Northern Baltic Sea phytoplankton communities at the beginning and end of the 20th century – a comparison of historical and modern species data

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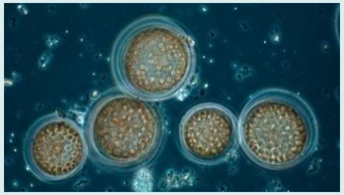

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PRIMARY RESEARCH PAPER

The northern Baltic Sea phytoplankton communities in 1903–1911 and 1993–2005: a comparison of historical and modern species data

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Abstract Despite over 100 years of phytoplankton research in the Baltic Sea, little is known about how the species composition has changed during this period, characterised by severe anthropogenic eutro-

groups. The most obvious differences were the increase of dinoflagellates and decrease in the diatom to dinoflagellate ratio in all seasons. Contrary to the widely held view that cyanophytes have gained

AIM OF STUDY:

To investigate whether, and how, the northern Baltic Sea phytoplankton community of the early 1900's differs from that of today

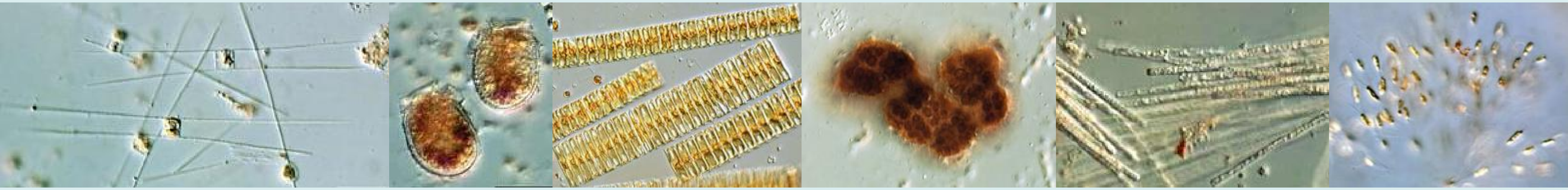
WHY STUDY THIS?

Despite more than 100 years of phytoplankton research, little is known about what has happened to the species composition

WHY DO WE NEED THIS INFORMATION?

The Baltic Sea has been heavily impacted by anthropogenic eutrophication since the 1950's – 1960's

→ reference values are needed to determine environmental targets;
this is required by the *EU Marine Strategy Framework Directive,*
and the *HELCOM Baltic Sea Action Plan*



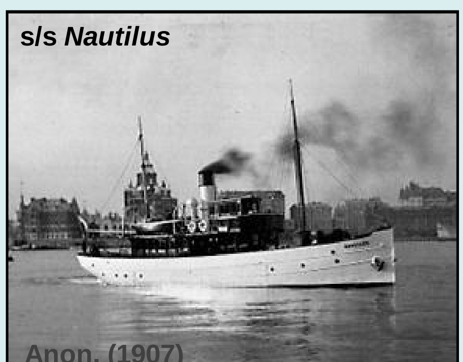
STUDY AREA

The northern Baltic Proper and western Gulf of Finland, 58°N→25°E

● **Historical ICES data**
- collected 1903–1911 on plankton cruises
- 25 stations sampled by Finland

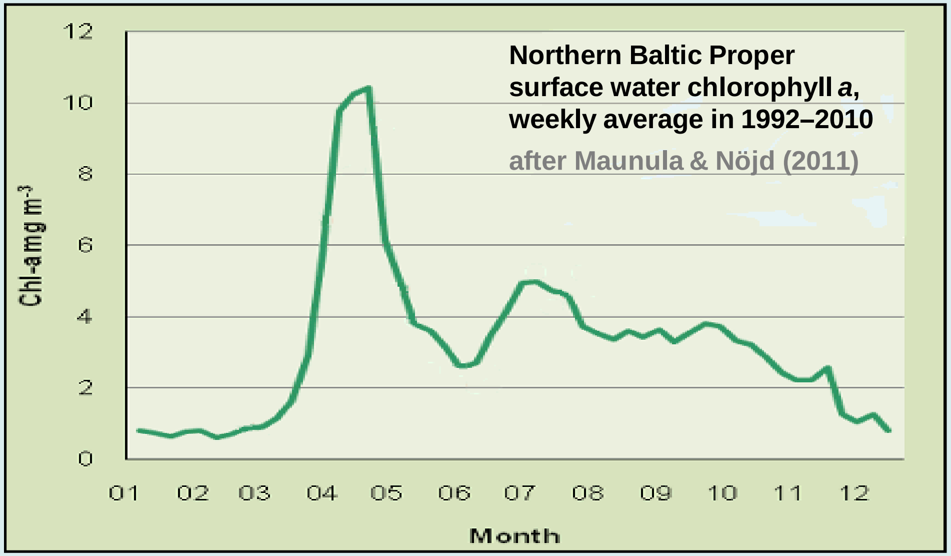
▲ **Modern Algaline data**
- collected 1993–2005 onboard merchant ships travelling between Germany and Helsinki
- semi-permanent stations

Icebreaker *Murtaja*
www.wikipedia.fi


s/s *Nautilus*
Anon. (1907)

m/s *Finnpartner*
www.balot-pictures.com

TEMPORAL COVERAGE & PARAMETERS



SAMPLES	Spring: May	Summer: Jul-Aug	Autumn: Oct-Nov	Total
ICES 1903 – 1911 9 yrs	147	164	107	418
Algaline 1993 – 2005 13 yrs	221	421	113	755
Total	368	585	220	1173

We investigated

- the biomass peaks in spring, summer, and autumn
- water temperature, salinity, max extent of sea ice cover, and wintertime NAO

METHODS

	Historical ICES data	Modern Algaline data
Sampling equipment	Müllergaze No. 20 plankton nets (mesh size 43-115,5 µm), several models	Automated flow-through sampling apparatus (discrete water samples)
Sampling depth	Surface haul, 20-0 m and 10-0 m vertical hauls	ca 5 m (but represents top ca 10-20 m layer as ship mixes water)
Preservative	? (Likely formalin or denaturated alcohol)	Acid Lugol's solution
Analysing technique	?	Utermöhl method
Phytoplankton abundance scale	rr = very rare r = rare + = not rare, not common c = common cc = very common	1 = very sparse 2 = sparse 3 = scattered 4 = abundant 5 = dominant

Two data sets collected with different methods (and sampling strategies)
→ extensive data preparation

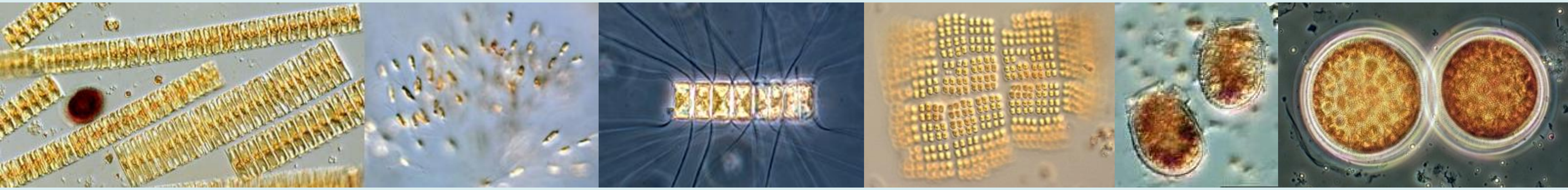
→ 31 taxa (dinoflagellates, cyanophytes, diatoms, chlorophytes, chrysophytes), of which 20 taxa were present in both data sets

WE WANTED TO KNOW

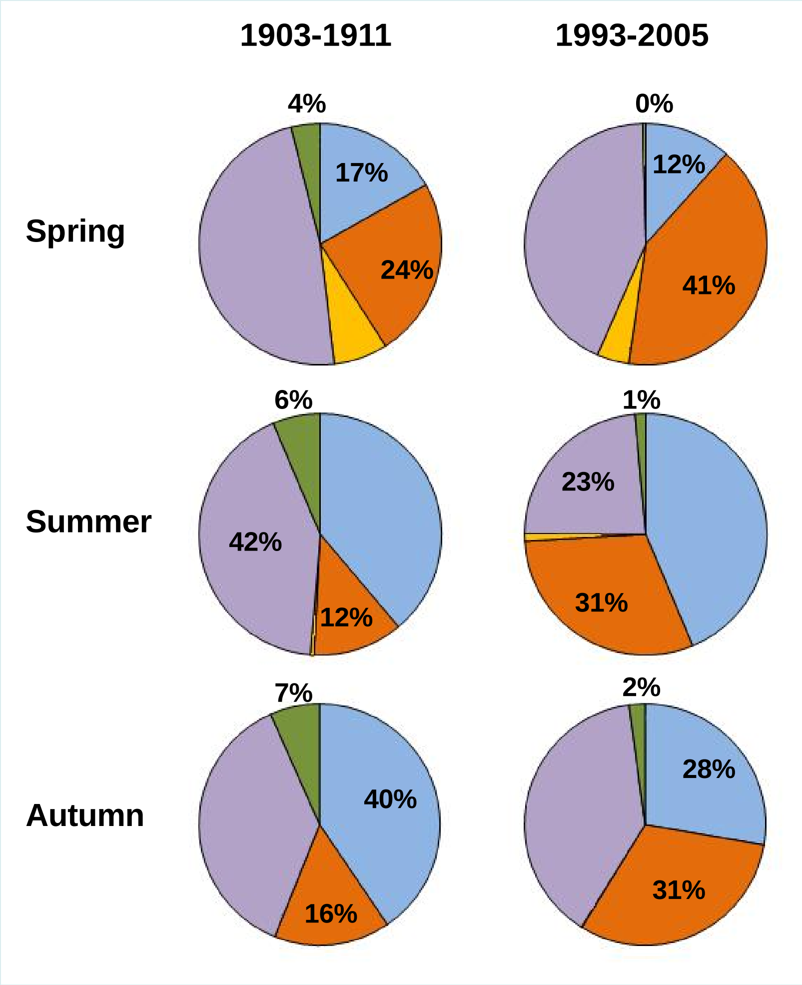
Do the historical and modern phytoplankton communities differ, and if so, which are the differences on group and species level?

Which factors cause the differences?

Does phytoplankton species composition data hold the potential to develop environmental indicators?



RESULTS: Community-level changes

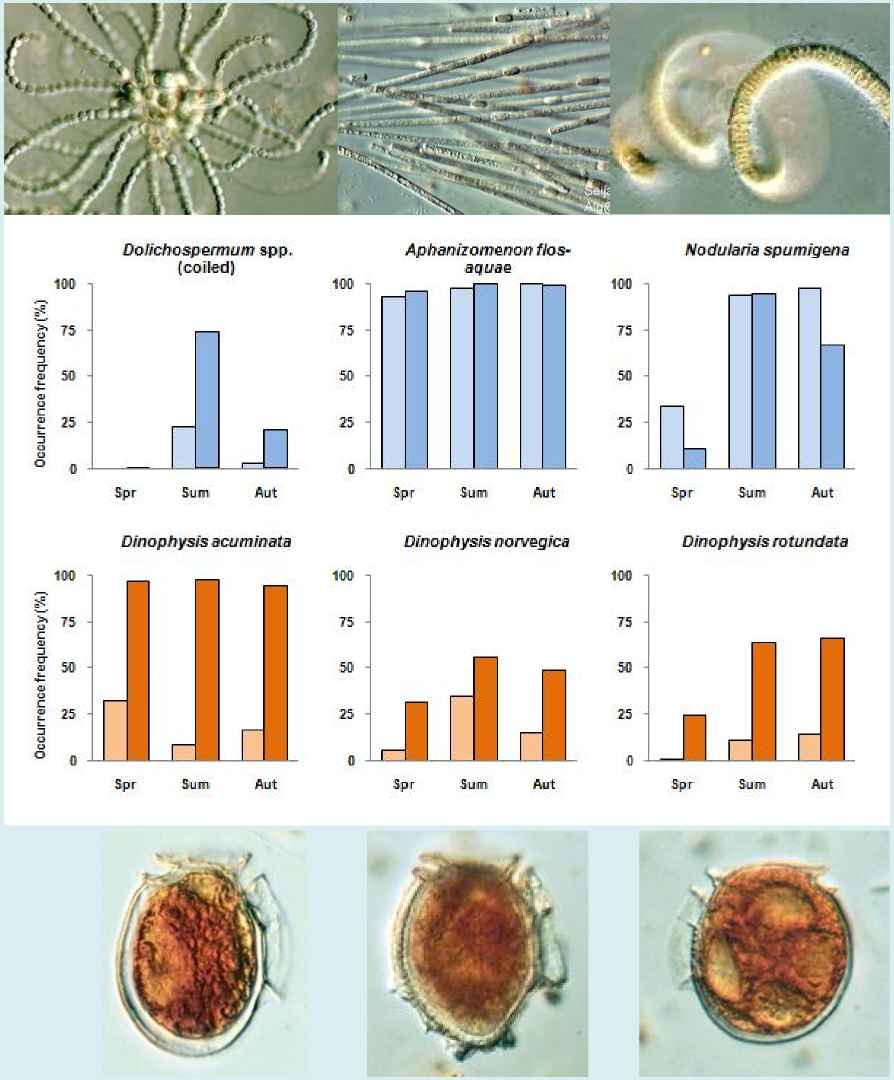


Based on the mean occurrence frequency sum ratios of all 31 taxa, the relative importance of phytoplankton groups in the early 1900’s and today differed during all three seasons:

Dinoflagellates:	⬆	all seasons
Cyanophytes:	⬇	in spring and autumn, no change in summer
Diatoms:	⬇	in summer; no change in spring and autumn
Chlorophytes:	⬇	all seasons
Chrysophytes:	▬	no change

Only percentages which differ significantly in the two periods (Mann-Whitney U-test) are shown

RESULTS: Changes in individual taxa



Harmful algae

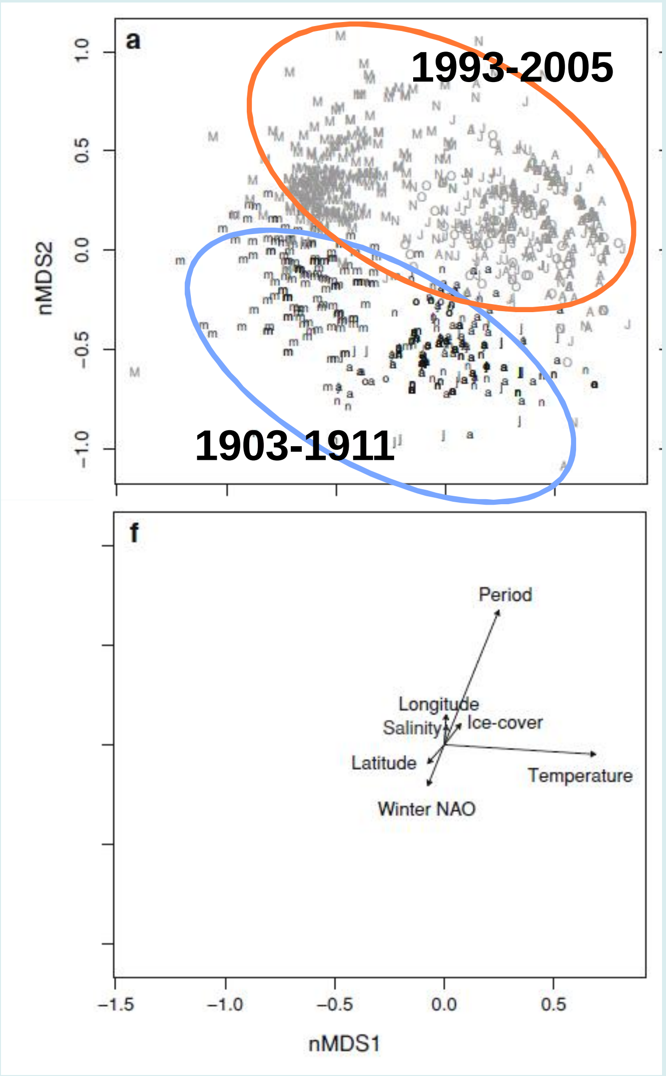
- bloom-forming cyanophytes: only 1 out of 3 taxa ⬆
- toxic dinoflagellates: all *Dinophysis* species ⬆

Based on occurrence frequencies

- most taxa exhibit clear differences in their occurrences during the two periods
- most taxa exhibit the same tendencies (⬆ or ⬇) in all seasons

Mean occurrence frequencies in the two periods. Left columns 1903-1911, right columns 1993-2005

RESULTS: Likely causes for centurial change?



Community analysis revealed clear differences in the phytoplankton compositions of the two periods

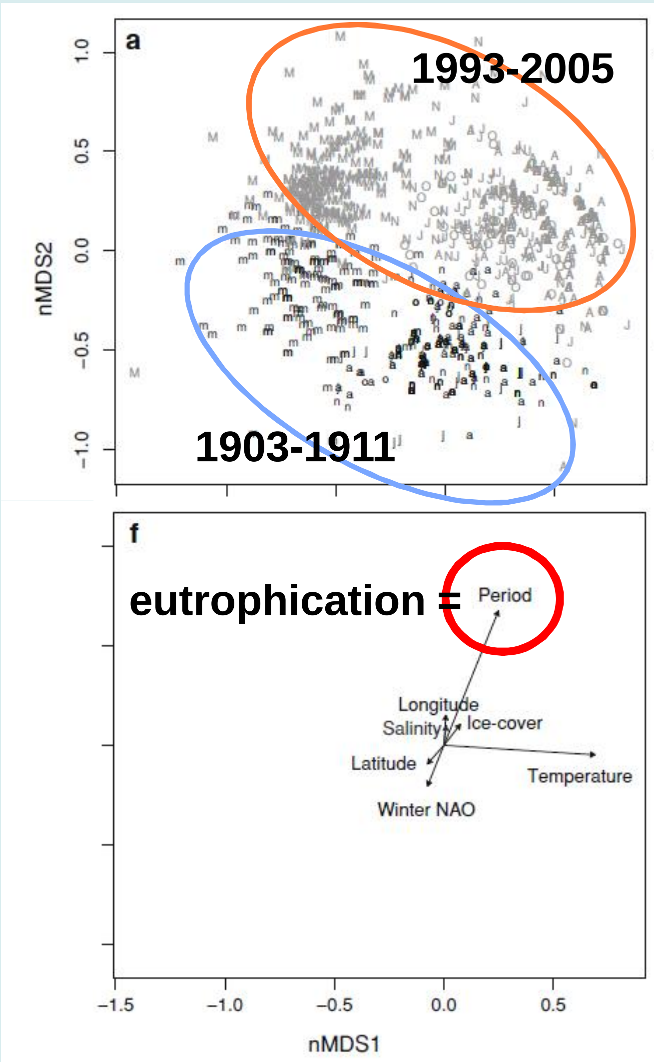
- Temperature ⬆
- Salinity ⬆
- Ice cover ▬
- Wintertime NAO ▬

→ did **not** explain the differences in the communities

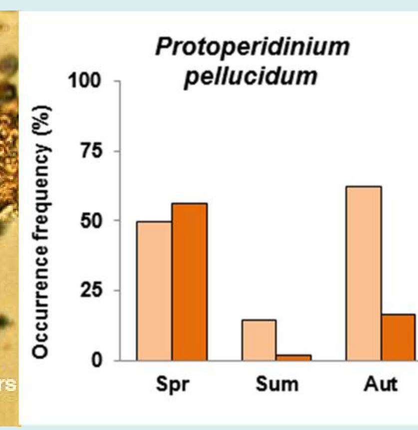
nMDS ordination with the presence/absence of the 20 taxa which occurred both in 1903-1911 and 1993-2005 as input

RESULTS: Likely causes for centurial change:

Eutrophication and climate change



		TEMPERATURE °C	
		Means	Change
Spring	1903 - 1911	5,1	+ 0,4*
	1993 - 2005	5,5	
Summer	1903 - 1911	14,6	+ 2,3***
	1993 - 2005	16,9	
Autumn	1903 - 1911	7,7	+ 3,4***
	1993 - 2005	11,1	



RESULTS: Potential eutrophication indicators

POTENTIAL INDICATORS	Change according to SIMPER analysis			Change in mean OCCURRENCE FREQ		
	Spr	Sum	Aut	Spr	Sum	Aut
Dinophysis acuminata	+	+	+	+	+	+
Dinophysis rotundata	+	+	+	+	+	+
Dinophysis norvegica	+	+	+	+	+	+
Anabaena/ Dolichospermum spp.	+	+	+	+	+	+
Skeletonema costatum sensu lato	+	+	+	+	+	+
Actinocyclus octonarius	+	+	+	+	+	+
Thalassiosira baltica	-	-	-	-	-	-
Chaetoceros danicus	-	-	-	-	-	+
Botryococcus braunii sensu lato	-	-	-	-	-	-

Oscillatoriales spp.; not recorded in 1903-1911 but present in 1993-2005

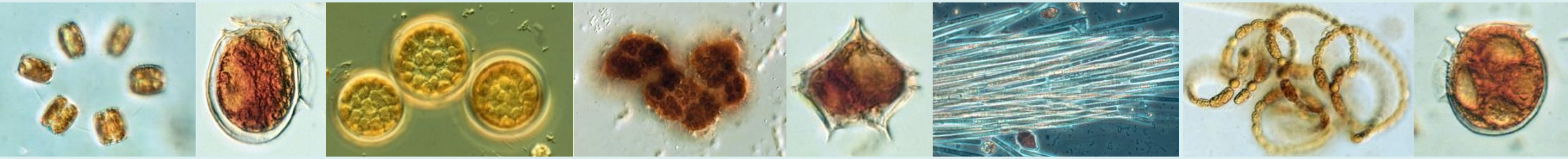
Consistent winners
i.e. taxa successful in all seasons in today's eutrophied conditions

Consistent losers

Due to being mixotrophic, heterotrophic, multi-species taxa, or otherwise unsuitable (due to non-consistent behaviour in our analyses or based on litterature),
→ none of our 10 candidates fulfilled the criteria of good indicator species

IN CONCLUSION

- This study provides new information on differences in the phytoplankton communities of the early 1900's and today
- The historical and modern phytoplankton communities in the northern Baltic Sea differ markedly
- An undefined ‘period effect’ was the most important factor separating the historical and modern phytoplankton communities. We interpret this ‘period effect’ as evidence for the direct and/or indirect influence of eutrophication
- We found some changes in the phytoplankton species compositions to be associated with warming water temperatures
- Our endeavour to find eutrophication bioindicators failed since none of the candidates fulfilled the criteria of good stand-alone indicator species
- Despite challenges, it is possible to extract information from historical phytoplankton data and to compare it with modern data



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All figures by the authors unless otherwise indicated

Thank you for your attention

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