IMPROVEMENTS IN WATER QUALITY OF A DANISH ESTUARY FOLLOWING NUTRIENT REDUCTIONS

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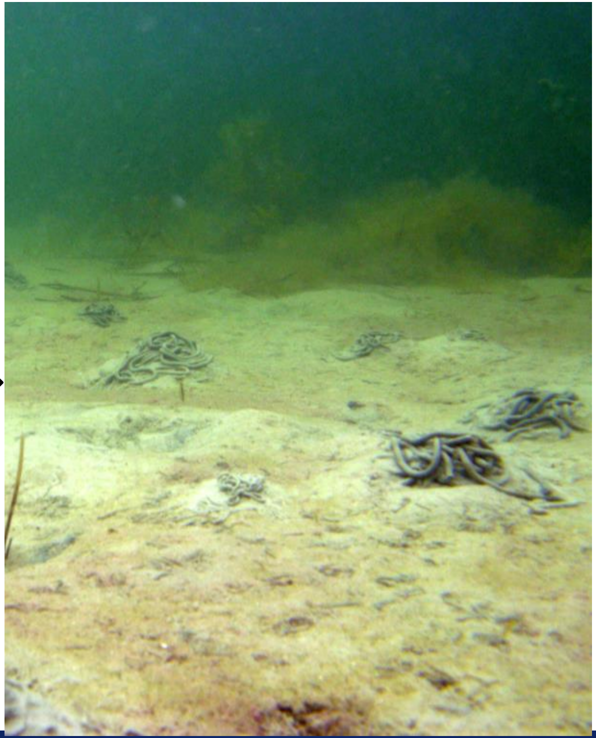
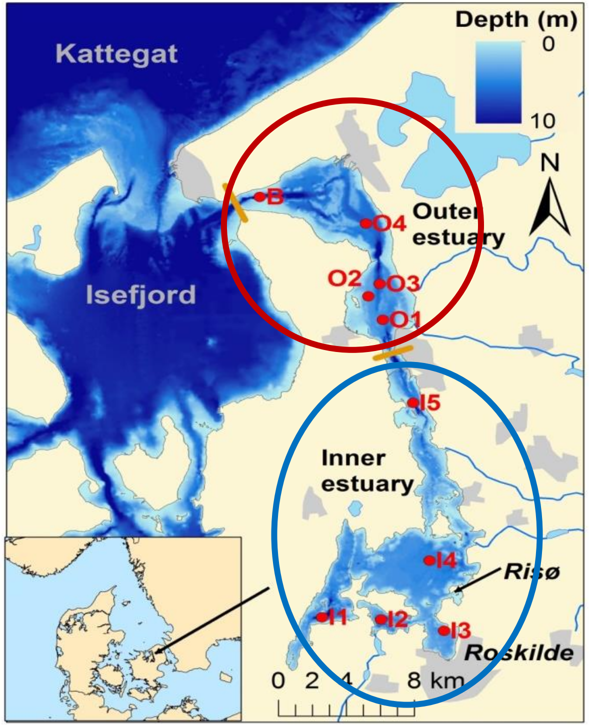
THE OLIGOTROPHICATION PATHWAY?



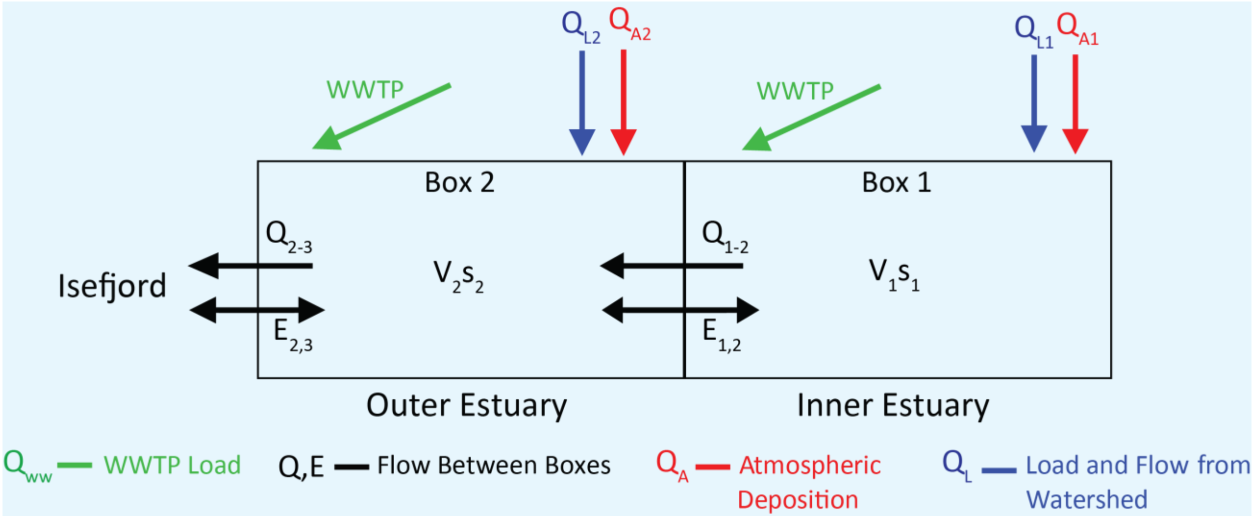
Which responses, where and how fast?

- Loading and concentrations
- Transformation and exchange processes
- Water quality and biological changes
- Recovery pathways

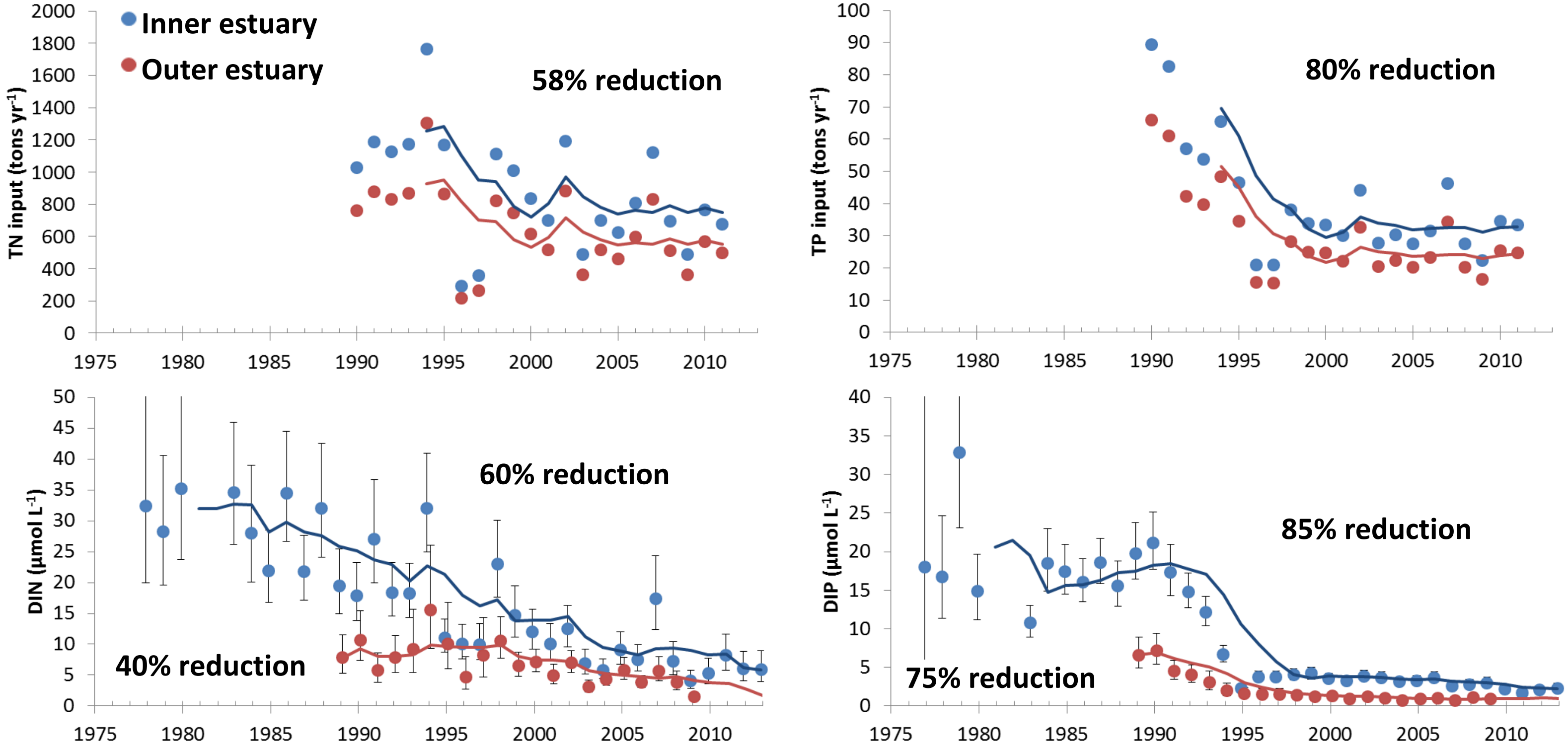
LONG-TERM MONITORING AND MODELLING



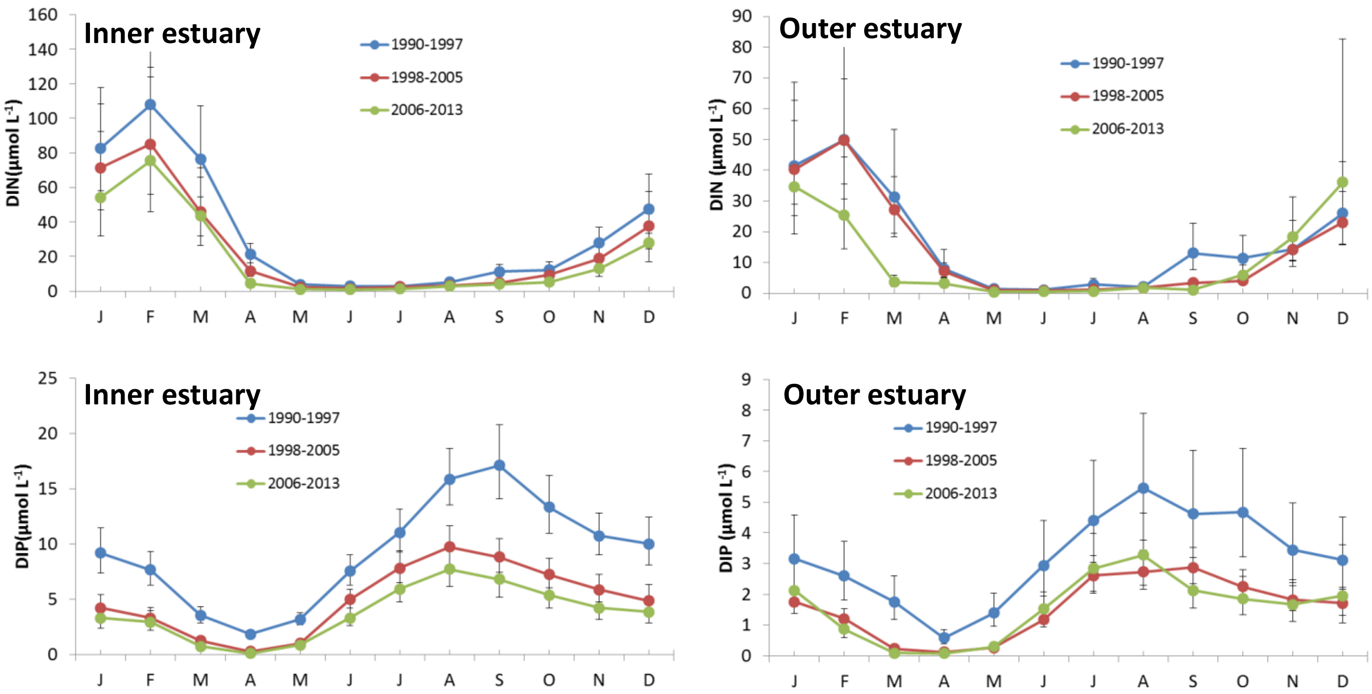
Box-model of physical mass balances



LOADINGS AND CONCENTRATIONS



SEASONALITY IN NUTRIENTS

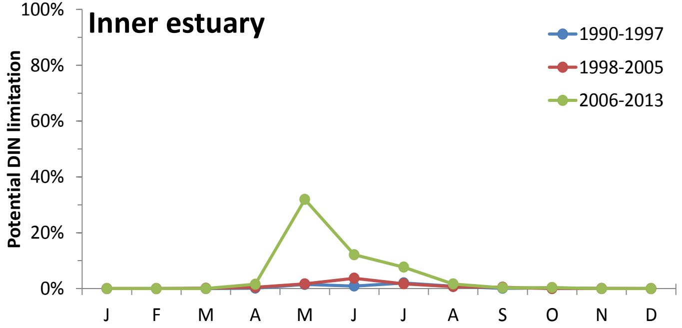


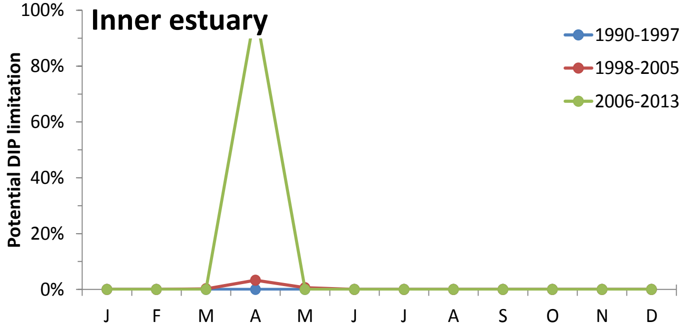
DIN declines occurred in spring and autumn – related to lower inputs

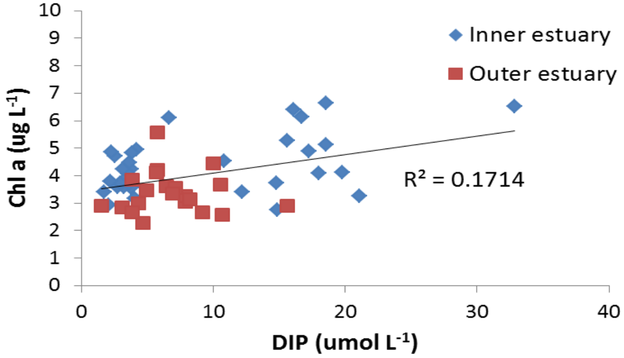
DIP declines due to reduced sediment release during summer and reduced inputs during winter

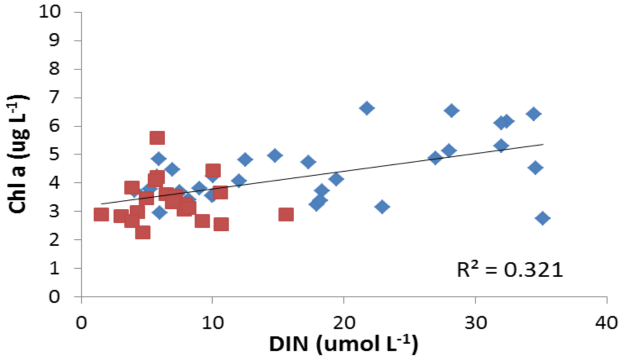
Continued high DIP release in summer

LIMITING NUTRIENTS





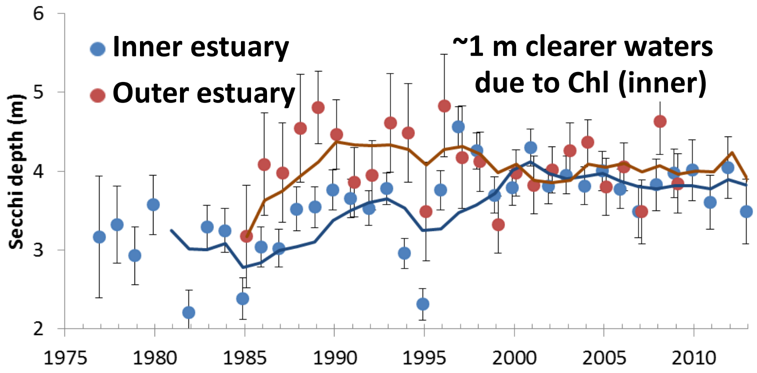


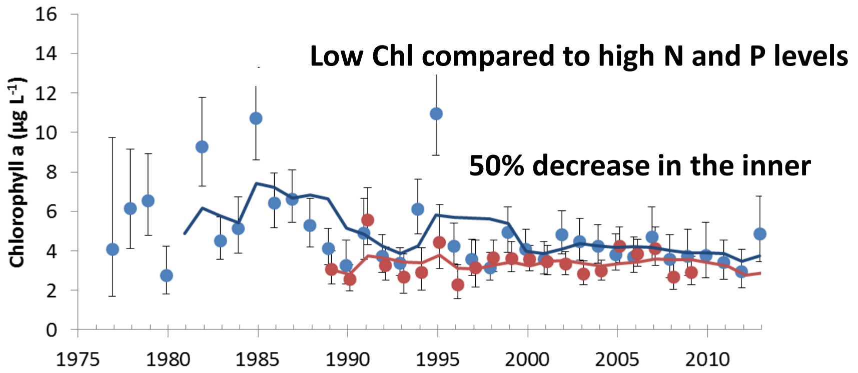


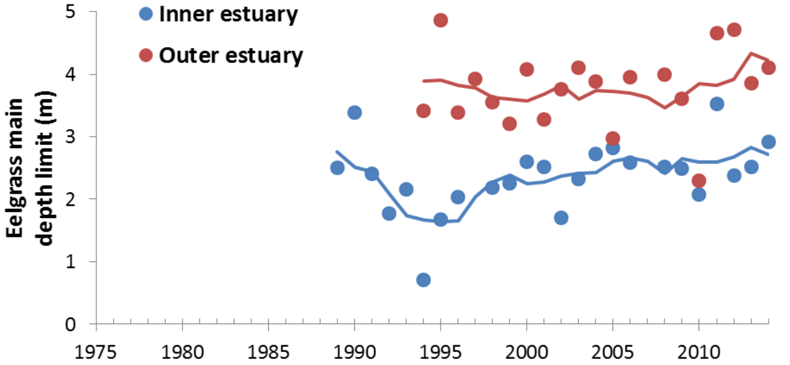
Outer estuary is strongly N and P limited → low response to further reductions

Inner estuary is mostly N limited

WATER QUALITY PARAMETERS

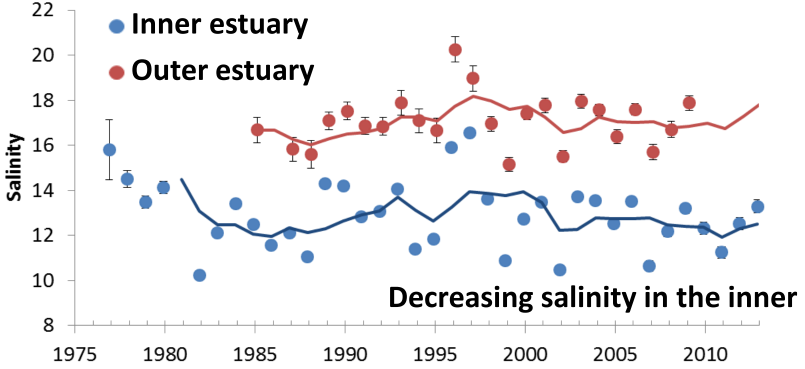


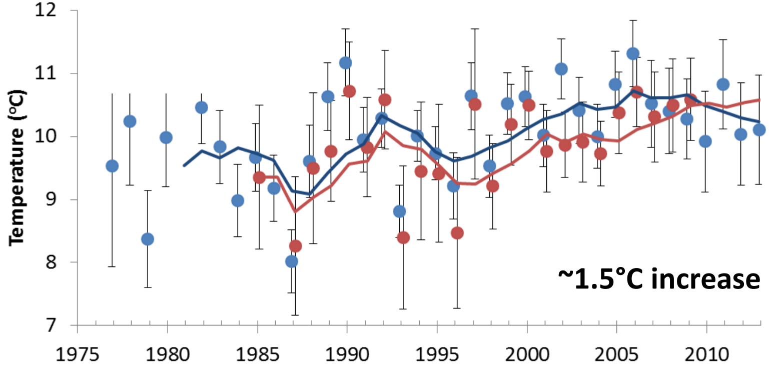


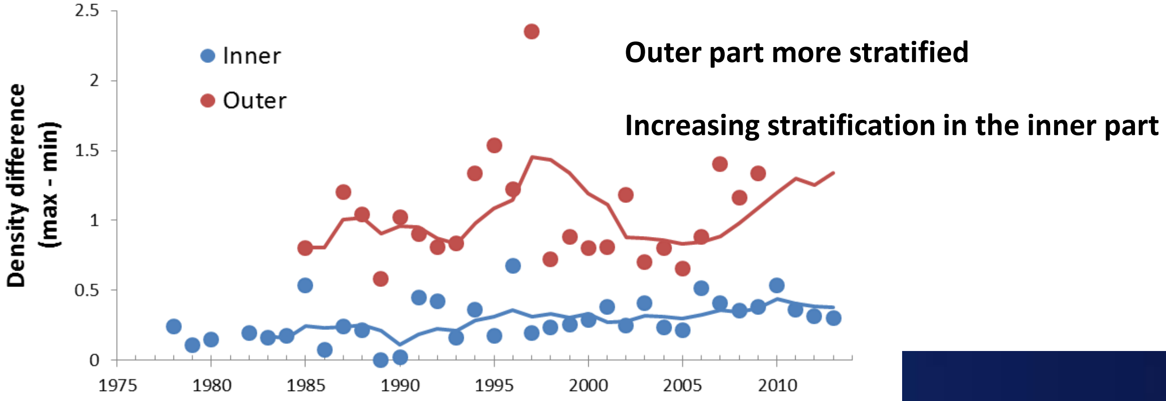


Increase of ~0.5m in the inner
Recent signs of increase in outer

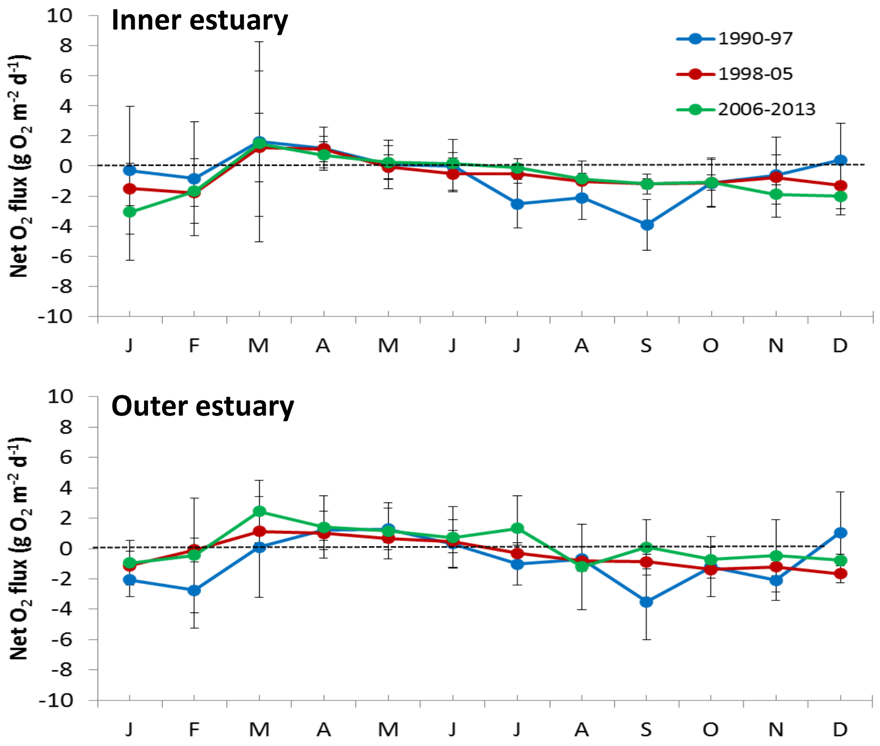
SALINITY AND TEMPERATURE







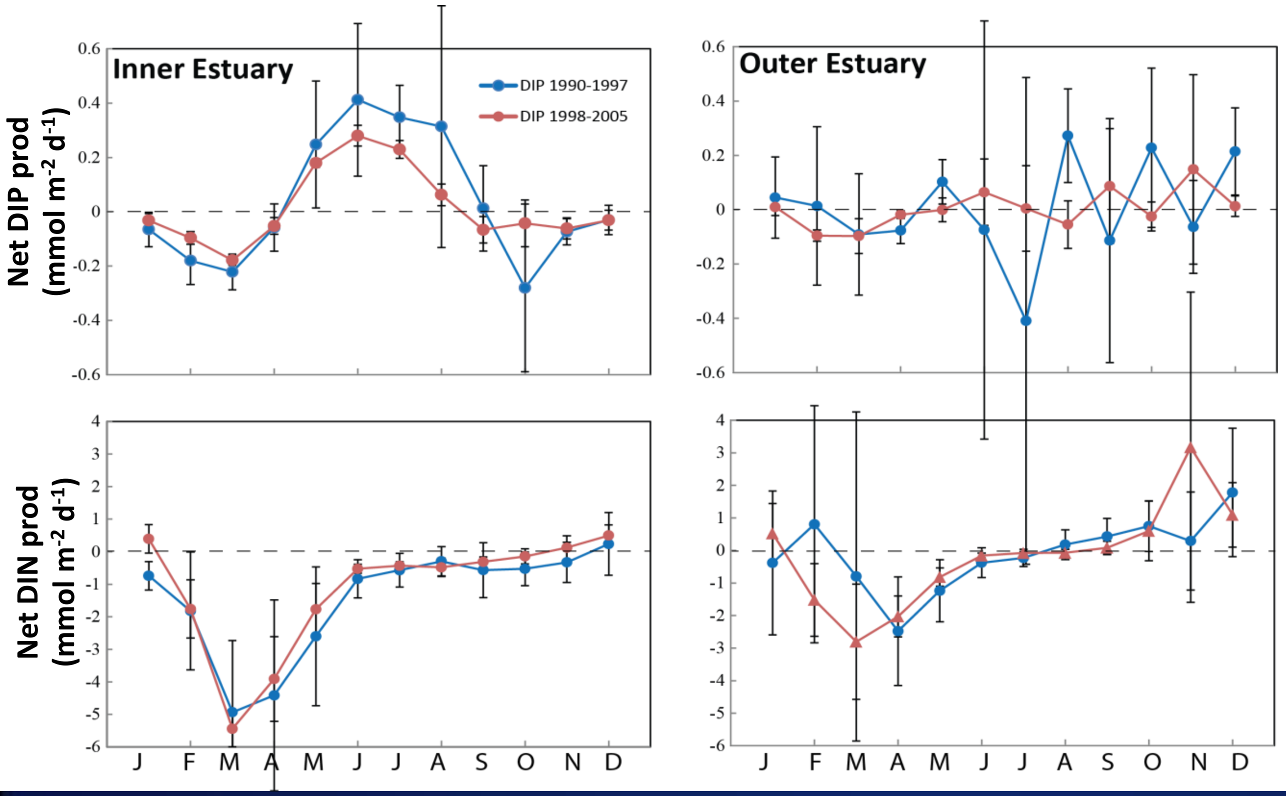
NET OXYGEN PRODUCTION



Increasing autotrophy in both parts of the estuary, with most changes during summer →

reduced ecosystem respiration and increased benthic primary production

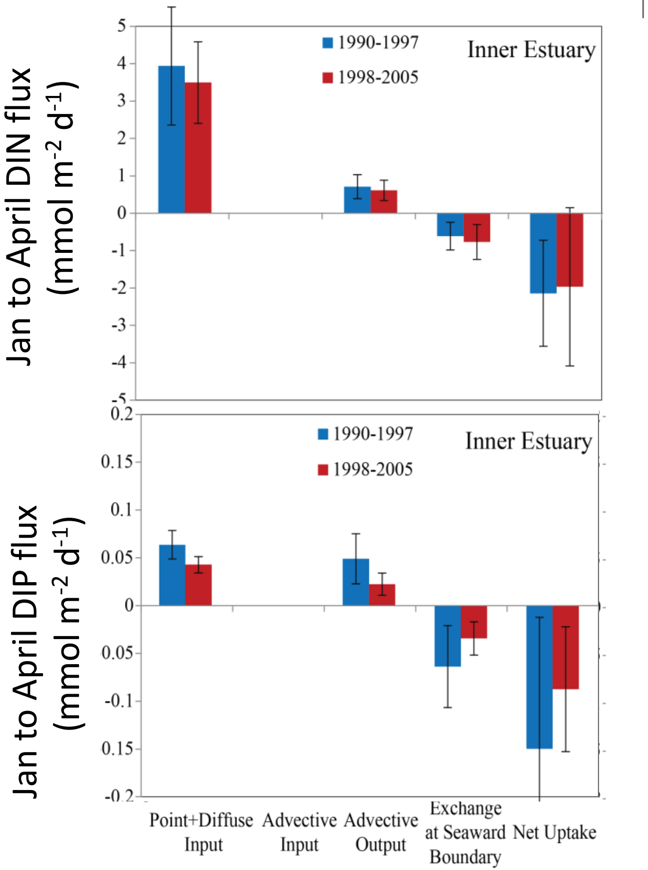
NET DIP AND DIN PRODUCTION



High prim prod during spring → large uptake of DIN and DIP (mostly inner)

Modest decrease in DIP release from sediments during summer (only inner)

NUTRIENT MASS BALANCES

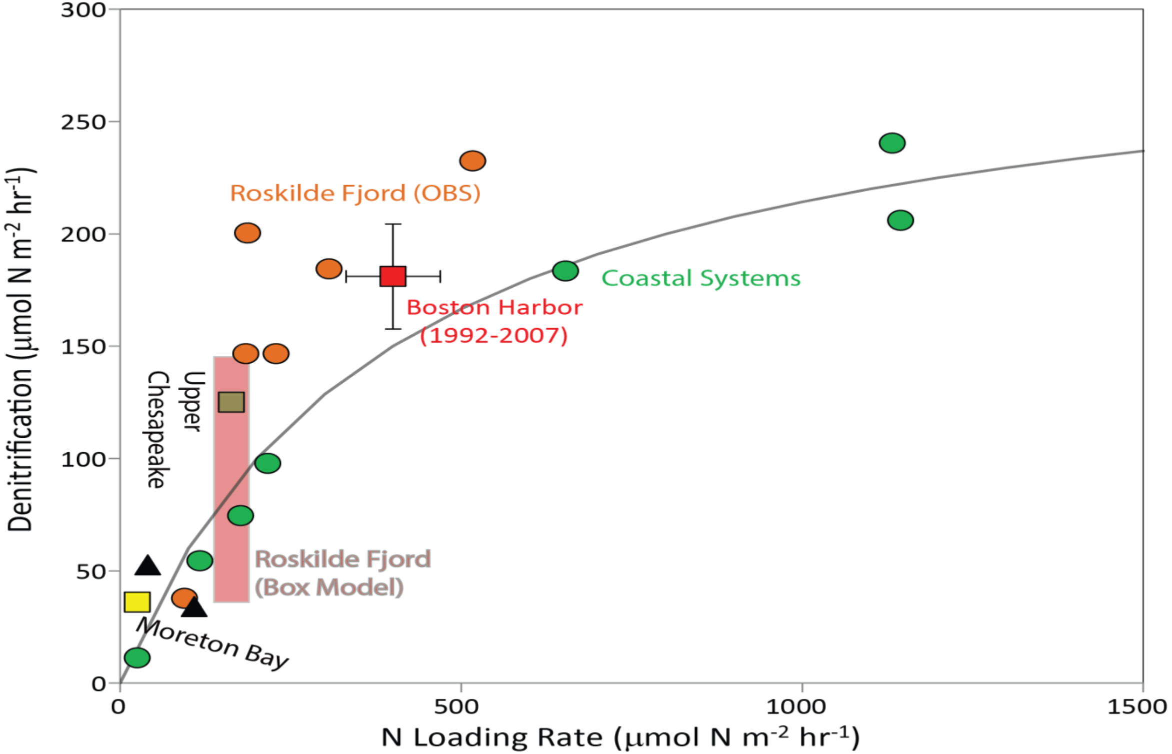


Small changes in DIN fluxes in both parts

Reduced DIP uptake in both parts over time

High exchange of both DIN and DIP at the outer part → Low retention in the estuary

REDUCED IMPORTANCE OF DENITRIFICATION



Rate of N removal will continue to decrease

STATUS OF THE BIOLOGICAL COMMUNITIES

Parameter	Inner part	Outer part	Target (WFD)
Eelgrass main depth limit	2.6m	4.2m	3.0 and 4.1m
Chl a	4.0µg /L	2.5µg /L	3.6 and 2.1µg /L
Benthic filter feeders	~3 g AFDW	< 0.5g AFDW	none

Annual means over the last 3 years

WHICH RESPONSES, WHERE AND HOW FAST?

1) **Impact and responses of Inner ≠ outer estuary**

2) **Three recovery phases:**

   I: Fast transformation and loss of C,N,P →

   a) reduced nutrient concentrations →

   b) gradual nutrient limitation (mostly DIN)

   c) slower removal of excess N and P over time

   II: Reduced pelagic PP and Chl →

   a) improved light at bottom

   b) fewer benthic filtrators

   c) lower ecosystem R but higher benthic PP

   III: Slow improvements in eelgrass → longer term storage of C,N,P

3) **Targets are getting close but changes in temp, precip. and wind may affect recovery**

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