Are we going to achieve sustainable shipping in the Baltic Sea?
Intro

• Shipping plays an important role in transport in the Baltic Region.
• It is subject to influences of political, technical or societal driving forces stimulating/encouraging its development.
• How the future of shipping might look like?
• How will the future shipping impact the environment?
• Scenarios created on trend/experience-related assumptions demonstrate possible outcomes.
• An analytical framework for the integrated assessment of shipping in the Baltic Sea was developed.

Source: Photo by Holger Link on Unsplash
Jana Moldanová: Sustainable Shipping

Erosion/resuspension

Invasive species  Contaminants  Nutrients  Acidification

Antifouling substances  Ballast water  Black water  Grey water  Tank cleaning  Cooling water  Scrubber water  Bilge water

Solid waste

Exhaust

CO₂ PM SOₓ NOₓ

Noise

Propeller shaft lubricants

Sketch by Ida-Maja Hassellöv 2018
DPSIR framework for assessment of operational shipping

Drivers
Ship traffic

Pressures
Ship emissions air
Ship emissions to water

Atmospheric chemistry models
Coupled ocean dynamics-biogeochemistry model
Underwater noise propagation model

State
Pollutant conc. in air and water, conc. of GHG, underwater noise levels, biodiversity

Impact
Ecosystem services including human health
Assessments of policy options

Response
Regulations
Policy measures
Scenario development

Ship activity data, emission factors, emission model
Assessment of health effects
Assessment of critical loads
Assessment of PEC/PNEC ratios

Jana Moldanová: Sustainable Shipping
What will the future look like?

Shipping in the Baltic is expected to keep on increasing in the future. At the same time the ships will likely become more fuel efficient and a number of regulations on emissions to air and water will be enforced. A number of factors will influence the environmental performance.

Probable developments:
- Change in traffic
- Larger ships
- New fuels
- Abatement equipment
- New legislation

Influences on:
- Air pollutants
- Water Pollution
- Greenhouse gases
- Noise

There is a need for...

Scenarios:
- Business as usual
- Scenarios in 3 SCCP’s
- No-regulation scenario
Drivers, scenario building

Ship types

Activity data (AIS)

Scenarios

Assumptions in trends in activity data

Assumptions in trends in emission factors

STEAM model

Drivers, scenario building

Assumptions in trends in activity data

Assumptions in trends in emission factors

STEAM model

Drivers, scenario building

Assumptions in trends in activity data

Assumptions in trends in emission factors

STEAM model
**BAU scenario**

<table>
<thead>
<tr>
<th>BAU scenario</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trends in traffic</strong></td>
<td>The number of ships will increase between 0 and 1.2 % annually, depending on segment.</td>
</tr>
</tbody>
</table>
| **Ships** | The size of ships increases 1.0% - 2.1 % annually, depending on segment.  
The fuel efficiency increases 1.3% - 2.25% annually.  
Scrubbers are assumed to be used for larger ships. |
| **Policy measures** | The Baltic and North Seas NO\textsubscript{X} emission control areas (Tier III demand for new engines from 2021).  
The energy efficiency design index (EEDI) regulations will drive the fuel efficiency increase.  
The EU fuel directive will drive an increase in the use of LNG.  
The Ballast water convention will be in place.  
A ban on waste and sewage disposal from passenger ships in the Baltic Sea will be in place. |

![Graph showing CO2, NOX, and Sewage emissions for years 2014, 2030, and 2040.](image-url)
From Drivers to Pressures – developments of STEAM model

Air pollution

STEAM model

Emission factors air pollutants

Air emissions
Impact is of the Tier III regulations for NO$_X$

**NO$_X$ emissions in tonne**

- **2014**: NECA (3.0E+05), noNECA (3.0E+05)
- **2030**: NECA (2.0E+05), noNECA (1.0E+05)
- **2040**: NECA (1.0E+05), noNECA (0.0E+00)
From Drivers to Pressures – water pollution

STEAM model

Shipe type specific discharge volumes or amounts: Bilge, ballast water, scrubber wash water, antifouling, etc.

Contaminant concentrations in discharges

Emissions to water

Sewage water release during year 2017 from Baltic Sea shipping

Cu(I)/O from anti-fouling paints
### Cumulative scenarios

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business as usual (SSP2)</td>
<td>Includes current trends in the development of shipping and already decided regulations</td>
</tr>
<tr>
<td>SSP1 - Sustainability</td>
<td>A development with high concern for the environment and good technology development</td>
</tr>
<tr>
<td>SSP3 - Fragmentation</td>
<td>Development in some regions and poverty in others. Continued fossil fuel dependency and failure to meet environmental goals.</td>
</tr>
</tbody>
</table>

![Bar chart showing cumulative scenarios](chart.png)

- **SSP1 2040**: Green bars
- **SSP2 2040**: Orange bars
- **SSP3 2040**: Pink bars

**Legend**:
- SSP1: 2040
- SSP2: 2040
- SSP3: 2040
Different types of emission/discharge patterns in the Baltic Sea (BAU)
From Drivers to Pressures – Underwater noise

STEAM model

Shipping induced underwater noise parameters (engine propeller, hull, speed)

Emissions of underwater noise
Shipping noise in the Baltic Sea area


Underwater noise emissions from Baltic Sea shipping. Noise energy in Joules/year is described in 63, 125 and 2000 Hz bands (1/3 octave bands). Two lowest bands are indicated by orange and blue bars and left axis, whereas the 2000 Hz band is plotted in grey and right axis.
From drivers to pressure – water pollution

Emissions to water
- Contaminants as passive tracers
- Nutrients

GETM 3D circulation model
- Atmospheric forcing
- Vertical mixing
- Advection

ERGOM Biogeo-chemical model
- Nutrients

Chemistry transport models: CMAQ, EMEP, SILAM model
- Atmospheric deposition

Water Cu concentrations

Emissions to water
- Sewage water release during year 2017 from Baltic Sea shipping
- Cu(I)/Cu from anti-fouling paints

Meteorology

Chemistry transport models: CMAQ, EMEP, SILAM model
- Atmospheric deposition

Water Cu concentrations

Meteorology
Contaminant concentrations in the water
Shipping pollution in relation to EU environmental directives

Copper concentrations exceeding EQS
From pressures to state – air pollution

Chemistry transport models:
Regional & urban scale

Atmospheric concentrations & depositions

Air emissions

Meteorology

Emissions
NO$_2$ concentration

**PRESENT**

**NoNECA (2040)**

**BAU (2040)**

- Total NO\textsubscript{x} emissions
- NO\textsubscript{x}-emissions from shipping
Effects of air pollution on health

From shipping: NO₂, PM₂.₅, Ozone
### Evaluation of effects on human health – efficiency of policy measures

<table>
<thead>
<tr>
<th>Policy options</th>
<th>Damage valuation, mid VOLY (M€/year)</th>
<th>Damage valuation, mid VSL (M€/year)</th>
<th>Valuation of lost working days (M€/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow steaming (SlSt-BAU)</td>
<td>-53</td>
<td>-211</td>
<td>-3</td>
</tr>
<tr>
<td>Stricter EEDI (BAU-EEDI)</td>
<td>-136</td>
<td>-527</td>
<td>-6</td>
</tr>
<tr>
<td>LNG (LNG-BAU)</td>
<td>-89</td>
<td>-356</td>
<td>-4</td>
</tr>
</tbody>
</table>

Evaluation of effects on human health (year 2040, compared to BAU)