

Eutrophication of Lake Peipsi

Causes, consequences and solutions

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Workplace



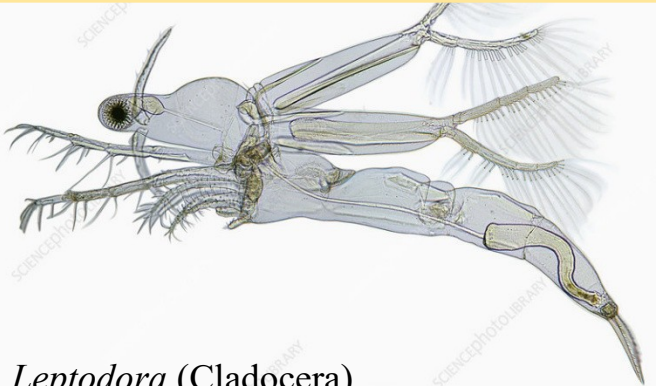
Centre for Limnology
(Estonian University of Life Sciences)

Lake Museum

Zooplankton

Importance of zooplankton:

- *Food for fish
- *Control phytoplankton biomass
- *Key component of food webs
- *Environmental indicator (climate change, eutrophication, biomani-
pulation, feeding pressure by predators)



Leptodora (Cladocera)



Lake Peipsi

***Area:** 3 555 km² (5th largest in EU)

***Lake parts:** Lake Peipsi *s.s.* (*sensu stricto*), Lake Lämmijärv, Lake Pihkva

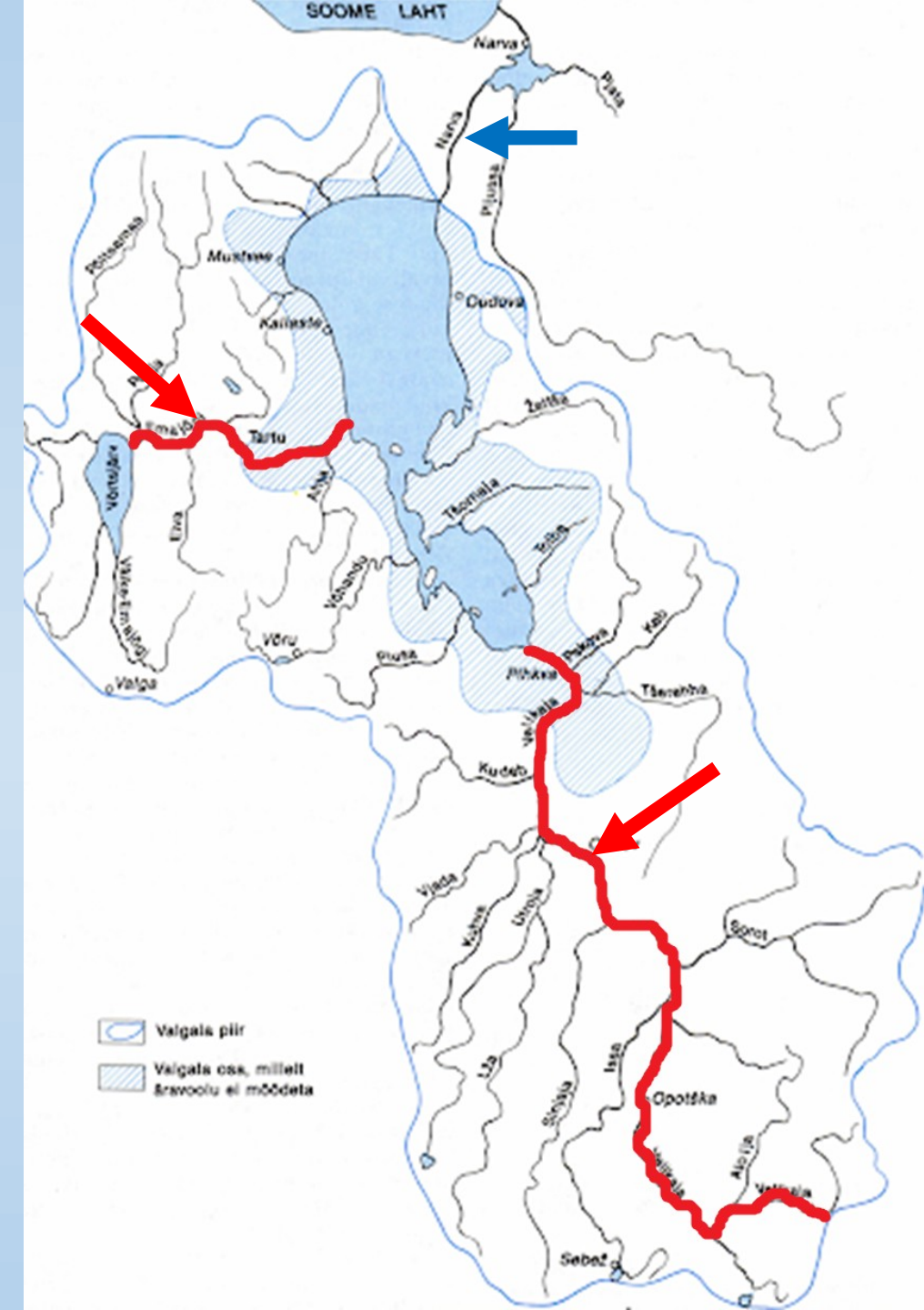
***Border lake:** 44% Estonia, 56% Russia

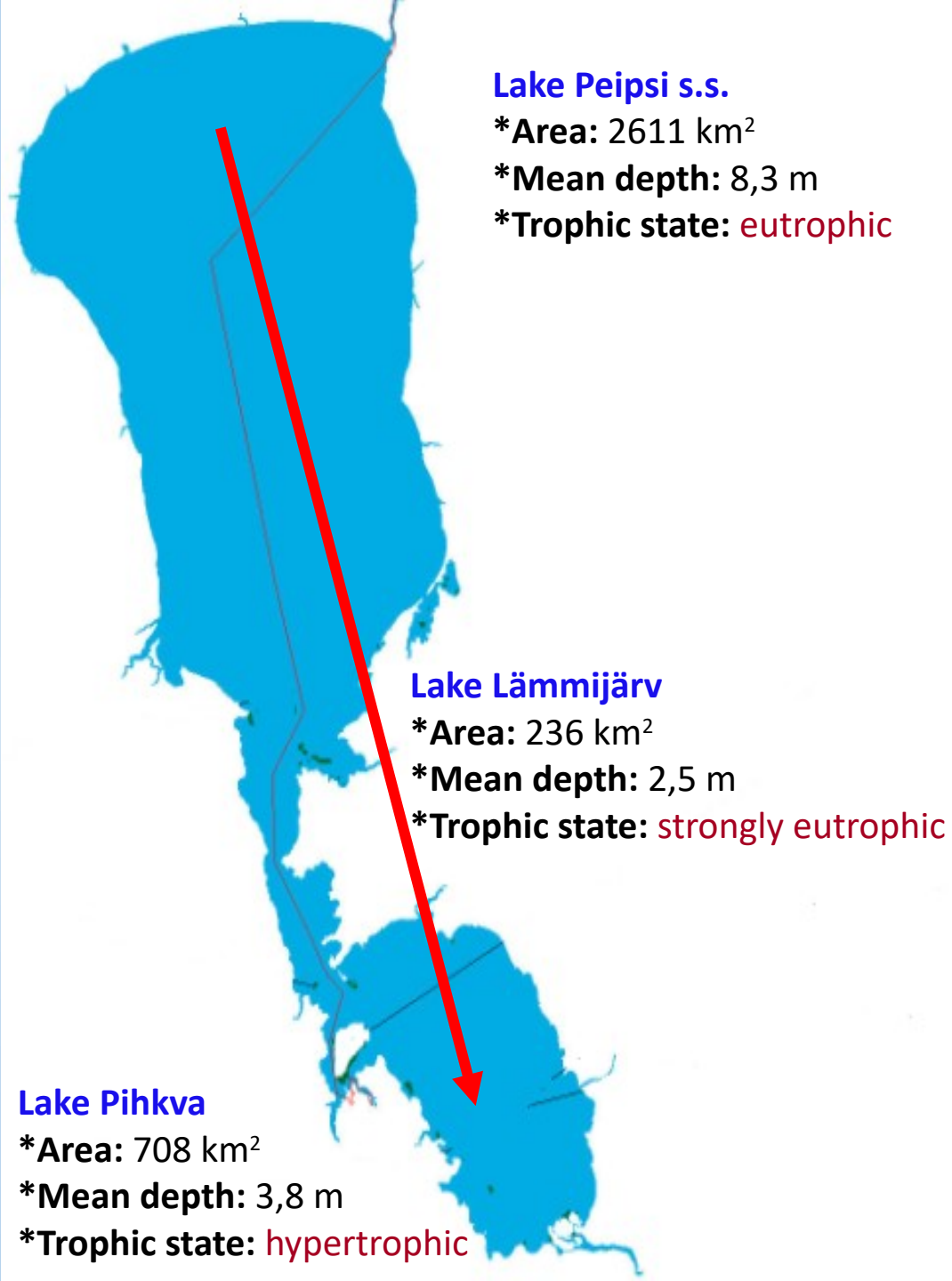
***Large lake = in-lake processes are complex and with a time lag.**



Catchment area and inflows

- *Catchment area: **47 802 km²** (59% Russian territory)
- *Over **1 million** people inhabit catchment = serious threat to lake status.
- *Over **240** inflows (rivers and streams) = impact on lake water quality.
- *Largest inflowing rivers: **Emajõgi** and **Velikaya**.
- *Emajõgi River brings **21%** and Velikaya River **54%** of total inflowing phosphorus.
- *Outflowing river – **Narva**.
- *Water retention time – **2 years**.





Trophic state of L. Peipsi

*Oligotrophic → Mesotrophic → Eutrophic → Hypertrophic

***Eutrophication = nutrient enrichment**

*Nutrient concentration **rises** towards north to south.

*In 60s, L. Peipsi s.s. was in **mesotrophic** state.

*In 70s-80s, **intensive pollution** took place => trophic state increased

*Trophic state of the lake is influenced by **climate change** and **water level**.

***Different trophic level of lake parts
=
different flora and fauna**

Importance of Lake Peipsi

- **High species diversity**
- **Fisheries** provide jobs, food and economic benefits
- **Freshwater resource**
- **Mud reserve** (agriculture, medical facilities)
- **Reed** as a building material
- **Recreation area**
- **Cultural value** (sacred sites, national symbols)



Regular monitorings of L. Peipsi (since 1960s)

Aims:

- Information about **current state**
- Supplement data series = **long-term trends**
- Assess/explain the **reasons for changes**
- Data for **planning and implementing conservation measures**

Different monitorings:

- hydrochemical monitoring (EKUK)
- hydrobiological monitorings: plankton, benthos, macrophytes (EMÜ),
- fish stock monitoring (TÜ)

Lake types

Water Framework Directive (WFD) – protect lakes, achieve good status.

Lake Peipsi is very large, shallow, unstratified and light-coloured = **unique water body (type VII)**

WFD type	Surface area (km ²)	Alkalinity (HCO ₃ ⁻ , mg/L)	Electrical conductivity (µS/cm)	Chlorides (mg/L)	Water colour (Pt-Co scale)	Stratification and water colour
I	< 10	> 240	> 400	< 25	< 100	Light-coloured, unstratified
II	< 10	80–240	165–400	< 25	—	Unstratified, regardless of water colour
III	< 10	80–240	165–400	< 25	—	Stratified, regardless of water colour
IV	< 10	< 80	< 165	< 25	≥ 100	Dark-coloured, regardless of stratification
V	< 10	< 80	< 165	< 25	< 100	Light-coloured, unstratified
VI – Lake Võrtsjärv	100–300	80–240	165–400	< 25	< 100	Unstratified, light-coloured
VII – Lake Peipsi	> 1000	80–240	165–400	< 25	< 100	Unstratified, light-coloured
VIII – Coastal lakes	Distance from the sea ≤ 5 km	—	—	> 25	< 100	Regardless of stratification and water colour

Assessment of the condition of Lake Peipsi

- Base documents of assesment of the status of L. Peipsi:
 - 1) **Water Framework Directive**
 - 2) **Environmental regulation** „Pinnaveekogumite moodustamise kord ja nende pinnaveekogumite nimestik, mille seisundiklass tuleb määrata, pinnaveekogumite seisundiklassid ja seisundiklassidele vastavad kvaliteedinäitajate väärtused ja seisundiklasside hindamise kord“
- Physicochemical quality elements: **pH, total nitrogen, total phosphorus, transparency**
- Biological quality elements: **phytoplankton, macrophytes, phytobentos and macrobenthos.**
- **Problem – zooplankton is not included!!**

Hydrobiologia (2011) 676:279–297
DOI 10.1007/s10750-011-0831-0

CLADOCERA AS INDICATORS

Zooplankton as indicators in lakes: a scientific-based plea for including zooplankton in the ecological quality assessment of lakes according to the European Water Framework Directive (WFD)

Erik Jeppesen · Peeter Nõges · Thomas A. Davidson · Jutta Haberman ·
Tiina Nõges · Kätlin Blank · Torben L. Lauridsen · Martin Søndergaard ·
Carl Sayer · Reet Laugaste · Liselotte S. Johansson · Rikke Bjerring ·
Suzanne L. Ambrose

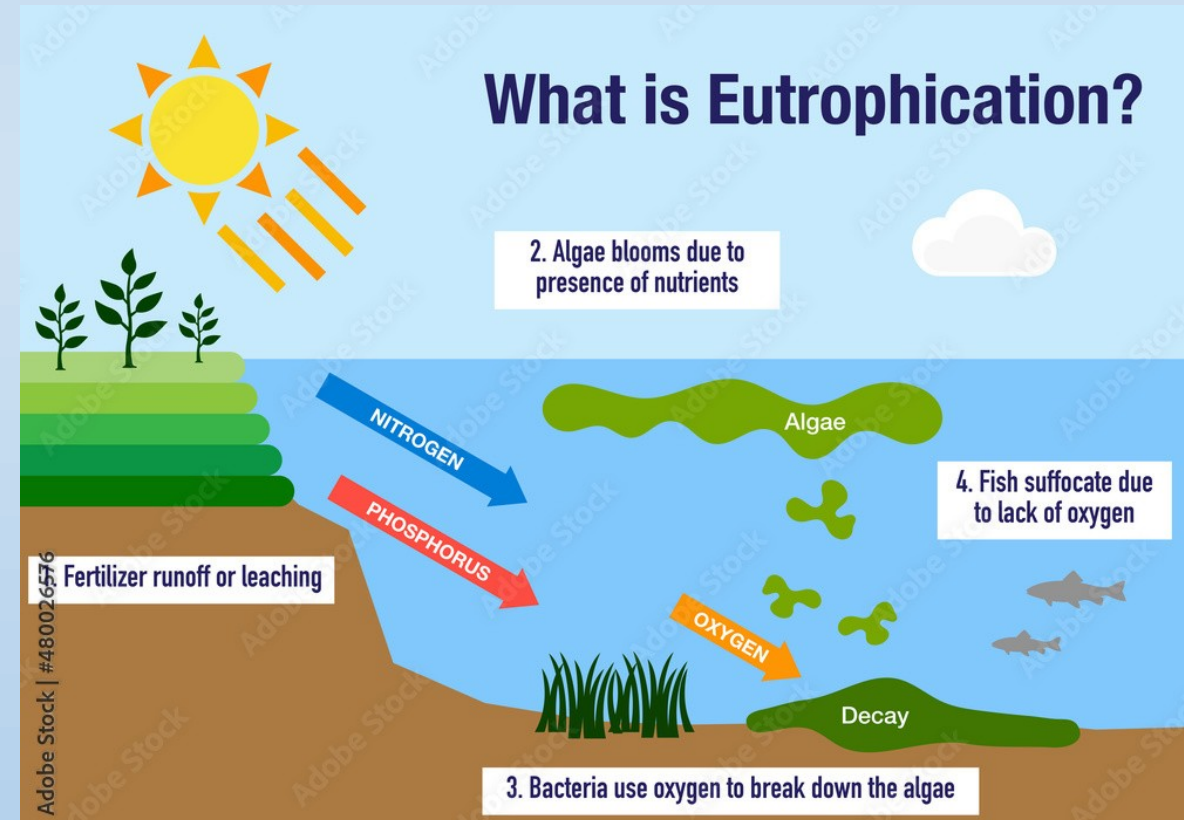
Limit values of physicochemical parameters (for L. Peipsi)

Quality indicator	Lake section	Very good	Good	Moderate	Poor	Very poor
Total phosphorus content P _{tot} , µg/l	Peipsi s.s.	<1	(17-25]	(25-49]	(49-79]	>79
	Lämmijärv and Pihkva	<30	(30-50]	50-85]	(85-135]	>135
Total nitrogen content N _{tot} , µg/l	Peipsi s.s.	≤300	(300-510]	(510-890]	(890-1300]	>1300
	Lämmijärv and Pihkva	≤490	(490-720]	(720-1200]	(1200-1600]	>1600
N/P ratio	Peipsi s.s.	≥50	(50-28]	(28-13]	(13-7]	<7
	Lämmijärv and Pihkva	≥38	(38-19]	(19-10]	(10-6.5]	<6.5
Secchi disk visibility, m	Peipsi s.s.	≥3.5	(3.5-2.5]	(2.5-1.5]	(1.5-1.0]	<1.0
	Lämmijärv and Pihkva	≥2.0	(2.0-1.5]	(1.5-1.0]	(1.0-0.7]	<0.7
pH	Peipsi s.s.	7.0-7.7	(7.7-8.1]	(8.1-8.3]	(8.3-8.6]	>8.6
	Lämmijärv and Pihkva	7.0-7.6	(7.6-8.0]	(8.0-8.3]	(8.3-8.8]	>8.8

Problems with Lake Peipsi – 1. eutrophication

- ***Eutrophication** – nutrient enrichment
- ***External pollution** – nutrients enter through inflows
- ***Internal pollution** – nutrient separation from sediments

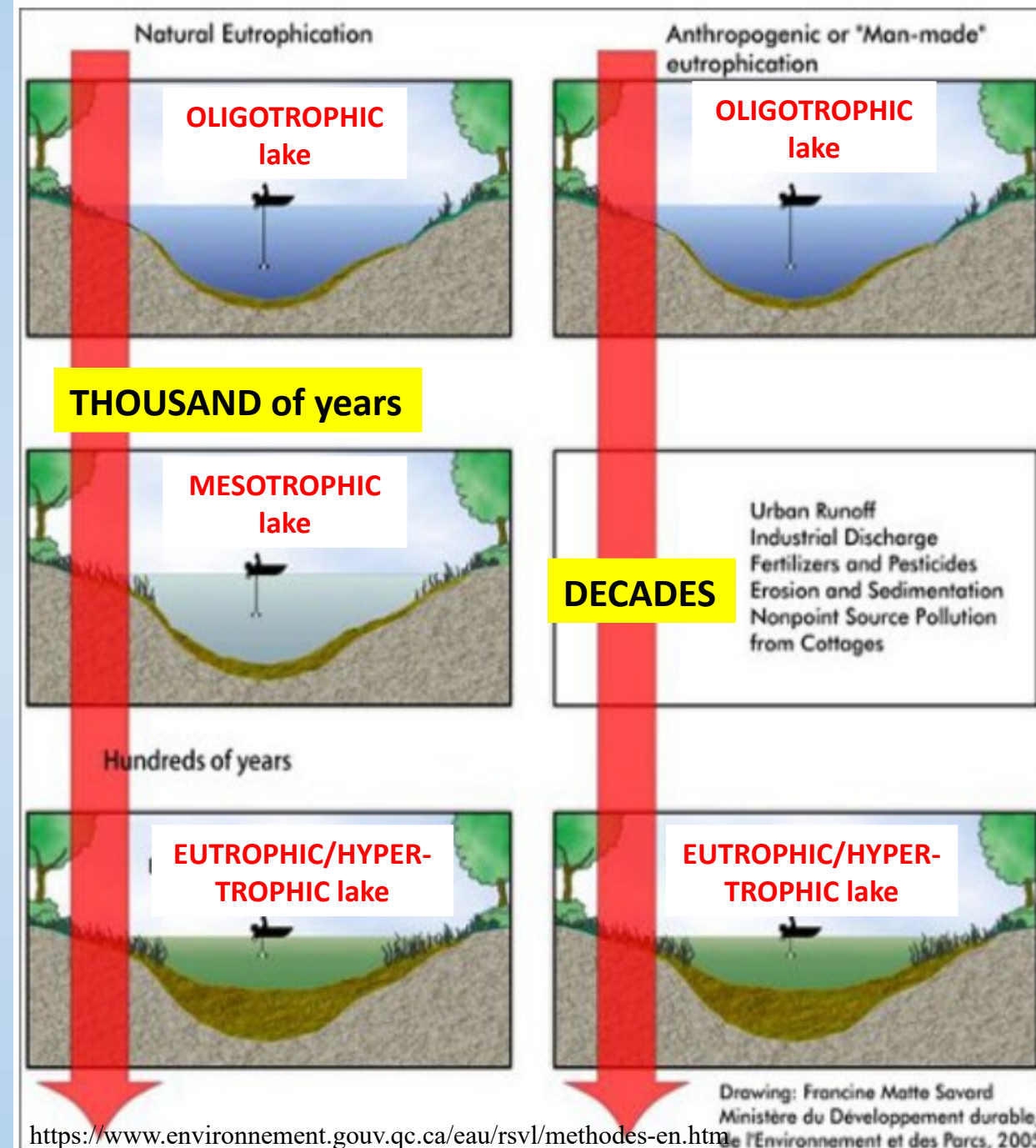
NB! In L. Peipsis internal pollution is 3 times greater than external pollution!



Why does eutrophication occur?

- 1) **Natural eutrophication** – lake ageing (slow process).
- 2) **Anthropogenic eutrophication** – man-made pollution (accelerated process).
 - factories
 - settlements
 - agriculture
 - recreation

Climate changes intensify eutrophication!



Water nutrients of L. Peipsi

*In L. Lämmijärv phosphorus concentration is **2 times higher** than in L. Peipsi s.s.

*Since 2018 – clear increase of nitrogen

*Since 2014 – slight increase of phosphorus

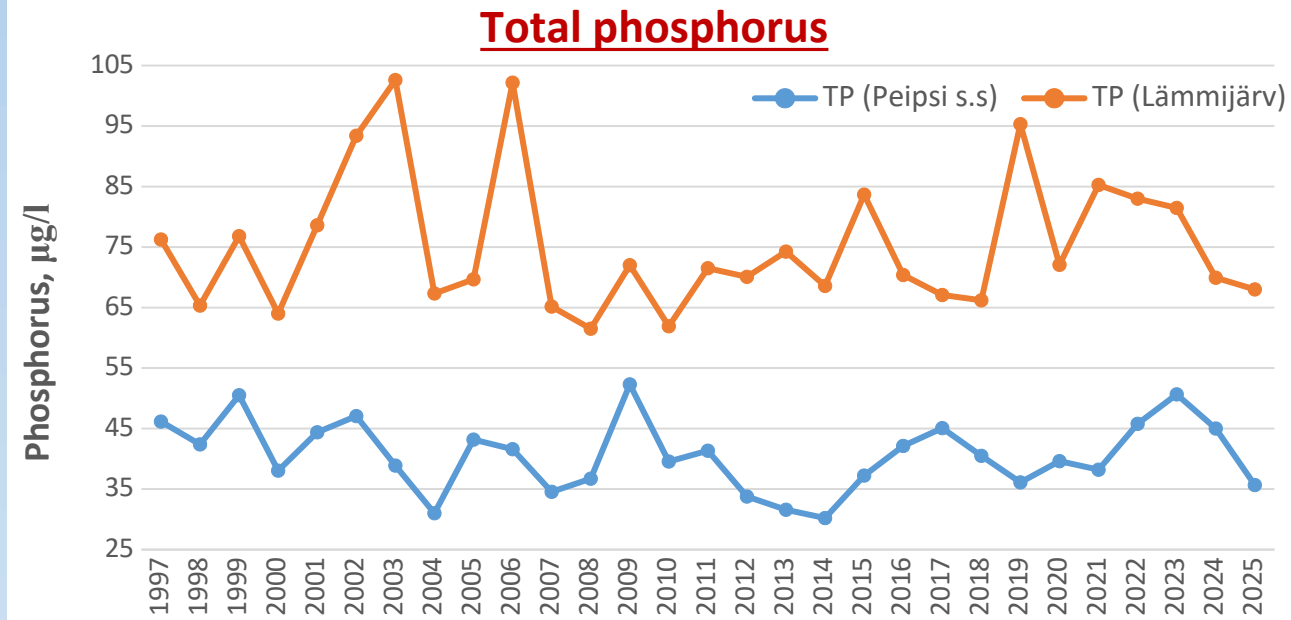


Figure. Total phosphorus concentration in L. Peipsi s.s. and L. Lämmijärv in 1997-2025

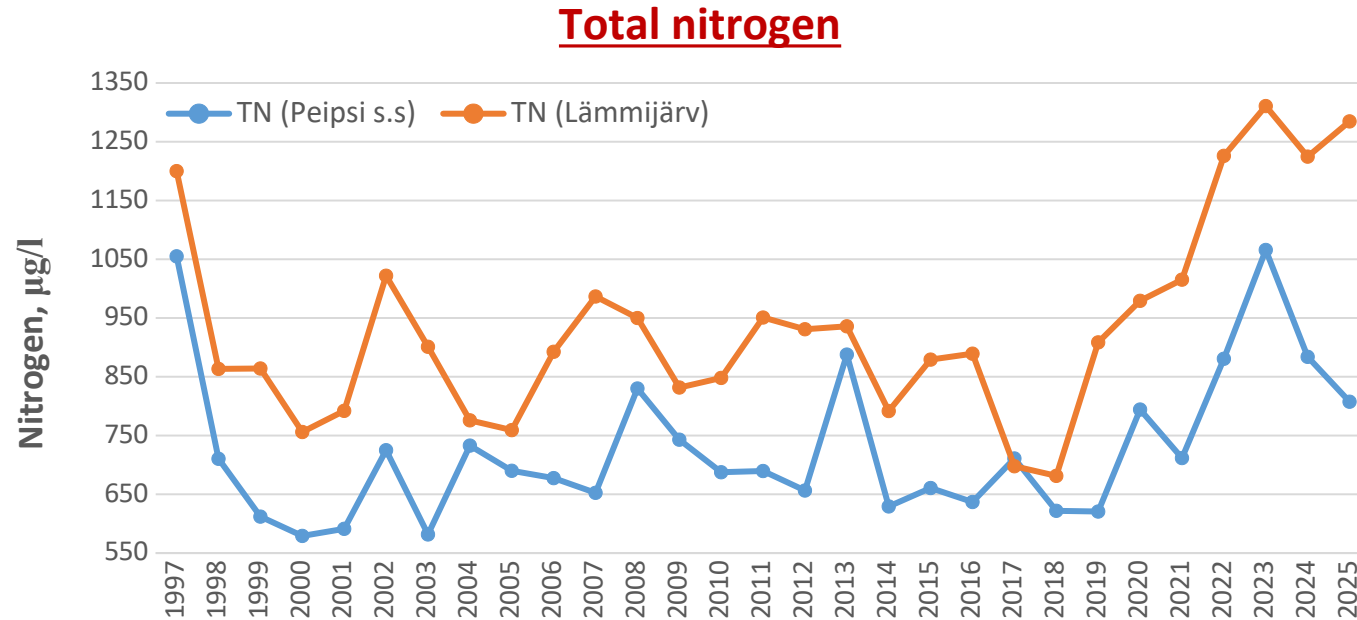


Figure. Total nitrogen concentration in L. Peipsi s.s. and L. Lämmijärv in 1997-2025

Consequences of eutrophication

1. Algal blooms: massive growth of cyanobacteria – harm water quality

- limit light penetration
- produce toxins
- harm water quality

Exelent conditions for blooms: **nutrients, warm water, windless weather**



Water blooms in L. Peipsi

*In L. Lämmijärv the biomass of cyanobacteria is **3 times** higher than in L. Peipsi s.s.

*Last 3 decades – biomass of cyanobacteria has slightly increase, blooms are more frequent and intence.

*2025. data = phtytoplanton indicators showed **moderate/poor** condition to L. Peipsi s.s., **poor** to L. Lämmijärv.

*Dominant genera of cyanobacteria: *Microcystis*, *Aphanizomenon*,
Dolichospermum, *Gloeotrichia*.

* **Concentration of cyanotoxins in coastal areas can be very high!**

Very good	Good	Moderate	Poor	Very poor
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Consequences of eutrophication

2. Proliferation of reed

Negative consequences:

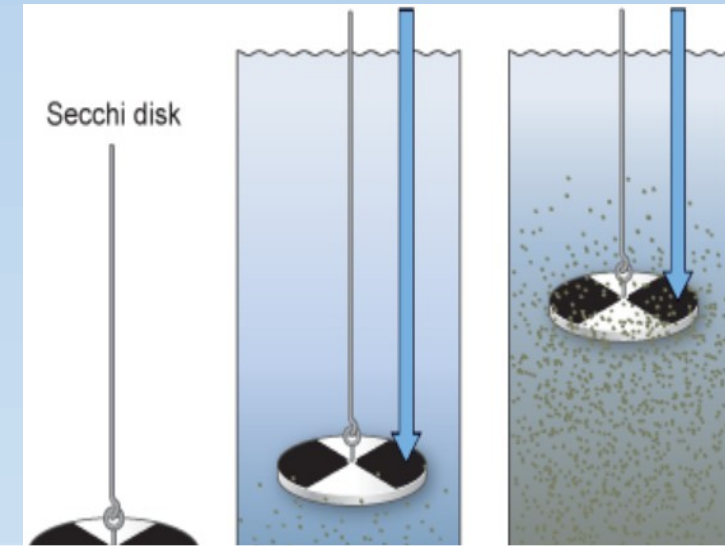
- species richness decreasing
- open area habitats are disappearing
- appropriate fish spawning areas are disappearing
- difficult access to the lake



Consequences of eutrophication

3. Water turbidity

- Eutrophic lakes = turbid water
- Water transparency is in decreasing trend: L. Lämmijärv is in worse condition
- Turbid water is not acceptable for all species!



Turbid

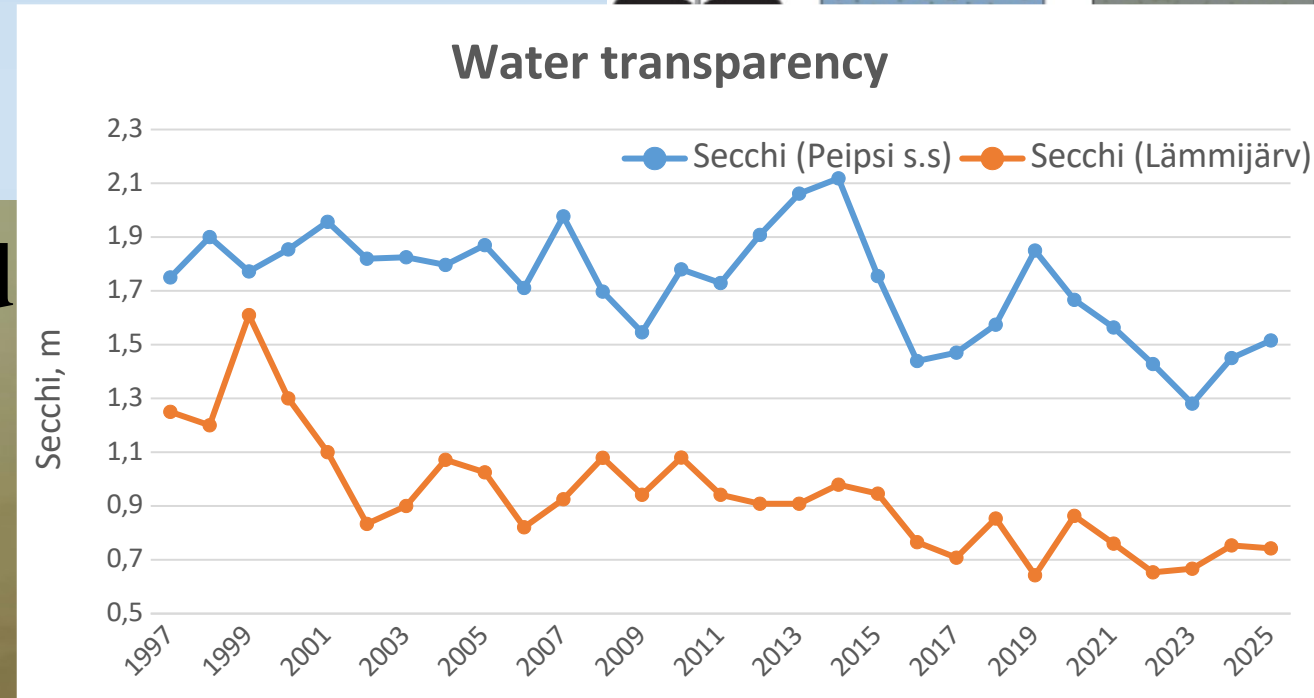


Figure. Water transparency in L. Peipsi s.s. and L. Lämmijärv during 1997-2025

Consequences of eutrophication

4. Bottom mud

- Dead organisms turn into mud
- Increase of mud layer is problem:
 - lake getting shallower = sensitive to environmental disturbances
 - lake's overgrowth
 - decrease of water quality
 - oxygen depletion
 - turbid water
 - loss of species richness
 - loss of spawning areas



Consequences of eutrophication

5. Fish kills and decline in fish stocks

***Massive fish kills** = combination of negative factors

- water blooms = toxins
- warm water with low oxygen
- low water level
- windless weather/still water

*Extensive water blooms = daily oxygen excess, oxygen deficiency at nighttime.

*Decomposing algae mass = release of ammonia (toxic to fish) = **fish kills!**

*Most sensitive are **fish larvae, young fish** and **cold-water species**.

*Last massive fish kill **in 2018**



Changes in fish community

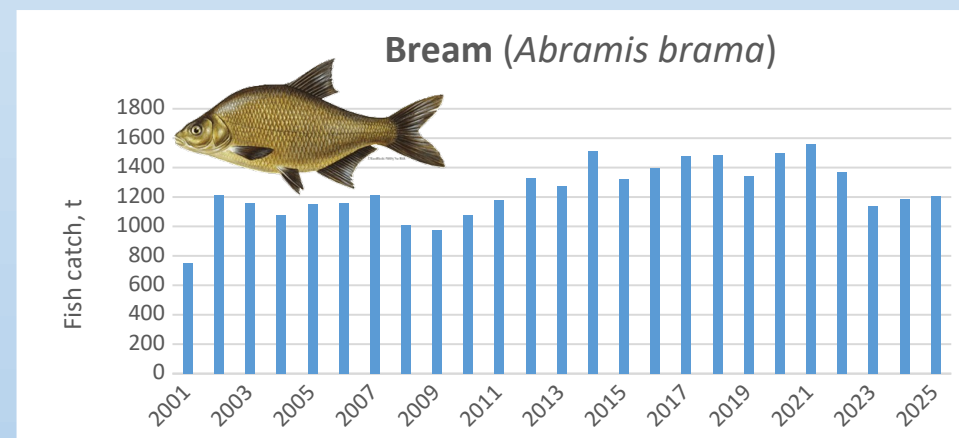
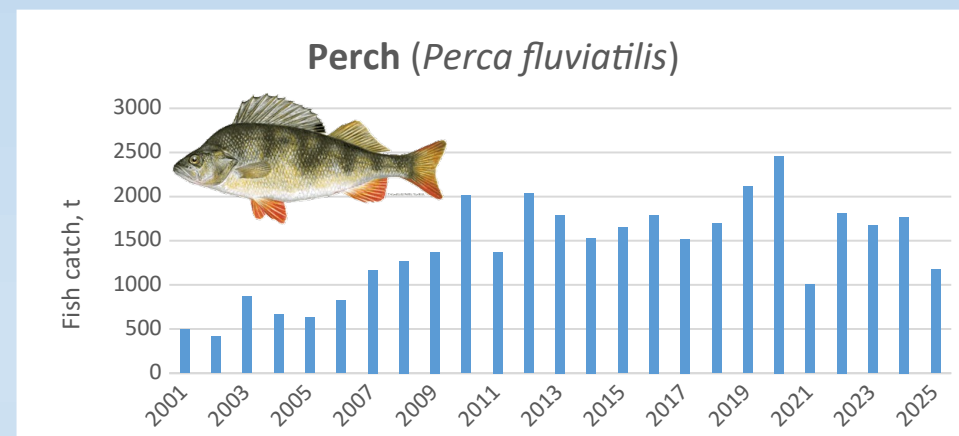
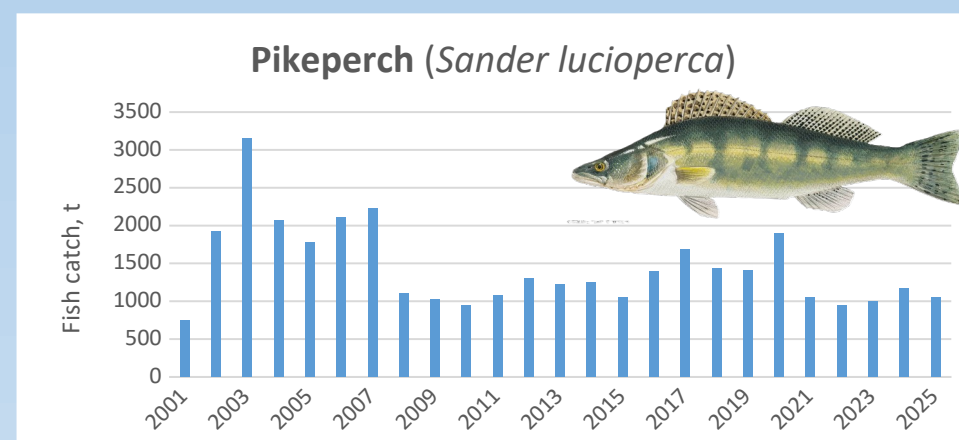
Warm-water species

*Fish population is dominated by **warm-water species**: pikeperch, perch and bream.

***Pikeperch**: most important commercial fish since 80s. Stock is in moderate status (poor feeding conditions).

***Perch**: the second most important commercial fish. Catches are decreasing.

***Bream**: catches and stock are high, in good status.



Fish catches from L. Peipsi s.s., L. Lämmijärv, L. Pihkva in 2025.
Data from report by Estonian Marine Institute (University of Tartu)

Changes in fish community

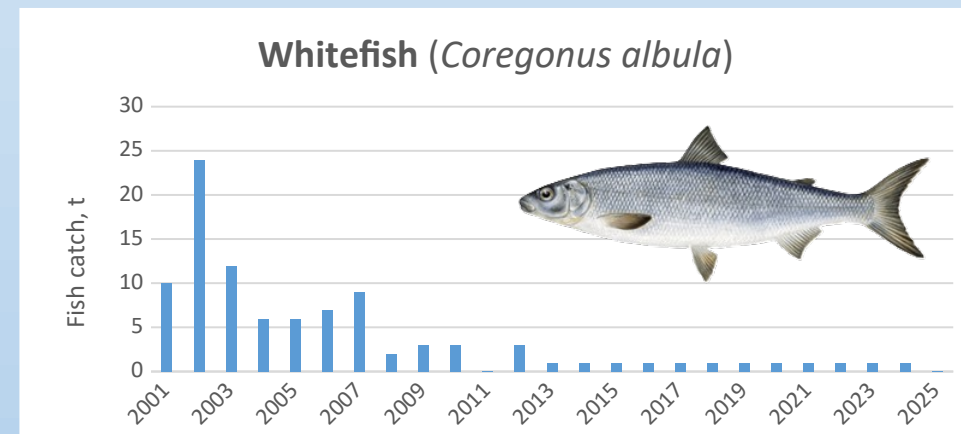
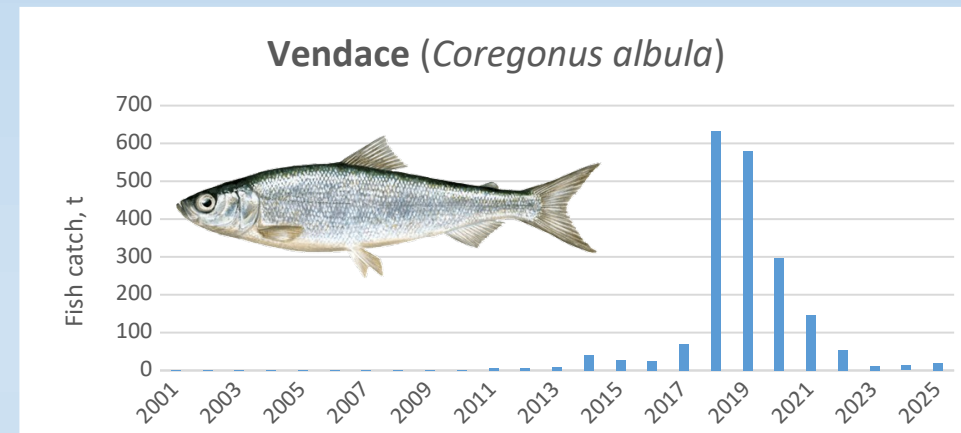
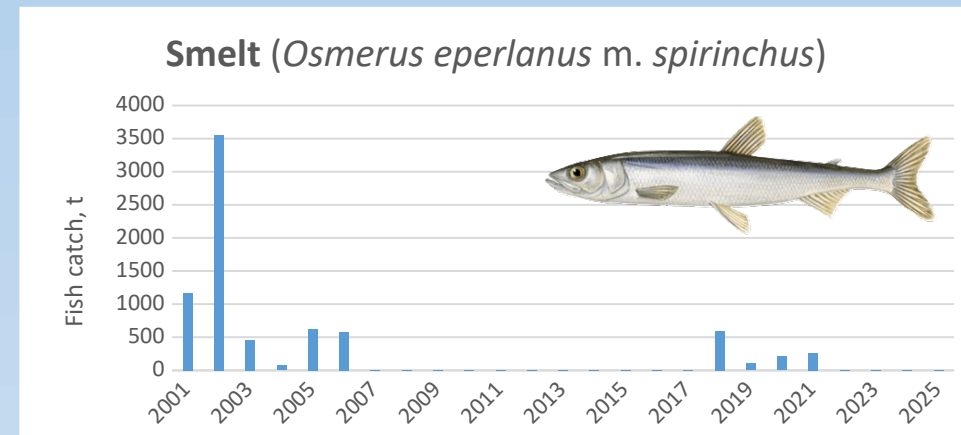
Cold-water species

*Catches of **cold-water species** have decreased drastically.

***Smelt**: earlier the catches reached to very high numbers. Unfavorable weather conditions and the increase of pikeperch abundance have caused smelt collapse. Commercial catches are forbidden.

***Vendace**: earlier very abundant. Shortening ice cover period, eutrophication and bad weather conditions caused the collapse.

***Whitefish**: unfavourable condition for development = abundance is very low



Fish catches from L. Peipsi s.s., L. Lämmijärv, L. Pihkva in 2025.
Data from report by TÜ Mereinstituut

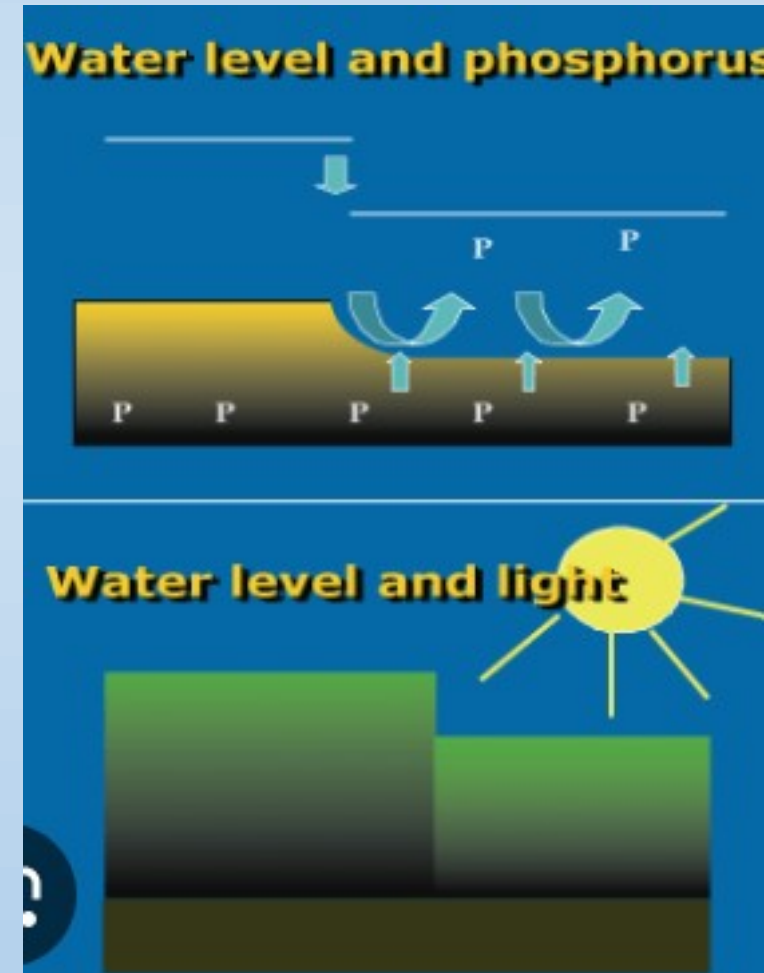
Problems with Lake Peipsi– **physical pollution**

- Physical pollution – „ghost nets“ and other **garbage**
- Negative impact to **fish, water birds, watercrafts**
- Garbage decomposes into **microplastics**
- Microplastics enter into **food chain**.



Problems with Lake Peipsi – **climate change**

- *Consequences of climate change – **higher water temperatures** and **low water level**.
- *Annual water level fluctuation – **1.5 m**.
- * Shallow lakes are **particularly sensitive** to climate changes and pollution
- *Higher water temperatures **promote water blooms**
- *High water temperatures promote **phosphorus release** from sediments.



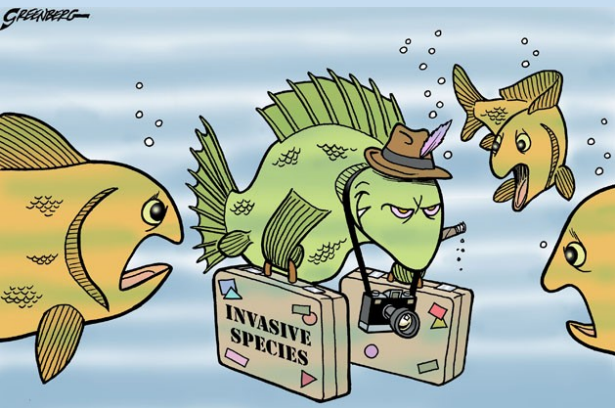
Problems with Lake Peipsi – **alien species**

***Alien species** – a species who has migrated into a new environment/habitat.

***Zebra mussel** (*Dreissena polymorpha*): very abundant. Problem – attach on rocks, other shells, pipes, nets, buoys, harbor facilities.

***Gmelinoides fasciatus** (rändvähk): inhabited in 70s for food for fish. Problem – significantly reduces species richness.

***Alien species disrupt the balance of the ecosystem - distribution is prohibited!**



Zebra mussel –
Dreissena polymorpha



Järve-kirpvähk – native species

1 cm



Gmelinoides fasciatus

Rändvähk – alien!

How to protect L. Peipsi?

- Avoid over fertilizing
- Use natural pesticides
- Use natural cleaning products
- Efficient wastewater treatment
- Don't introduce alien species
- Don't throw garbage into lake
- Continued trawling of “ghost nets”
- Increasing people's environmental awareness
- Cooperation with Russian scientists
- Regular monitoring of L. Peipsi



The first L. Peipsi monitoring in May 1962 with vessel „Bioloog“



Research vessel „Önneleid“



Winter sampling in 1966 vs 2024

1966



2024



Winter monitoring in 1966 vs 2024

1966



Juta Haberman, Reet Laugaste

2024



Kadi Palmik, Kätlin Blank

Winter monitoring in 1996



Unknown man, Reet Laugaste, Jutta Haberman

Idle moment in 1966 vs 2022

1966



Jutta Haberman

2022



Kätlin Blank

Summer monitoring outfit in 1963 vs 2021

1963



Jutta Haberman

2021



Kätlin Blank

Thank you for your attention!

