Baltic Sea - Bathing Water Quality

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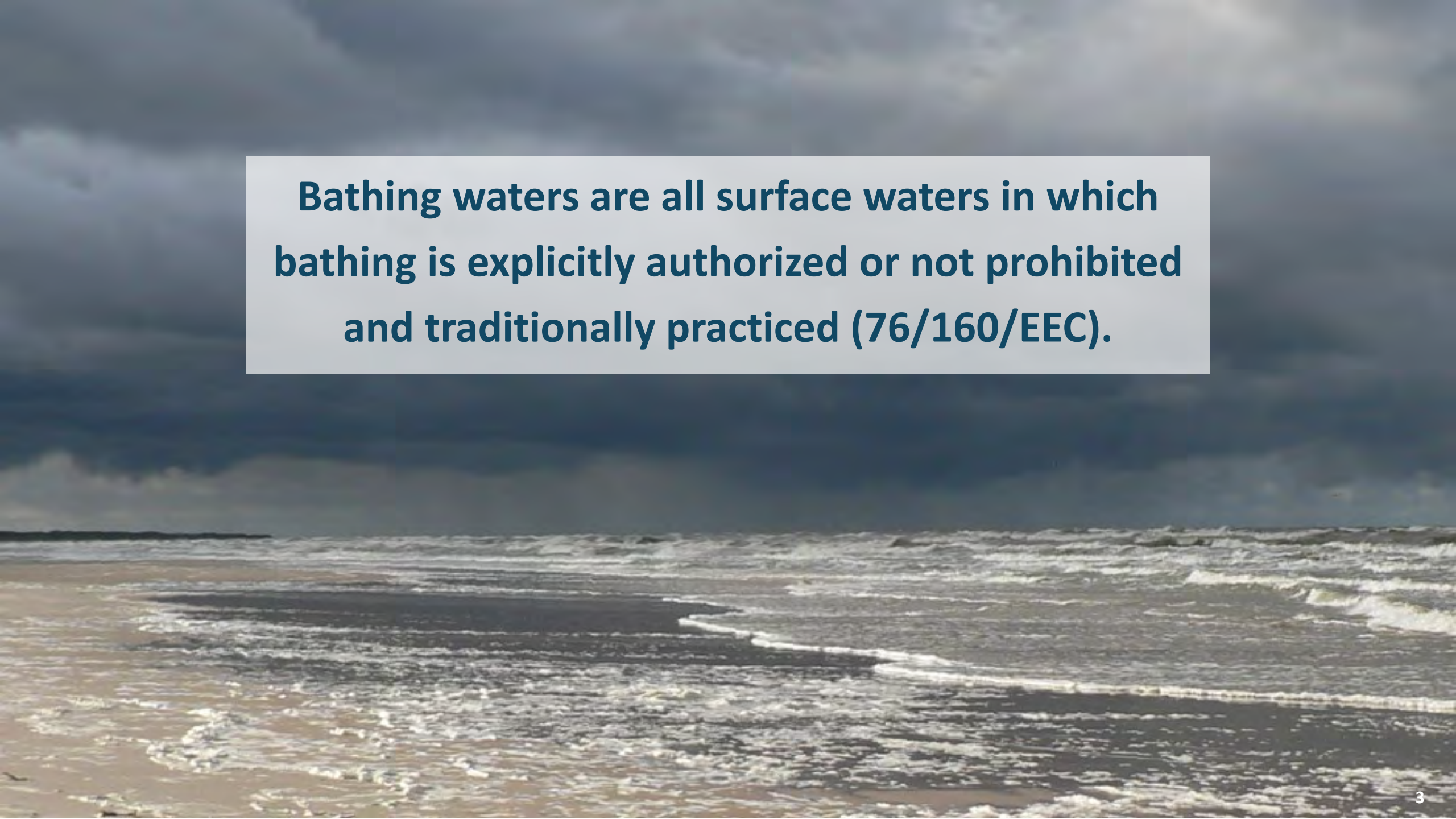
Overview

1. Background & legal framework
2. State in Europe & the Baltic
3. Case studies – problems & hot spots
4. New challenges & climate change
5. Conclusions



Bathing waters are all surface waters in which bathing is explicitly authorized or not prohibited and traditionally practiced (76/160/EEC).

1. Hazards: Causes and sources of bathing illness

Agent	Illness	Probable Source	Transmission Pathway
Campylobacter spp.	Gastroenteritis, fever	Human and animals	Ingestion
Enteropathogenic *E. coli*	Bloody diarrhea, abdominal cramp	Human and animals	Ingestion
Helicobacter pylori	Gastritis, abdominal pain	Human and animals	Ingestion
Legionella spp.	Pneumonia, gastroenteritis	Natural	Inhalation
Leptospira spp.	Fever, headache, vomiting, jaundice	Natural and animals	Ingestion
Salmonella spp.	Gastroenteritis, fever, pain	Human and animals	Ingestion
Mycobacterium avium	Respiratory disease	Natural	Inhalation/contact
Vibrio vulnificus	Infection in pre-existed open wound	Natural	Wound infection
Shigella spp.	Bacillary dysentery, abdominal pain	Human	Ingestion
Adenovirus	Gastroenteritis, respiratory disease	Human	Ingestion, inhalation
Noroviruses	Gastroenteritis		
Rotaviruses	Gastroenteritis		
Coxsackievirus	Mild febrile illness to myocarditis		
Enteroviruses	Central nervous system, ocular and respiratory infections		Ingestion
Echovirus	Diarrhea, secretions from the eyes or throat	Human	Ingestion
Hepatitis A virus	Liver disease	Human	Ingestion
Hepatitis E virus	Liver disease	Human and animals	Ingestion
Cryptosporidium	Diarrhea, abdominal pain, fever	Human and animals	Ingestion
Giardia	Diarrhea, abdominal cramp	Human and animals	Ingestion
Microsporidia	GI illness, diarrhea	Human and animals	Ingestion
Naegeria fowleri	Meningoencephalitis	Natural	Contact
Schistosoma spp.	GI illness, haematuria	Human	Ingestion, Contact
Entamoeba histolytica	Amoebic dysentery	Human	Ingestion

Human & animal are the dominating source

Ingestion is the major pathway

Tiwari et al. (2021). Int. J. Environ. Res. Public Health 18, 5513

1. Souces of hazards

The most common hazards in recreational waters are microbial pathogens introduced by faecal contamination from humans and animals (WHO, 2021).

Sources of faecal contamination can include:

- discharges from wastewater treatment plants, sewer and septic tank breaks or overflows, open drains, and urban stormwater;
- excreta from livestock animals, birds and dogs at the water use site or transported by runoff;
- direct contamination from recreational water users or local beach toilet facilities;
- faecal waste disposal from boats.

Settlements

Agriculture

1. Faecal pathogens in raw sewage

- *Escherichia coli (E.coli)* and intestinal enterococci, are common intestine bacteria.
- Outside the body they usually survive only a few days.
- Therefore, they can serve as indicators for faecal contamination in the aquatic environment.

Pathogen/indicator organism	Disease or role	Microbes/L
Viruses		
Adenoviruses	Respiratory disease, gastroenteri-tis	10^2–10^9 GC
Astrovirus	Gastroenteritis	10^3–10^7 GC
Hepatitis A virus	Hepatitis	Undetected to 10^9 GC
Hepatitis E virus	Hepatitis	Undetected to 10^5 GC
Norovirus (and other caliciviruses)	Diarrhoea, vomiting	10^2–10^9 GC
Enterovirus	Poliomyelitis, mild febrile illness, myocarditis, meningitis	Undetected to 10^4 (cell culture)
Rotavirus	Diarrhoea, vomiting	10^2–10^8 GC
F+ coliphages	Indicator organism	10^5–10^7 PFU
Somatic coliphages	Indicator organism	10^6–10^8 PFU
Bacteria		
Campylobacter spp.	Gastroenteritis	10^3–10^6 MPN 10^6 GC
Escherichia coli	Indicator organism (except specific pathogenic strains[a])	10^7–10^8 CFU or MPN
Intestinal enterococci	Indicator organism	10^6–10^7 CFU or MPN
Salmonella spp.	Gastroenteritis	Up to 10^5 MPN
Shigella spp.	Bacillary dysentery	10^2–10^8 MPN
Vibrios such as *Vibrio cholerae*, *V. parahaemolyticus* and *V. vulnificus*	Gastroenteritis	<10–10^5 MPN
Parasitic protozoa[c]		
Cryptosporidium spp.	Diarrhoea	10–10^4 oocysts
Entamoeba histolytica	Amoebic dysentery	Undetected to 100 cysts
Giardia duodenalis	Diarrhoea	10–10^5 cysts
Helminths[b]		
Ascaris spp.	Ascariasis	5–450 ova
Ancylostoma spp. and *Necator* sp.	Anaemia	5–190 ova
Trichuris spp.	Diarrhoea	10–40 ova

Viruses

Bacteria

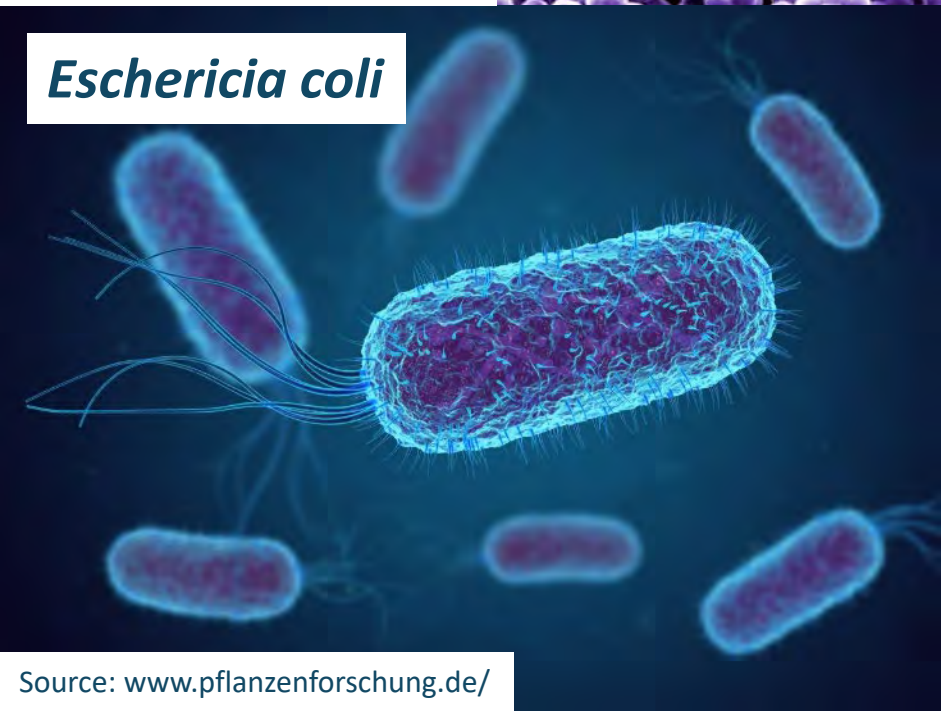
Protozoa

Parasites

CFU: colony forming unit; GC: gene copies; MPN: most probable number; PFU: plaque forming unit.

WHO (2021): Guidelines on recreational water quality

Source: Janice Haney Carr, USCDCP



Source: www.pflanzenforschung.de/

1. Bathing Water Quality indicators: *E. coli* & enterococci

- Both show high concentrations in sewage (~10^7 Colony Forming Units/liter).
- Both are relatively easy to detect.
- Enterococci are a subgroup of faecal streptococci.
- The survival in nature depends on environmental factors. Enterococci survive longer in aquatic environments than *E. coli*.
- The ratio between both indicates how old a pollution is and enables a back-tracking to the emission spot.
- Both are usually harmless.

E. coli O157

Emerged in Europe in the 1990's and can cause severe, potentially life-threatening, illness (Coia, 1998).

1. The European Bathing Water Directive (2006)

Directive	Indicator (colony forming unit, CFU)
76/160/EEC	Total coliforms (CFU/100 ml)
76/160/EEC	Faecal coliforms (CFU/100 ml)
2006/7/EC	*E. coli* (CFU/100 ml)
2006/7/EC	Intestinal enterococci (CFU/100 ml)

Ian Hill, https://sitn.hms.harvard.edu/

1. The European Bathing Water Directive (2006): Indicator thresholds

➡ **The Directive (2006) has more specific indicators and stricter thresholds, but…**

➡ **..no complementing parameters and sampling is less frequent (> monthly; ~ 4 per season).**

Directive	Indicator (colony forming unit, CFU)	Excellent (G)	Good (I)	Insufficient
76/160/EEC	Total coliforms (CFU/100 ml)	< 500	500 – 10 000	> 10 000
76/160/EEC	Faecal coliforms (CFU/100 ml)	< 100	100 – 2 000	> 2 000
2006/7/EC	*E. coli* (CFU/100 ml)	< 250	250 – 500	> 500
2006/7/EC	Intestinal enterococci (CFU/100 ml)	< 100	100 – 200	> 200

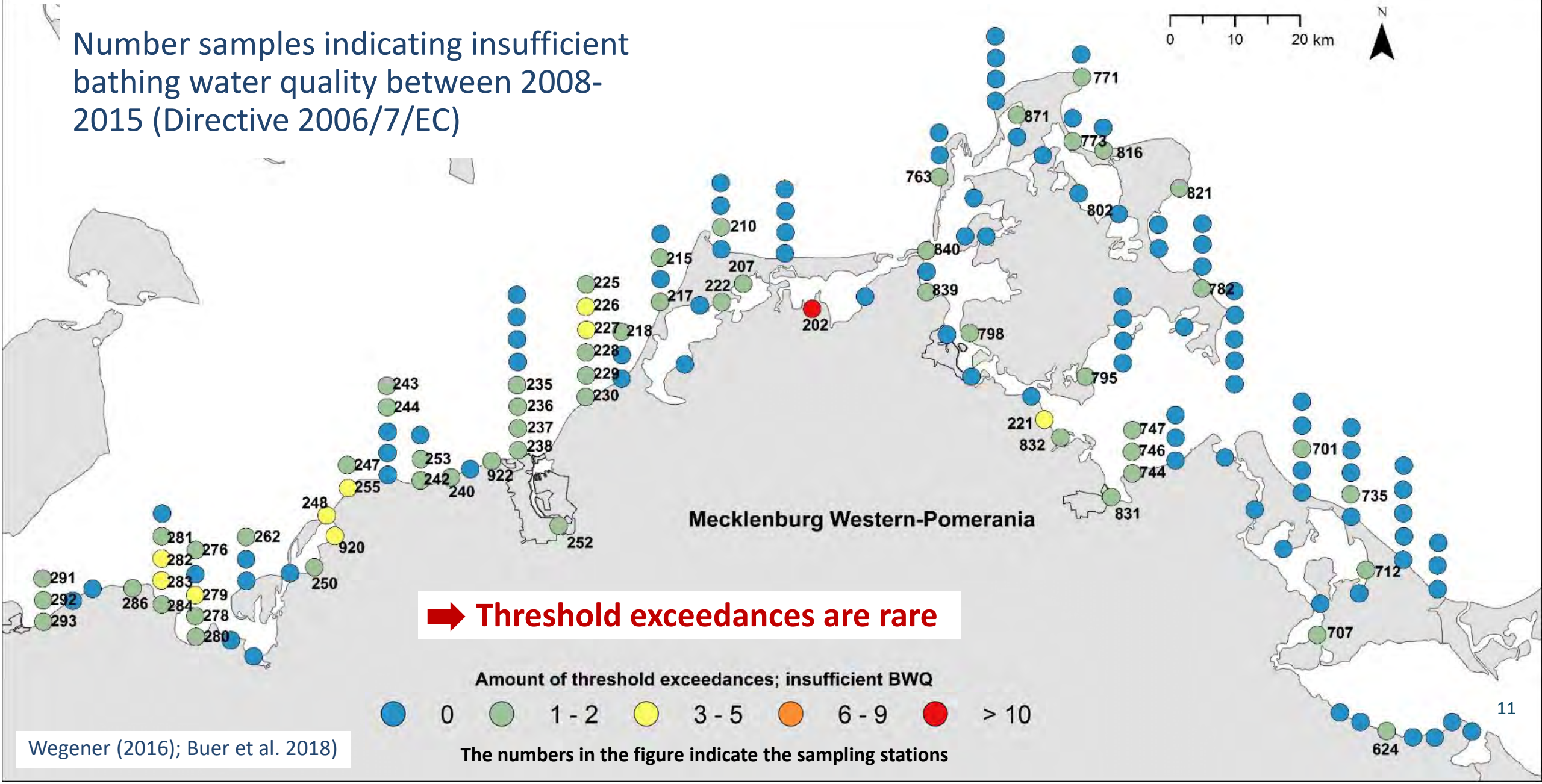
2. Bathing water quality on Europe

- ~ 15,000 coastal & transitional bathing waters exist in the EU (363 in Germany).
- In the EU, 85.3 % show an excellent quality (EEA 2000).

https://www.eea.europa.eu/.../state-of-bathing-waters

2. Bathing Water Quality at the German Baltic coast – *E. coli*

Number samples indicating insufficient bathing water quality between 2008-2015 (Directive 2006/7/EC)

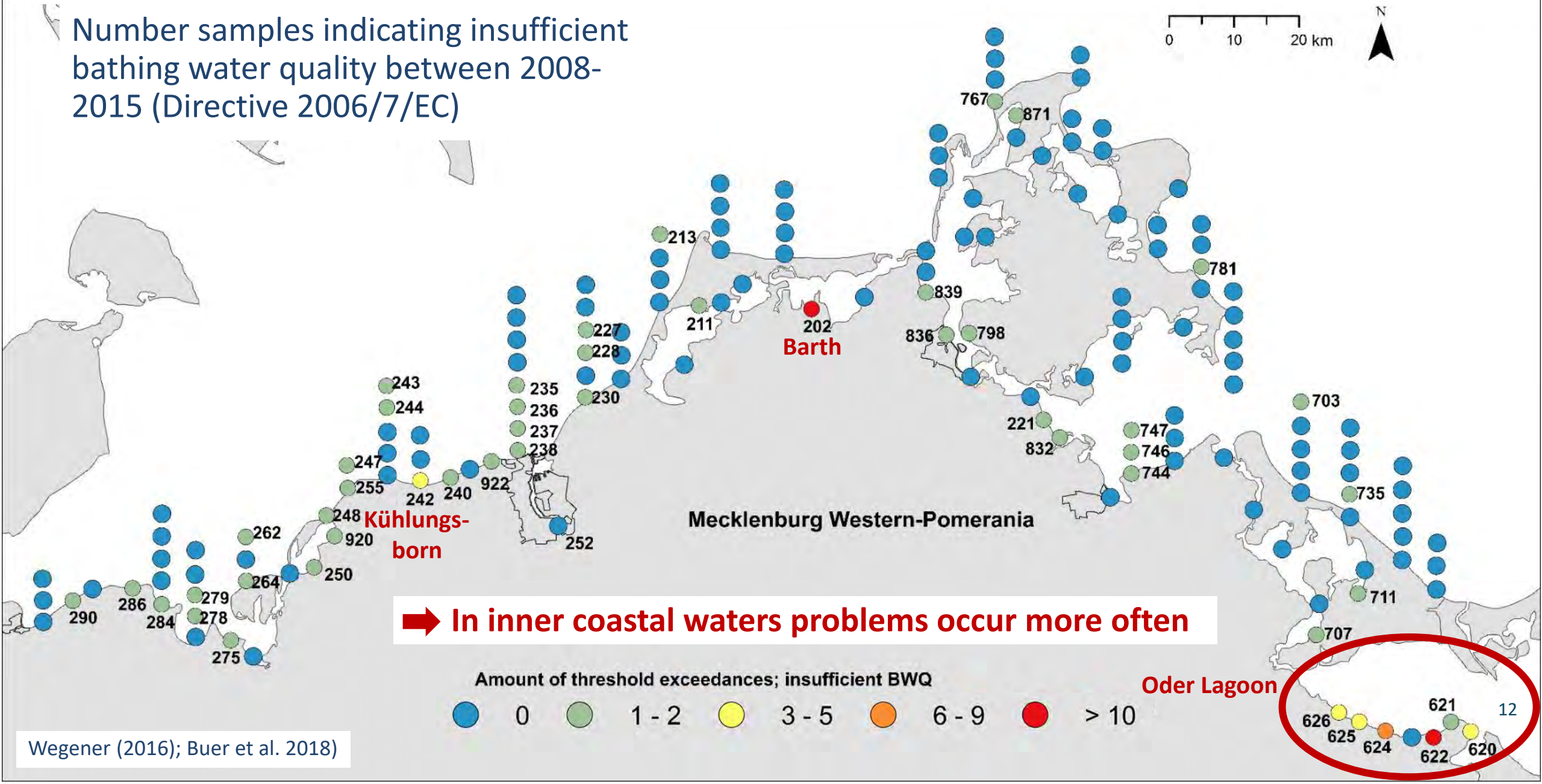


➡ **Threshold exceedances are rare**

Wegener (2016); Buer et al. 2018)

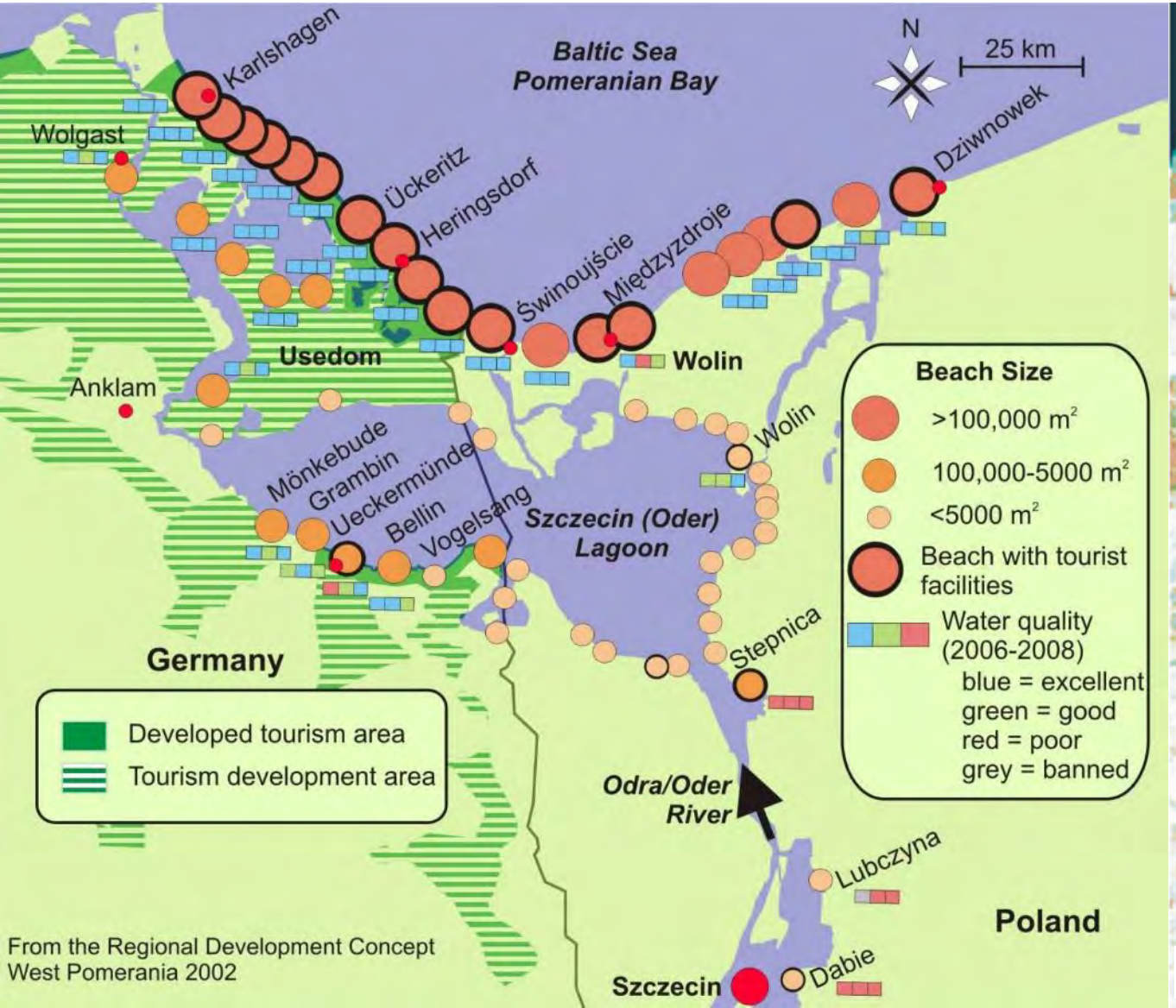
2. Bathing Water Quality at the German Baltic coast – Enterococci

Number samples indicating insufficient bathing water quality between 2008-2015 (Directive 2006/7/EC)



Wegener (2016); Buer et al. 2018)

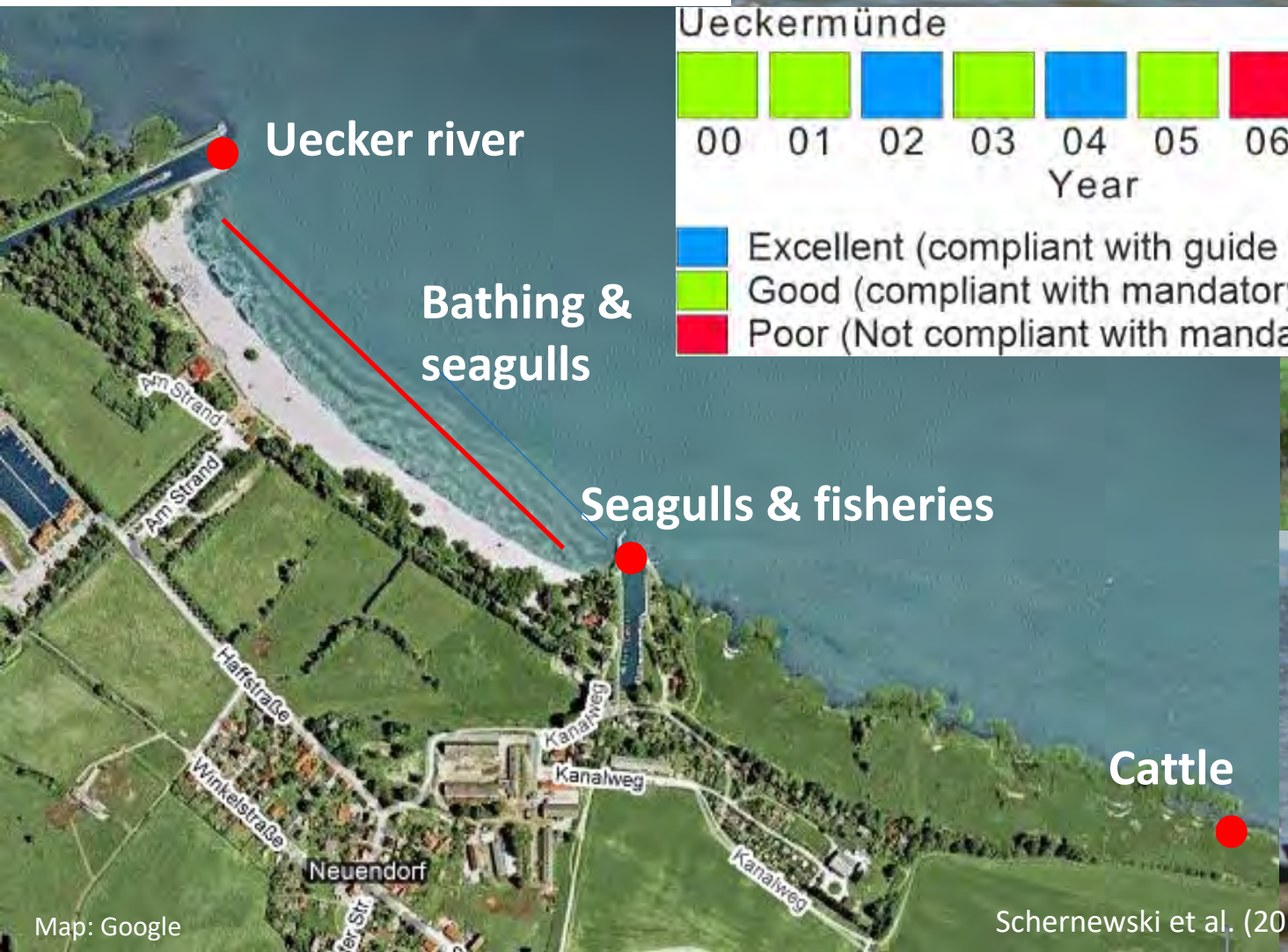
3. The Odra/Oder Lagoon:
Tourism, beaches and bathing water quality



Siegel (2001)

3. Ueckermünde:

Allocation and quantification of *E.coli* sources

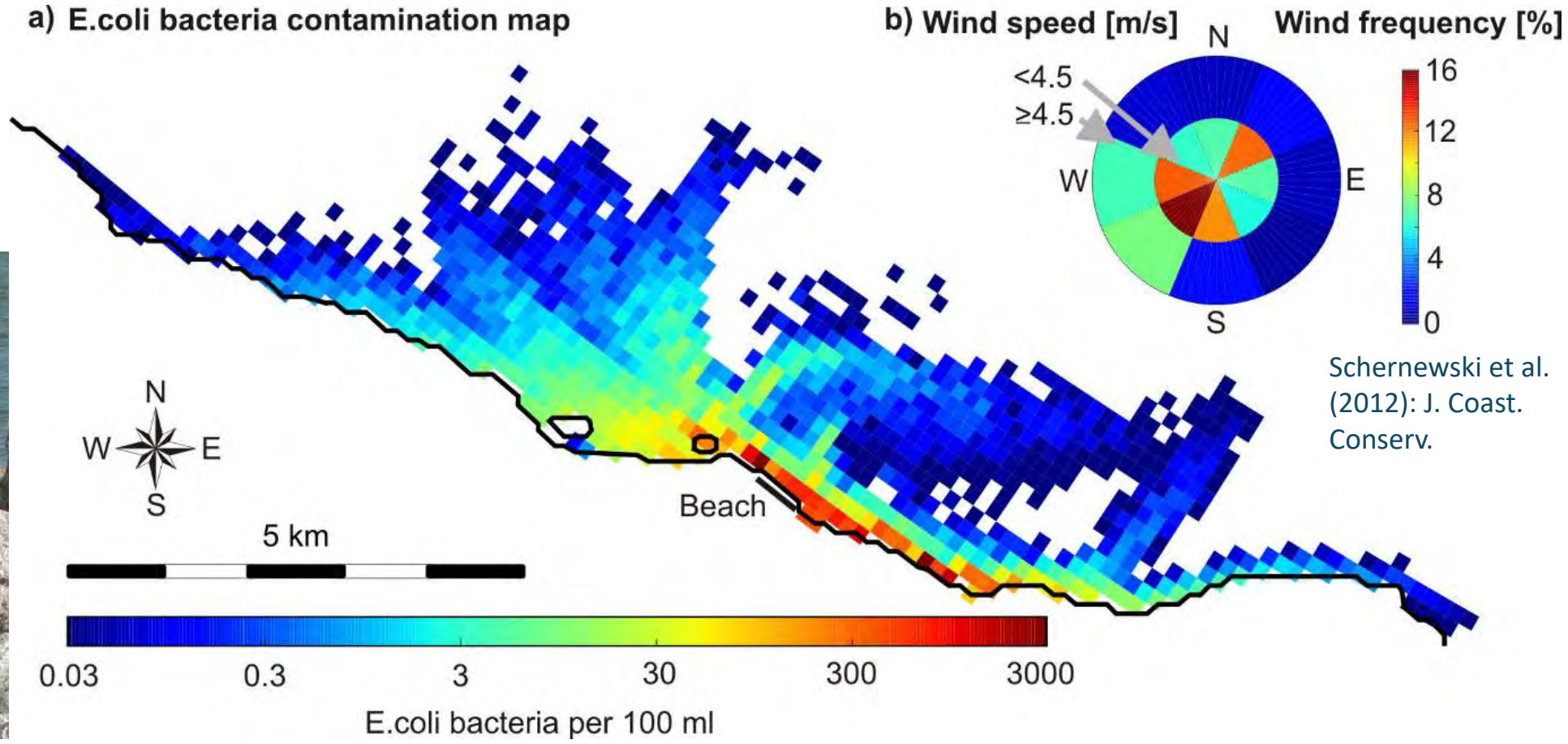


Map: Google

Schernewski et al. (2012): J. Coast. Conserv.

3. Ueckermünde:

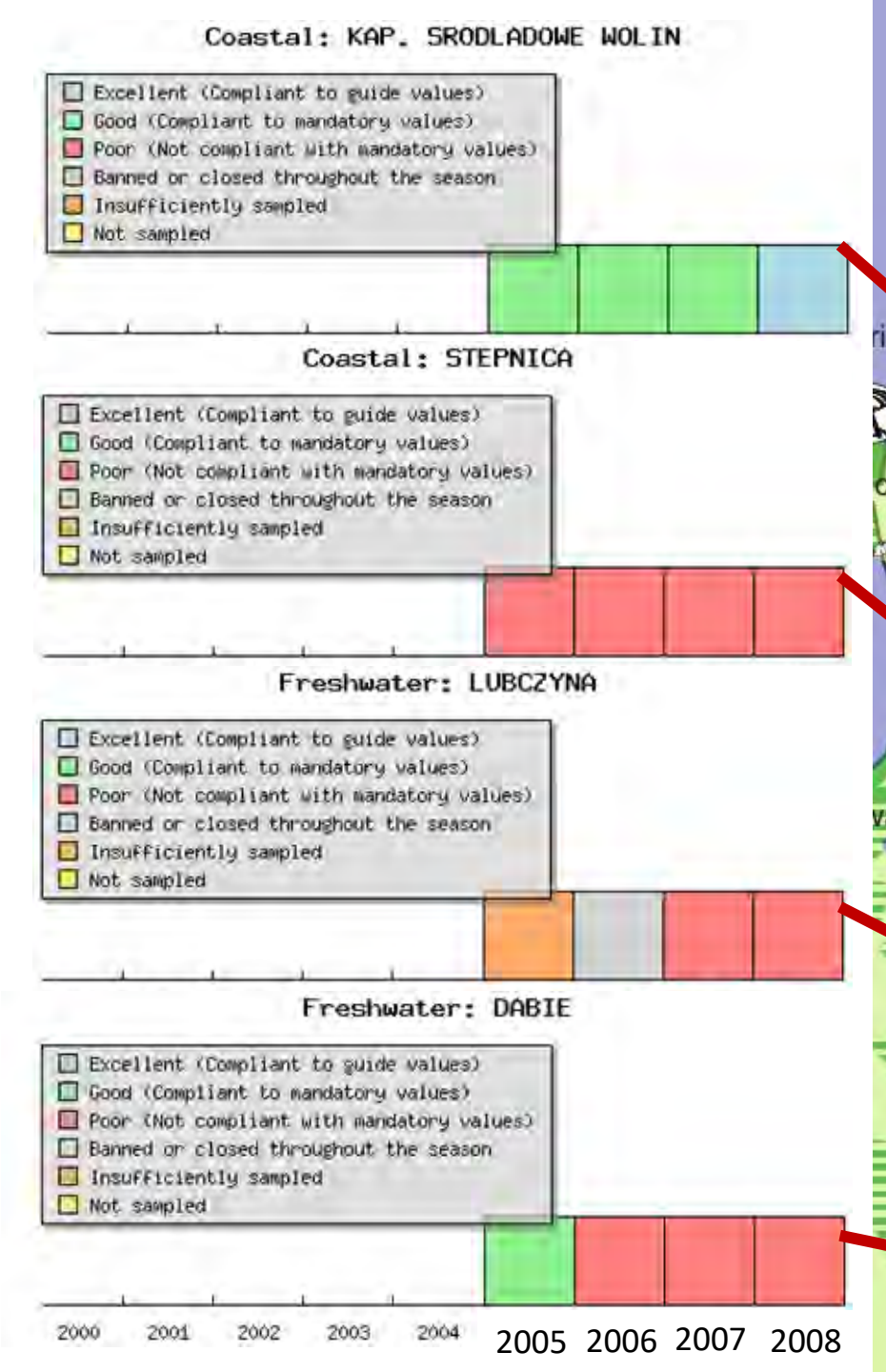
E.coli average pollution map

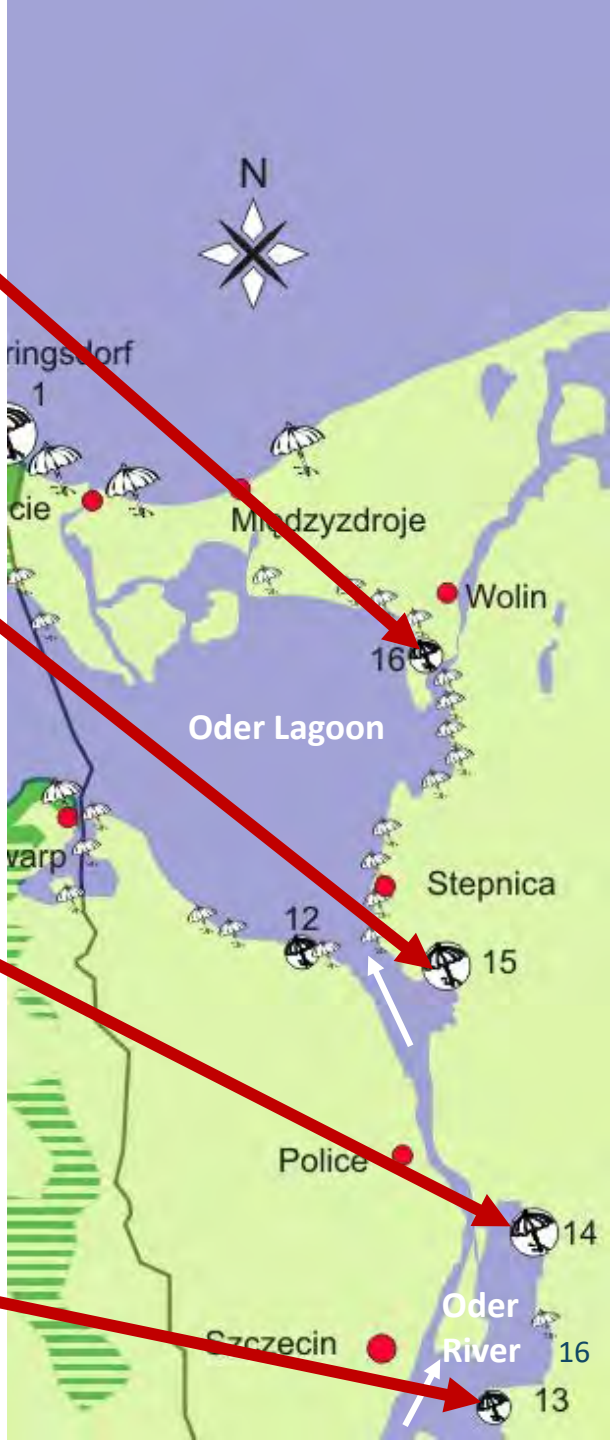


Schernewski et al. (2012): J. Coast. Conserv.

- The lagoon environment favors *E.coli* survival and even may enable growth.
- The dominating (under all wind direction) near shore transport favors high *E.coli* concentrations at the beaches.
- In Ueckermünde, high *E.coli* concentrations are usually linked to strong rain events with increased surface runoff.
- Frequently exceeded Enterococci thresholds indicate a long-distance transport and distant pollution sources (e.g. cormorant colonies, resting birds)

3. Oder river mouth:
Bathing water quality

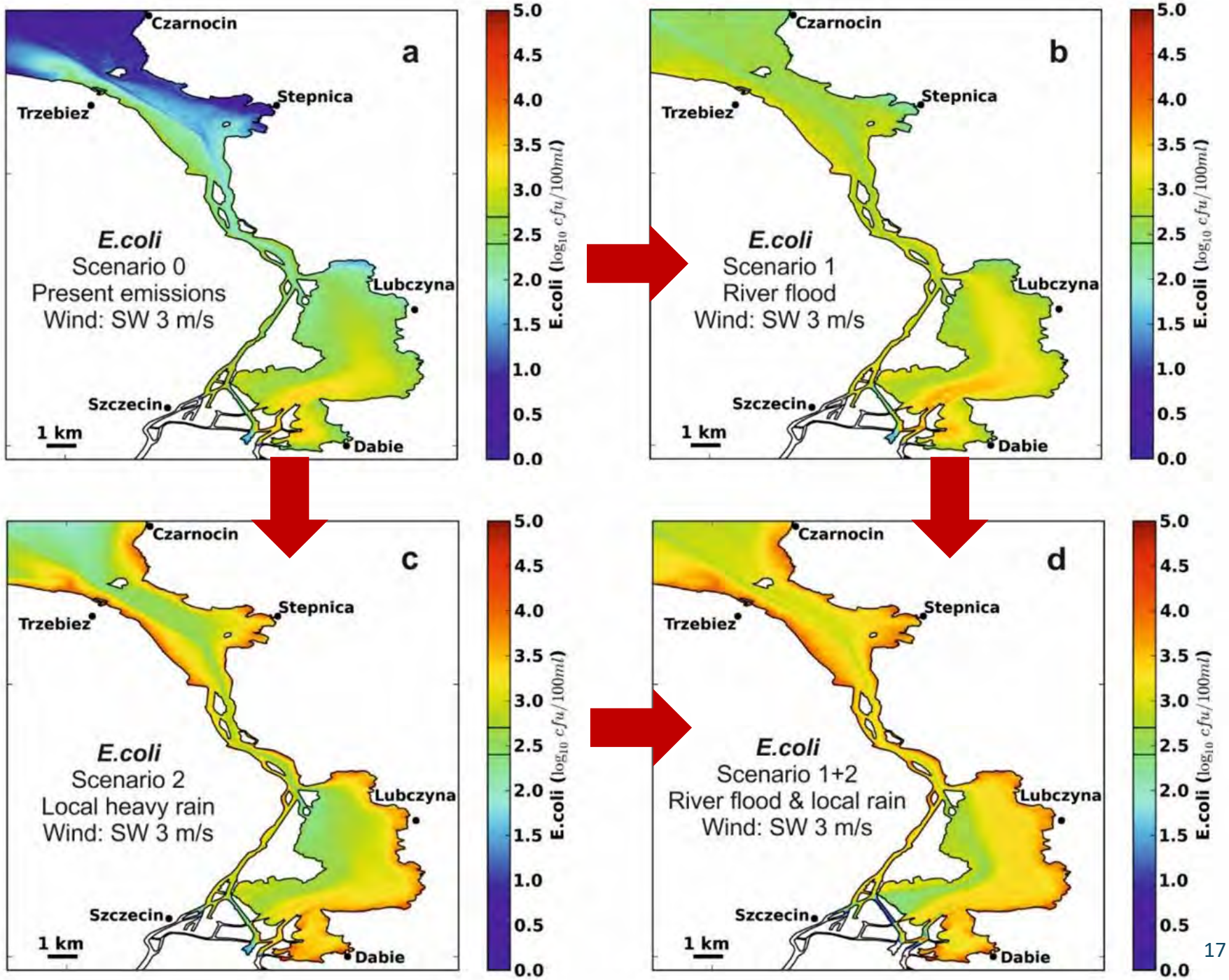




3. Oder river mouth:

E.coli pollution during river floods and local heavy rains

- Local emissions during heavy rains and river floods cause high E. coli concentrations and poor bathing water quality.
- Climate change may increase bathing water problems.



Schippmann, Schernewski & Walczykiewicz (2014)

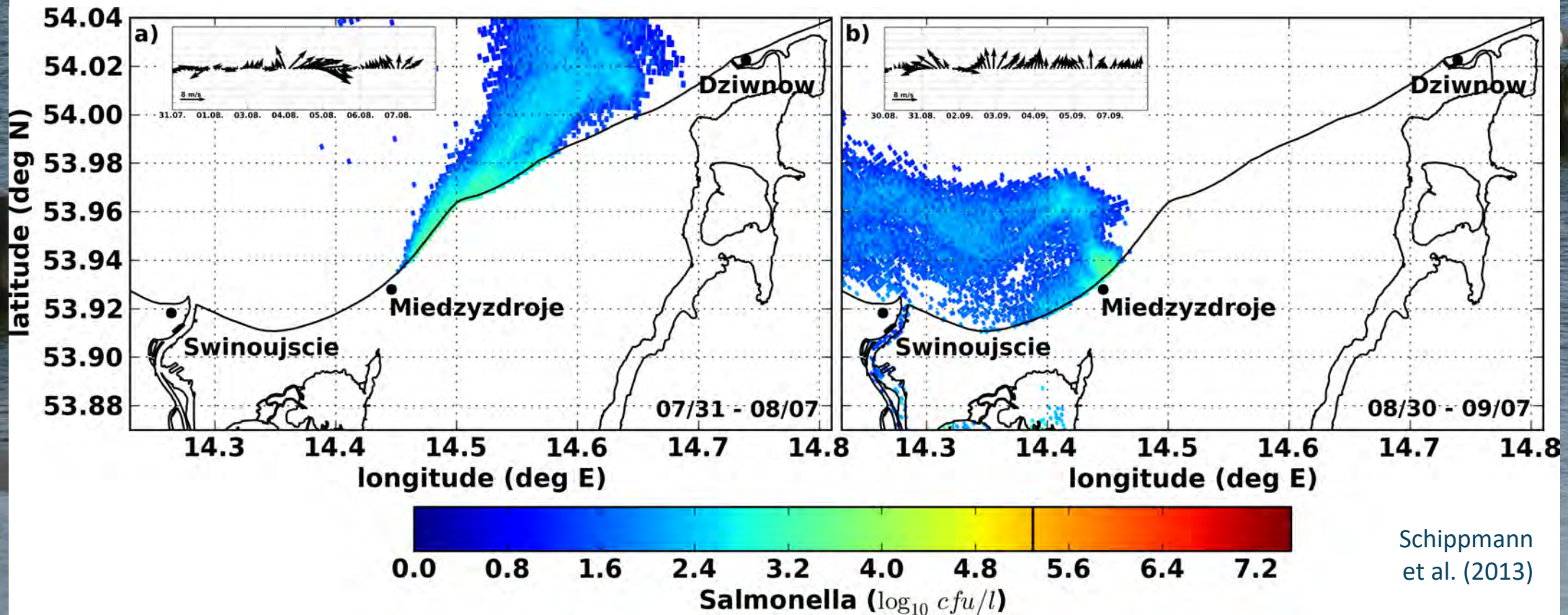
3. Baltic coast:

Salmonella pollution in the seaside resort Miedzyzdroje in August 2008.

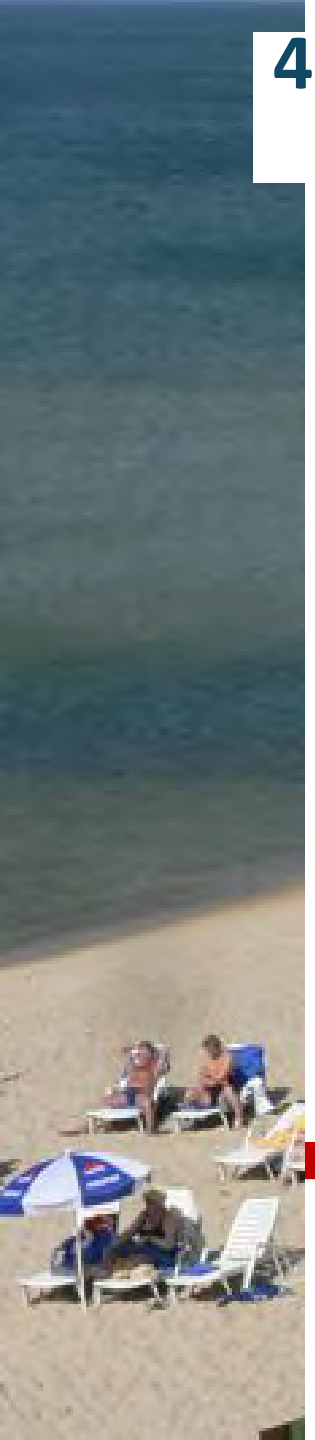
- Salmonella caused a bathing prohibition for more than 4 weeks.
- Model simulations suggest a variable and wide-ranging transport but hardly an infection risk.

➡ **A good bathing water quality does not mean that no microbial hazards exists!**

➡ **The Directive covers only a narrow spectrum of potentially pathogenic agents!**



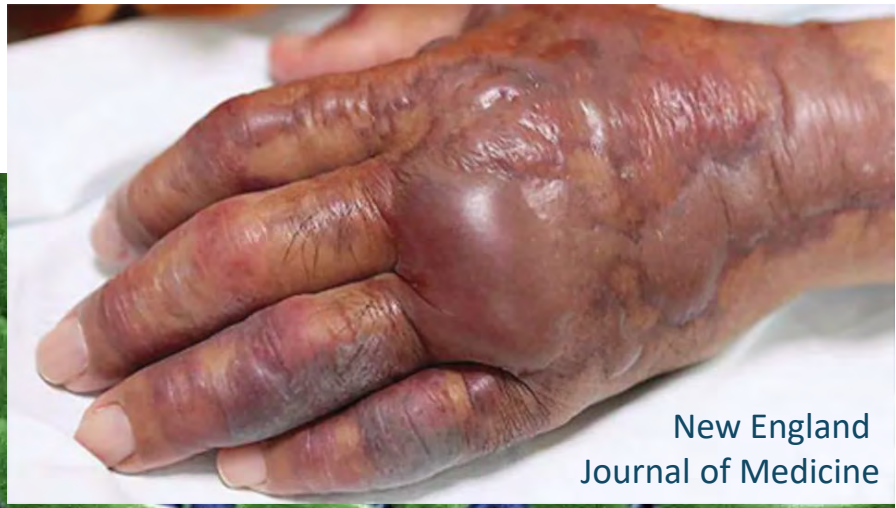
Schippmann et al. (2013)



4. 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 single German Baltic beaches.
- At the German Baltic coast, several persons died after an infection.
- In Germany, a regular monitoring takes place since 2004.



New England Journal of Medicine

Janice Carr, USCDCP

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

4. Bathing water quality and climate change

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	iaundice						++

* 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)

5. Conclusions

- The coastal bathing water quality in Europe is usually excellent.
- The European Bathing Water Directive uses *E.coli* and enterocci as quality indicators.
- They indicate faecal pollution but do not reflect all microbial hazards in waters.
- In the Baltic, climate change seems to increase the likelihood of summerly heavy rains and floods, which cause bathing water quality problems.
- Climate change with increasing water temperatures favors many ‘new’ and ‘un-known’ human-pathogenic organisms.

Thank you for your attention!

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