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ECU

# Could seasonal mean sea level variations explain long-reported nutrient outwelling in the southeast coastal ocean?

François Birgand[1], Randall Etheridge[2], Mike Burchell[1]

1: NCSU 2: ECU

1

# Nutrient 'outwelling': A 50 year old tale

Autumn 1962 Ecology, Vol. 43, No. 4

ENERGY FLOW IN THE SALT MARSH ECOSYSTEM OF GEORGIA[1]

JOHN M. TEAL

*Woods Hole Oceanographic Institution, Woods Hole, Massachusetts*

At the same time the tides remove 45% of the production before the marsh consumers have a chance to use it and in so doing permit the estuaries to support an abundance of animals.

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## A Research Challenge: Evaluating the Productivity of Coastal and Estuarine Water

*1968.*
*Proceedings of the 2nd Sea Grant Conference,*
*University of Rhode Island, Kingston, pp. 63-64.*

*Eugene P. Odum*

Most fertile zones in coastal areas capable of supporting expanded fisheries result either from the "upwelling" of nutrients from deep water or from "outwelling" of nutrients and organic detritus from shallow-water nutrient traps such as reefs, banks, seaweed or sea grass beds, algal mats and salt marshes. The importance of the latter as "primary production pumps" that "feed" large areas of adjacent waters has only been recently recognized, and

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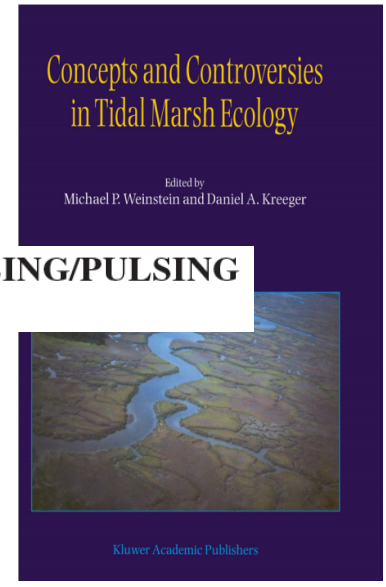
## TIDAL MARSHES AS OUTWELLING/PULSING SYSTEMS

Odum, 2002

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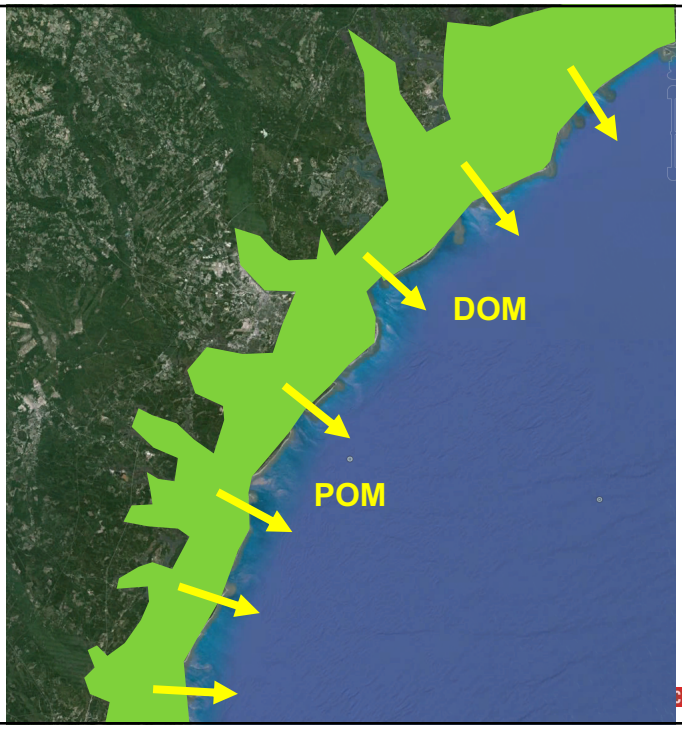
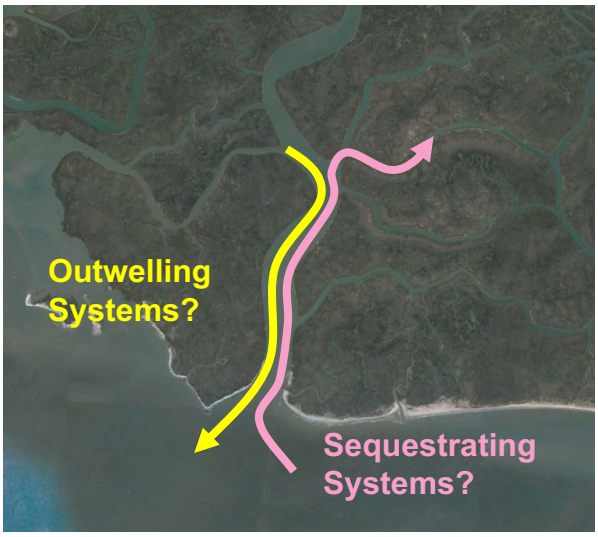



*Google Earth, off the coast of Georgia*






*Google Earth, off the coast of NC*

# INTRIGUING DATA FUELING THE DEBATE

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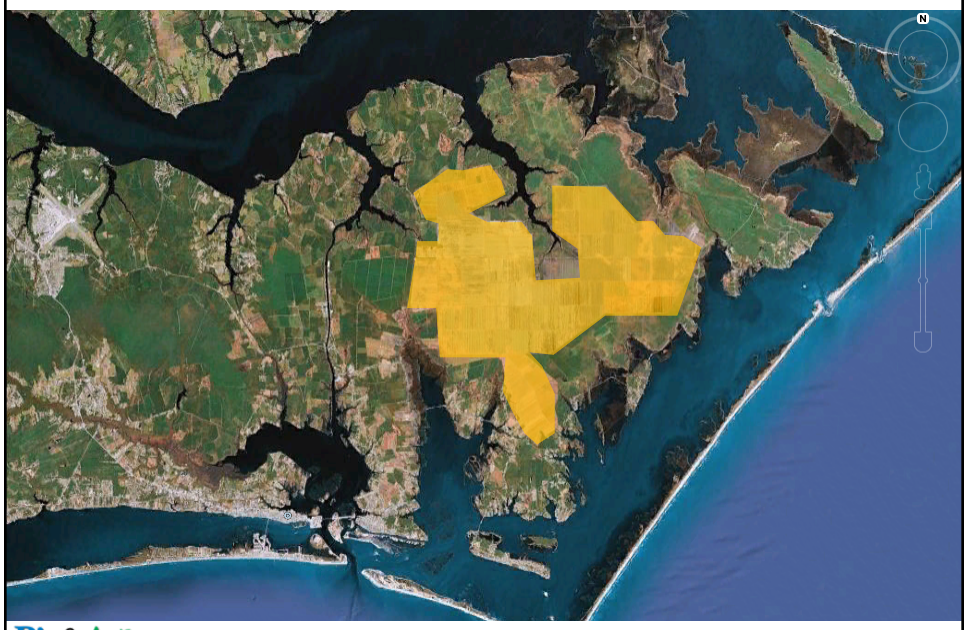

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## Construction

## Restoration

September 2007

November 2012

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# One of the Project Goals

- Ability of a restored coastal marsh to provide ecosystem services, including
  - water quality: dissipate excess nutrients from upstream agricultural drainage

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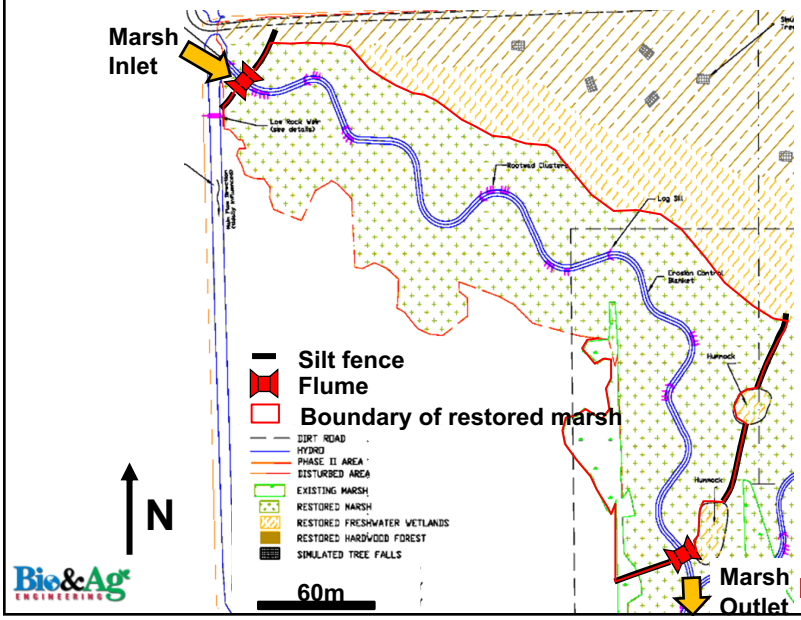
# Methods: mass balance

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# Flow Monitoring

- Doppler Velocity and water depth recorded every 15 minutes in flume
- Use manual stream gauging to relate Doppler velocity to actual flow in the flume

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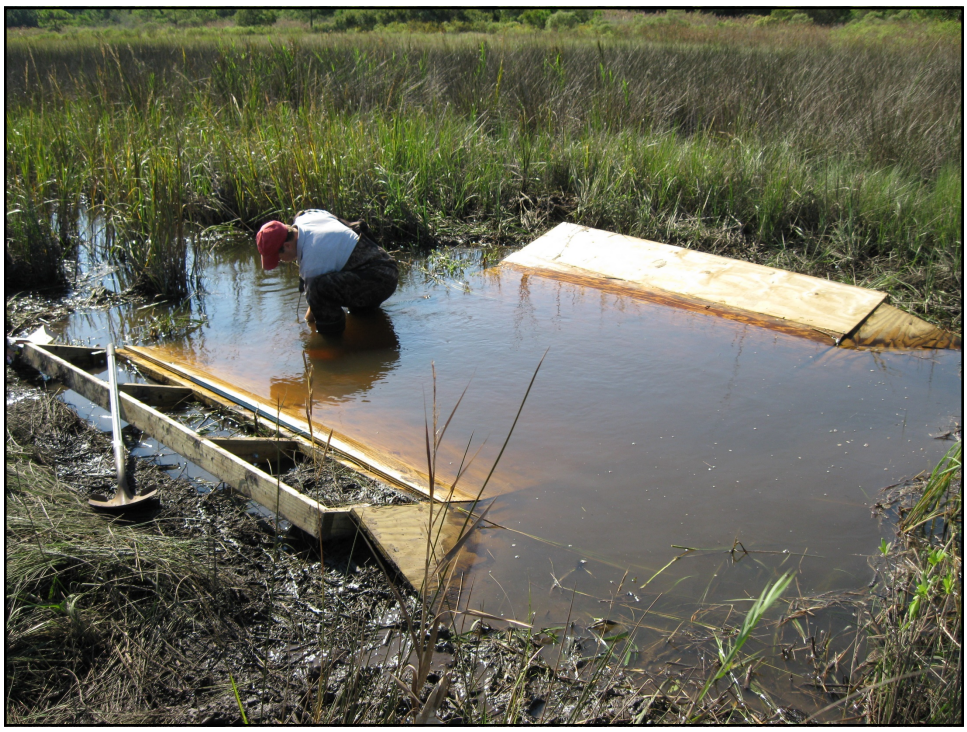
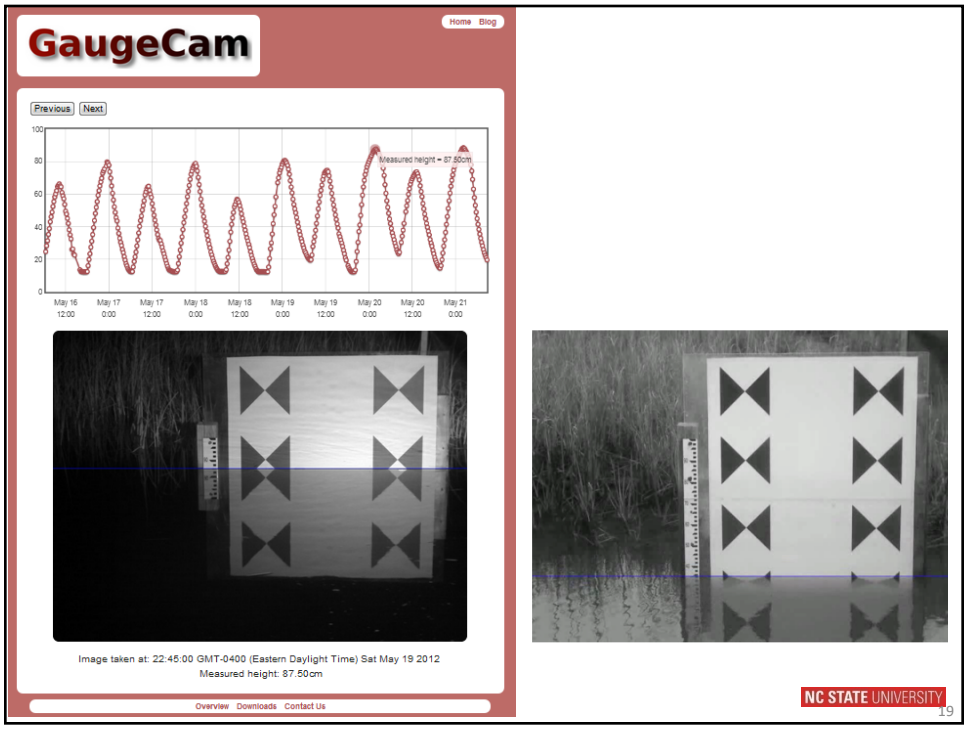
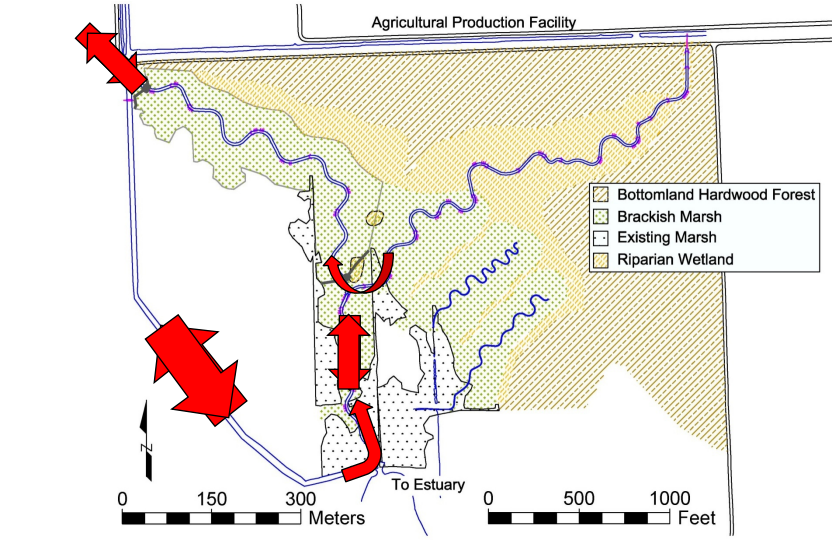





# Water Movement in the Marsh

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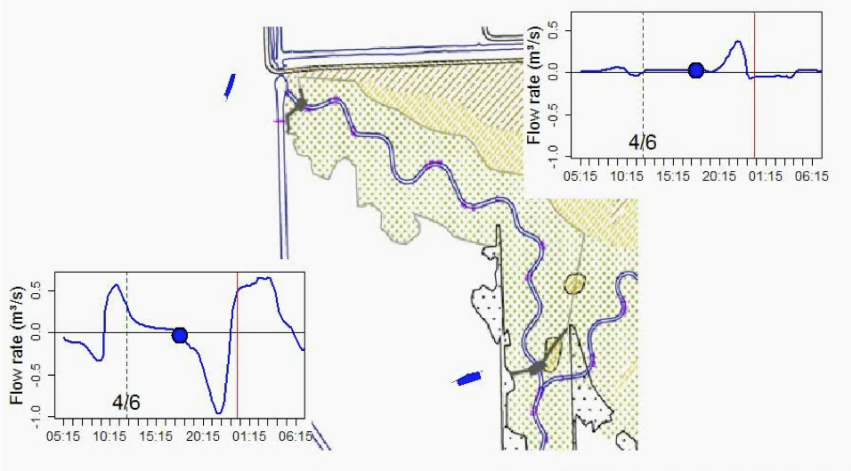
# Flow dynamics

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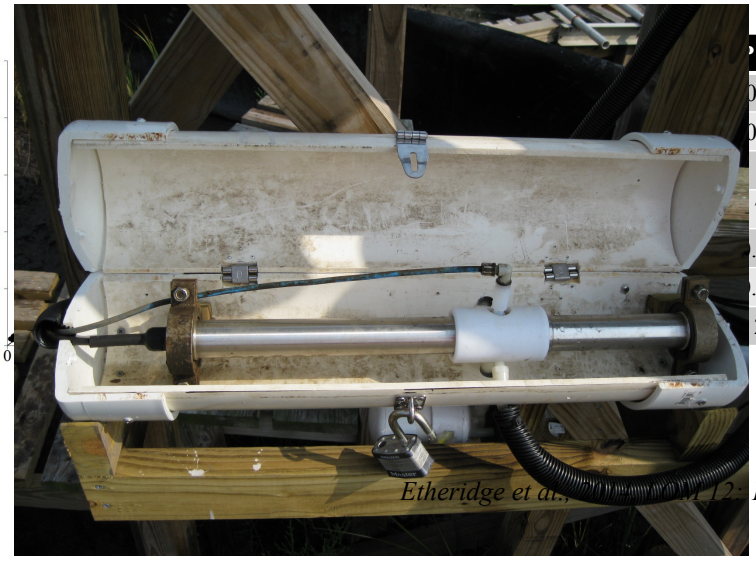
# Nutrient Monitoring




| (mg L$^{-1}$) |
|---|
| 0.1 |
| 0.3 |
| 1 |
| 7 |
| .01 |
| .02 |
| 2 |

*Etheridge et al.* *10-22*

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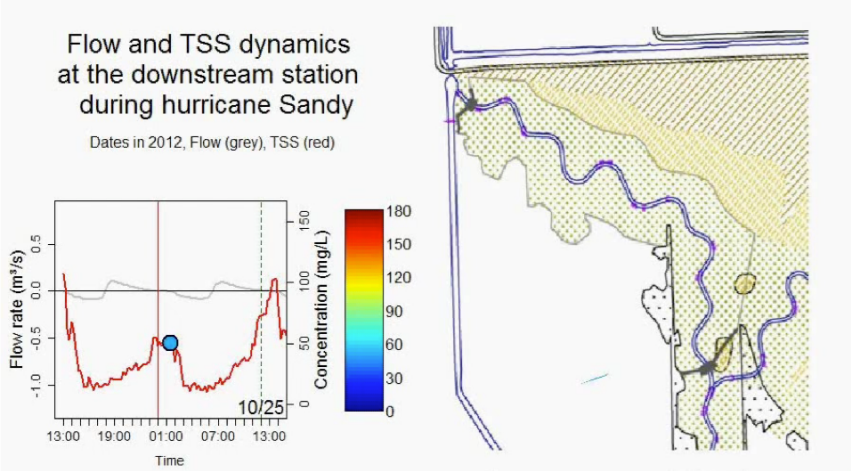
# TSS dynamics

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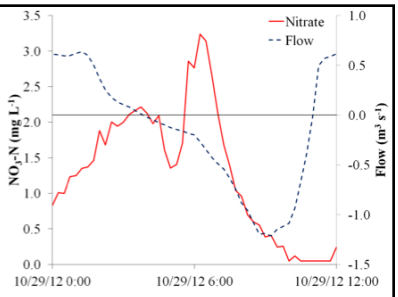
# Mass Balance




$$M = k\sum_{i=1}^{i=t} q_i c_i \Delta t$$

- M = total mass of N either exported or imported (kg)
- t = time (min)
- k = constant for converting units
- $q_i$ = water flow at time i ($m^3\ s^{-1}$)
- $c_i$ = concentration at time i ($mg\ L^{-1}$)

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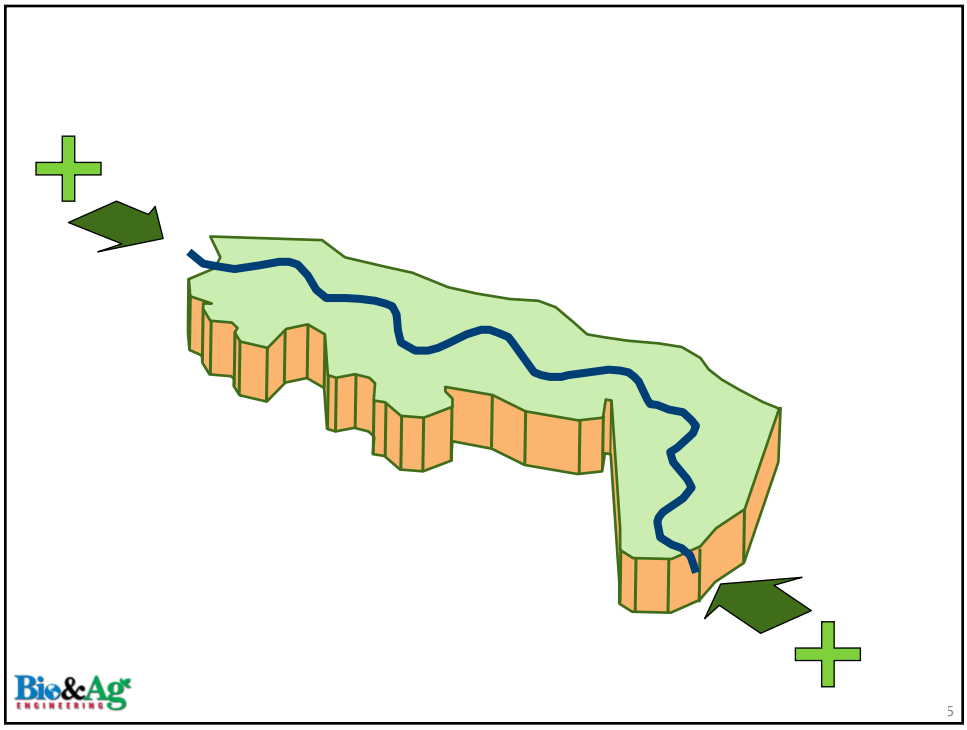
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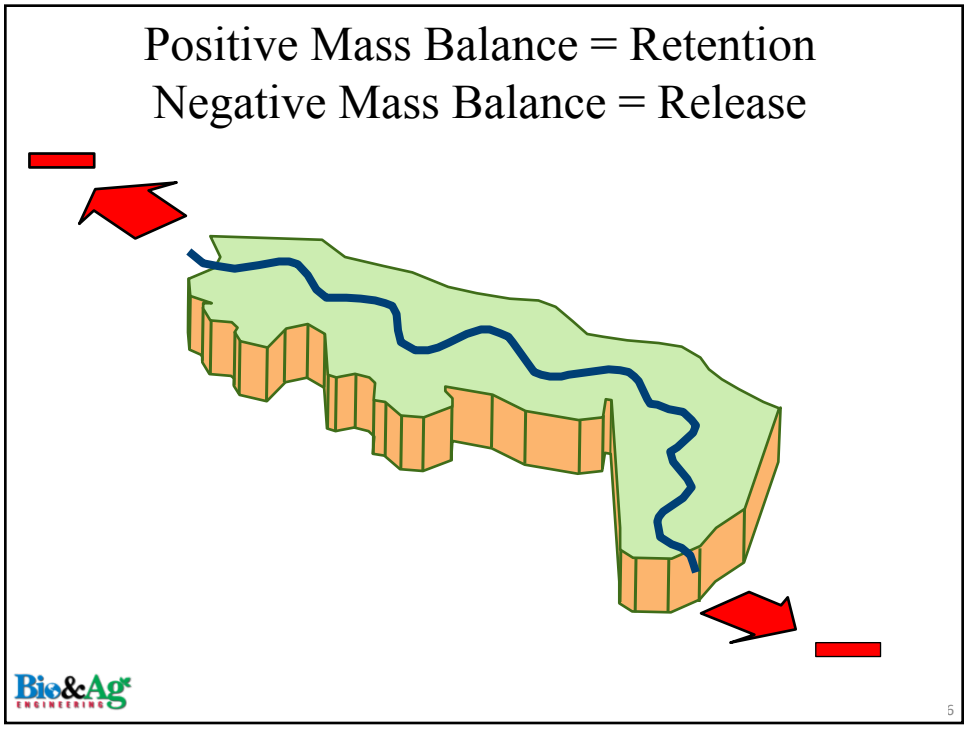
Positive Mass Balance = Retention
Negative Mass Balance = Release
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# BACK TO THE INTRIGUING DATA

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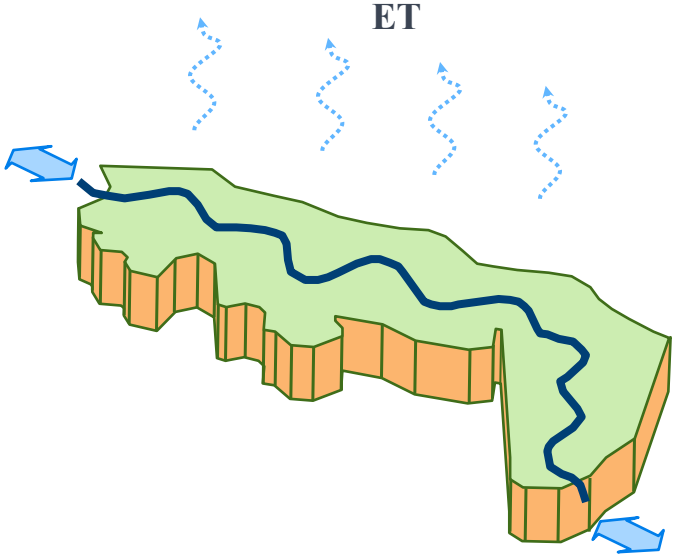
## ET



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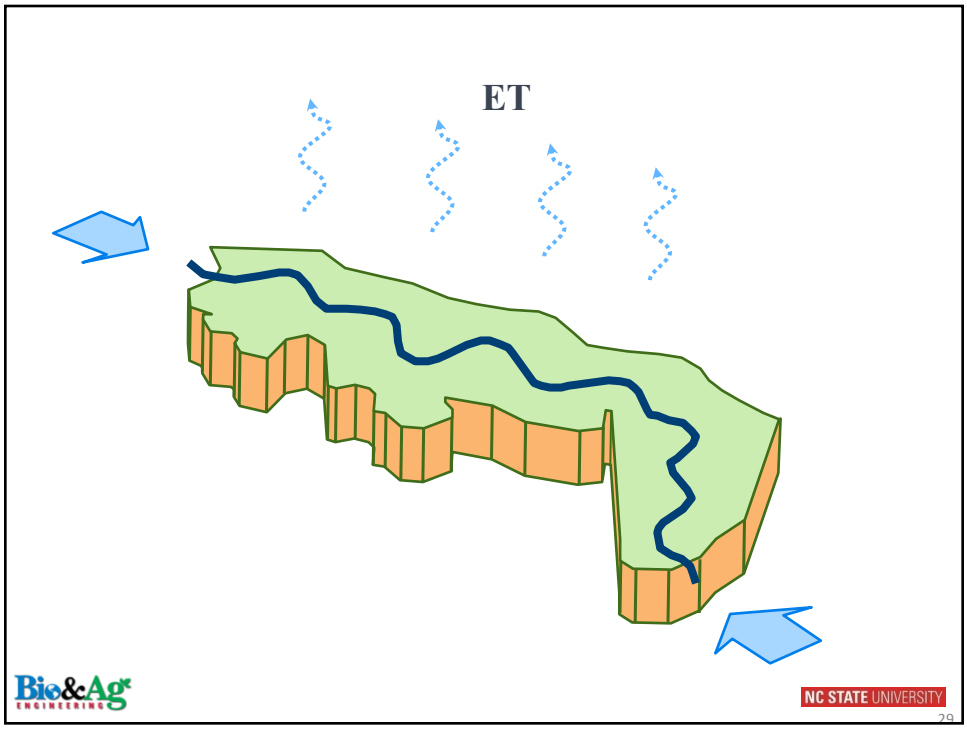
ET
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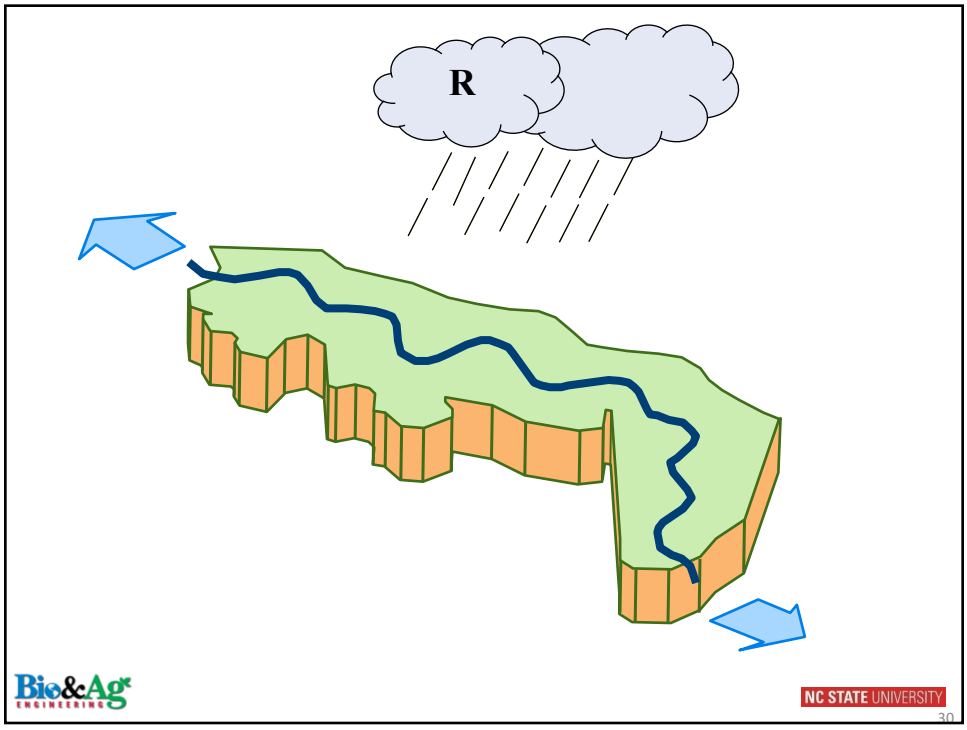
R
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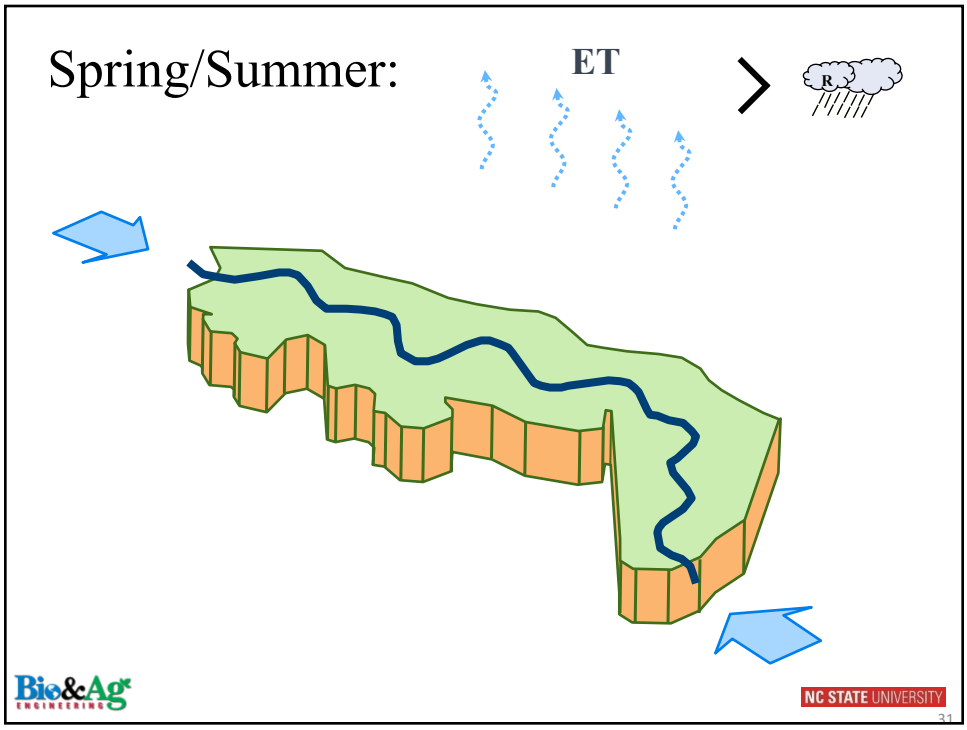
Spring/Summer:
ET
R
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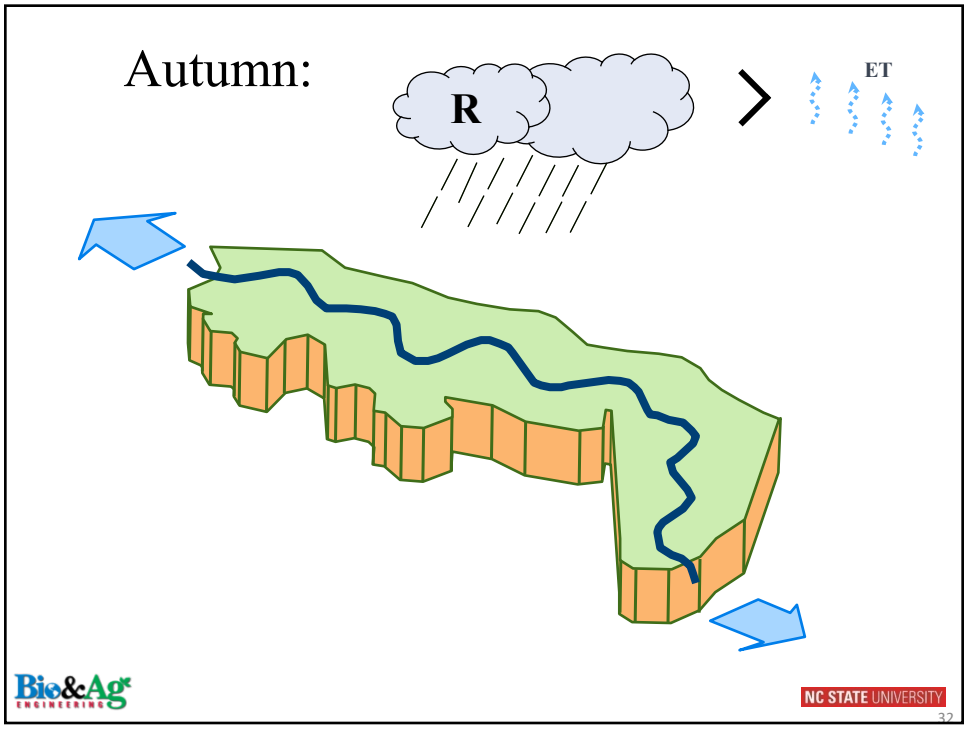
Autumn:
R
ET
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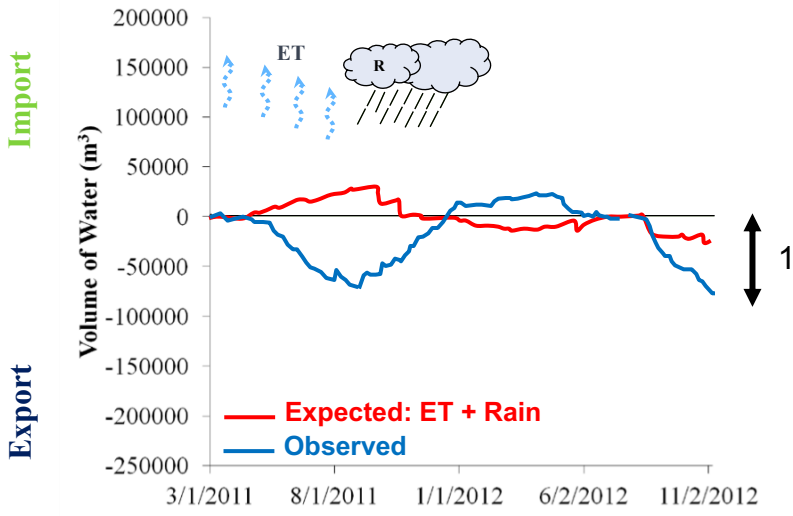
# Water balance intrigue…




**2-way water pump!**

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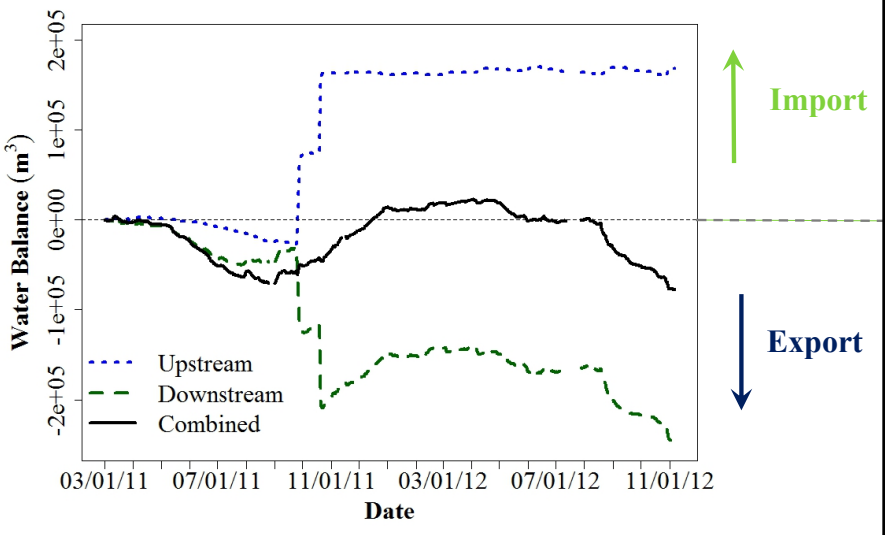
# Water Balance

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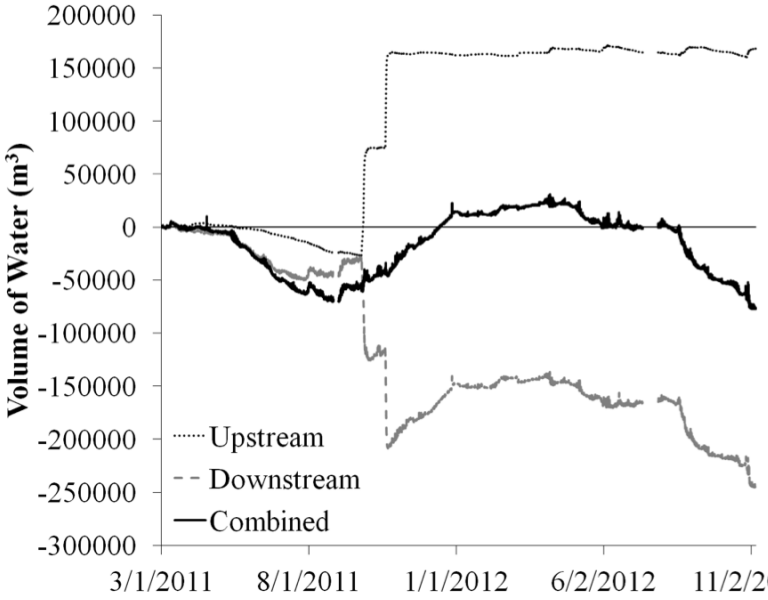
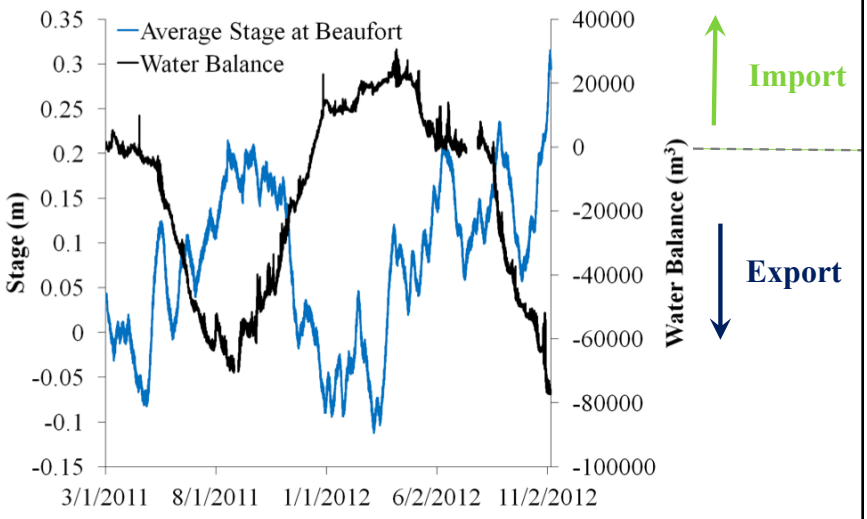
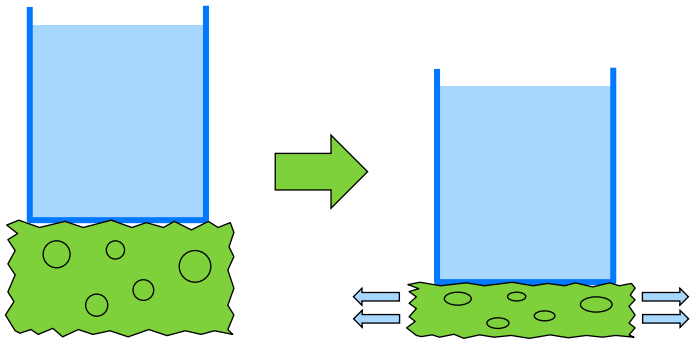
# Water Balance at the Flow Stations




# Water Balance



# A sponge model ?



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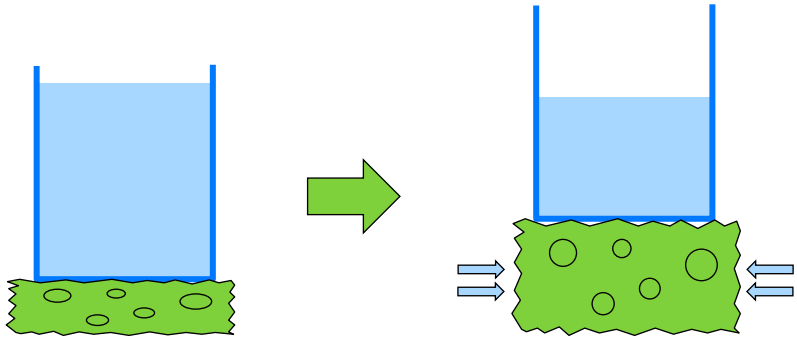
# A sponge model ?



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# Intriguing coincidences

- Charleston, SC:
  - largest mean seasonal sea level cycles in the US…!
  - Outwelling: described of the coast of Georgia…
  - Coastal plain areas where sedimentary deltaic layering
- New England:
  - low mean sea level cycles
  - Rocky sediments
  - No evidence of outwelling

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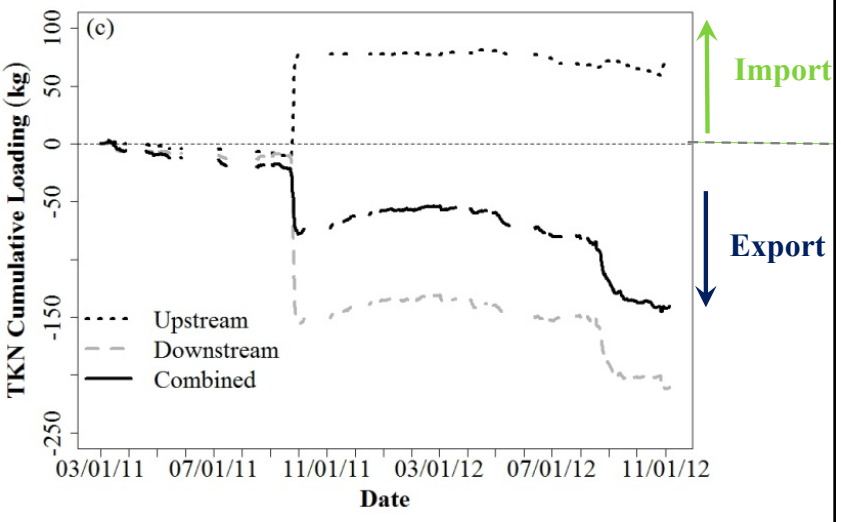
# TKN balance: net export

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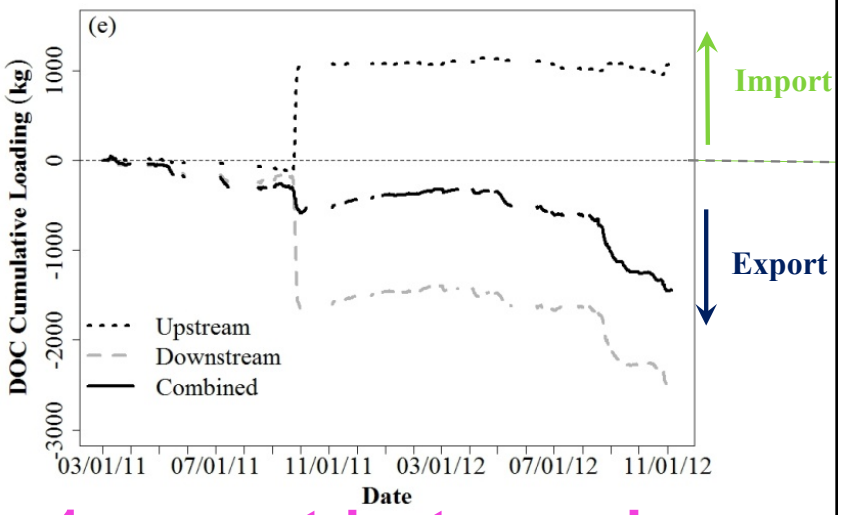
# DOC balance: net export




**1-way nutrient pump!**

# Mass Balance Summary

| Parameter | Input Mass (kg) | Output Mass (kg) | Mass Balance (kg) | Percent Retention |
|---|---|---|---|---|
| **$NO_3$-N** | **470** | **430** | **40** | **9%** |
| TKN | 1,290 | 1,410 | -120 | -9% |
| TN | 1,760 | 1,840 | -80 | -5% |
| DOC | 18,000 | 19,400 | -1,400 | -8% |
| $PO_4$-P | 57 | 59 | -2 | -4% |
| TP | 117 | 125 | -8 | -7% |
| TSS | 48,000 | 51,000 | -3,000 | -6% |

# Conclusion

- We have either made all our measurements wrong,
- We are up to something and what we saw might be something that exists everywhere there is spongious sediment and high seasonal variations of sea levels
- Or…?

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**Questions?**

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