The effect of discharge on productivity in a shallow-water subtropical estuary

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Objectives:

- To apply a first-principals model to a complex system.
- Study the historical ecosystem response following increased discharge events.
- Determine if the model has predictive power that can provide insight into the possible response to climate change.

Location:

- Weeks Bay, a National Estuarine Research Reserve (NERR) within Mobile Bay on the Gulf of Mexico.

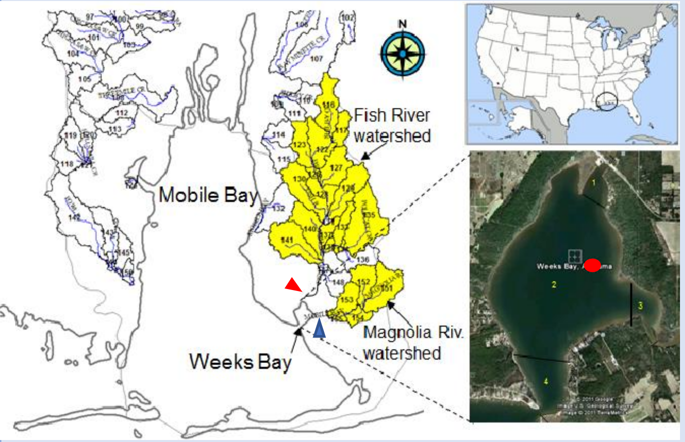


Figure from Vladimir J. Alarcon et al. 2012

Major tributaries in Weeks Bay

▲ Fish River (FR) ▲ Magnolia River (Mag) ● Groundwater (Not shown)
● Site wide monitoring platform (SWMP)

1. Lucas LV, Thompson JK, Brown RL. 2009. Why are diverse relationships observed between phytoplankton biomass and transport time? Limnol. Oceanogr., 54(1), 381–390
2. Cole BE, Cloern JE. 1987. An empirical model for estimating phytoplankton productivity in estuaries. Mar. Ecol. Prog. Ser. Vol 36: 299-305.
3. Alarcon VJ, Mcanally W, Pathak SR. 2012. Comparison of Two Hydrodynamic Models of Weeks Bay, Alabama. DOI: 10.1007/978-3-642-31075-1_44
4. Montiel D, Lamore A, Stewart J, Dimova N. 2019. Is Submarine Groundwater Discharge (SGD) Important for the Historical Fish Kills and Harmful Algal Bloom Events of Mobile Bay. Estuaries and Coasts (2019) 42:470–493.

Background

- The Lucas transport model[1] predicts biomass from discharge, growth, and losses.
- We tested this model in a complex system using discharge, community respiration (loss rate), and a productivity estimator, BZI[2] (growth rate).

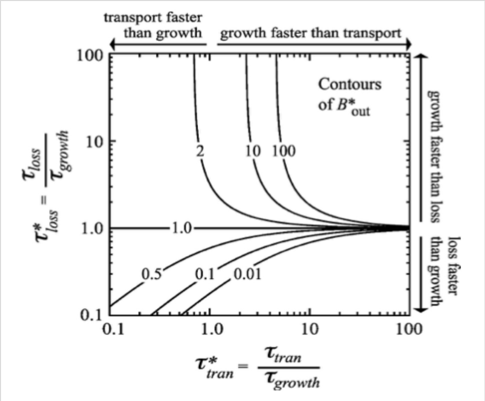


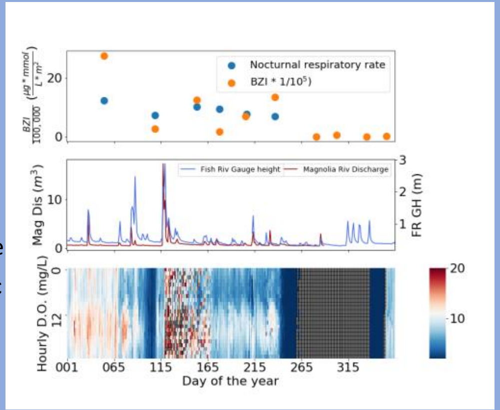
Figure from Lucas et al. 2009

τ = timescale

- When $\tau_{loss} > \tau_{growth}$, $\tau^*_{loss} > 1$.
  - Loss is occurring slower than growth and biomass increases.
- $\tau_{transport}$ determines the how long growth or loss is acting upon a water parcel moving through the system.

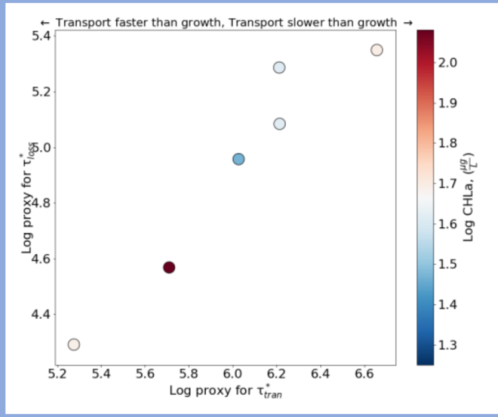
Methods:

- As part of the NERR, the SWMP collects monthly chlorophyll and continuous O_2 data (time-series to the right).
- Discharge data is collected by the USGS.
- Using a subset of the time-series, I looked at data from 2015.
- $\frac{1}{\tau_{loss}}$ was proxied using nocturnal $\frac{dO_2}{dt}$.
- $\frac{1}{\tau_{growth}}$ was proxied using the BZI model, where productivity is estimated from Chla (B), photic depth (Z), and incident irradiance (I).
- Photic depth was substituted with $\frac{1}{\text{turbidity}}$, with which it scales.
- $\frac{1}{\tau_{tran}}$ was proxied using 2-week mean discharge.



Results

- The proxies for τ^*_{loss} and τ^*_{tran} are plotted below. Log chlorophyll is indicated using a colour gradient.
- The observed distribution is not consistent with the predictions of the Lucas model.



Conclusion

- Our results are inconsistent with the Lucas model.
- Sources of difference would include
  - Under sampling – future analysis will include additional years.
  - BZI might be an inaccurate representation of growth – this will be tested against a fully resolved bio-optical productivity model.
  - The assumption of a 2-week lag between discharge and ecosystem response may lead to inaccuracy – future analysis will include testing with different lag periods.
  - The Lucas model does not include the effects of groundwater discharge, which is an important driver in this system[4].