BONUS SHEBA – Sustainable Shipping and Environment of the Baltic Sea region

Update on the project achievements in 2017

2017-11-07 / Gdansk

SHEBA

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

SHEBA Objectives and Structure

Objectives

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

- the environmental,
- 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

Runtime

SHEBA is running from April 1st 2015 to March 31st 2018

Applying for extension to July 31st 2018

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

WP7
- Coordination

WP 6
- Interaction with stakeholders
- Data products and their dissemination
- Dissemination, education

WP1 Policies, scenarios and activity data
- Drivers (policies, economy, regulations)
- Scenarios (Technology, fuel, modal shift)
- Shipping activity data

WP2 Air Pollution
- Air pollutant sources
- Transport and transformation, deposition maps
- Effects on human health and land ecosystems

WP3 Water Pollution
- Line emissions sources (antifouling, open-loop scrubbers)
- Point emission sources (Litter, sewage, bilge & ballast water, closed loop scrubber sludge)
- Fate of pollutants in the Baltic Sea
- Effects of pollutants on the Baltic Sea ecosystem

WP4 Noise
- Noise sources
- Noise propagation
- Noise effects and conflict maps

WP5 Assessments
- Good environmental status descriptors
- Integrated assessment of economic, societal and ecological impacts
- Ecosystem services

Shipping activity data using AIS data from HELCOM

- Data available for 2011, 2012 (&2014)
- STEAM-emissions model

Ship TrafficEmission Assessment Model of air pollutants, water pollutants and noise for 2012 calculated

Used to calculate baseline and scenario emissions of:

- Air pollutants
- Water pollutants
- Underwater noise

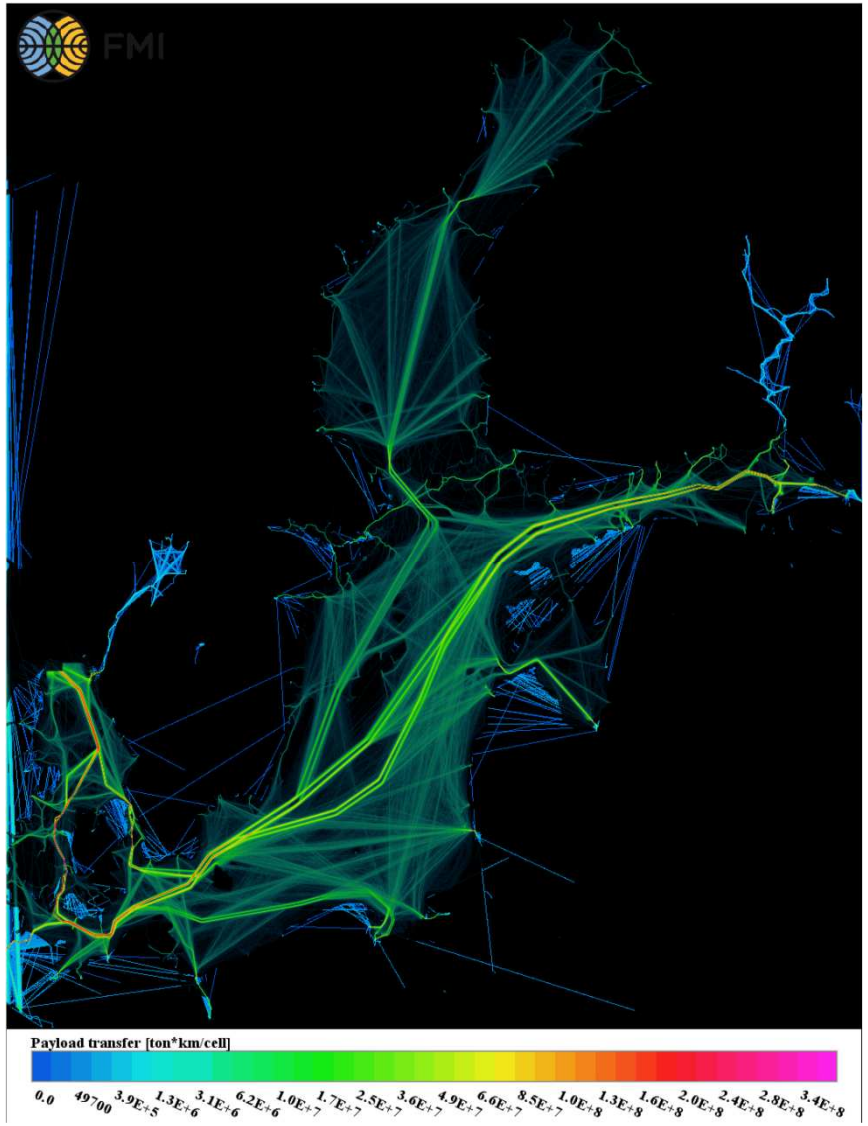
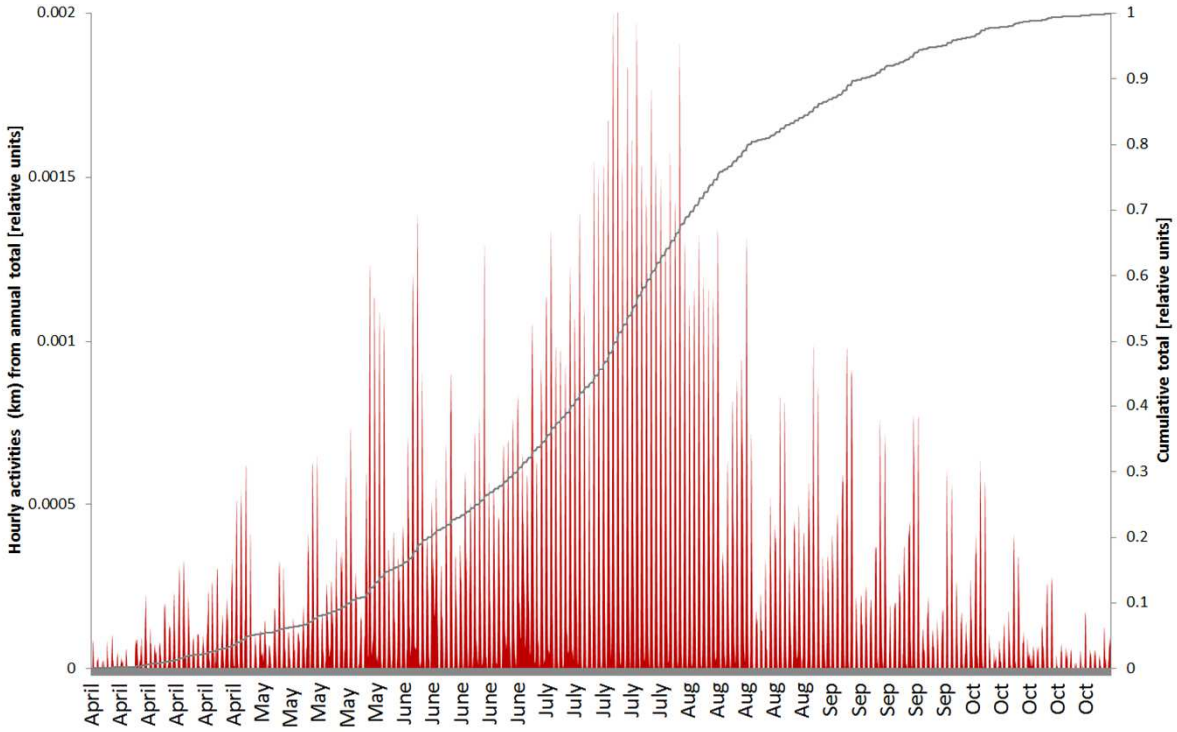


Figure: Modelled annual cargo transport work from shipping at the Baltic Sea in 2014 based on the provided Helcom AIS dataset.

Pleasure boats

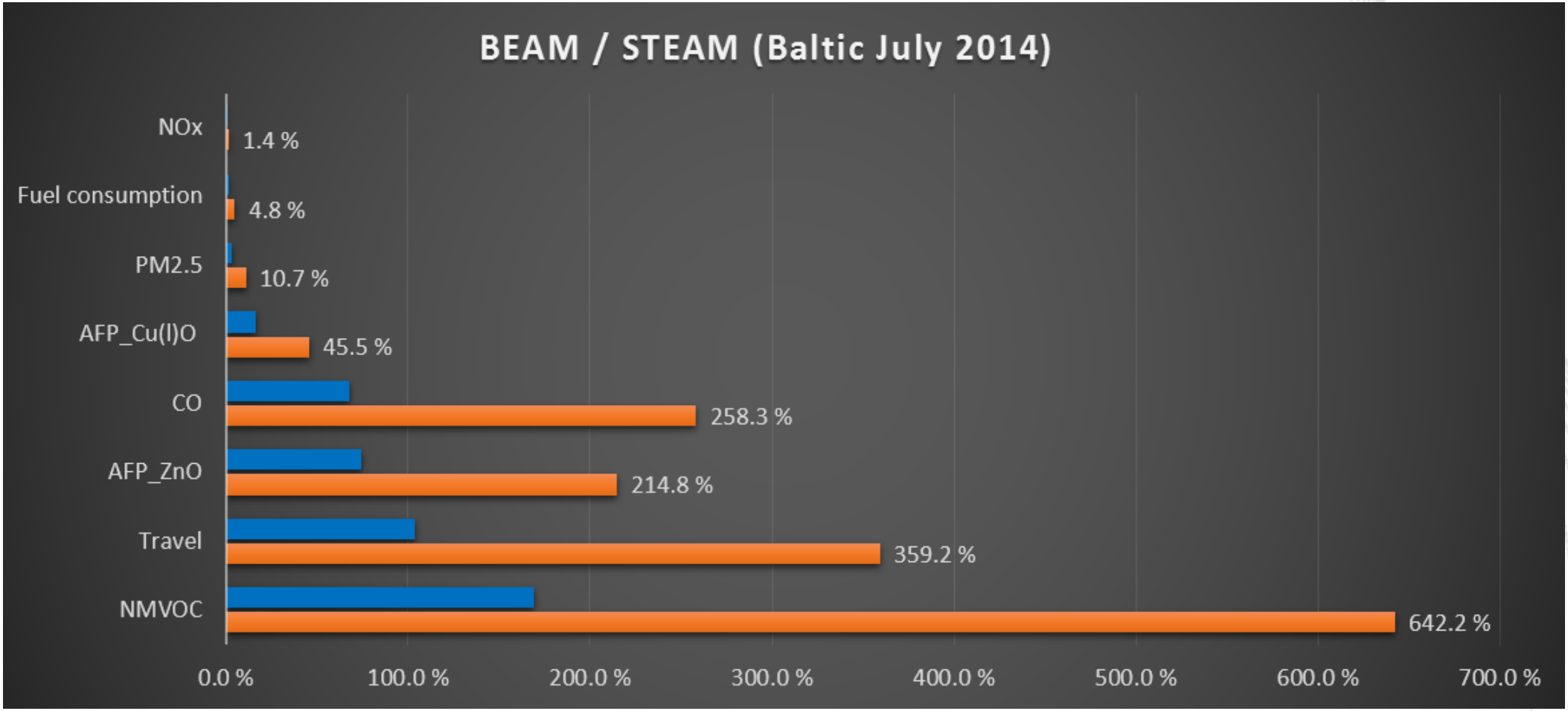
Database with activity data for **recreational shipping** produced based a top-down inventory based on survey data on fuel sales statistics, marina locations and fleet composition provided by the SHEBA partners, combined with satellite image analysis (spotted 3000 locations with 250 000 PB:s) and AIS data to calculate the temporal variation. A newly developed pleasure boat emission modelling approach developed by FMI (BEAM model)



Estimated temporal profile of pleasure boat activities at the Baltic Sea based on AIS-data. X-axis: hour of year, y-axis: relative activity weighting (fraction of total)

Leisure boat fuel consumption in kg/grid cell/year (Johansson, 2016)

Pleasure boat emissions compared against STEAM vessels (commercial shipping)



Field measurement campaign

The 67’ research-equipped Challenge yacht (S/Y Hrimfare) was used.

Sample measurements were done in the water column and in air along shipping lanes and along transects crossing three shipping lanes.

Measurements

- Oceanographic measurements

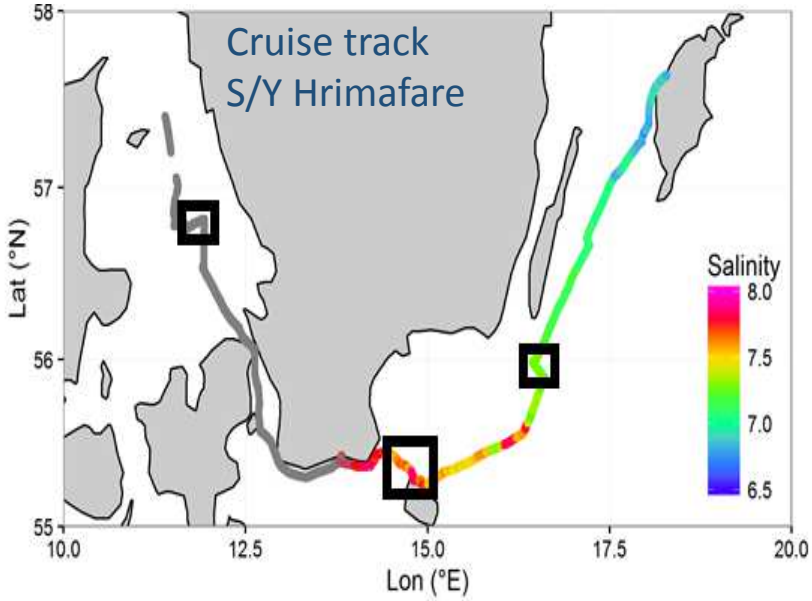
  For example: salinity, temperature, pH, alkalinity

- Air pollutants

  For example: CO_2, SO_2, NOx, Particulate matter

- Water pollutants

  For example: nutrients, metals, nano- and micro-particles



Scenario development

Scenario years: 2030 / 2040

Business as usual scenario:

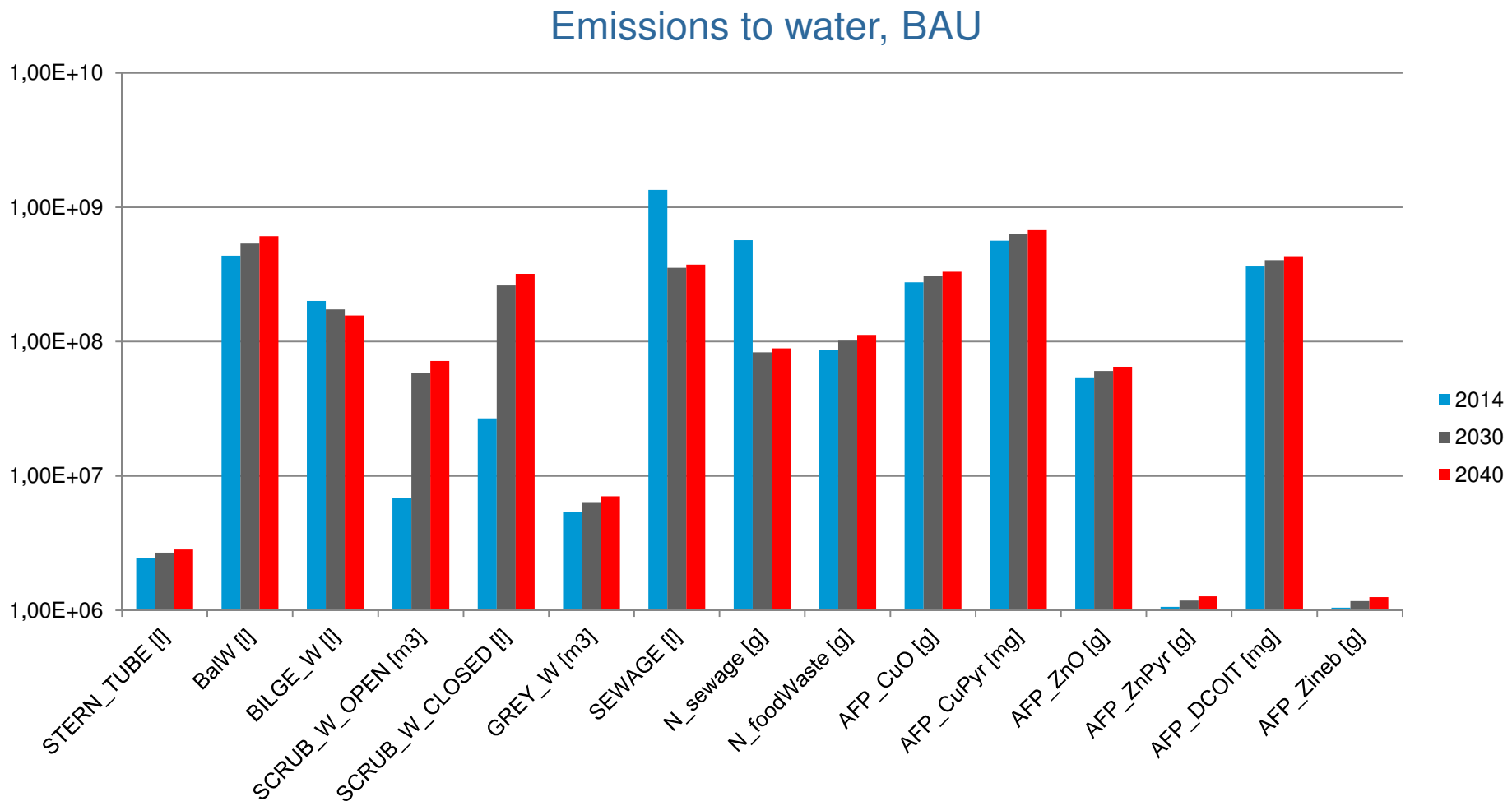
Table 1: Included potential regulations in BAU

Topic	Included in BAU	Technologies	Comment
SOx emissions	SECA limit (0.1%) from 2015, global limit (0.5 %) from 2020	Assumed 10 % of ships are using LNG in 2040, use of scrubbers for all ship types in 2030 is 15 % and in 2040 20 % (based on fuel heat content), equally divided open and closed scrubbers*	The change of the global limit have no direct impact on BAU but may influence technology choices
NOx emissions	Tier III from 2021 for new ships	For Tier III basically use of selective catalytical reduction (SCR), exhaust gas recirculation (EGR) or LNG fuel	
Emission of greenhouse gases	The decided EEDI limits plus further actions	Described as EEDI and further technical improvements and more efficient operation	
Use of LNG	LNG 10 % of ships in 2040*	Dual fuel mainly	
Sewage water	Regulation for passenges ships (cruise ships and RoPax)	For passenger ships: 50 % of ships deliver to ports, 50 % have treatment plants which are 80 % effective	
Hull paint	Following current trends		

Source: Fridell et al, 2016

Note: *Based on SHEBA elicitiation exercise with experts

Emissions from shipping in the Baltic Sea calculated for the Business-As-Usual scenario

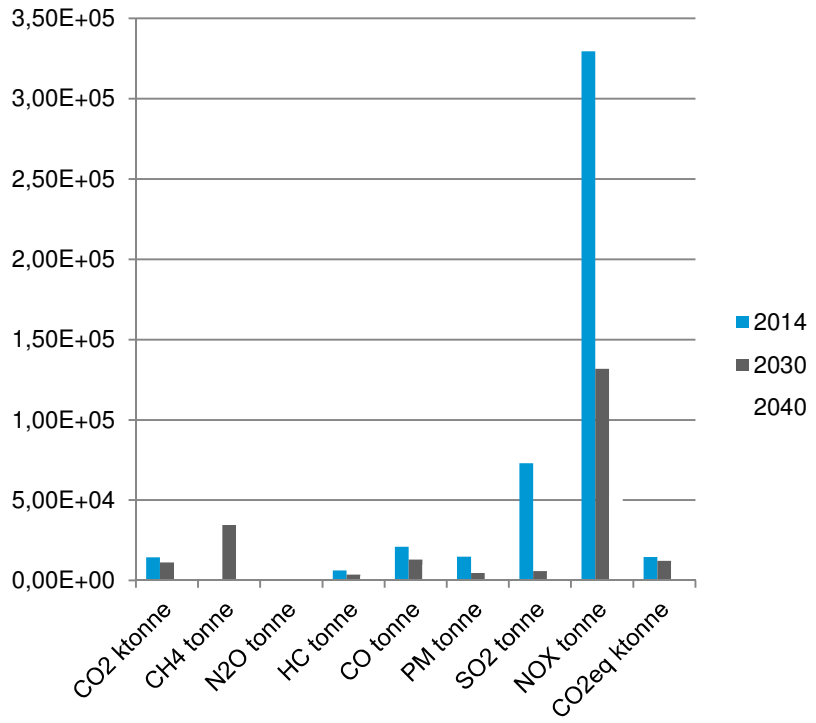


Scenario development

Scenario years: 2030 / 2040

Alternative scenarios:

- NoNECA scenario – introduction of NECA (Nitrogen oxides Emission Control Areas) in the Baltic Sea and North sea does not take place
- No emissions to water scenario
  - Toxic paint is assumed not to be used for ships that spend most of their time in the Baltic Sea
  - The scrubbers used are supposed to be only of the closed type
  - The emissions of greywater, sewage and food waste is zero
  - Stern tube oil is assumed to be zero for all new ships from 2020
- LNG scenario – On average, 26.5% of all ships are LNG-fueled by 2040 (different assumptions for 13 vessel categories, from BONUS SHEBA expert elicitation)
- Slow Steaming scenario - The average cruising speed reduced with 10% in 2030 and 2040 compared with the 2014



Emissions to air in LNG scenario

Air Pollution – regional scale

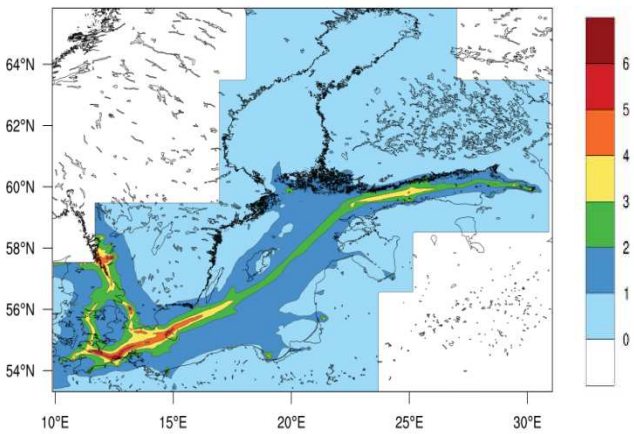
Year 2012:

- Ensemble of 3 models: CMAQ (HZG), SILAM (FMI), EMEP (MetNo, ENVISUM)
- Contribution of shipping to concentration of air pollutants and deposition of eutrophying and acidifying species
- Calculation of exposure, health impacts and associated costs with the TSAP methodology for the Baltic Sea region
- Calculation of exceedances of critical loads for eutrophication and acidification for land ecosystems

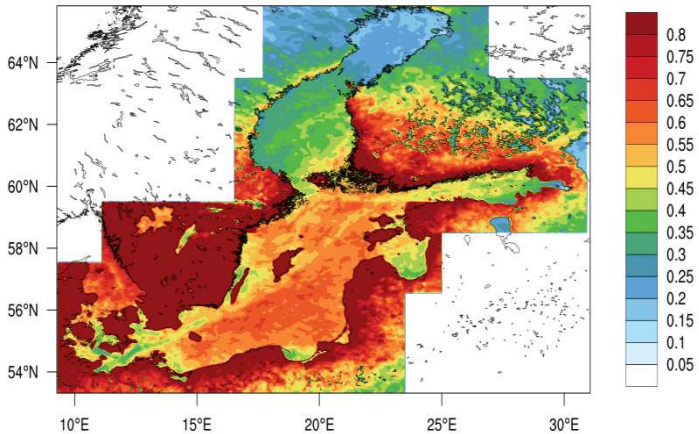
Year 2040:

- Scenarios BAU and NoNECA, CMAQ model
- Contribution of shipping to concentration of air pollutants and deposition of eutrophying and acidifying species

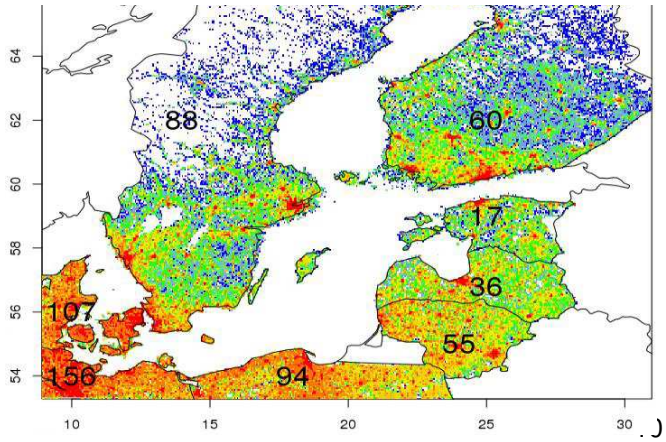
Contribution of shipping to NO2 concentrations 2012 ppb



Accumulated deposition of N from shipping in 2012 kgN/ha



Respiratory hospital admitions due to PM from shipping 2012, cases

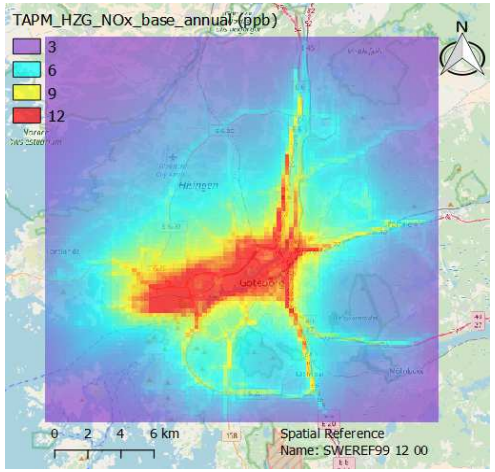


Air Pollution – city scale

Gothenburg – TAPM model
Rostock – CityChem model
Gdynia-Gdansk-Sopot – CityChem model
Riga – CityChem model

- High contributions of shipping to the air pollution close to the harbour areas (up tp 30%)
- Gothenburg study: Contribution of the regional shipping ise as high as the contribution of shipping in and around the harbour for particulate matter and c.a. 30% of the local shipping contribution for NOx

a)



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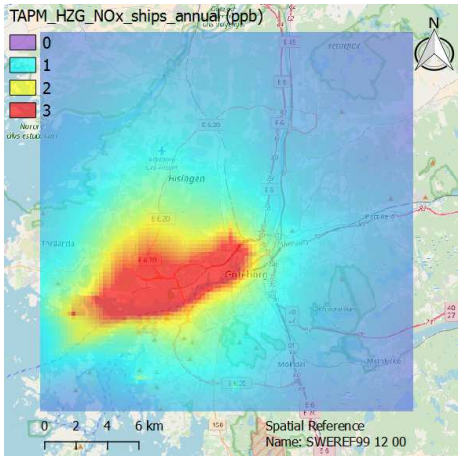

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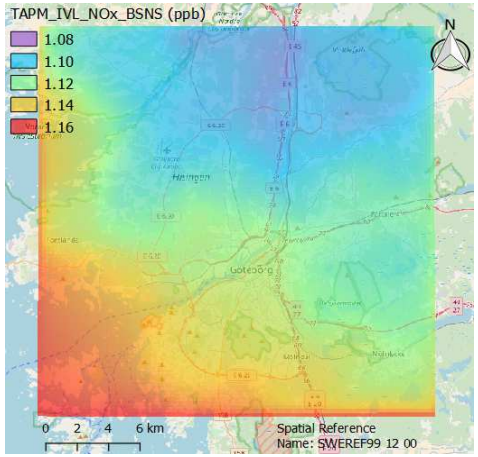

Concentrations of NOx in Gothenburg (a) and contributions to NOx concentrations from local shipping (b) and from regional shipping outside the Gothenburg coast (c)

Shipping emissions to water in BONUS SHEBA

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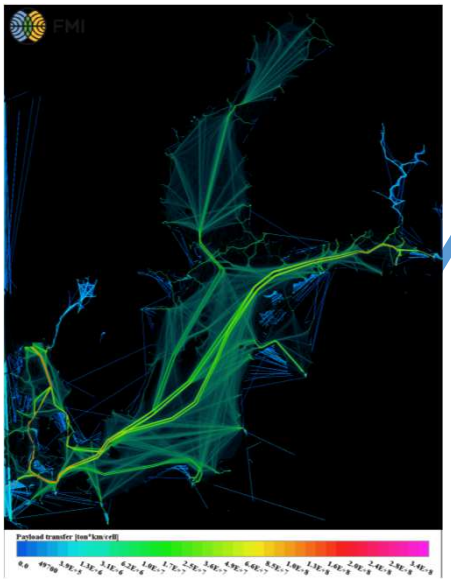
Ship types

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

Activity (AIS) data



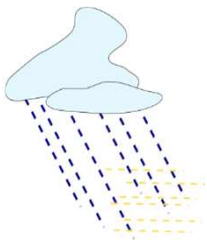
Year 2012

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

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Shipping emissions to water in BONUS SHEBA

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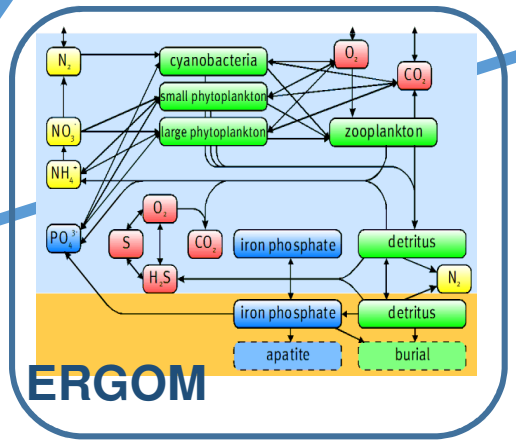
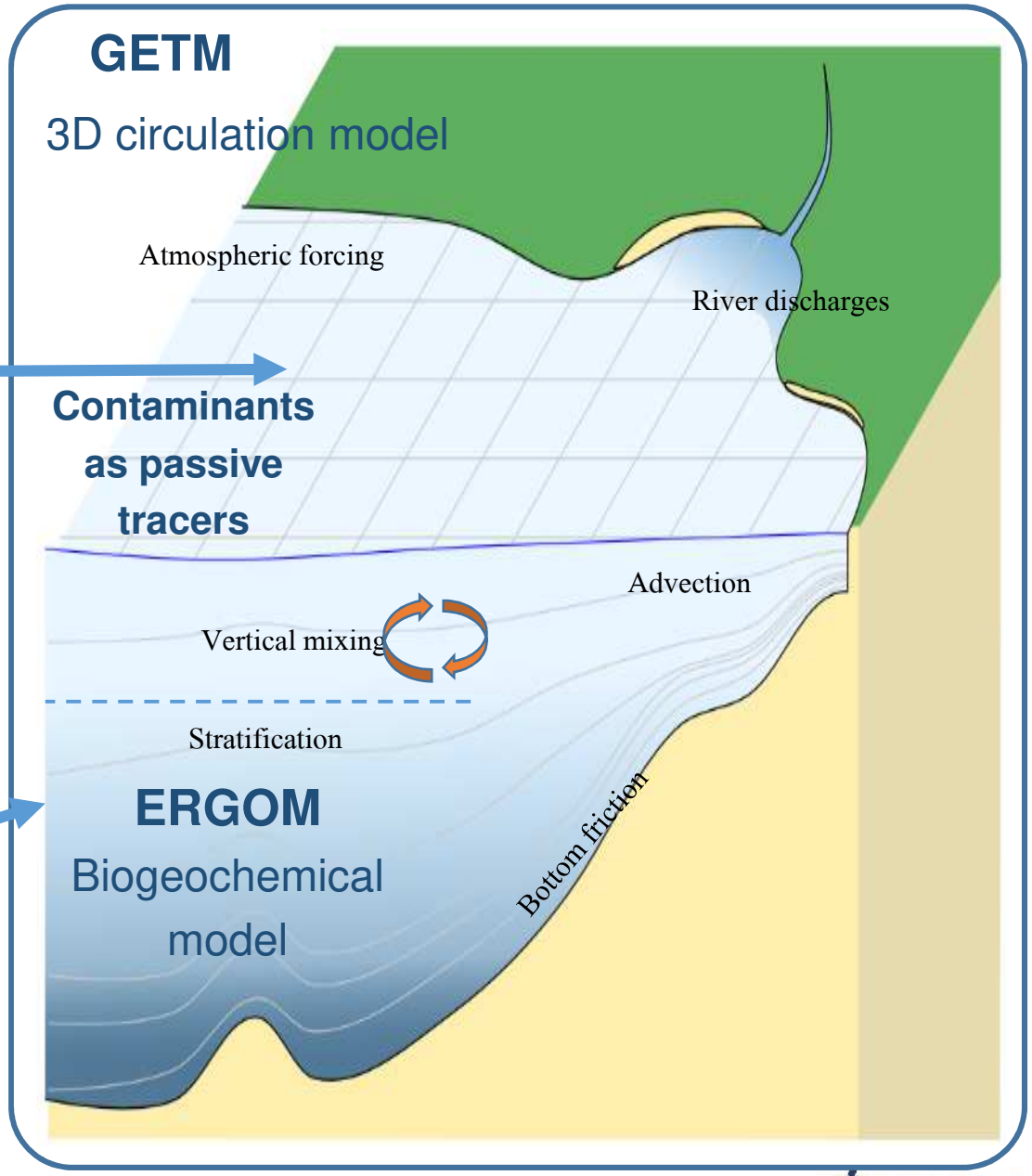
Contaminant concentrations in discharges

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

Amounts of contaminants
Copper
Zinc
Pyrene
Naphthalene
DBCM





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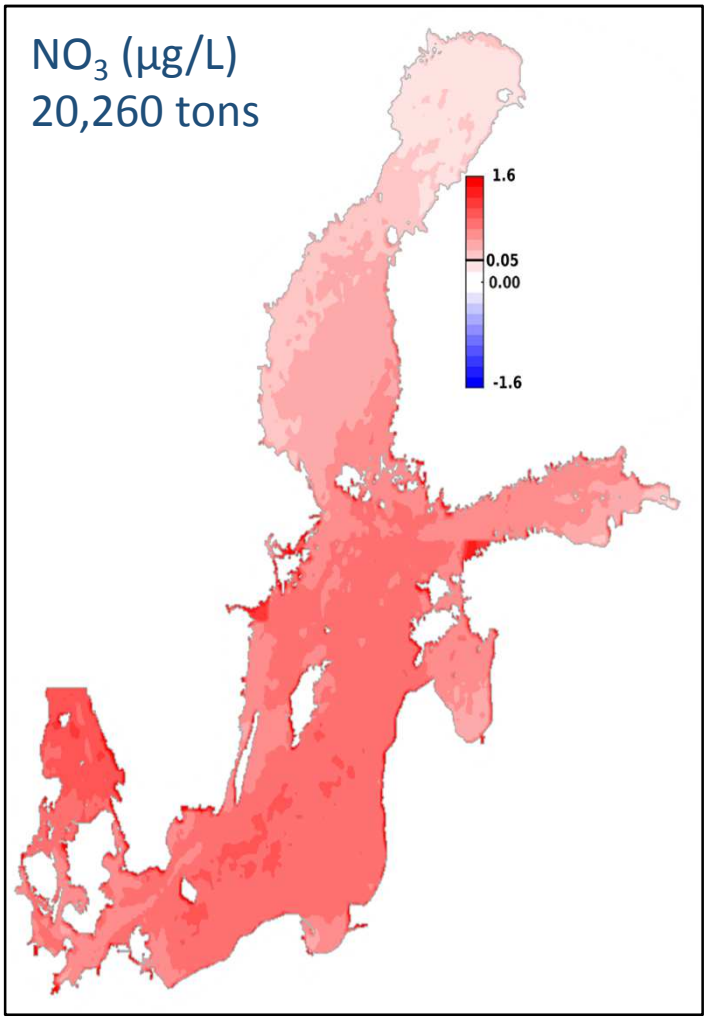
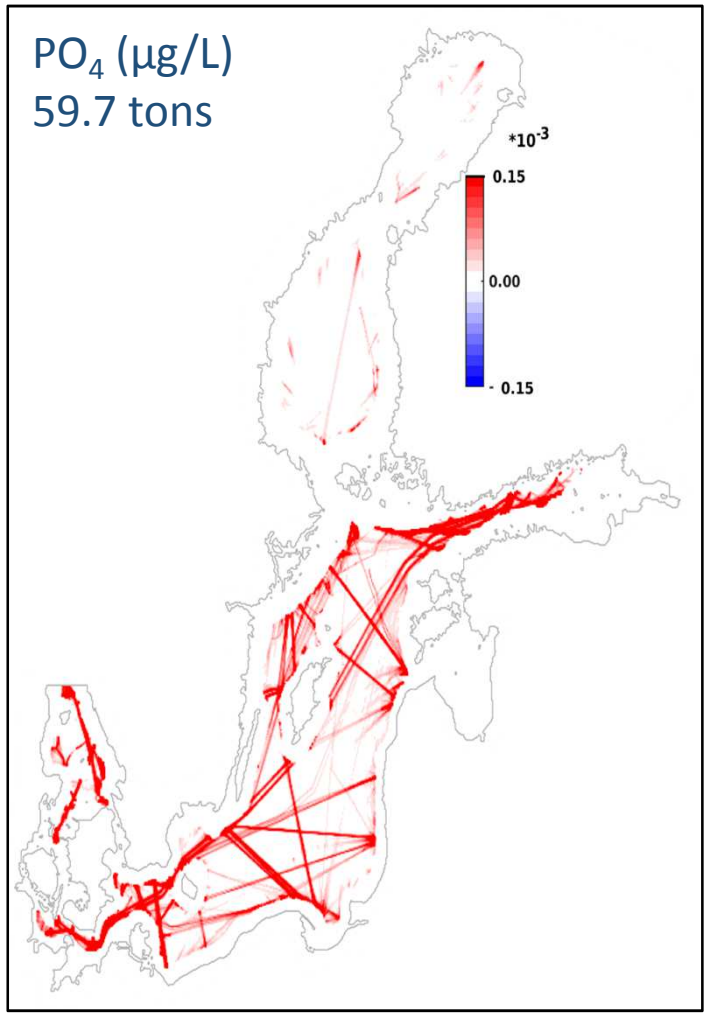
Example Nutrient emissions

Total loads of NO_3 and PO_4 from shipping

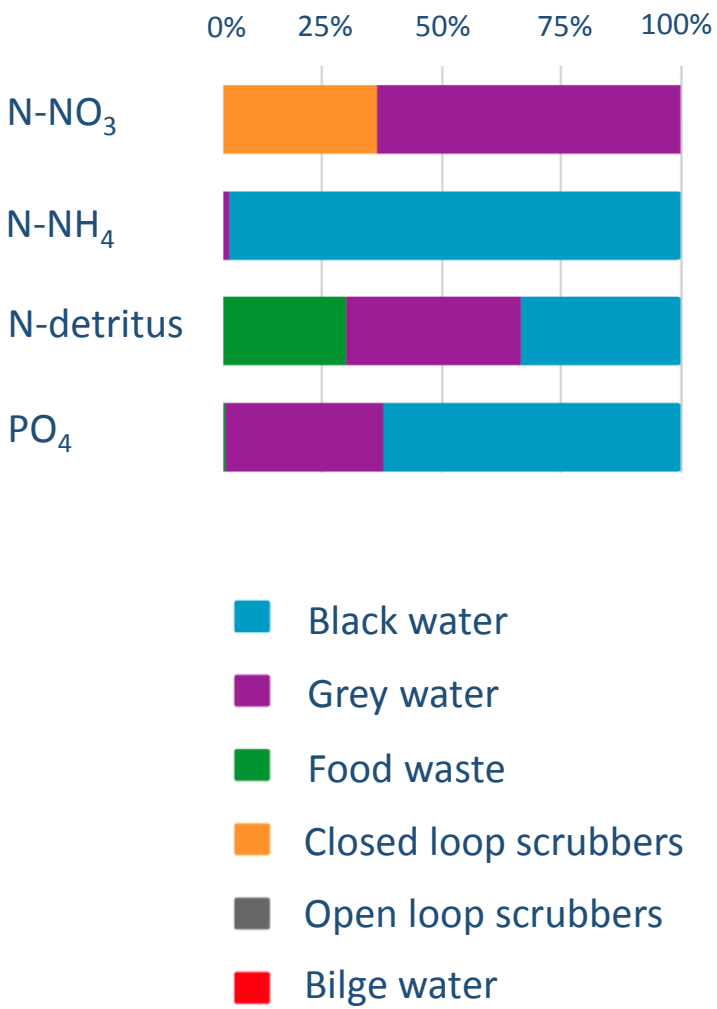


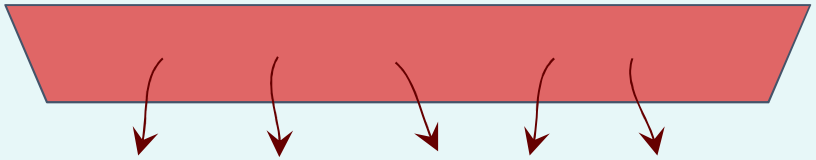
99.97% of NO_3 is emitted to air from exhausts.



99.07% of PO_4 is emitted directly to water.

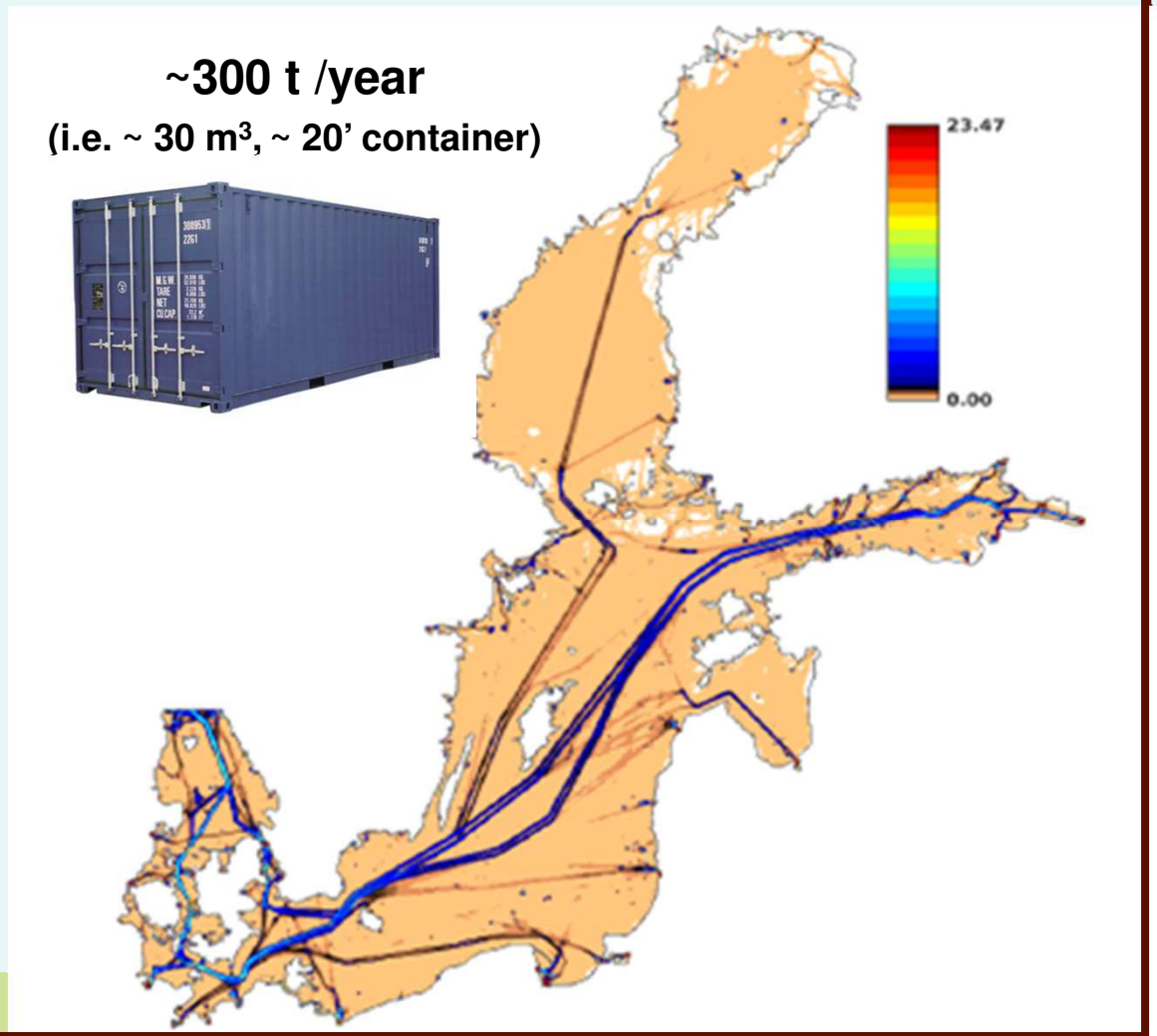
Nutrients emitted directly to water





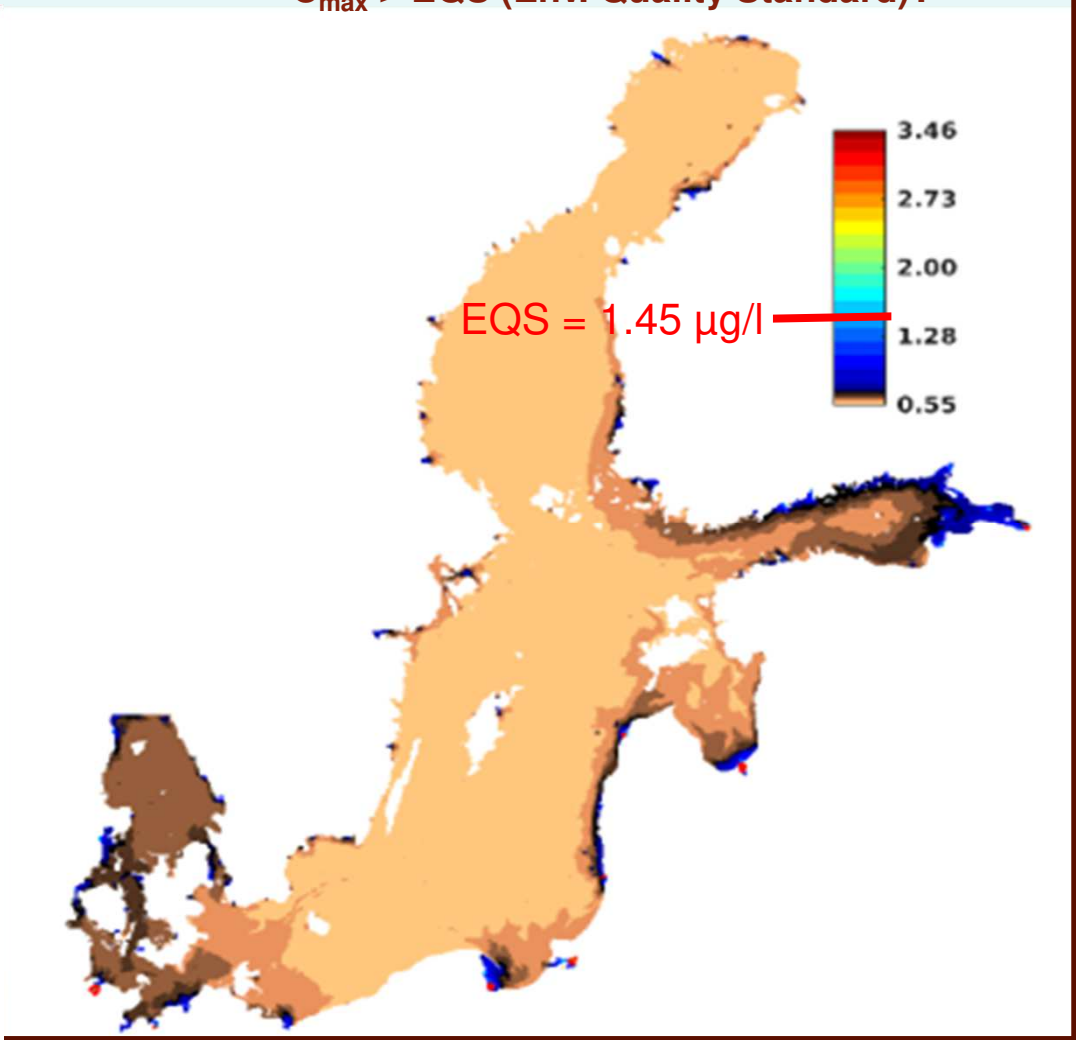
Cu source: > 99% Antifouling paint

Cu emission from ships



Maximum water Cu concentrations

C_{max} > EQS (Env. Quality Standard)?



WP 4 Underwater Noise

1. Description of shipping **noise sources**
2. **Sound propagation** under water
3. **Impacts** to marine life

WPWork done:
The methodology for description of shipping induced noise parameters implemented into the STEAM model, emission inventory calculated

A noise fingerprint library (database)

Noise propagation modelling performed for 2 areas

The fish noise-exposure experiment at the Tvärminne zoological station (59.845572N, 23.248574E), Hanko, Finland in May-Aug 2016
(herring, perch, roach, pike perch)

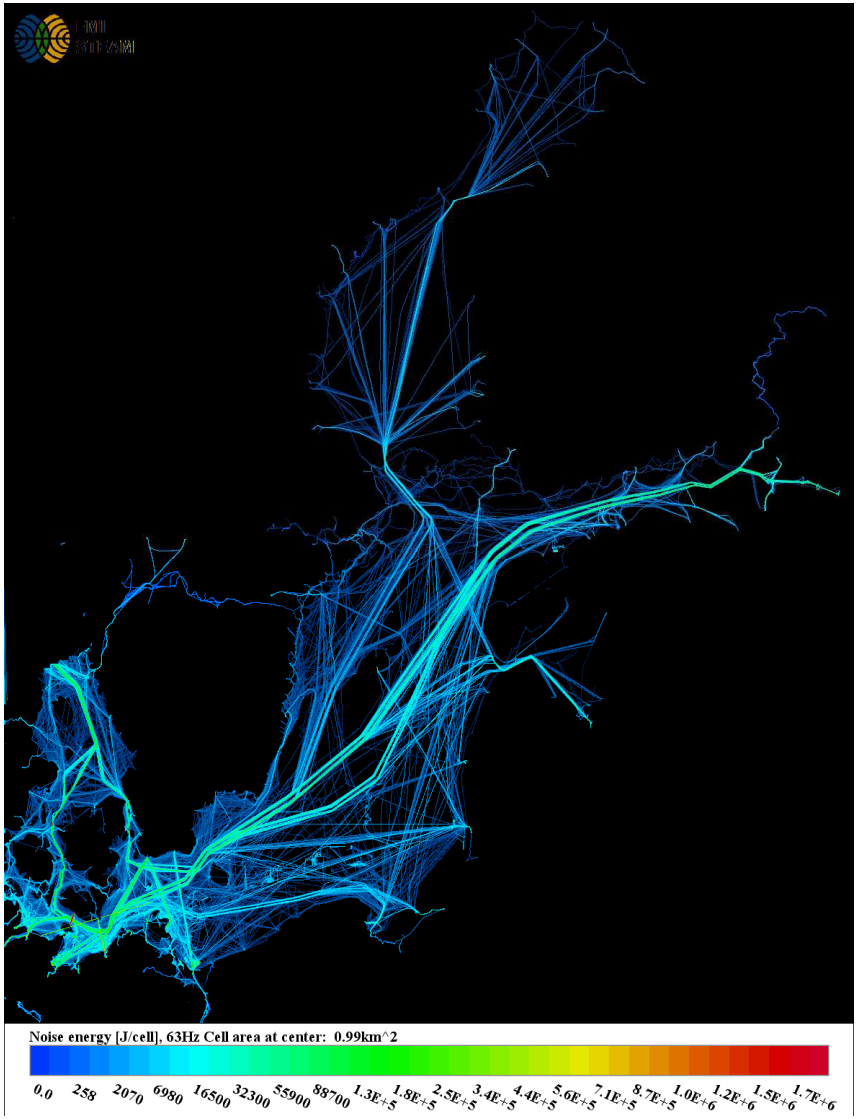


Figure 3. Shipping sound energy (63 Hz) in the Baltic Sea region. The unit is joules per square kilometre.

WP 4 Underwater Noise

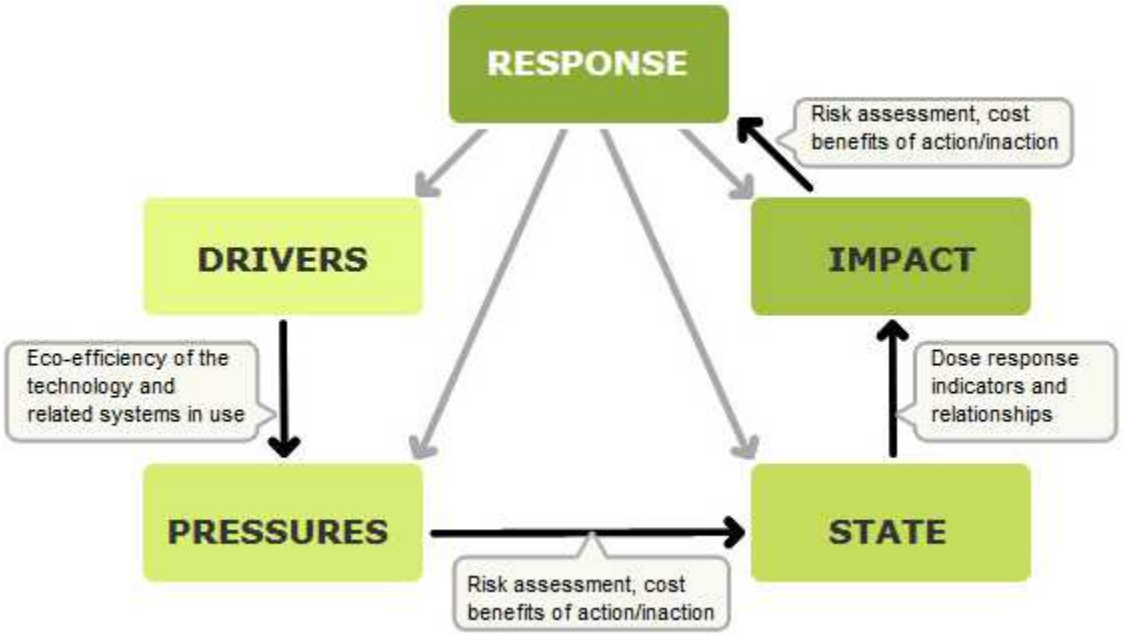
Fish experiment at Tvärminne zoological station June-July 2016

WP5 - assessments

Analytical framework for the integrated assessment of shipping in the Baltic Sea

Assessment of changes to ecosystem services compared to Business As Usual

Integrated assessment and policy analysis to reduce pressures from shipping in the Baltic Sea



SHIPPING AND THE ENVIRONMENT - From Regional to Global Perspectives

2nd BONUS Symposium

24-25 October 2017

Gothenburg, Wallenberg Conference Centre

International conference on the environmental impact of shipping and its importance within policy, marine spatial planning and the maritime transport sectors. The conference was jointly organised by the BONUS SHEBA project and by the International Surface Ocean - Lower Atmosphere Study (SOLAS) and is a part of BONUS Symposia series.

115 participants from 16 countries participated at the conference, 60 oral and poster presentations

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