Monitoring of antifouling copper in target marinas

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Why?

- Before being allowed on the market, all biocidal products, including antifouling biocidal products, are assessed for their risk to Humans and the Environment
- Environmental Risk Assessment principle;
- If what you can expect to see in the environment is a higher level than what you consider safe, that's not good
- Or, put another way
- If $\frac{\text{Predicted Environmental Concentration}}{\text{Predicted No Effect Concentration}} > 1$
  - The product is considered to have an unacceptable risk, and is not authorised for use
- Environmental concentrations are "Predicted" using mathematical models

The Modelling

- For most Product Types (e.g. disinfectants, insecticides, preservatives) Environmental Concentrations are estimated on a Regional Scale
- Models are built upon a lot of assumptions
  - Number of households in a Region, Population of the Region, How frequently toilets get cleaned, How many mosquitoes need killing, How much biocide works its way out of a Sewage Treatment Plant, etc., etc., etc…
  - Few of these assumptions are "testable"
    - *"Testable" (adjective): able to be tested or tried: "a testable hypothesis" · "empirically testable predictions" · "testable models"*
- Antifouling Coatings are almost unique
  - Concentrations of biocides from paints intended for the yacht market are estimated on the Local Scale, inside the confines of specific marinas, selected based upon certain criteria

Testable

- Using MAMPEC, biocide (specifically copper) concentrations in 17 Baltic Transition and 38 Baltic marinas are calculated

Marine Compartment

Environmental Emission Scenarios for Product Type 21: Biocides used as antifouling products

PNEC Values	
PNECsw Inside Marina (ug/l)	2.6
PNECsed Inside Marina (ug/g dw)	98.8
PNECsw Surrounding Marina (ug/l)	1.15
PNECsed Surrounding Marina	98.8

Baltic Transition Scenario Average PEC values and Risk Characterisation

Scenario	Sceanrio Country | Code	Substance	PECsw inside marina (average, dissolved, ug/l)	PECsusp. inside marina (average, ug/g dw)	PECsw surrounding (average dissolved, ug/l)	PECsusp. surrounding (average, ug/g dw)	PEC:PNEC SW inside marina	PEC:PNEC SUSP inside marina	PEC:PNEC SW surrounding	PEC:PNEC SUSP surrounding
Baltic Transition Marina 01	DE 10	Copper	2.40E+00	1.88E+02	1.10E+00	1.64E+01	9.25E-01	1.90E+00	9.58E-01	1.66E-01
Baltic Transition Marina 02	DE 2	Copper	2.55E+00	2.07E+02	1.11E+00	1.72E+01	9.81E-01	2.10E+00	9.64E-01	1.74E-01
Baltic Transition Marina 03	DE 3	Copper	1.99E+00	1.34E+02	1.10E+00	1.64E+01	7.66E-01	1.35E+00	9.59E-01	1.66E-01
Baltic Transition Marina 04	DK 4	Copper	1.16E+00	2.35E+01	1.10E+00	1.62E+01	4.45E-01	2.38E-01	9.57E-01	1.64E-01
Baltic Transition Marina 05	DK 5	Copper	3.22E+00	2.95E+02	1.11E+00	1.69E+01	1.24E+00	2.99E+00	9.62E-01	1.71E-01
Baltic Transition Marina 06	DK 9	Copper	2.47E+00	1.97E+02	1.10E+00	1.65E+01	9.50E-01	2.00E+00	9.59E-01	1.67E-01
Baltic Transition Marina 07	DK 1	Copper	6.92E+00	7.84E+02	1.10E+00	1.67E+01	2.66E+00	7.93E+00	9.61E-01	1.69E-01
Baltic Transition Marina 08	DK 10	Copper	2.13E+00	1.52E+02	1.10E+00	1.63E+01	8.19E-01	1.54E+00	9.58E-01	1.65E-01
Baltic Transition Marina 09	DK 11	Copper	7.21E+00	8.23E+02	1.11E+00	1.69E+01	2.77E+00	8.33E+00	9.62E-01	1.71E-01
Baltic Transition Marina 10	DK 2	Copper	3.99E+00	3.98E+02	1.10E+00	1.65E+01	1.54E+00	4.03E+00	9.59E-01	1.67E-01
Baltic Transition Marina 11	SE 15	Copper	1.33E+00	4.61E+01	1.11E+00	1.75E+01	5.11E-01	4.67E-01	9.66E-01	1.77E-01
Baltic Transition Marina 12	DE 11	Copper	3.64E+00	3.53E+02	1.10E+00	1.67E+01	1.40E+00	3.57E+00	9.61E-01	1.70E-01
Baltic Transition Marina 13	DE 6	Copper	2.64E+00	2.19E+02	1.10E+00	1.66E+01	1.02E+00	2.22E+00	9.60E-01	1.68E-01
Baltic Transition Marina 14	DE 7	Copper	2.15E+00	1.55E+02	1.10E+00	1.64E+01	8.27E-01	1.57E+00	9.58E-01	1.66E-01
Baltic Transition Marina 15	DE 9	Copper	4.50E+00	4.64E+02	1.10E+00	1.62E+01	1.73E+00	4.70E+00	9.57E-01	1.64E-01
Baltic Transition Marina 16	DK 3	Copper	1.26E+00	3.77E+01	1.10E+00	1.66E+01	4.86E-01	3.81E-01	9.60E-01	1.68E-01
Baltic Transition Marina 17	SE 3	Copper	1.74E+00	1.01E+02	1.10E+00	1.64E+01	6.69E-01	1.02E+00	9.58E-01	1.66E-01
		90th Percentile Value	5.47E+00	5.92E+02	1.11E+00	1.71E+01	2.10E+00	5.99E+00	9.63E-01	1.73E-01
		Maximum	7.21E+00	8.23E+02	1.11E+00	1.75E+01	2.77E+00	8.33E+00	9.66E-01	1.77E-01
		Minimum	1.16E+00	2.35E+01	1.10E+00	1.62E+01	4.45E-01	2.38E-01	9.57E-01	1.64E-01

Testable

- Using MAMPEC, biocide (specifically copper) concentrations in 17 Baltic Transition and 38 Baltic marinas are calculated

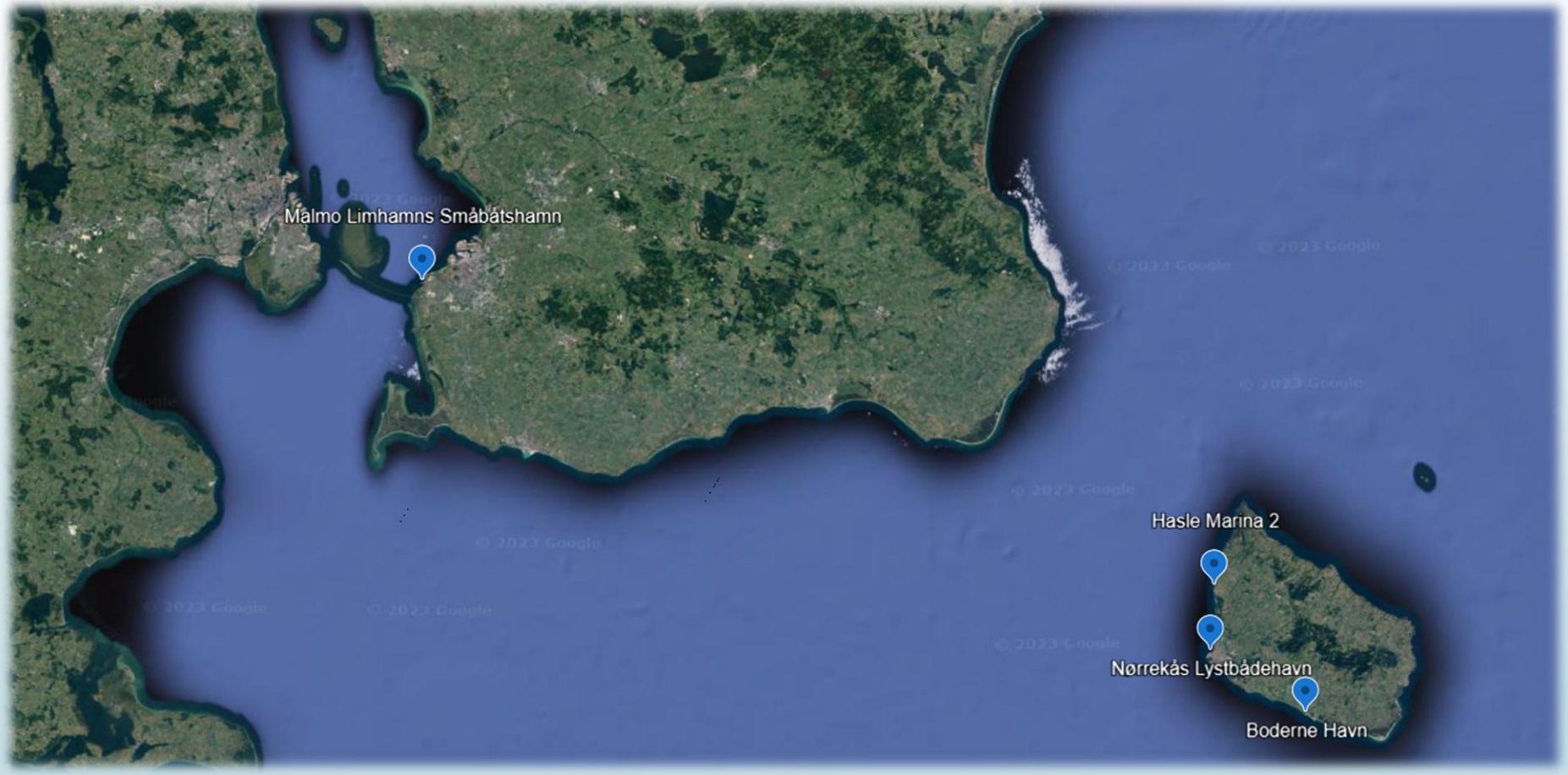
$$\frac{\text{Predicted Environmental Concentration}}{\quad}$$

- PEC is readily testable, it can be measured
  - Copper, as an element, is simple to analyse
  - Copper, as an element, is stable in stored samples
- Antifouling use in the Baltic is a mature market
  - Yacht owners who need them, use them
  - Copper levels are now as they were historically, or will be in the future (with caveats)
  - Picture of "before" BPR removes products from the market because of the approval status

Not easily testable, since site specific properties modify the impact of copper

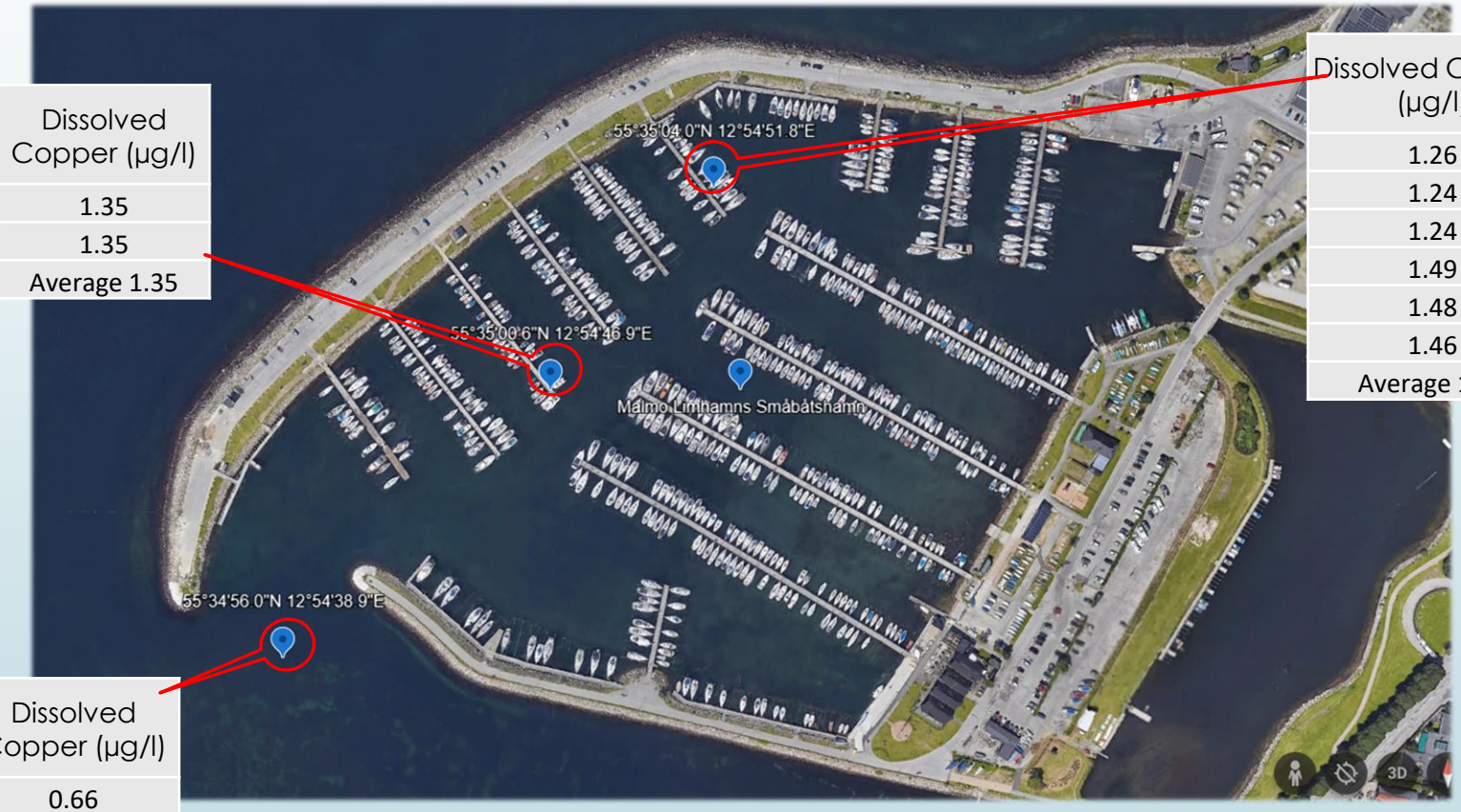
4.6 mg/l DOC
(typical in Baltic region) leads to a PNEC = 4.3 µg Cu/L

Survey #1 (September 2023)



Malmo Limhamns Småbåtshamn (Baltic Transition, SE3)

PECs (LR = 10 µg /cm^2/day)
Dissolved: 1.74 µg /L



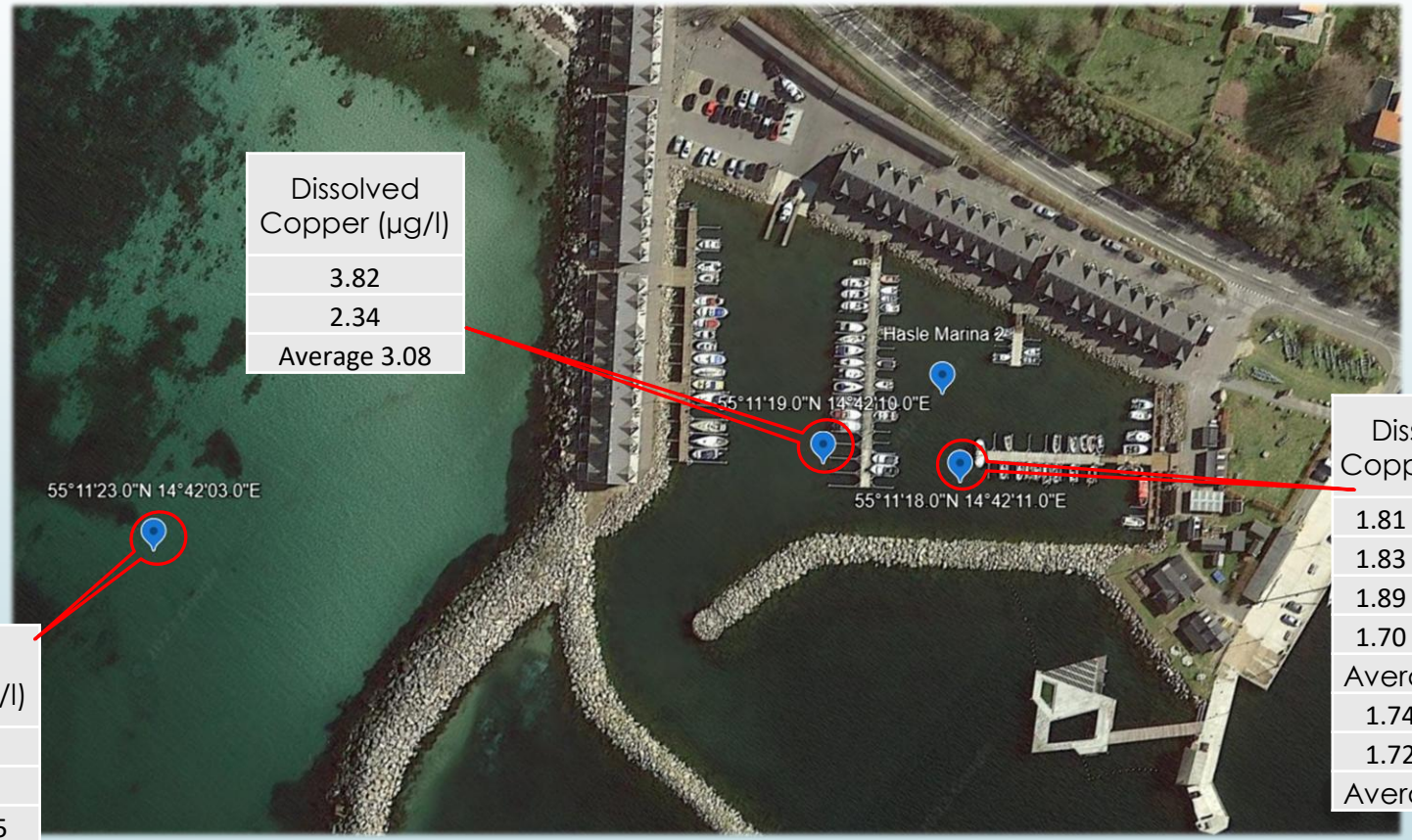
Dissolved Copper (µg/l)
1.35
1.35
Average 1.35

Dissolved Copper (µg/l)
1.26
1.24
1.24
1.49
1.48
1.46
Average 1.36

Dissolved Copper (µg/l)
0.66
0.45
Average 0.55

Hasle Marina 2 (Baltic, DK15)

PECs (LR = 10 µg /cm^2/day)
Dissolved: 8.92 µg /L



Dissolved Copper (µg/l)
3.82
2.34
Average 3.08

Dissolved Copper (µg/l)
1.81 (surface)
1.83 (surface)
1.89 (surface)
1.70 (surface)
Average 1.81
1.74 (5.3 m)
1.72 (5.3 m)
Average 1.73

Dissolved Copper (µg/l)
0.36
0.34
Average 0.35

Boderne Havn (Baltic, DK12)

PECs (LR = 10 µg /cm^2/day)
Dissolved: 12.0 µg /L

Dissolved Copper (µg/l)
2.93
3.05
Average 2.99

Dissolved Copper (µg/l)
1.27
1.19
Average 1.23

Dissolved Copper (µg/l)
0.44
0.35
0.33
0.30
0.28
0.27
Average 0.33

Nørrekås Lystbådehavn (Baltic, DK13)

PECs (LR = 10 µg /cm²/day)
Dissolved: 24.4 µg /L

Dissolved Copper (µg/l)
0.91
1.10
Average 1.01

Dissolved Copper (µg/l)
0.39
0.37
Average 0.38

Dissolved Copper (µg/l)
0.85
0.82
0.81
0.64
0.62
0.61
Average 0.73

Survey #2 (July 2025)

Morarna Road Marina (Sweden, SE10)

PECs (LR = 10 µg /cm^2/day)
Dissolved: 7.8 µg /L

Uutela Marina (Finland, FI7)

PECs (LR = 10 µg /cm^2/day)
Dissolved: 5.3 µg /L

Åminne marina (Finland, FI5)

PECs (LR = 10 µg /cm^2/day)
Dissolved: 7.2 µg /L

Pärnu marina (Estonia, EE8)

PECs (LR = 10 µg /cm^2/day)
Dissolved: 2.9 µg /L

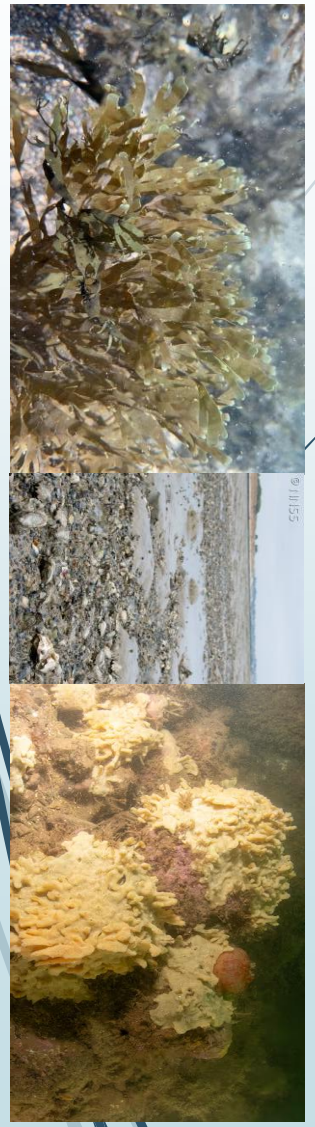
Klaipeda Marina (Lithuania, LT1)

PECs (LR = 10 µg /cm^2/day)
Dissolved: 6.3 µg /L

Ventspils Yacht Harbour (Latvia, LV2)

PECs (LR = 10 µg /cm^2/day)
Dissolved: 4.7 µg /L

What does this all mean?

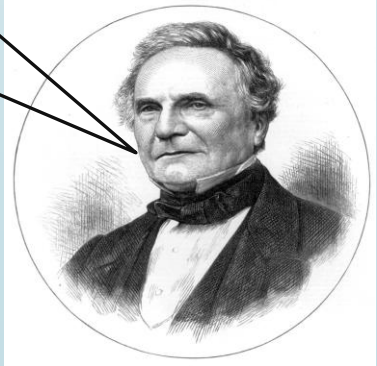


- The Risk Assessment modelling is clearly inaccurate
- Products will be (not) approved
  - Not because there is a real problem
  - But because the modelling is poor
  - Not Fit for Purpose
- BPR has the potential to ensure yacht owners use less effective products to protect their vessels
- Poorly protected vessels = higher risk of invasion by NIS
- Higher risk of invasion by NIS = increased risk of entire ecosystem change
- Current Risk Assessment paradigm aims to protect the aquatic community in heavily populated marinas
  - A community already impacted by the ongoing human activity
- Ironically, particularly vulnerable areas are beauty spots and nature reserves where these poorly protected vessels will go for a day-trip

What's going wrong?

- MAMPEC works, when parameterised well
  - e.g. Malmo Limhamns Småbåtshamn
- MAMPEC is only as good as the information it is based on
  - GIGO (garbage in, garbage out)
- MAMPEC requires some 30 variables to define a marina
- To obtain useful results many of those need to be correct
  - Water exchange incorrect?
    - Overpredict PECs
  - Leach rate wrong?
    - Overpredict PECs
  - Boat size/density wrong?
    - Overpredict PECs

> On two occasions I have been asked, "Pray, Mr. Babbage, if you put into the machine wrong figures, will the right answers come out?" ...
> —Charles Babbage, *Passages from the Life of a Philosopher*



Thank you

Questions?