NATURAL NITROGEN REMOVAL IN THE SEA

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WWTP BALTIC SEA

FUNCTION,

MAINTENANCE AND

DISTURBANCES IN FUNCTION

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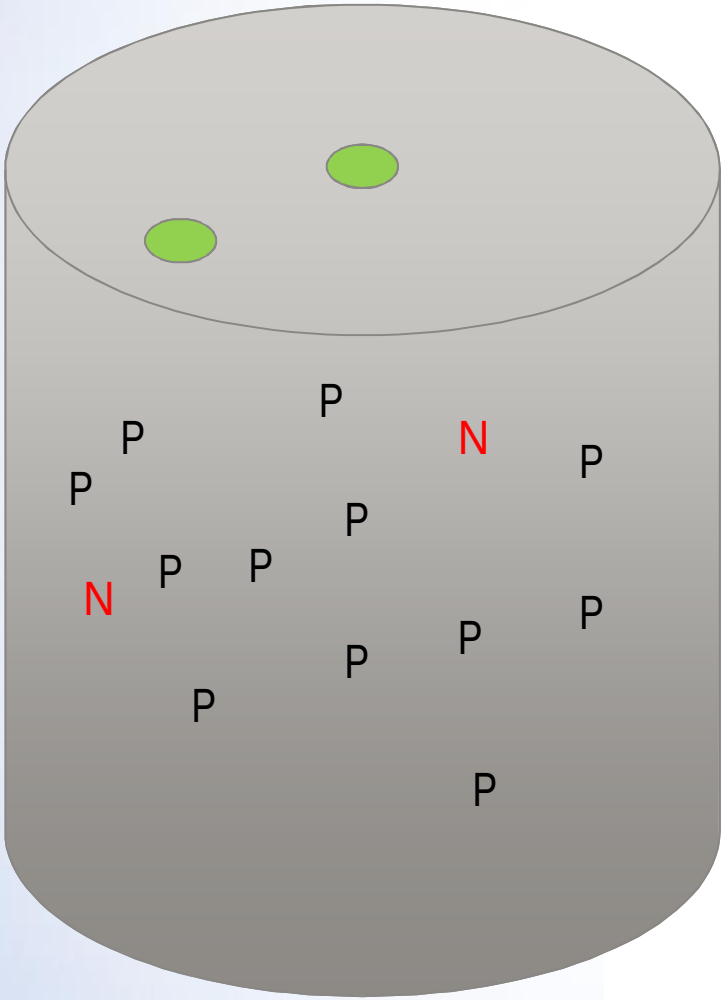
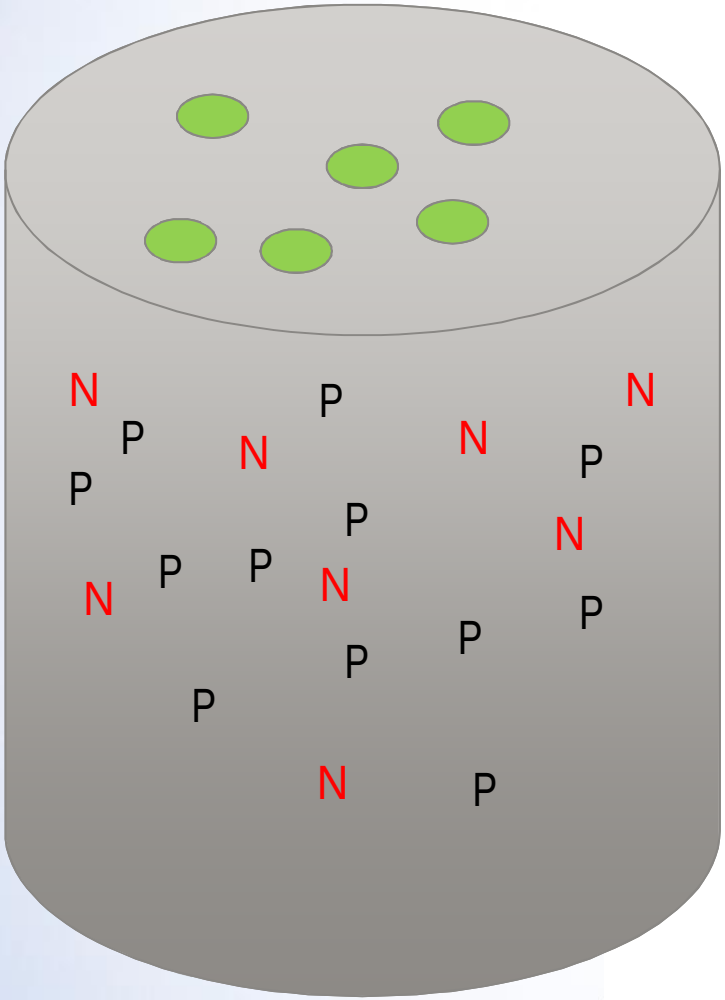
NITROGEN LIMITED BALTIC



ALGAL GROWTH IS LIMITED BY LACK OF NITROGEN N

IN MOST PARTS OF THE BALTIC SEA

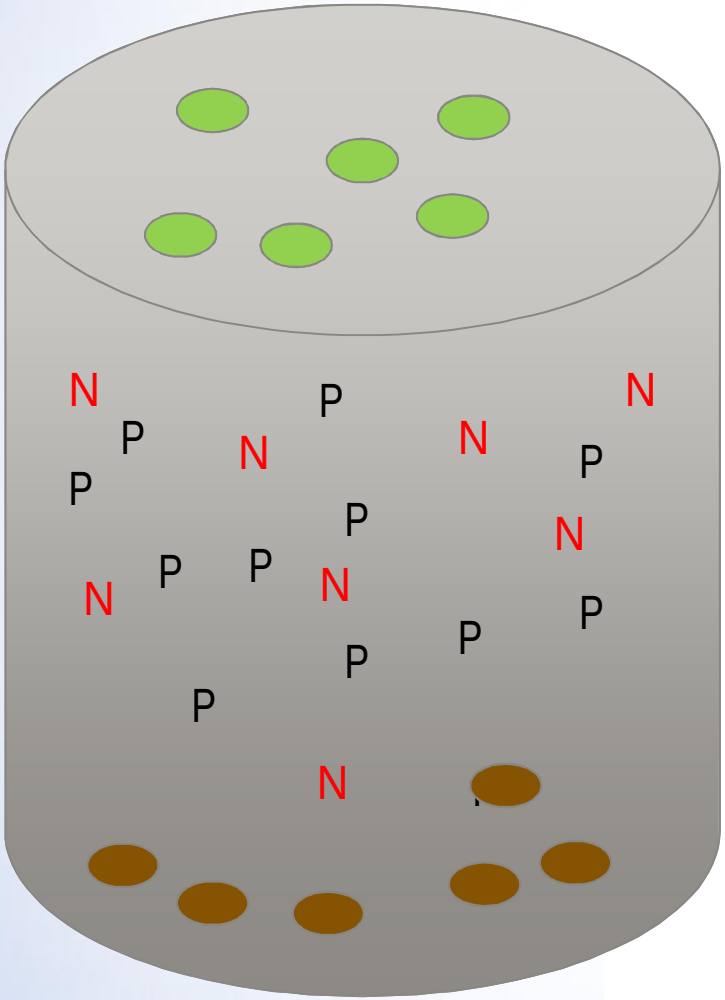
NITROGEN LIMITED BALTIC



MORE NITROGEN

-MORE ALGAE

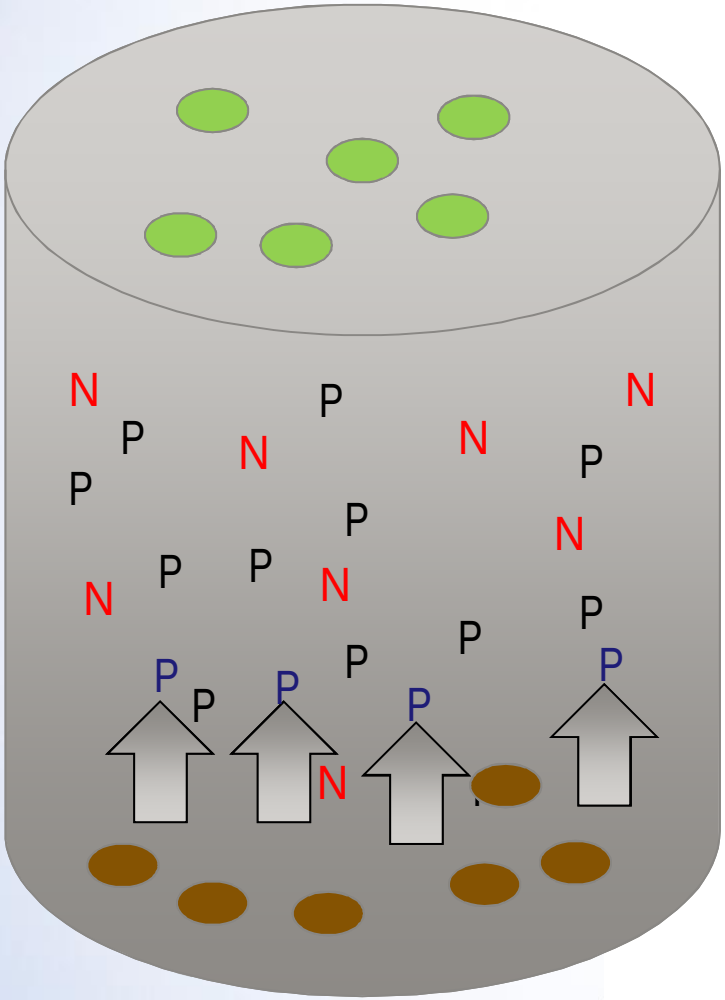
NITROGEN LIMITED BALTIC



MORE ALGAE

-MORE DEAD, DECOMPOSING ALGAE AT THE BOTTOM

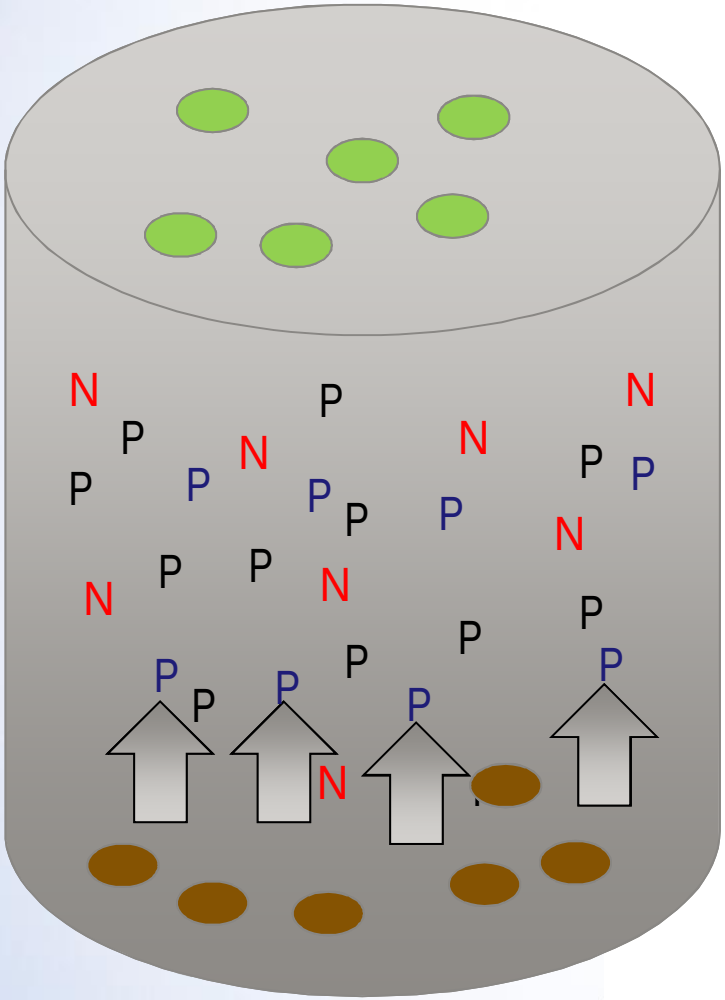
NITROGEN LIMITED BALTIC



MORE DECOMPOSING ALGAE AT THE BOTTOM

-ANOXIA, P RELEASE

NITROGEN LIMITED BALTIC

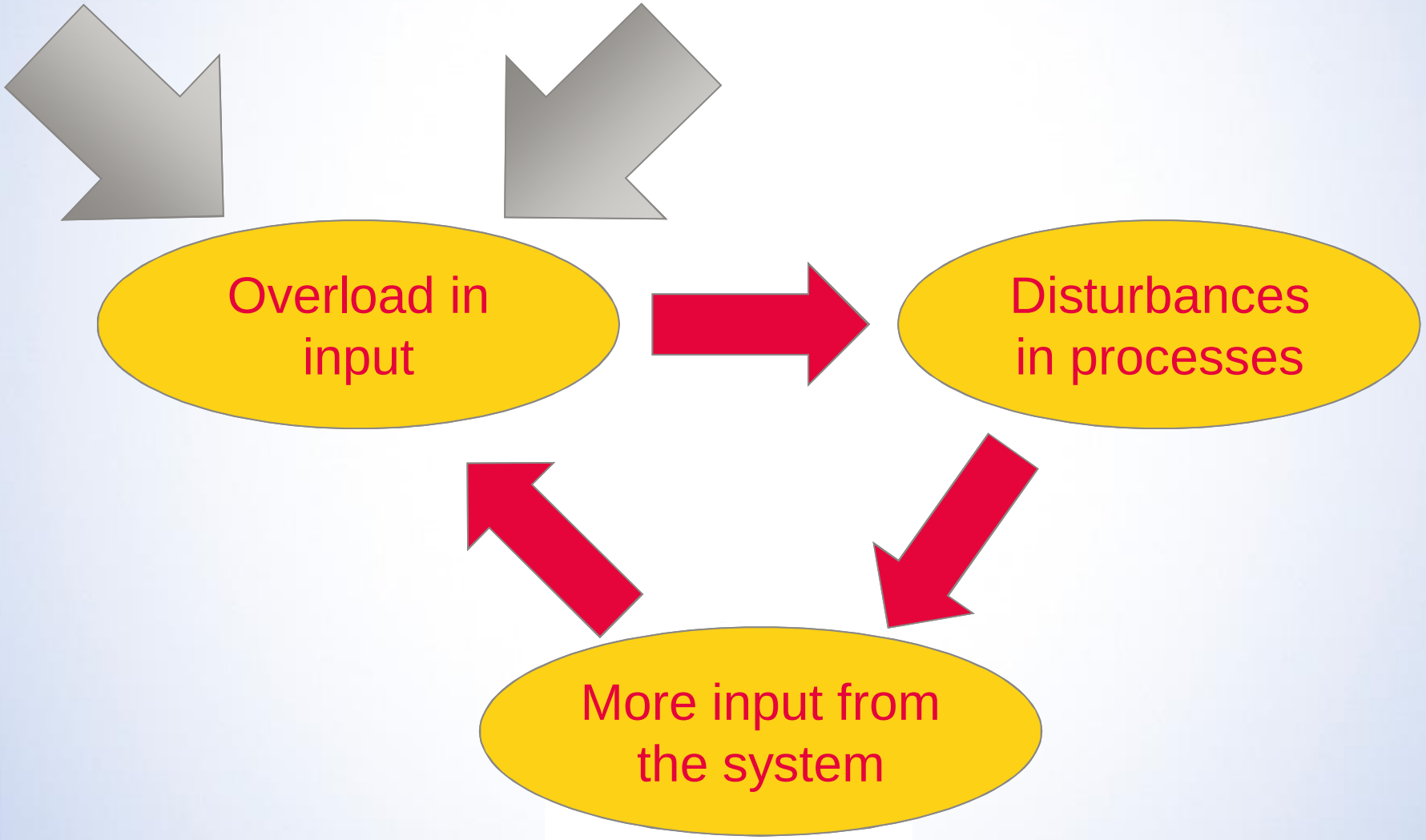


ANOXIA, P RELEASE

- **BLOOMS OF CYANOBACTERIA**

-> MORE N IN THE SYSTEM

VICIOUS CYCLE OF NUTRIENT OVERLOAD



BALTIC ECOSYSTEM FIGHTS BACK

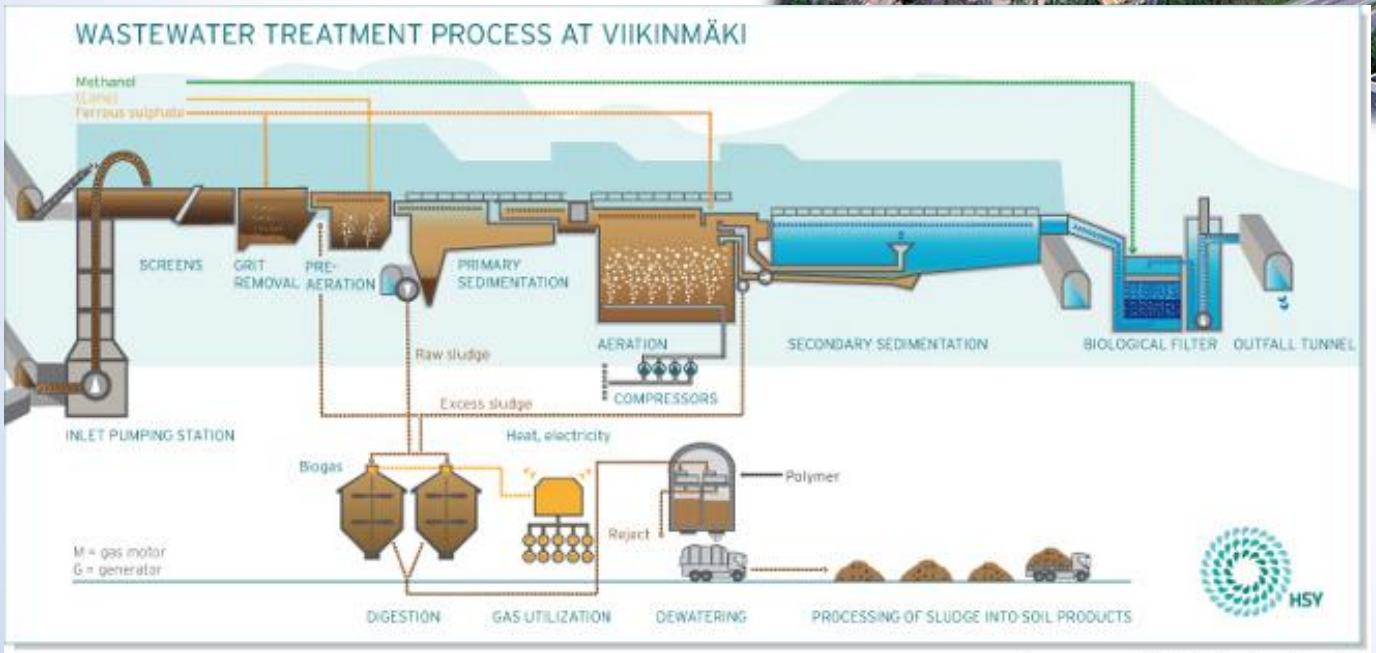
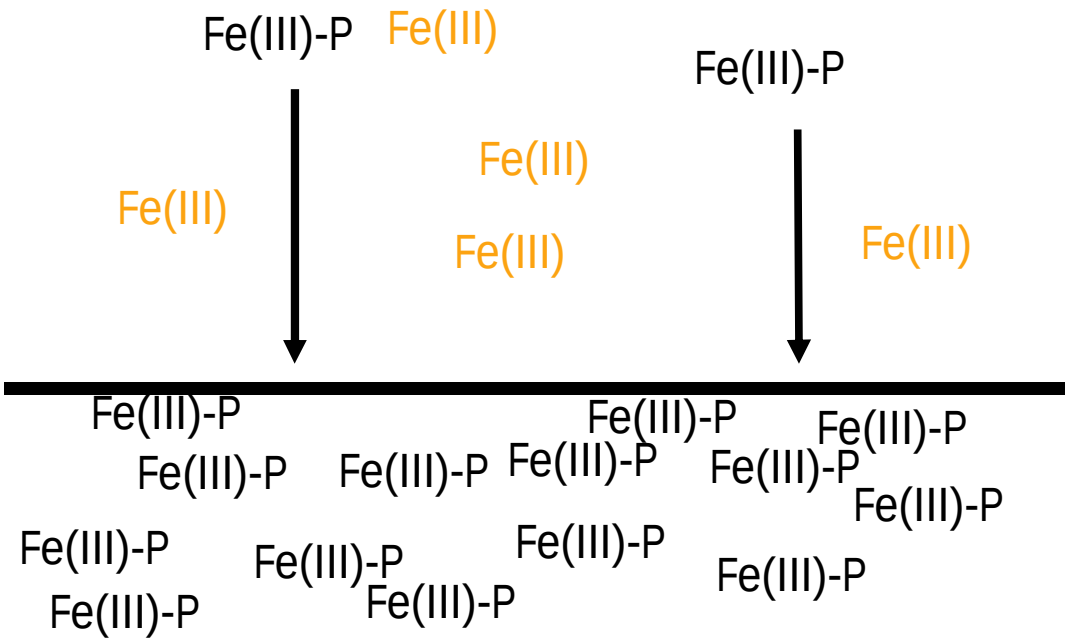


Image credit: HSY/Sopiva Design

PHOSPHORUS REMOVAL: OPTIMAL FUNCTION

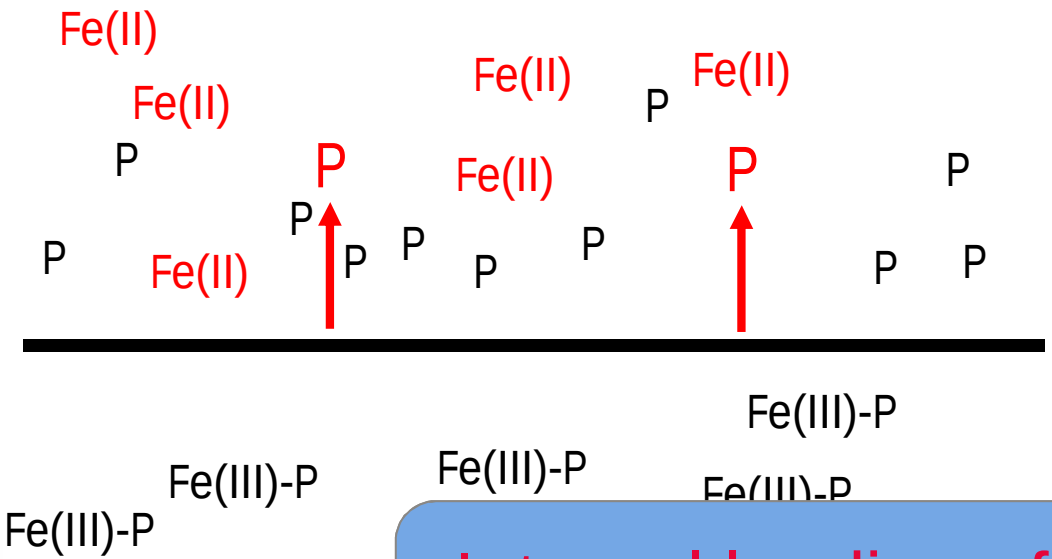
In oxic conditions phosphates released in mineralization precipitate at the bottom of the sea



"Healthy", oxic sediment surface.

PHOSPHORUS REMOVAL: DISTURBANCE IN FUNCTION

In anoxic conditions iron is reduced and phosphates released back into water column



"Dead", anoxic sediment surface.

Internal loading of phosphorus

NITROGEN REMOVAL: OPTIMAL FUNCTION

In oxic conditions ammonium released in mineralization is first oxidized to nitrate.

Nitrate then diffuses to anoxic sediments and is reduced to nitrogen gas by microbes.

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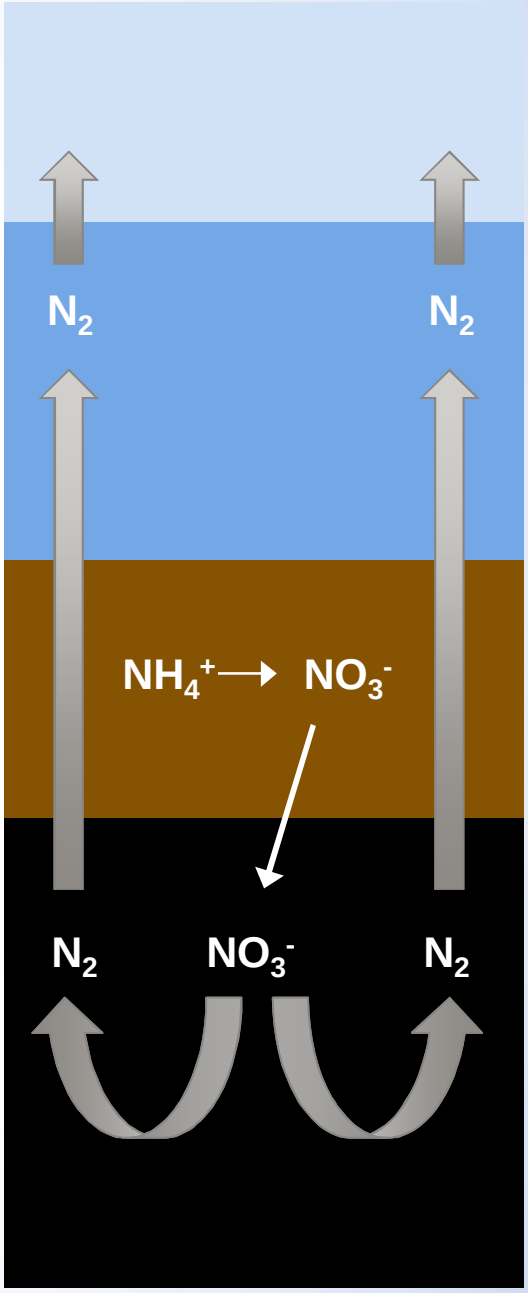
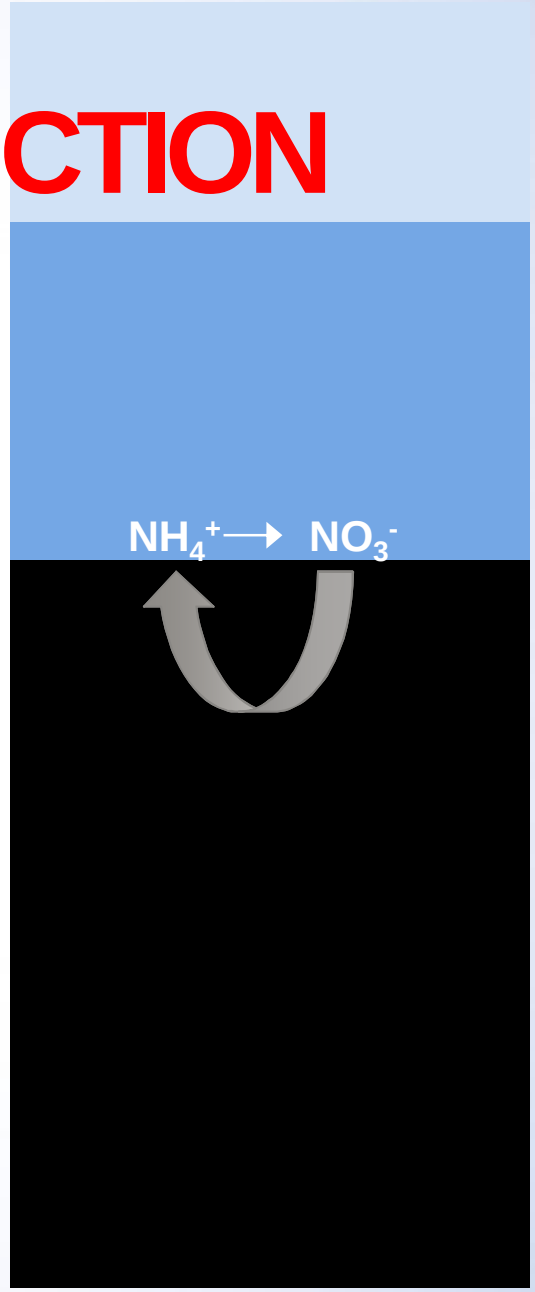


NITROGEN REMOVAL:
DISTURBANCES IN FUNCTION

First warning: persistent hypoxic conditions switch nitrogen removal to nitrogen cycling – ammonium is oxidized to nitrate, followed by reduction back to ammonium instead of nitrogen gas

Nitrogen storage



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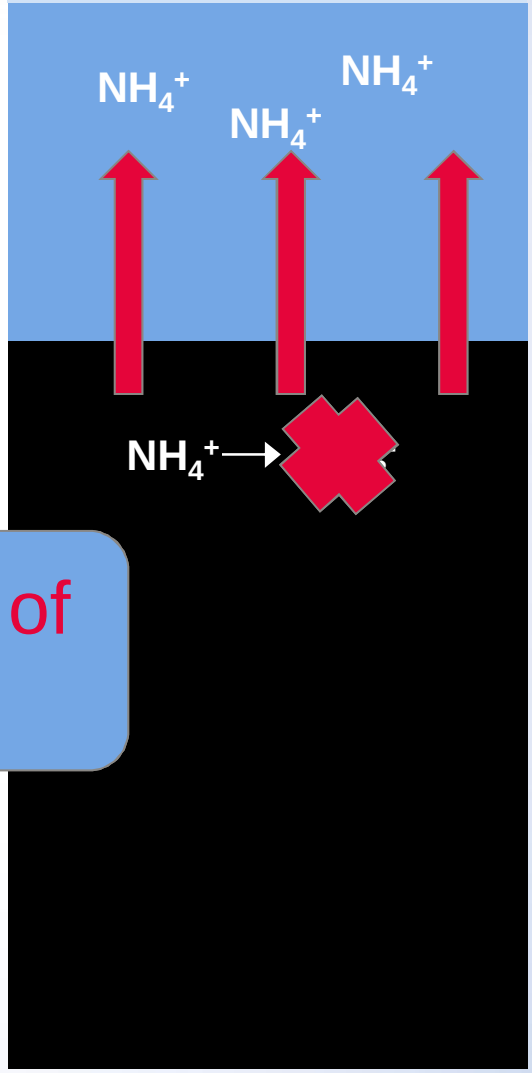
NITROGEN REMOVAL:
DISTURBANCES IN FUNCTION

In anoxic conditions ammonium cannot be oxidized to nitrate at all, and stays in the water ecosystem



Internal loading of nitrogen

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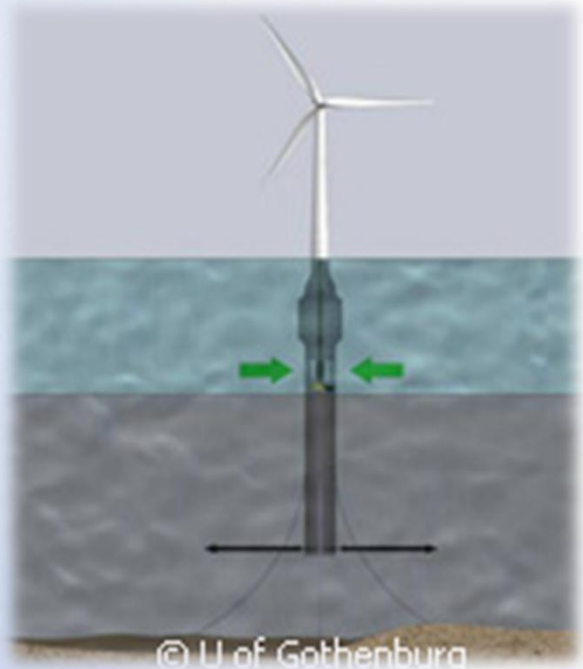
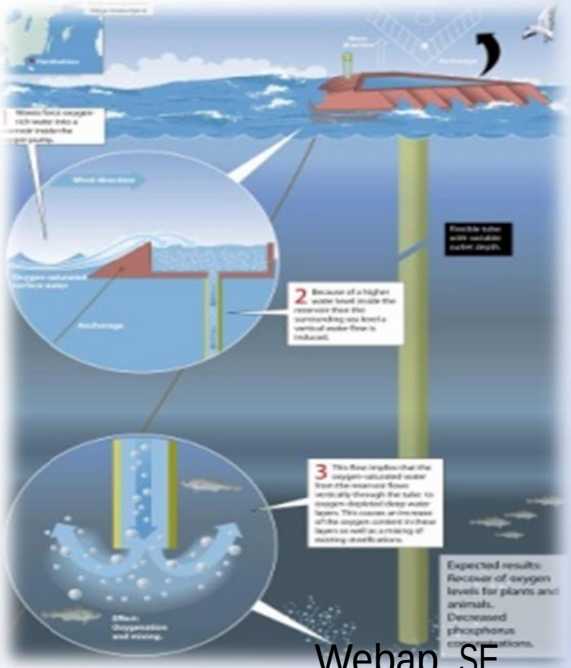
WWTP MAINTENANCE VIA ENGINEERING SOLUTIONS?

“If lack of oxygen is the problem, doesn’t it go away if we *add* oxygen”?

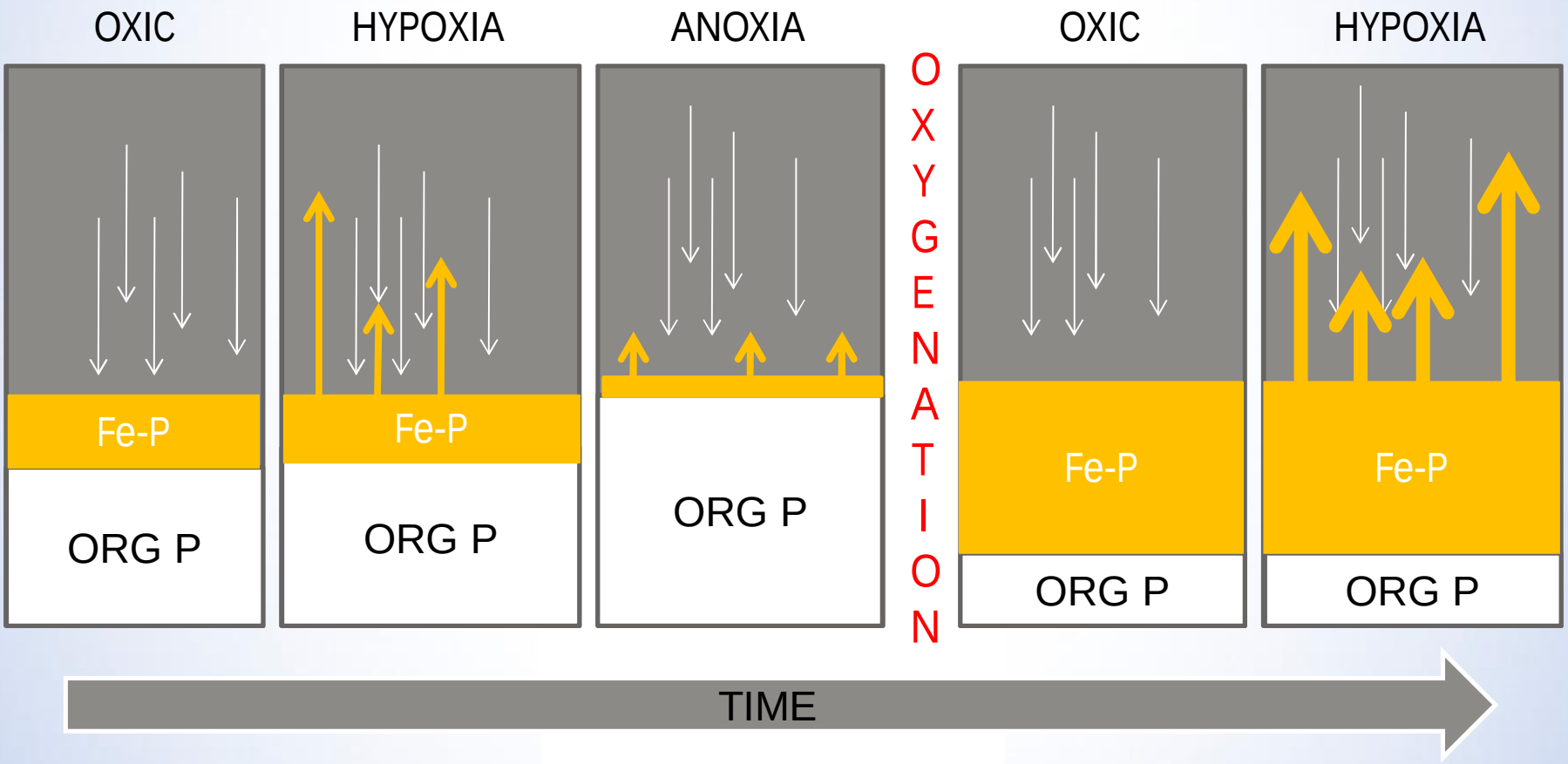


SYKE, FI



Webap, SE

CREATING A "PHOSPHORUS BOMB" ?



HUFFING AND PUFFING FOR NOTHING?

Aeration: ammonium goes down, nitrate goes up = high nitrification, high denitrification

No aeration: ammonium goes up, nitrate goes down = no nitrification, decreasing denitrification based on accumulated nitrate

Unpublished research results
Holmroos et al submitted

DENITRIFICATION RESPONSIBLE FOR < 5 % OF NITRATE DECREASE

The rest was nitrate reduction back to ammonium = nitrogen storage

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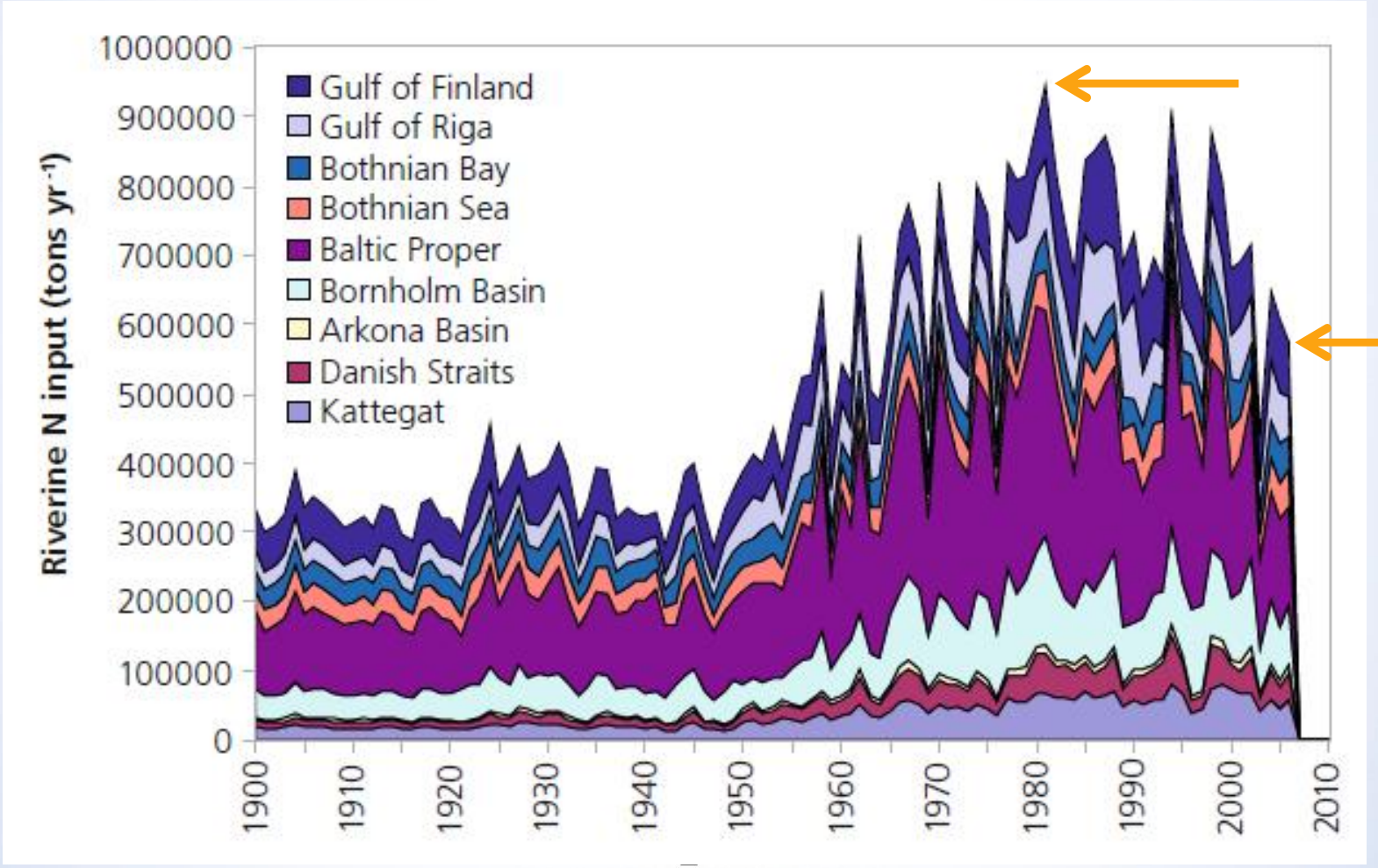
MANAGEMENT IMPLICATIONS?

AVOID ENTERING HYPOXIA AND ANOXIA
= KEEP THE NUTRIENTS AT LAND

THERE ARE NO SHORTCUTS

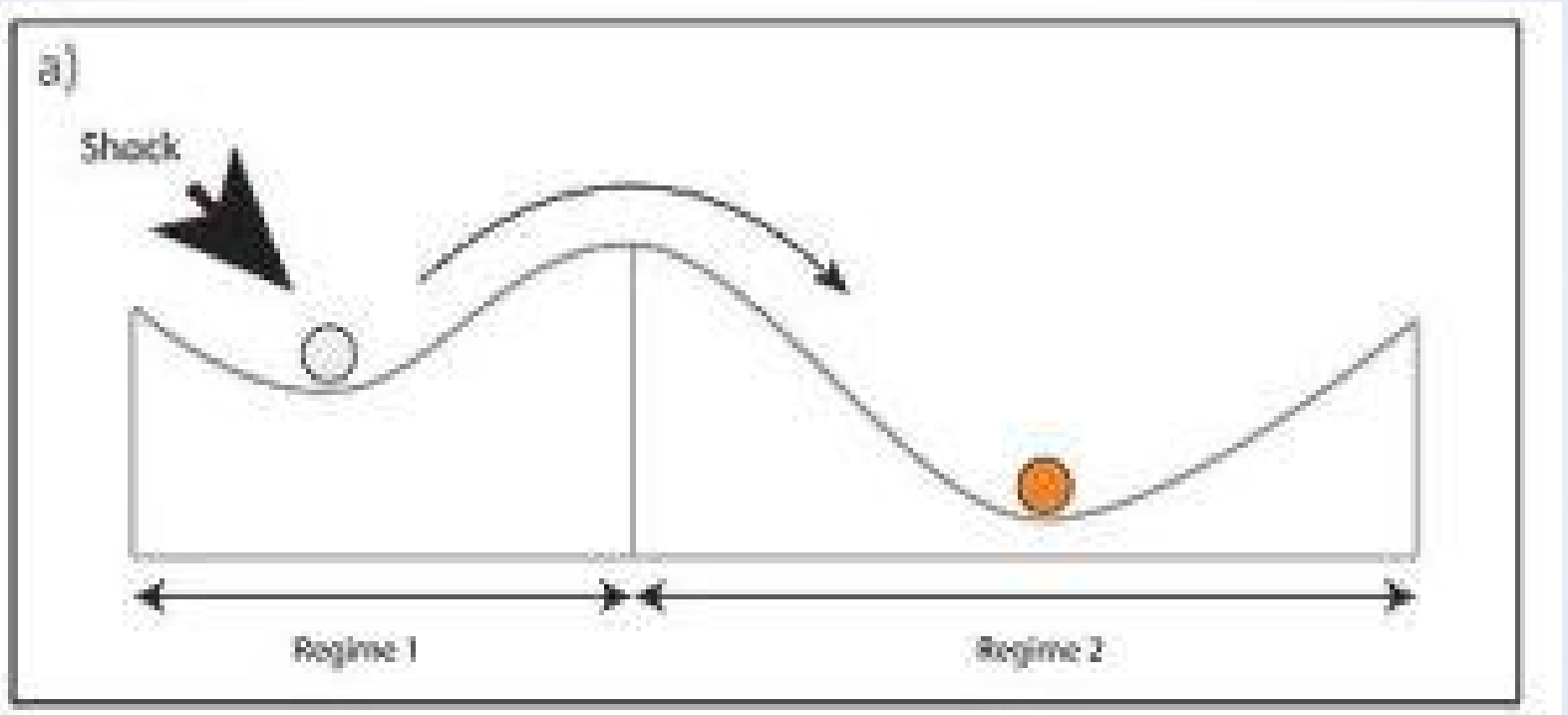
Engineering solutions may not only not rescue the sea but may also cause unforeseen new problems

BUT WE HAVE ALREADY REDUCED LOADING SO MUCH !?!



HELCOM 2013

NATURE PREFERS STEADY STATE



Biggs et al 2011

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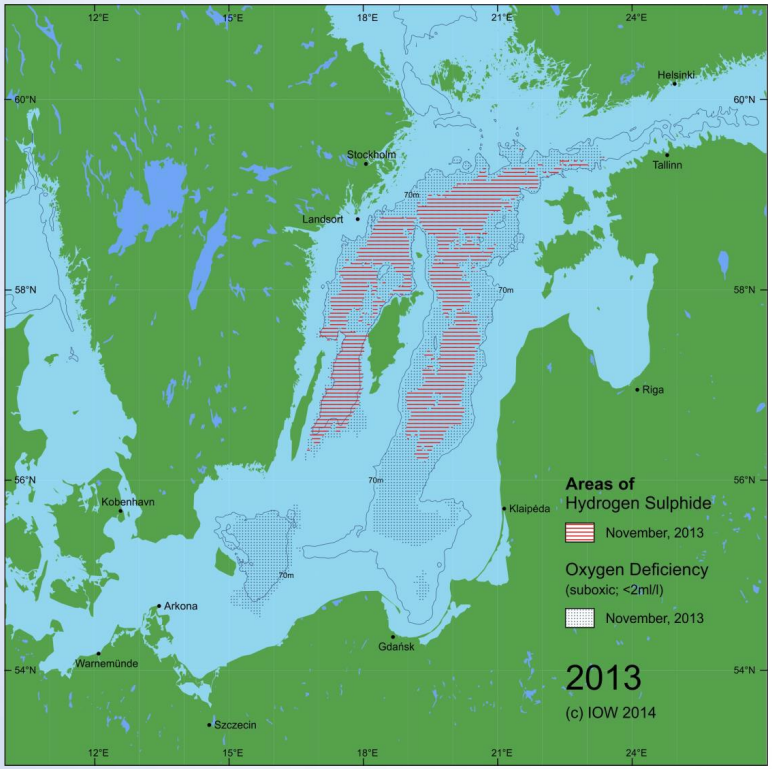
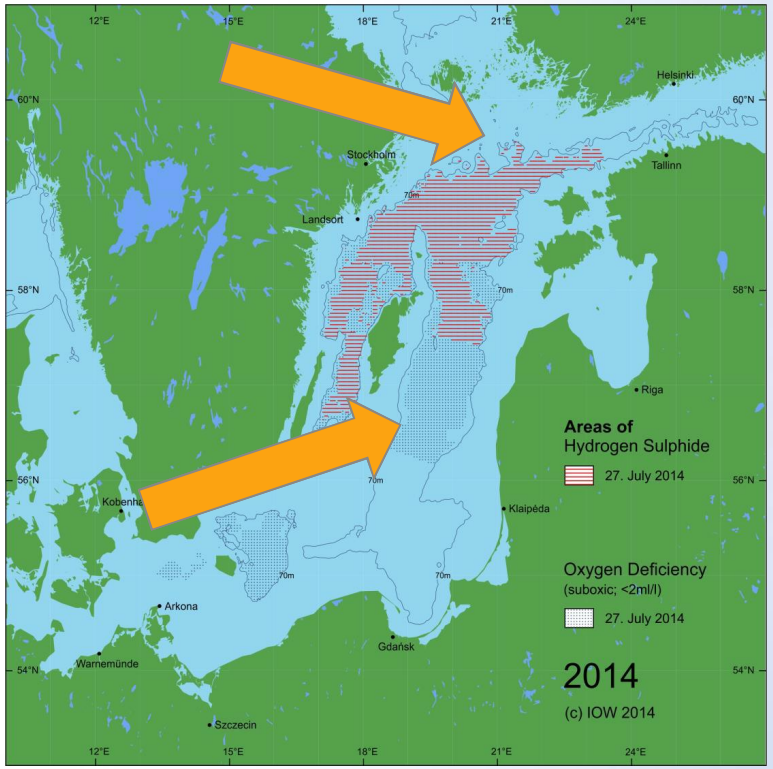
HOWEVER –
NATURE DOES IT BETTER!

SMALL INFLOW – SMALL RELIEF IN MAIN BASIN…

Saltwater inflows in February and March 2014 reached the Gotland deep in summer 2014





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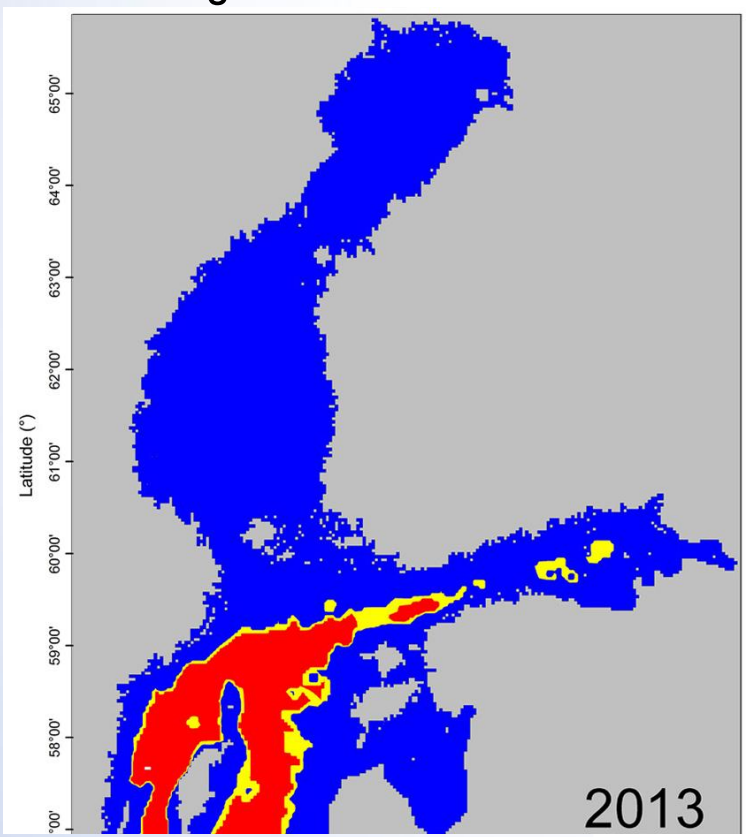
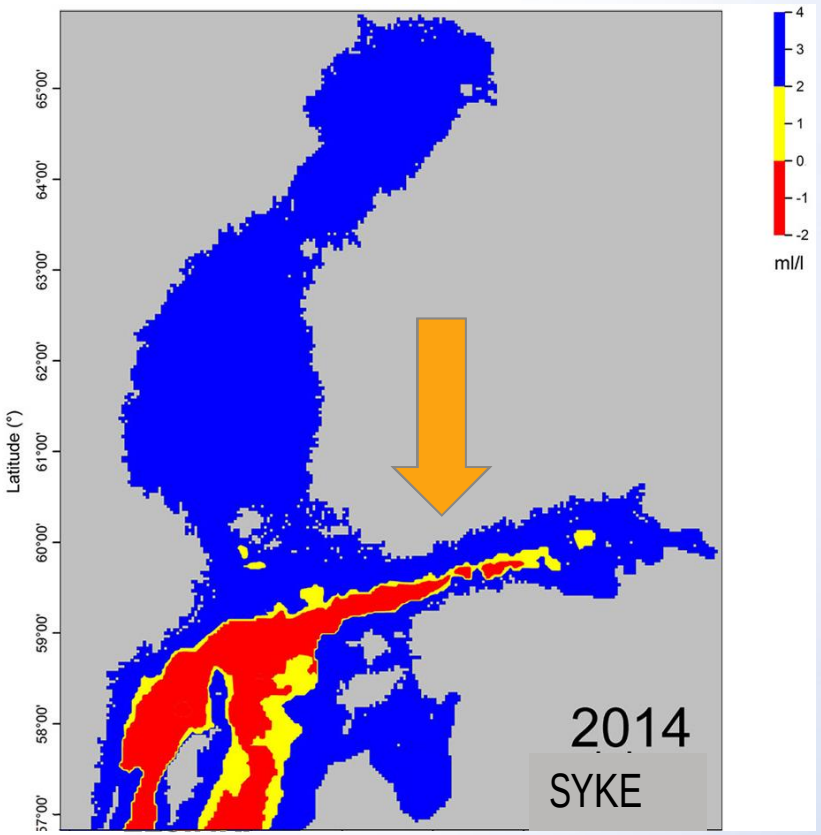
… AND A HIGH PRICE TO PAY IN THE GULF OF FINLAND

The inflow pushes the old, stagnant water northward. This salty, anoxic water flows to the Gulf of Finland, poisoning life at the bottom and preventing normal water mixing.





BIG INFLOW –
BIG RELIEF… FOR A WHILE

- 200 km^3 in December 2014
- 3RD largest since measured, starting 1880
- Previous this big inflow in 1951

- More cod
- More benthic fauna
- Healthy nutrient cycles

LET'S HELP THE NATURE TO HEAL ITSELF!

The large inflow may have been just the extra help the Baltic Sea needed to start recovering – but only if we reduce the loading.

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Thank you!
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