The Baltic Sea - Climate Change

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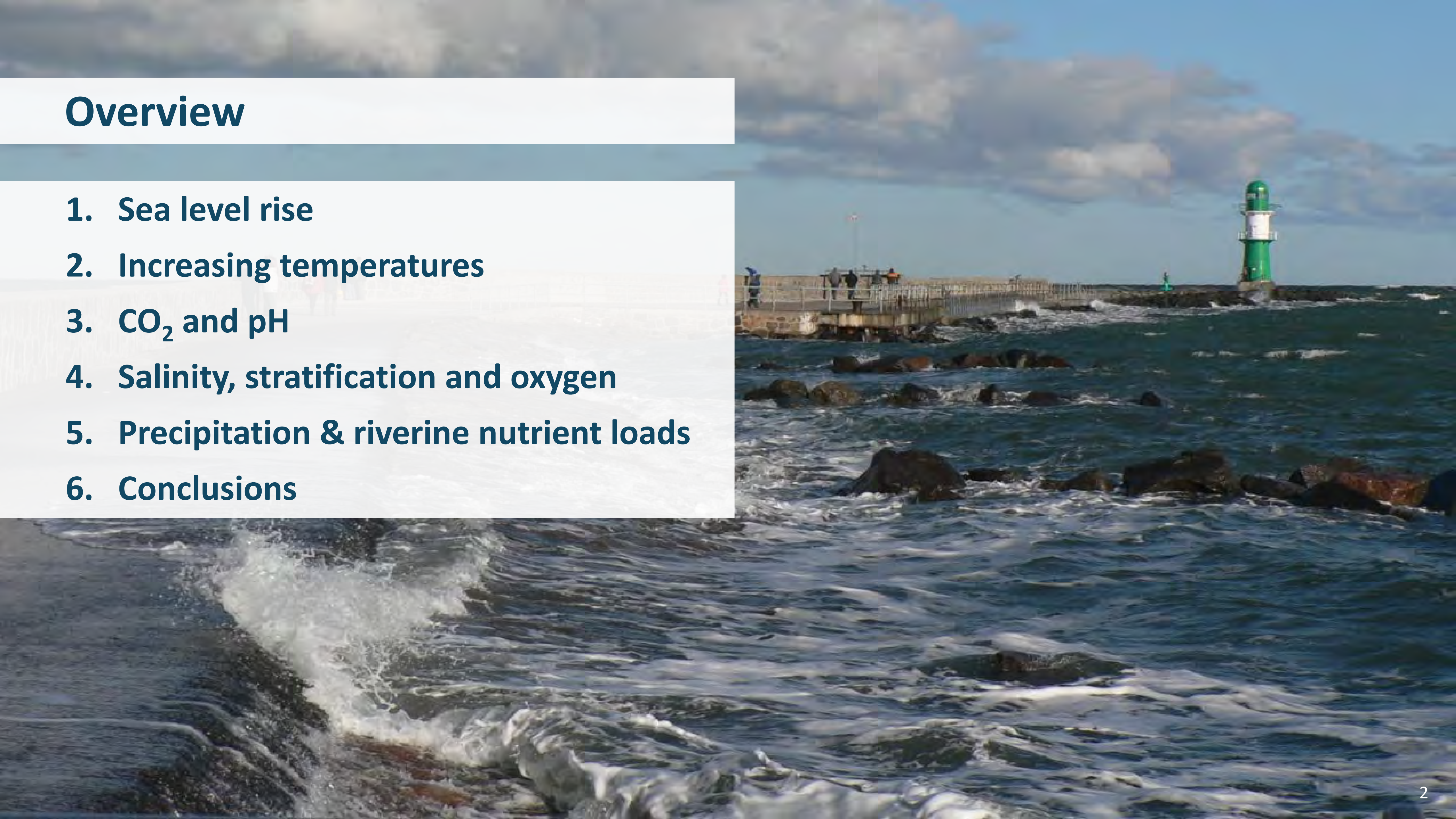
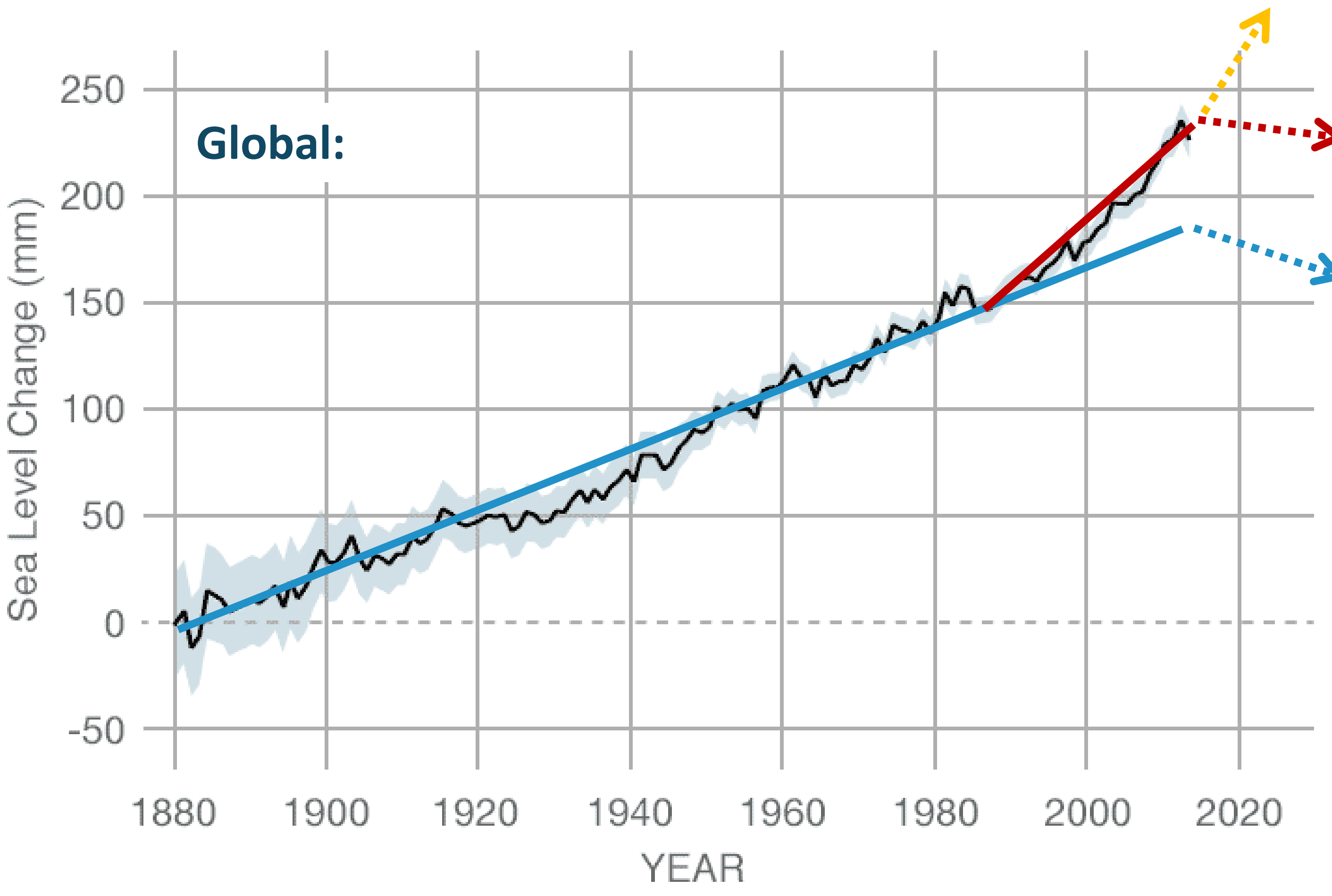
Overview

1. Sea level rise
2. Increasing temperatures
3. CO_2 and pH
4. Salinity, stratification and oxygen
5. Precipitation & riverine nutrient loads
6. Conclusions



1. Sea level rise



https://earthscience.stackexchange.com/

Baltic Sea:

Sea level rise projections 2100:
Up to 10 mm per year

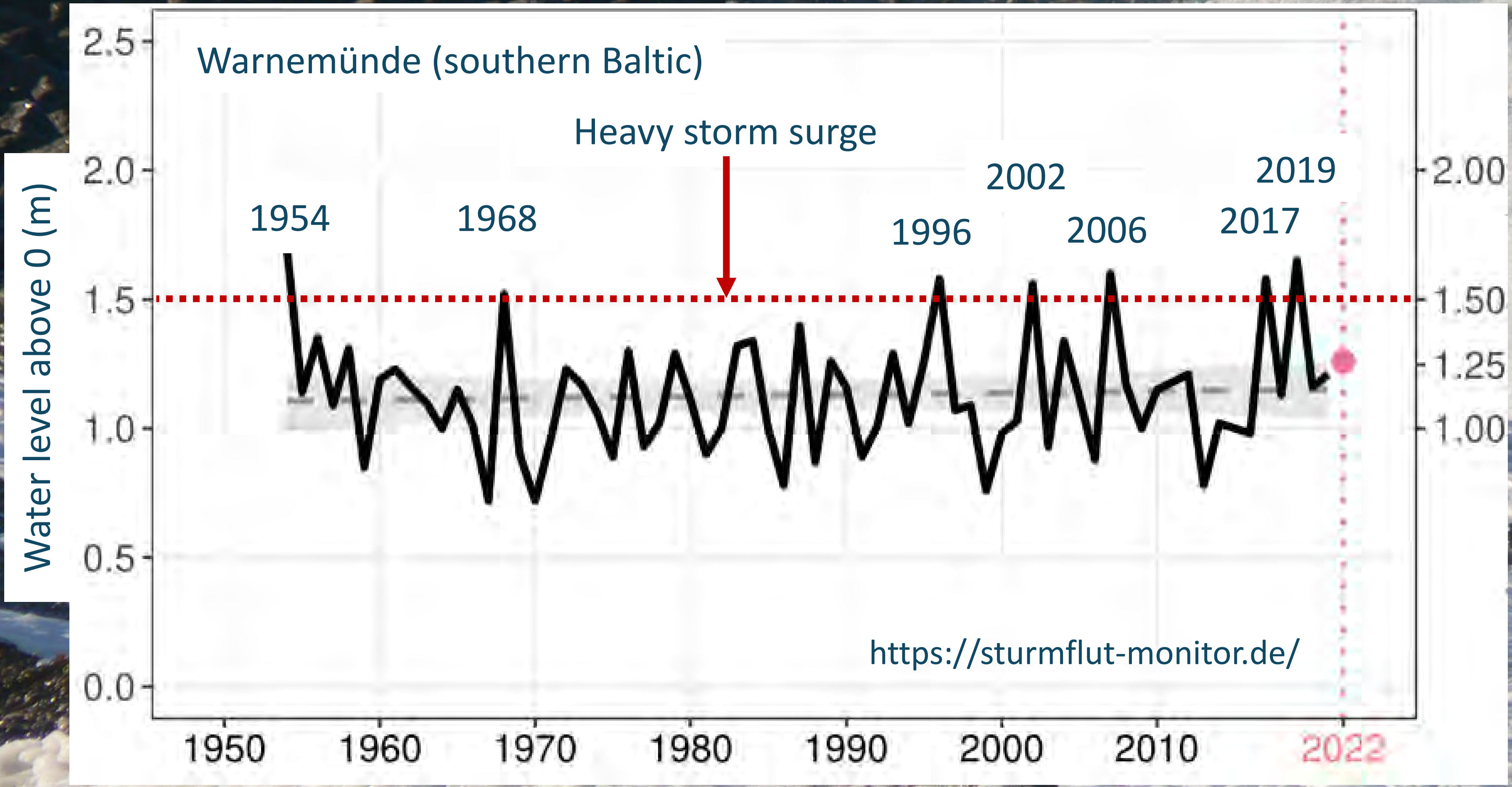
Present sea level rise :
3-4 mm per year

Historic sea level rise :
1-2 mm per year

BACC II – Report (2015)

1. Storm surges

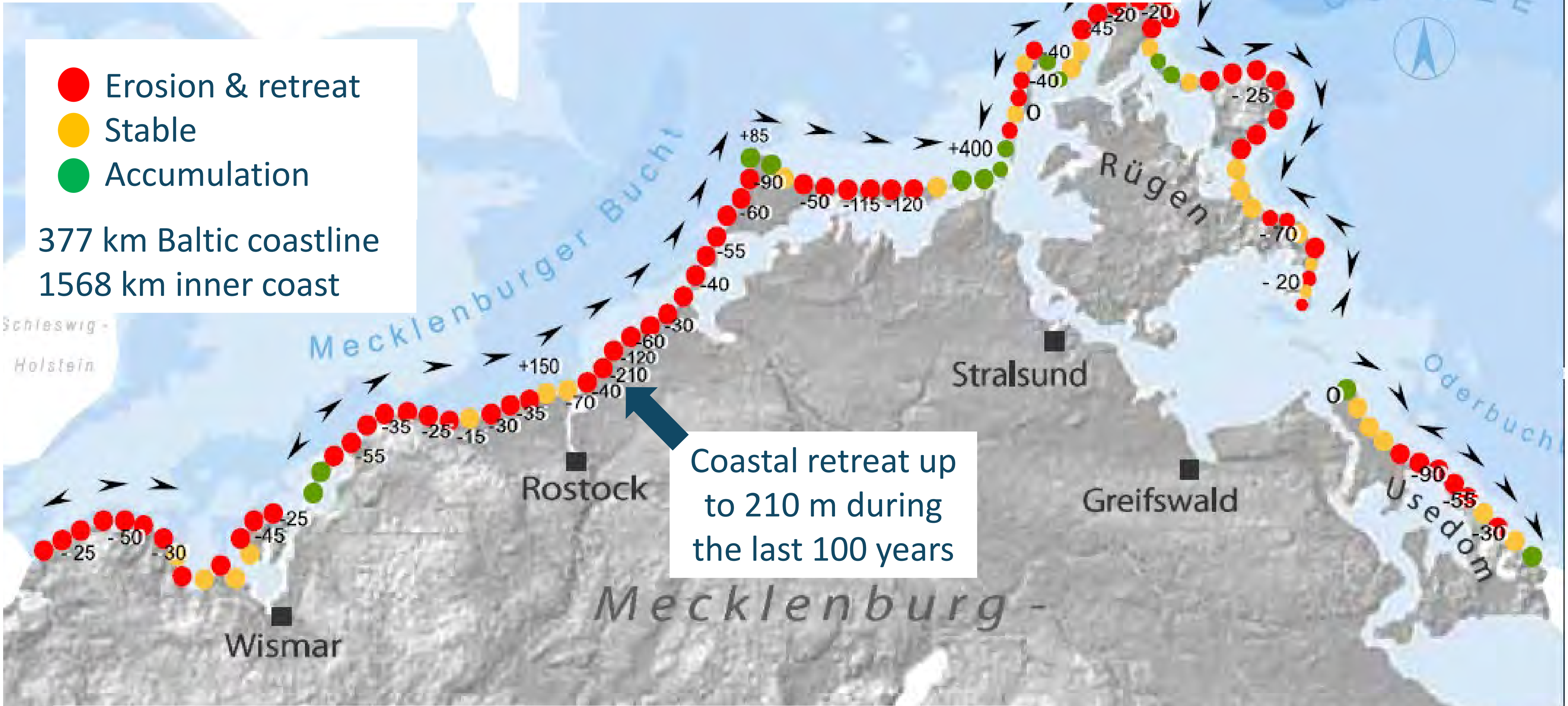
- ➢ Tendency towards a higher likelihood of storm surges
- ➢ Uncertain future changes in extreme winds and waves



1. Coastline changes at the eastern German Baltic coast

- Erosion & retreat
- Stable
- Accumulation

377 km Baltic coastline
1568 km inner coast

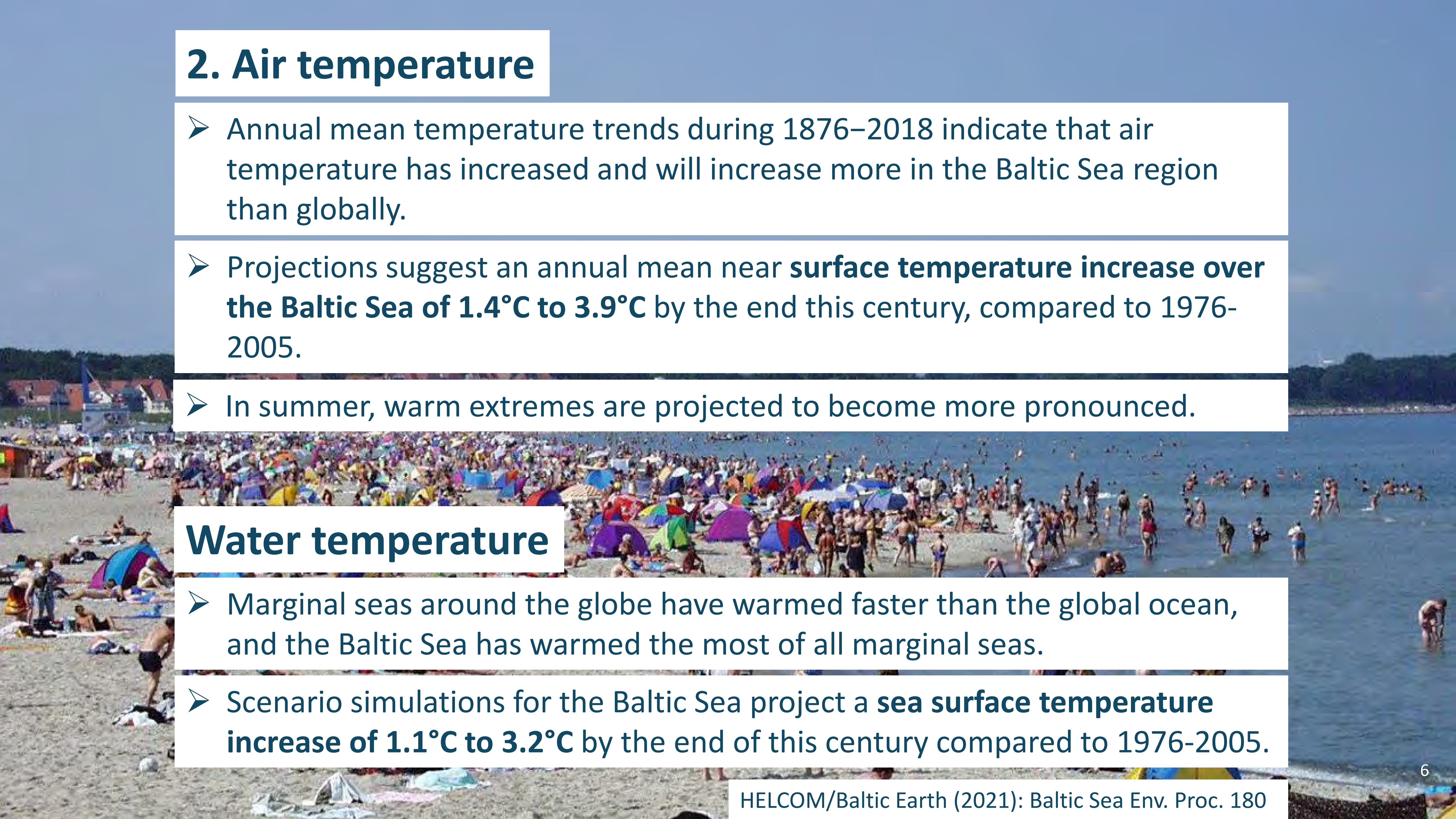


Coastal retreat up to 210 m during the last 100 years

Annual coastal protection costs are about 15 million €/year.

Coastal erosion will increase in future.

Regelwerk Küstenschutz MV (2009)



2. Air temperature

- Annual mean temperature trends during 1876–2018 indicate that air temperature has increased and will increase more in the Baltic Sea region than globally.
- Projections suggest an annual mean near **surface temperature increase over the Baltic Sea of 1.4°C to 3.9°C** by the end this century, compared to 1976-2005.
- In summer, warm extremes are projected to become more pronounced.

Water temperature

- Marginal seas around the globe have warmed faster than the global ocean, and the Baltic Sea has warmed the most of all marginal seas.
- Scenario simulations for the Baltic Sea project a **sea surface temperature increase of 1.1°C to 3.2°C** by the end of this century compared to 1976-2005.

HELCOM/Baltic Earth (2021): Baltic Sea Env. Proc. 180

2. Tourismus & beach management – will problems increase?

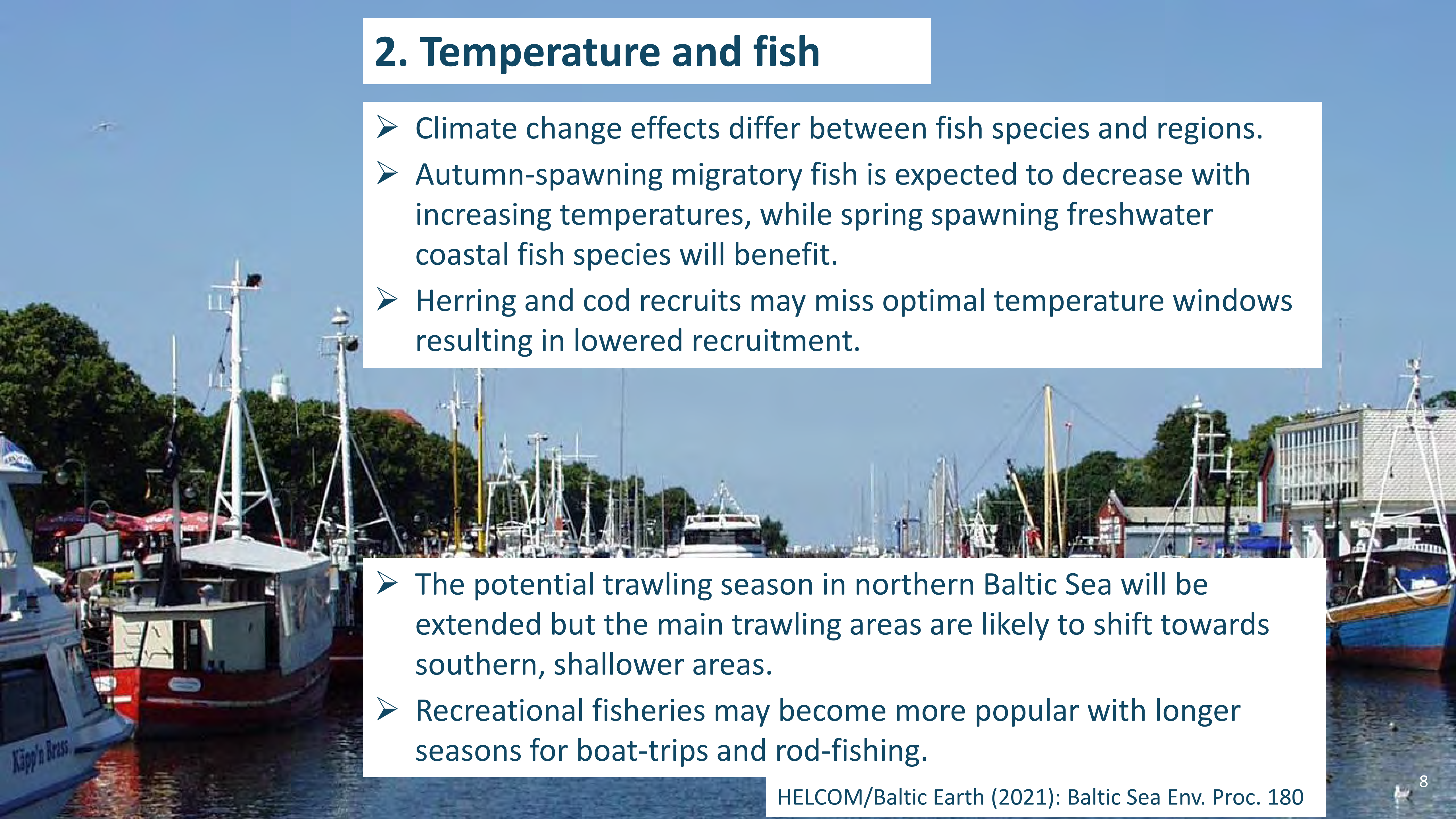
Problems:

- Increasing tourismus (longer season) and increasing urbanisation pressure (‚climate refugees') cause intensified beach usage.
- Increasing erosion and coastal protection measures reduce the beach area.

➡ Coastal squeeze

Consequences:

- Increasing costs for beach maintenance
- Increasing pressure on coastal habitats
- Modifications of the coastline due to hard-substrate for protection measures
- Off-shore sandbanks - conflict between beach nourishment and nature protection



2. Temperature and fish

- Climate change effects differ between fish species and regions.
- Autumn-spawning migratory fish is expected to decrease with increasing temperatures, while spring spawning freshwater coastal fish species will benefit.
- Herring and cod recruits may miss optimal temperature windows resulting in lowered recruitment.
- The potential trawling season in northern Baltic Sea will be extended but the main trawling areas are likely to shift towards southern, shallower areas.
- Recreational fisheries may become more popular with longer seasons for boat-trips and rod-fishing.

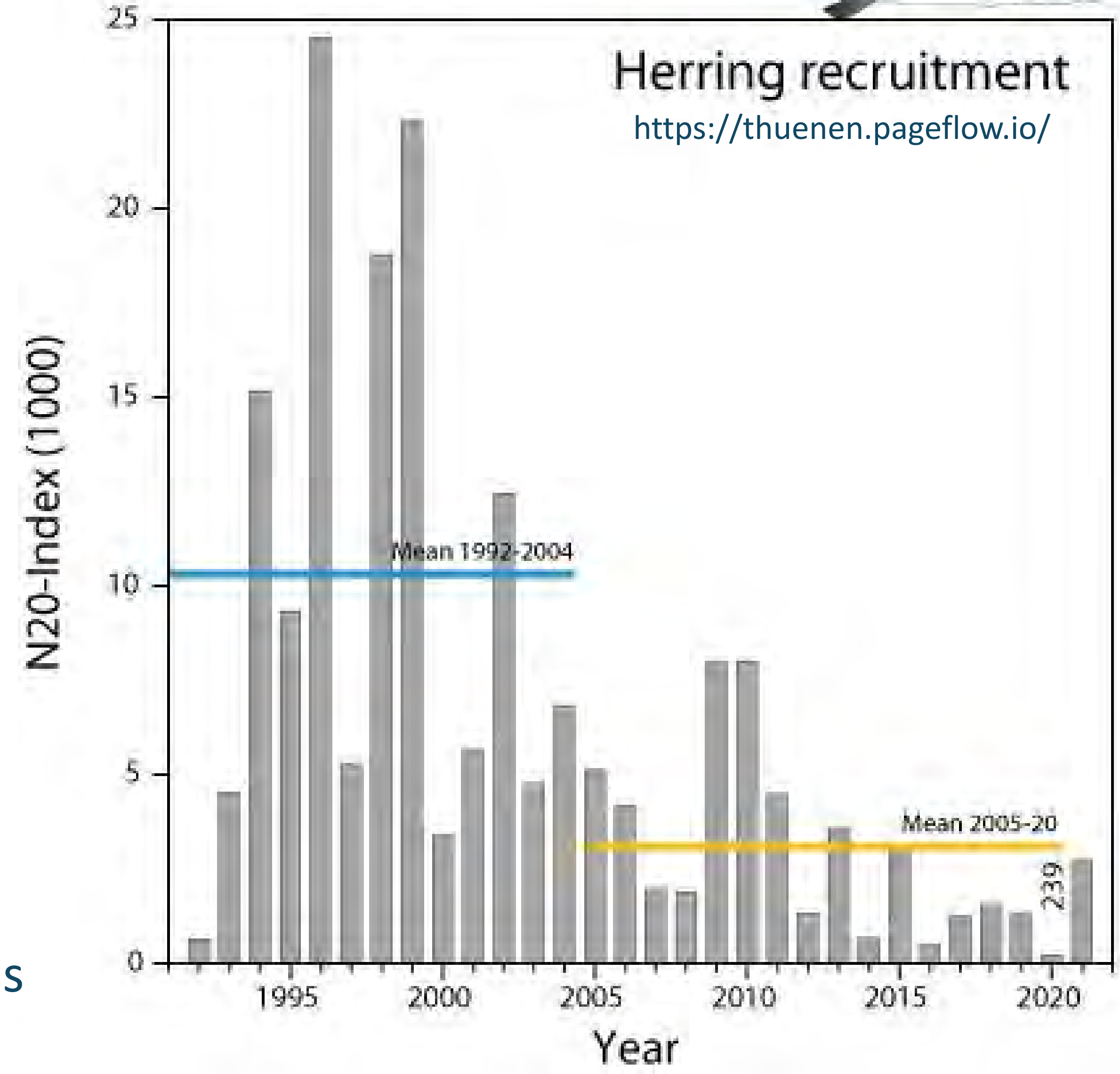
HELCOM/Baltic Earth (2021): Baltic Sea Env. Proc. 180

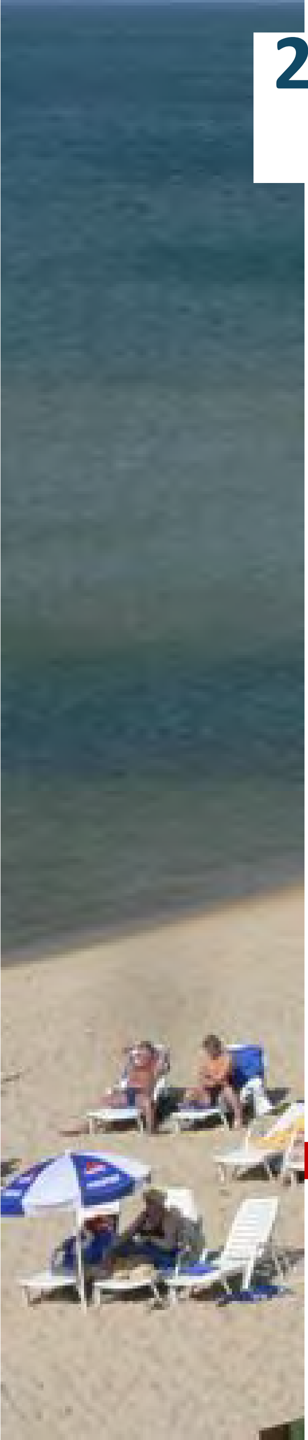
2. Temperature & food webs

- In Greifswald Bay (western Baltic Sea) the number spring-spawning herring larvae is decreasing.
- Herring catches dropped from 200,000 t (1992) to 22,000 t (2020).
- Higher temperatures cause earlier spawning in spring, the eggs develop faster and the larvae hatch earlier.
- The larvae require external food (zooplankton) three weeks earlier compared to the 1990‘s.
- Zooplankton (crustaceans) is not available at that time, because its development depends on phytoplankton which is light driven.

➡ Decoupling of food webs with strong ecological and economic consequences

Polte et al. (2021): Front. Mar. Sci. 8: 589242



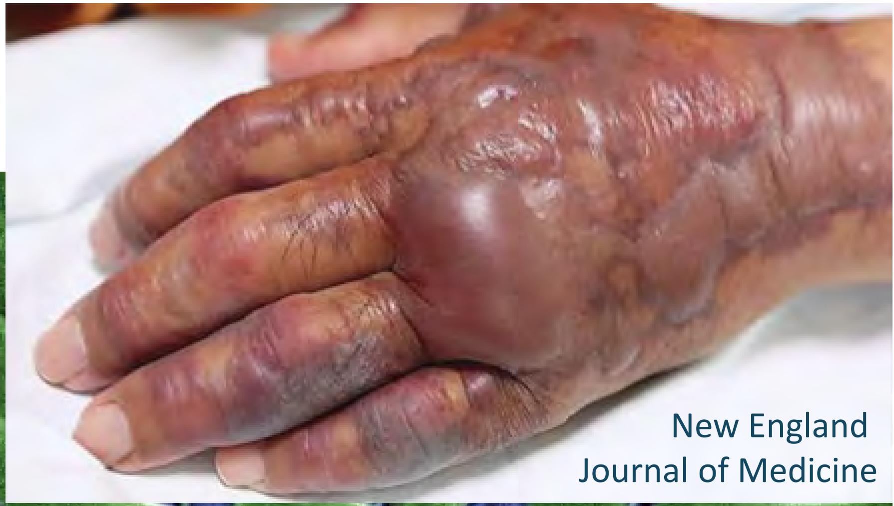


2. Temperature & bathing water quality

Unknown hazards e.g. *Vibrio vulnificus* bacteria

- *Vibrio vulnificus* is naturally present in marine and brackish waters.
- It can enter the body through open wounds when swimming or via seafood.
- *When Vibrio vulnificus* infections worsens into septicaemia, the mortality rate is high.
- *Vibrio cholerae*, causing cholera, is a near relative.
- Very high *Vibrio vulnificus* concentrations have been observed at German Baltic beaches.
- At the German Baltic coast, several persons died after an infection.
- In Germany, a regular monitoring takes place since 2004

→ ***Vibrio vulnificus develops fast at temperatures above 20°C. It benefits from shallow waters and climate change.***



New England Journal of Medicine

Janice Carr, USCDCP

2. Temperature & bathing water quality

Most important organisms which are a serious health risk for bathers in The Netherlands (Pond, 2005; Giessen et al., 2004) as well as changes in risk due to the anticipated climate change.

organism	disease*	oxygen	temp. (max.)	fresh/marine	dry/wet	vector	increased risk
Bacteria							
Escherichia coli O157	abdominal cramping, bloody diarrhoea		< 5 19.3-41.0 (b)	fresh	wet	cattle	0
Legionella pneumophila	Legionnaires' disease	aerobic	25- 35 (60)	fresh/brackish	wet	free-living	++
Leptospira icterohaemorrhagiae	leptospirosis (Weil's disease)	aerobic	28-30; < 42		wet	rats	++
Listeria monocytogenes	listeriose (meningoencephalitis)	anaer. + aer.	3-42		wet/dry		0
Mycobacterium avium	lung damage	low	up to 45		wet/dry	animals, humans	++
Salmonella spp.	(para)typhus	fac. anaer.		fresh/marine	wet	animals, humans	0
Shigella spp.	dysentery	fac. anaer.	12-37 (20)		wet	man, gorilla	0
Vibrio cholerae	diarrhoea	fac. anaer.		fresh	wet/dry	free-living	++
Vibrio vulnificus	necrotising wound, infections, gastrenteritis	fac. anaer.		marine	wet	free-living	++
Algae							
Pfiesteria piscicida	skin irritation, nervus system problems	aerobic		marine	wet	free-living	++
Protozoa							
Brucella spp.	brucellosis					cattle	0
Clostridium botulinum	paralysis	low	> 20	fresh/marine	wet	birds	+++
Cryptosporidium parvum	diarrhoea			fresh/marine	wet-oocysts	mammals	++
Giardia duodenalis	diarrhoea				wet-oocysts	animals, humans	++
Microsporidia	infection digestive tract				wet-spores	animals, humans	0
Naegleria fowleri	meningoencephalitis		25-35	fresh warm	wet-sediment	free-living	++
Viruses							
Human adenovirus	upper respiratory tract						++
coxsackievirus	gastro-enteritis						++
echovirus	gastro-enteritis						++
hepatitis A	jaundice						++
hepatitis E	jaundice						++

* only the most important diseases

Many human-pathogens benefit from climate change.

„New" human-pathogens may enter our waters, but will not be detected with the existing monitoring.

0 = no increased risk, ++ = slightly increased risk, +++ = increased risk

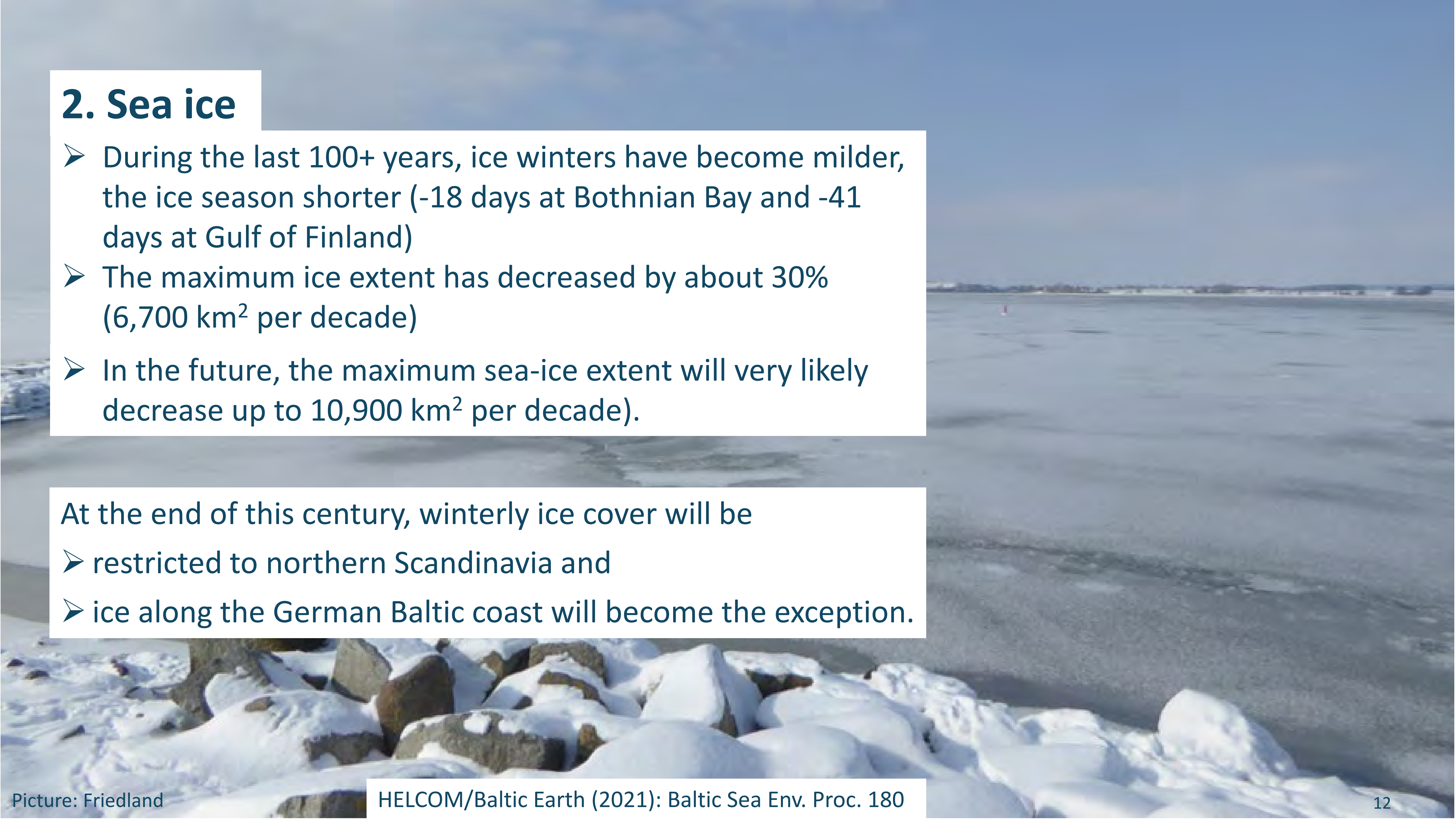
Source: Roijackers & Lürling (2007)

2. Sea ice

- During the last 100+ years, ice winters have become milder, the ice season shorter (-18 days at Bothnian Bay and -41 days at Gulf of Finland)
- The maximum ice extent has decreased by about 30% (6,700 km^2 per decade)
- In the future, the maximum sea-ice extent will very likely decrease up to 10,900 km^2 per decade).

At the end of this century, winterly ice cover will be

- restricted to northern Scandinavia and
- ice along the German Baltic coast will become the exception.



Picture: Friedland

HELCOM/Baltic Earth (2021): Baltic Sea Env. Proc. 180

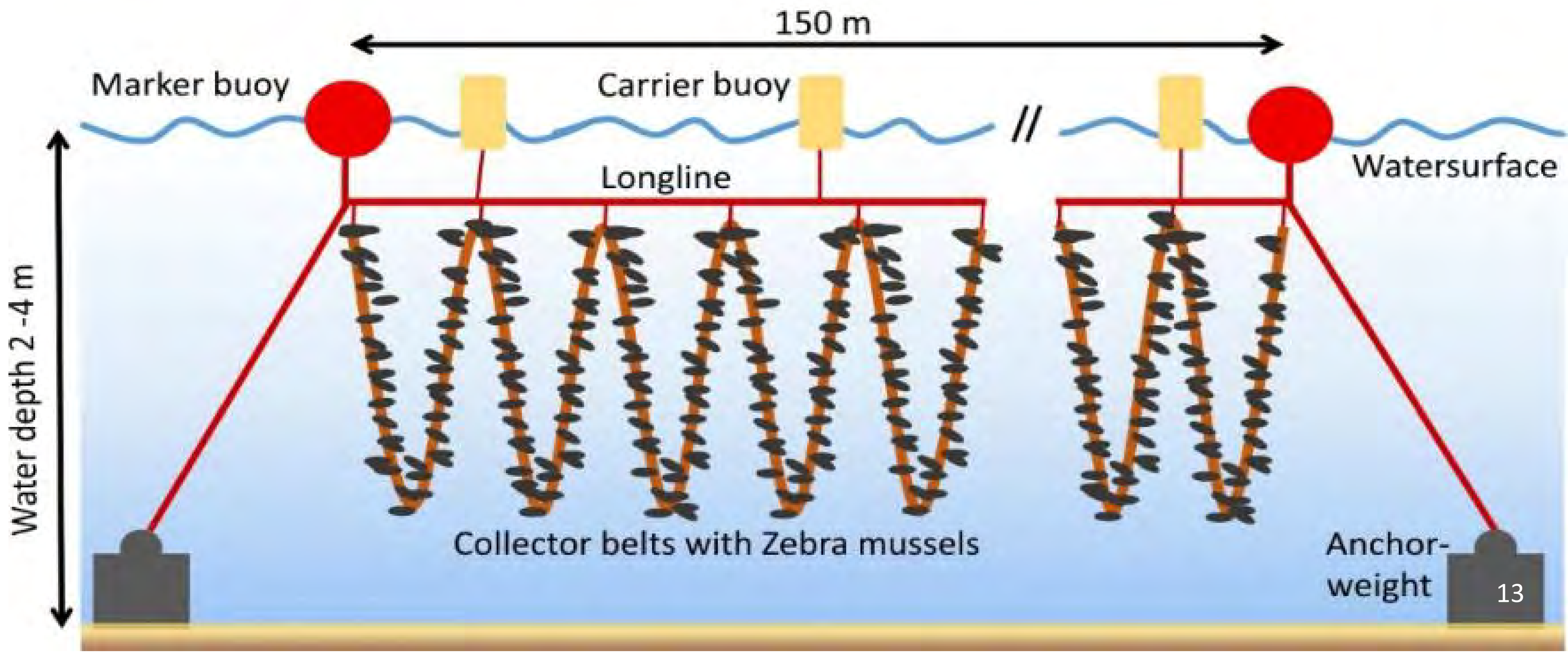
2. Ice & new uses: mussel farming

- A measure to remove nutrients, reduce algal blooms and increase water transparency.
- Mussels are a high-quality protein source.
- Mussel meal can substitute fish meal.

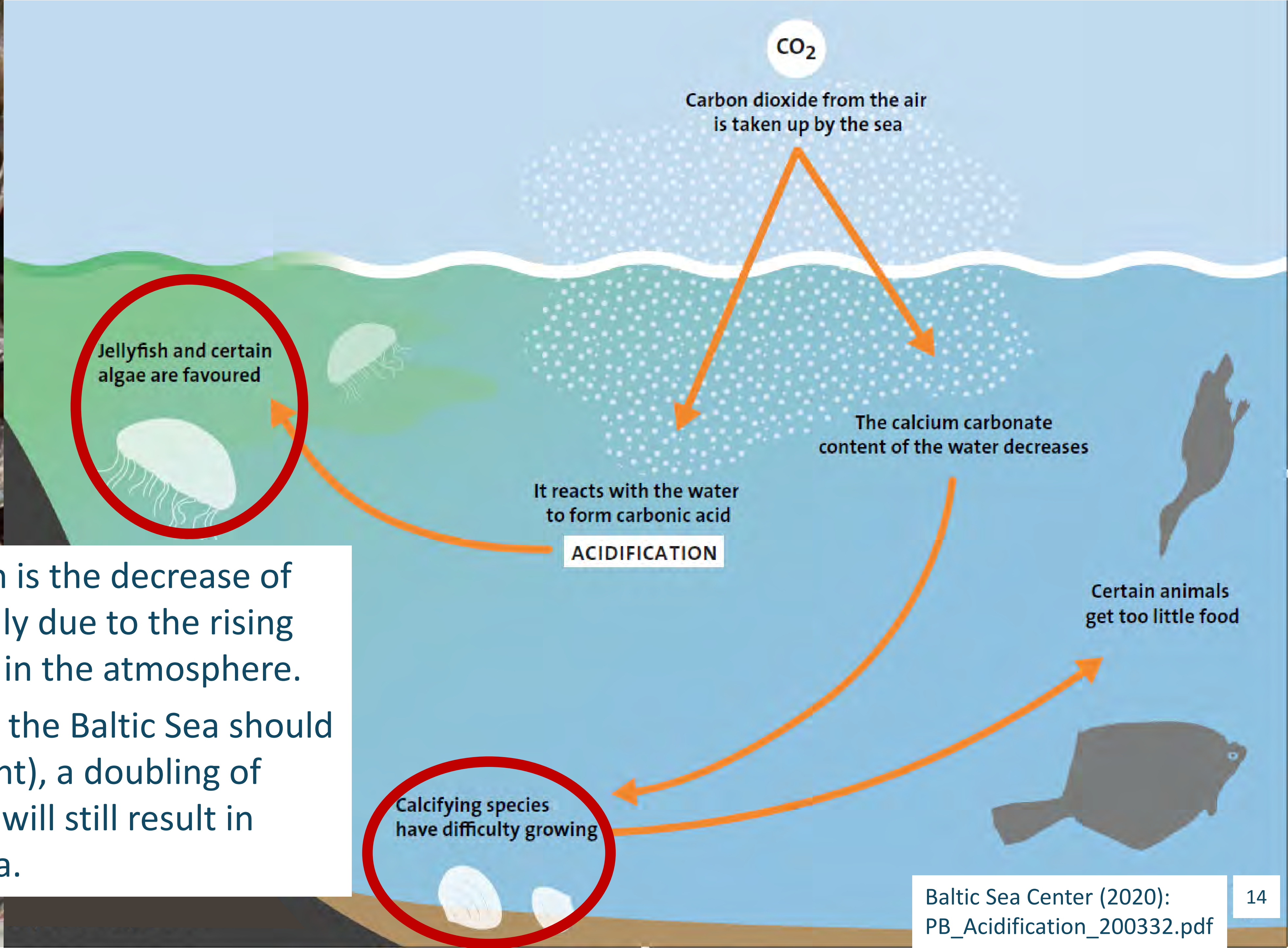
➡ High temperatures favour mussel cultivation.

➡ Drifting ice, the major threat for mussel farms in the Baltic, is reduced.

Schernewski, Stybel & Neumann (2012)



3. CO_2 and pH



- Ocean acidification is the decrease of seawater pH, mainly due to the rising CO_2 concentration in the atmosphere.
- Even if alkalinity in the Baltic Sea should increase (catchment), a doubling of atmospheric pCO_2 will still result in lower pH in the sea.

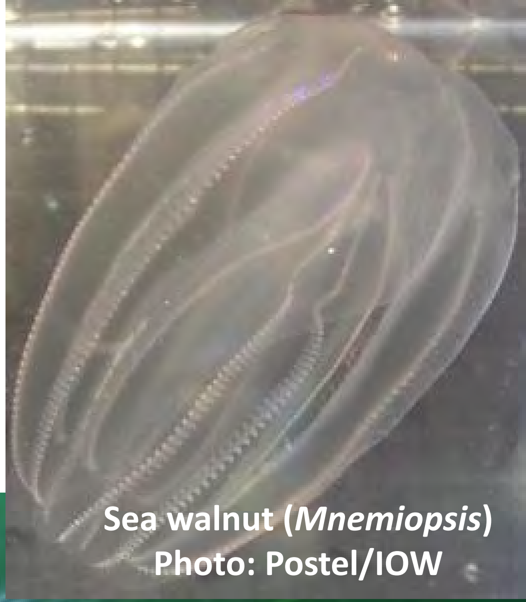
Baltic Sea Center (2020): PB_Acidification_200332.pdf

3. Jellyfish – pH and temperature

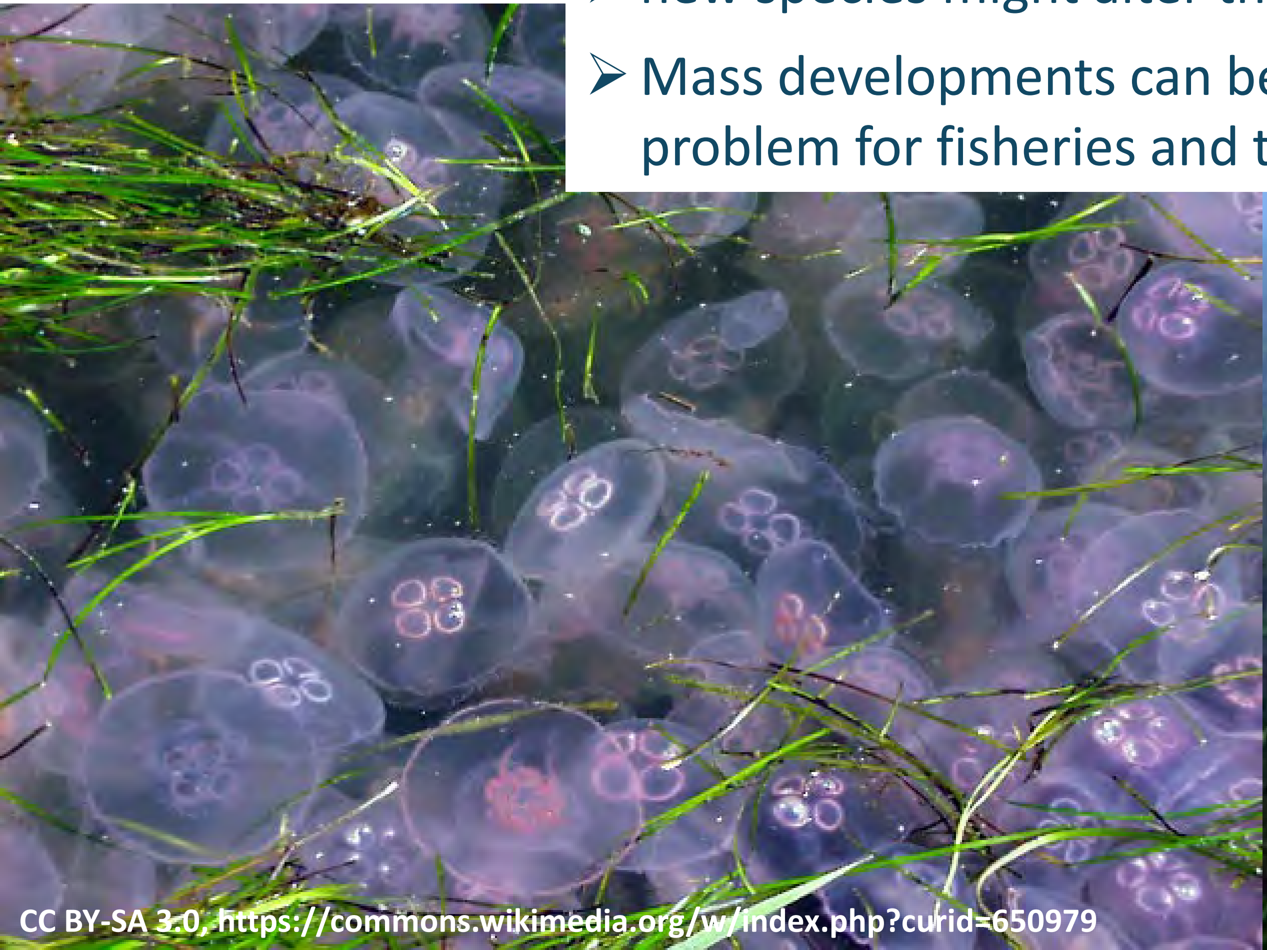
High temperatures and a low pH may favour jelly fish (together with overfishing).

Problems:

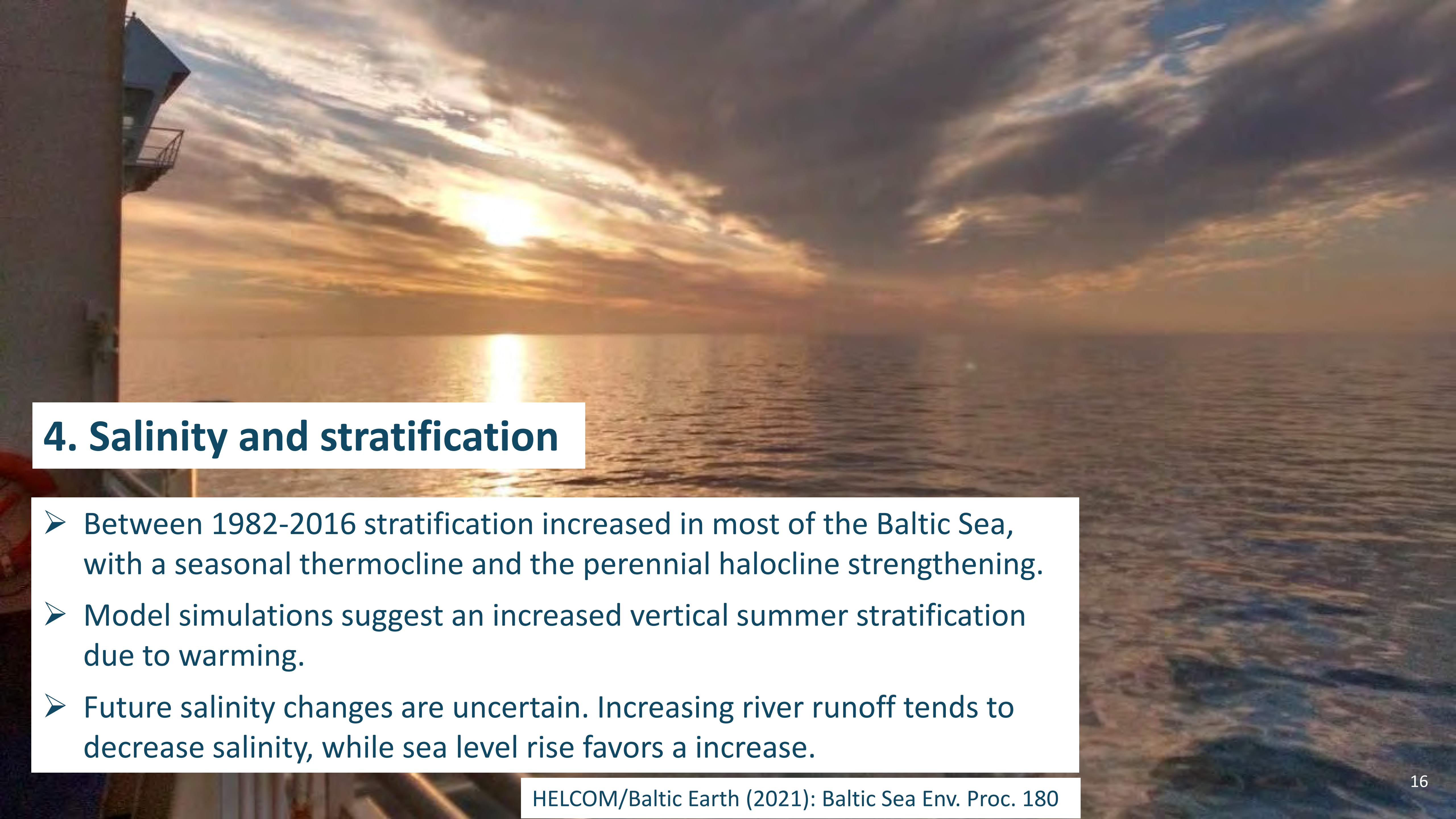
- Jellyfish prey on fish eggs and larvae,
- reduce the food (zooplankton) for fish, and
- new species might alter the ecosystem.
- Mass developments can become a problem for fisheries and tourism



Sea walnut (*Mnemiopsis*)
Photo: Postel/IOW



Moon jellyfish (*Aurelia*)
Photo: Niedzwiedz



4. Salinity and stratification

- Between 1982-2016 stratification increased in most of the Baltic Sea, with a seasonal thermocline and the perennial halocline strengthening.
- Model simulations suggest an increased vertical summer stratification due to warming.
- Future salinity changes are uncertain. Increasing river runoff tends to decrease salinity, while sea level rise favors a increase.

HELCOM/Baltic Earth (2021): Baltic Sea Env. Proc. 180

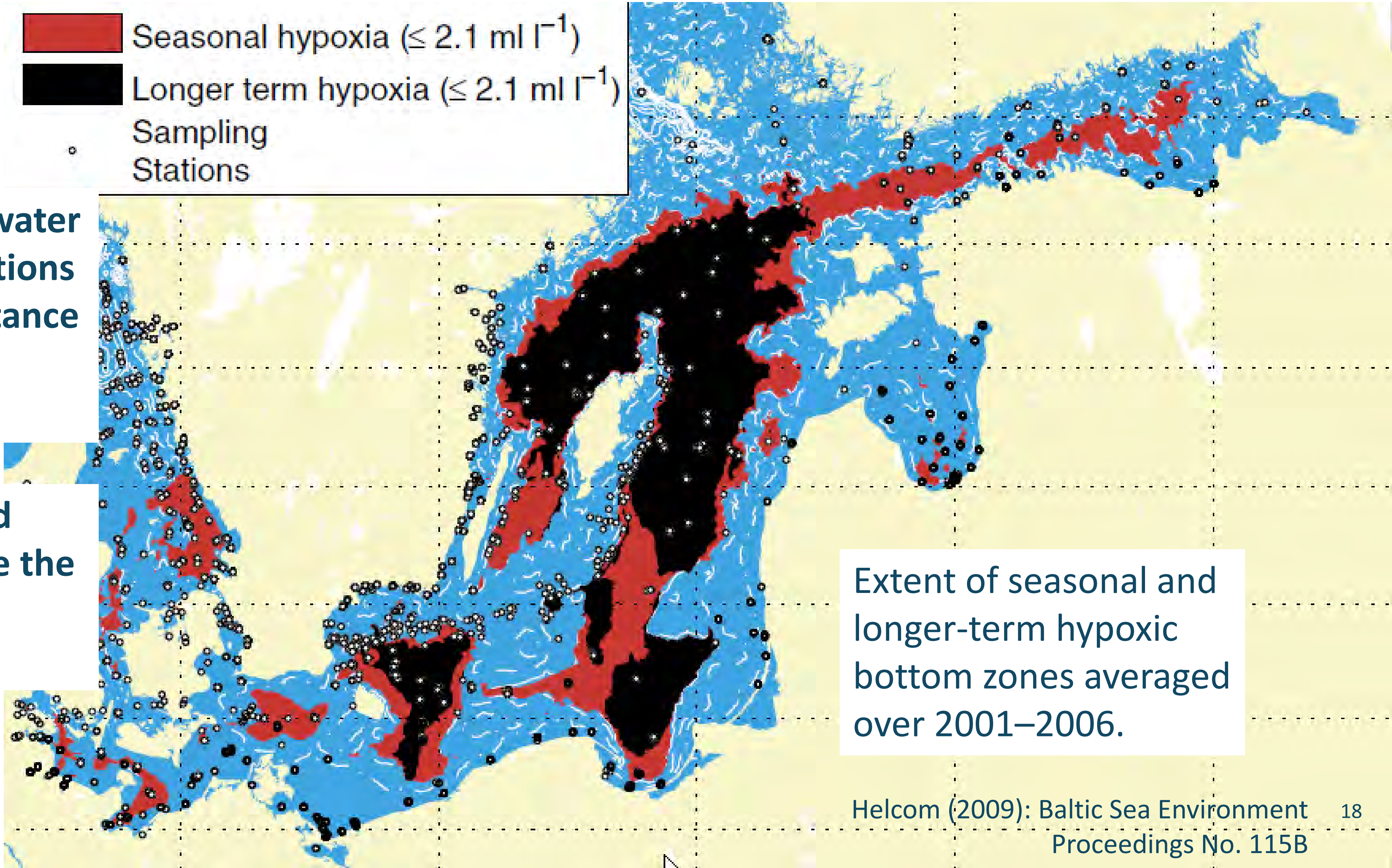
4. Oxygen

- In 2016, the annual maximum extent of hypoxia covered an area of about 70,000 km^2, whereas 150 years ago is was presumably small.
- Climate warming may enhance oxygen depletion in the Baltic Sea.

  By reducing air-sea and vertical transports of oxygen and by reinforcing eutrophication through intensifying internal nutrient cycling and stimulating nitrogen-fixing cyanobacteria blooms.
- The future development of deep-water oxygen conditions will mainly depend on the nutrient loads scenario.

HELCOM/Baltic Earth (2021): Baltic Sea Env. Proc. 180

4. Oxygen-free sea bottom zones in the Baltic Sea

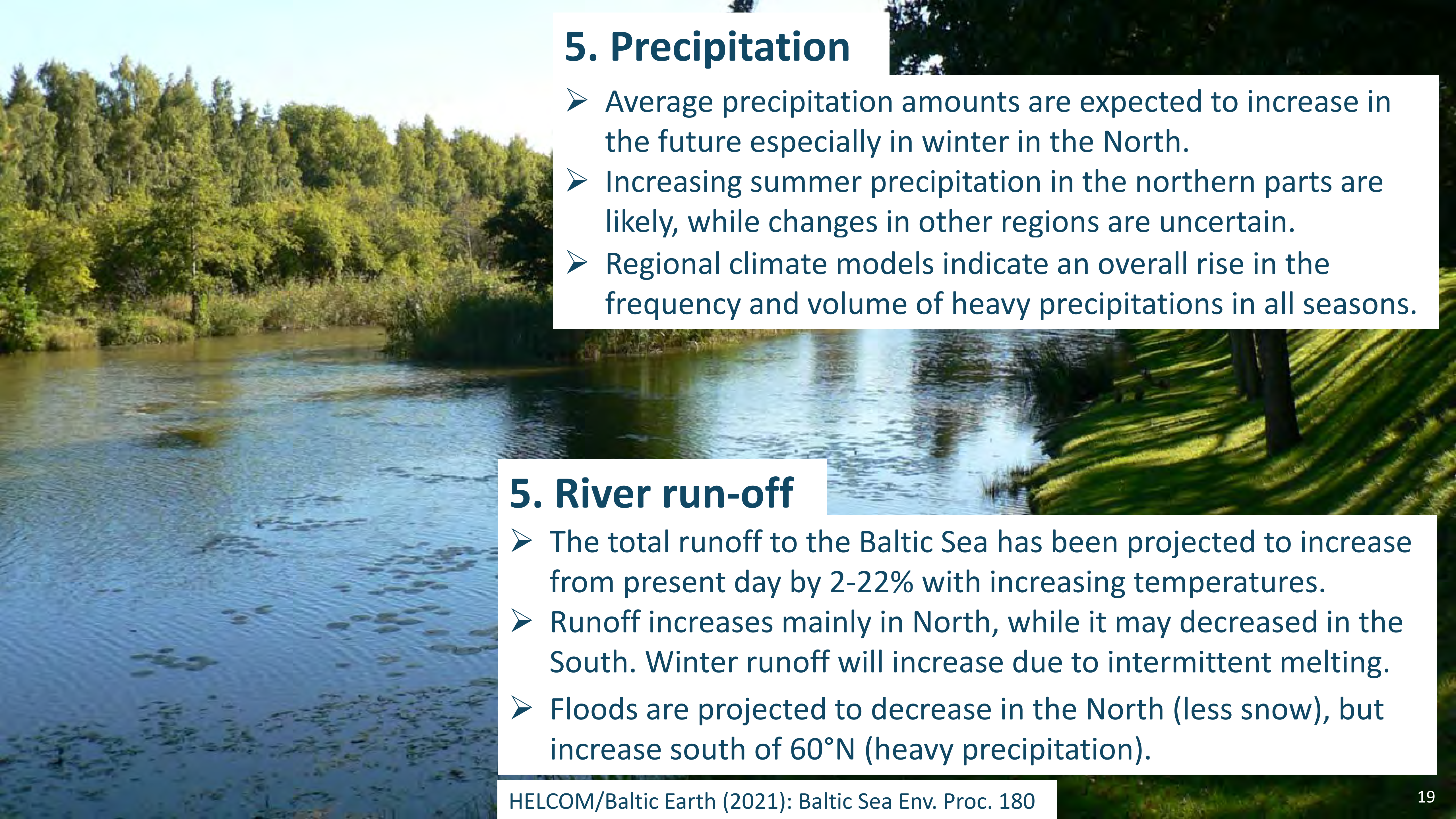


Changes in deep-water oxygen concentrations are of high importance for the Baltic Sea ecosystem.

Nutrient loads and eutrophication are the major controlling factors.

Extent of seasonal and longer-term hypoxic bottom zones averaged over 2001–2006.

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



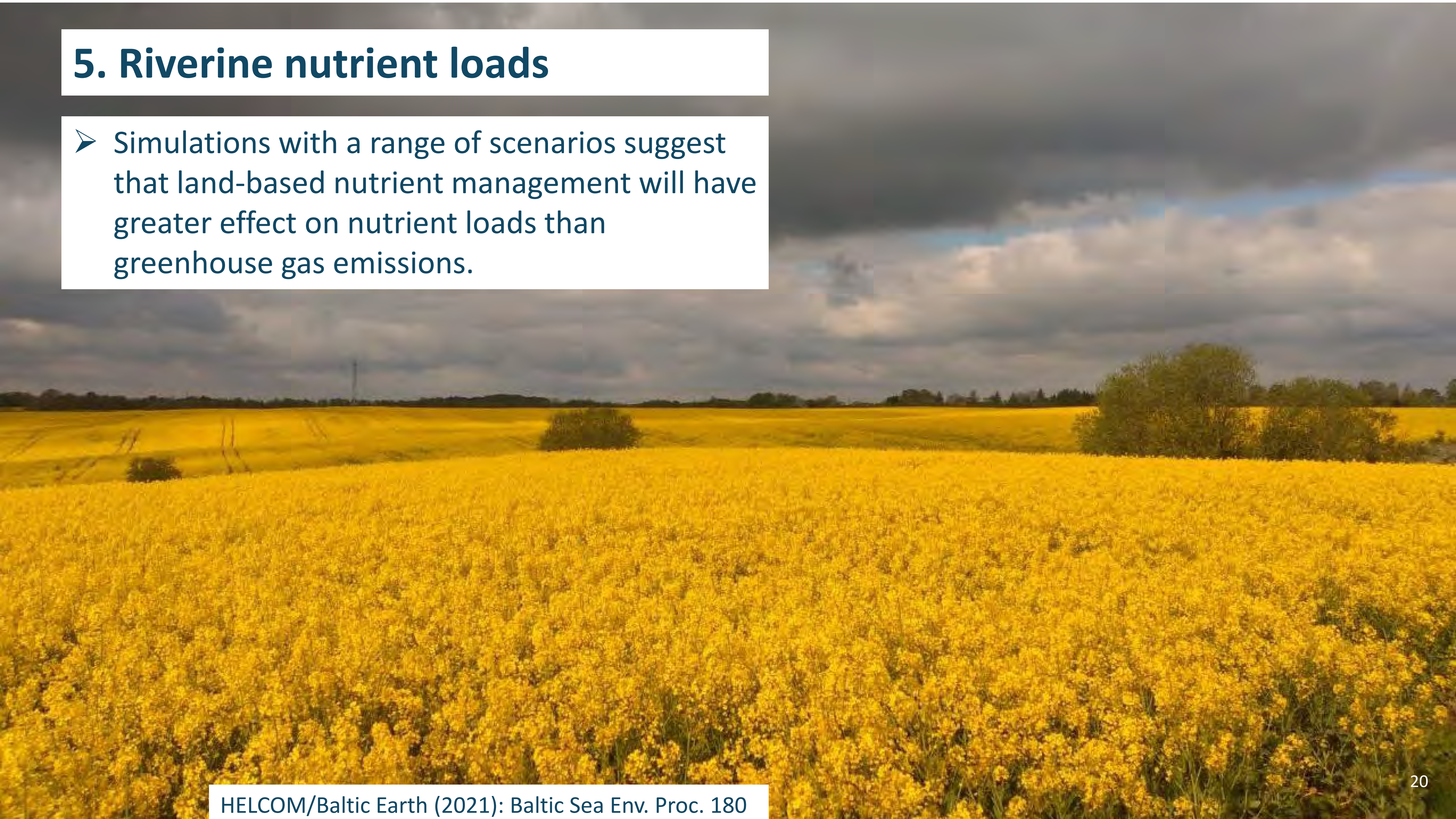
5. Precipitation

- Average precipitation amounts are expected to increase in the future especially in winter in the North.
- Increasing summer precipitation in the northern parts are likely, while changes in other regions are uncertain.
- Regional climate models indicate an overall rise in the frequency and volume of heavy precipitations in all seasons.

5. River run-off

- The total runoff to the Baltic Sea has been projected to increase from present day by 2-22% with increasing temperatures.
- Runoff increases mainly in North, while it may decreased in the South. Winter runoff will increase due to intermittent melting.
- Floods are projected to decrease in the North (less snow), but increase south of 60°N (heavy precipitation).

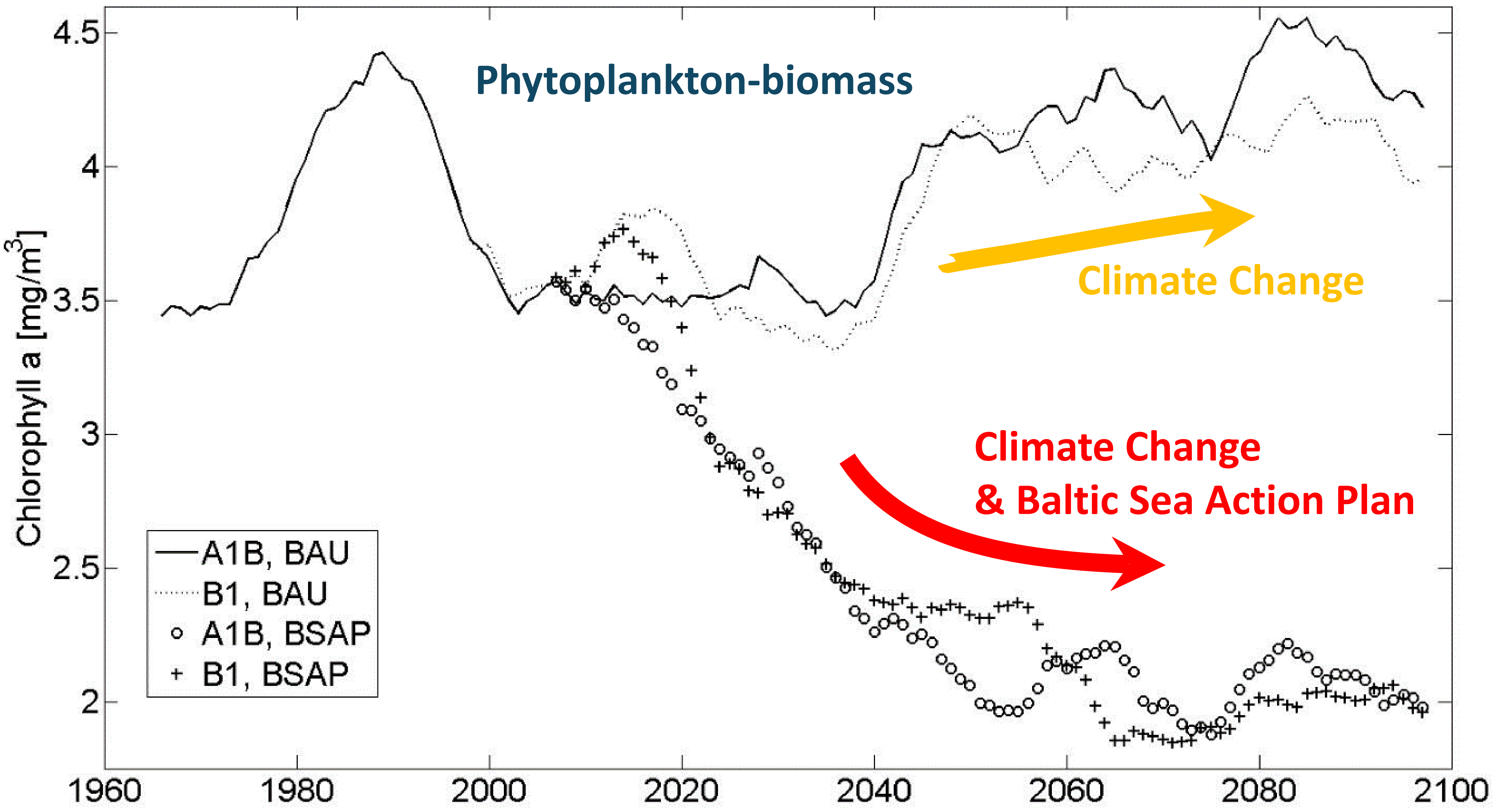
HELCOM/Baltic Earth (2021): Baltic Sea Env. Proc. 180



5. Riverine nutrient loads

- Simulations with a range of scenarios suggest that land-based nutrient management will have greater effect on nutrient loads than greenhouse gas emissions.

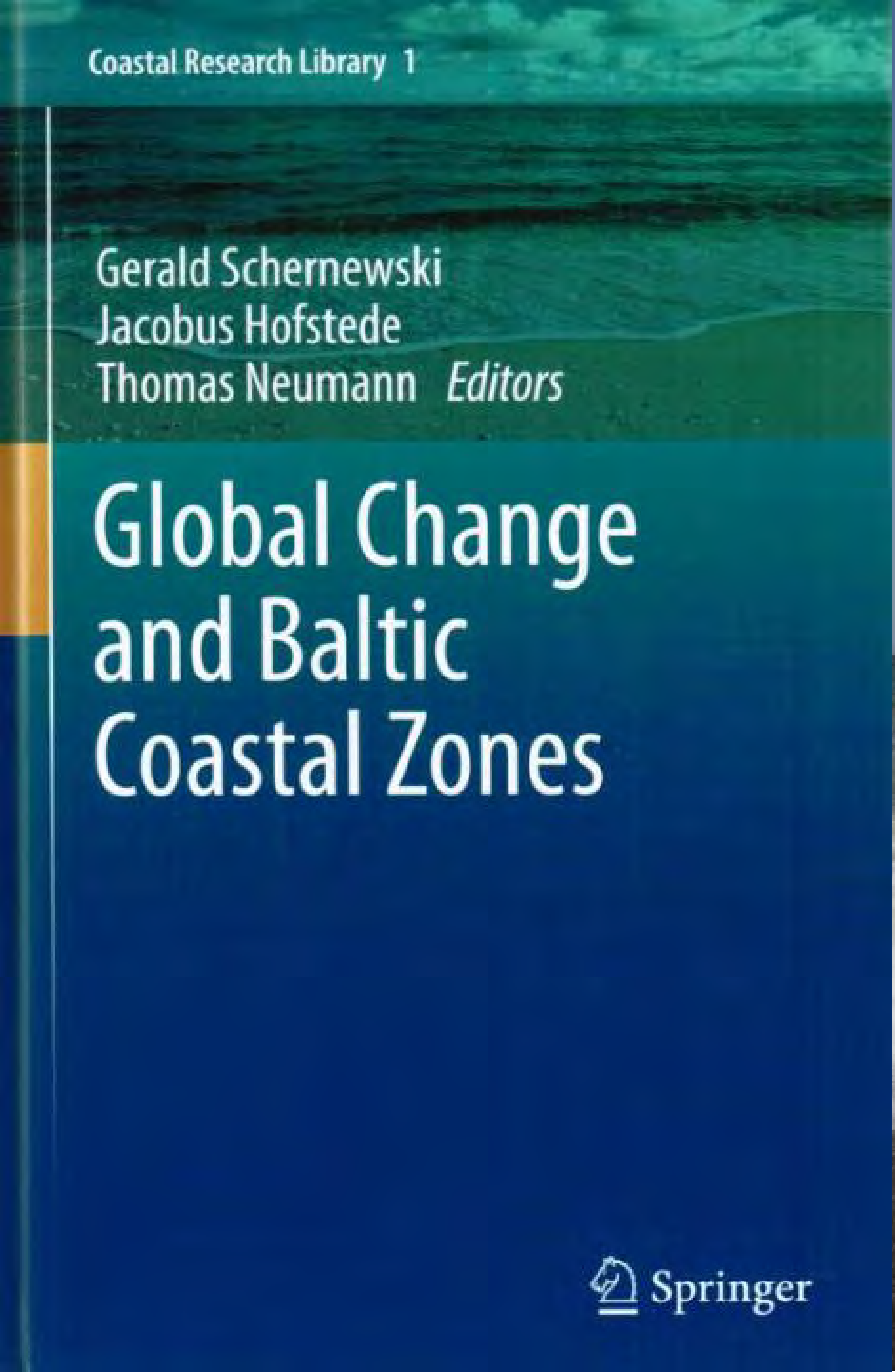
5. Climate change and eutrophication management



Friedland, Neumann & Schernewski (2012): J Marine Systems 105-108

5. Conclusions

- Climate change affects the Baltic Sea ecosystem in multiple ways and may cause some strong local effects.
- Human pressures (e.g. nutrient loads or fishing) have a much stronger effect on the ecosystem compared to climate change.
- In the southern Baltic, sea level rise and coastal erosion seems to be the biggest challenge.
- Increasing temperatures will have several economic benefits (tourism).



Thank you for your attention!

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