Effect of increasing load of allochtonous organic carbon and inorganic nutrients on a marine food web.

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Baltic Sea

Karta: SMHI

Large river inflow of dissolved organic carbon (DOC)

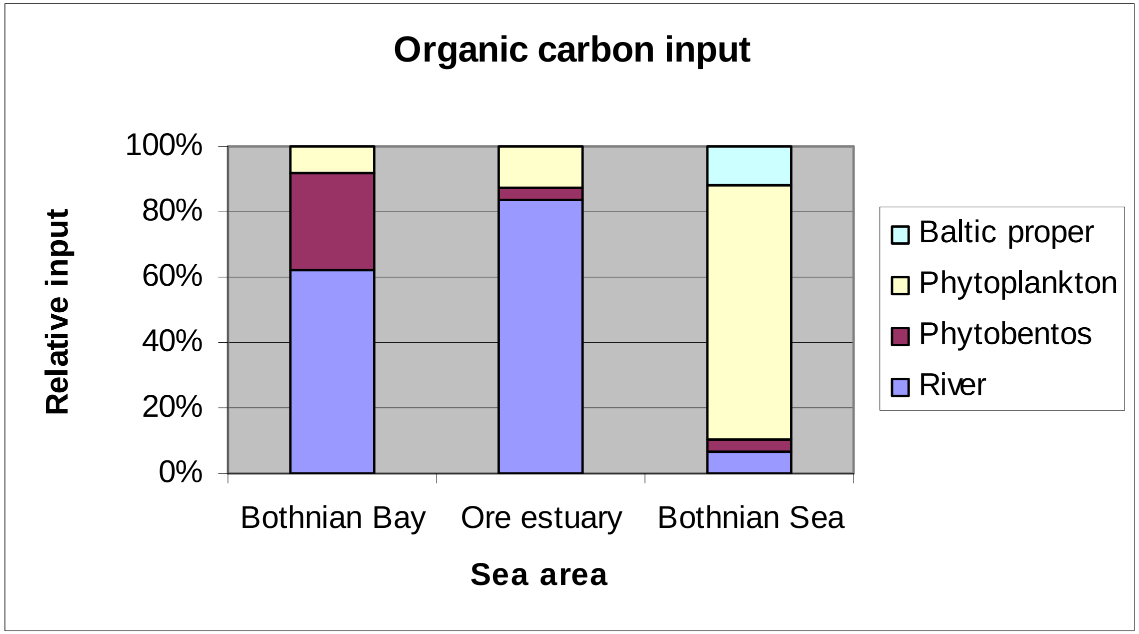
Elmgren (1984): Phytoplankton production constitute the base of the food web in the Baltic proper.

River carbon	(mmol C dm^{-2} yr^{-1})
Bothnian Bay	18
Ore estuary	208
Bothnian Sea	7.7

Sandberg et al. 2004. Terrigegous carbon constitute the base in the northern Baltic sea.

Andersson et al. 1996

Relative input of dissolved organic carbon (DOC) and photosynthetically fixed carbon to the Gulf of Bothnia



River input dominates in the north and in coastal areas.

Phytoplankton input dominates in the south.

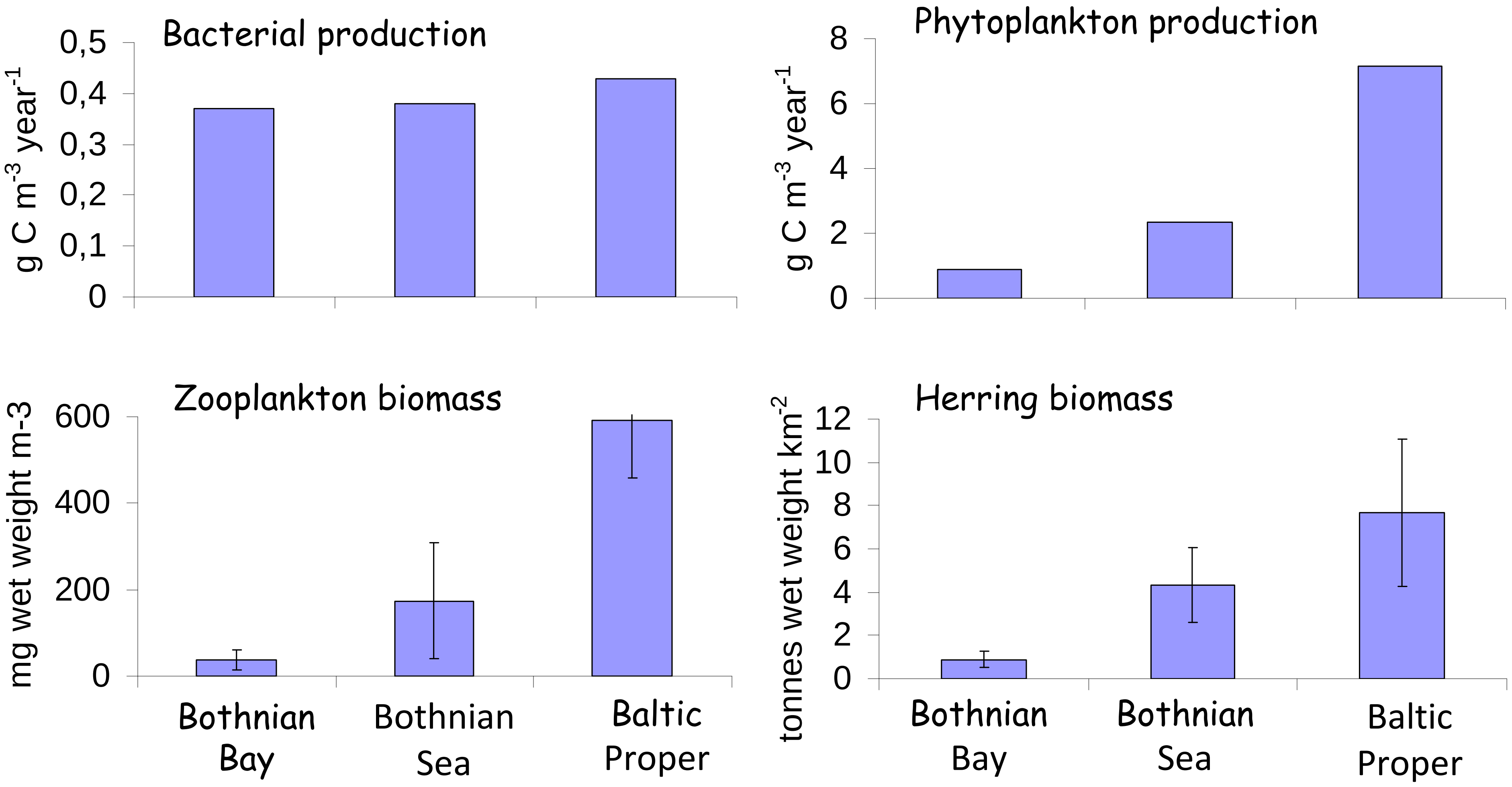
Sandberg et al. 2004

Field data off-shore stations:

Annual average	Bothnian Bay	Bothnian Sea	Baltic Proper
Temperature (°C)	5.05	6.60	9.28
Salinity (‰)	3.03	5.18	6.52
Carbon fixation /Respiration	0.5	0.97	?
TDOC[d] (mol C m^{-2} yr^{-1})	1.8	0.8	?
Primary Production PP (mol C m^{-2} y^{-1})	1.5	3.9	14.3
Bacterial Production BP (mol C m^{-2} y^{-1})	1.01	1.5	0.7
PP : BP	**57:43**	**74:26**	**95:5**

Samuelsson et al. 2006

Differences in basins…



Data from UMSC monitoring program 1993-2003; Larsson & Hagström 1982; Elmgren 1989; Flinkman et al. 1998; Johansson et al. 2004, ICES herring statistics

Båmstedt et al. in prep

Climate change

- Is predicted to cause increased precipitation in northern Europe.
- → Increased river inflow to the Baltic Sea.

  → Darker water in the coastal areas

  → Increased concentration of DOC

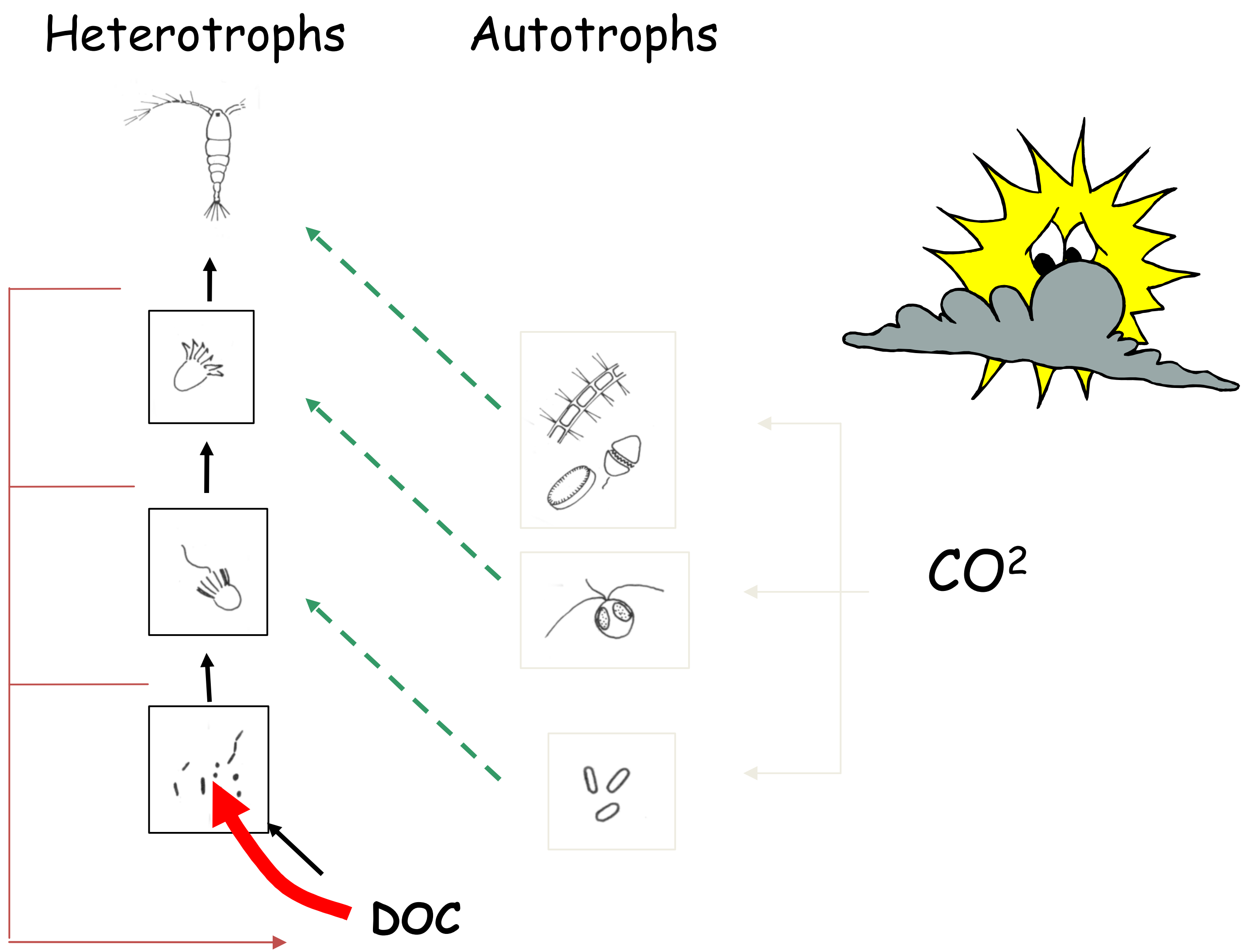
  → Changed concentrations of inorganic nutrients.

Growth of heterotrophic bacteria may be promoted/unaffected while growth of autotrophic phytoplankton may be hindered due to increased light limitation.

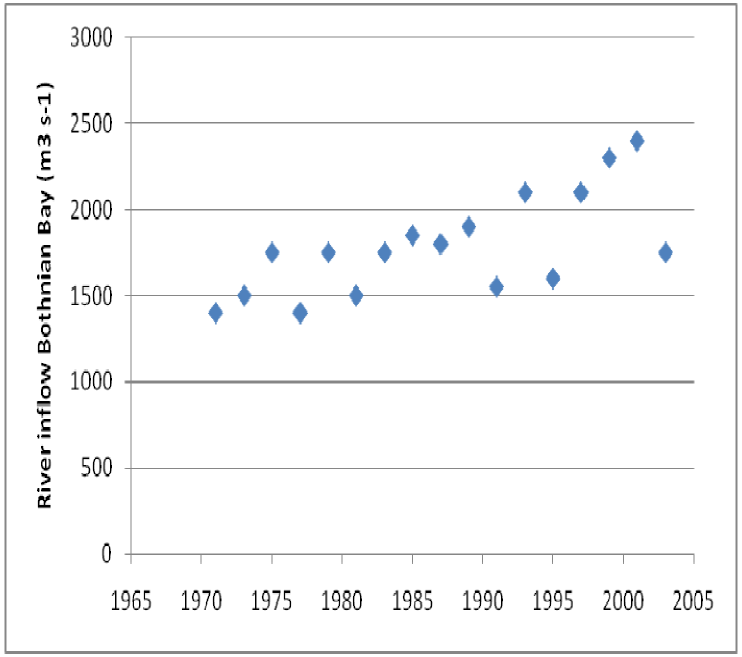
The aquatic ecosystem in some areas may change from being phytoplankton based to being bacteria based.

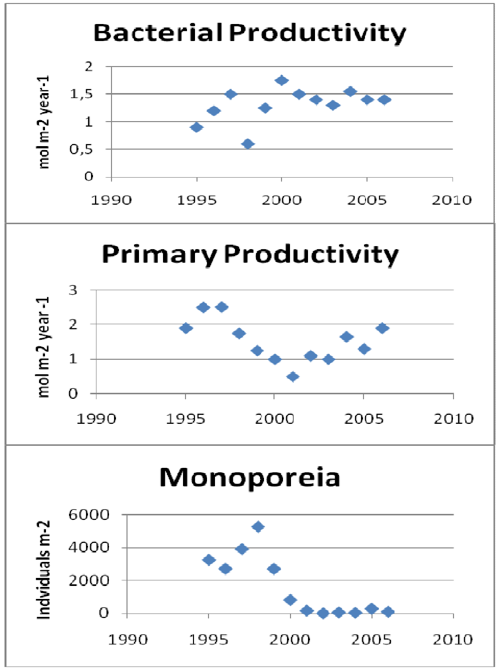
AUTOTROPHY → HETEROTROPHY

Climate-change scenario



Any sign of changes in the Gulf of Bothnia?





In northern Sweden precipitation has increased 30% during the last 15 years. (Source SMHI)

Peaks of river inflow at the end of the 90's.

Phytoplankton primary production decreased 98-01

Bacterial production unaffected

Benthic fauna Monoporeia decreased drastically, >80% of the variation explained by changes in primary productivity.

Wikner and Andersson manuscript

Hypotheses:

Increased river inflow will increase inflow of C, N, P.
C is brown.
What does this mean to the productivity and pelagic food web function?

Will the productivity increase or decrease?

Traditionally increased flooding is assumed to cause increase productivity and eutrophication.

However some studies indicate that if C is imported concomittantly with N and P, then bacterial growth is promoted and phytoplankton are disfavoured.

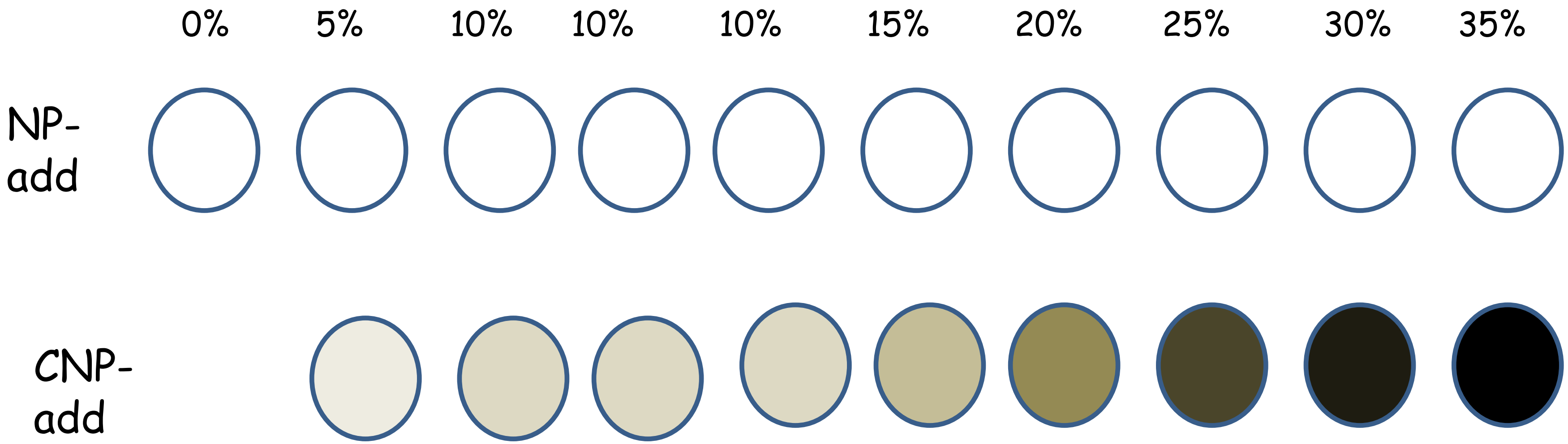
Blomqvist et al. 2001. Microb Ecol.
Thingstad etal . 2008. Nature

Average Tot C/N/P stoichiometry in the Baltic Sea (molar ratio off-shore stations surface water)

	C	**N**	**P**
Rivers entering the Gulf of Bothnia:	1293	62	1
Bothnian Bay	68	53	1
Bothnian Sea	27	19	1
Baltic Proper	17	15	1

Experimental set-up:

Indoor mesocosms 500 L, 15C, light 12 h d-1, 1 month



C/N/P ratio in additions: 330/16/1

Similar to rivers in the northern Baltic Sea.

DOC: Humic acid (Fluka 53680)

Similar carbon content as isolated DOC from the Öre river.

Bacteria did grow with the same growth rate on both carbon substrates.

Rel. Add.	Humic acid C umol L-1 d-1	DIN umol L-1 d-1	DIP umol L-1 d-1
0	12,61	0,61	0,04
10	25,55	1,23	0,08
15	38,33	1,85	0,12
20	51,10	2,46	0,15
25	63,71	3,07	0,19
30	76,66	3,70	0,23
35	89,26	4,30	0,27

Brackish seawater, northern Baltic Sea

Metazooplankton
Copepod (*Eurytemora affinis*)

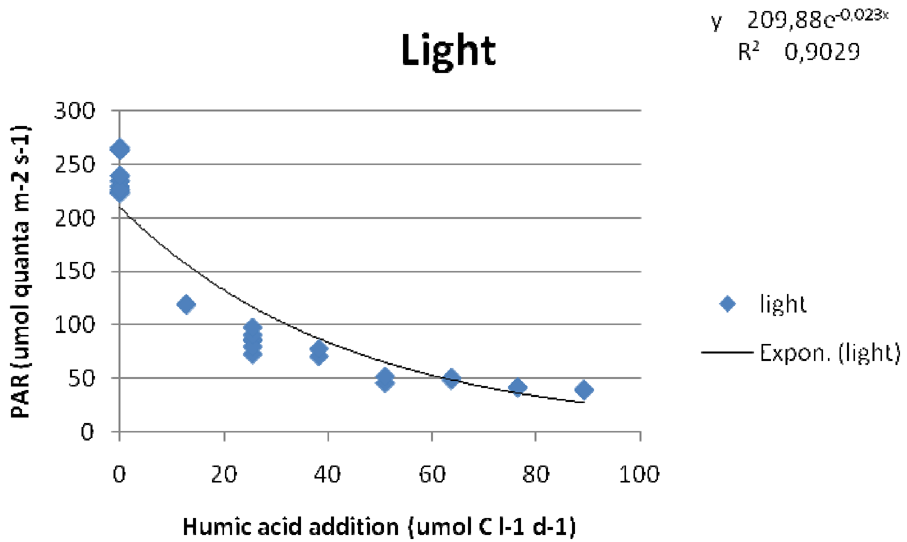
Ciliates
e.g. *Strobilidium* spp

Heterotrophic nanoflagellates
e.g. *Paraphysomonas* spp.

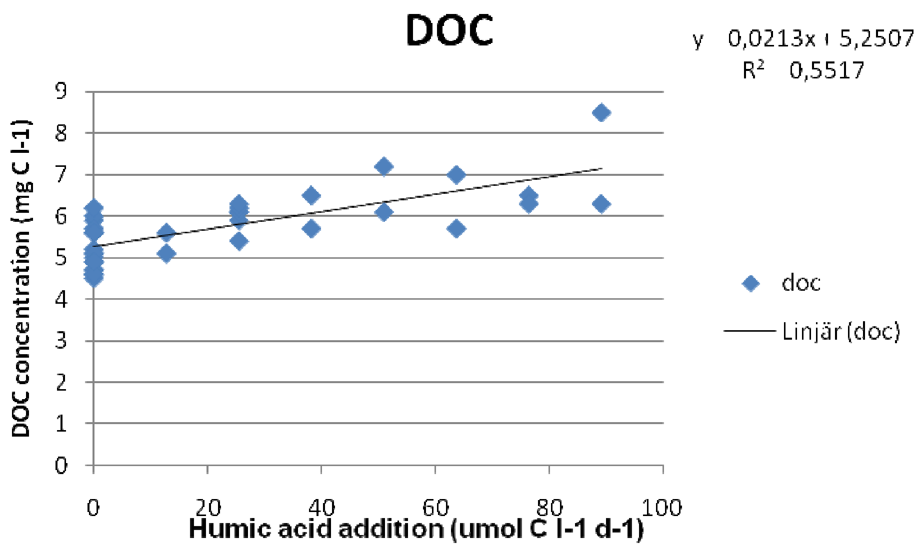
Phytoplankton
Autotrophic, mixotrophic

Bacteria
Heterotrophic

Average light showed an exponential decrease with increasing humic acid addition



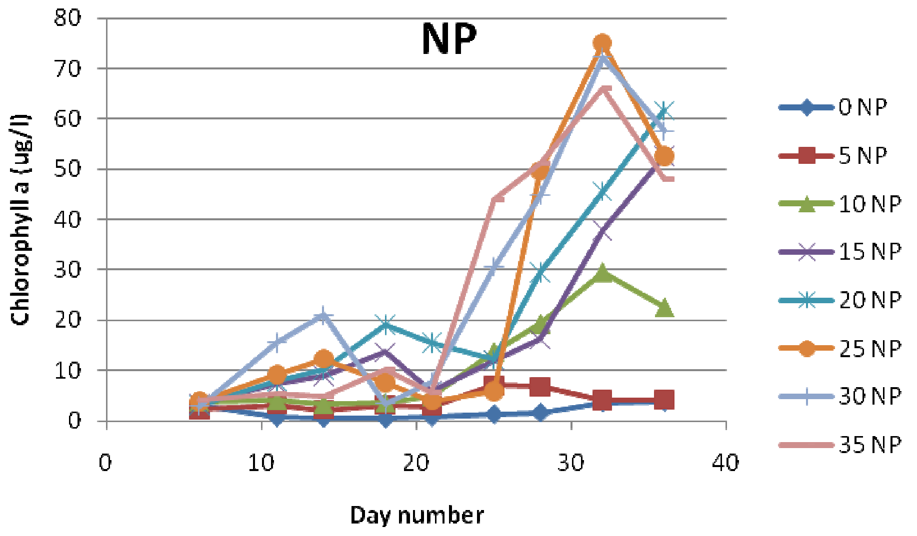
DOC increased with increasing humic acid addition, but not in proportion to the addition.

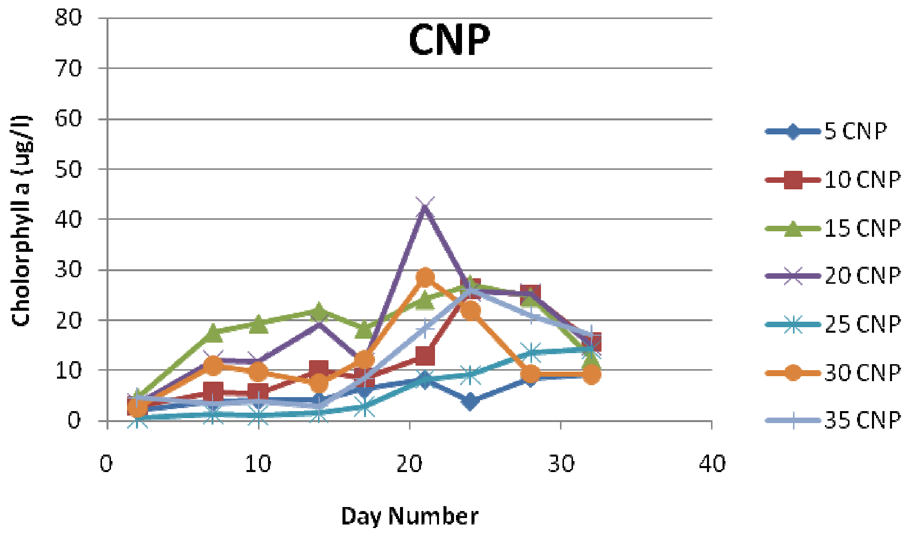


Chlorophyll a (phytoplankton biomass) was higher in the light treatments (NP) than in the humic acid treatments (CNP).

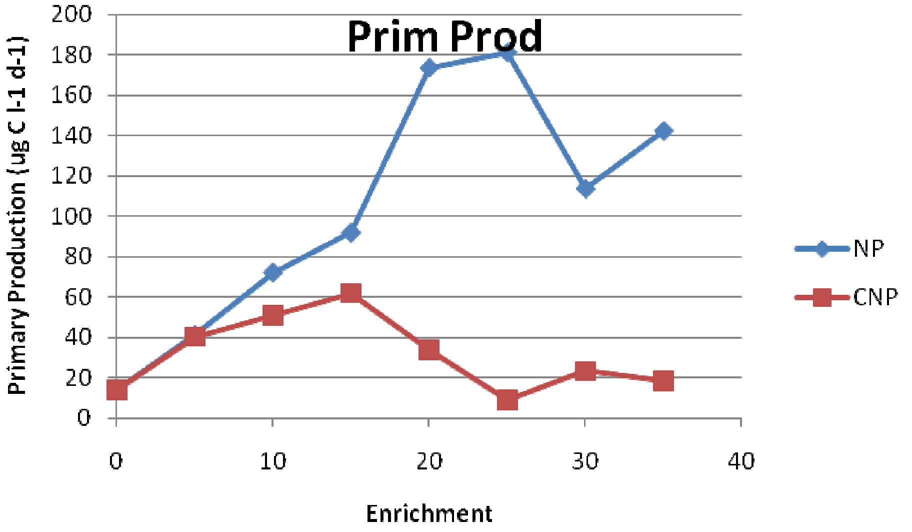
Chla increased consequtively with increasing NP enrichment in the light treatments.

Chla was highest in the intermediated enrichments in the CNP treatments.

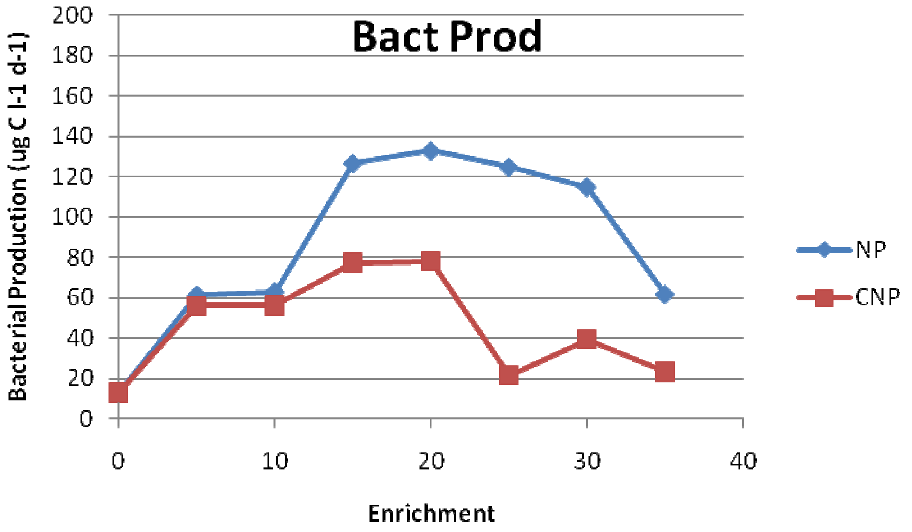




Primary production increased with enrichment in the NP but not in the CNP treatment.

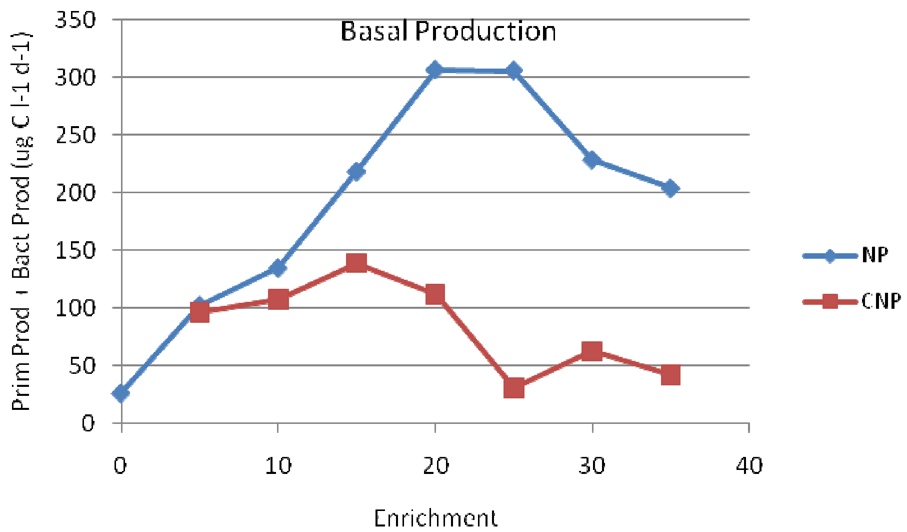


Bacterial Production seemed to follow the primary production.



Enrichment led to 10 times higher production of the basal trophic level in the NP treatments.

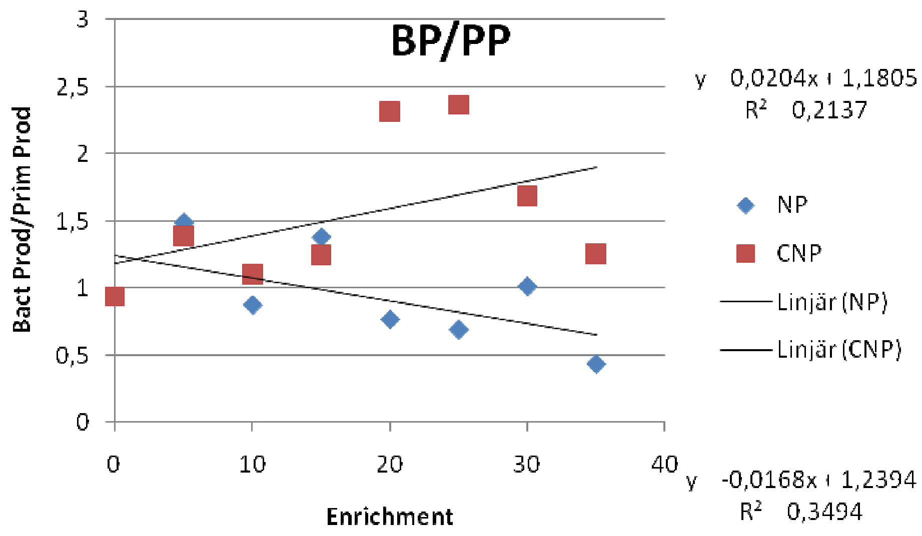
Enrichment led to decreased production ofthe basal trophic level in the CNP treatments.



Basal trophic level = Phytoplankton + Bacteria

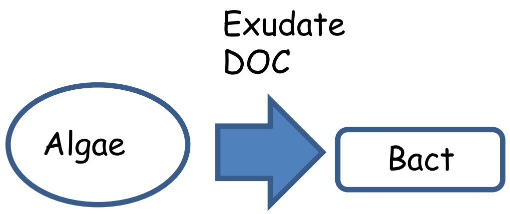
Hypothesis:
Increased river inflow , e.g. due to climate change may cause decreased production in the northern Baltic Sea (Gulf of Bothnia).

Bacterial production to primary production ratio increased with enrichment in the CNP treatment, while it decreased in the NP treatment.



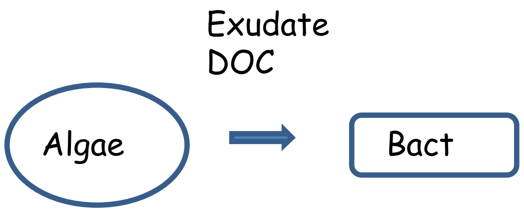
CNP treatments indicated some use of humic acids.

Low NP



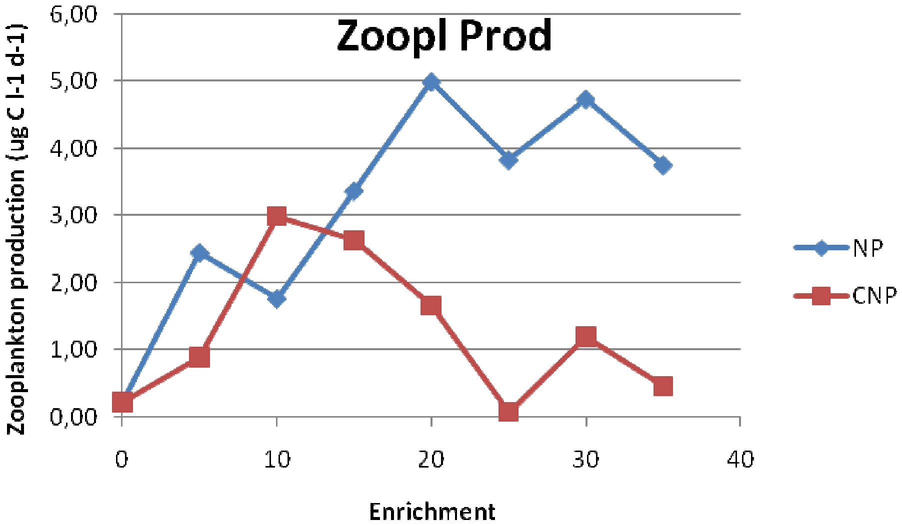
High BP/PP

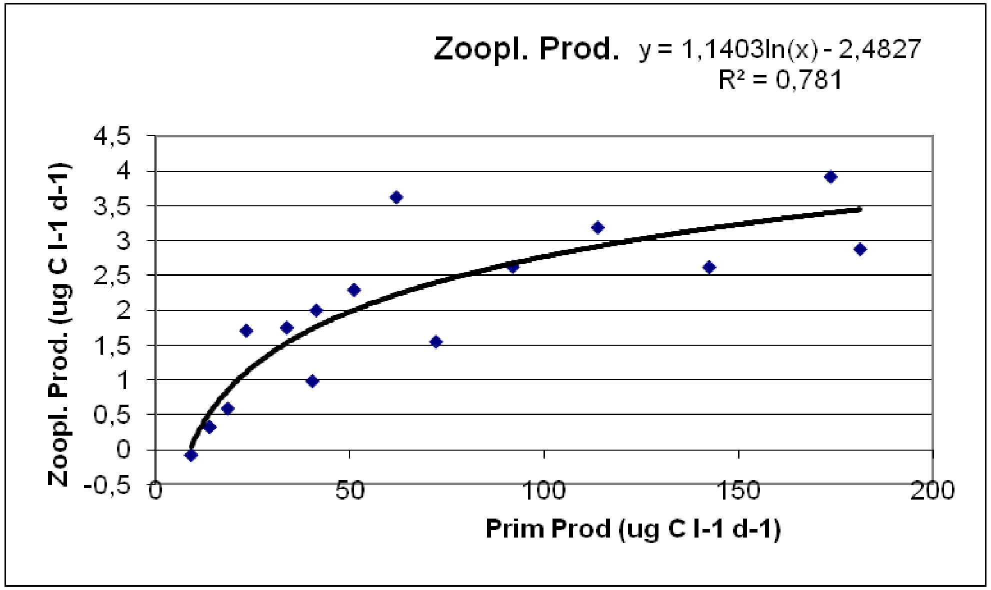
High NP



Low BP/PP

Zooplankton production followed the primary production.





Conclusions:

Our data supported the hypothesis that increasing load of C, N and P decrease phytoplankton productivity.

Food web structure changed: Bacterial production became more important than phytoplankton primary production in the humic acid additions. Change to heterotrophy.

Hypotheses:

Likely that climate change in the northern Baltic Sea will:

Decrease phytoplankton primary productivity due to increased precipitation and increased inflow of C together with N and P.

Increased heterotrophy

More of the carbon will be chanelled via the microbial food web which in turn means more losses of carbon (due to more trophic levels). This will decrease productivity at higher trophic levels such as fish.

Climate change → oligotrophication in the northern Baltic Sea.