BALTSEM - a marine model for decision support at the Baltic Sea

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Forcing | Results

Account: VIII BSSC 2011, St. Petersburg, 22-26 August 2011

BALTSEM - a marine model for decision support at the Baltic Sea

Oleg P. Savchuk

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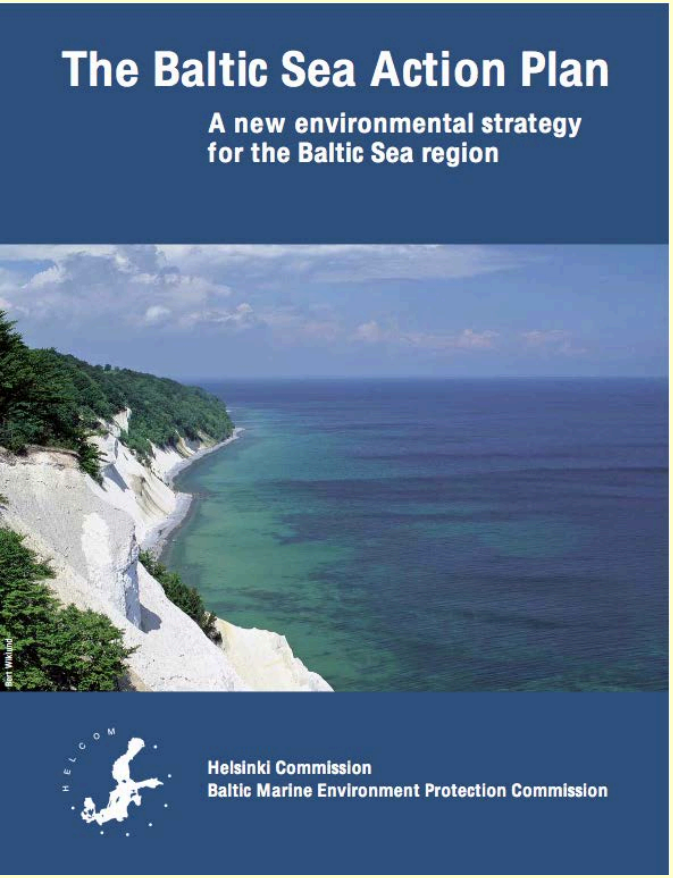


Eutrophication segment of the BSAP:

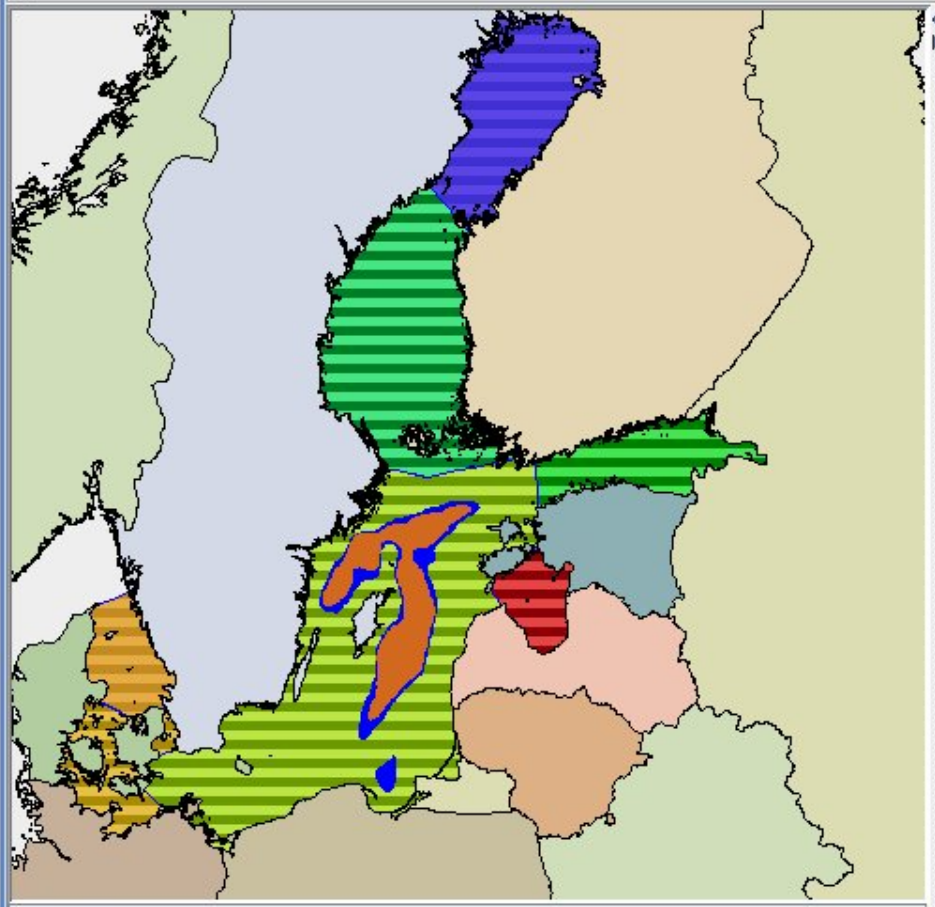
- ***is based on allowable nutrient inputs from the land of 600,000 tonnes nitrogen and 21,000 tonnes phosphorus annually***
- ***with actual average (1997-2003) land loads of 737,720 t TN and 36,310 t TP the total required reductions are about 135,000 t TN and 15,000 t TP***
- ***these numbers have been estimated with the marine biogeochemical model SANBALTS, which is a component of the decision support system Baltic Nest***

Baltic Nest

Tools

Cost calculation | Marine model | Watershed model | Fish model | Riverine and marine data | EMEP data

File



Palette

Flip

Min 21.32 | Step 0.10 | Max 259.52

Primary production | Draw

#0: Contemporary

#1: BSAP

Automatically calculate Min and Max values for the palette

Forces

Atmospheric depositions | Loads from Skagerrak

River loads | Point sources loads

	Labile Org...	Stable Or...	Inorganic N	Labile Org...	Stable Org...	Inorganic P
Bothnian ...	7114	28455	15867	1549	172	864
Bothnian ...	8192	24576	24018	1371	152	934
Baltic Pro...	34672	81900	116686	3731	1081	1934
Gulf of Fin...	15116	45350	46214	3401	489	970
Gulf of Riga	12680	23548	42174	588	93	749
Danish St...	3888	5832	21173	653	73	684
Kattegat	7177	10765	26315	862	96	615

http://nest.su.se/nest

Comment: BSAP | Calculate

Result

Variables | Biogeochemical fluxes | Transport | Network analysis

	Total N	Total P	Transparency	
Bothnian Bay	22.5	0.2	5.8	6.6
Bothnian Sea	19.5	0.4	7.0	8.0
Baltic Proper: 0 - 60m	18.5	0.5	7.0	8.1
Gulf of Finland	24.6	0.6	6.0	5.9
Gulf of Riga	41.6	0.7	4.5	4.2
Danish Straits	18.9	0.6	7.7	7.7
Kattegat	17.0	0.6	8.5	9.0
Baltic Proper: 60m -...	20.9	1.5		

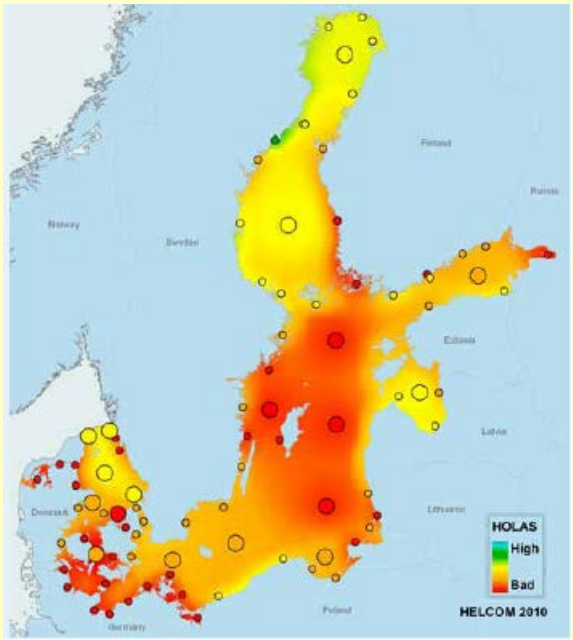
SANBALTS, validated and published

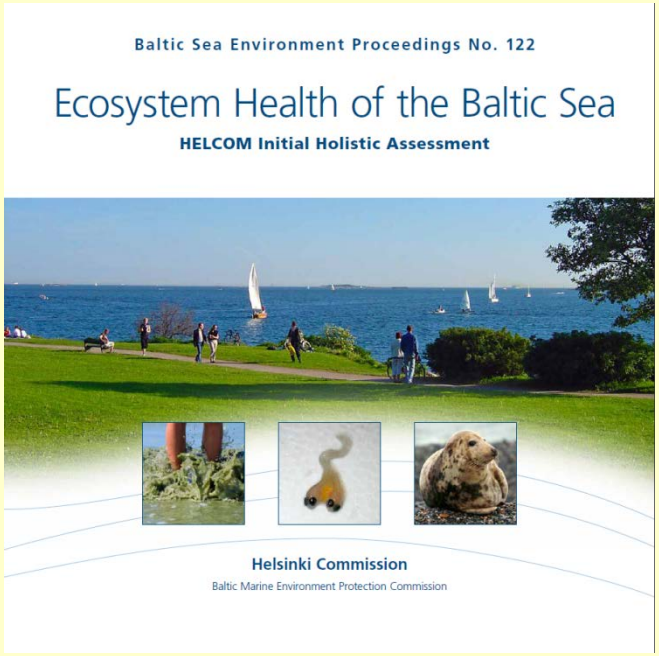
#1: BSAP | Clear history

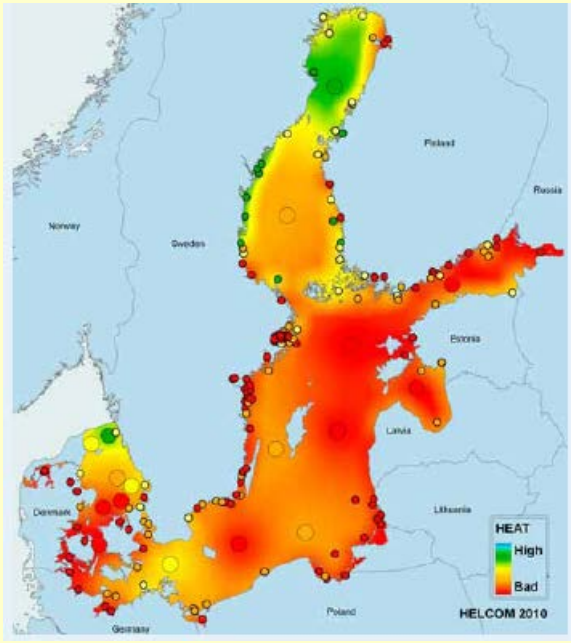
Hypoxic area: #0 = 41974, #1 = 26928 Difference = +15045.5 [km^2]

State of ART: within EAM an important role in defining ES and EO set forward, e.g. by BSAP, MSFD, WFD, UWWTD, ND and many other acronyms to come, belongs to some conventional numbers that are used for relevant painting. Often, such numbers include winter surface nutrients and summer chlorophyll, i.e. seasonally varying indicators. Concurrently, climate fluctuations in a system with long residence times demand multi-decadal time scales

Policy driver	Status classification				
	Unaffected/Acceptable		Affected/Unacceptable		
HELCOM BSAP	Unaffected by eutrophication		Affected by eutrophication		
MSFD	Good Environmental Status		Polluted		
WFD	High ES	Good ES	Moderate ES	Poor ES	Bad ES
UWWTD	Unpolluted/non-sensitive		Polluted/sensitive		
ND	Unpolluted		Polluted		



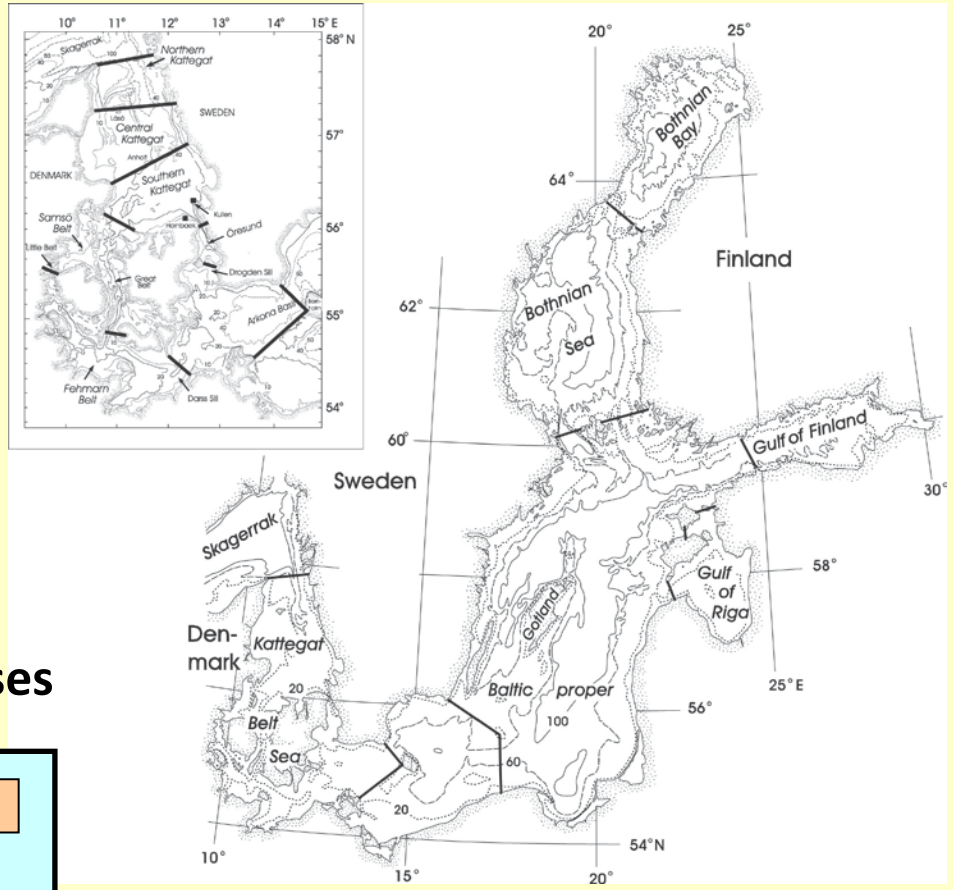




BAltic sea Long-Term large-Scale Eutrophication Model

Main characteristics:

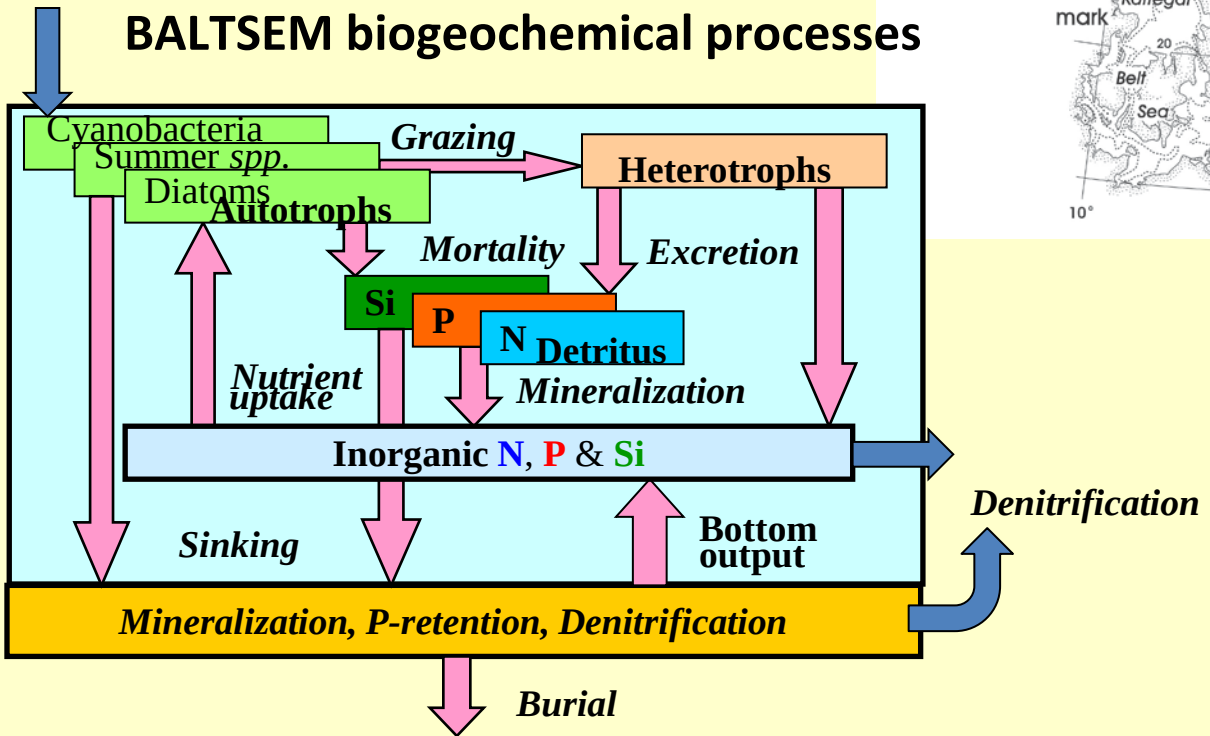
- **13 sub-basins**
- **High vertical resolution**
- **Water exchange between- and water mixing within sub-basins are described from well-founded HD principles**
- **Meteorological and nutrient loading boundary conditions are reconstructed from the best available data, here for 1970-2006**



Sub-basin boundaries

Nitrogen fixation

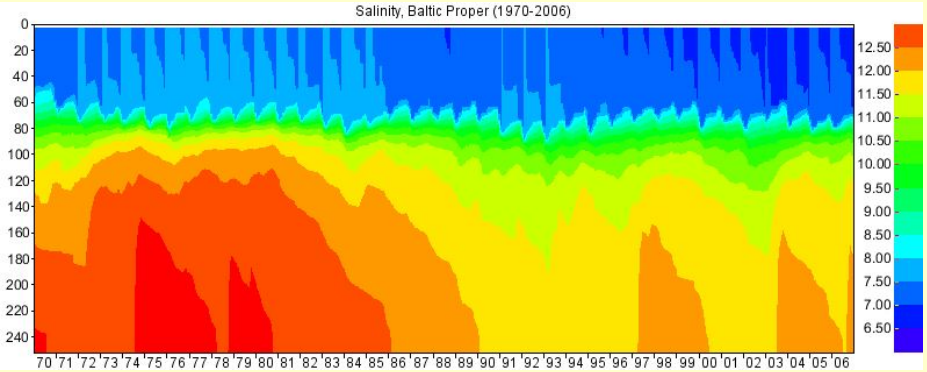
BALTSEM biogeochemical processes

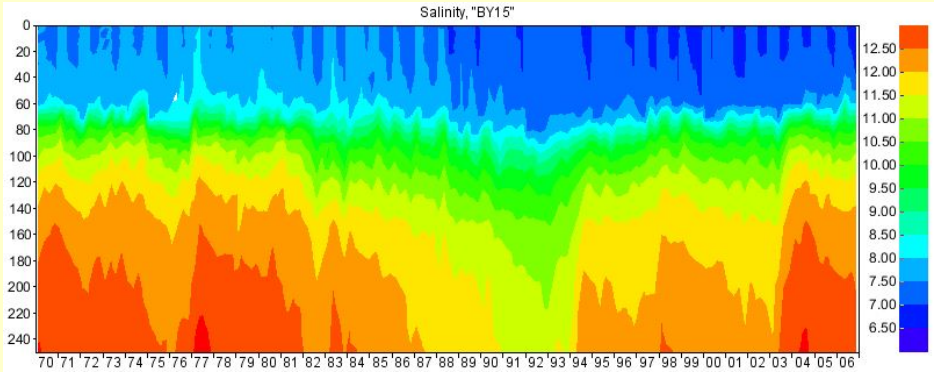


Long-term dynamics in the Gotland Sea (1970 – 2006)

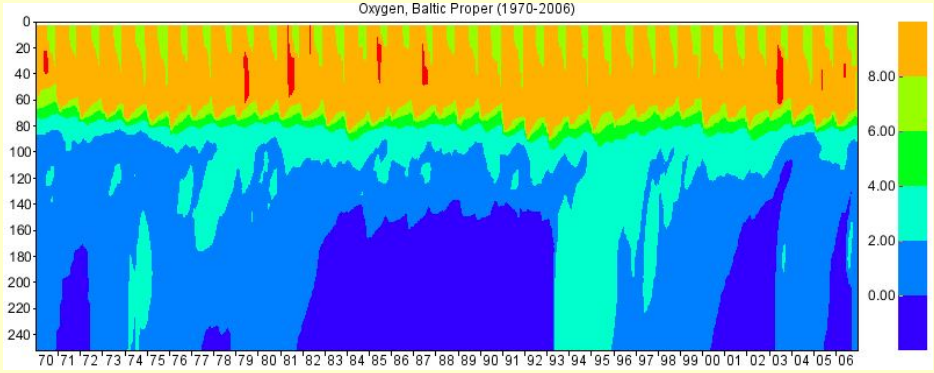
Simulation ***Observations***

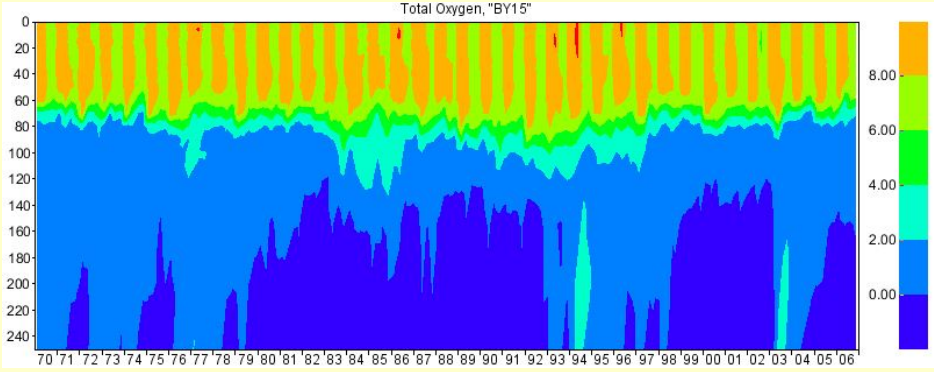
Salinity (psu)





Oxygen (mL/L)

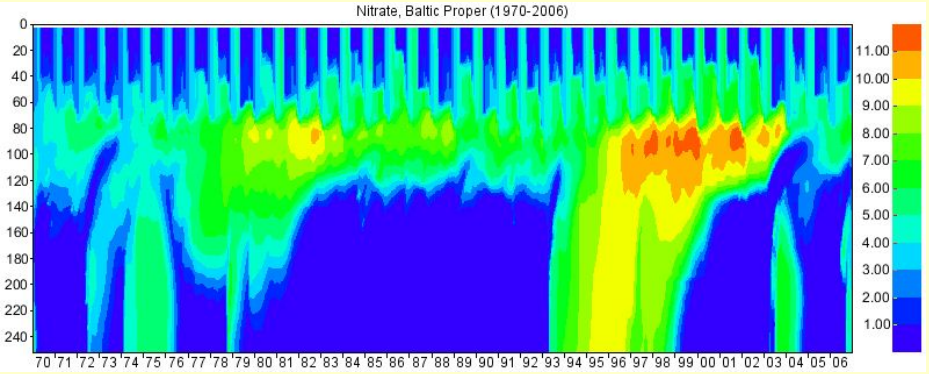


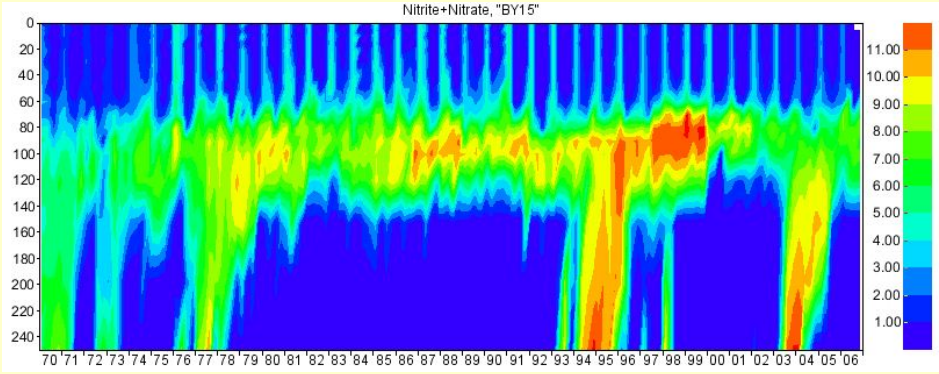


Long-term dynamics in the Gotland Sea (1970 – 2006)

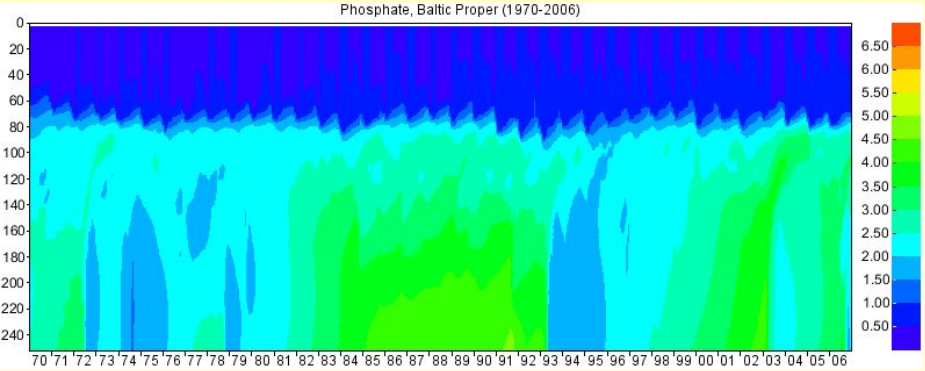
Simulation ***Observations***

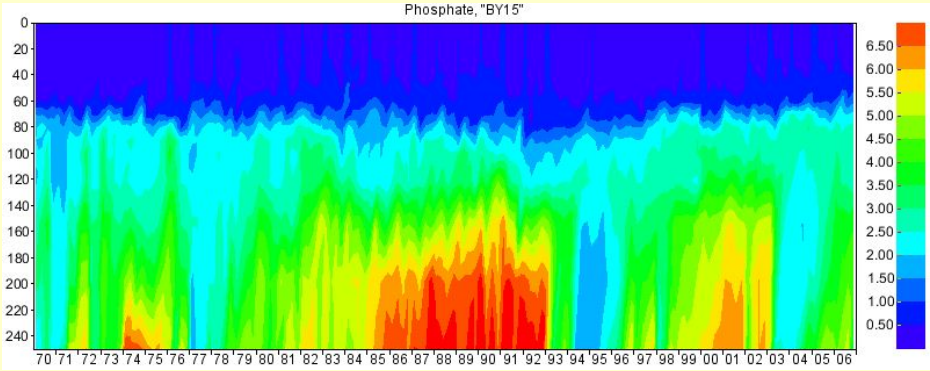
Nitrate (µM)





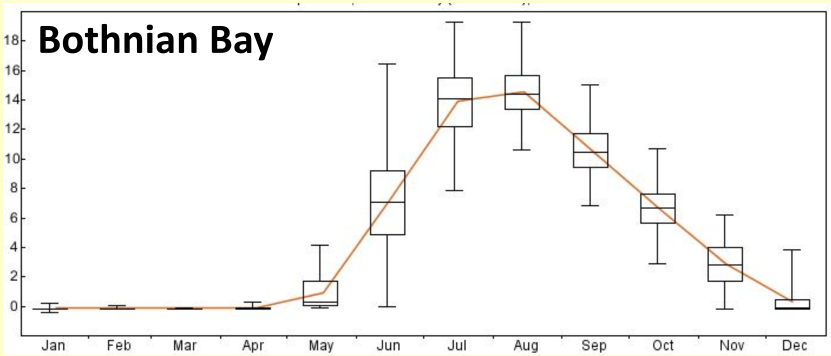
Phosphate (µM)

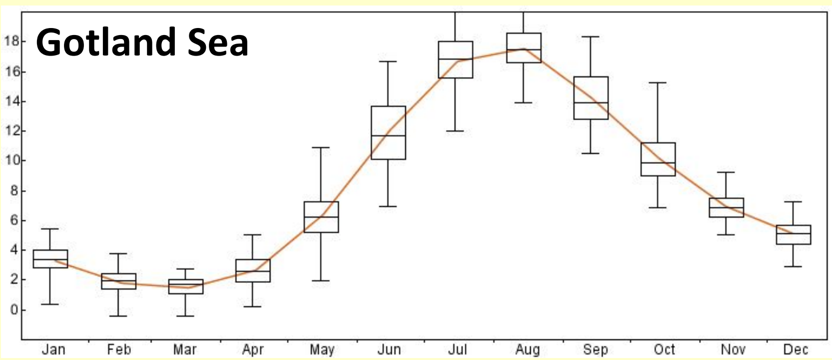


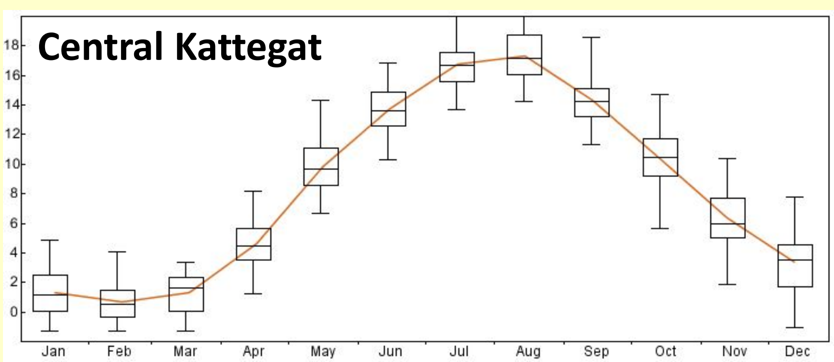


Meridional gradients of seasonal dynamics

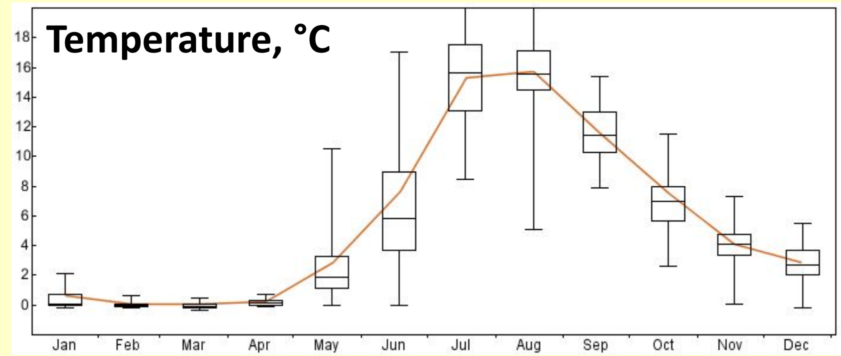
Simulation

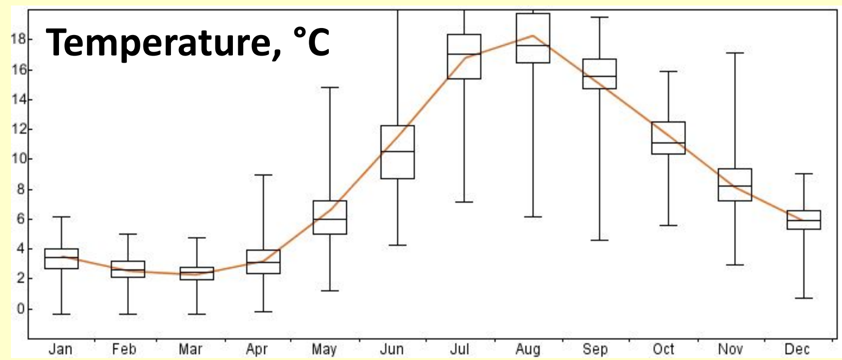


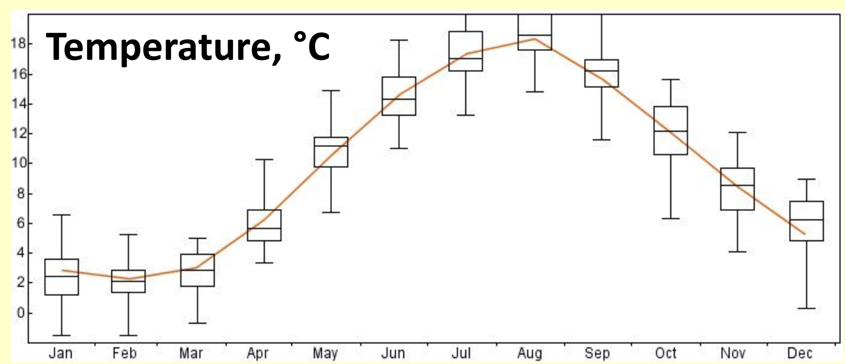




Observations







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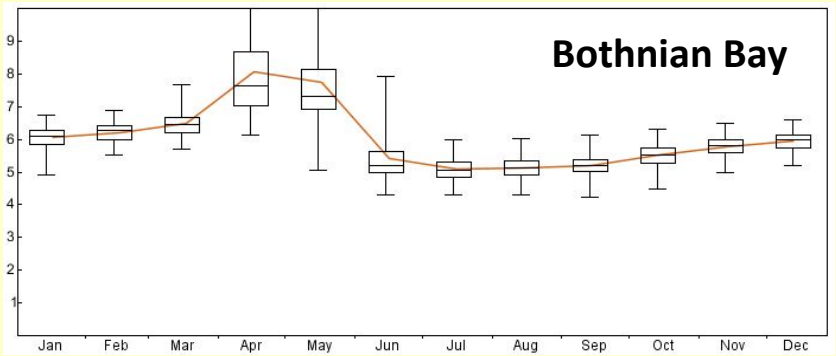

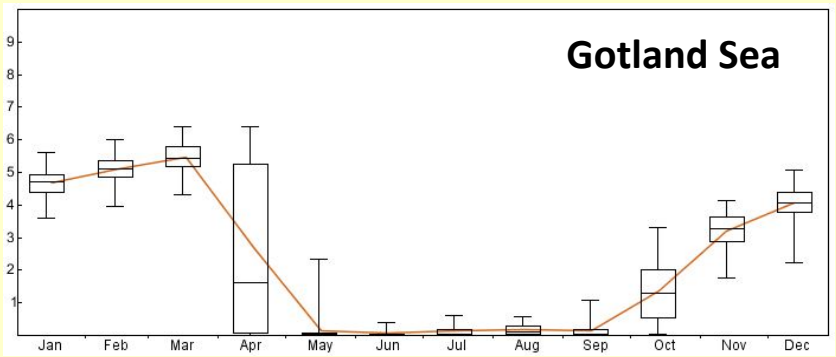

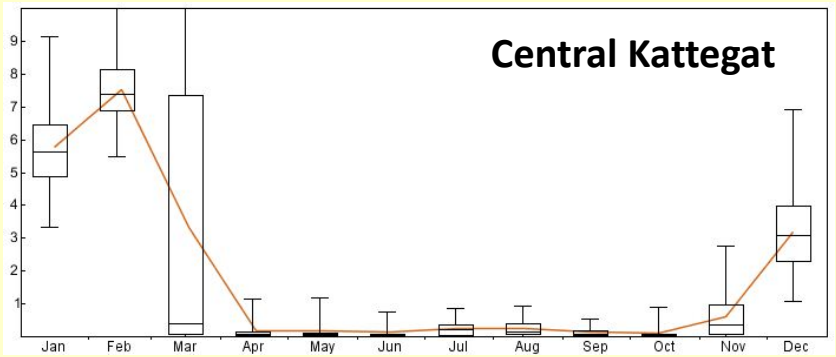

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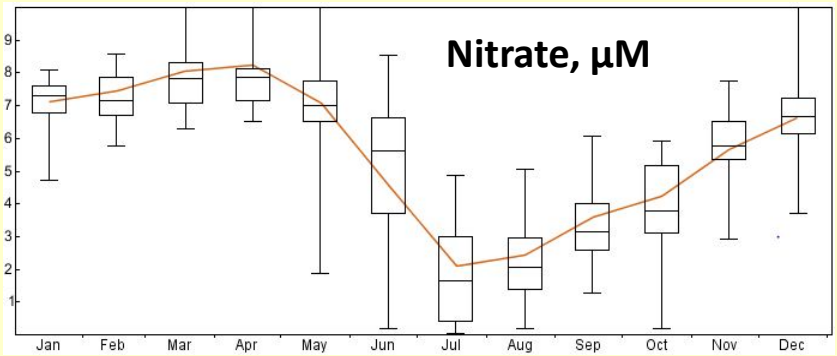
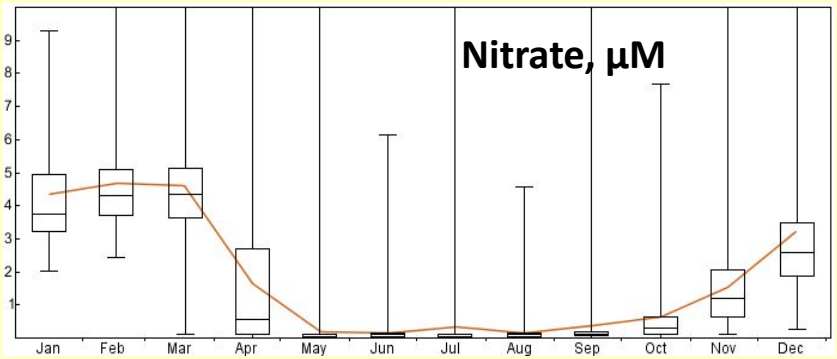
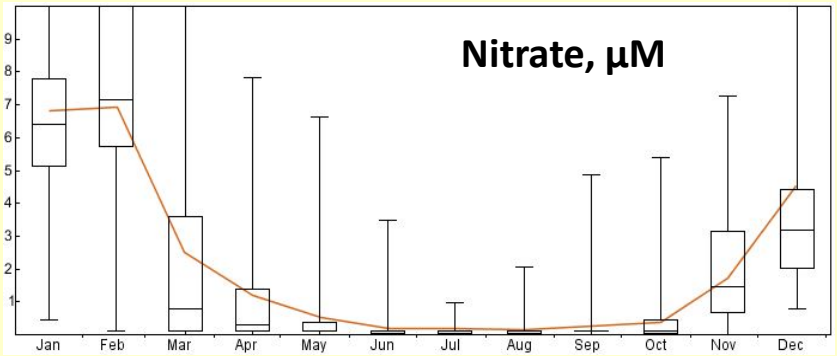
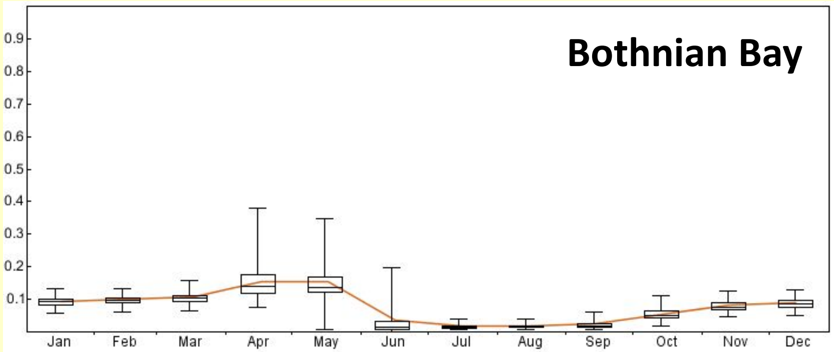


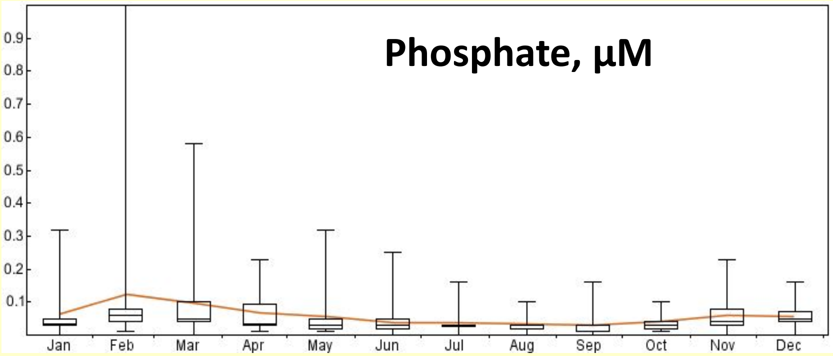


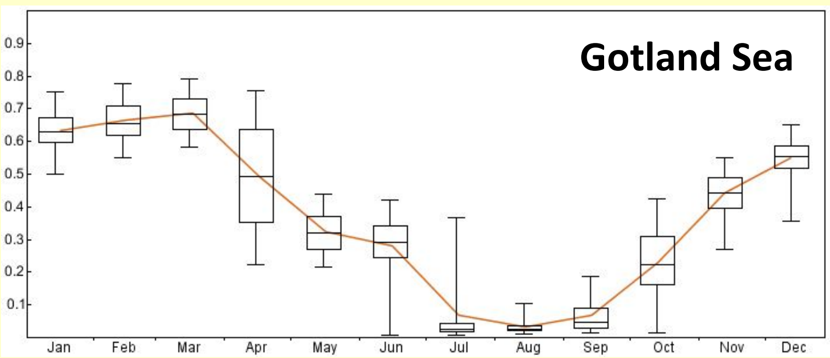


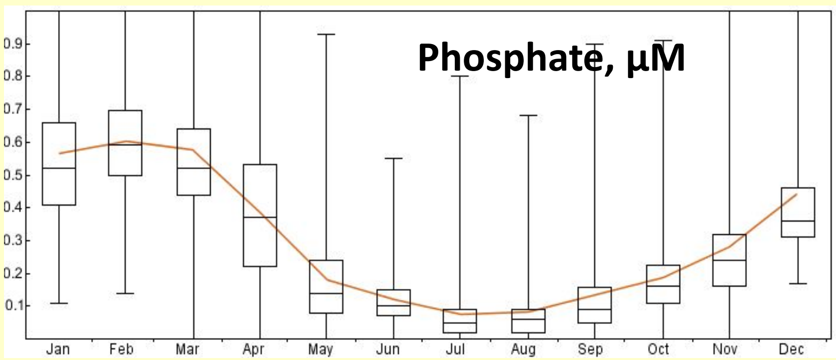
Meridional gradients of seasonal dynamics

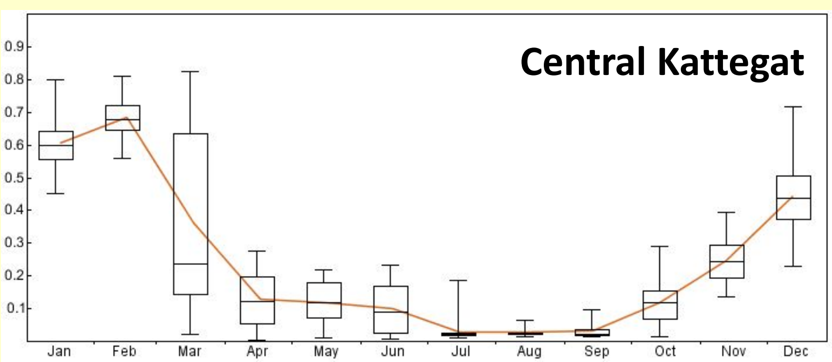
Simulation | *Observations*

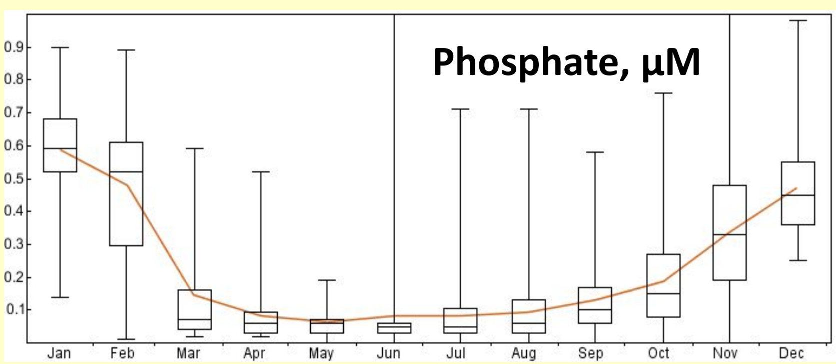












Quantitative comparison with a “cost function”

$$\omega = \frac{\sum \left| \left(C^i_{\mathrm{mod}} - C^i_{obs} \right) \right|}{N \times \mathrm{SD}_{\mathrm{obs}}};$$

C_{mod} – modelled concentration,
C_{obs} – observed concentration,
SD_{obs} – standard deviation of observations;
N – number of compared pairs *i*

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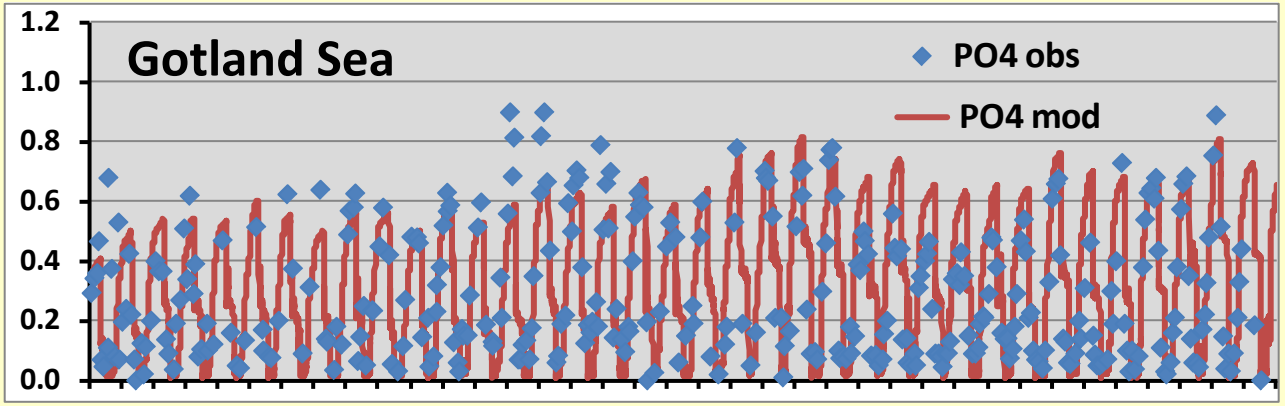
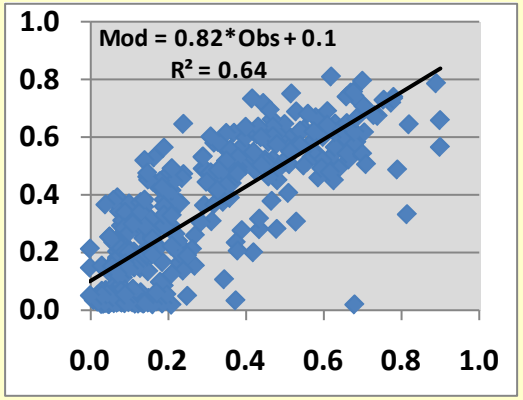
Daily simulated and monthly averaged observations



Monthly means



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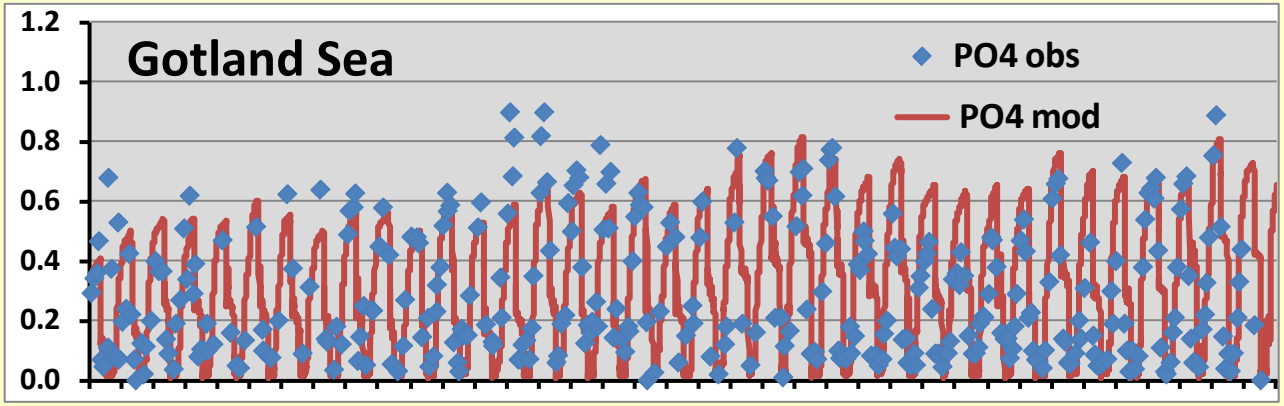

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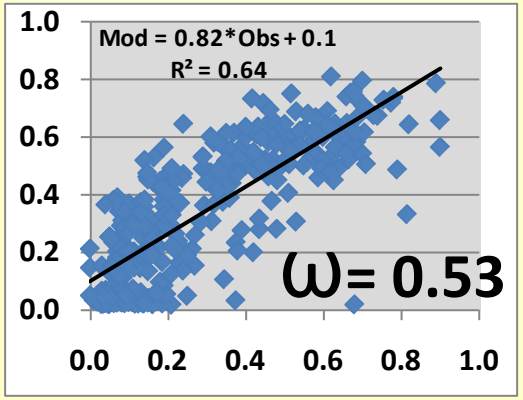

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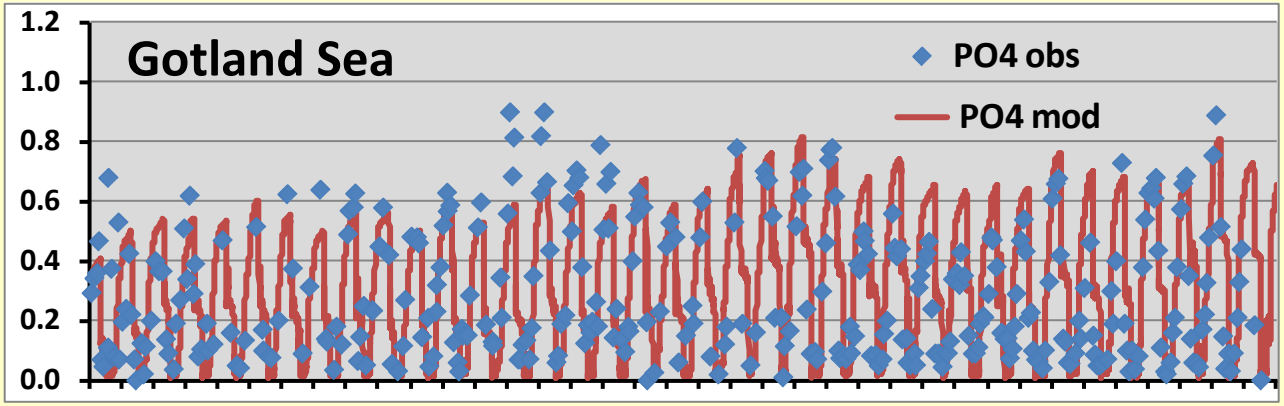
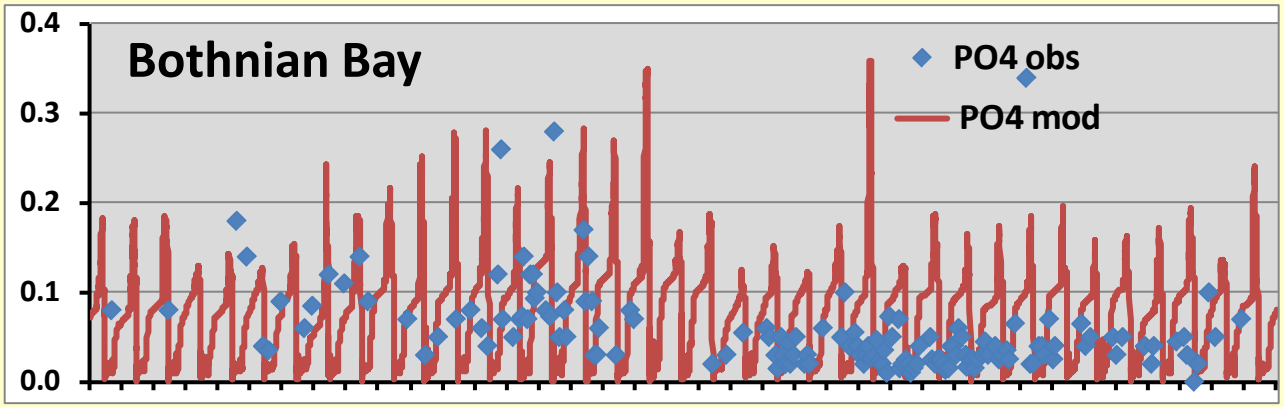
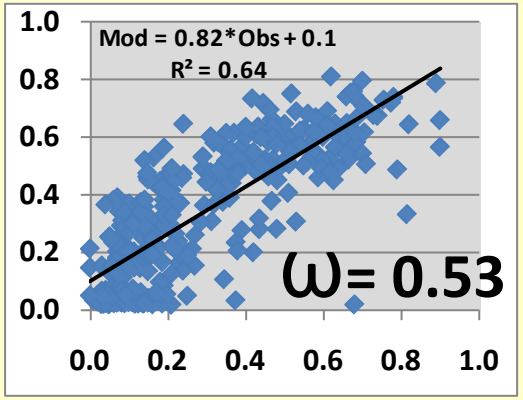
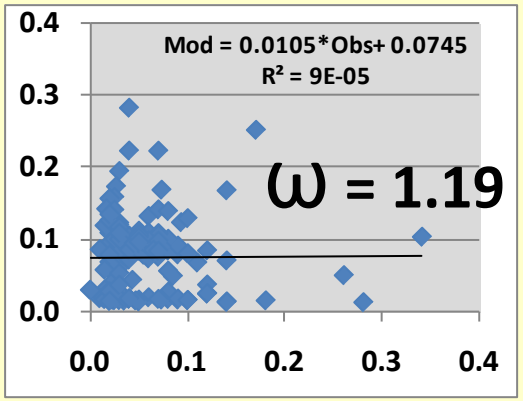
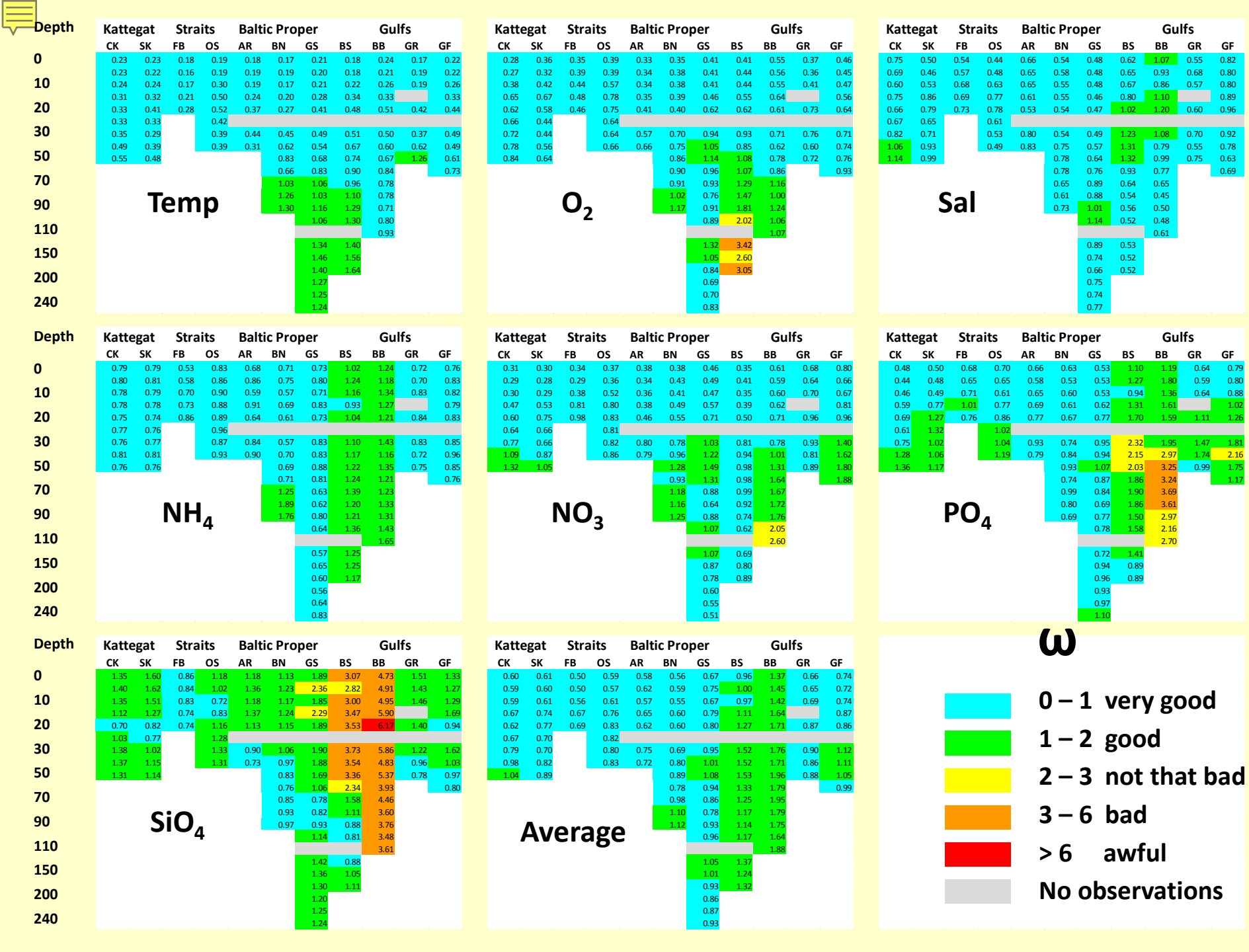




Monthly means



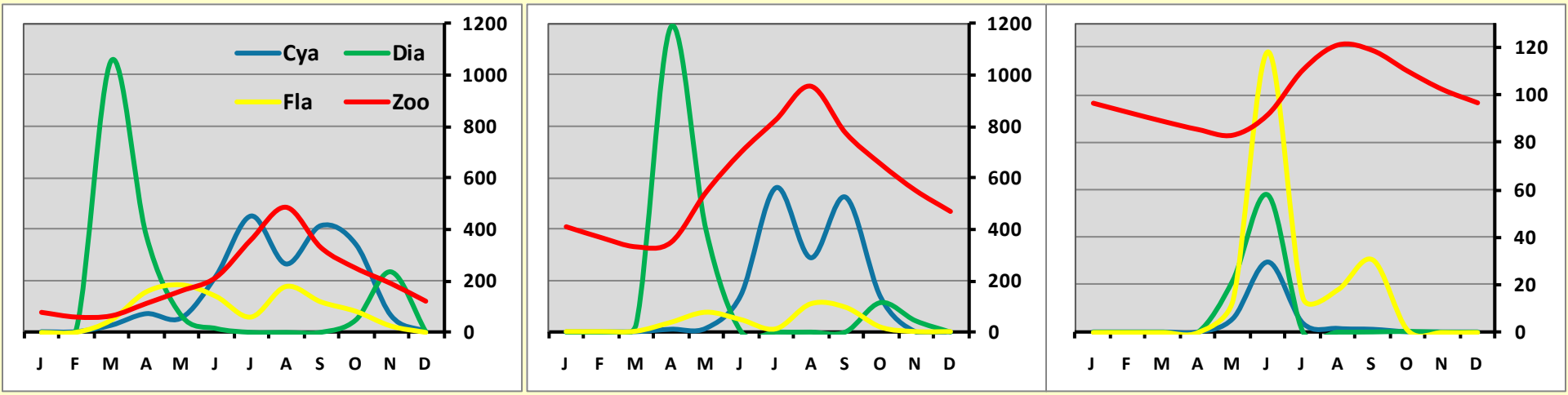



Depth
Kattegat Straits Baltic Proper Gulfs
CK SK FB OS AR BN GS BS BB GR GF
0
10
20
30
50
70
90
110
150
200
240
Temp
O2
Sal
NH4
NO3
PO4
SiO4
Average
ω
0 – 1 very good
1 – 2 good
2 – 3 not that bad
3 – 6 bad
> 6 awful
No observations

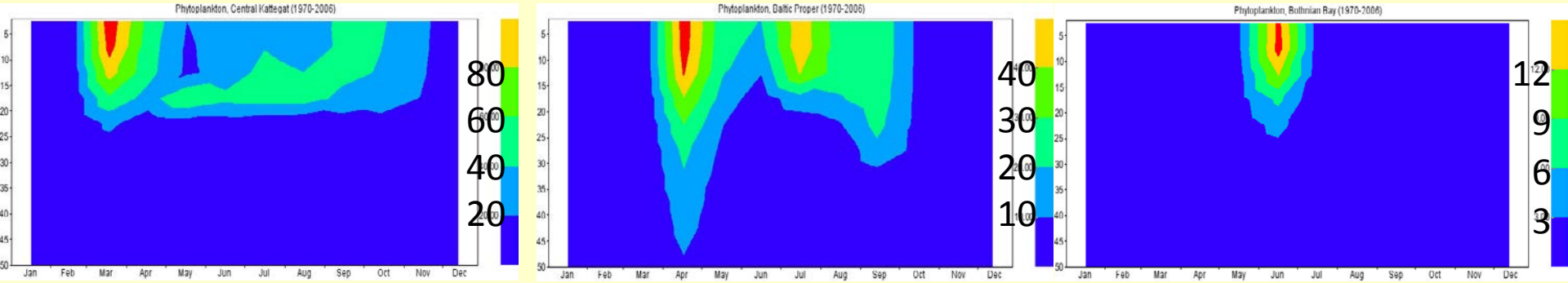
Seasonal dynamics of plankton variables

Long-term (1970-2006) monthly means,
Note different scales

Central Kattegat ***Gotland Sea*** ***Bothnian Bay***



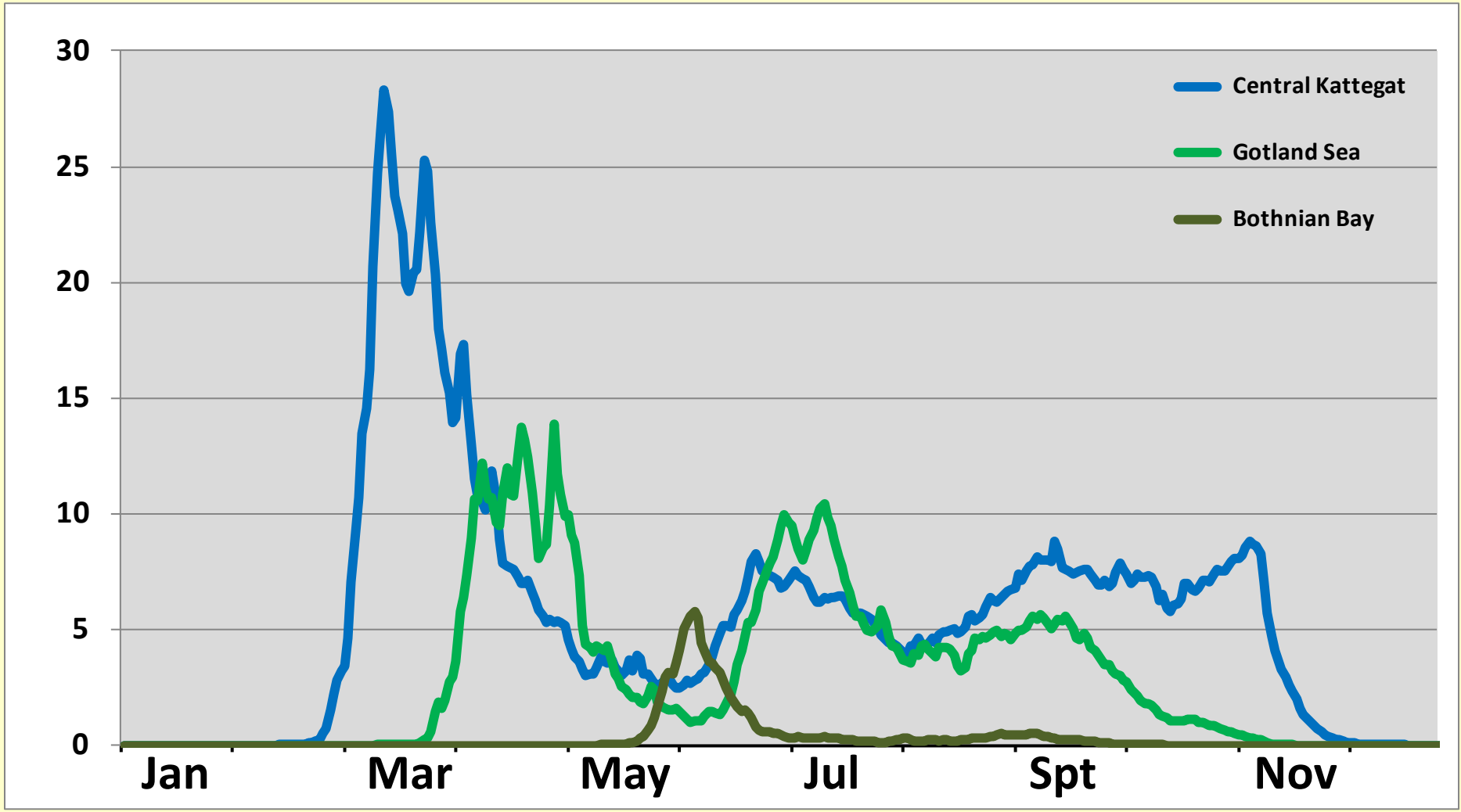
Vertically integrated plankton groups (mg C m^{-2})



Time-depth distribution of total phytoplankton (mg C m^{-3})

Seasonal dynamics of total phytoplankton

Long-term (1970-2006) surface daily means (mg N m^{-3})

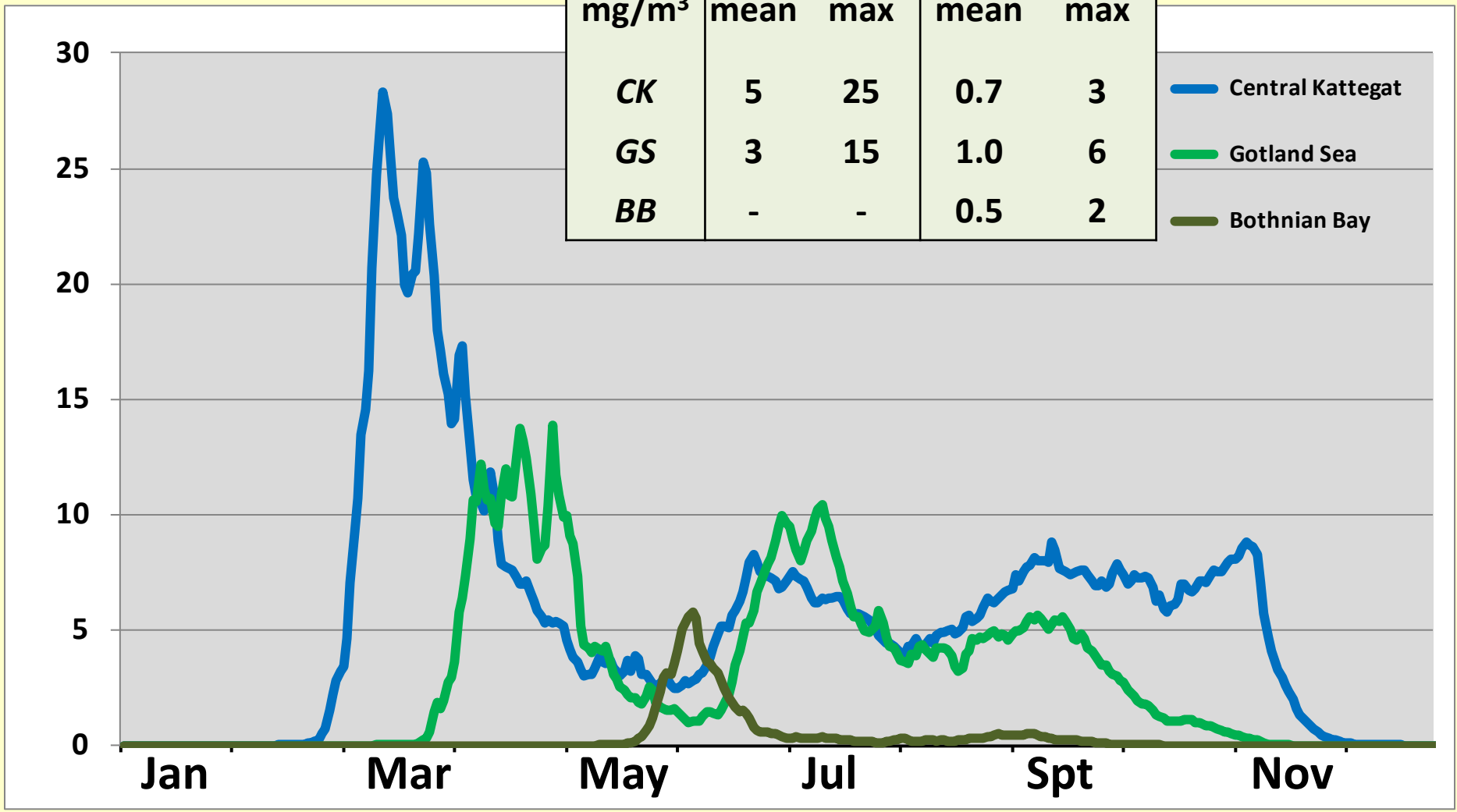


Seasonal dynamics of total phytoplankton

Long-term (1970-2006) surface daily means (mg N m^{-3})

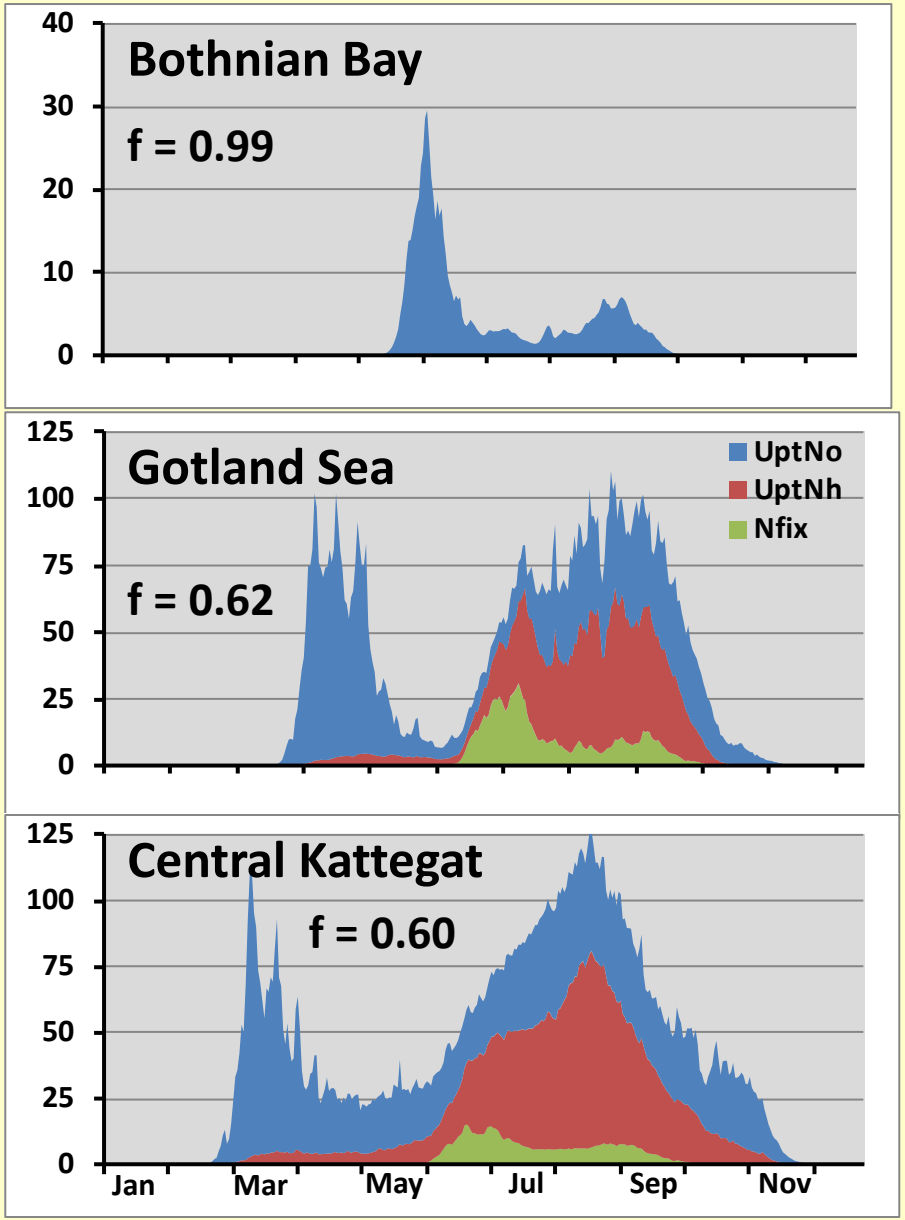
C:Chl"a"= 30 (spring) or 60 (summer)

Chl a	Spring		Summer	
mg/m^3	mean	max	mean	max
CK	5	25	0.7	3
GS	3	15	1.0	6
BB	-	-	0.5	2



Seasonal dynamics of nitrogen uptake

Long-term (1970-2006) daily mean water column integrals (mg N m^{-2})



Long-term (1970-2006) average budget

10^3 tonnes $year^{-1}$

Baltic Proper

	N fixation	Atm dep	Landload	
	296	198	291	
		3.4	23	
<= to DS	Uptake		Recycling	<= fr Gulfs
64	2757		2073	90
15	436		311	20
fr DS=>	Sinking		Output	to Gulfs=>
52	1053		331	58
12	138		114	17
		77		
	Burial	Denitrification		
	90	592		
	16			

Kattegat

	N fixation	Atm dep	Landload	
	22	27	52	
		0.3	2	
<= to Ska	Uptake		Recycling	<= fr DS
146	357		209	117
30	54		31	28
fr Ska =>	Sinking		Output	to DS =>
124	156		53	92
24	21		19	22
		0.0		
	Burial	Denitrification		
	11	91		
	2			

mg m^{-2} day^{-1}

	N fixation	Atm dep	Landload	
	3.6	2.4	3.5	
		0.04	0.28	
<= to DS	Uptake		Recycling	<= fr Gulfs
0.8	33		25	1.09
0.18	5.2		3.7	0.24
fr DS =>	Sinking		Output	to Gulfs=>
0.6	13		4	0.7
0.15	1.7		1.4	0.21
		0.9		
	Burial	Denitrification		
	1.1	7.1		
	0.19			

	N fixation	Atm dep	Landload	
	2.7	3.4	6.4	
		0.04	0.29	
<= to Ska	Uptake		Recycling	<= fr DS
18	44		25.7	14
3.7	6.7		3.8	3.4
fr Ska =>	Sinking		Output	to DS =>
15	19		6	11
3.0	2.6		2.3	2.7
		0.0		
	Burial	Denitrification		
	1.4	11.2		
	0.28			

Long-term (1970-2006) average budget of the entire Baltic

10^3 tonnes $year^{-1}$

	N fixation	Atm dep	Landload
	425	333	600
		6.2	50

<= to Ska	Uptake	Recycling
146.2	4614	3281
29.9	720	492
fr Ska =>	Sinking	Output
123.9	1873	626
24.0	250	205
	78	

Burial	Denitrification
156	1025
32	

mg m^{-2} day^{-1}

	N fixation	Atm dep	Landload
	2.8	2.2	4.0
		0.04	0.33

<= to Ska	Uptake	Recycling
1.0	31	21.7
0.2	4.8	3.3
fr Ska =>	Sinking	Output
0.8	12.4	4.1
0.2	1.7	1.4
	0.5	

Burial	Denitrification
1.0	6.8
0.2	

HELCOM's good intentions

(when science meets management, then politics beats science)

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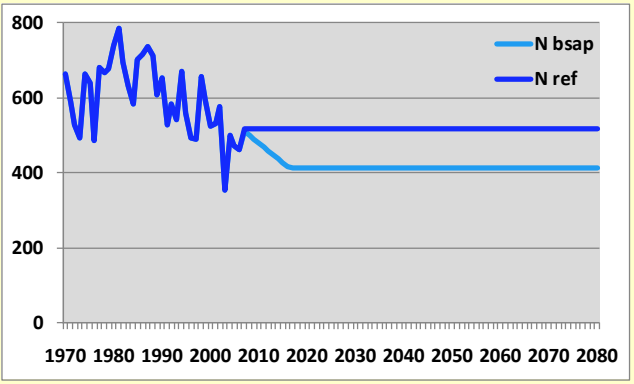
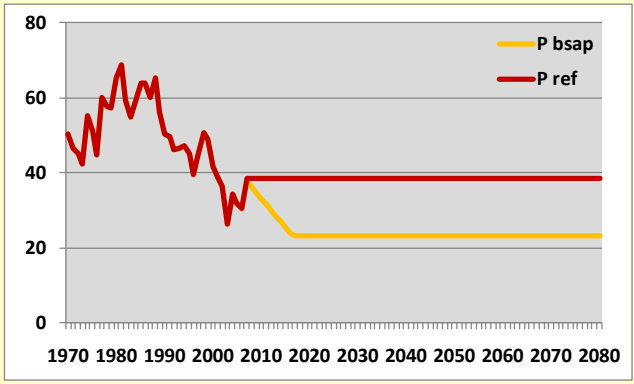
HELCOM's wishful thinking

(when science meets management, then politics beats science)

Nitrogen loads (Kt N/yr)



Phosphorus loads (Kt P/yr)



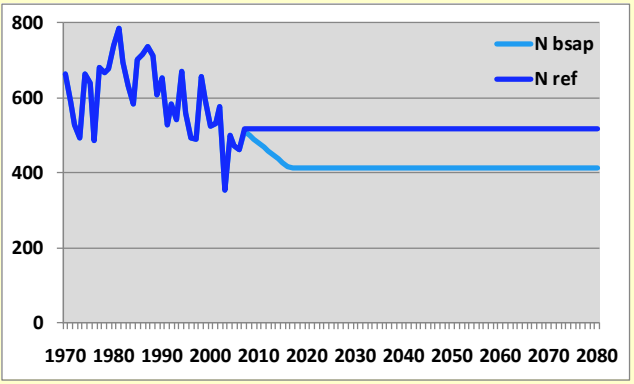
HELCOM's wishful thinking

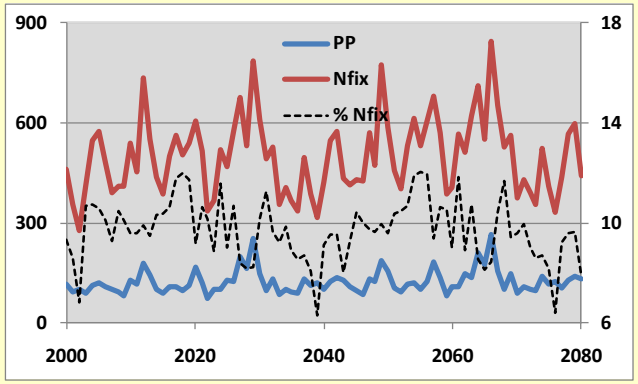
(when science meets management, then politics beats science)

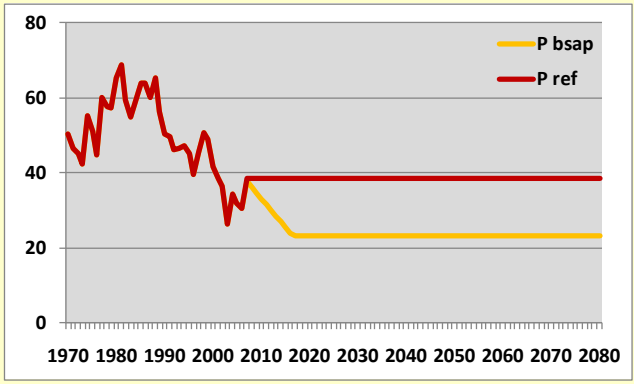
Nitrogen loads (Kt N/yr)

Reference dynamics, Baltic Proper
net primary production (PP,gC/m2/yr),
nitrogen fixation (Nfix, Kt/yr)
direct contribution of Nfix in PP (%)

Phosphorus loads (Kt P/yr)







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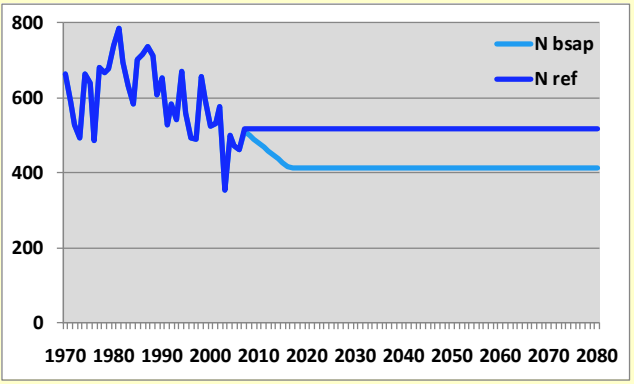
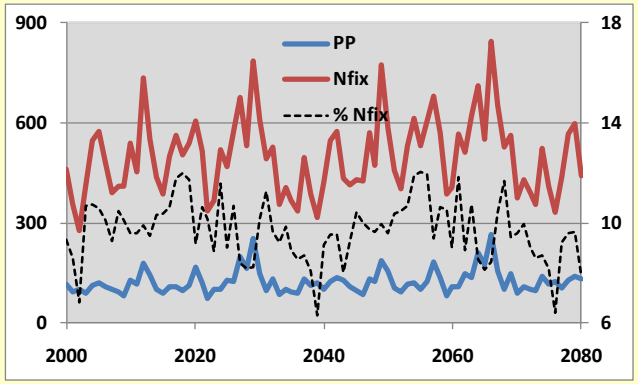
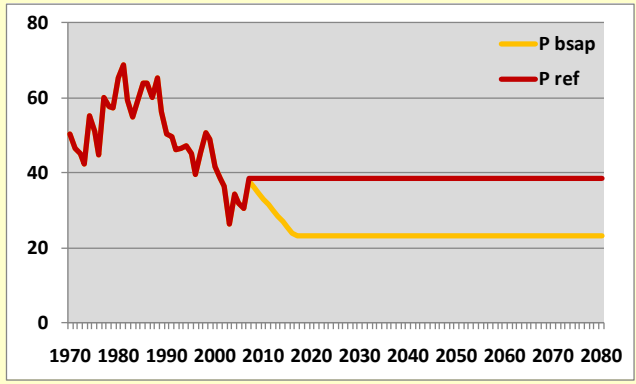
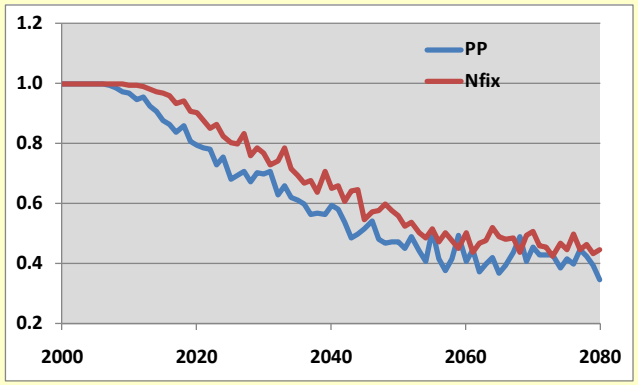






Both N & P reduction



HELCOM's wishful thinking

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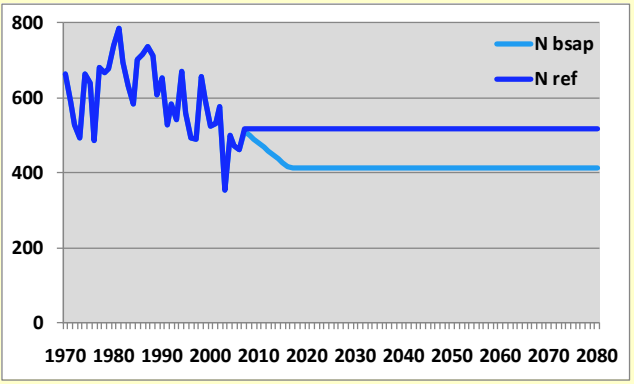
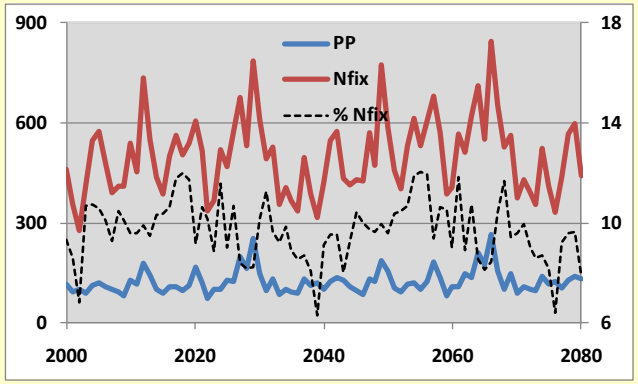
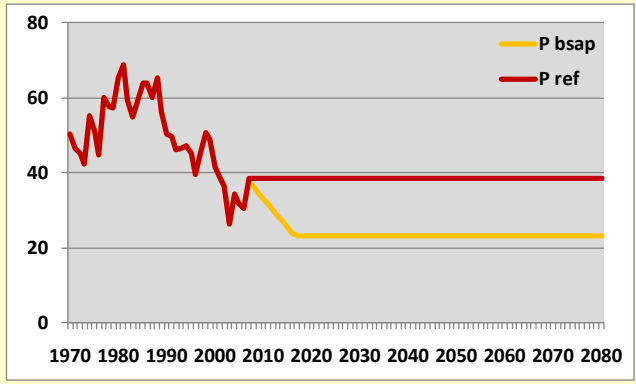
Nitrogen loads (Kt N/yr)

Reference dynamics, Baltic Proper
net primary production (PP,gC/m2/yr),
nitrogen fixation (Nfix, Kt/yr)
direct contribution of Nfix in PP (%)

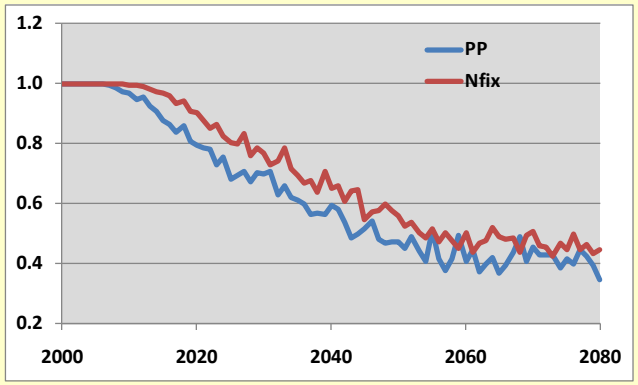
Phosphorus loads (Kt P/yr)



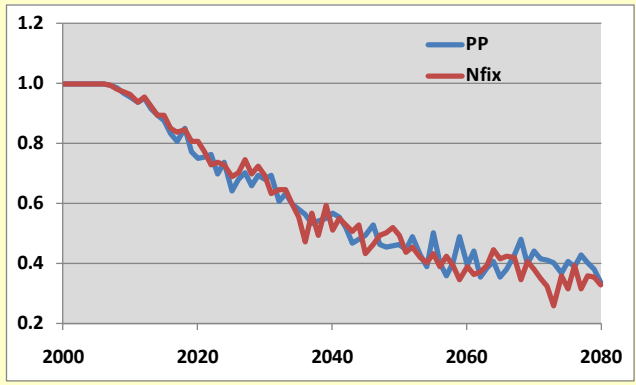




Both N & P reduction



Only P reduction



HELCOM's wishful thinking

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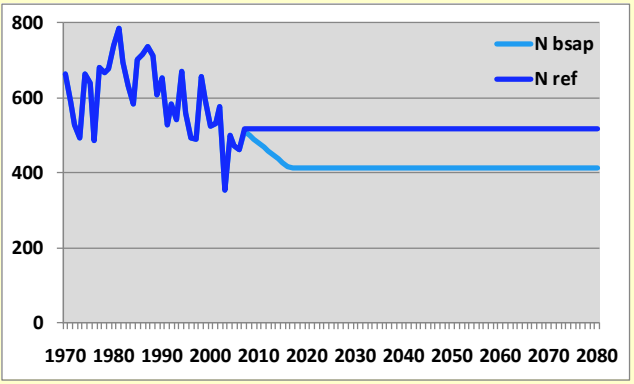
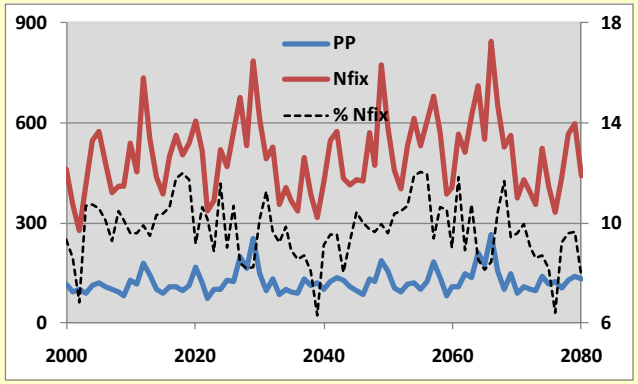
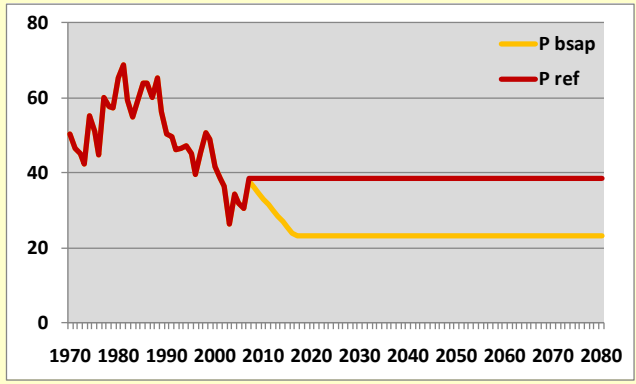
Nitrogen loads (Kt N/yr)

Reference dynamics, Baltic Proper
net primary production (PP,gC/m2/yr),
nitrogen fixation (Nfix, Kt/yr)
direct contribution of Nfix in PP (%)

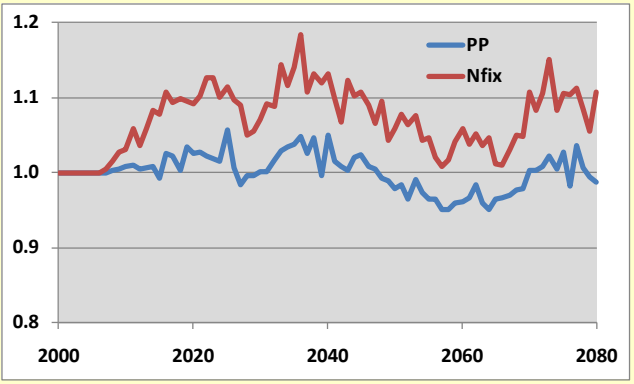
Phosphorus loads (Kt P/yr)



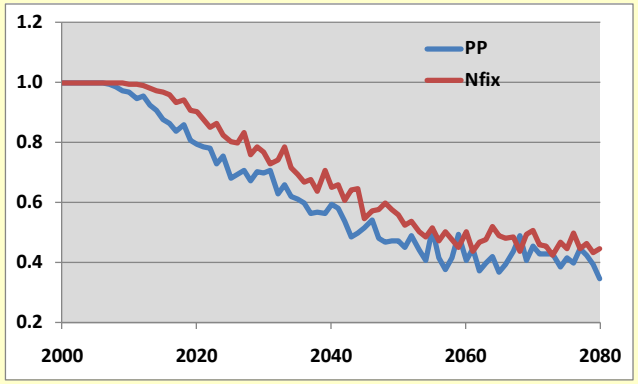




Only N reduction



Both N & P reduction



Only P reduction