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EMERGE

# EMERGE update

PA SHIP, 11.06.2024

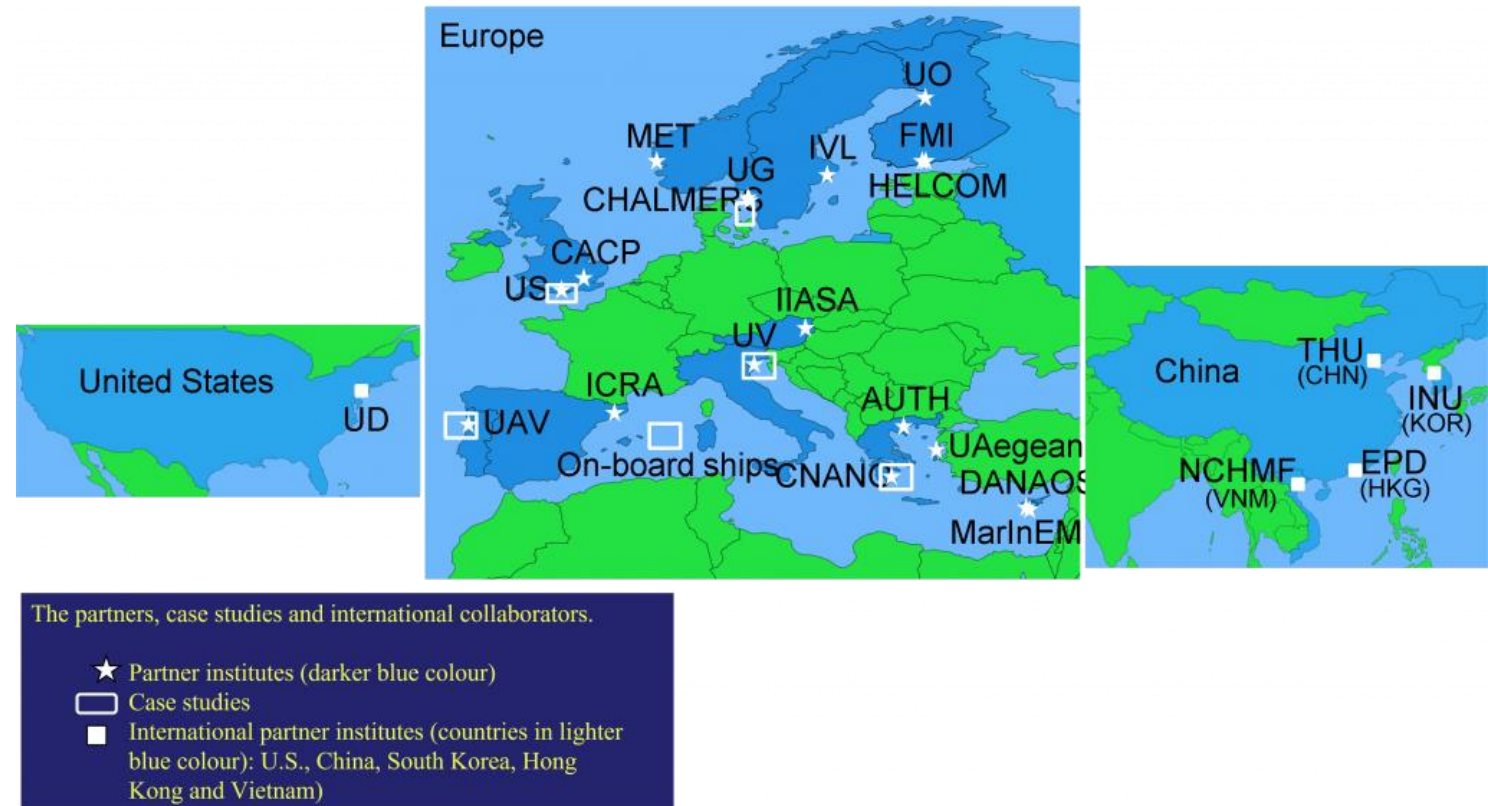
Erik Fridell

IVL Swedish Environmental Research Institute



# Evaluation, control and Mitigation of the EnviRonmental impacts of shippinG Emissions

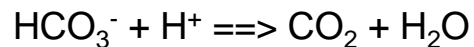
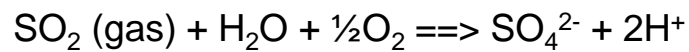
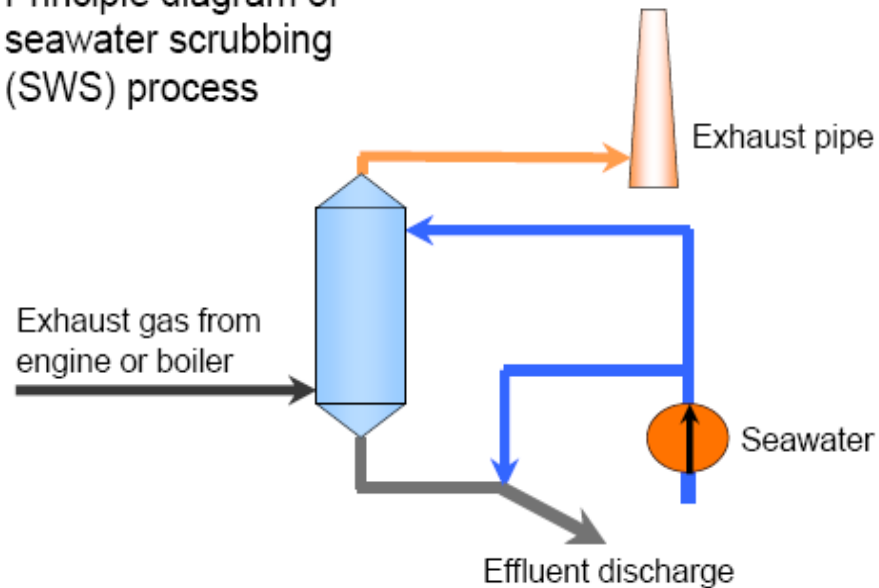
- H2020 project EMERGE
  - 2/2020-5/2024
  - 18 partners
    - 9 Universities
    - 6 research institutes
    - 2 companies
    - 1 international organization
- Reduction of environmental impacts of shipping, considering
  - Air emissions
  - Discharges



# Scrubbers

## Sulphur removal from exhaust gas

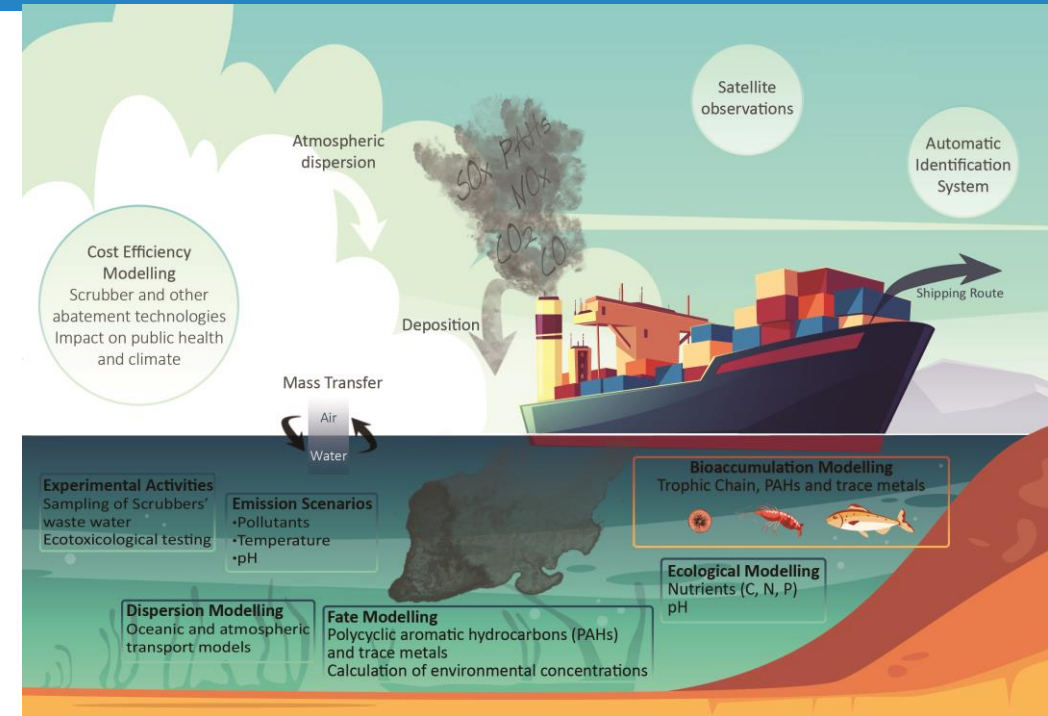
Principle diagram of seawater scrubbing (SWS) process



- Scrubbers are used in combination with high-sulphur heavy fuel oil as a low-cost alternative to low-sulphur fuel.
- The exhaust is brought in contact with scrubber water (bubbling, or mist).
- $\text{SO}_2$  reacts with salt and form ions.
- The water is sometimes treated before returned to sea
- Can be open with seawater or closed loop with freshwater and NaOH

# Comprehensive approach to look at air and water pollution together

- In the past, air emission scenarios have been used to study the effectiveness of policy changes
  - Emission Control Areas, Global S cap, GHG emissions...
- However, some regulatory changes to curb ship sourced pollution may also have side effects;
  - Ban of organotin compounds in antifouling paints → Cu
  - $\text{NO}_x$ ,  $\text{SO}_x$  reduction by switching to LNG → Methane
  - $\text{NO}_x$  abatement, use of ammonia as a fuel →  $\text{N}_2\text{O}$ , ammonia
  - $\text{SO}_x$  abatement using Exhaust Gas Cleaning Systems (EGCS) → New pollution source through discharges



# Onboard experiments

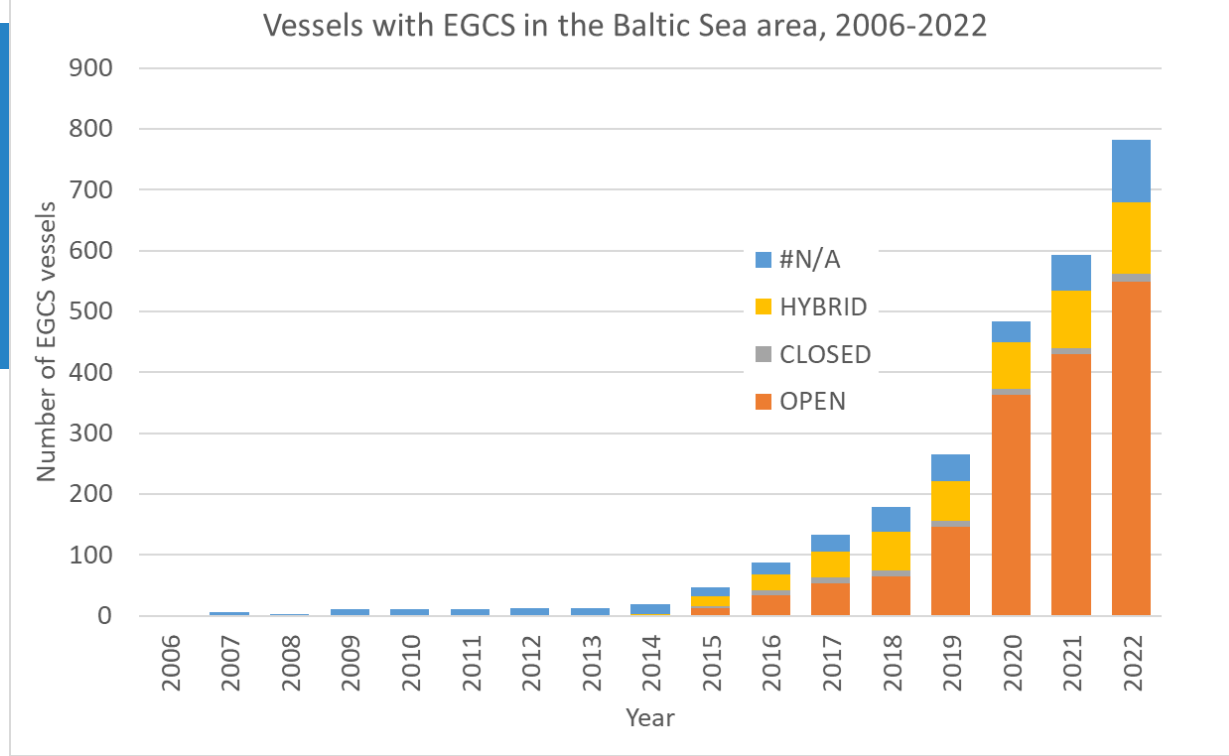
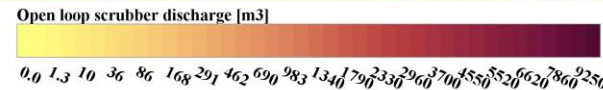
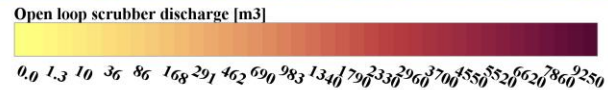
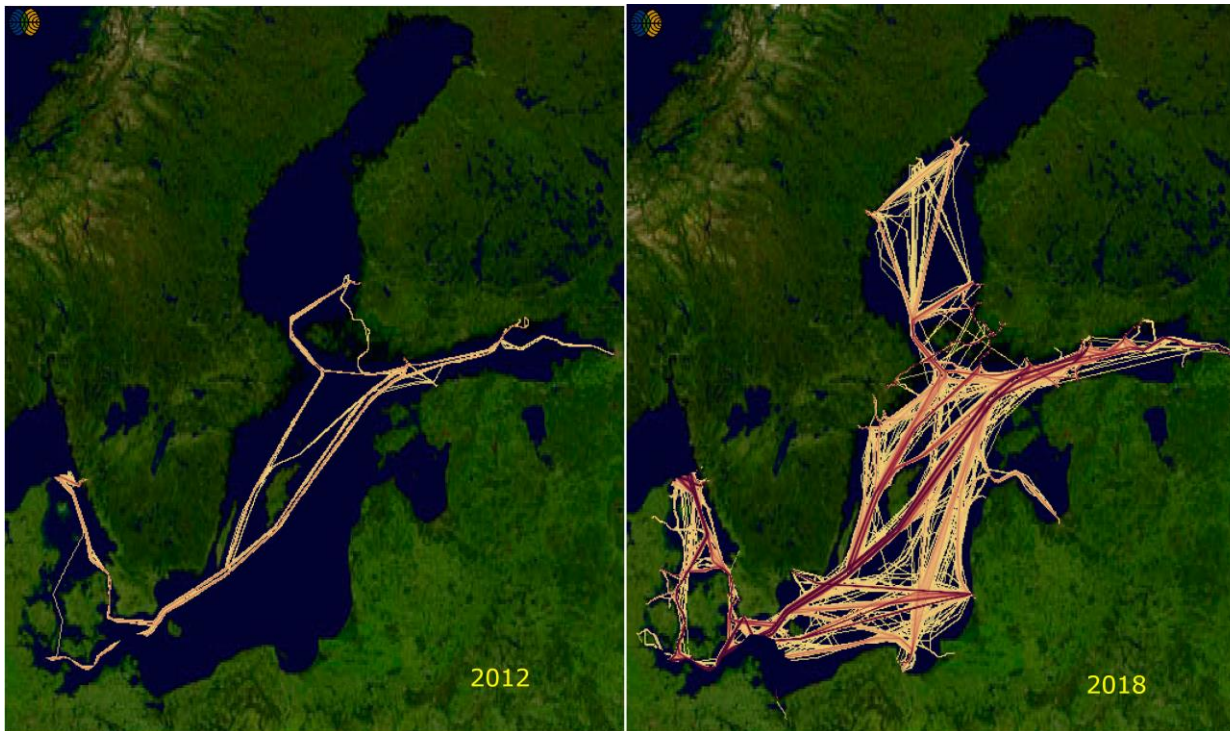
- Onboard of a containership, Dec 2021
- Collect EGCS effluent samples along the journey
- Air emission measurements during normal operation of a ship
- Fuel switching
- Chemical characterization
- Toxicity testing



Image from EMERGE D2.3

# EGCS in the Baltic Sea area

Project baseline year is 2018, just before EGCS installations increased significantly, in anticipation of global 2020 Sulfur cap



Type	Open	Closed	Hybrid	#N/A
Ropax	15	4	14	0
Roro cargo	18	0	20	7
Cruise vessel	19	4	12	5
Containership	48	4	26	1
Vehicle carrier	5	0	12	5
Crude oil tanker	131	0	5	32
Oil product tanker	62	0	10	21
Lpg tanker	11	0	11	4
General cargo ship	48	1	6	1
Bulk cargo ship	174	0	2	25
Refrigerated cargo ship	7	0	0	1
Chemical tanker	8	0	0	0
<b>Total</b>	<b>546</b>	<b>13</b>	<b>118</b>	<b>102</b>

Images and data from HELCOM Maritime Discharges report for 2022  
 Jalkanen et al, Ocean Science, 2021

# ChemicalDrift - Benzo-a-pyrene from open loop scrubbers 2018 and 2050 (scenario 3)

## Discharges from EGCS

2018



Open loop EGCS discharge [liters/cell] Cell area at center: 38.795 km<sup>2</sup>  
 0.0 3.2E+5 2.5E+6 8.7E+6 2.0E+7 4.0E+7 6.9E+7 1.1E+8 1.6E+8 2.3E+8 2.7E+8

2050



EGCS Open Loop discharge [liters/cell] Cell area at center: 38.795 km<sup>2</sup>  
 0.0 3.2E+5 2.5E+6 8.7E+6 2.0E+7 4.0E+7 6.9E+7 1.1E+8 1.6E+8 2.3E+8 2.7E+8

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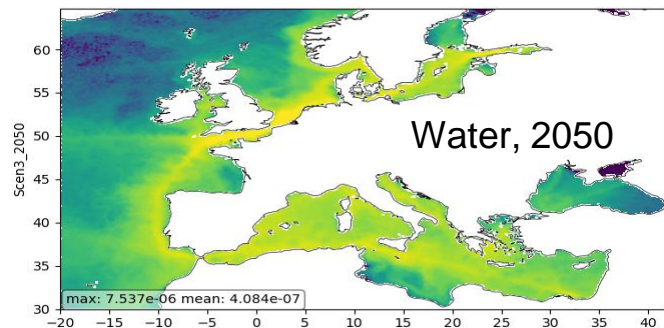


Closed loop EGCS discharge [liters/cell] Cell area at center: 38.795 km<sup>2</sup>  
 0.0 1070 8630 29100 69000 1.3E+5 2.3E+5 3.7E+5 5.5E+5 7.8E+5 9.2E+5

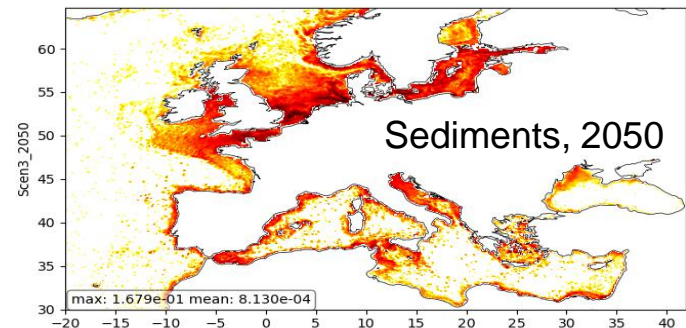


EGCS Closed Loop discharge [liters/cell] Cell area at center: 38.795 km<sup>2</sup>  
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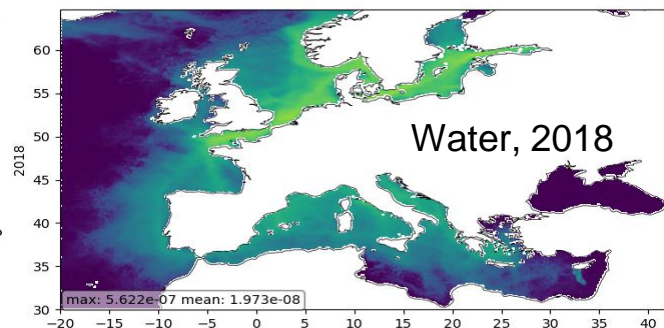
Images from FMI



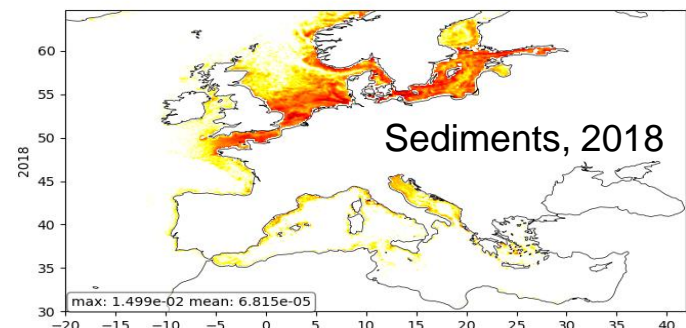
Water, 2050



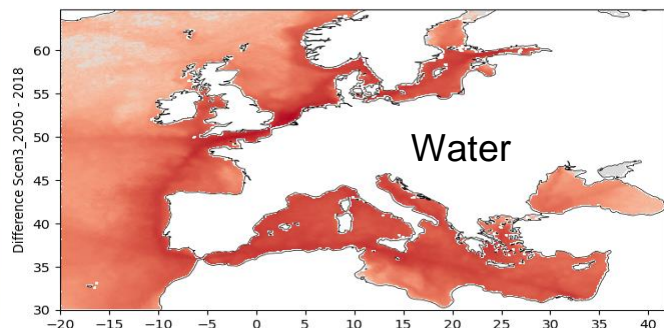
Sediments, 2050



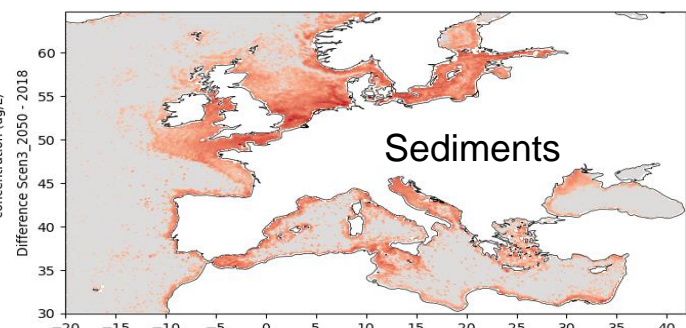
Water, 2018



Sediments, 2018



Water



Sediments

Images from Metno

Top left: Benzo-a-pyr in water, 2050, max EGCS

Top right: BaP in sediments, 2050, max EGCS

Center left: BaP in water, 2018 baseline

Center right: BaP in sediments, 2018 baseline

Bottom left: Difference 2050-2018

Bottom right: Difference 2050-2018

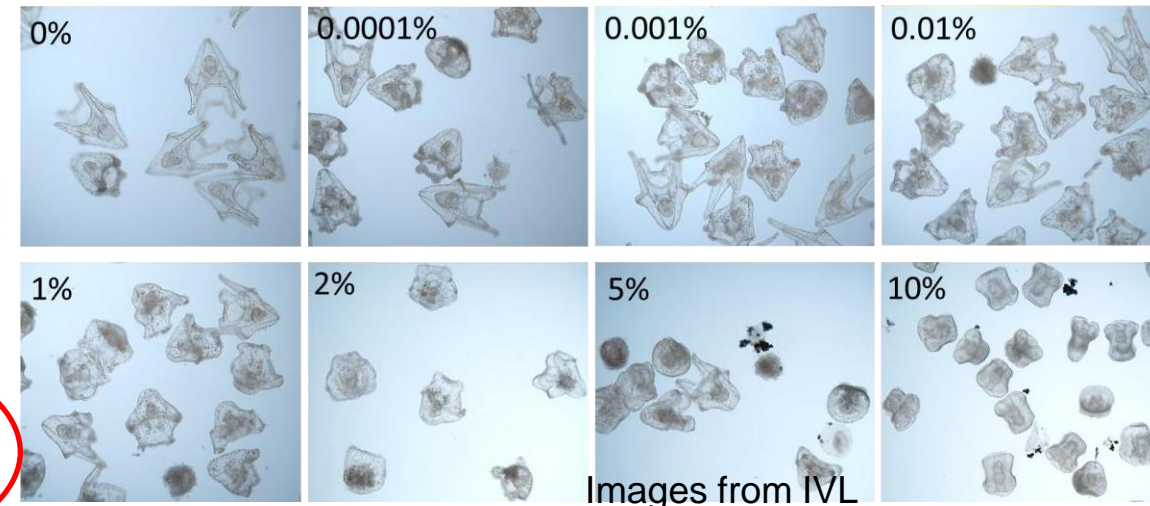
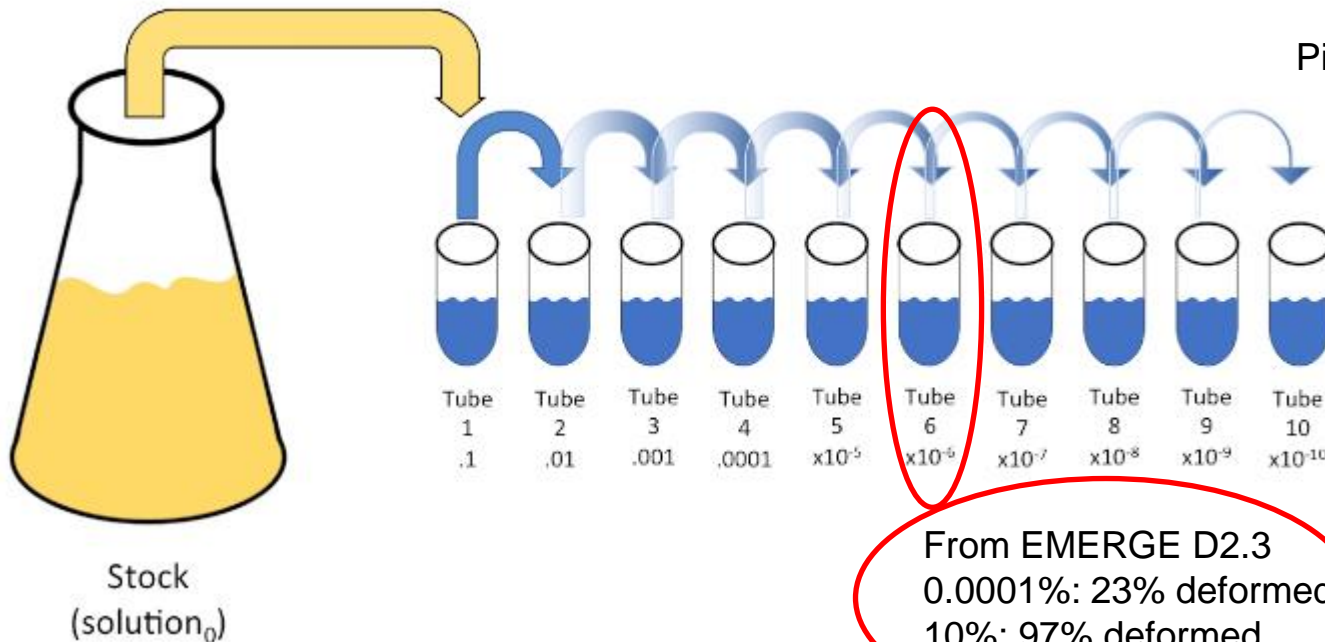
# Whole Effluent Testing

- For complex mixtures
- Dilute the sample to a series
- Observe test organisms
  - Breeding, development, feeding, mortality

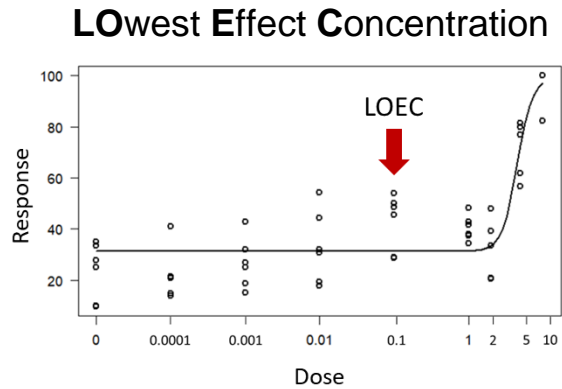
Observation: One can comply with EGCS washwater criteria (PAH16, Turbidity, pH), and still cause harm.



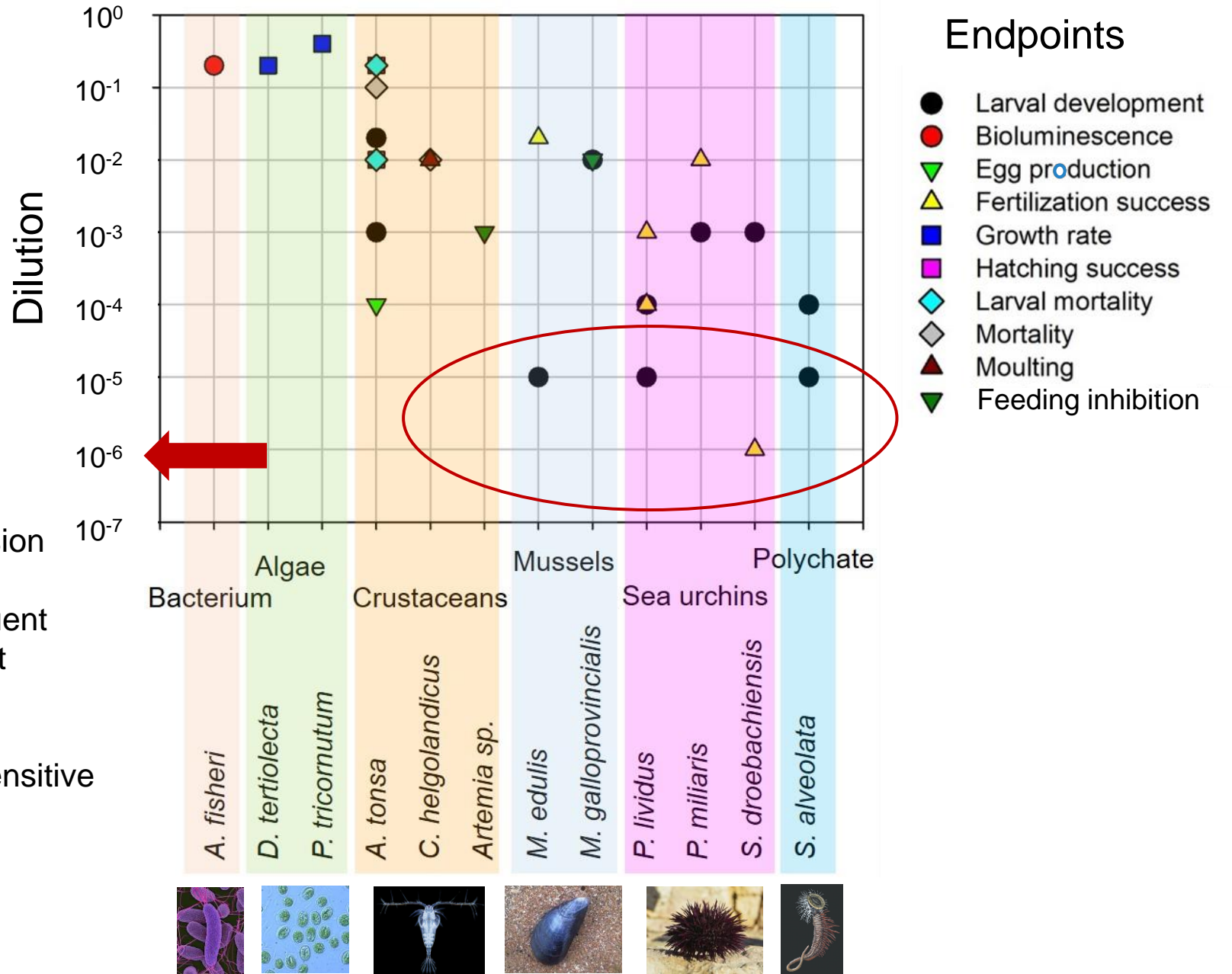
Picture shows development of green sea urchins



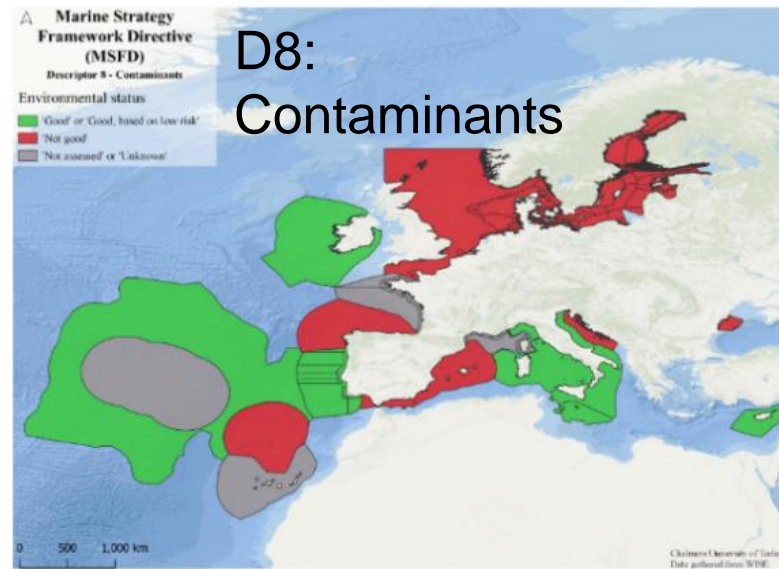
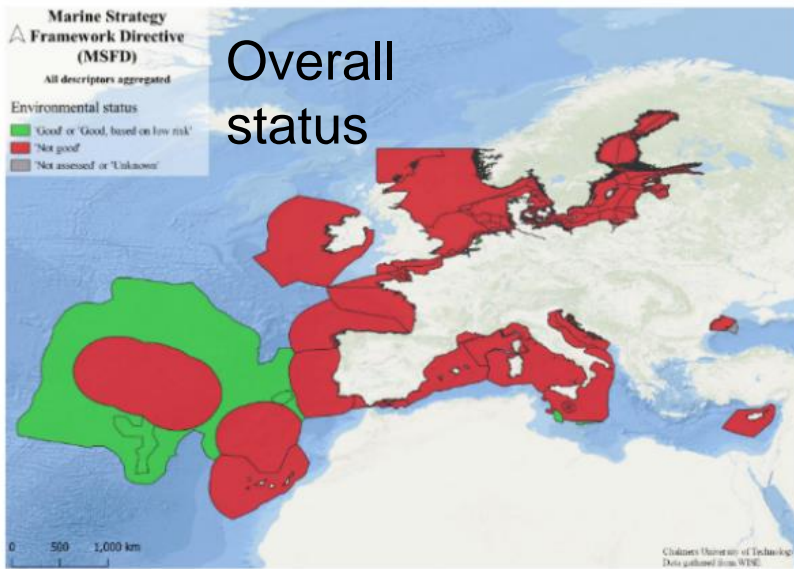
# Main findings: Ecotoxicological experiments and tests



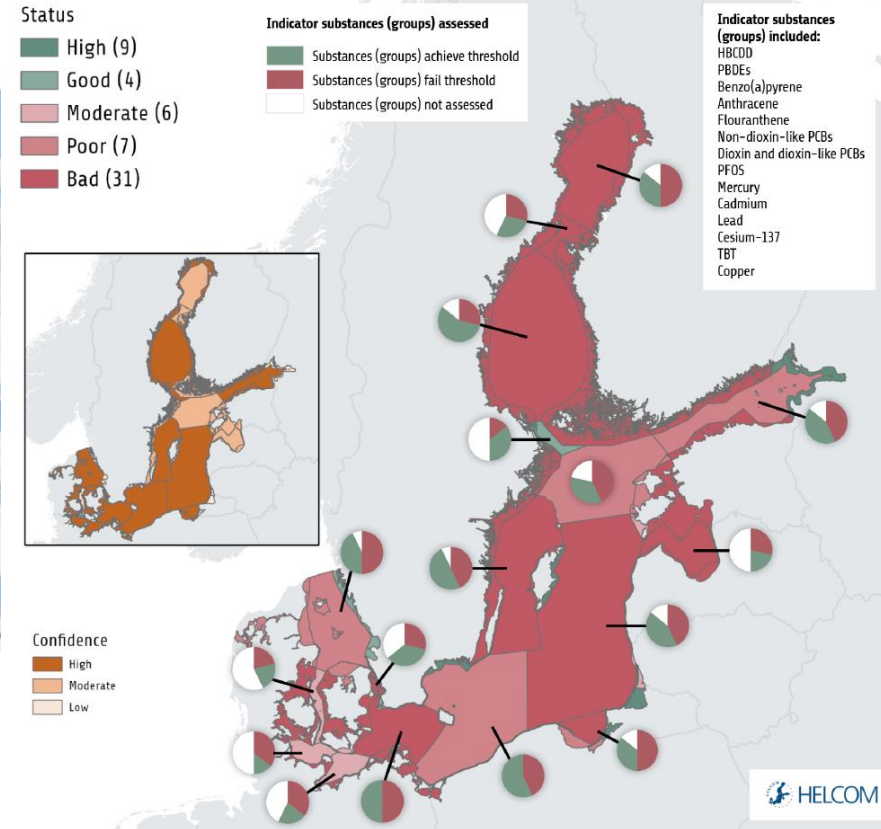
- 20+ experiments conducted at different European laboratories
- Many organism groups - same conclusion
- Negative effects at very low EGCS effluent concentrations – often at the lowest test concentration
- Early developmental stages are very sensitive – do not reach adulthood



# Current status of sea areas in Europe



## Integrated Contamination Status Assessment



- Maps:
  - <https://water.europa.eu/marine>
  - HELCOM HOLAS3 Assesment (Fig 4.7)
- Note, only ships are considered in EMERGE, many other sources exist



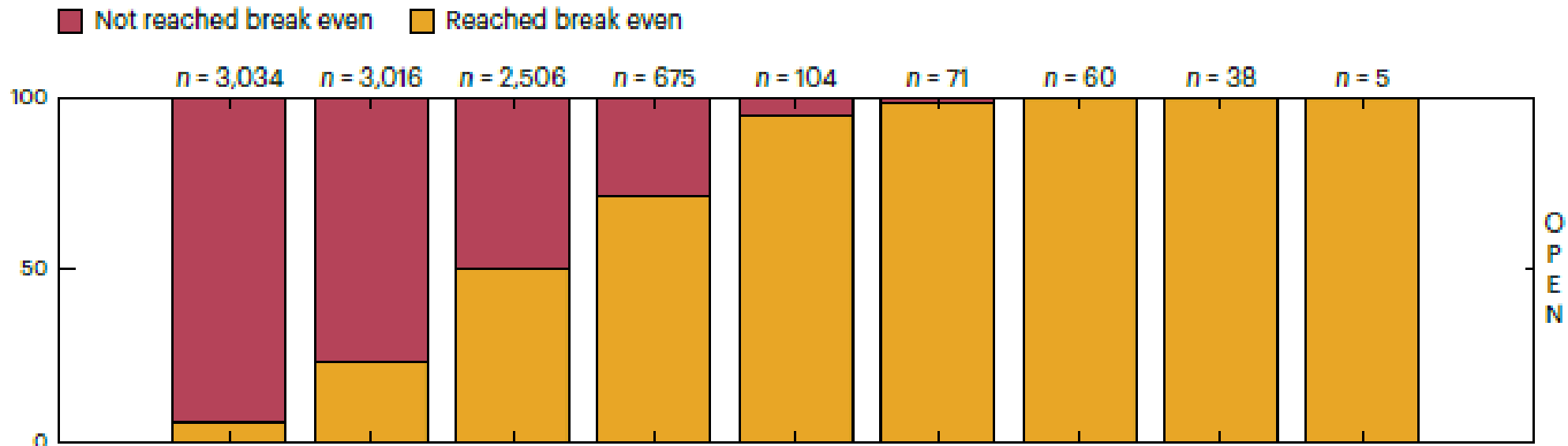
# Strong economic incentives of ship scrubbers promoting pollution

Received: 1 November 2023

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Ships with open loop scrubbers that reach economic break-even vs. year after investment

# Summary

- Combination of environmental impacts modeling considering both the atmosphere and the oceans
  - Identification of tradeoffs, reducing air pollution but increasing water pollution
  - Regulating EGCS effluent release within 12 nm will delay the transportation of pollution to coastal areas, but will not prevent it
- Composition of EGCS effluent samples, much more complex than just polyaromatic hydrocarbons and metals
- Whole effluent testing with multiple organisms
  - Dilution of EGCS effluents to learn when no effects can be seen
  - With dilution ratio of 1:1,000,000 most sensitive endpoints still suffer
- EGCS effluents harmful for marine environment, however
  - impact depends on species and development stage
    - Previous studies: No direct impact on e.g fish, but no information of sublethal effects
  - If low levels of food webs are impacted, then anything above that level can be impacted
  - most EU coastlines and archipelago areas are affected
  - Effects are still felt 10-30 km outside the shipping lanes
- Material available for policy measures, if needed
  - Can meet most of the criteria of EGCS impact assessments with EMERGE work → IMO

# Thank you

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