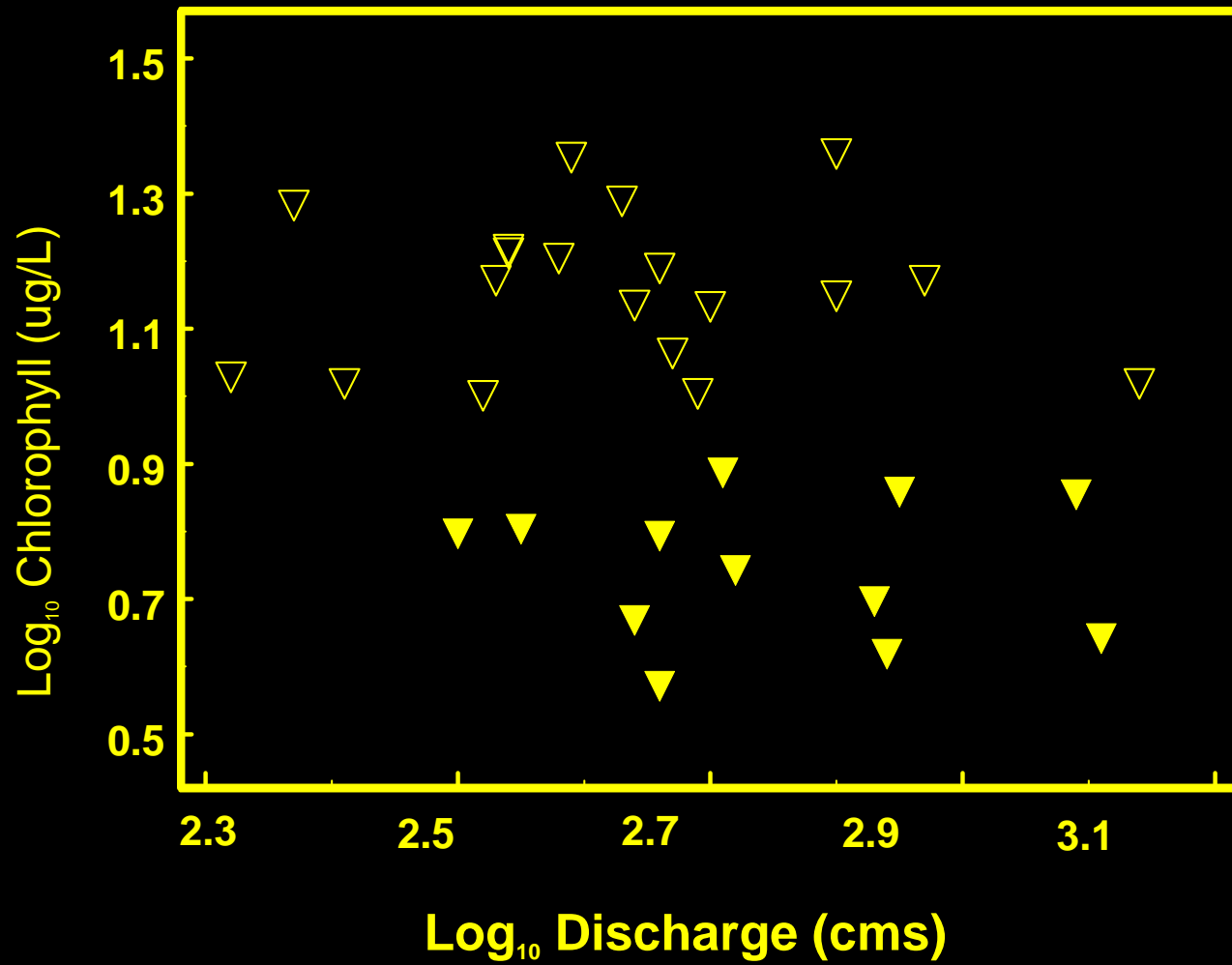






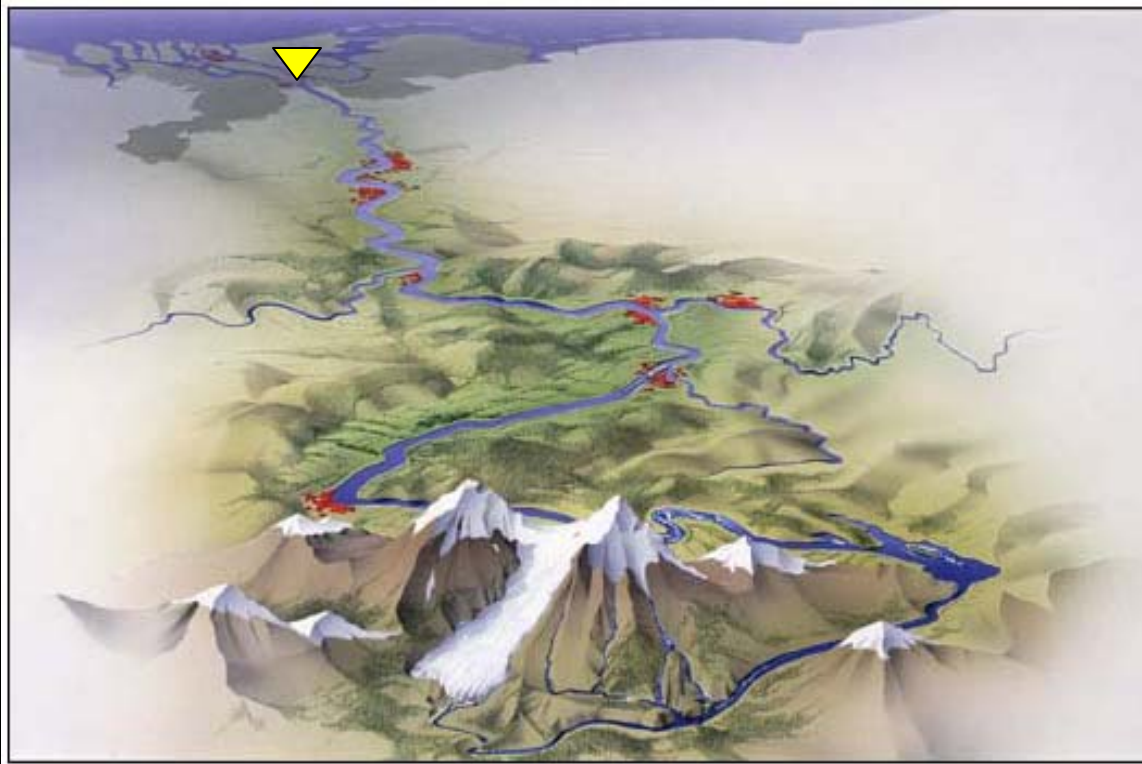




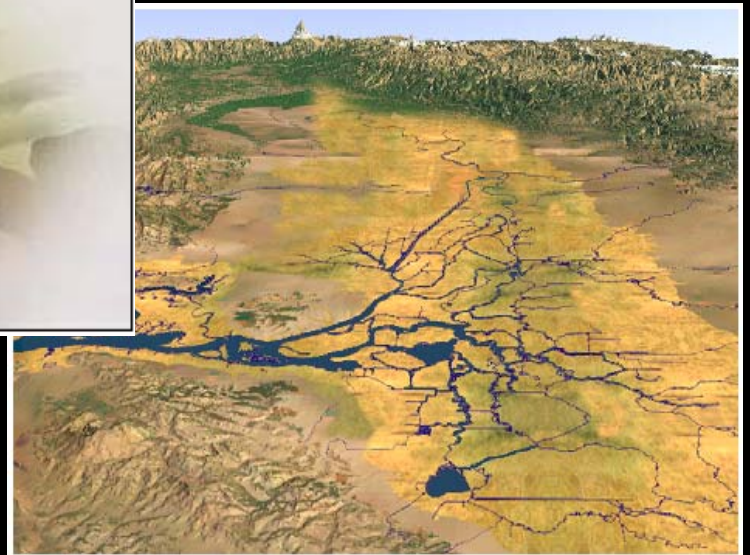




## Lobith, Netherlands

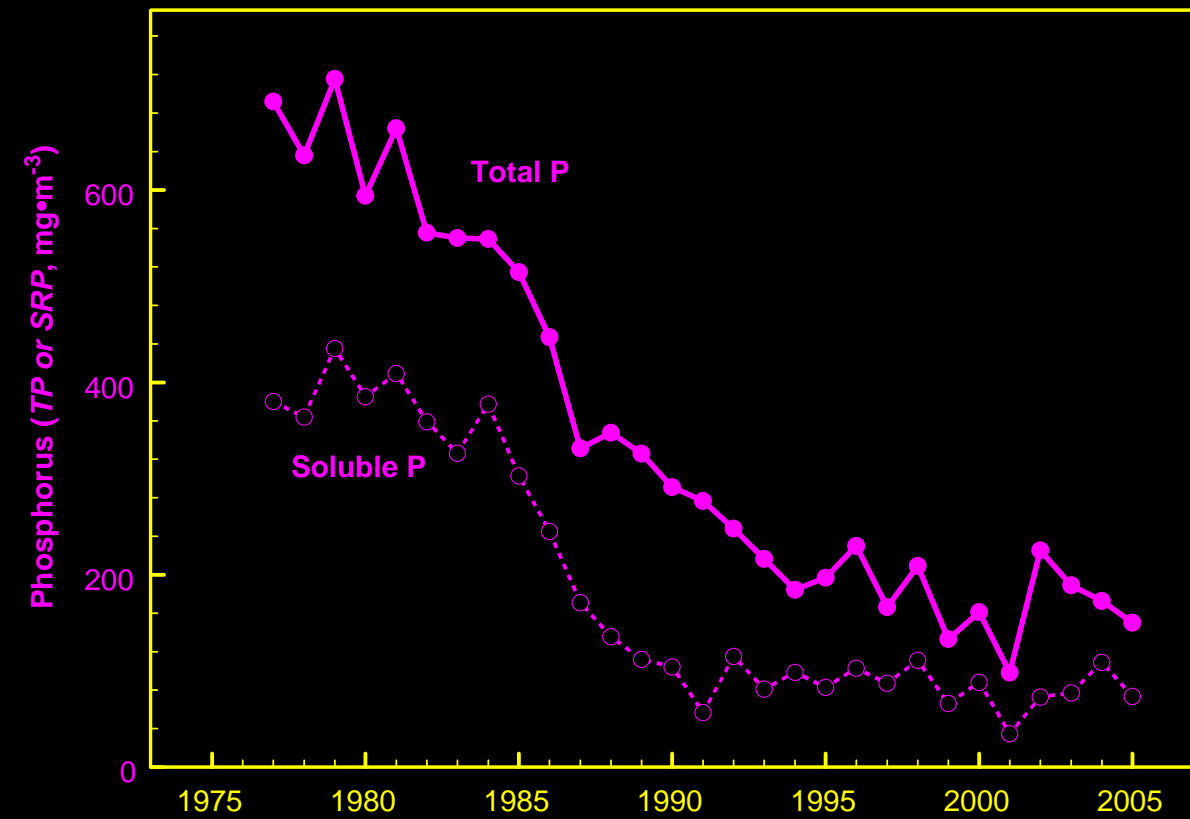


Delta

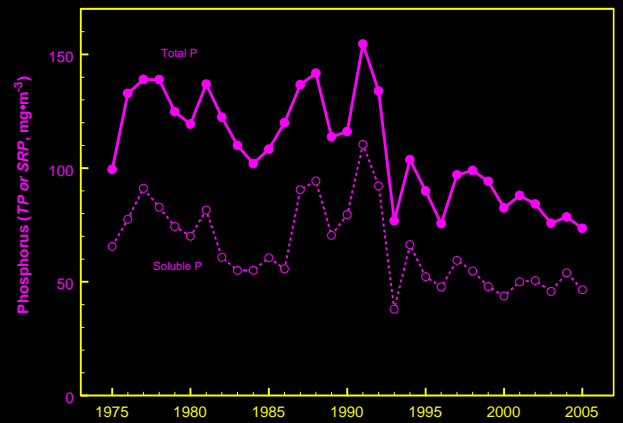


| <b>System</b> | <b>Area<br/>(km<sup>2</sup>)</b> | <b>Flow<br/>(cms)</b> | <b>Depth<br/>(m)</b> | <b><i>TSS</i><br/>(mg/L)</b> |
|---------------|----------------------------------|-----------------------|----------------------|------------------------------|
| <b>Rhine</b>  | <b>185,000</b>                   | <b>2,052</b>          | <b>6.0</b>           | <b>31</b>                    |
| <b>Delta</b>  | <b>90,650</b>                    | <b>561</b>            | <b>5.5</b>           | <b>15</b>                    |

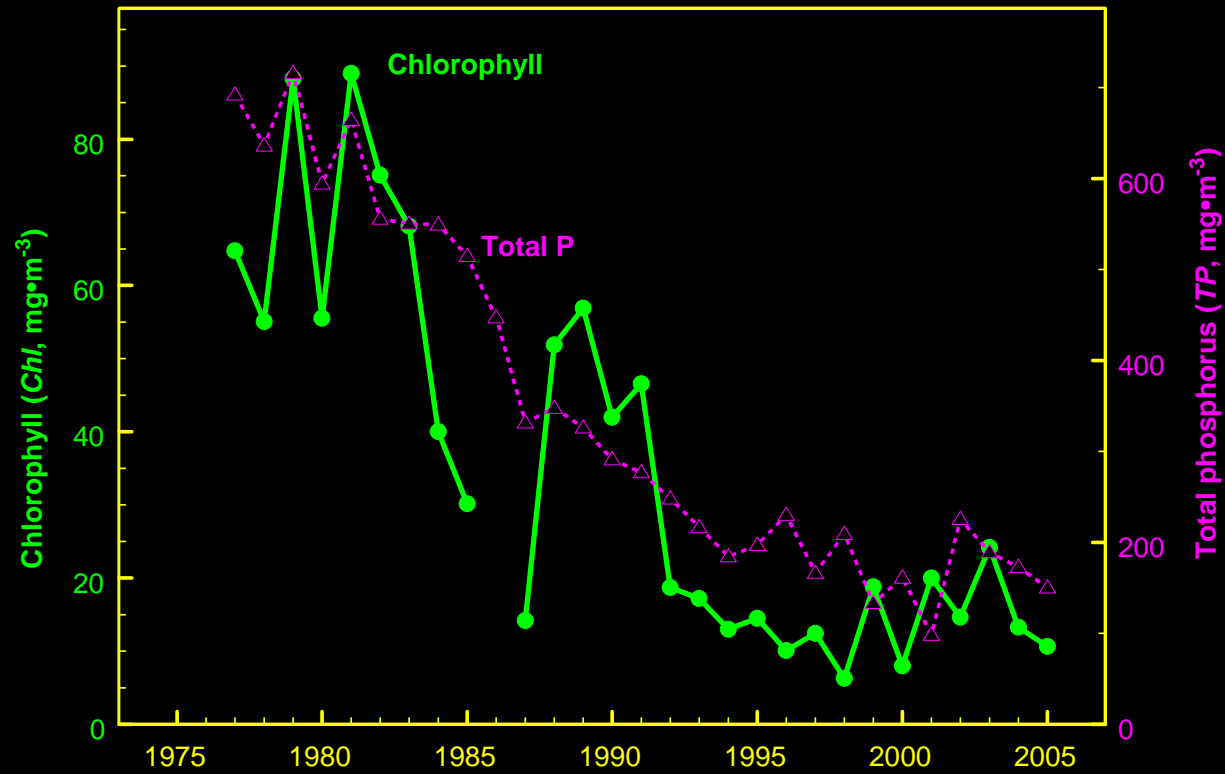
# Rhine



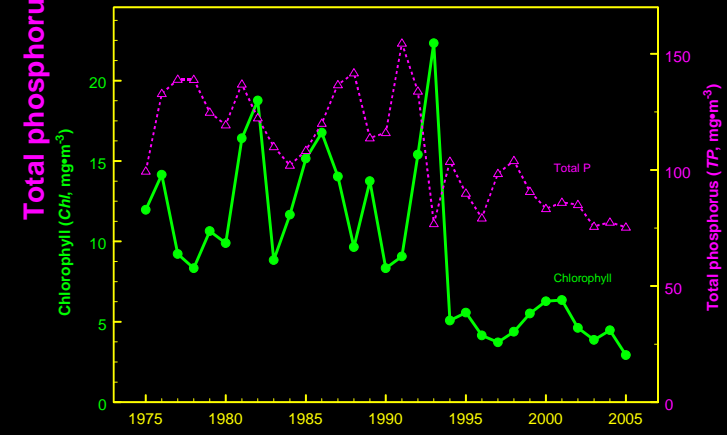
# Delta

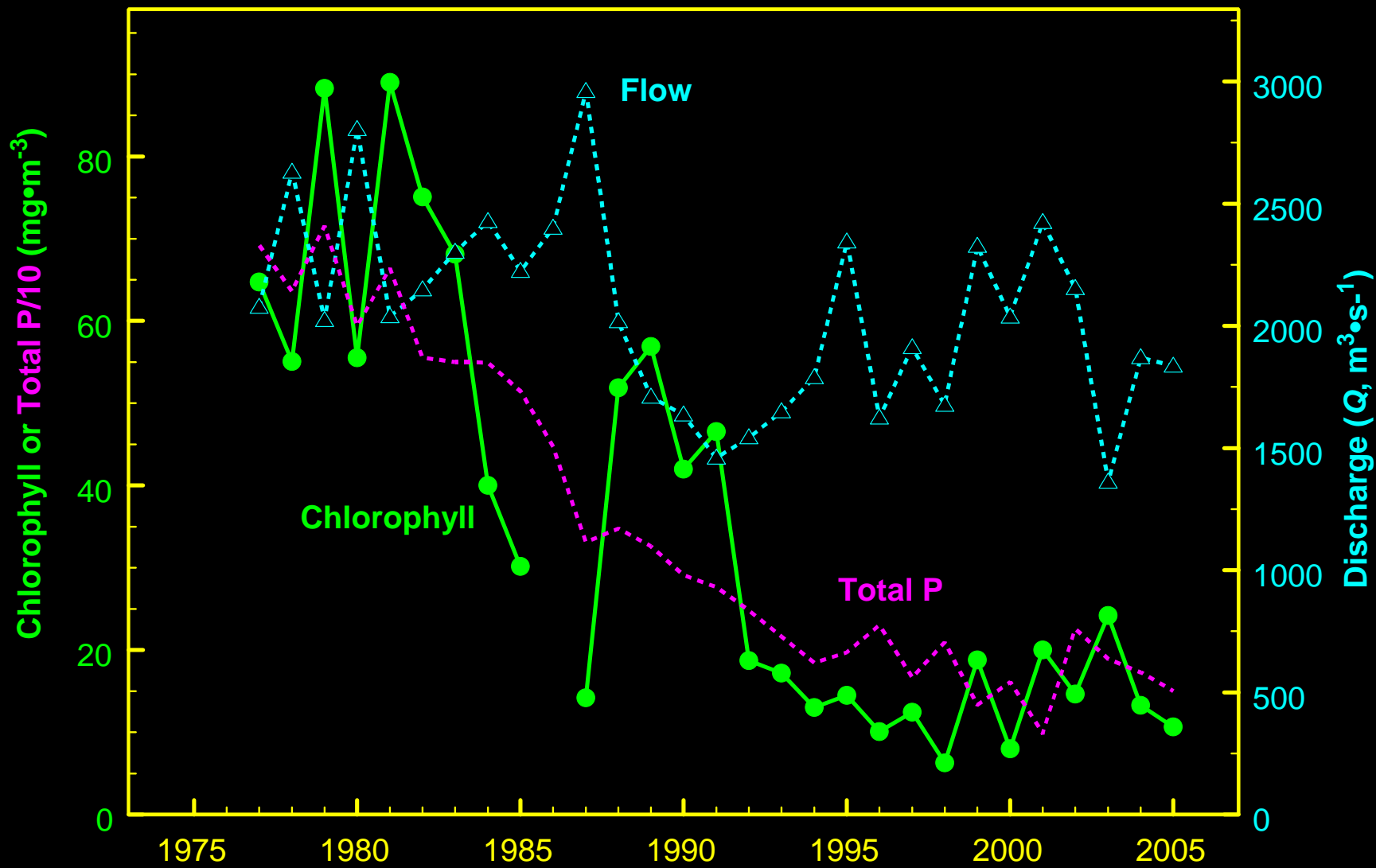


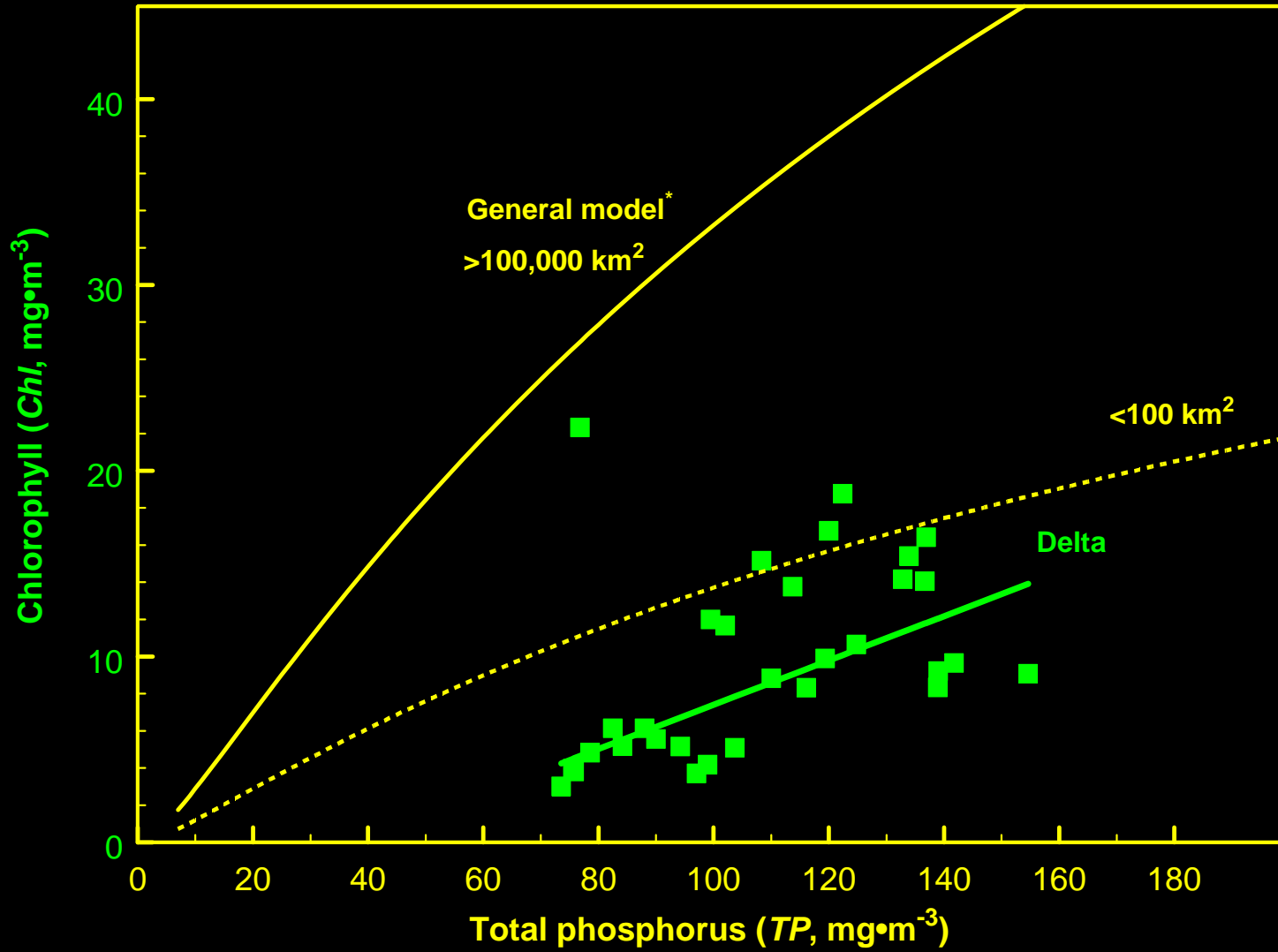
# Rhine



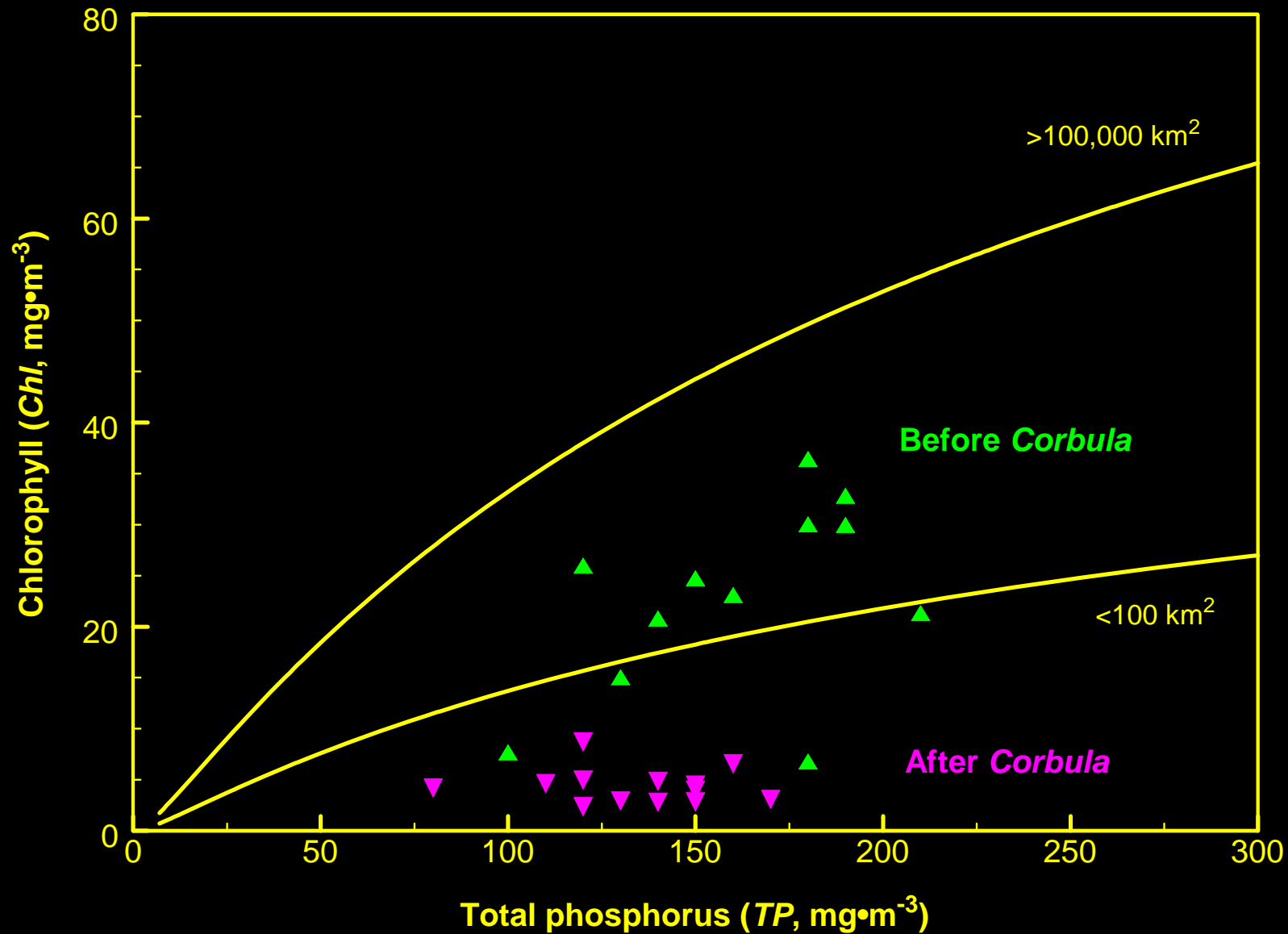
# Delta

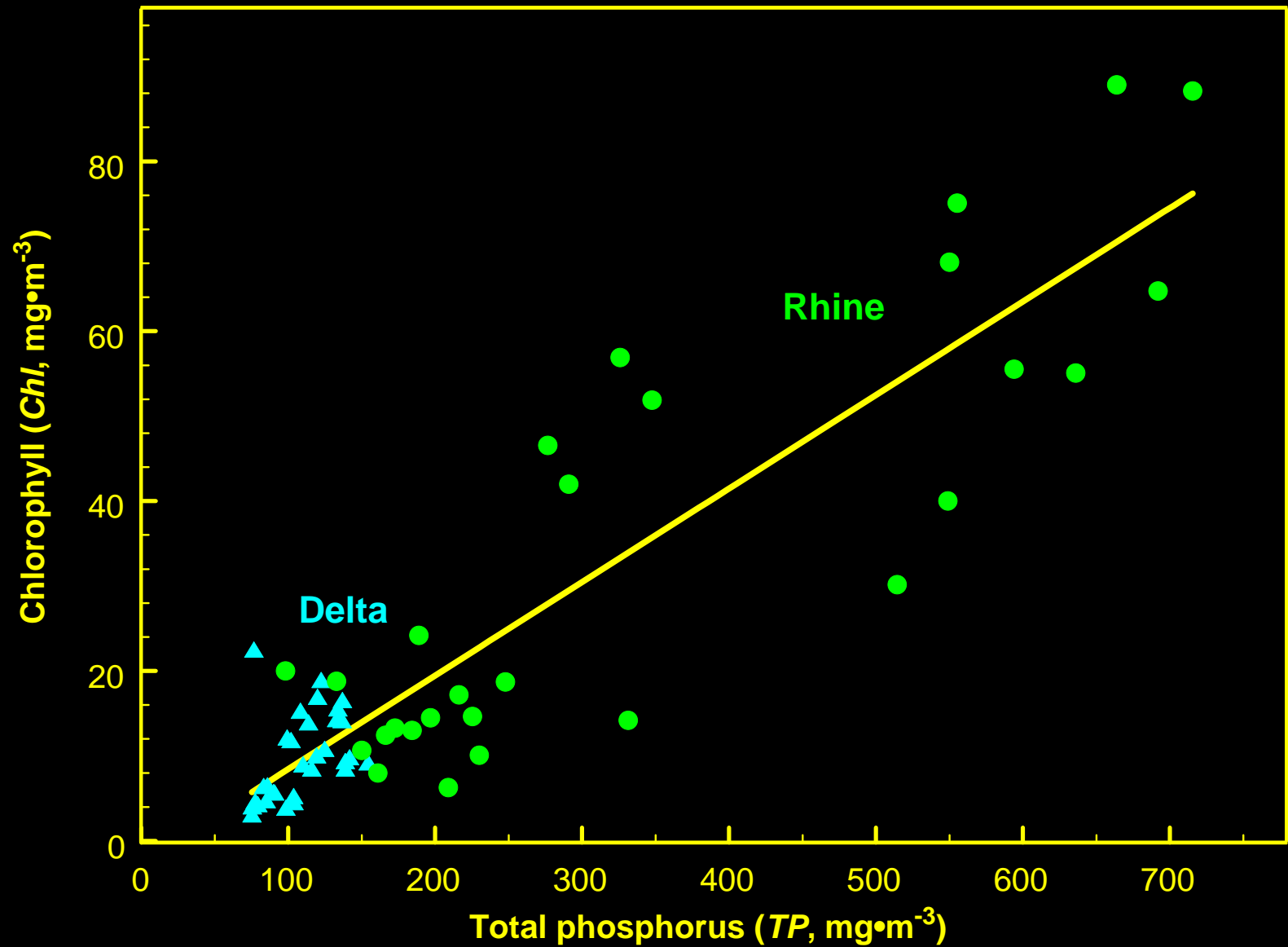




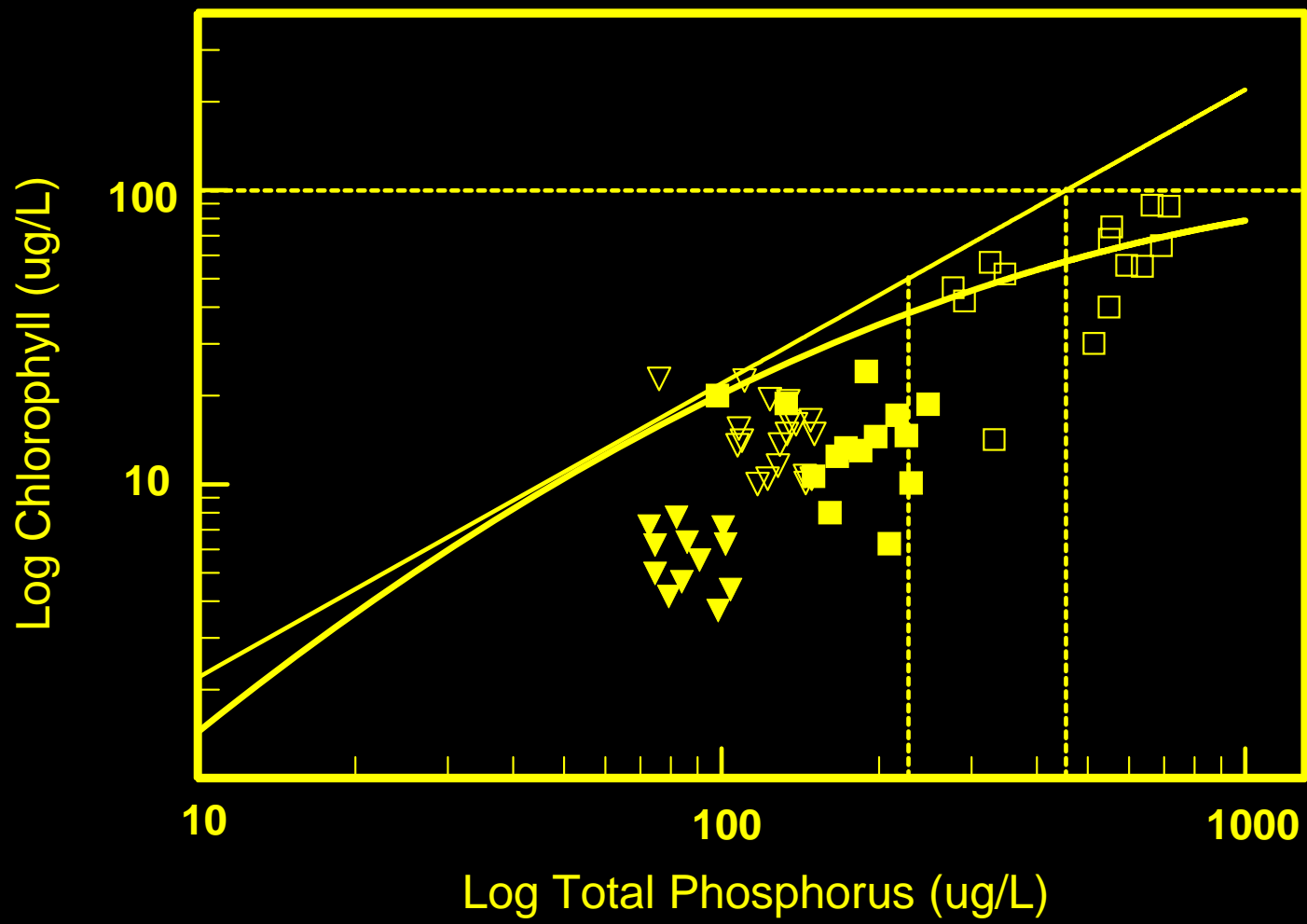


\*Van Nieuwenhuysse, E.E., and J.R. Jones. 1996. Phosphorus-chlorophyll relationship in temperate streams and its variation with catchment area. *Can. J. Fish. Aquat. Sci.* 53: 99 - 105









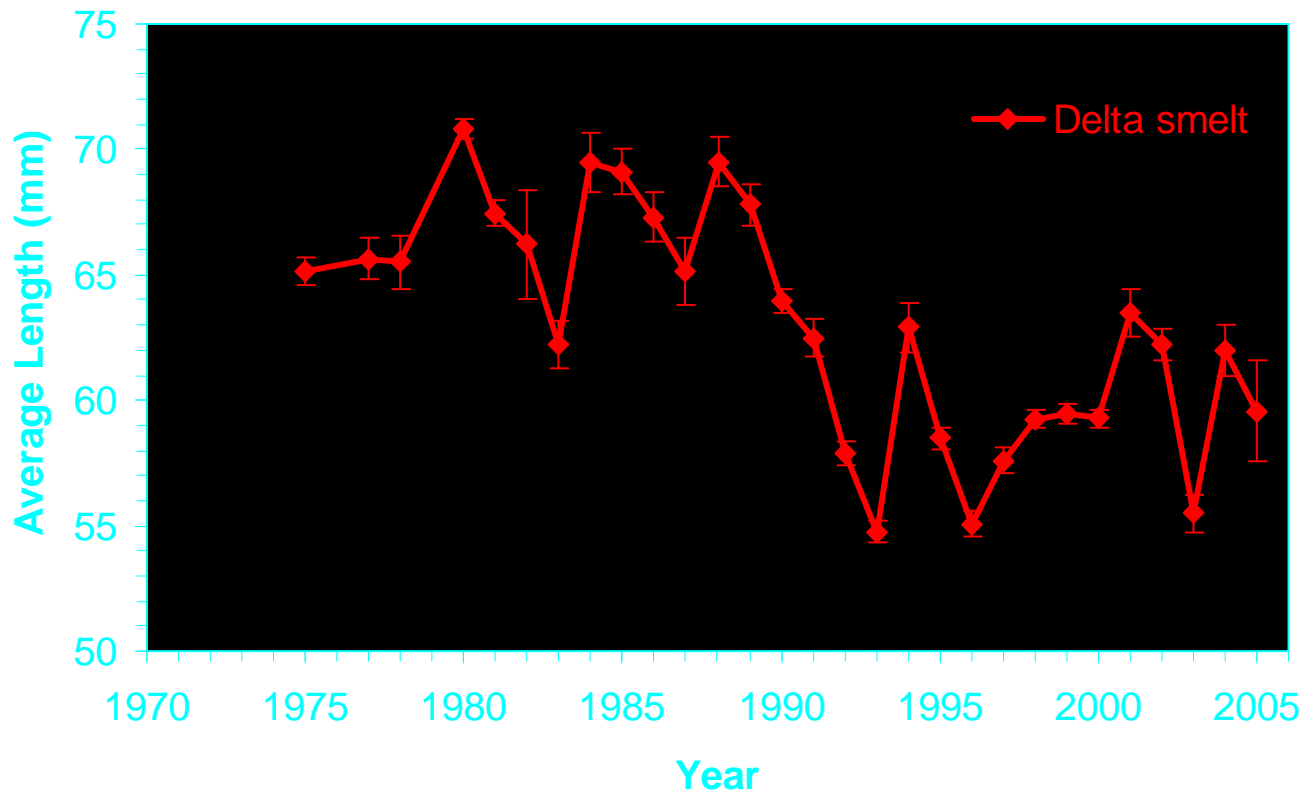
# Conclusions

- Delta is phosphorus-limited
- Delta *Chl:TP* is low because loss is high
- To boost Delta *Chl*, increase *TP* and reduce loss
- Need whole-system scale experiment

# Acknowledgements

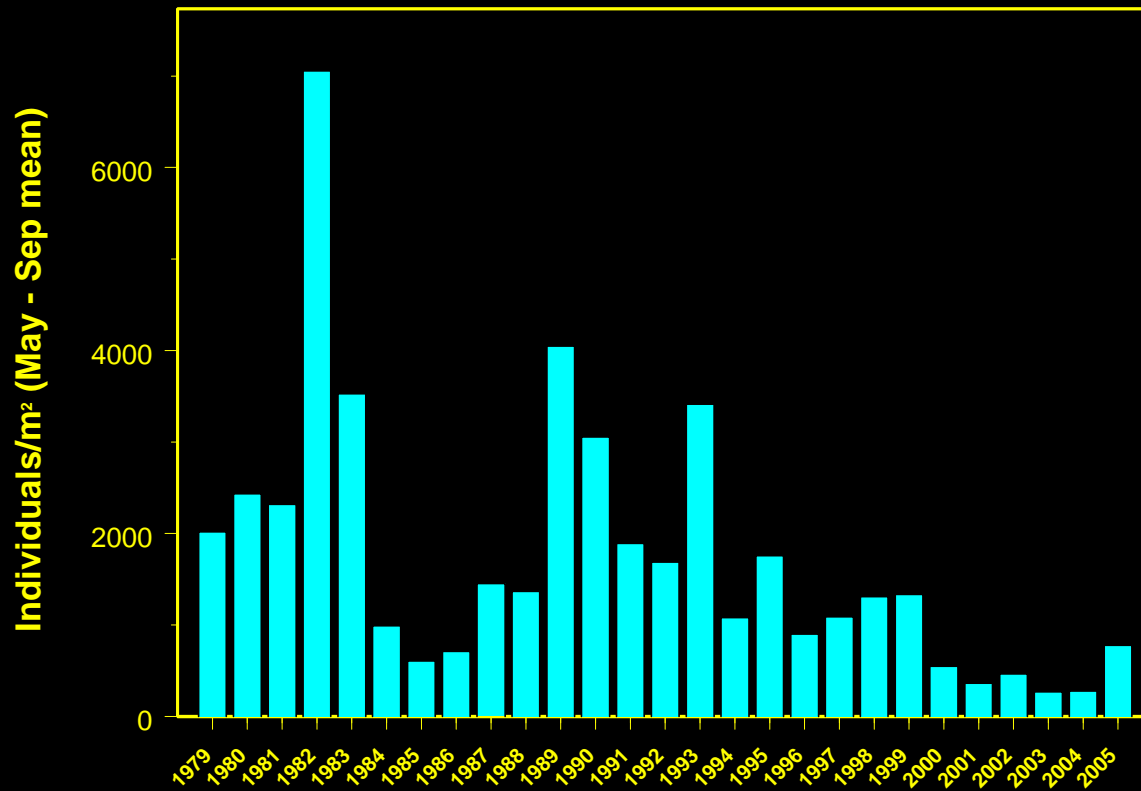
- IEP-Environmental Monitoring Program
- Milton Preszler, Sacramento Regional County Sanitation District
- Leo van Ballegooijen, Dutch Governmental Institute on Inland Water Management and Waste Water Treatment

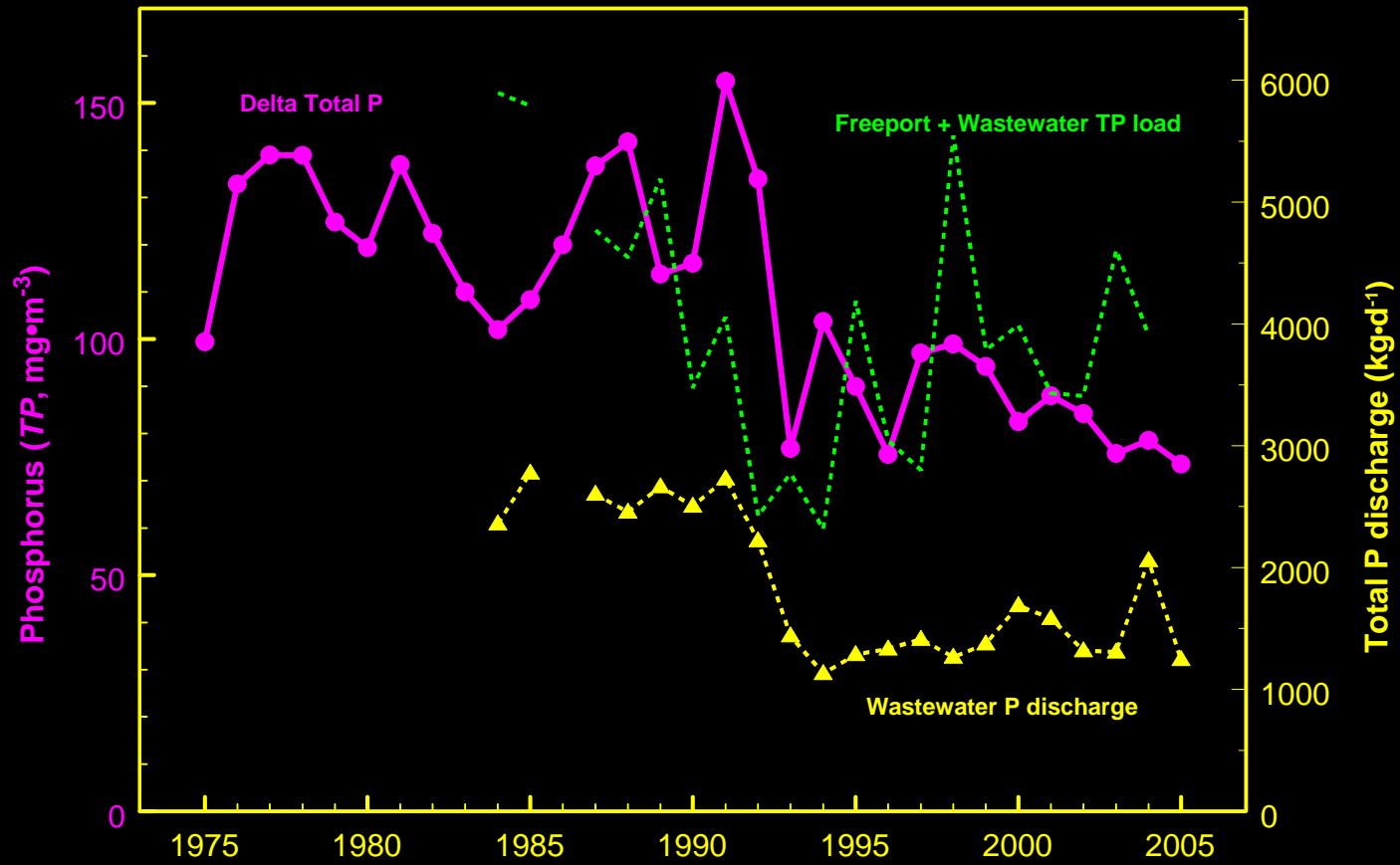


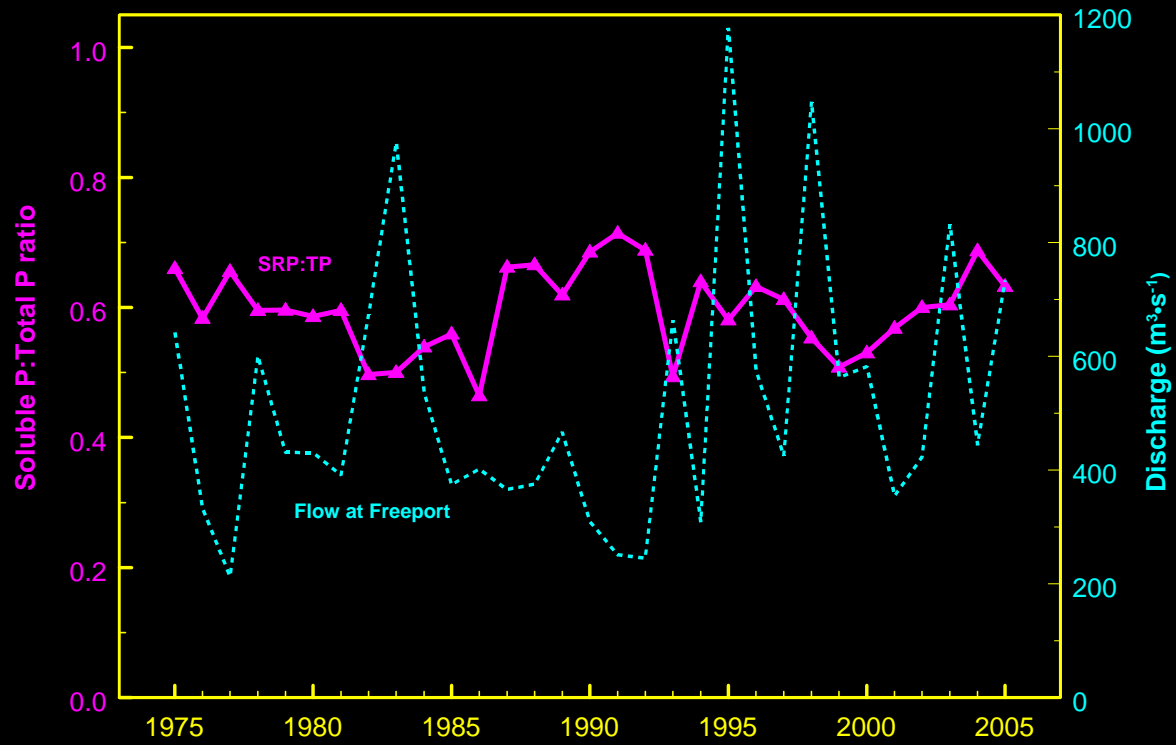


Source: California Department of Fish and Game

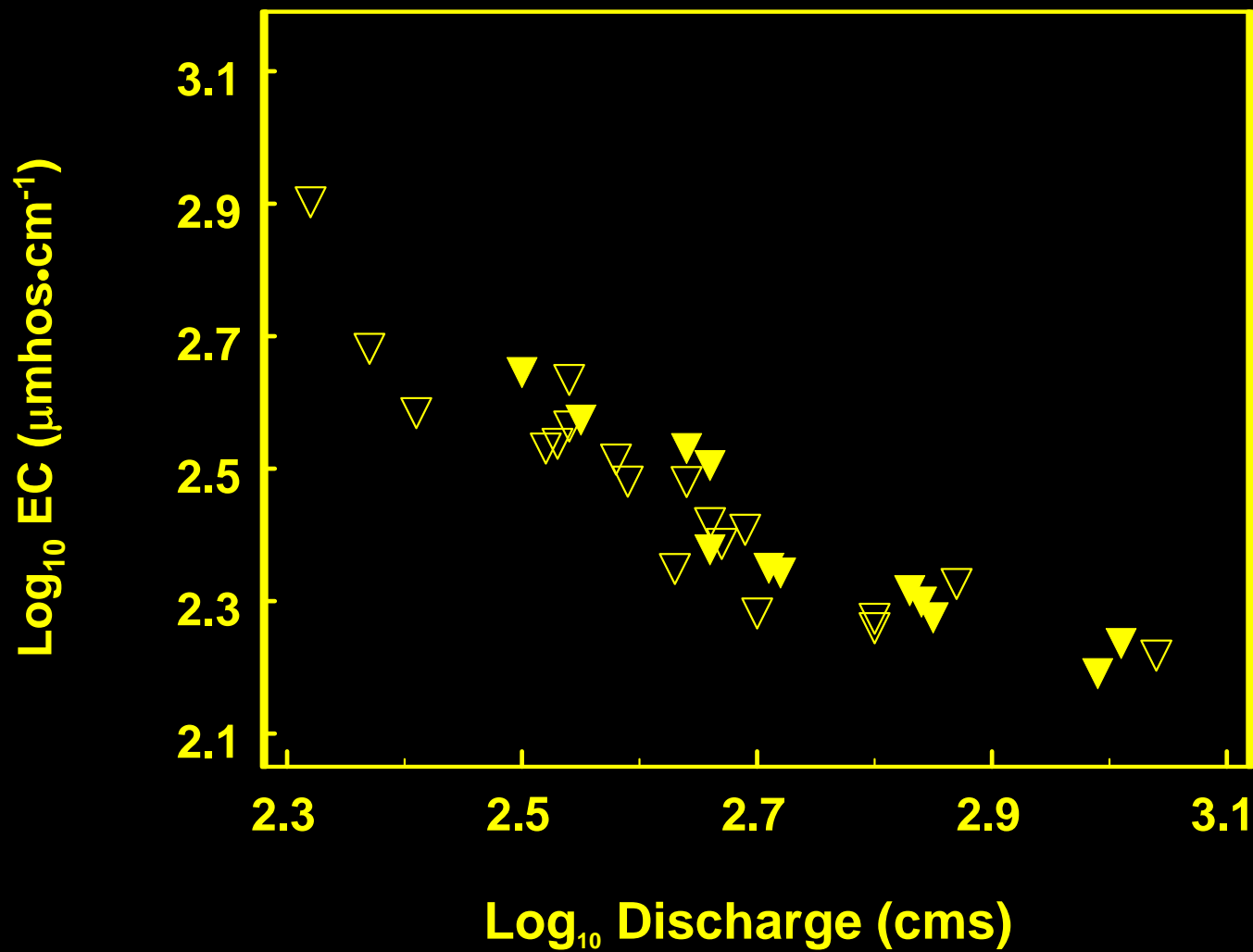
## *Corbicula fluminea* at D-28A

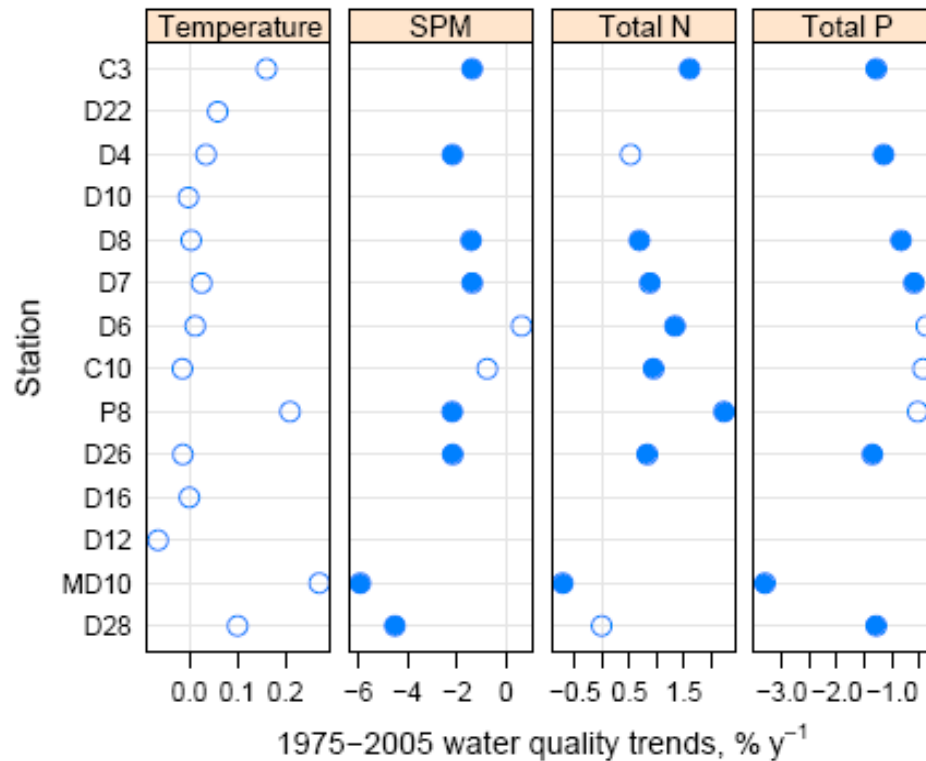












**Figure 12.** Long-term trends in water quality variables during 1975–2005. Trends are expressed as the Theil-Sen slope divided by the long-term median for the station. Trends are adjusted for river inflow and *p*-values are corrected for seasonal serial correlation. Trends are not plotted for stations with inadequate data during this period. *Solid circles*, *p* < 0.05 level according to the Seasonal Kendall test.

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