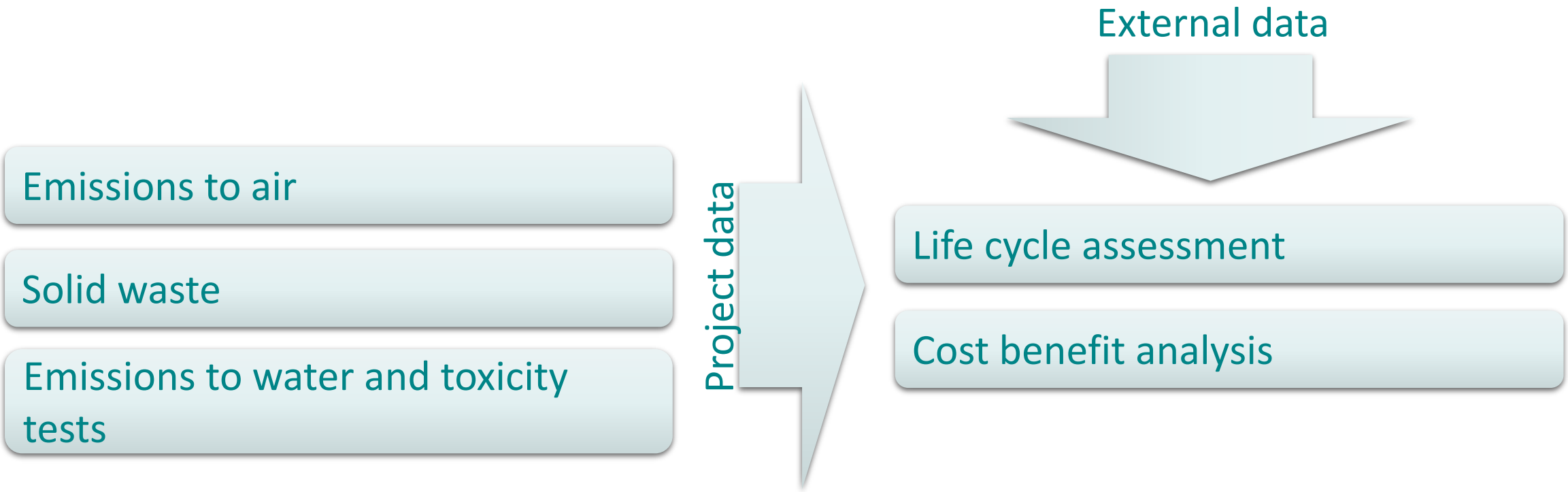
Environmental risks from the use of marine exhaust gas scrubbers

ivl
Swedish Environmental Research Institute

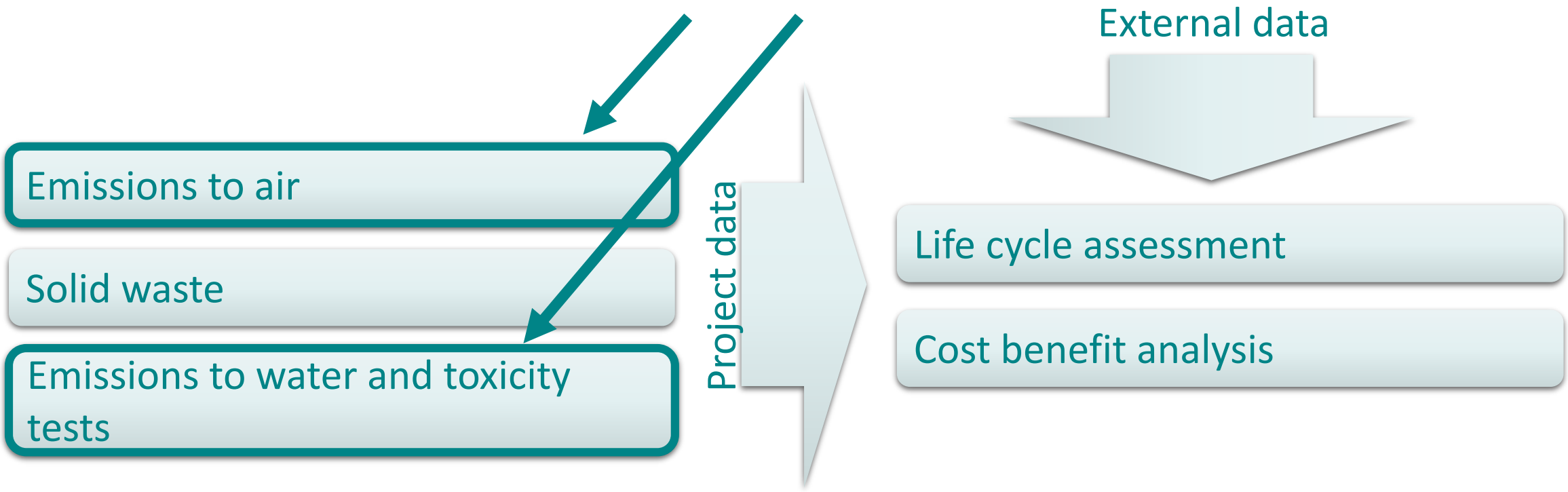
CEF programme

Study setup



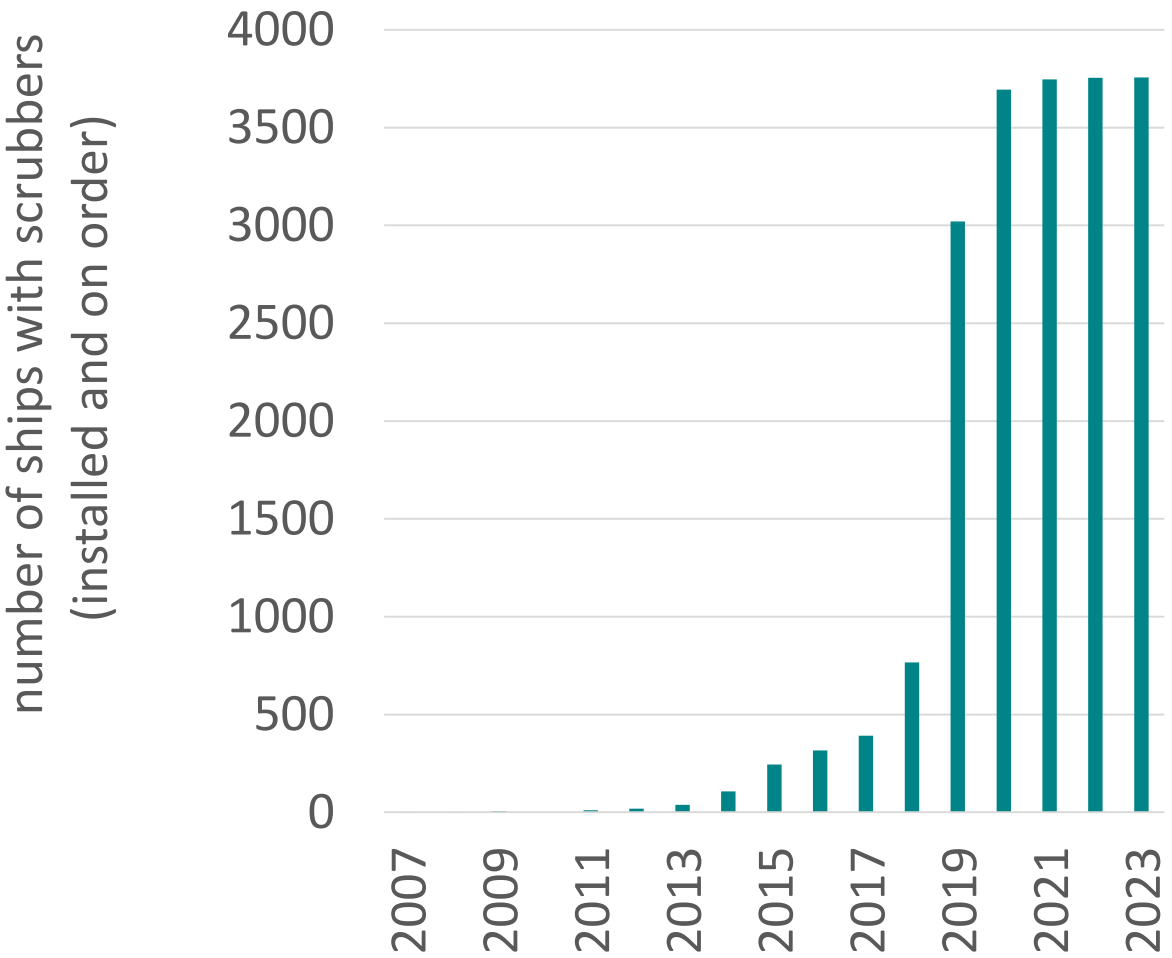
Asked to provide analyses with high environmental relevance

Study setup

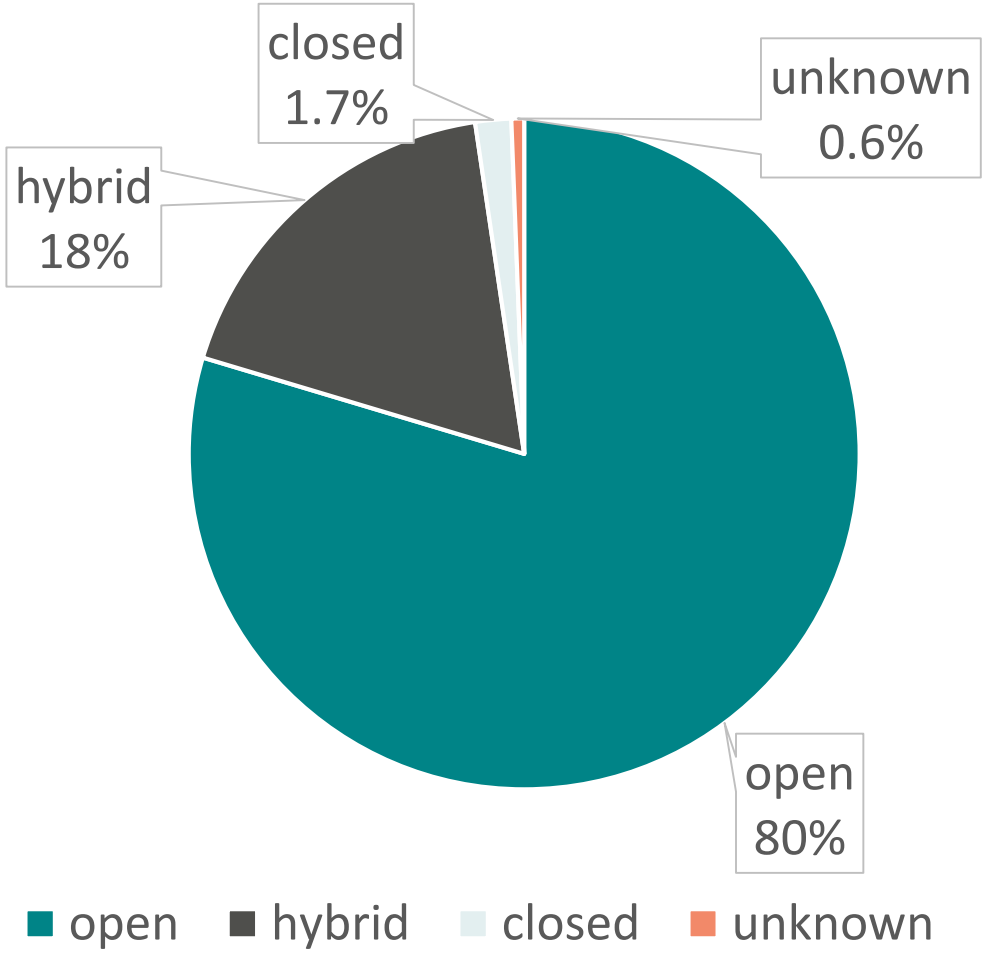

External data
Emissions to air
Solid waste
Emissions to water and toxicity tests
Project data
Life cycle assessment
Cost benefit analysis

Exh. gas scrubbers on ships

https://afi.dnvgl.com/Statistics?repId=2



Number of ships with scrubbers (installed and on order)

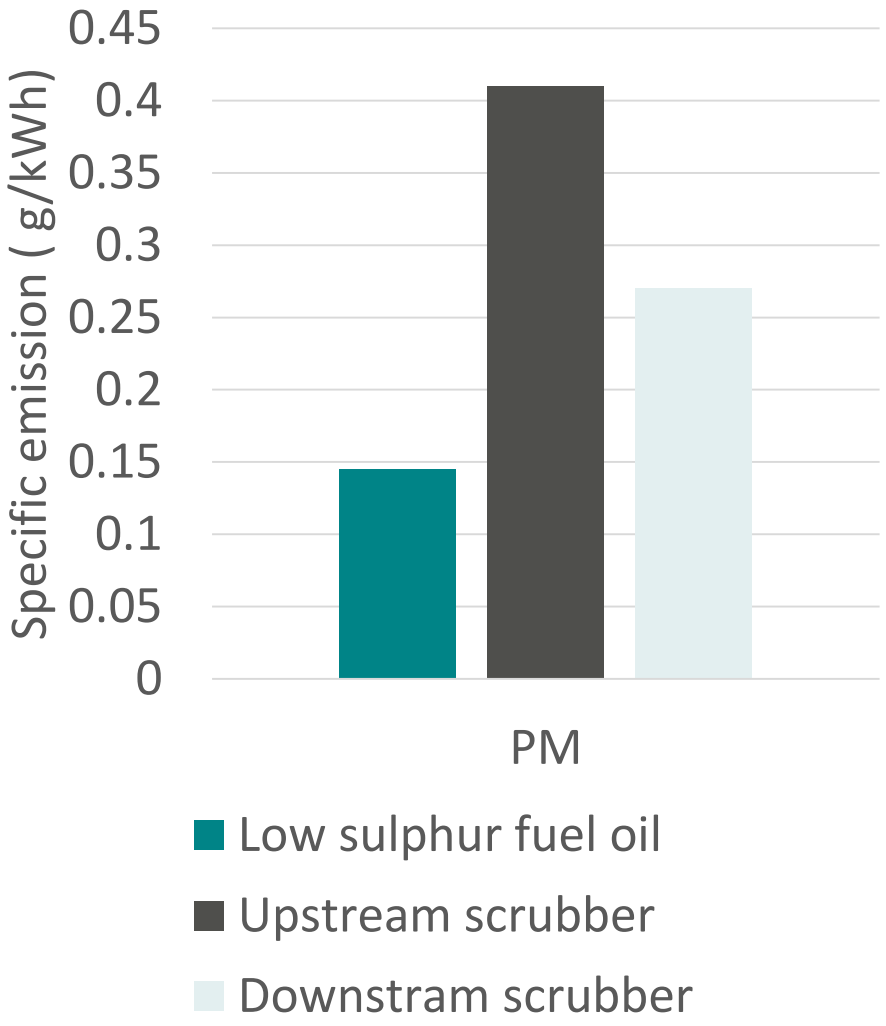


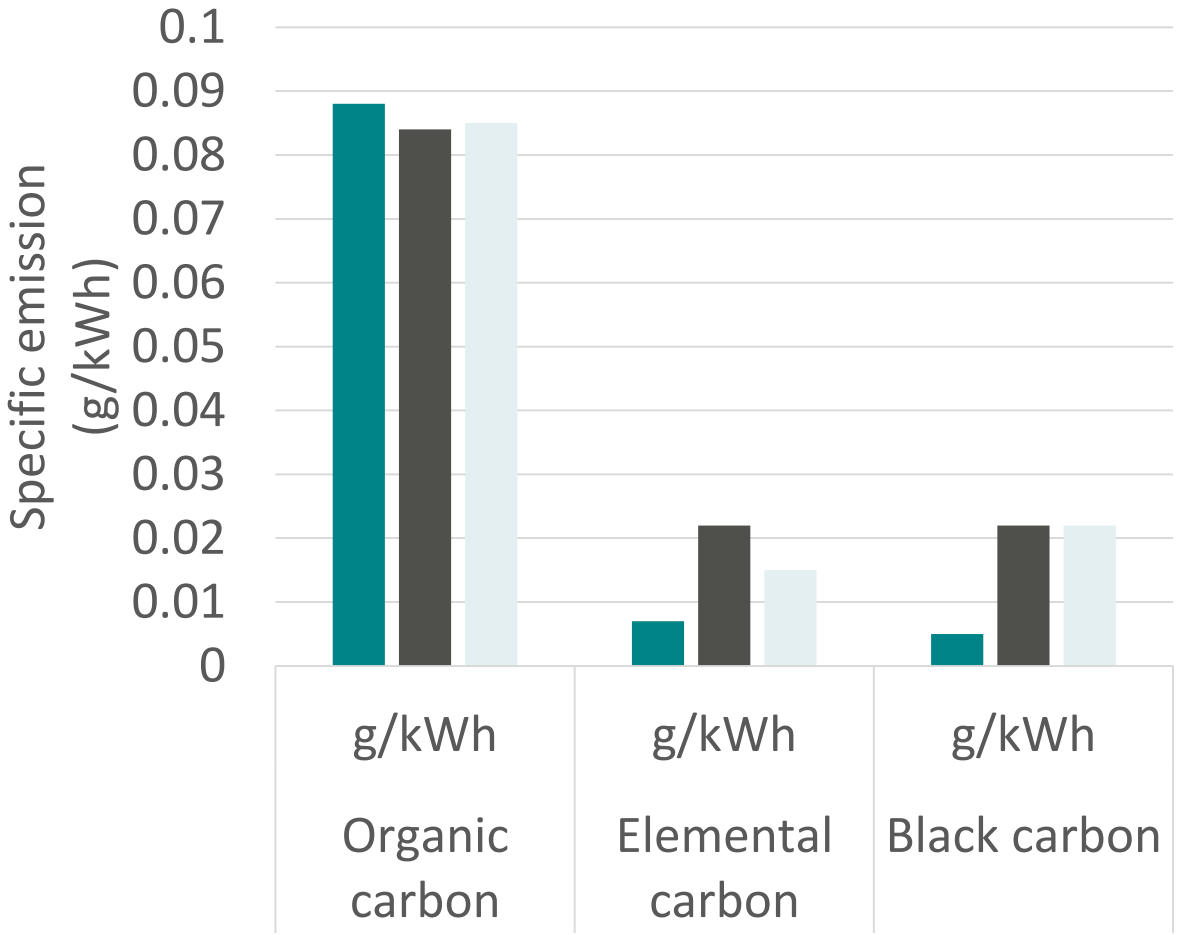
Studied alternatives

- Low sulphur fuel oil
- Heavy fuel oil and closed-loop scrubber
- Heavy fuel oil and open-loop scrubber

Note: a closed loop scrubber is not actually closed. Discharge of approximately 10 m^3/h in our study, power of 34 000 kW. Corresponding volume of open-loop discharge approximately 300 m^3/h.

Engine load 75-85 %

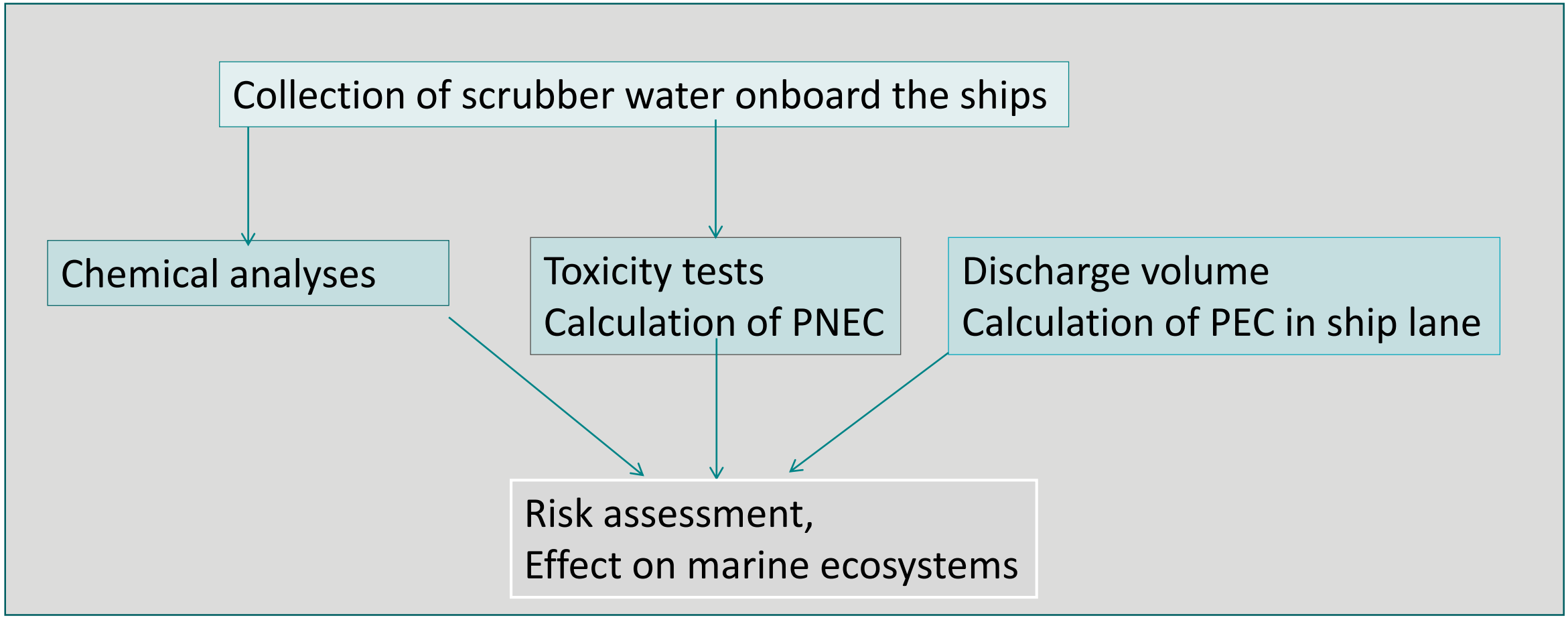




- Comparing exhausts of LSFO and HFO + closed loop scrubber indicated that the LSFO alternative was associated with less emissions of many important species.
- Difficulties in measuring particles downstream a scrubber related to the temperature (approximately 20 ◦C) and the humidity. The gas is heated and diluted.
- Engines are tuned to different fuel qualities. This engine had run for a long time on an LSFO from the same bunker supplier. Engines tuned to HFO may well have higher specific emissions when using low sulphur fuels.

… What about the emissions to water?

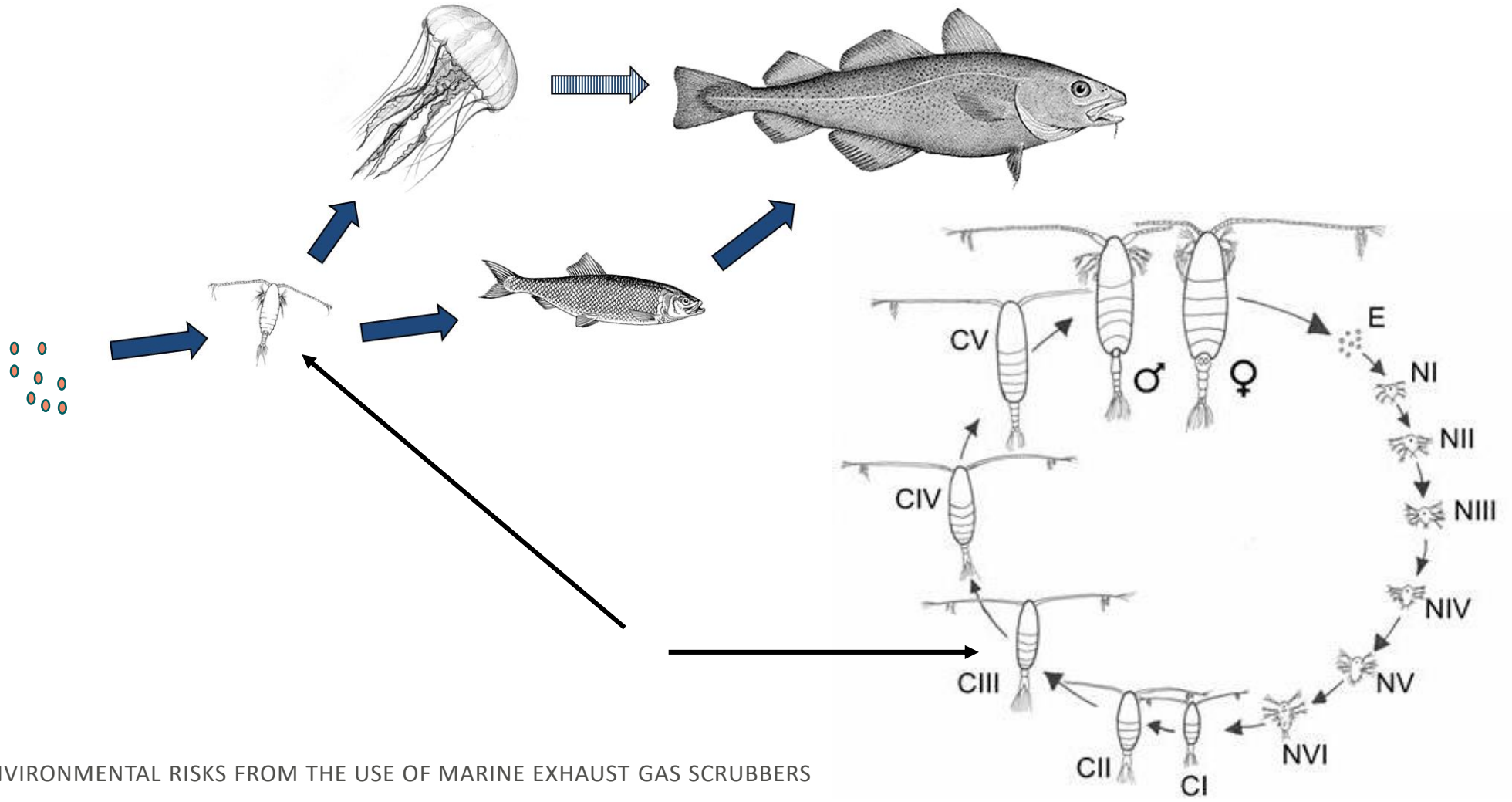
Testing of effluent water from closed and open loop systems



PNEC = Predicted No Effect Concentration

PEC = Predicted Environmental Concentration

Test organism:
juvenile stage of Calanus (a zooplankton species)



Ecological relevance of *Calanus* as test organism

- Calanus is a zooplankton, a key target group for discharged scrubber water
- Calanus is key species in marine pelagic food webs; most fish in the North sea and Skagerrak feed on this species during some period of their life cycle.

Test parameters in toxicity test

- Mortality rate — Most sensitive
- Life stage development
- Feeding rate
- Metabolic rate/respiration rate
- Lethargy (measures the narcotic effect of compounds)

Effects of scrubber water on mortality in Calanus

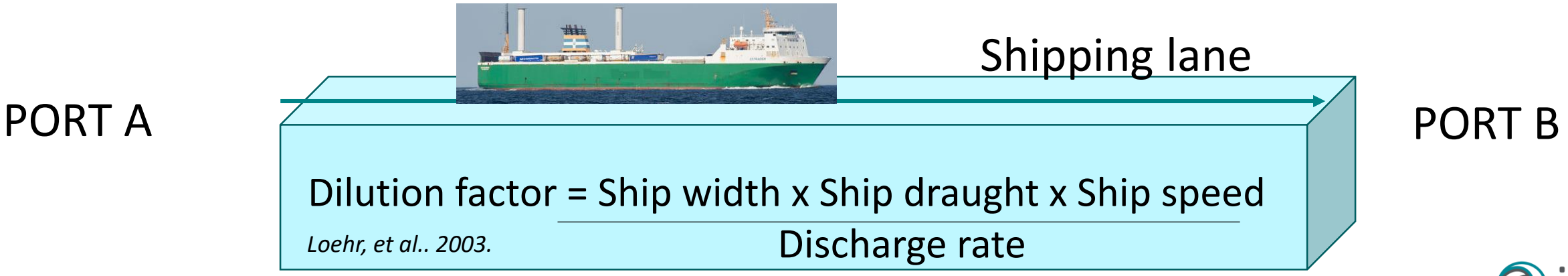
Ship A, Closed loop		Ship B, Open loop	
Scrubber water conc. (%)	Mortality rate (d^{-1})	Scrubber water conc. (%)	Mortality rate (d^{-1})
0	0.0000 ± 0.0000	0	0.0000 ± 0.0000
0.04	0.0097 ± 0.0029	1	0.0064 ± 0.0023
0.2	0.0139 ± 0.0029	5	0.0113 ± 0.0011
0.5	0.0158 ± 0.0056	10	0.0328 ± 0.0032
1	0.0519 ± 0.0059	40	0.1403 ± 0.0151
2	0.0389 ± 0.0064		
5	>1		

In red: lowest concentration statistically different from control

Assessment of risk on the marine environment

1. Calculation of Predicted No Effect Concentration (PNEC) for scrubber water, using the lowest toxic concentration + a safety factor of 1000

2. Estimating the Predicted Environmental Concentration (PEC) of scrubber water in the water around the shipping lane, using a dilution factor



PEC/PNEC ratios for scrubber water in ship lanes after passage of one ship

*PEC/PNEC < 1 is considered low risk

	Calculated PNEC for scrubber water in seawater	Predicted PEC of scrubber water around ship lane	PEC/PNEC*
Ship A Closed loop	0.0004 mL L^{-1}	0.0015 mL L^{-1}	3.8
Ship B Open loop	0.01 mL L^{-1}	0.063 mL L^{-1}	6.3

Conclusions:

- PM, PAH, and BC from HFO + scrubbers were not reduced to the levels measured for low sulphur fuel oil.
- Significant effects of scrubber water on zooplankton mortality in the lowest tested concentrations: 0.04% closed loop water and 1% open loop water
- Effects not correlated to pH but to other compounds in the water
- Dilution of discharged scrubber water from 1 passage results in shipping lane concentrations above ”safe concentrations”
  Predicted No Effect Concentration/Predicted Environmental Concentration (PNEC/PEC) > 1
- Important to find sensitive species/sensitive life stages of species, otherwise risks will be underestimated

Reports are available at www.ivl.se

Thank you

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