Baltic Sea Eutrophication

Gerald Schernewski

Leibniz-Institute for Baltic Sea Research, Warnemünde, Germany
Klaipeda University, Lithuania

Overview

1. The Baltic Sea - special features
2. Eutrophication - definition & consequences
3. Eutrophication - problems in the Baltic Sea
4. Eutrophication - causes
5. Eutrophication - trends
6. Baltic Sea assessments & summary

Helcom: http://stateofthebalticsea.helcom.fi/in-brief/our-baltic-sea/

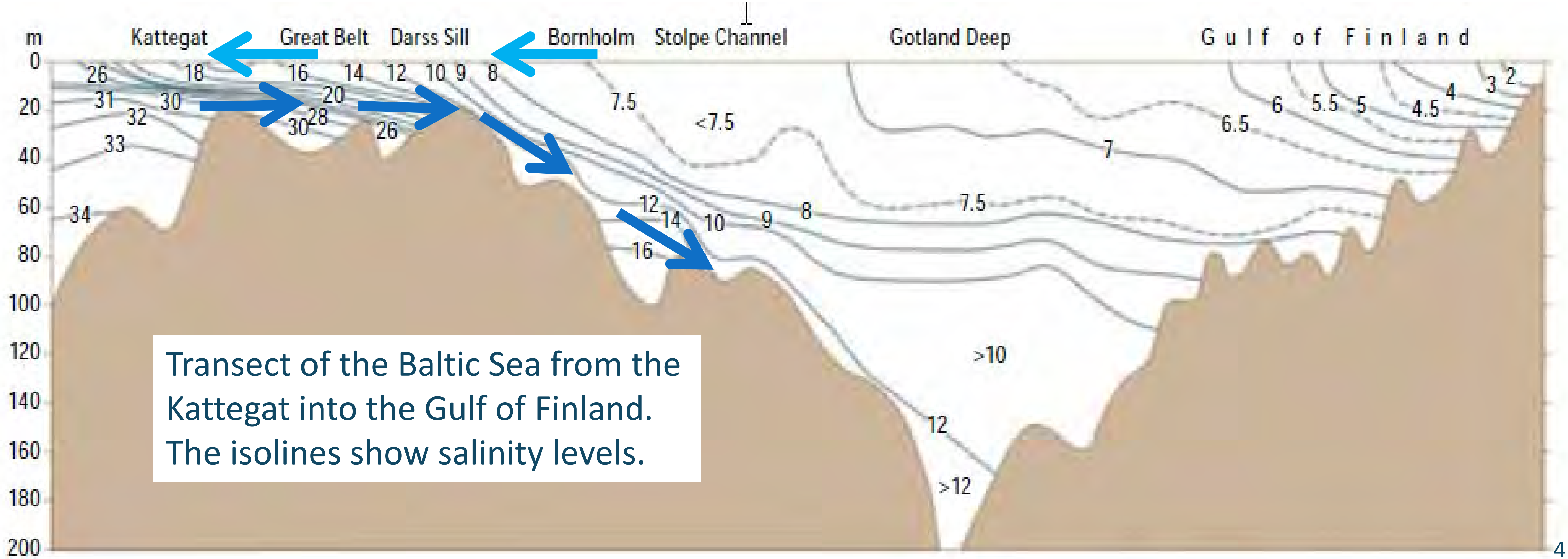
1. The Baltic Sea – special features

Area:	412 560 km²
Volume:	21 631 km³
Water residence time:	25-30 years
South-north-spread:	ca. 1300 km
West-east-spread:	ca. 1000 km
Average depth:	52 m
Maximum depth:	460 m
Catchment:	1 734 000 km²
Population:	85 millions

It is bordered by 9 countries (Denmark, Sweden, Finland, Russia, Estonia, Latvia, Lithuania, Poland and Germany)

1. The Baltic Sea – special features

- More than 250 rivers discharge 660 km³ water per year to the Baltic
- Periodically, North Sea water with high salinity enters and maintains gradients in the Baltic Sea



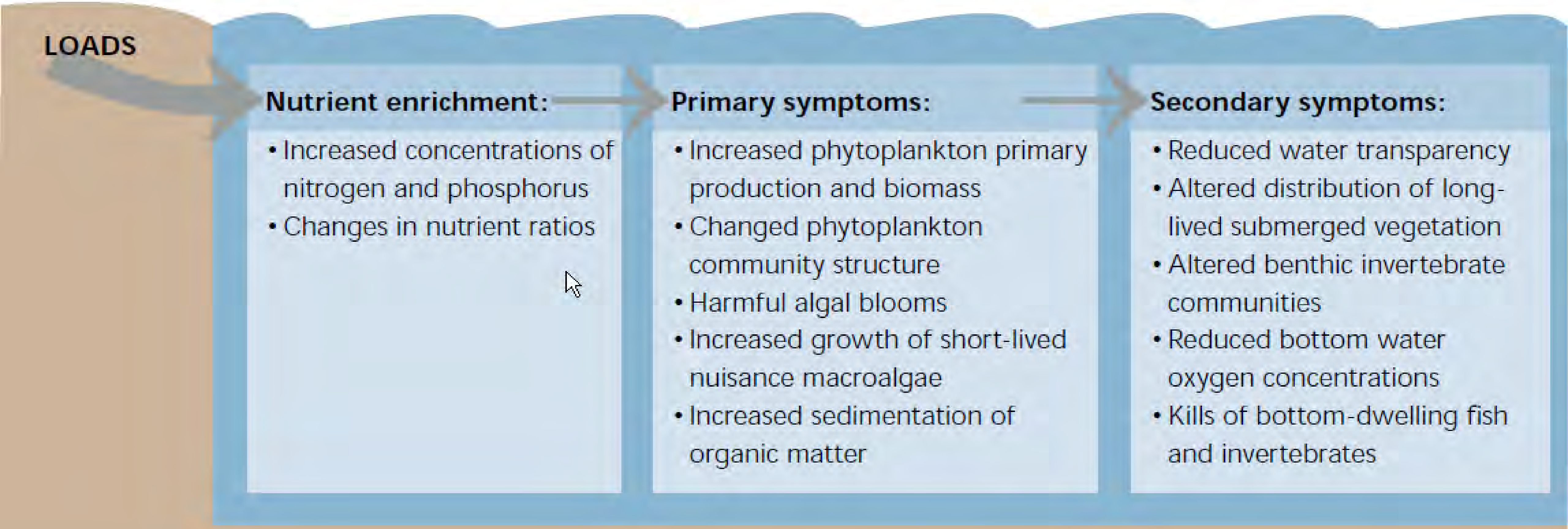
Transect of the Baltic Sea from the Kattegat into the Gulf of Finland. The isolines show salinity levels.

After Leppäranta & Myrberg (2008)

2. Eutrophication - definition & consequences

Eutrophication means the enrichment of aquatic systems with nutrients (nitrogen and phosphorus) and a subsequent increase in phytoplankton productivity

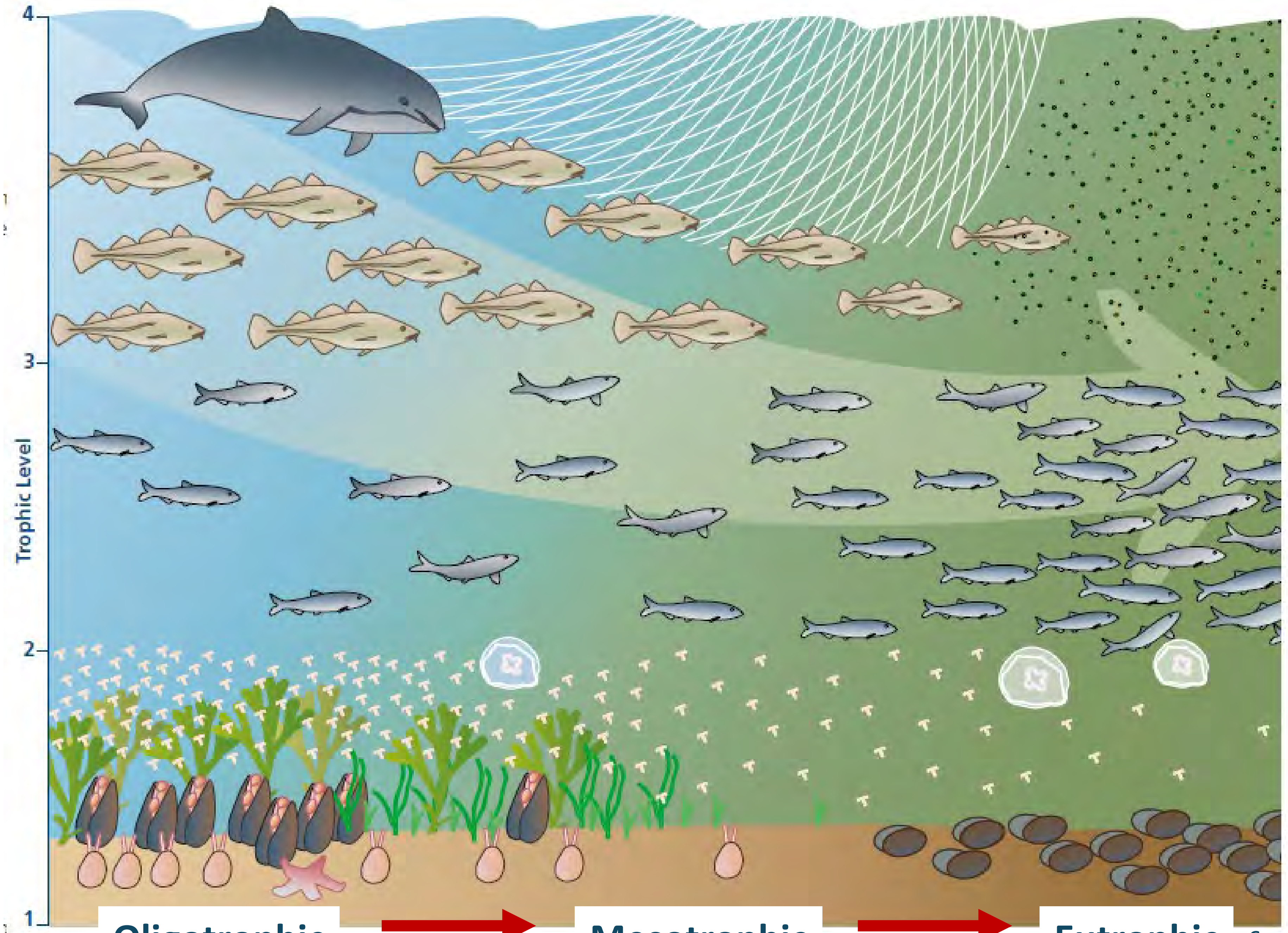
A simple conceptual model of eutrophication symptoms in the Baltic Sea:



HELCOM (2009) based on Cloern (2001): Balt. Sea. Env. Proc. No. 115

2. Definition & consequences

Eutrophication as a gradual process: Changes in food-web structure due to overfishing and eutrophication in the Baltic Sea.



HELCOM (2010): Balt. Sea Environ. Proc. No. 122, adapted from Watson and Pauly (2001)

3. Eutrophication in the Baltic Sea – blue algae blooms

Source: ESA (2005)

Schernewski (2014)

3. Eutrophication in the Baltic Sea – macroalgae

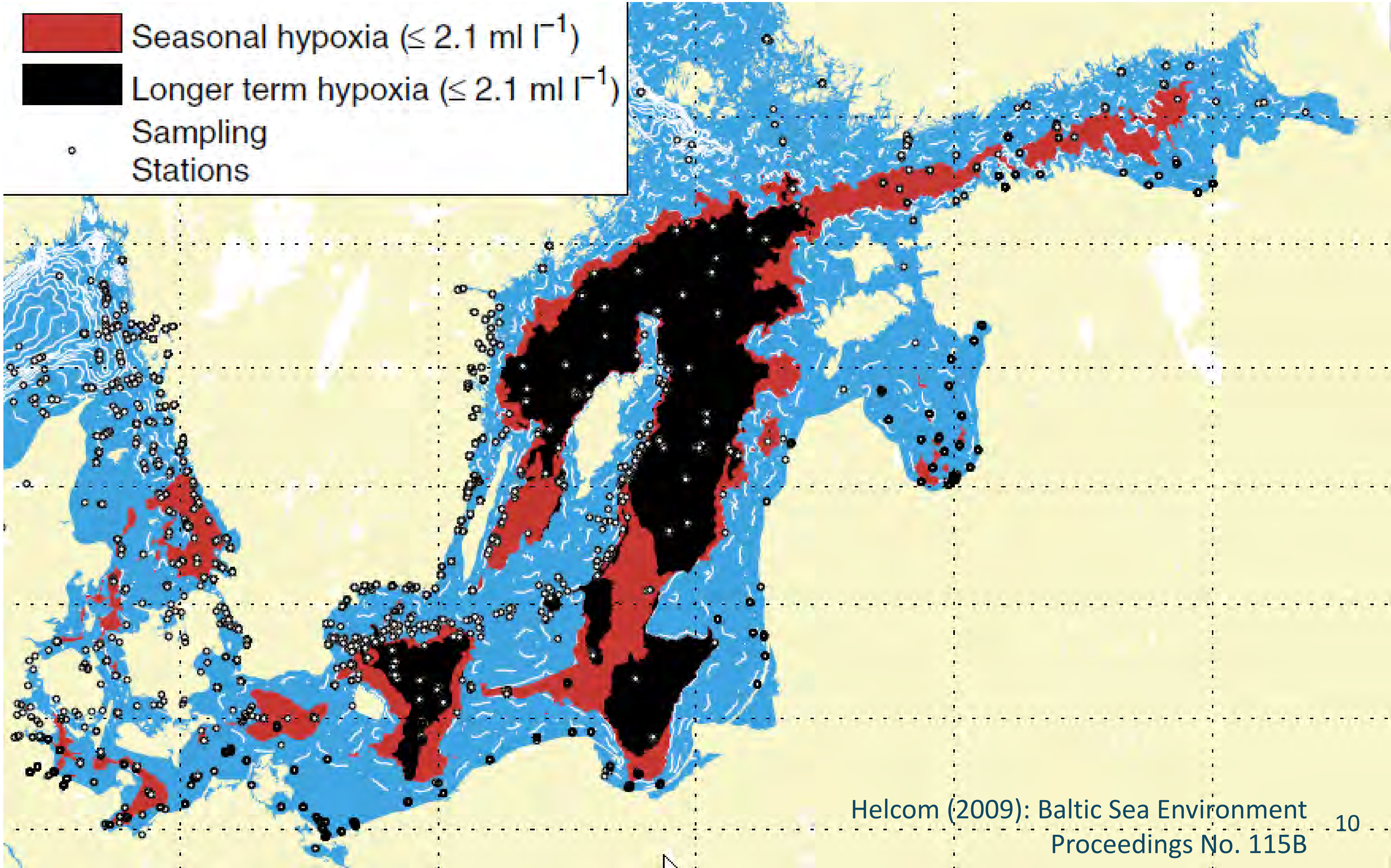
Schernewski (2019): Rügen

3. Eutrophication in the Baltic Sea – hypoxia

Pictures: Schernewski

3. Eutrophication in the Baltic Sea – hypoxia

Extent of seasonal and longer-term hypoxia averaged over 2001–2006.

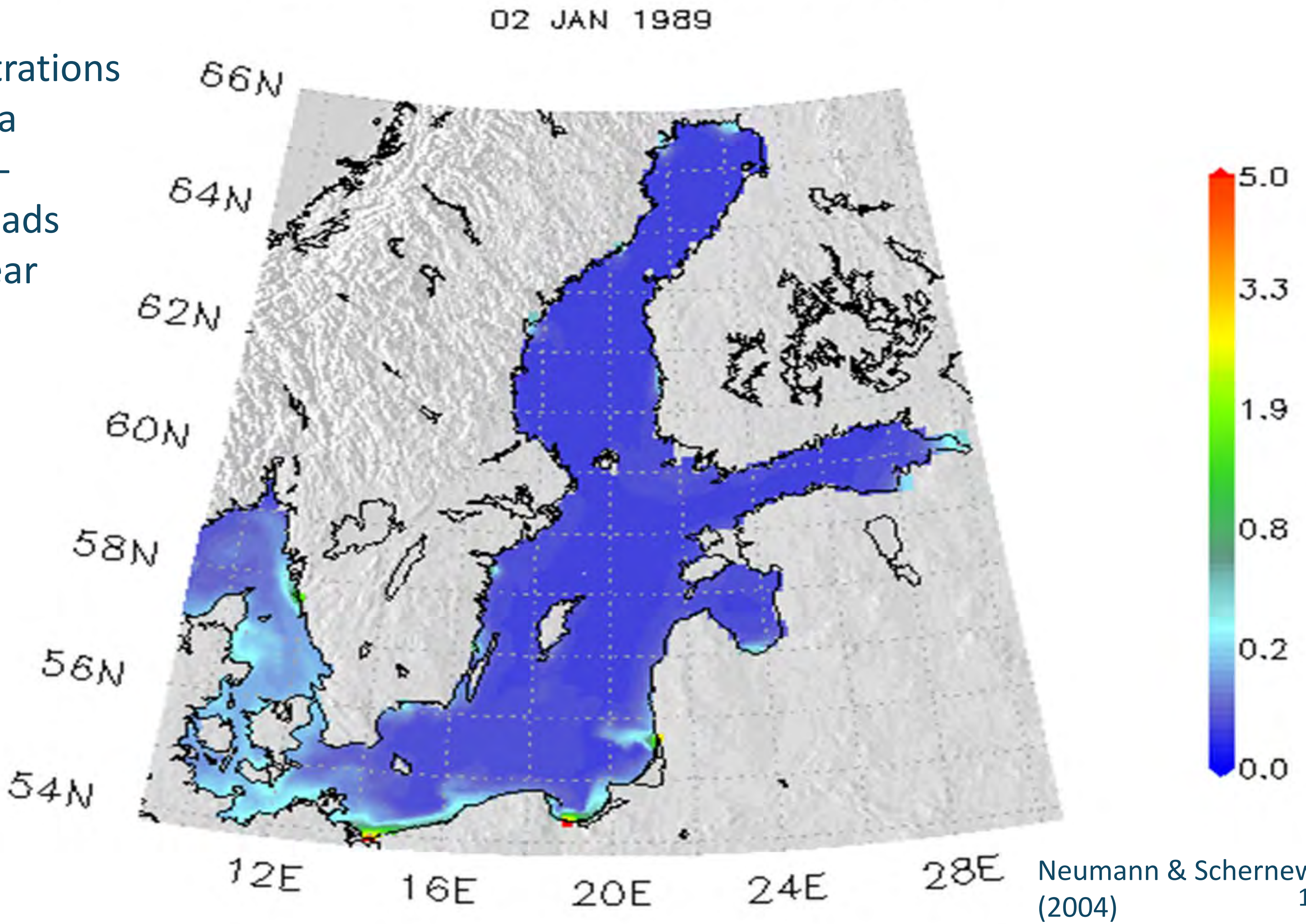


How does the seasonal development in the Baltic Sea looks like?

Helcom (2009): Baltic Sea Environment Proceedings No. 115B

3. Eutrophication – seasonal phytoplankton dynamic in the Baltic Sea

Chloropyll-a concentrations (mg/m³) near the sea surface (0-10m). Pre-industrial nutrient loads and forcing of the year 1989.



Neumann & Schernewski (2004)

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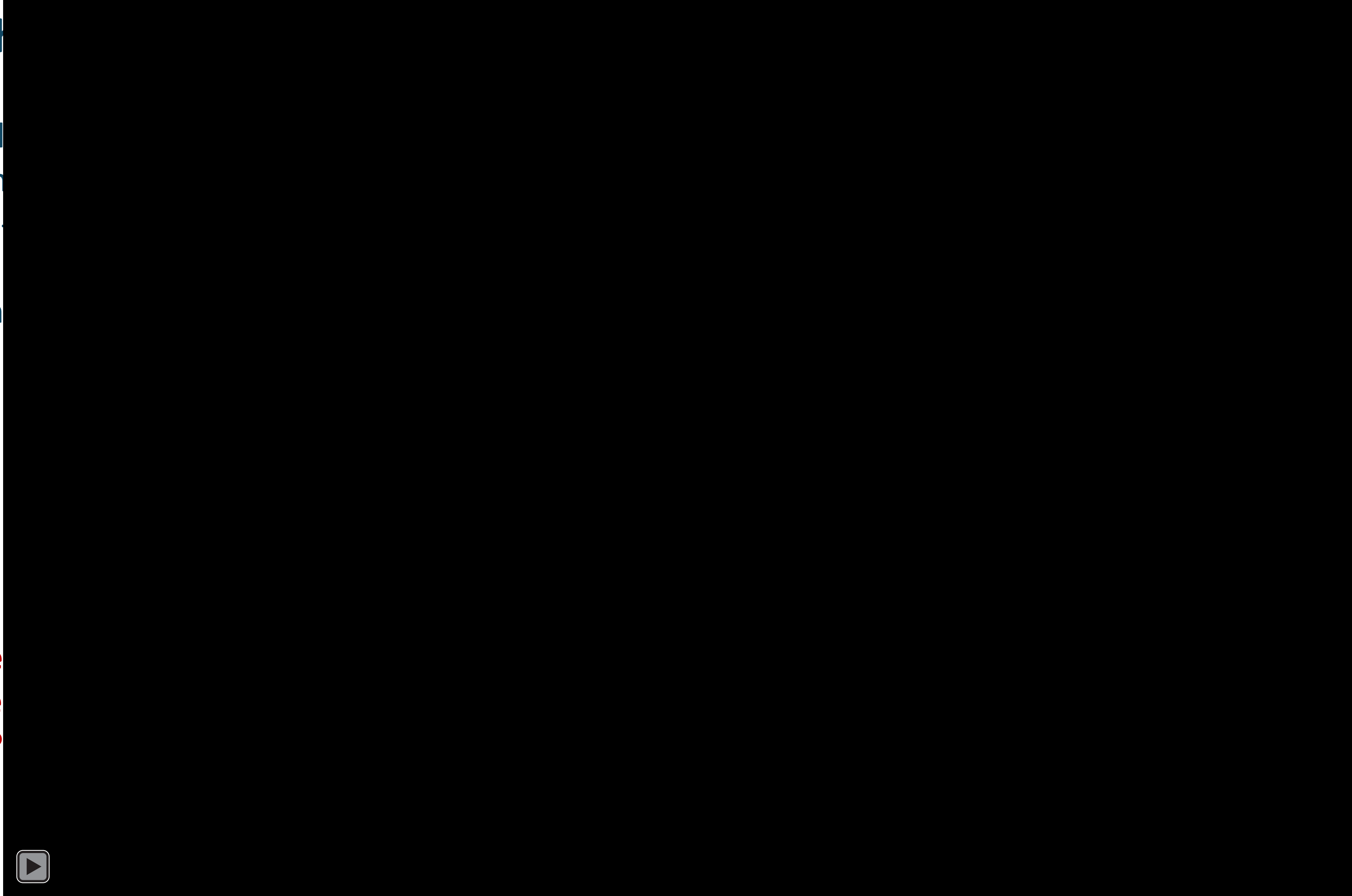
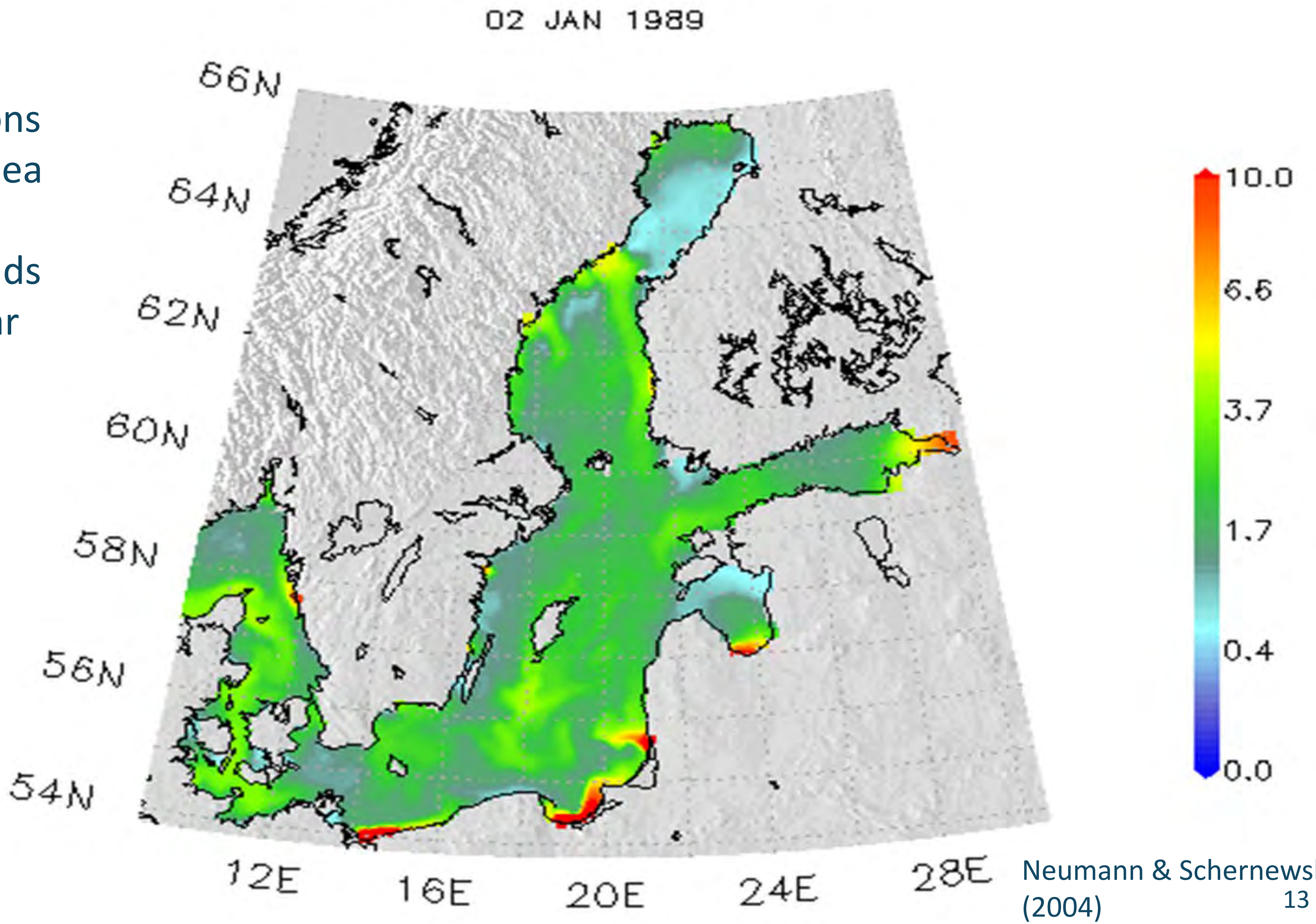


3. Eutrophication – seasonal nitrogen dynamic in the Baltic Sea

Dissolved inorganic nitrogen concentrations (mmol/m³) near the sea surface (0-10m). Pre-industrial nutrient loads and forcing of the year 1989.



Neumann & Schernewski (2004)

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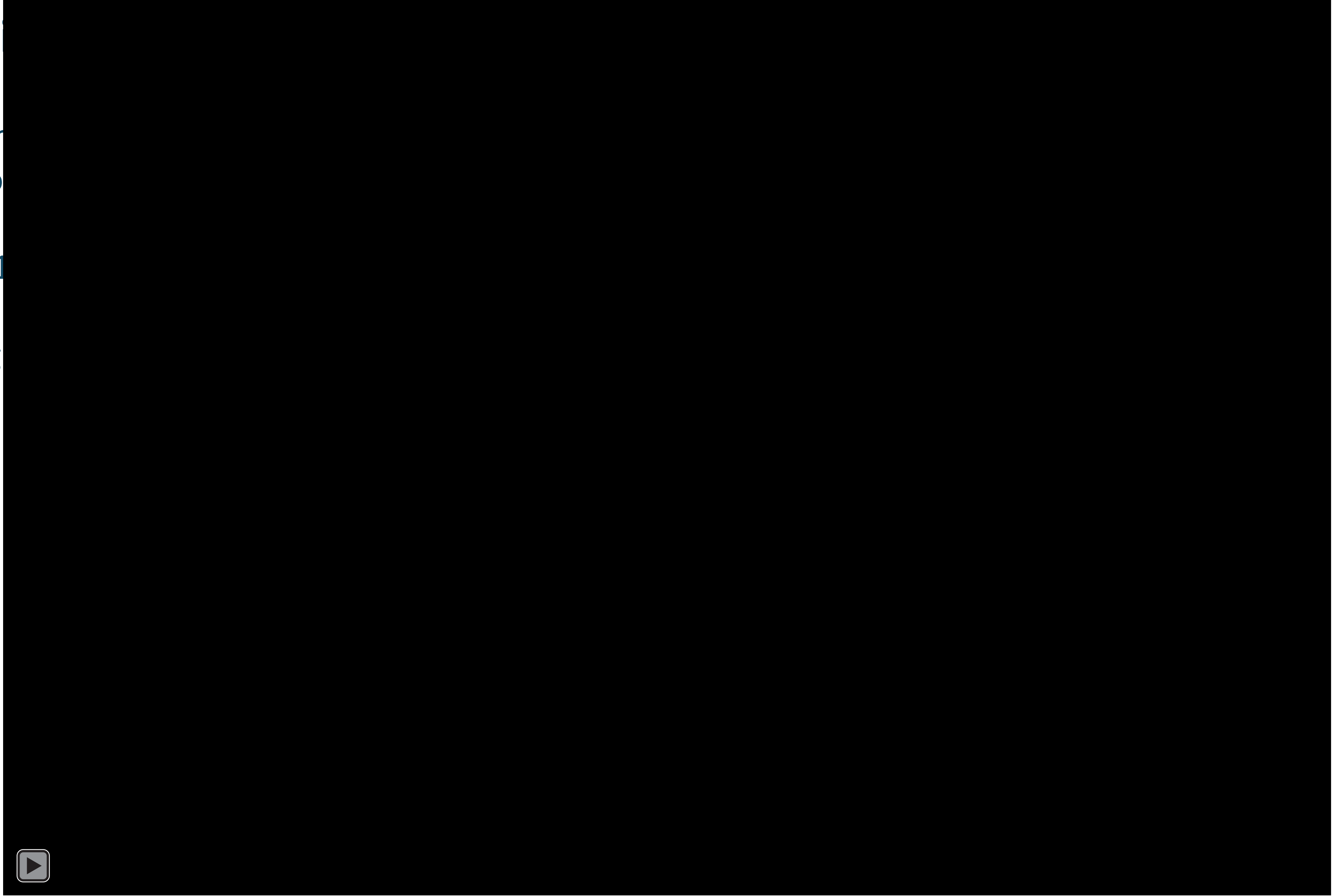
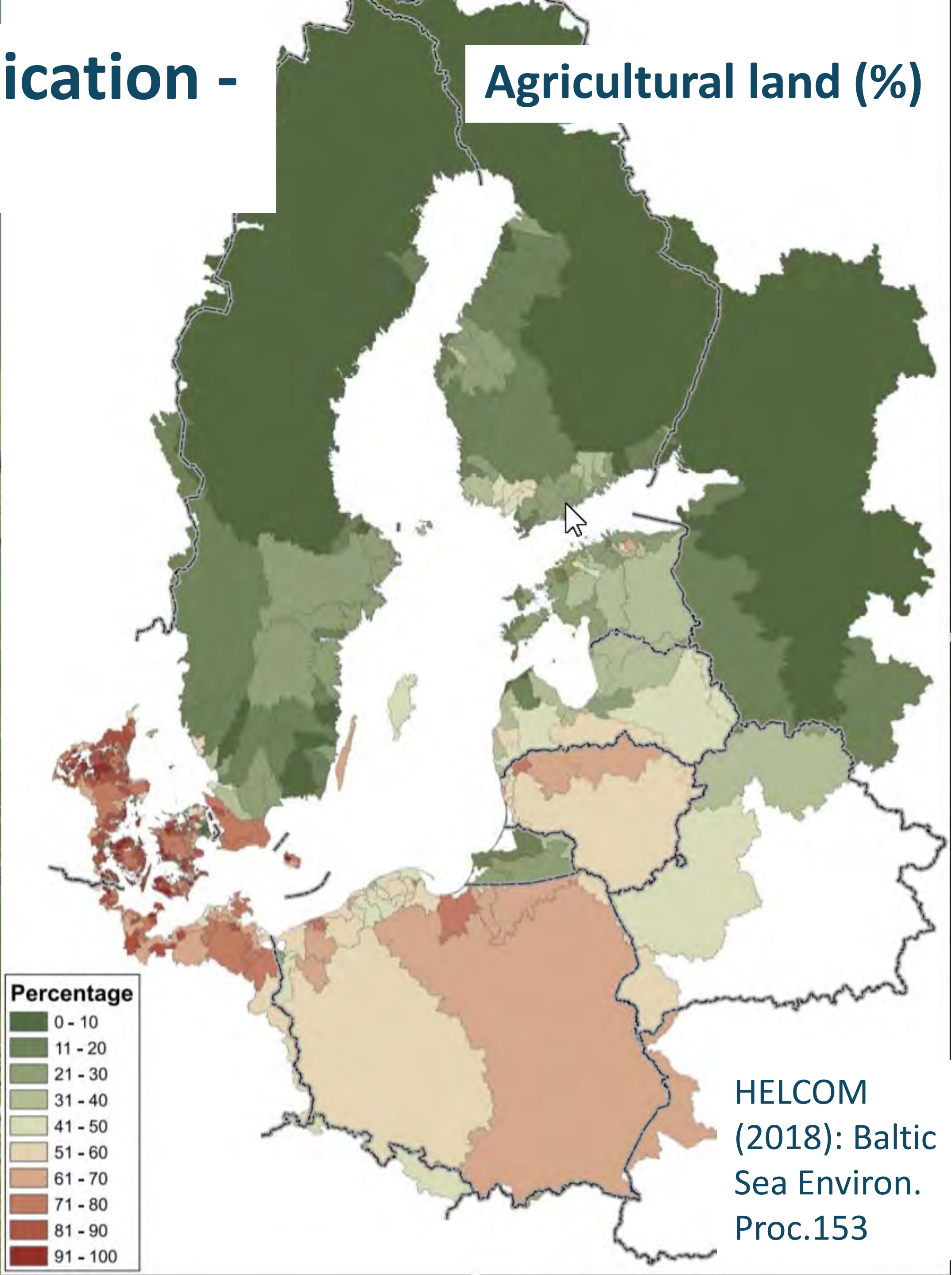


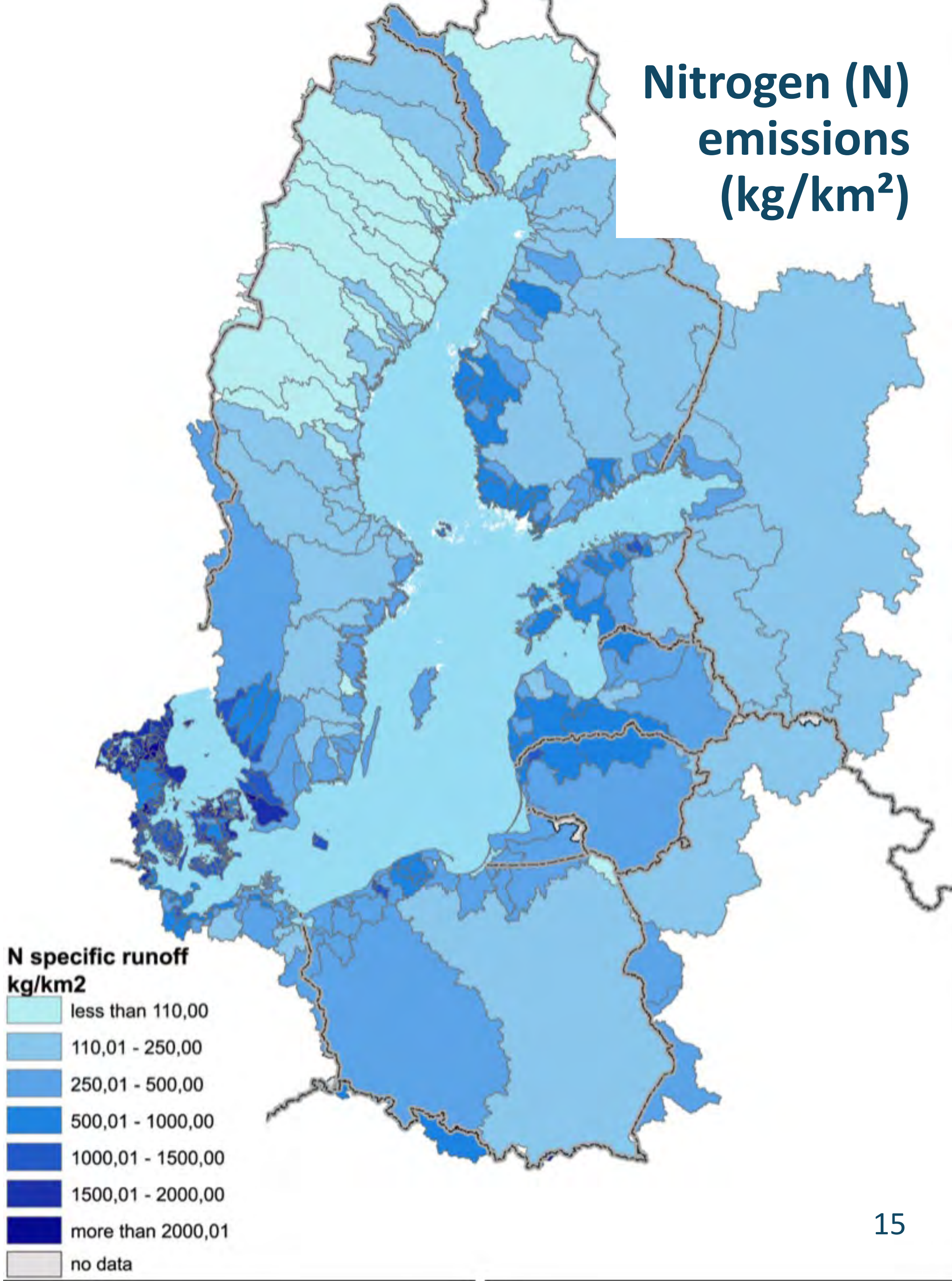
4. Eutrophication - causes

Agricultural land (%)



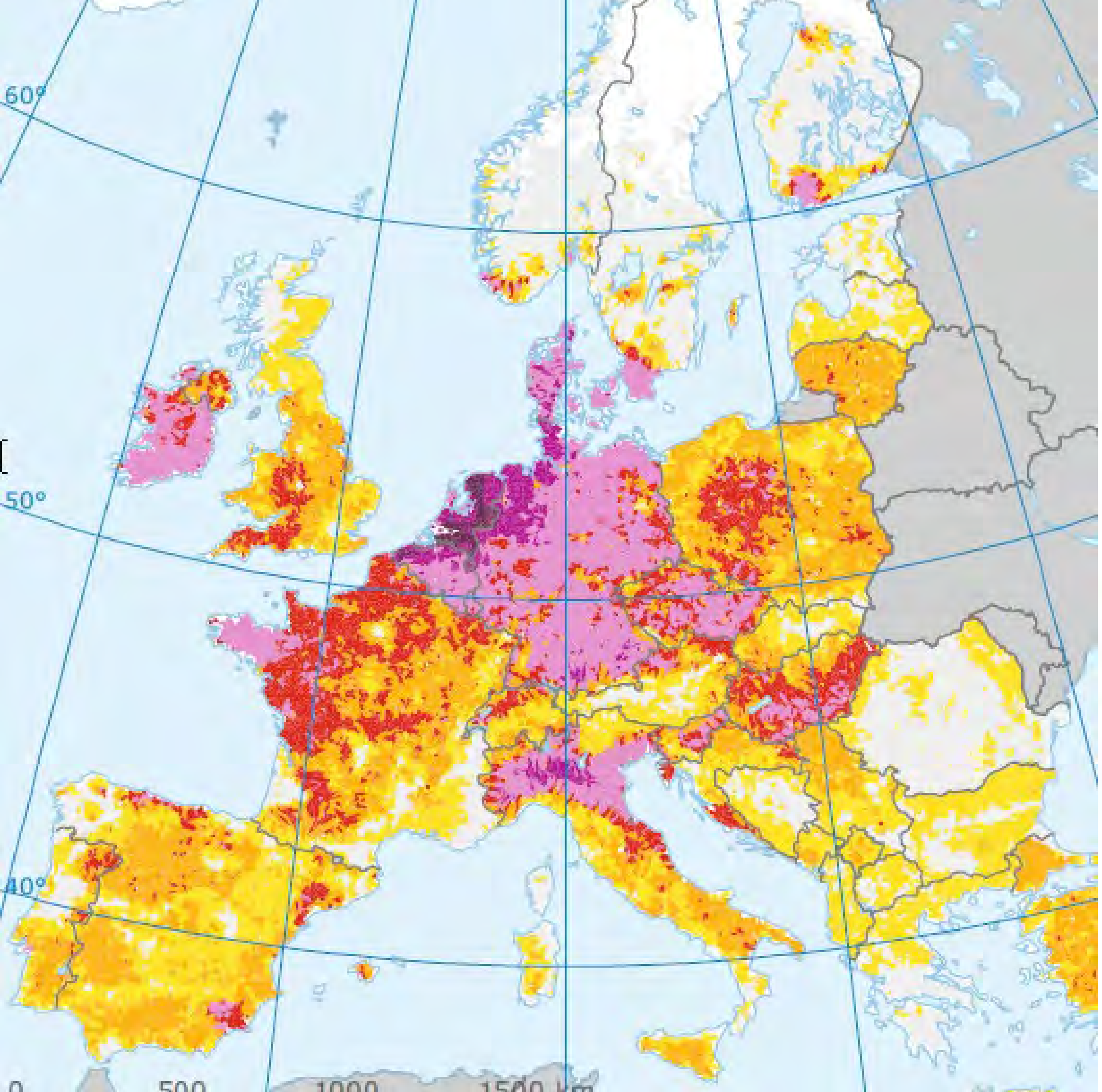
HELCOM (2018): Baltic Sea Environ. Proc.153

Nitrogen (N) emissions (kg/km²)



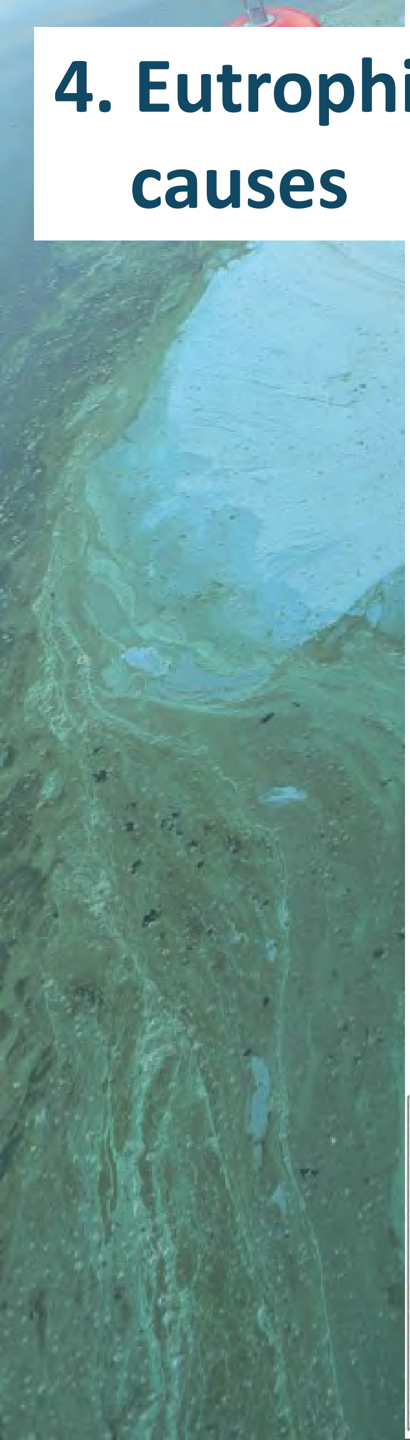
4. Eutrophication - causes

Estimated nitrogen surplus (Difference between inorganic and organic fertilizer application, atmospheric deposition and fixation compared to uptake by crops) for the year 2005 across Europe.

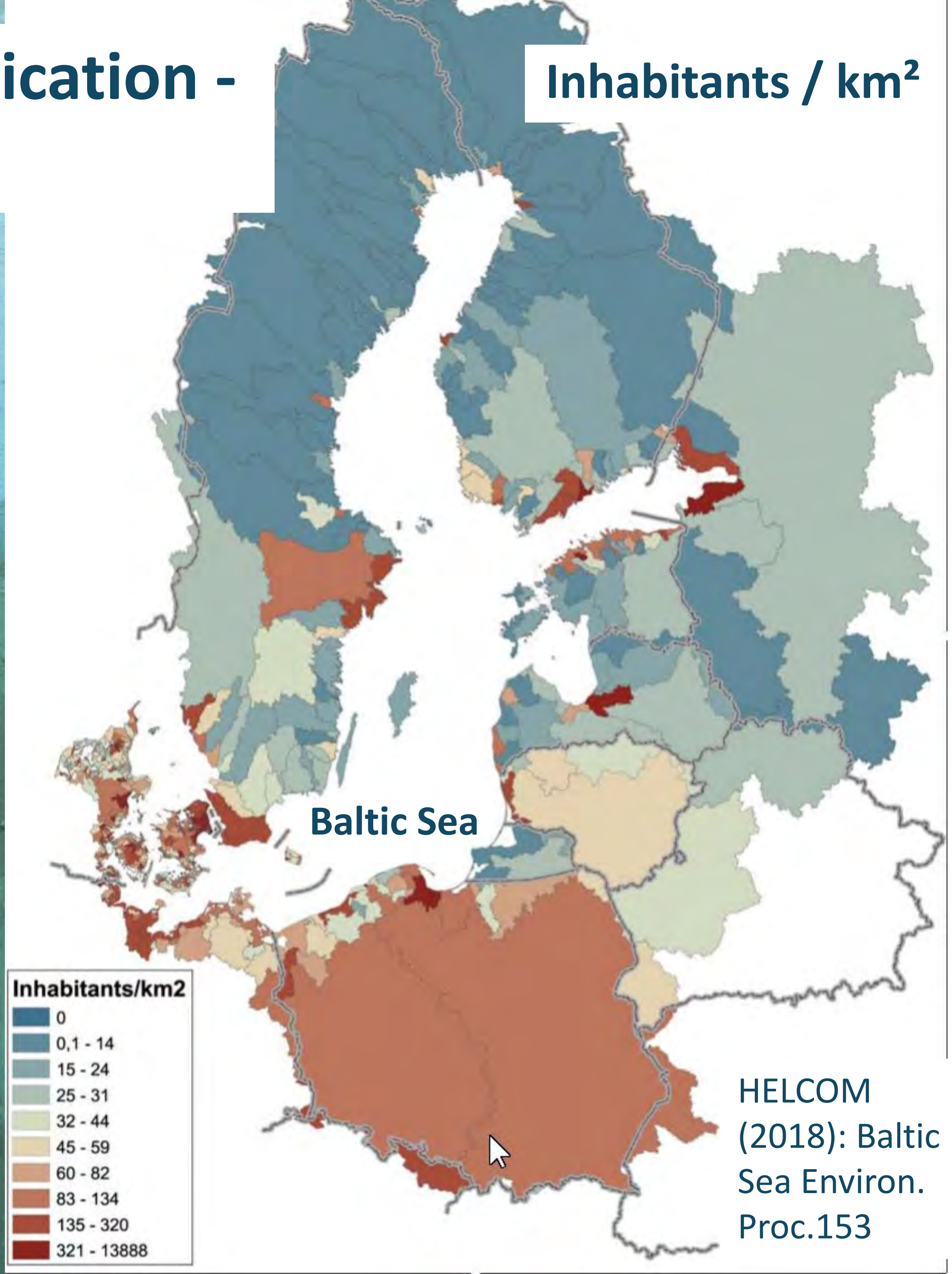


HELCOM (2011): Baltic Sea Environment Proceedings No. 128; based on EEA/JRC (2010)

4. Eutrophication - causes

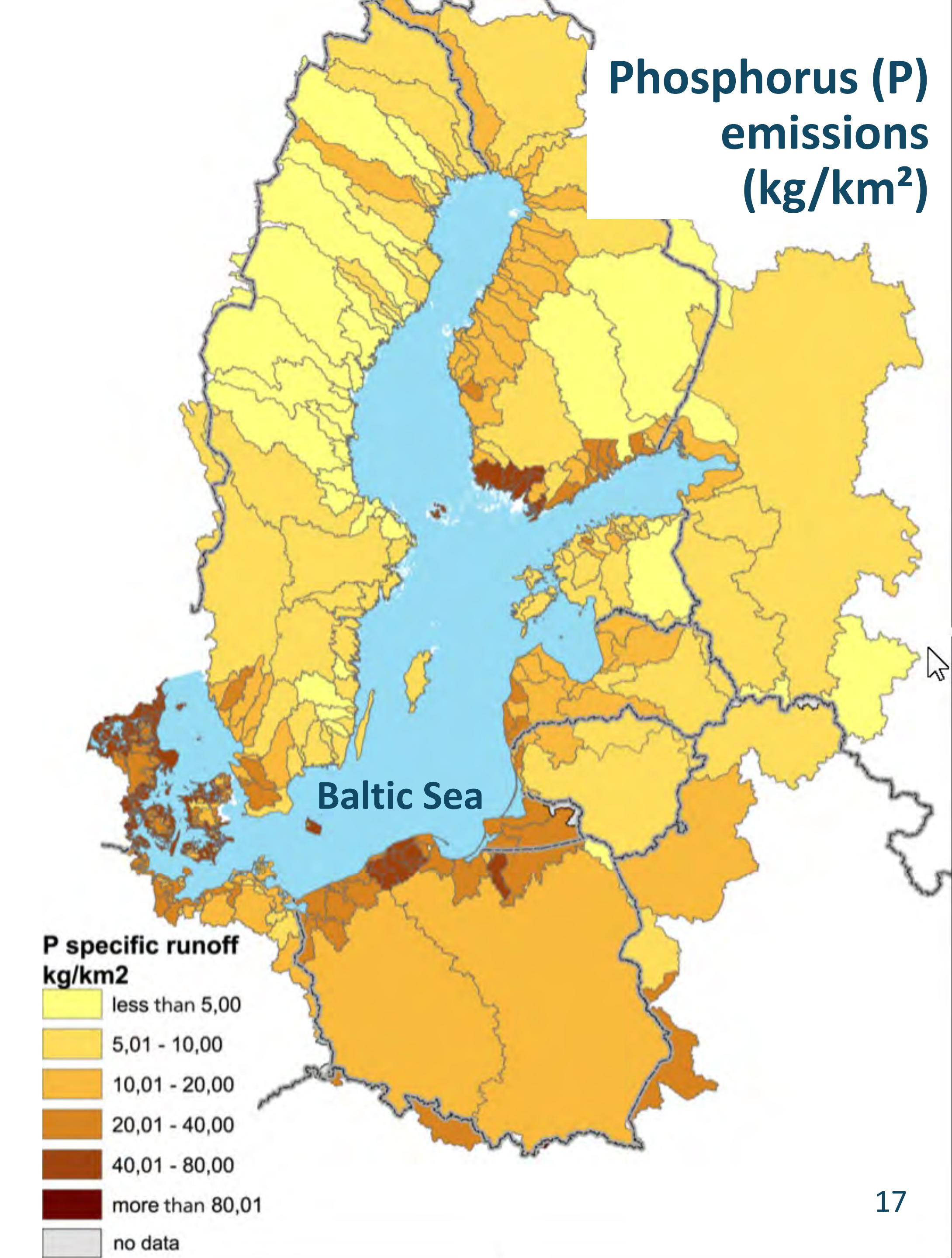


Inhabitants / km²



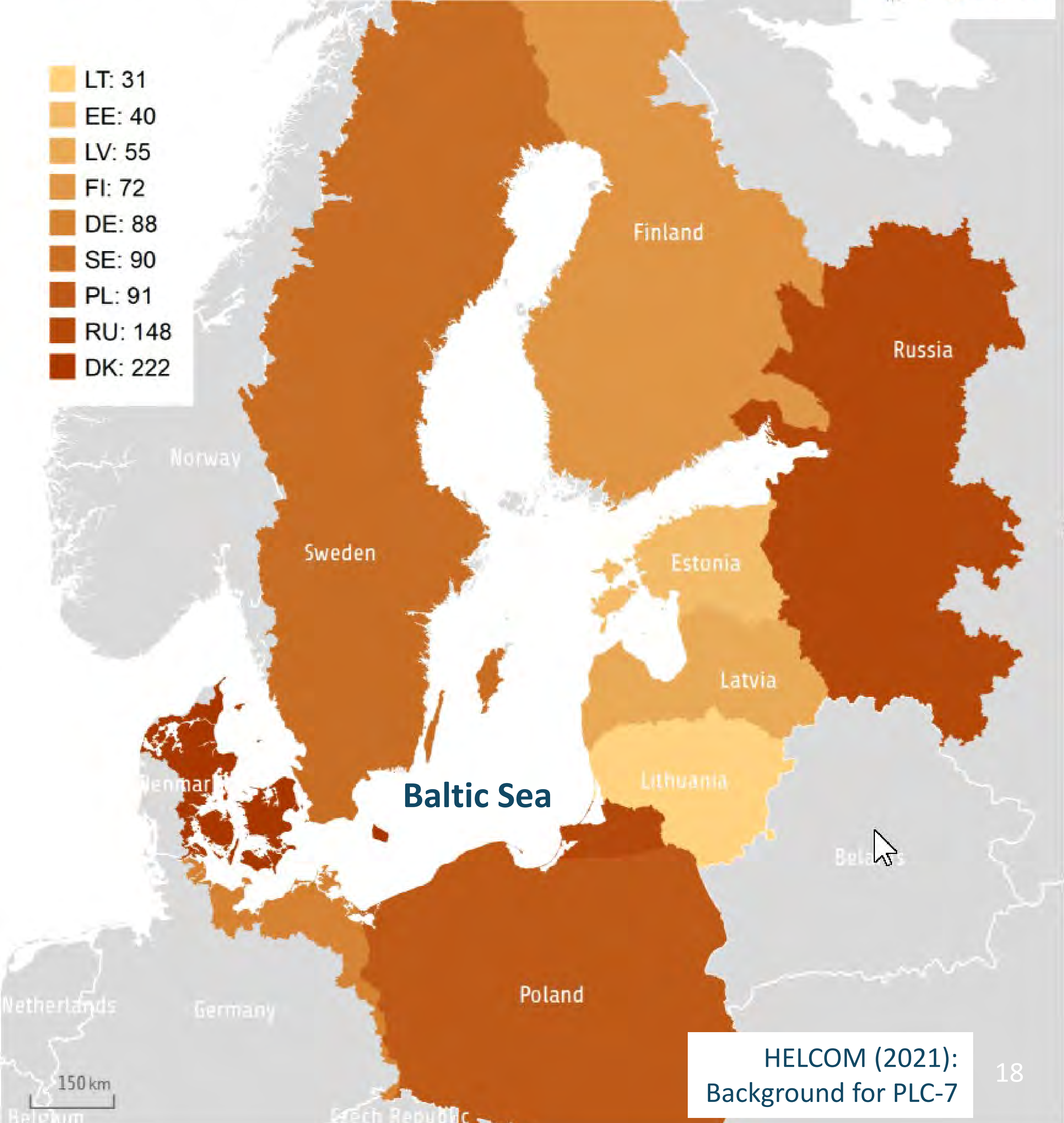
HELCOM (2018): Baltic Sea Environ. Proc.153

Phosphorus (P) emissions (kg/km²)



4. Eutrophication - causes

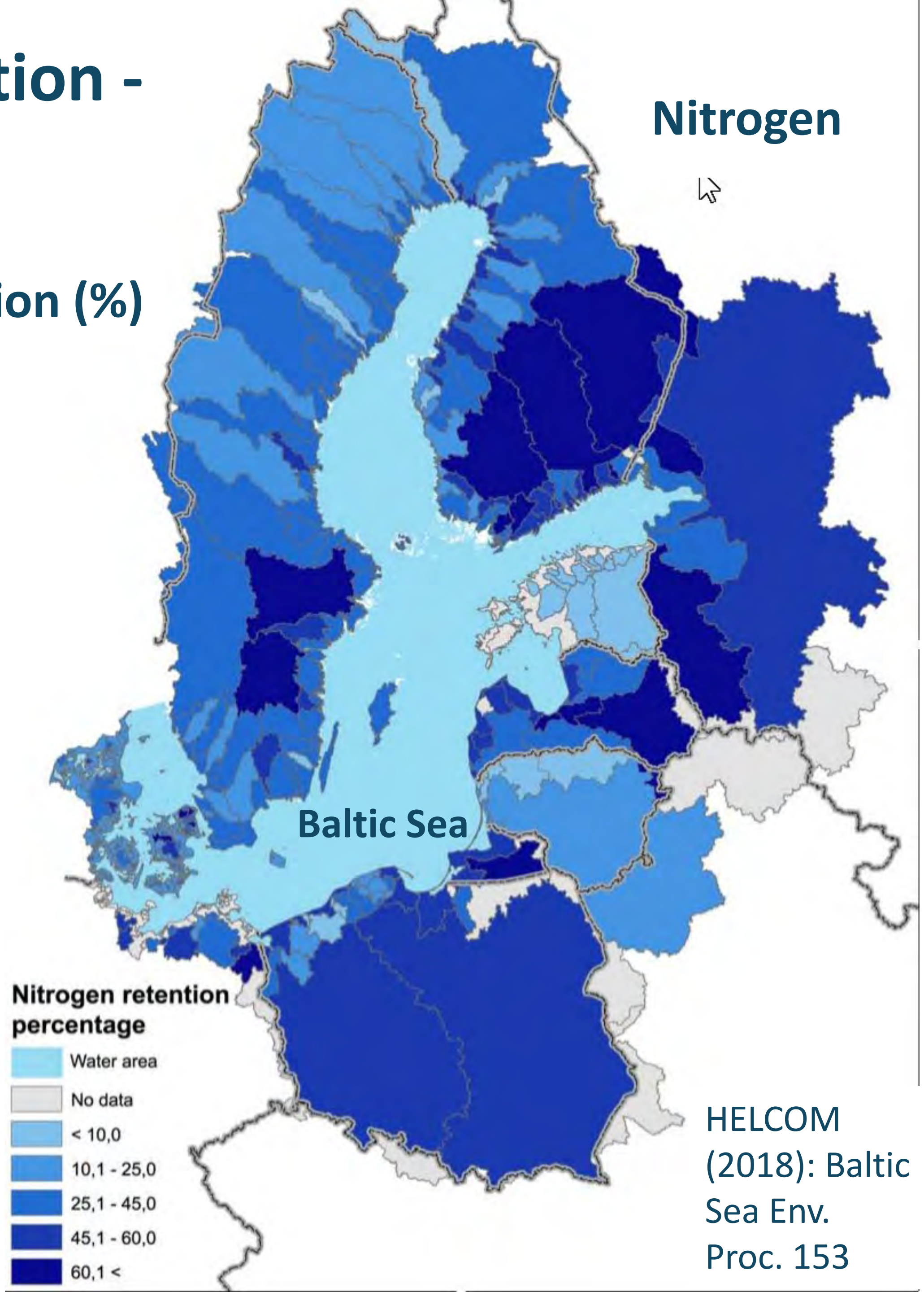
Livestock units per agricultural area in 2017

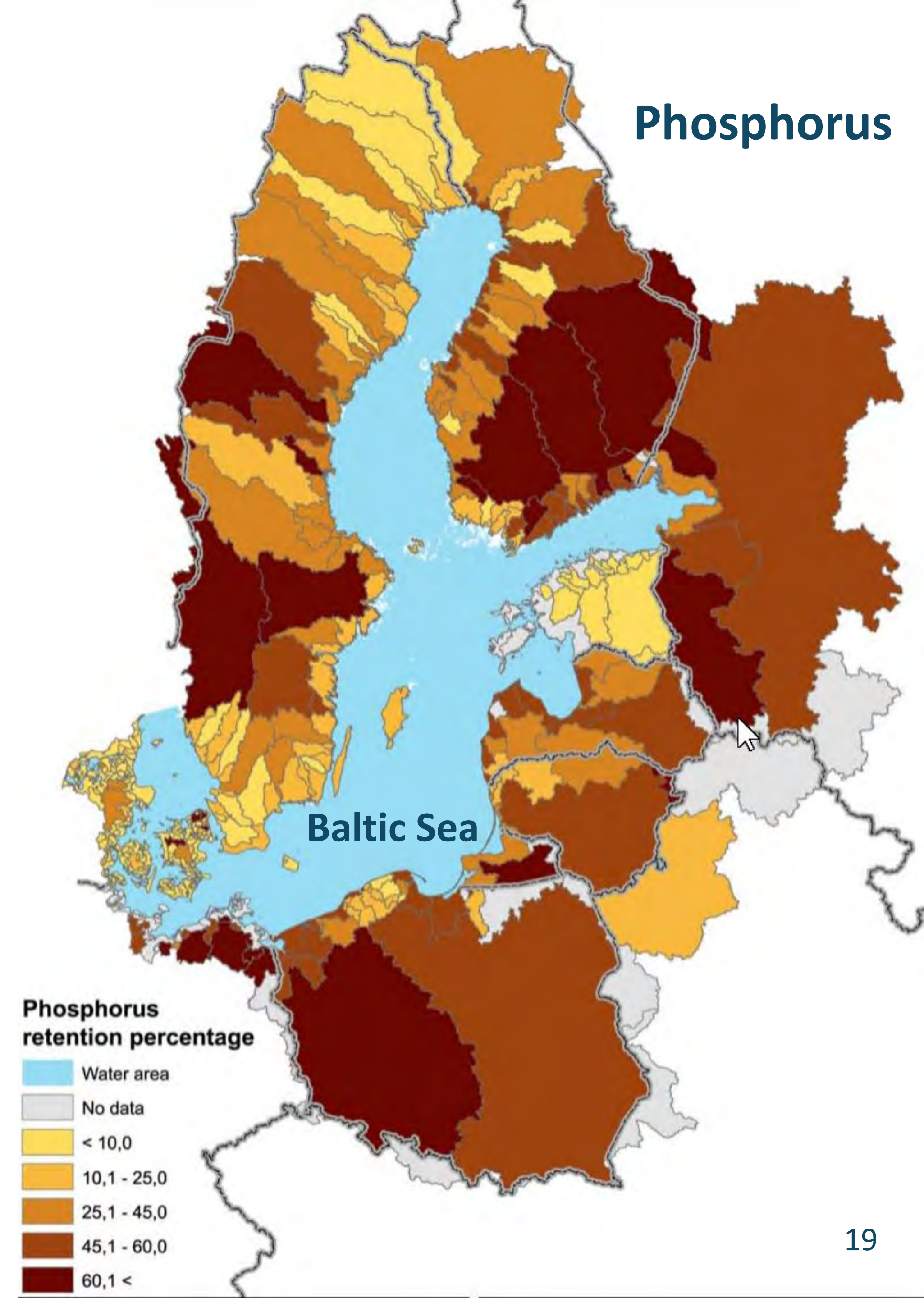


HELCOM (2021): Background for PLC-7

3. Eutrophication - causes

Nutrient retention (%)





HELCOM (2018): Baltic Sea Env. Proc. 153

4. Eutrophication - causes

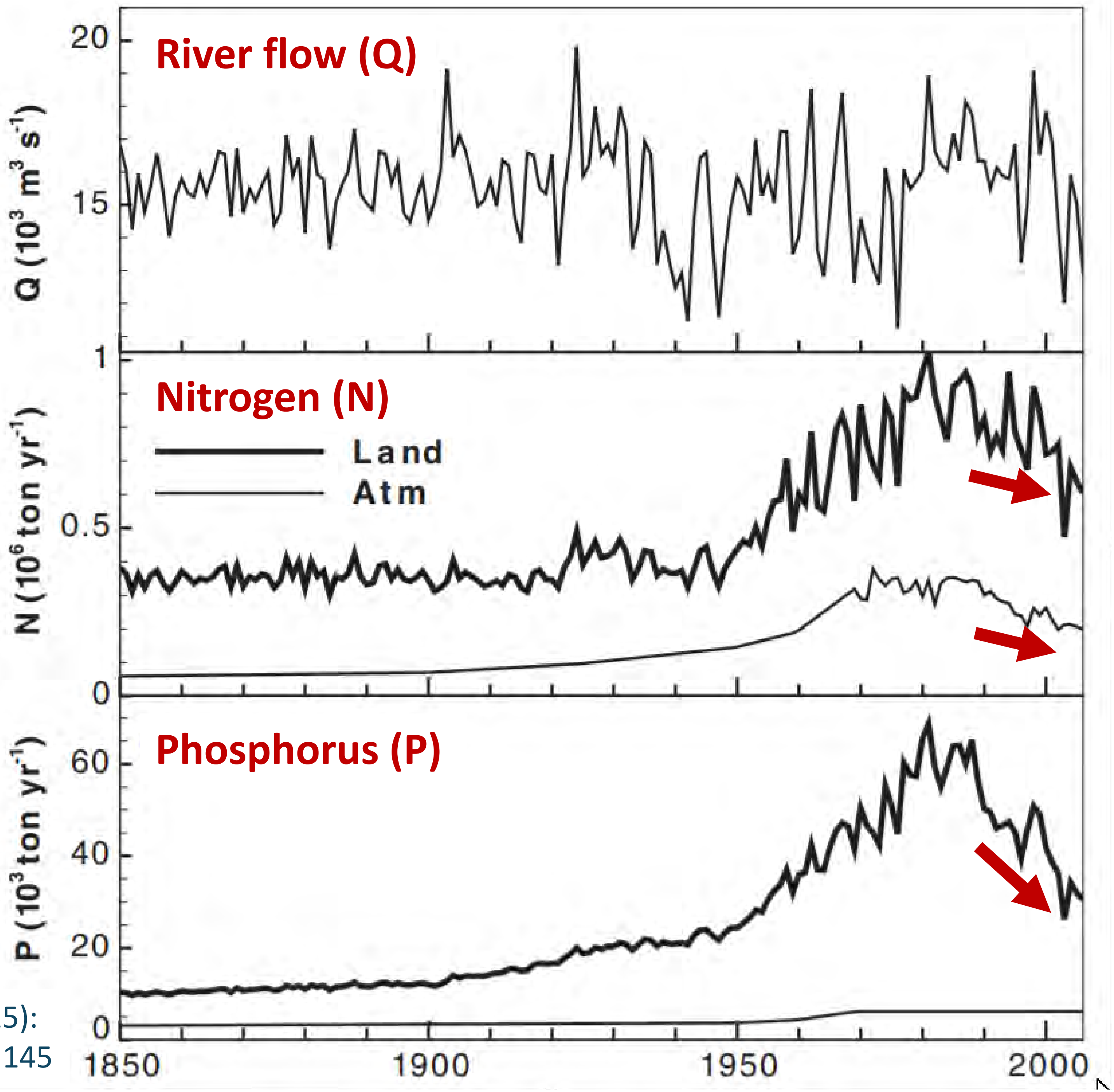
Waterborne and airborne inputs of phosphorus and nitrogen to the Baltic Sea in 2010 (water flow normalized)

Country	Flow (m^3s^{-1})	Nitrogen (t)			Phosphorus (t)		
		Water-borne	Airborne	Total	Water-borne	Airborne	Total
Denmark	313	40,881	15,914	56,795	1,797		1,797
Estonia	452	25,362	3,180	28,542	667		667
Finland	2,326	62,255	9,722	71,977	2,973		2,973
Germany	128	24,145	38,327	62,472	596		596
Latvia	1,369	81,539	3,457	84,996	3,109		3,109
Lithuania	790	55,980	4,969	60,949	2,326		2,326
Poland	2,880	270,287	31,278	301,565	14,845		14,845
Russia	3,577	93,186	14,813	107,999	6,208		6,208
Sweden	5,863	104,702	14,207	118,909	3,649		3,649
Baltic Shipping			13,523	13,523			
EU20			39,987	39,987			
Other air			29,227	29,227			
Atmos. P sources						2,087	2,087
Total	17,698	758,337	218,604	976,941	36,168	2,087	38,255

HELCOM (2015): Baltic Sea Environment Proceedings No. 145

5. Eutrophication - trends

Long-term time series of annual average total river flow, nitrogen, and phosphorus loads from land and atmosphere to the **whole Baltic Sea**.

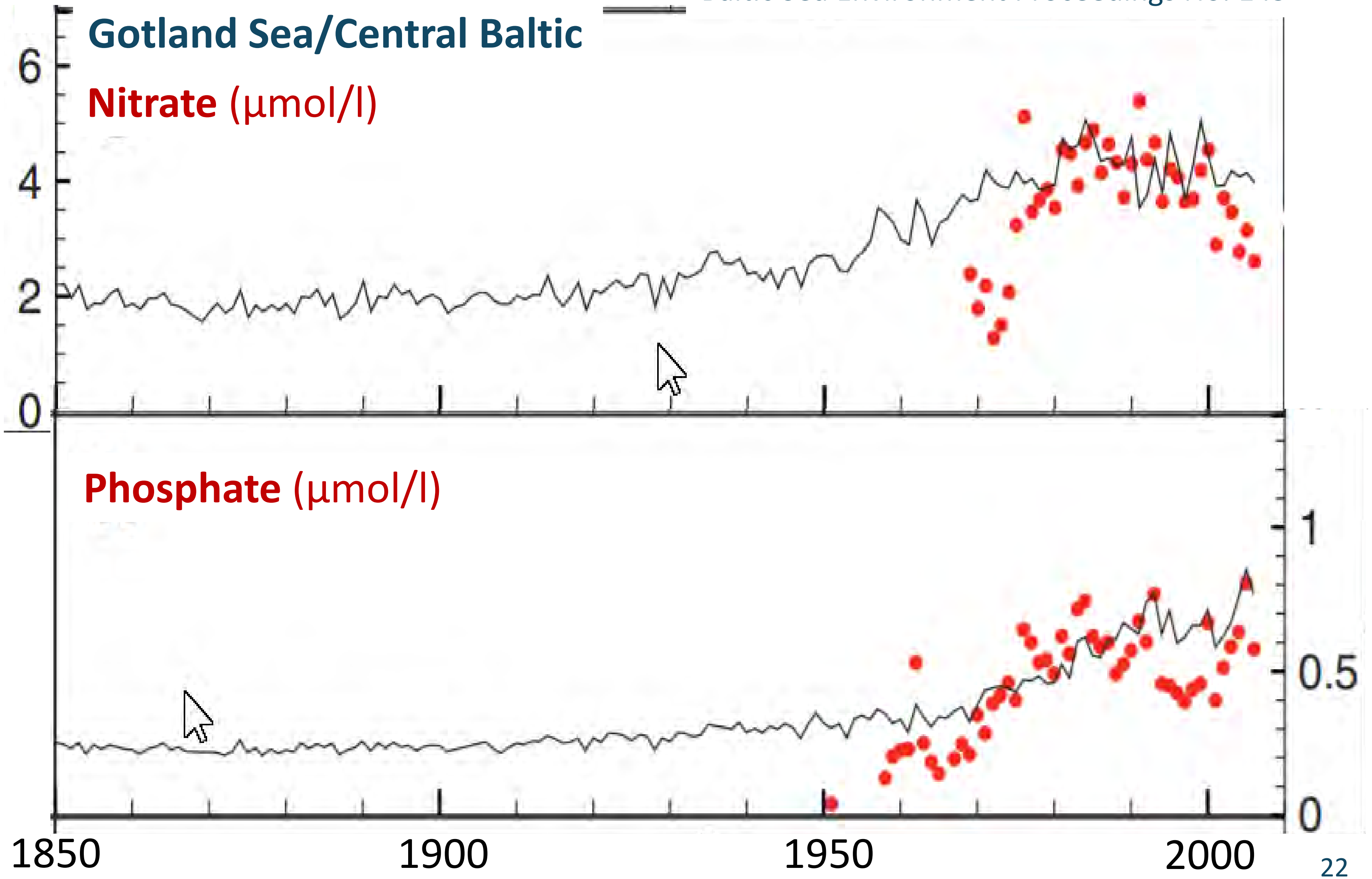


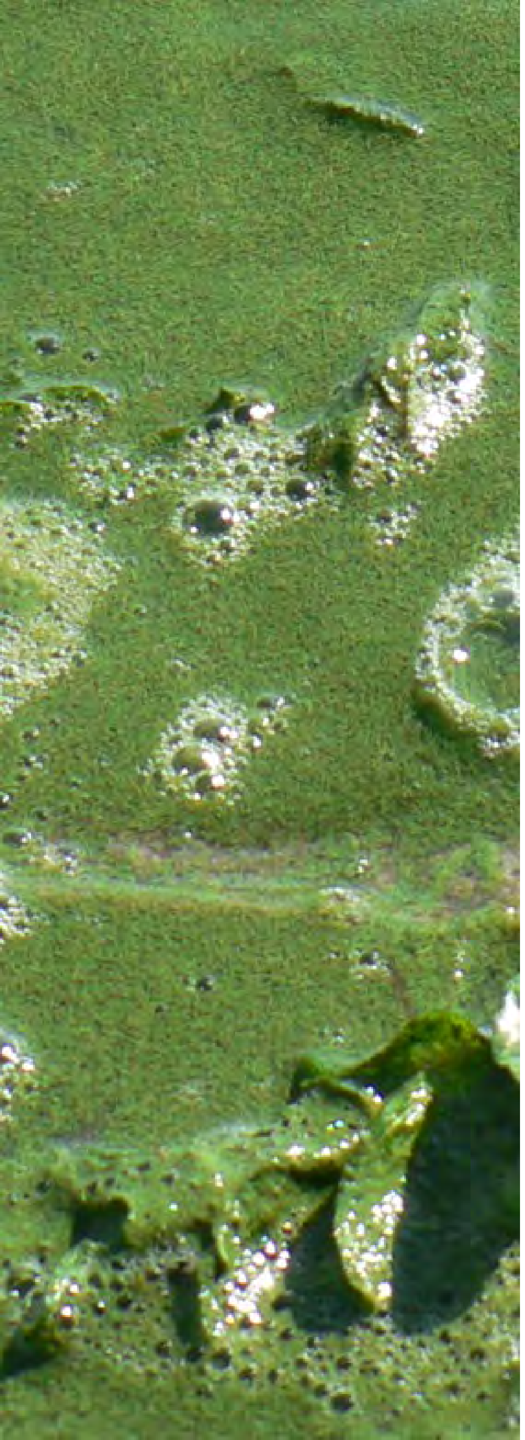
Gustafsson et al. (2012) in HELCOM (2015): Baltic Sea Environment Proceedings No. 145

5. Eutrophication - trends

Winter average surface nitrate and phosphate concentrations in Gotland Sea. Lines are modelled and red dots are averages made from observations.

Gustafsson et al. (2012) in HELCOM (2015): Baltic Sea Environment Proceedings No. 145



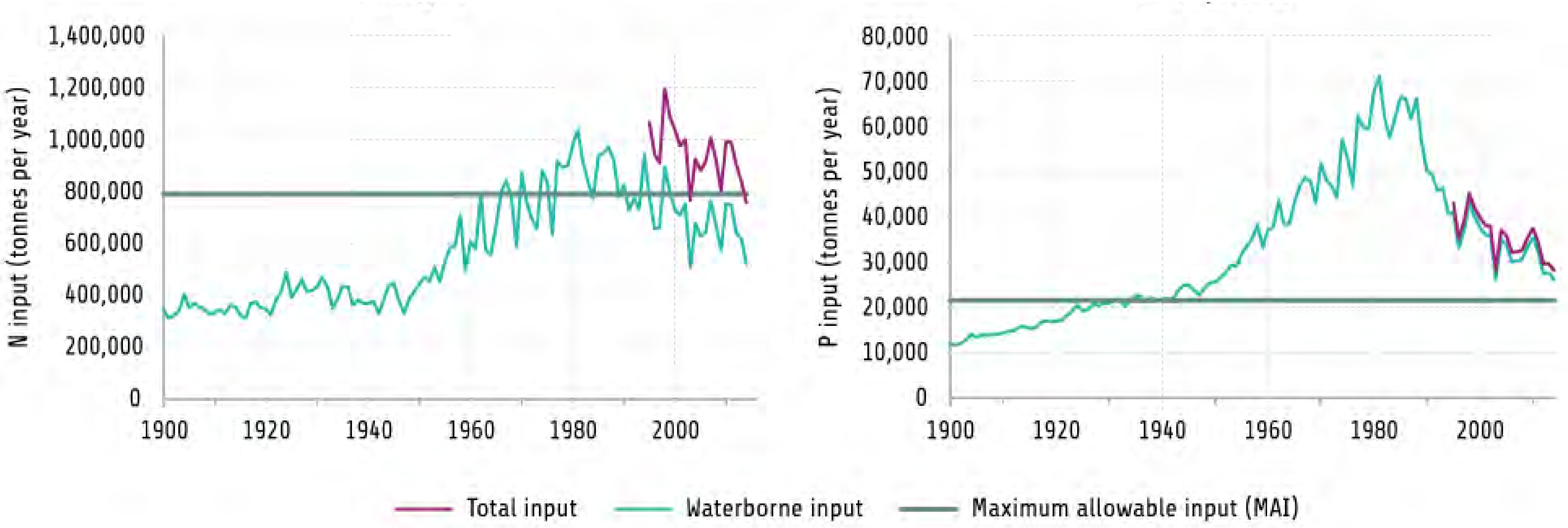


6. Eutrophication - assessments

- Primary production (algae growth) in the open Baltic Sea is limited by nitrogen.
- Blue algae are able to fix atmospheric nitrogen and can overcome nitrogen shortages in the water.
- Therefore, a positive effect of riverine N-load reductions on the open Baltic Sea is questionable.
- As a consequence, eutrophication management has a stronger focus on phosphorus reductions.
- For both nutrients, maximum allowable inputs (MAI) that allow a good environmental status in the sea are defined.
- The state of eutrophication is assessed based on the eutrophication ratio (ER) which includes dissolved inorganic nitrogen and –phosphorus, chlorophyll-a concentrations, Secchi-depth and oxygen debt.

6. Eutrophication - assessments

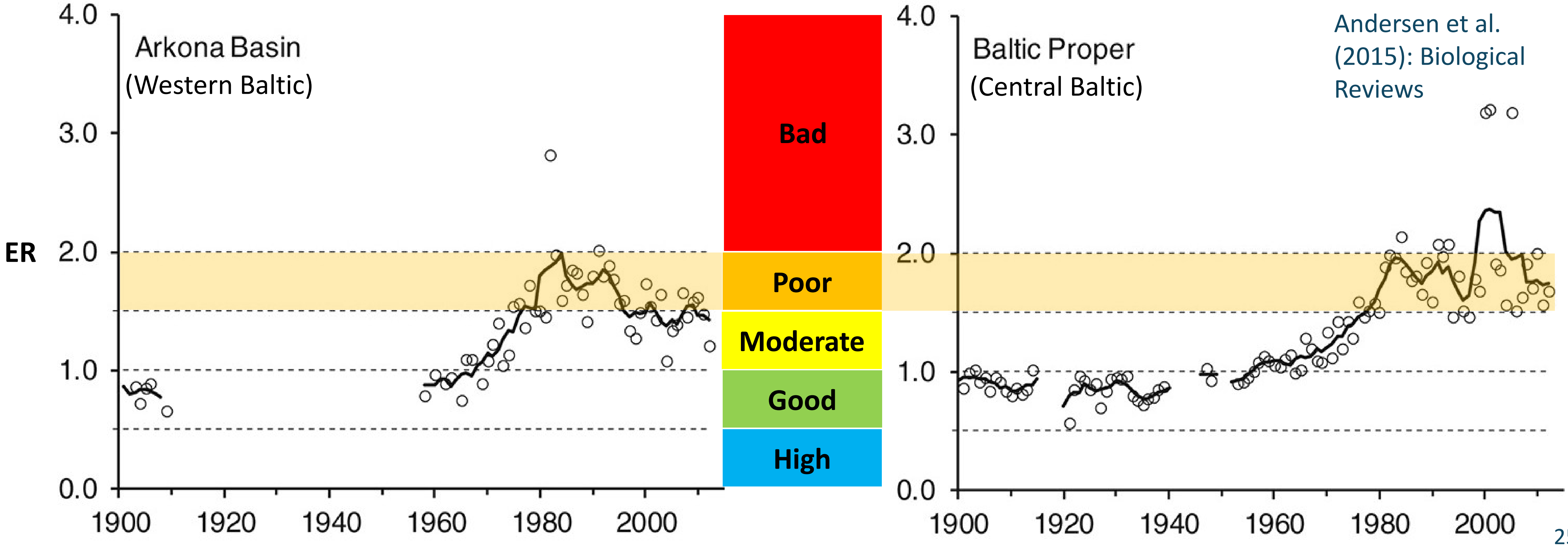
Temporal development of waterborne total nitrogen and phosphorus inputs to the Baltic Sea from 1900 to 2014



HELCOM (2018): Baltic Sea Environment Proceedings 155; Gustafsson et al. (2012); Savchuk et al. (2012)

6. Eutrophication - assessments

Integrated assessment of eutrophication status (eutrophication ratio, ER) for the period 1901–2012. Dashed lines represent boundaries for eutrophication status classes. The solid line is the 5-year average.

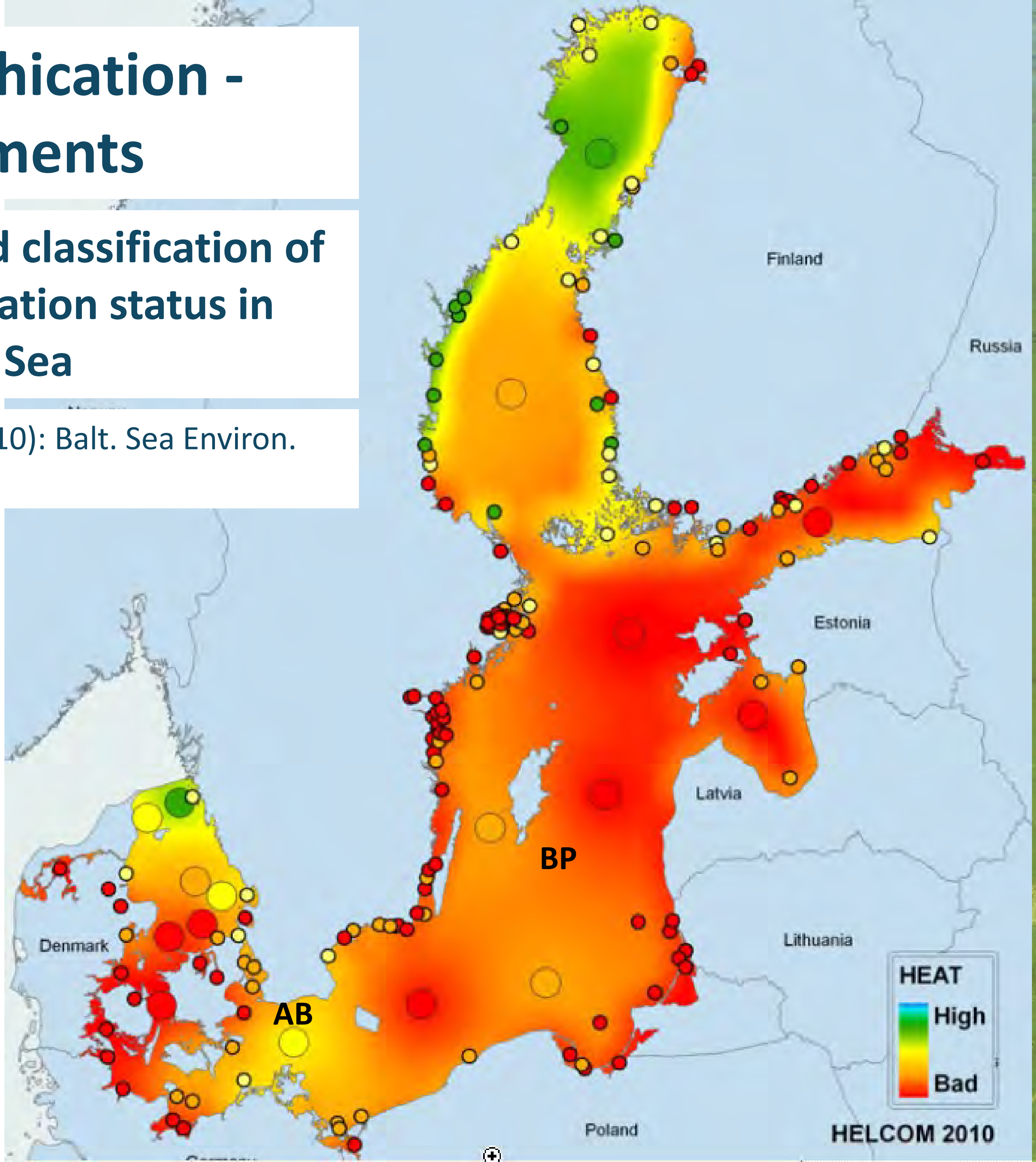


Andersen et al. (2015): Biological Reviews

6. Eutrophication - assessments

Integrated classification of eutrophication status in the Baltic Sea

HELCOM, (2010): Balt. Sea Environ. Proc. No. 122



Summary

- The relatively large Baltic catchment and the humid climate favor high riverine discharge and high nutrient loads
- Intensive agriculture is a major cause for high nutrient loads and eutrophication
- The relative shallowness makes the Baltic Sea sensitive to eutrophication
- The state of eutrophication is mostly poor or moderate
- Nutrient loads are declining but the long water residence time in the sea does not allow a fast recovery

Thank you for your attention!

Prof. Dr. Gerald Schernewski
gerald.schernewski@io-warnemunde.de
Leibniz-Institute for Baltic Sea Research, Warnemünde, Germany; Klaipeda University, Lithuania