2nd Baltic Earth Conference

Shipping and the environment in the Baltic Sea region - results of the BONUS SHEBA project

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and the SHEBA teams

from

IVL, HZG, Chalmers, FMI, FOI, CINaM, TUT, Syke, SDU, MIG, Ecologic Institute

SHEBA

Helmholtz-Zentrum Geesthacht

Centre for Materials and Coastal Research

BONUS

SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

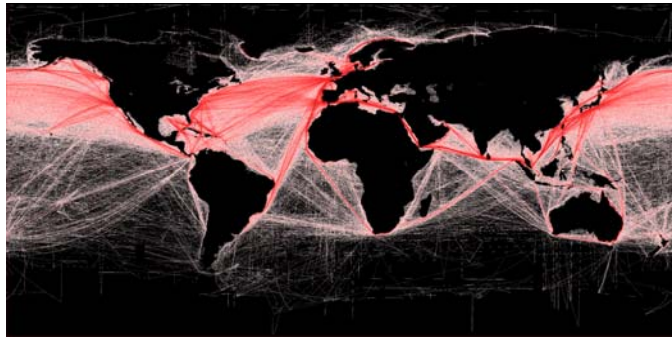
EU STRATEGY FOR THE BALTIC SEA REGION FLAGSHIP

Baltic Earth

Earth System Science for the Baltic Sea Region

14 June 2018 / Helsingor

Driver Shipping



Halpern et al. 2008

- 90% of global trade is carried by international shipping
- Shipping accounts for approximately 3 % of annual global CO_2 emissions *(Smith et al. 2014)*
- Baltic Sea area is hooked up to that trading system

  → busy shipping area; up to 15 % of global cargo

  – 3500–5500 ships per month *(Madjidian et al. 2013)*
  – 50% cargo ships, 20% tankers, 11% passenger ships *(Parsmo et al. 2016)*

Marine Traffic 7/6/2018

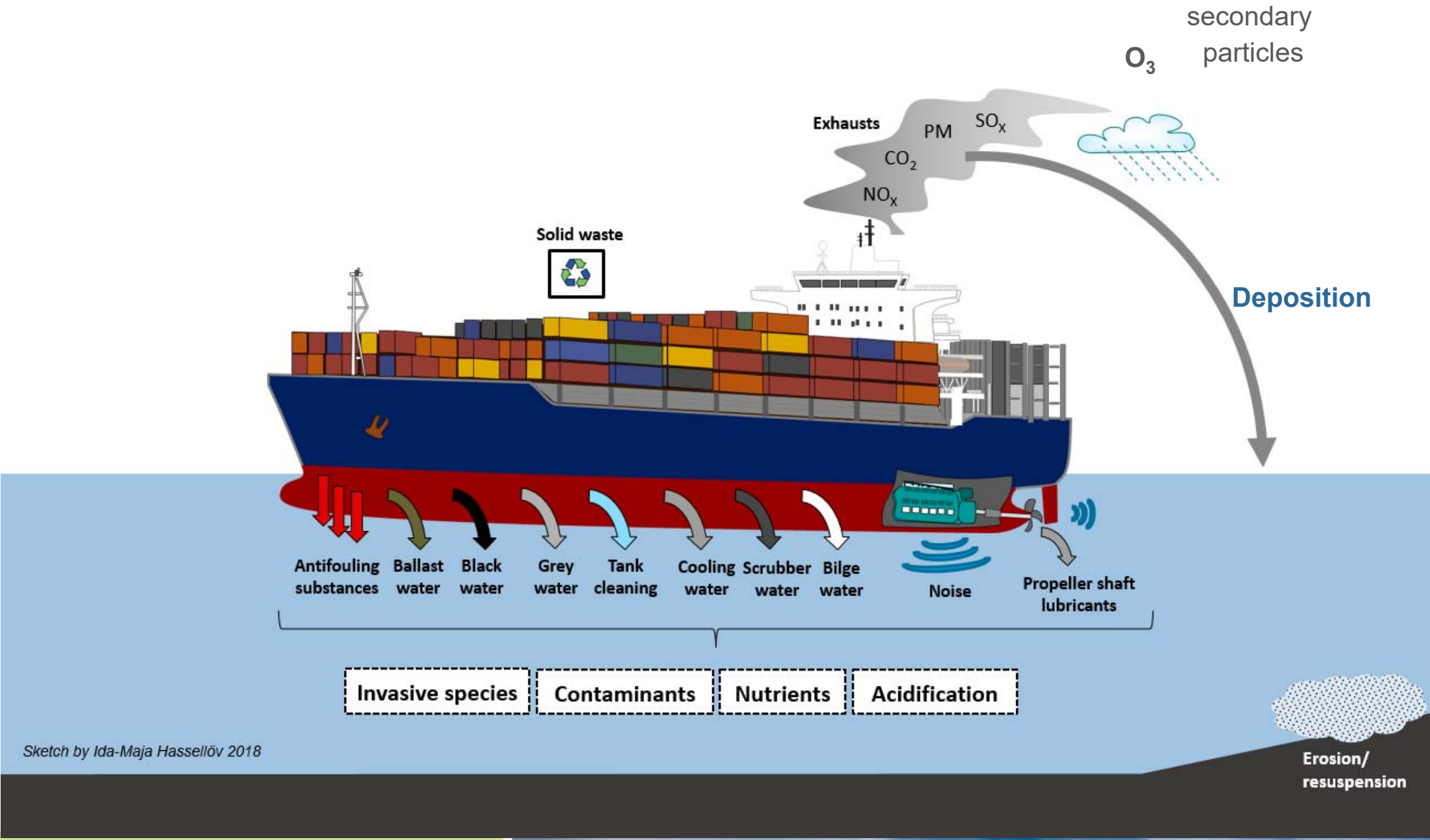
- Shipping impacts the environment on multiple ways

  → emissions of matter and energy

  - to air *(GHGs, pollutants)*
  - to water *(contaminants, nutrients)*
  - underwater noise

Photo: M. Quante

Emissions from Shipping



SHEBA Objectives and Structure

Objectives

The aim of Sheba is to provide an **integrated** and in-depth **analysis** of

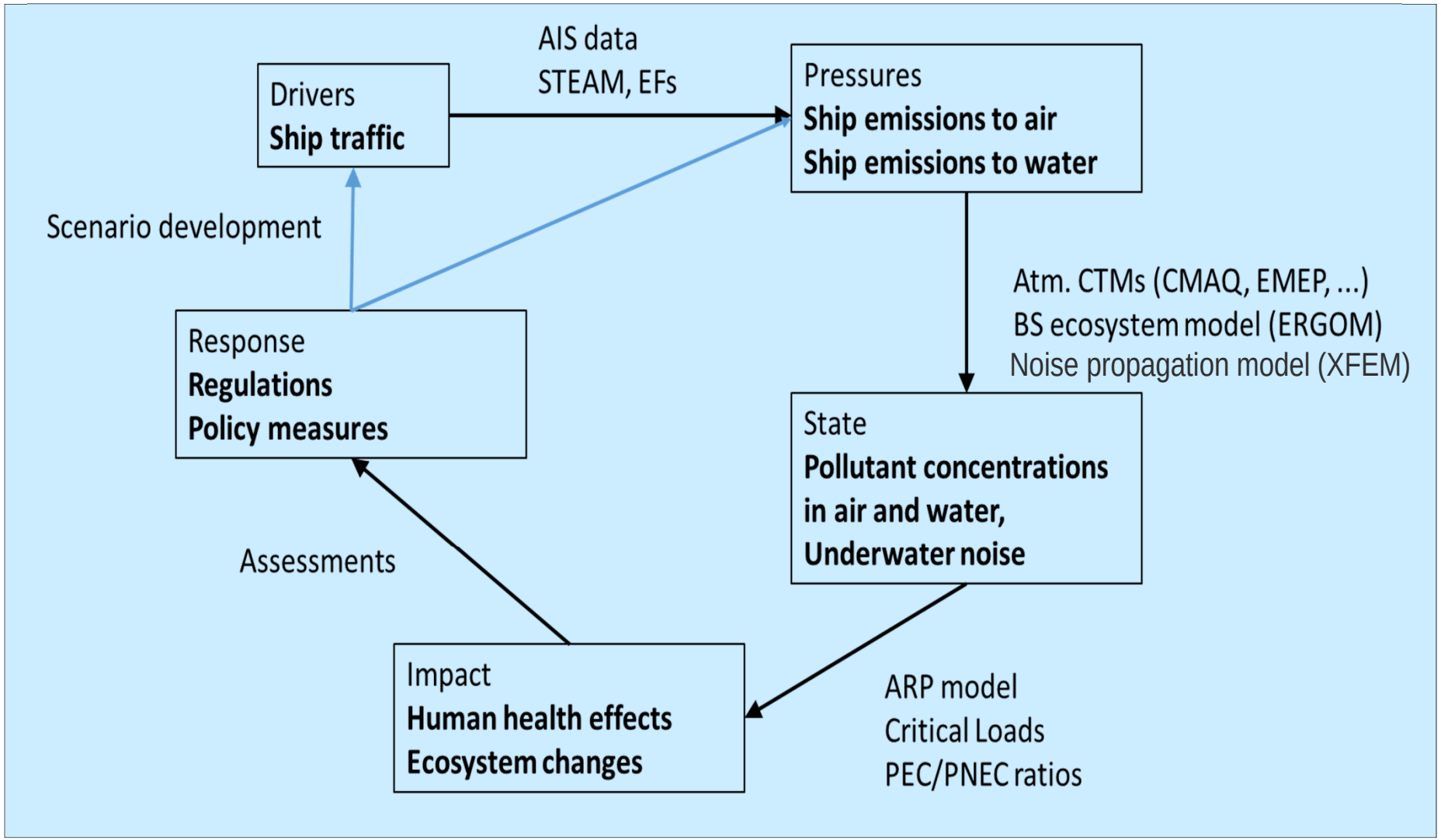
- the ecological,
- economic
- and social impacts

of shipping in the Baltic Sea and to **support development of the related policies** on EU, regional, national and local levels

SHEBA is an affiliated project of Baltic Earth

SHEBA`s research and coordination is structured into 7 working packages (WPs):

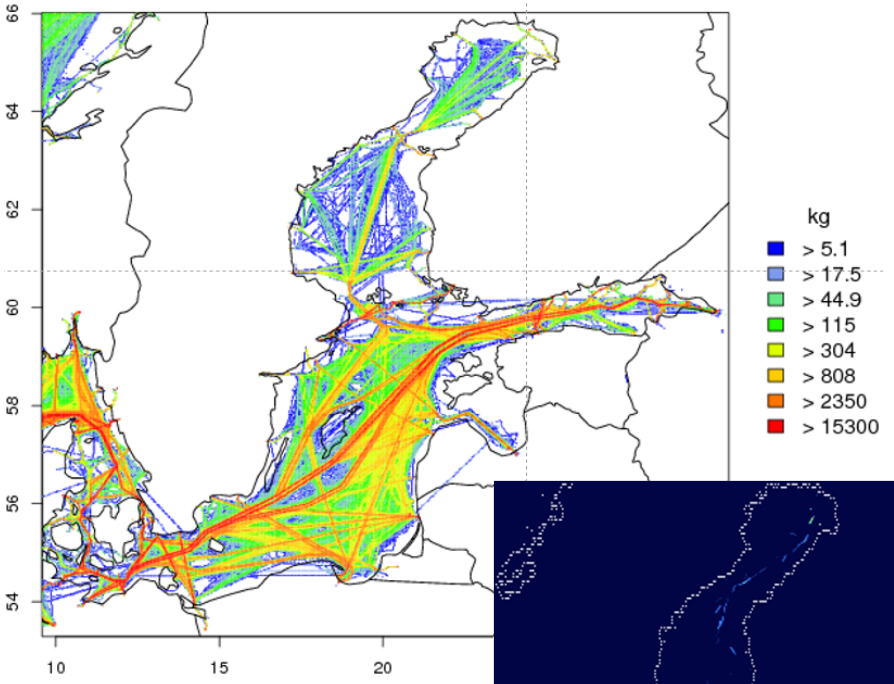
DPSIR framework for the assessment of operational shipping



(Moldanova et al. 2018)

Emission Inventories & Scenario Building

Example NO_x

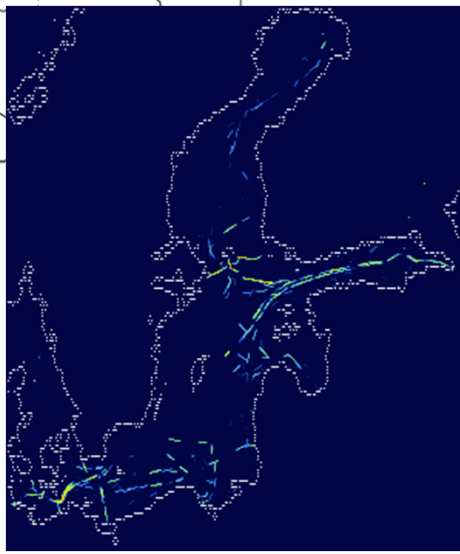


Ship activity + emission factors (spectra)

→ emission inventories

for emissions to air and water
including underwater noise

by extended AIS based STEAM Modell (FMI)



AIS 2012

Shipping: present day situation (2014), future (2030 and 2040)
– future in accordance with socio-economic scenarios (SSPs*)

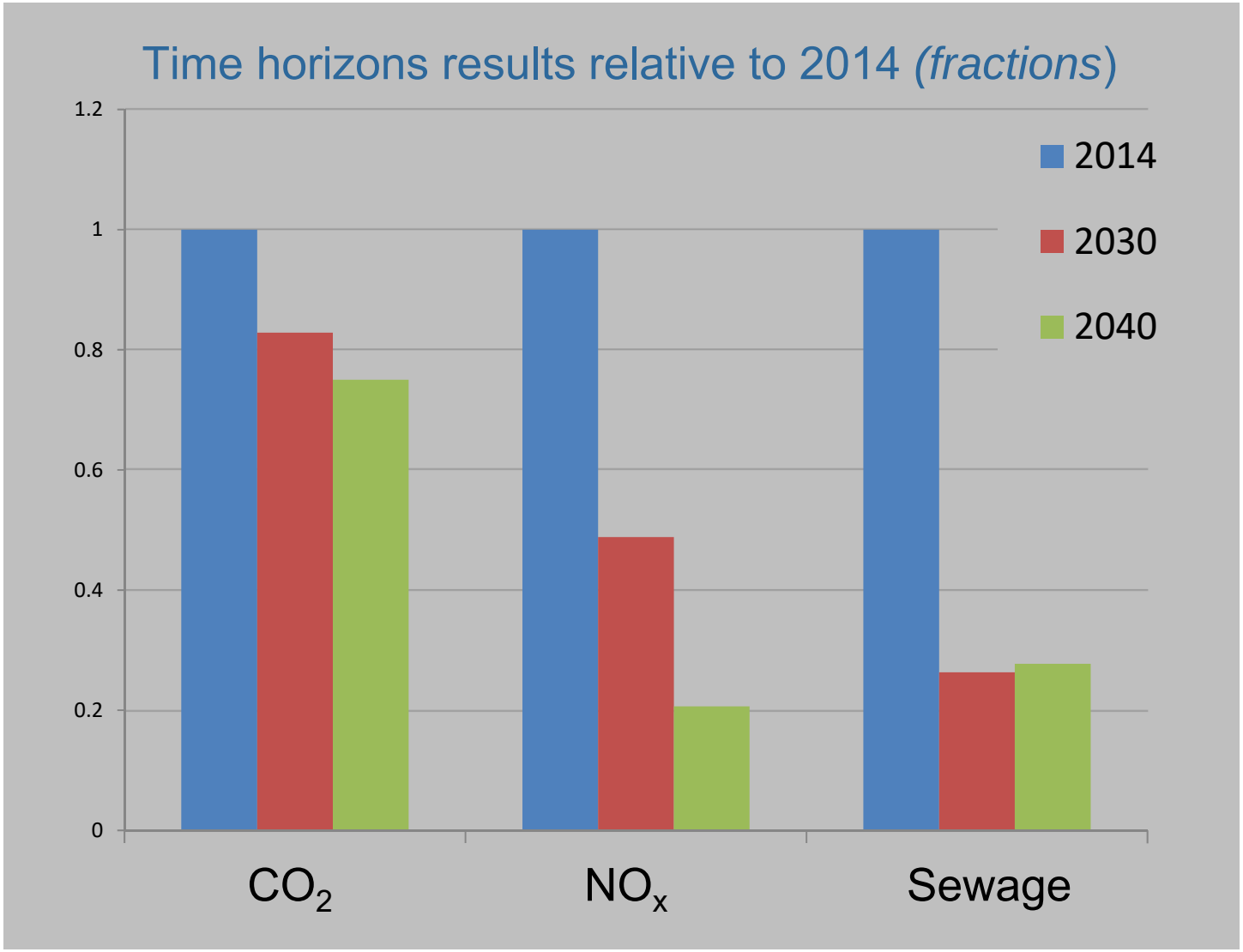
BAU, NoNECA, EEDI, Modal shift, Slow steaming, LNG …

Scenario building has been supported by stakeholder consultations and elicitation

**Shared Socioeconomic Pathways e.g. Riahi et al. 2017*

Business as usual scenario (BAU)

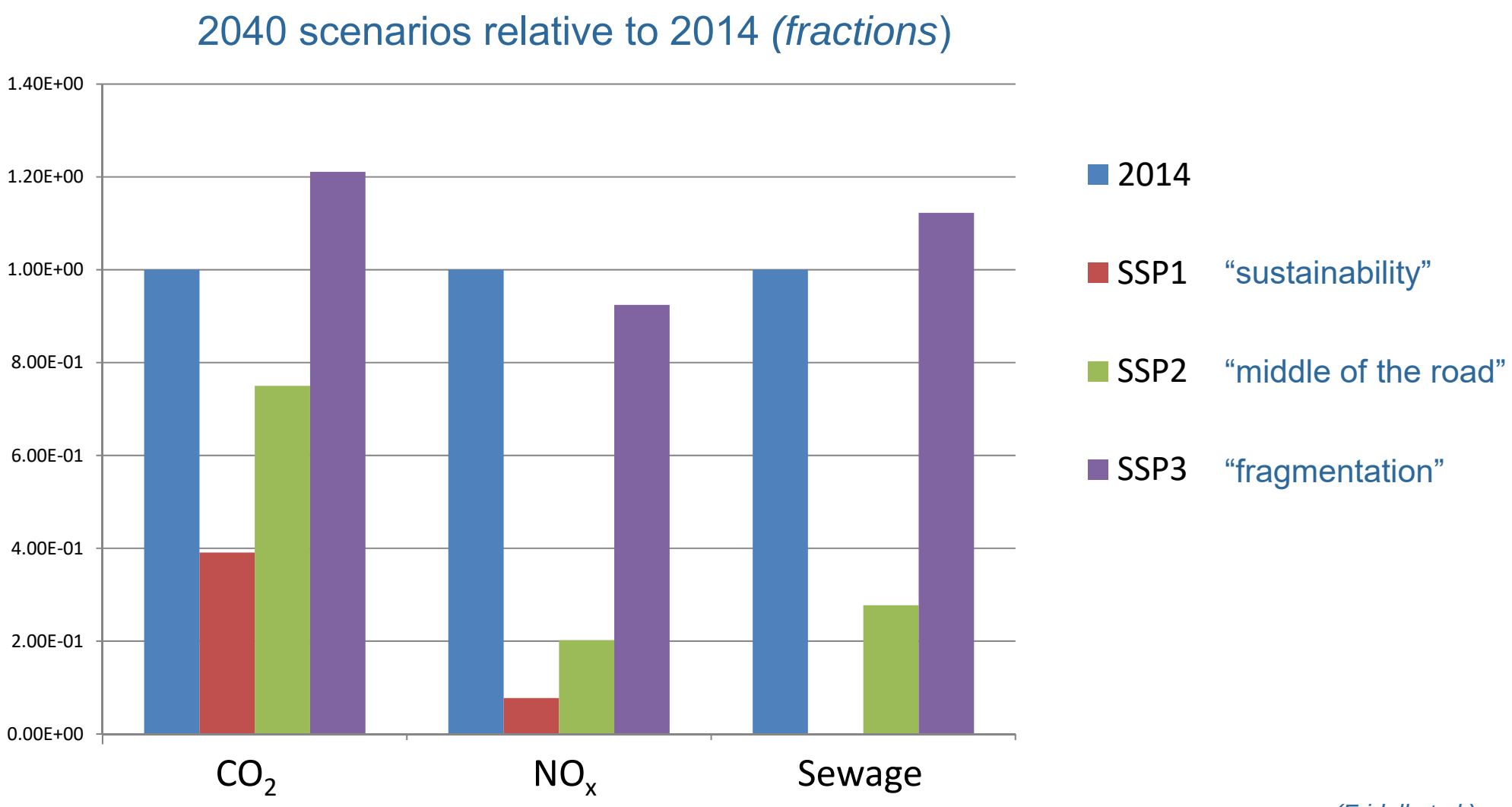
(current trends continue, decided regulations will enter into force; NECA, EEDI, MARPOL sewage)



(Fridell et al.)

Scenarios related to SSCP`s*

(imply different developments in shipping volumes, types of fuel use and environmental policies)



(Fridell et al.)

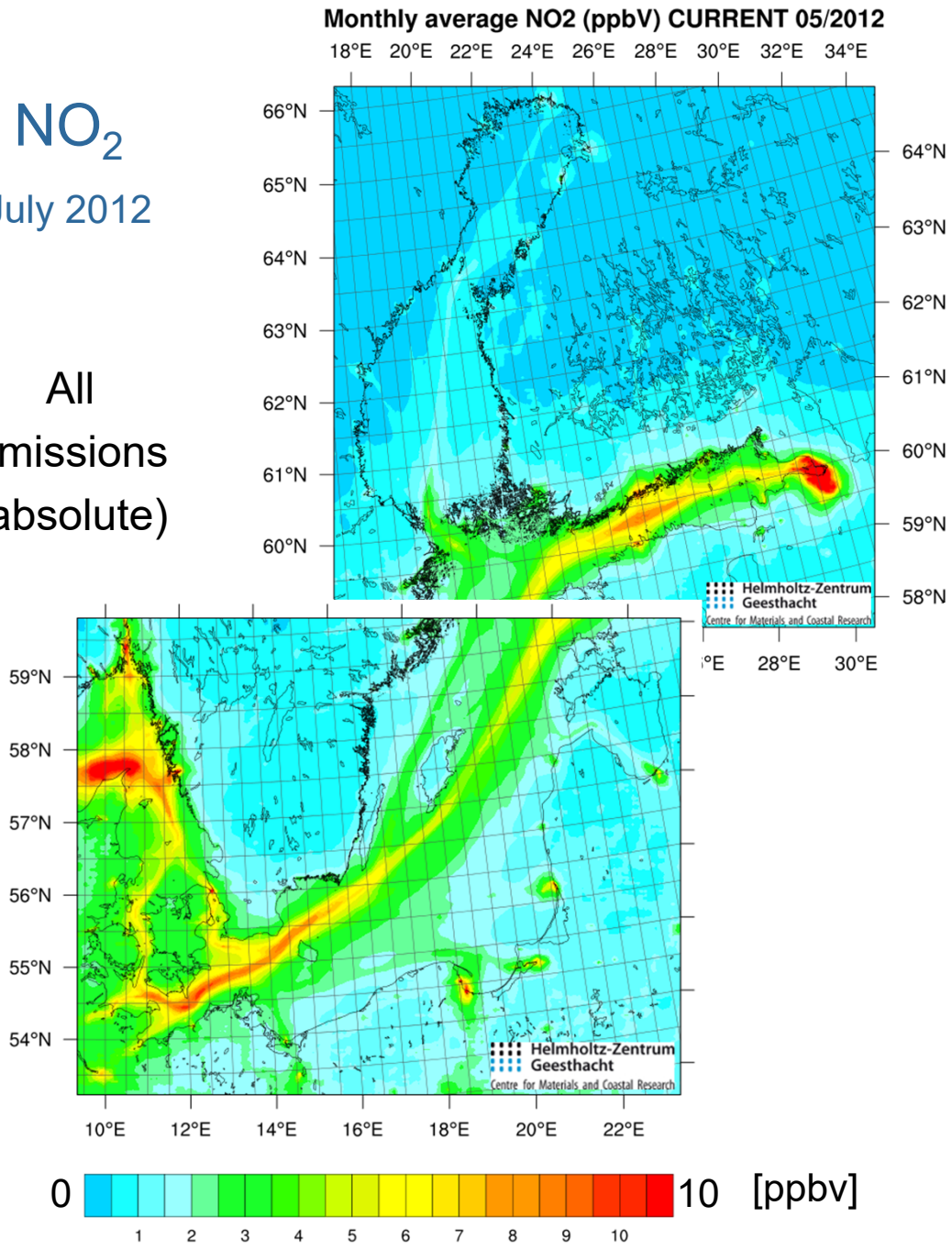
**Shared Socioeconomic Pathways e.g. Riahi et al. 2017*

Regional scale chemistry transport modelling

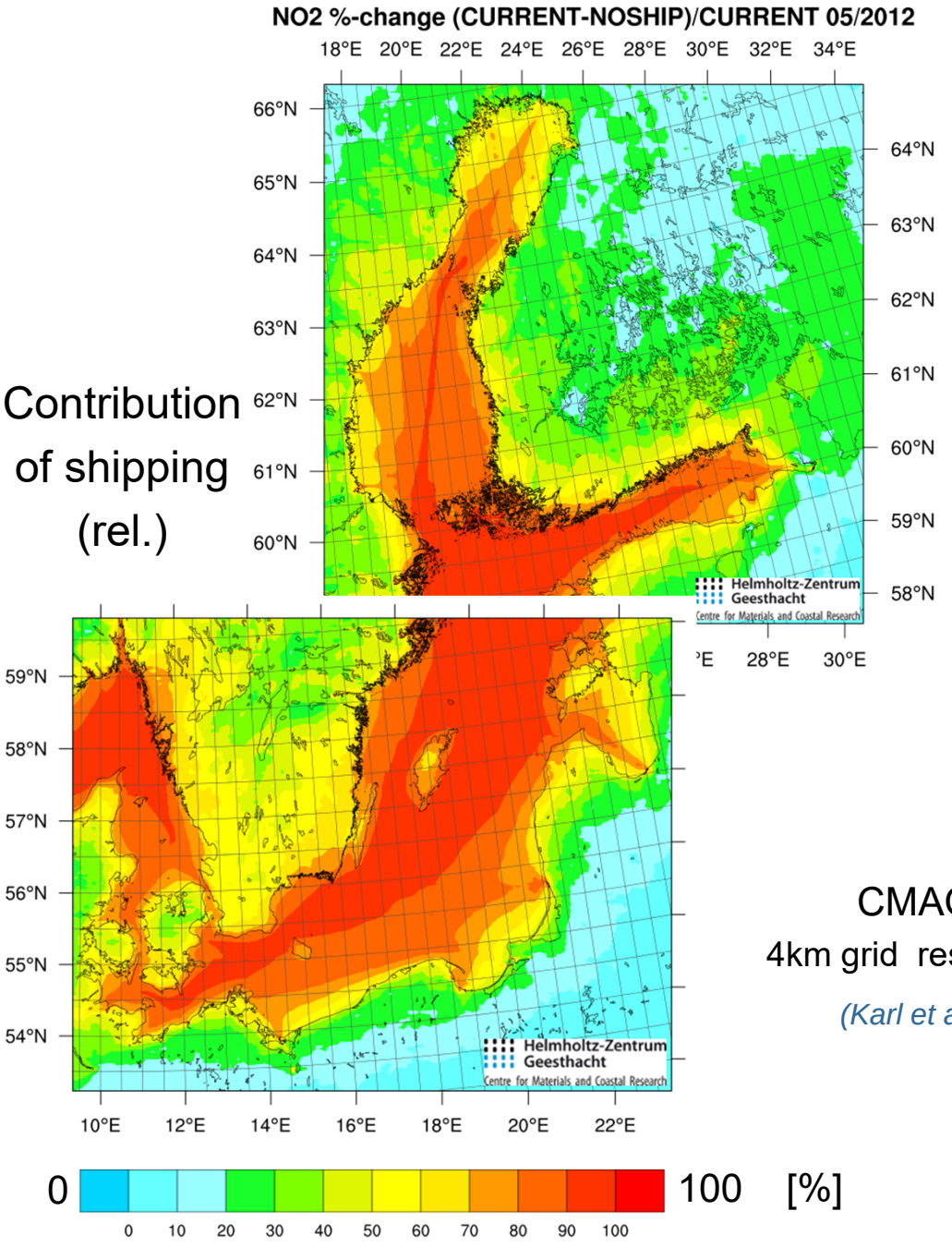
NO_2

July 2012

All emissions (absolute)



Contribution of shipping (rel.)



CMAQ
4km grid res.

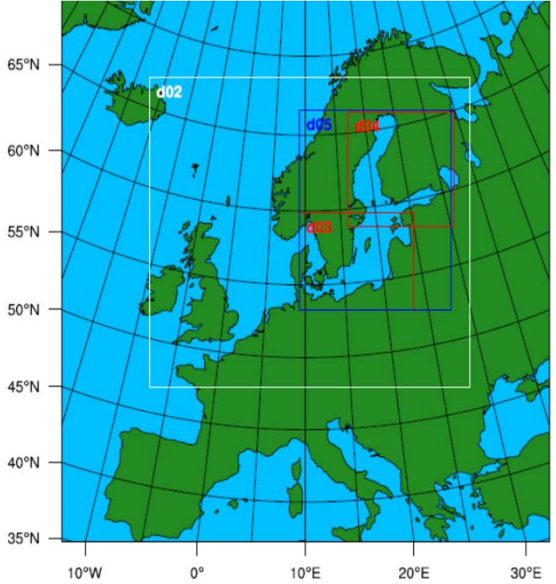
(Karl et al.)

Air pollution concentrations

SHEBA used chemistry transport model systems to assess the fate of air emissions NO_x, SO_2, PM, BC …

→ O_3, secondary aerosols

HZG: CMAQ; IVL/MetNo: EMEP; FMI: SILAM CTM



HZG: CMAQ Set-up

	Present (2012)	NoNECA (2040)	BAU (2040)	EEDI (2040)
Ship emission of NO_x in Baltic Sea [kt/yr]	330	166	68	94
Ship emission of $PM_{2.5}$ in Baltic Sea [kt/yr]	14.9	5.2	5.2	7.3
NO_2 Avg. JJA ship contribution to ambient NO_2 [ppbV]	0.64	0.33	0.16	0.19
$PM_{2.5}$ Avg.JJA ship contribution to ambient $PM_{2.5}$ [µg/m³]	0.29	0.06	0.05	0.13

Karl. et al. 2017

Business as usual (BAU)

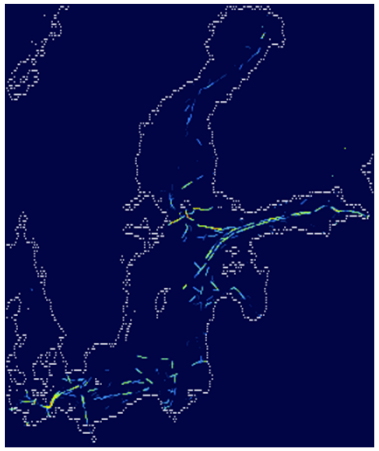
No implementation of NECA-2021 (NoNECA) Low efficiency increase (EEDI)

Approach/Methods - Shipping emissions to water

Ship types

Shipe type discharge volumes or amounts:
Bilge
Ballast water
Antifouling, etc.

Activity (AIS) data



Year 2012

STEAM model

Shipping emissions

Air emissions

CMAQ model

Atmospheric depositions

Discharge volumes
Bilge
Stern tube oil
Ballast water
Grey water
Black water
Food waste
Open loop scrubber
Closed loop scrubber

Amounts
Antifouling
NO_3
NH_4
PO_4
Detritus

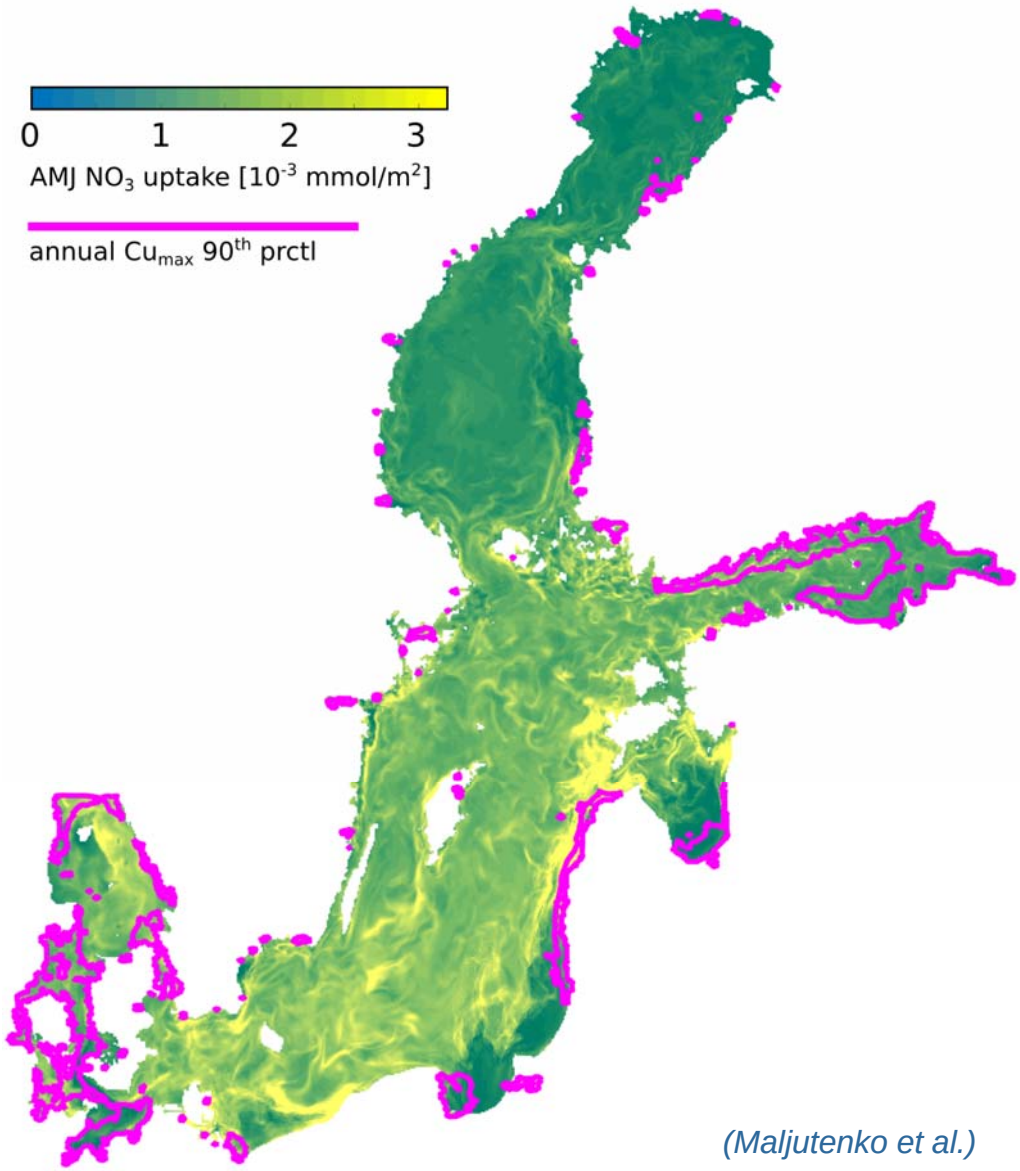
into **GETM** **ERGOM**

(Hassellöv, Eriksson et al.)

Shipping emissions to water – transport and effect

Nutrients from shipping mainly:

- **nitrogen oxides** via exhaust and N-deposition
- **phosphate** via black and grey water



(Maljutenko et al.)

Figure: Shipping related **nitrate uptake by phytoplankton** from April to June in 2012 (colour bar).

Pink contour lines **90th percentile of annual maximum copper** concentrations in 2012.

300 tons of copper emitted annually by shipping, 99 % from anti-fouling paint

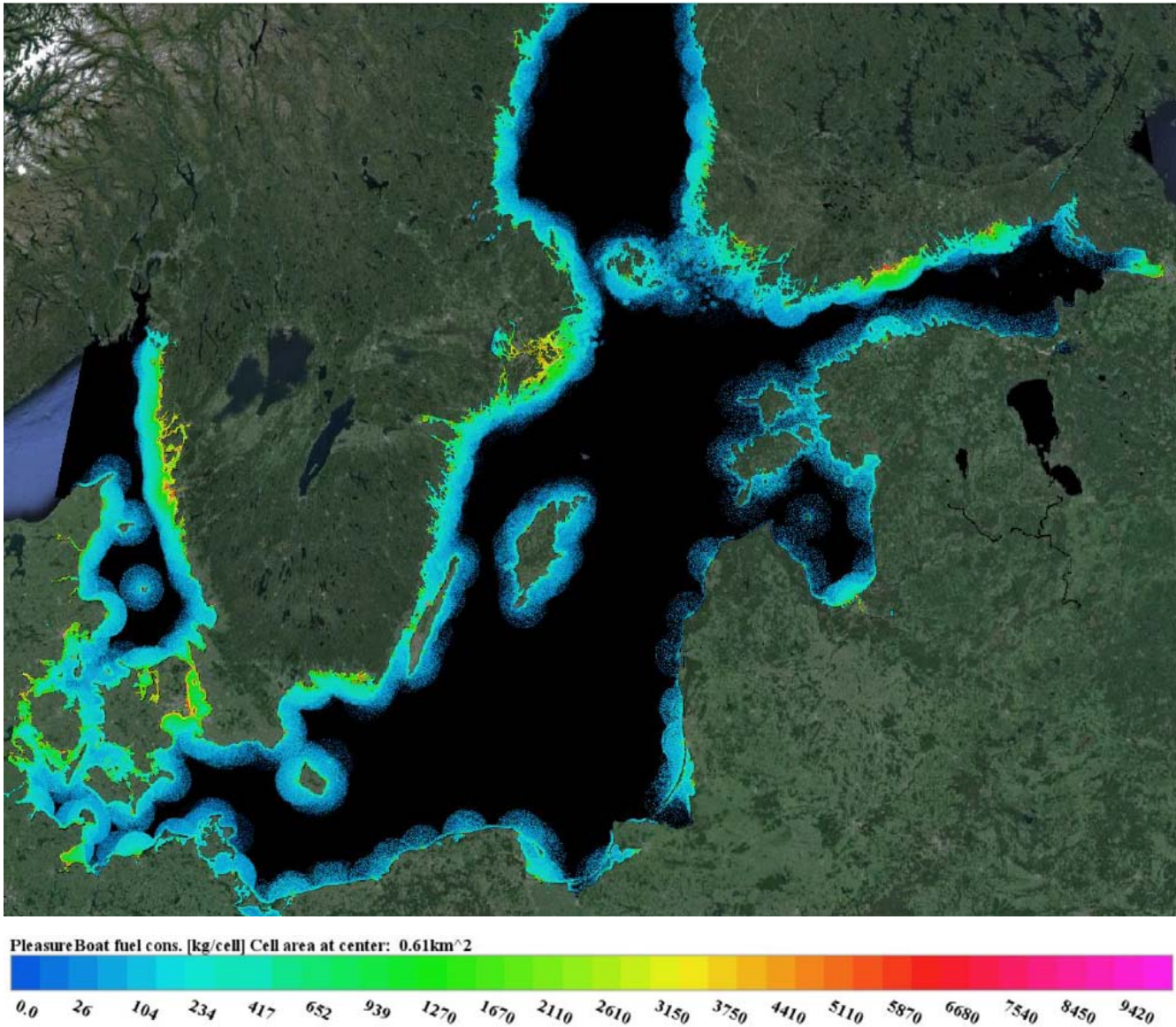
Leisure boat study

- Model developed for activities and emissions

➢ more than 3000 marina locations at the Baltic Sea
> 250 000 leisure boats

➢ Relevant i.e. for NMVOC, CO, antifouling paints

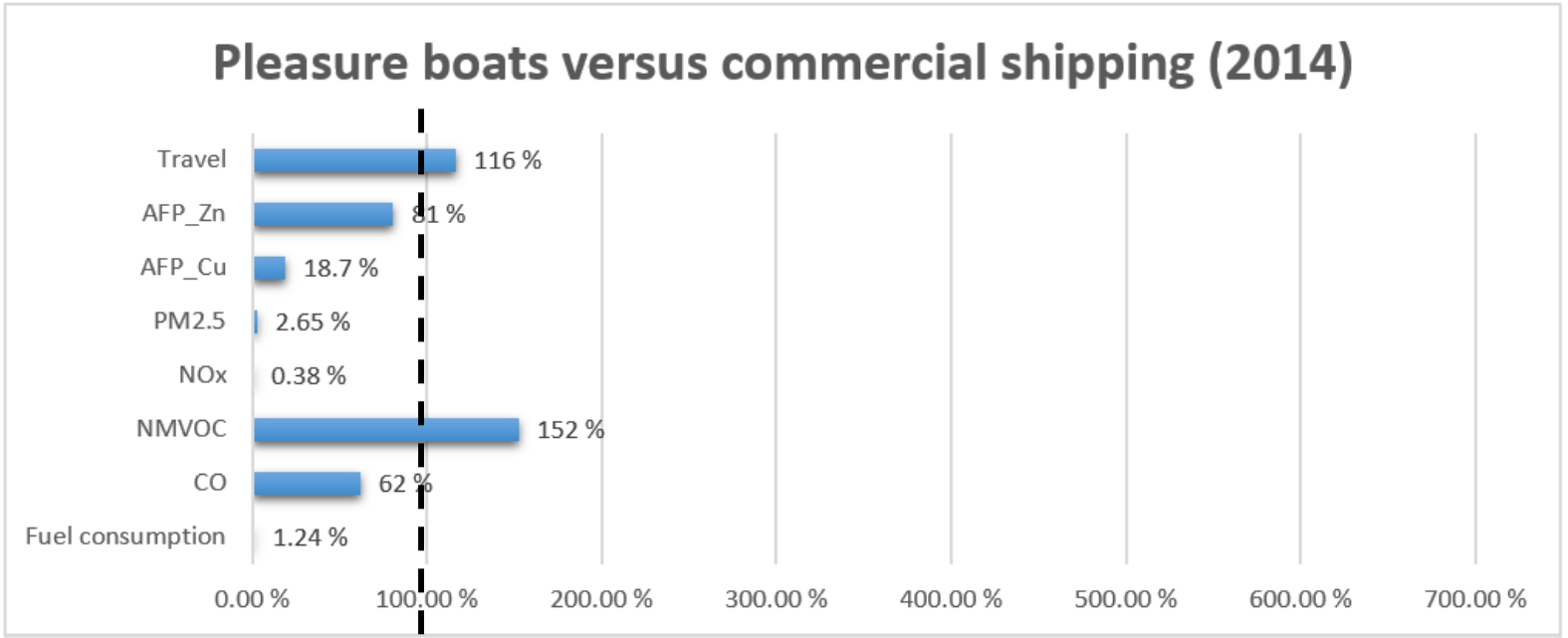
Annual fuel consumption

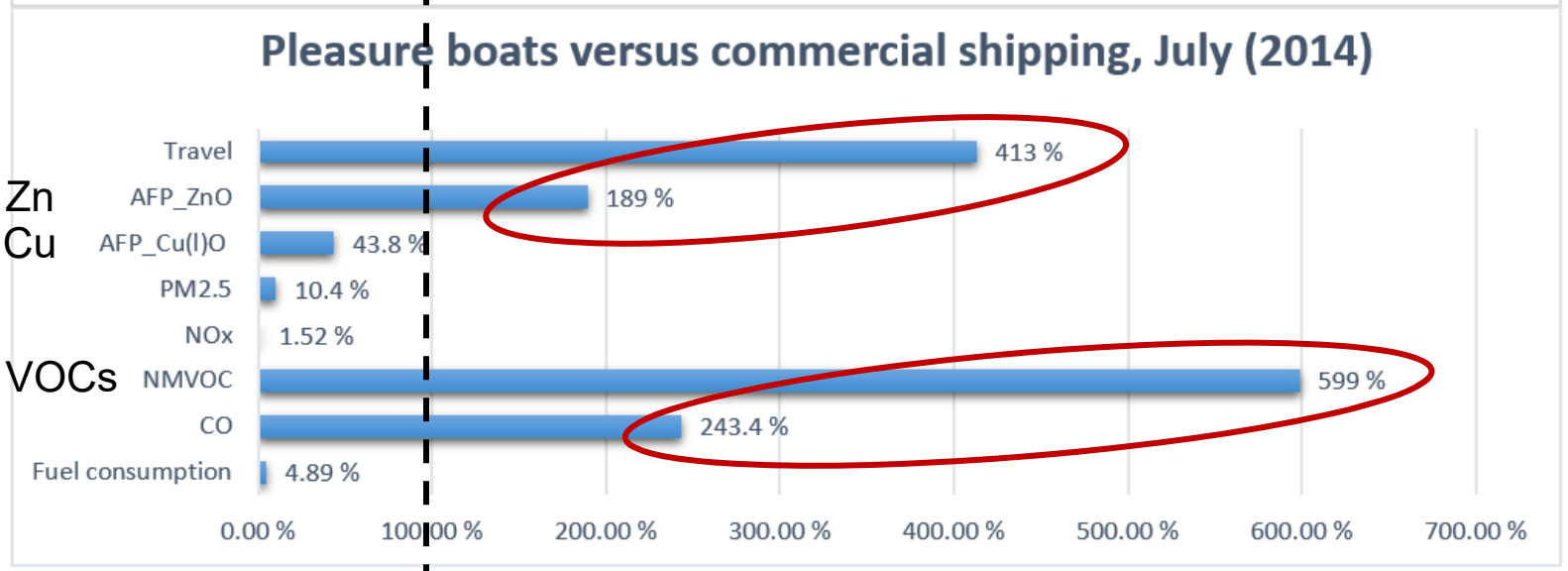


annual fuel consumption in kg/grid cell/year

(Johansson et al.)

Leisure boat study





anti-fouling Zn Cu

non-methane VOCs CO

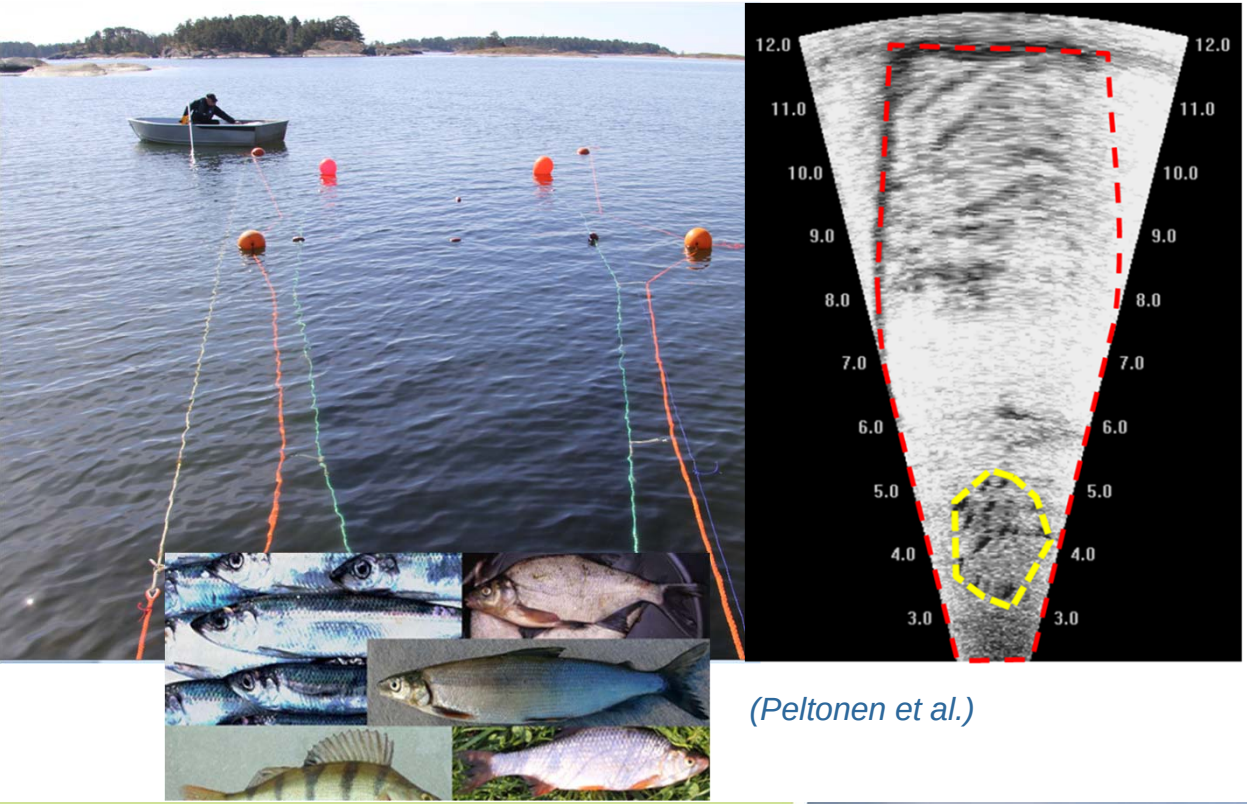
100 %

(Johansson et al.)

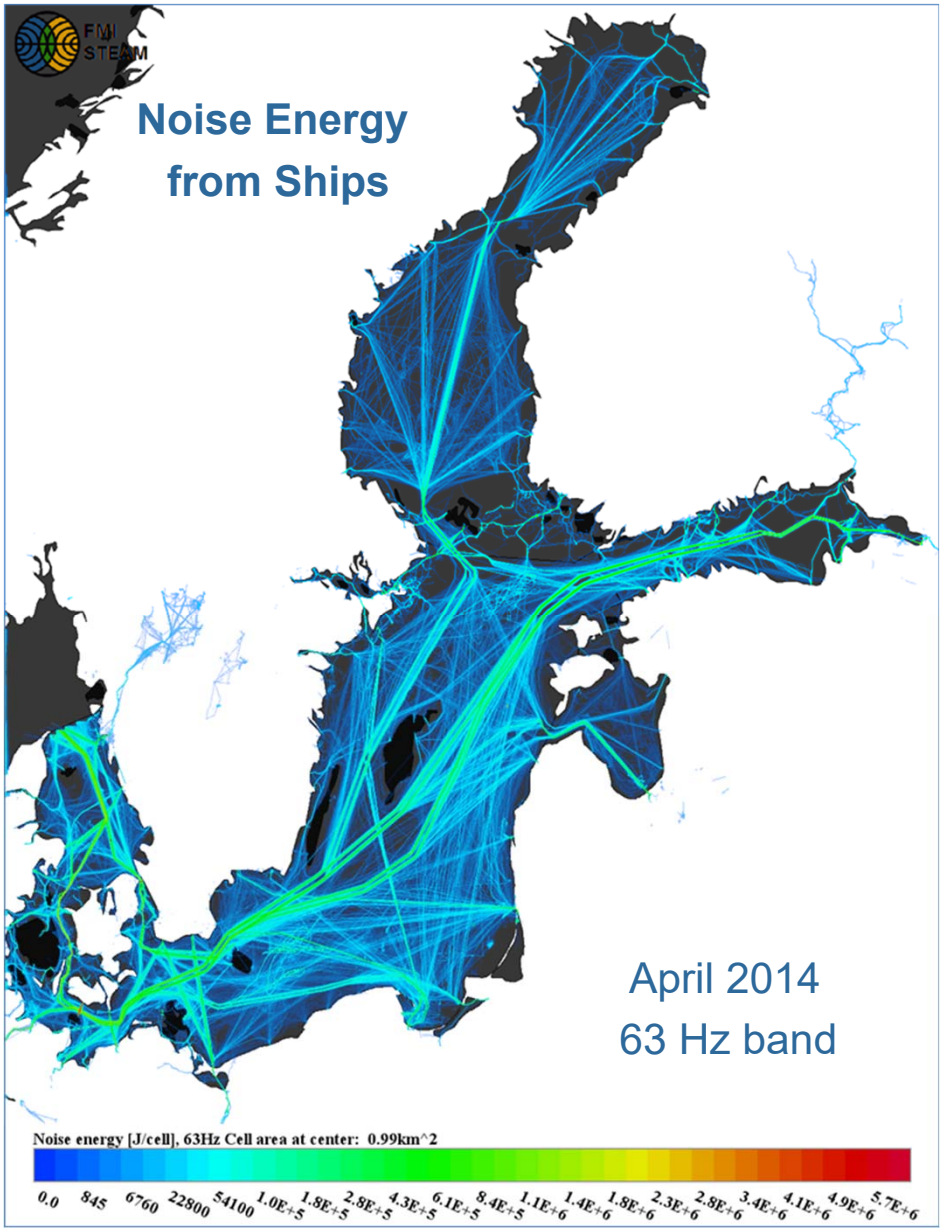
Underwater noise

- Shipping **noise sources** description
- **Sound propagation** modelling
- **Impacts** to marine life

Noise impact fish experiment



(Peltonen et al.)



in J per grid cell (0.9 km$^{2)}$,scale 0 to 5.6 E+6 J

(Jalkanen et al.)

Integrated assessment of economical, societal, ecological impacts

→ DPSIR framework for shipping

- Abatement costs estimation

  share of abatement costs of water emissions (17 %; copper dominant) lower than costs of air emissions (83 %, NO_x dominant)

- Policy options

  list of 20 policy options established
  ranking in progress (based on survey and expert elicitation)

- Impacts / Synthesis

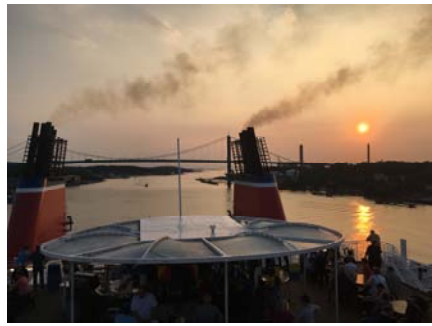
  health, ecosystem impacts (risks, critical loads)
  work in progress

Policy options
#1 Sea grass protection: Restrictions on number of boats mooring in certain areas and better enforcement
#2 Speed regulation: Zoning and maximal speed (Baltic-wide)
#3 Excluding the noisiest ships / limits on average noise level
#4 Promoting biocide-free anti-fouling paint and alternatives (research funding, financial support for pilots)
#5 Reduced limits for biocidal release rate for anti-fouling paints
#6 Guidance on integration of antifouling paints in river basin management plans (RBMPs) and national marine strategies
…ister regulation on s…
…omoting us… …ergy sources, e.g. bio…
#11 Limits on methane slip … engines (due to incomplete combustion, …
#12 Promoting use of electric power for running the engine (battery–driven)
#13 Promoting shore power in ports
#14 Green port fees linked to ship emissions/pollutants
#15 Introduction of national fairway dues (charges) which are linked to ship emissions/pollutants
#16 Initiatives to simplify procedures in ports, e.g. use of communication tools to adjust speed to arrive in ports
#17 Promote vessel scrapping to reduce environmental impacts of fleets (financial support)
#18 Establish PM (including black carbon) emission standards for ships
#19 Implementation of a CO_2-tax for shipping
#20 Establishing of an emission trading scheme for greenhouse gases from shipping

List of 20 policy options *(Tröltzsch et al.)*

Closing remarks

- **SHEBA was really a multidisciplinary project, many perspectives**



- **Achivements:**
  - extensive shipping scenarios
  - activity based emission inventories for shipping in the BS
  - scenario based calculations of dispersion and impacts of:
    - ⊗ air pollutants ⊗ water pollutants ⊗ underwater noise

- **Still many uncertainties !**

- **Results will be published in international scientific journals**
  (i.e. special issue ACP, Ocean Science)

- **Data will be made available at the end of the project**

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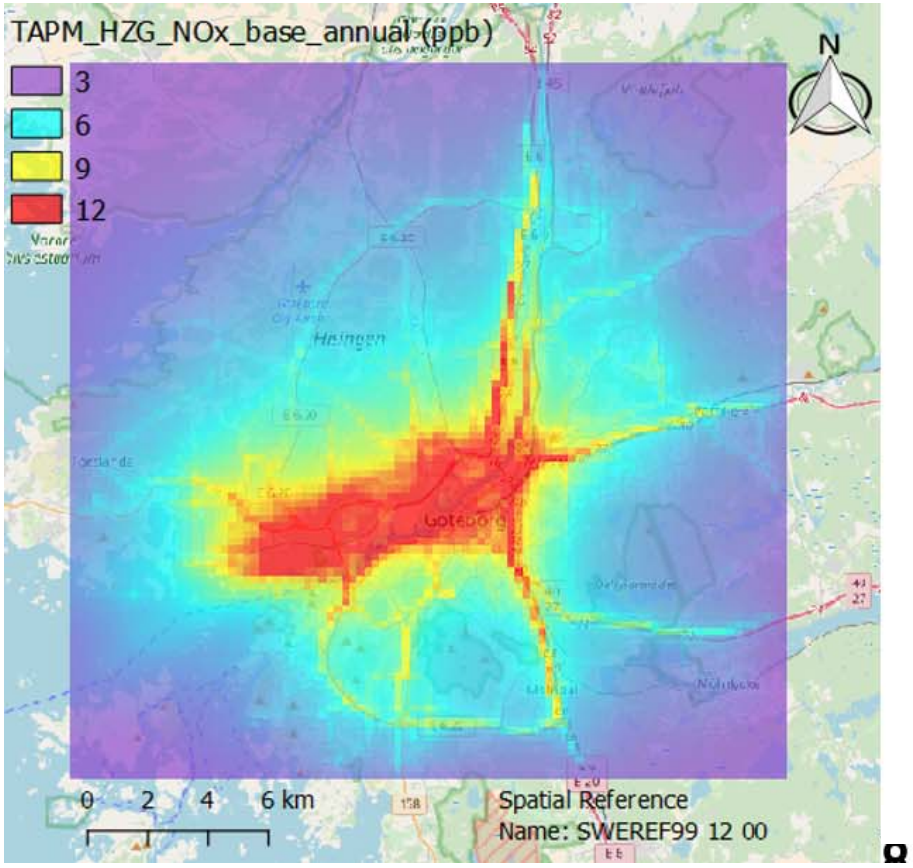
City Scale Chemistry Transport Modelling

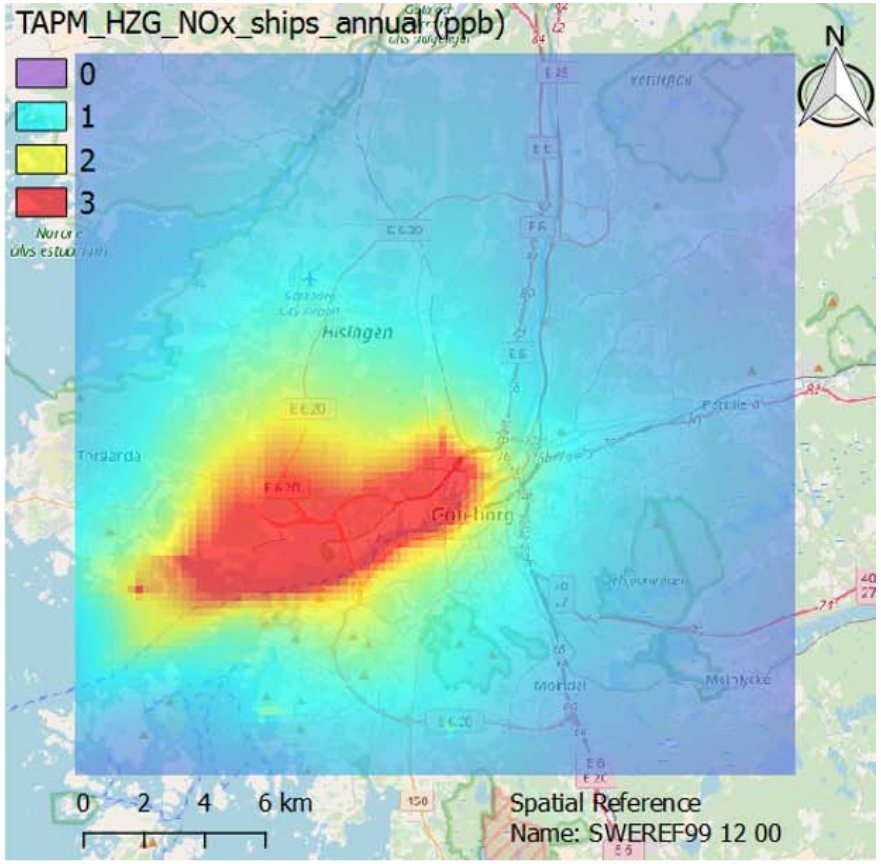
(Photo: M. Quante)

Example NO_x for Gothenburg

All sources



Ship contributions (~25 %)



(Ramacher et al.)

also Rostock, Gdansk-Gdyna, Riga with TAPM and City-Chem EPISODE

Field campaign - S/Y Hrimfare

Measurements in water and air along and in three transects crossing shipping lanes.

- Hydrographic parameters

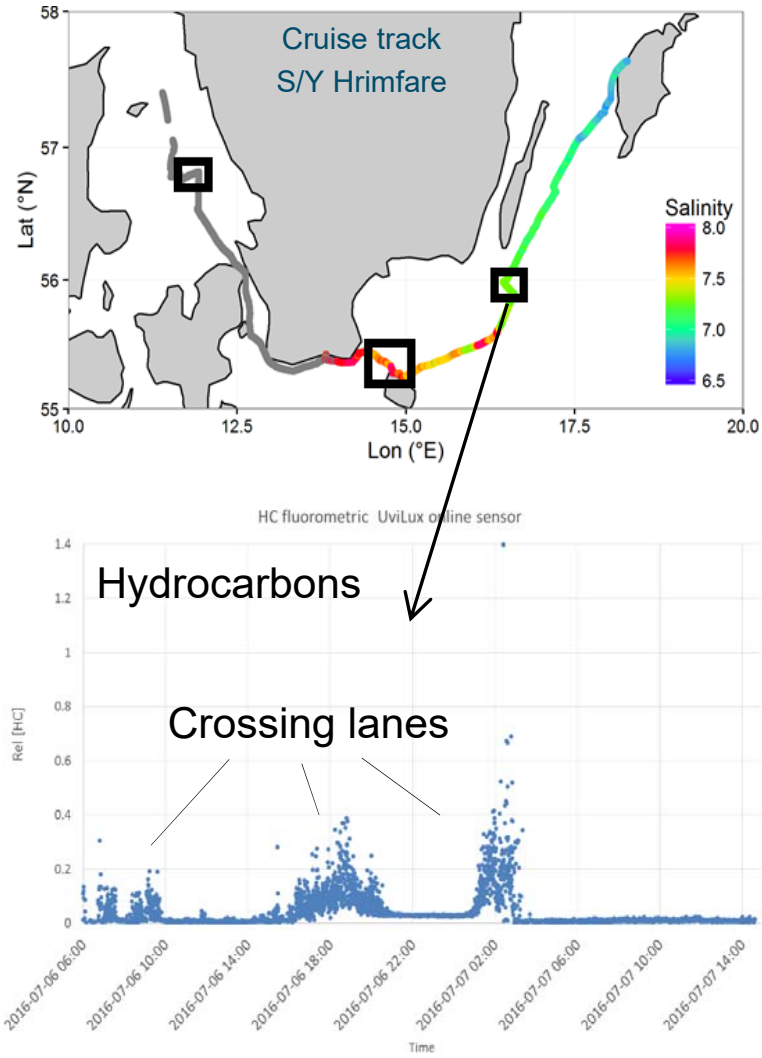
  Salinity, temperature, pH, alkalinity

- Air measurements

  CO_2, **SO_2, NO_X, Particles**

- Water measurements

  Nutrients, metals, PAH, **HC**, **Particles**



*! Pollutants marked in **bold font** indicate that a signature of the shipping lanes was detectable*

Thank You

Bundesministerium
für Bildung
und Forschung

Innovation Fund Denmark
Eesti Teadusagentuur
Estonian Research Council
ACADEMY OF FINLAND
ptj
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NATUR VÅRDS VERKET
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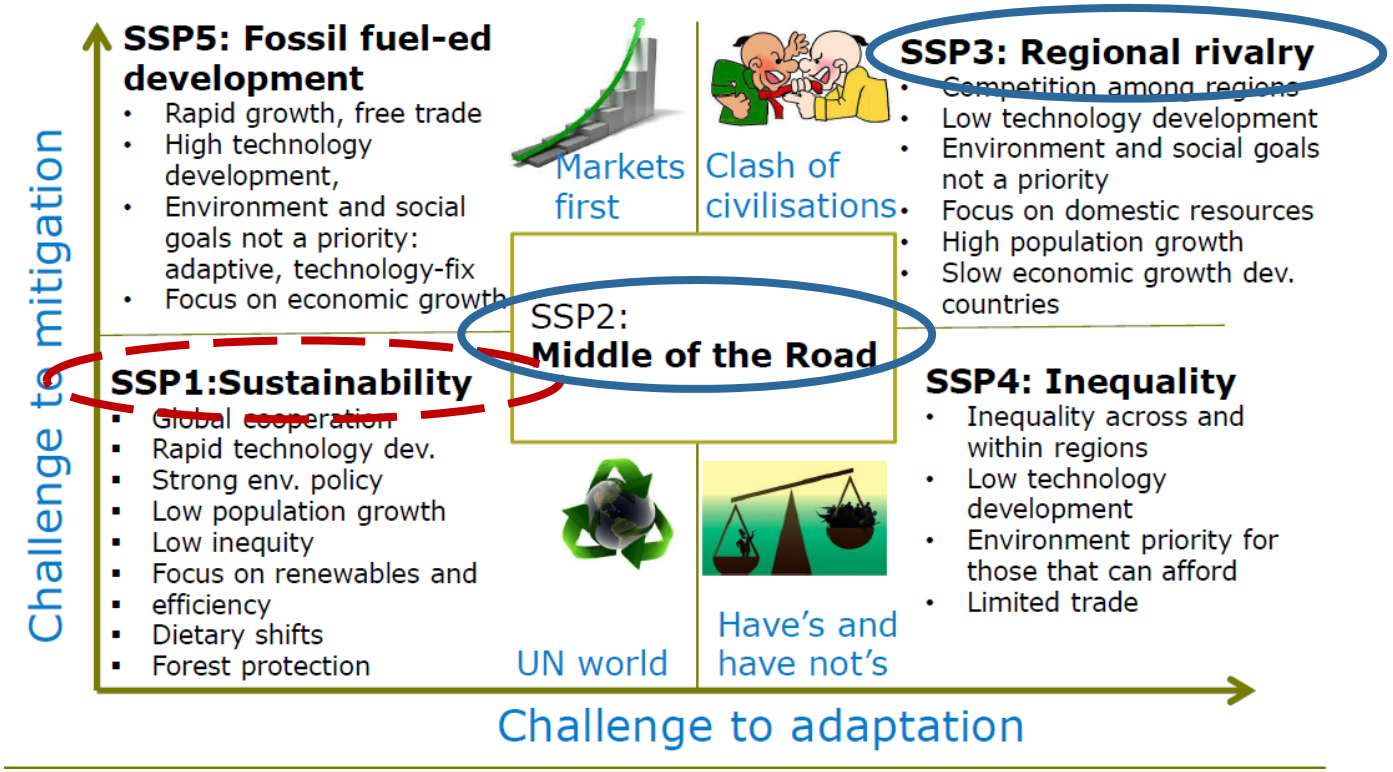
cnrs
Aix Marseille université

https://www.sheba-project.eu/

Photo: M. Quante

Scenario building



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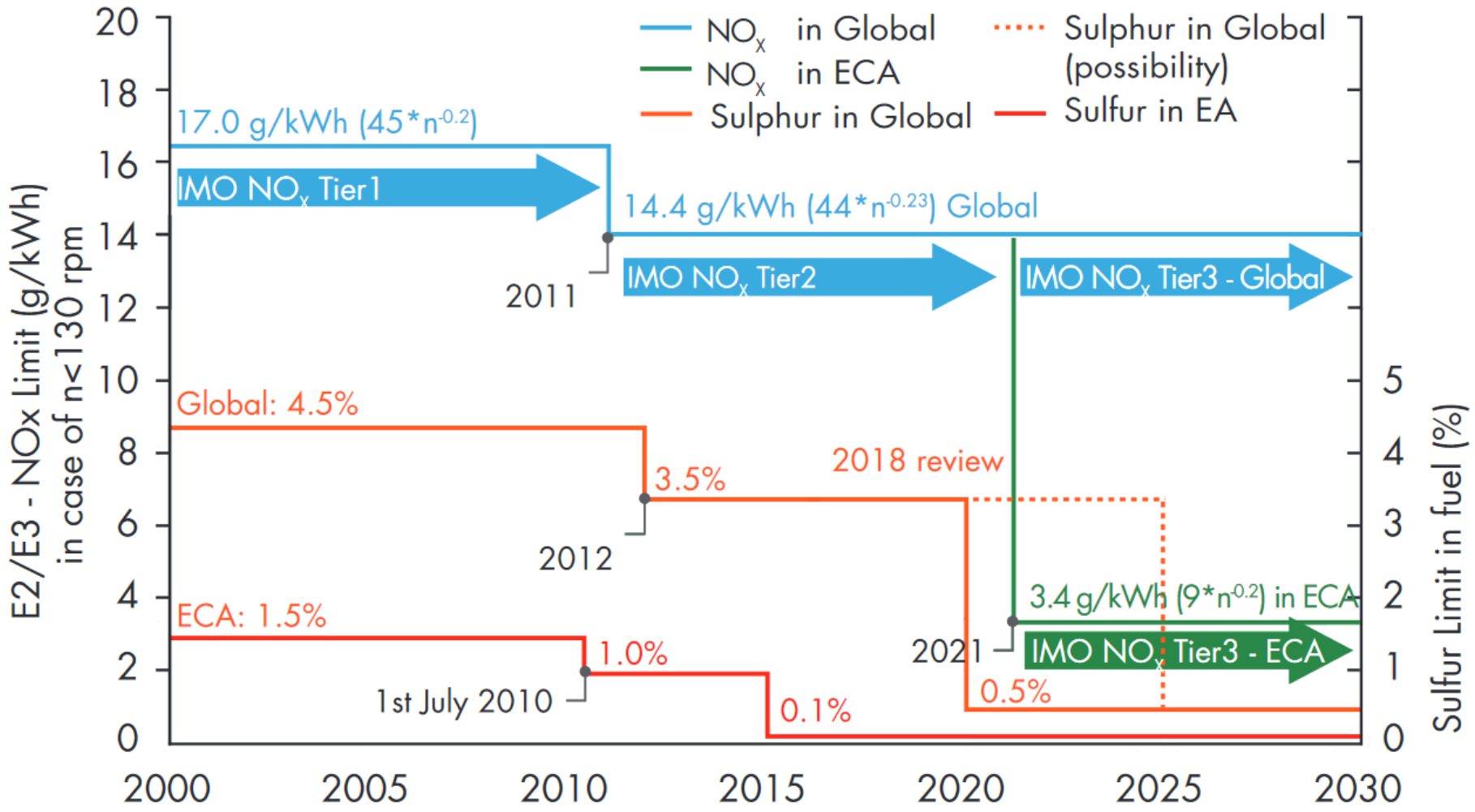
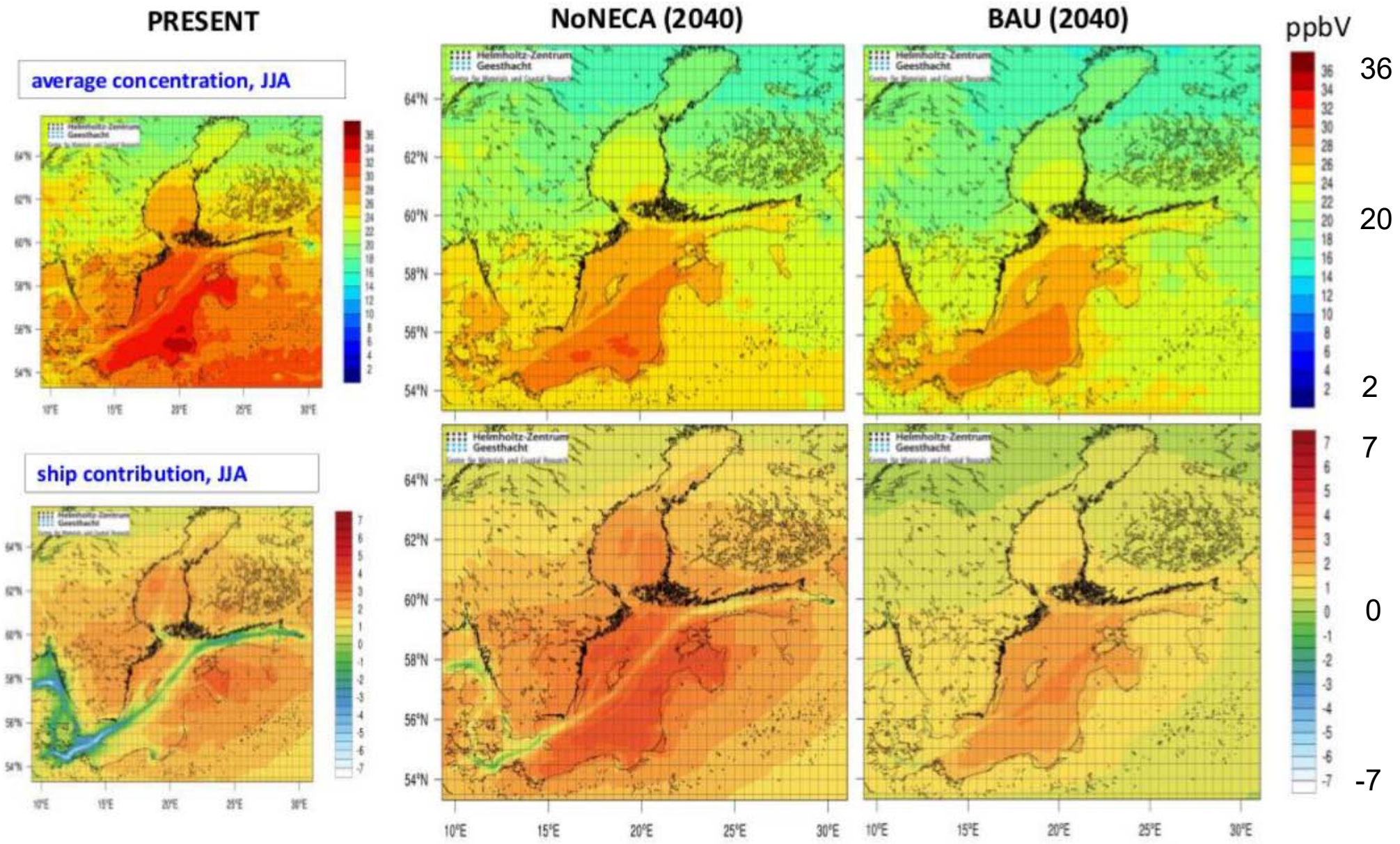
Regulations for reducing ship emissions



Ozone from CTM (HZG CMAQ)



Karl et al. 23