QUIET AND GREEN: EXPLORING OPPORTUNITIES TO ENHANCE ENERGY EFFICIENCY WHILE SIMULTANEOUSLY ADDRESSING UNDERWATER NOISE IN COMMERCIAL SHIPPING

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Agenda

- Sustainable shipping
- Air emission
- URN & commercial vessels
- Synergy between improvement of energy efficiency and reduction of URN from commercial vessel
- Discussion & Conclusions

Sustainable shipping

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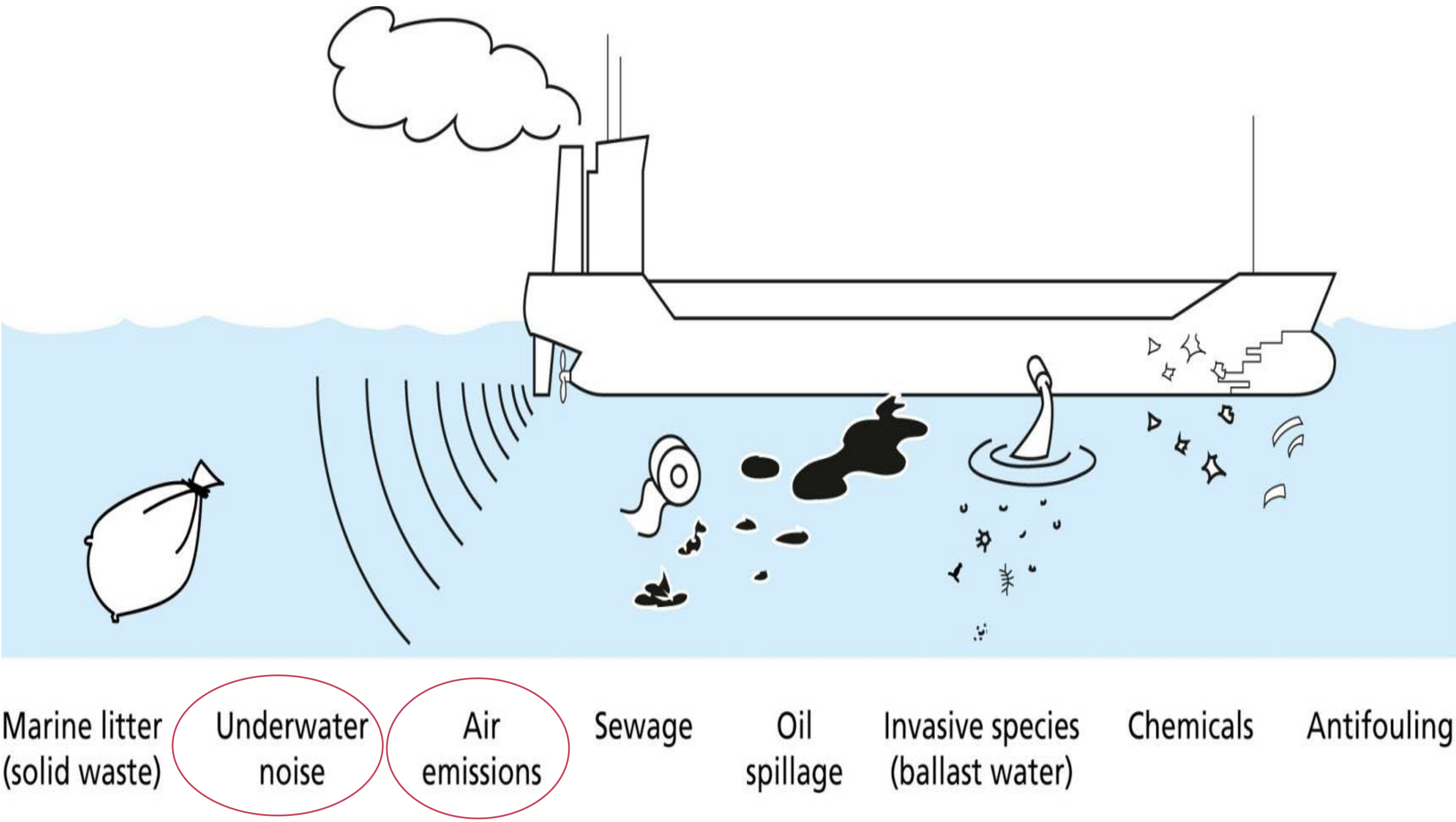
Sustainable Shipping



Source: Adopted from (MEM, 2018)

Air Emission

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Air Emission

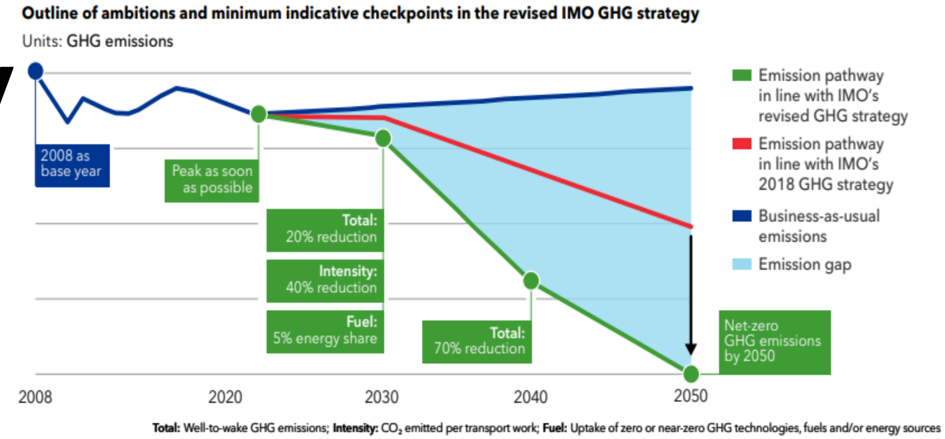
- Shipping contributes **2.89% of global Greenhouse Gas** emissions annually and **5%-10% of sulphur oxides** and **17%-31% of nitrogen oxides**.

- More than **50% of air emissions** from shipping occur in coastal areas and about **400 km from ports** (López-Aparicio et al., 2017);

- More than **12% of health impacts** in Europe are due to **air pollution** associated with ship traffic and the issue contributes to **60 000 deaths annually globally**, **3 700 premature deaths** in California;

- Imposes annual external costs of **€12 billion** on the 50 largest ports in the organisation for Economic Co-operation and Development (OECD) (Merk, 2014).

IMO 2023 GHG Strategy

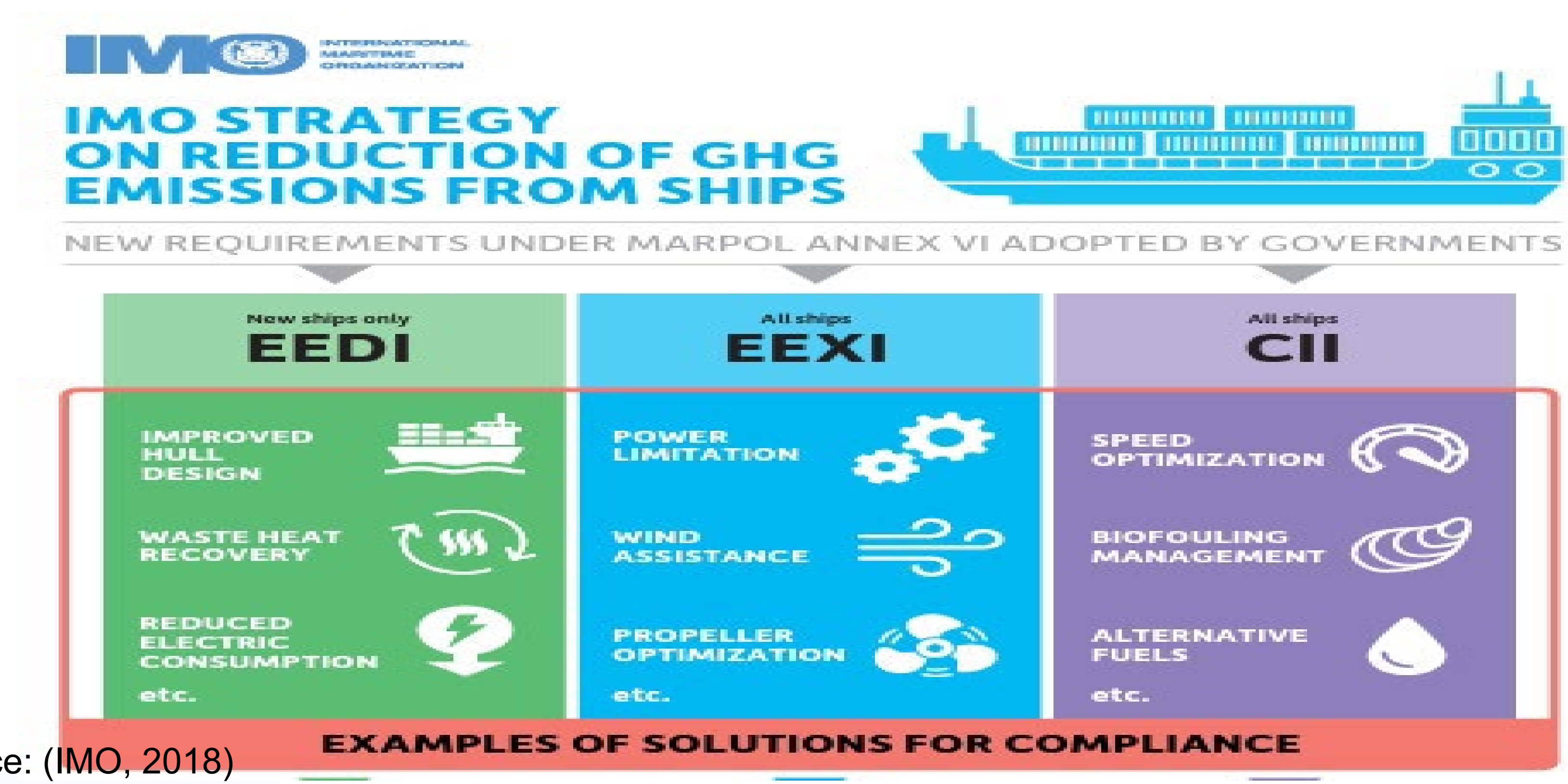


- IMO revised GHG strategy;
  - **Net Zero** GHG emissions by or around **2050.**
  - Reducing total annual emissions by at least **20%, striving for 30%**, by **2030** and by at least **70%, striving for 80%, by 2040** compared to 2008.
  - Availability of zero or near-zero emissions technologies, fuels, and energy sources for the shipping industry to represent a minimum of **5% and striving for 10% of the energy** used by international shipping by **2030.**

Energy Efficiency Requirements & Implications

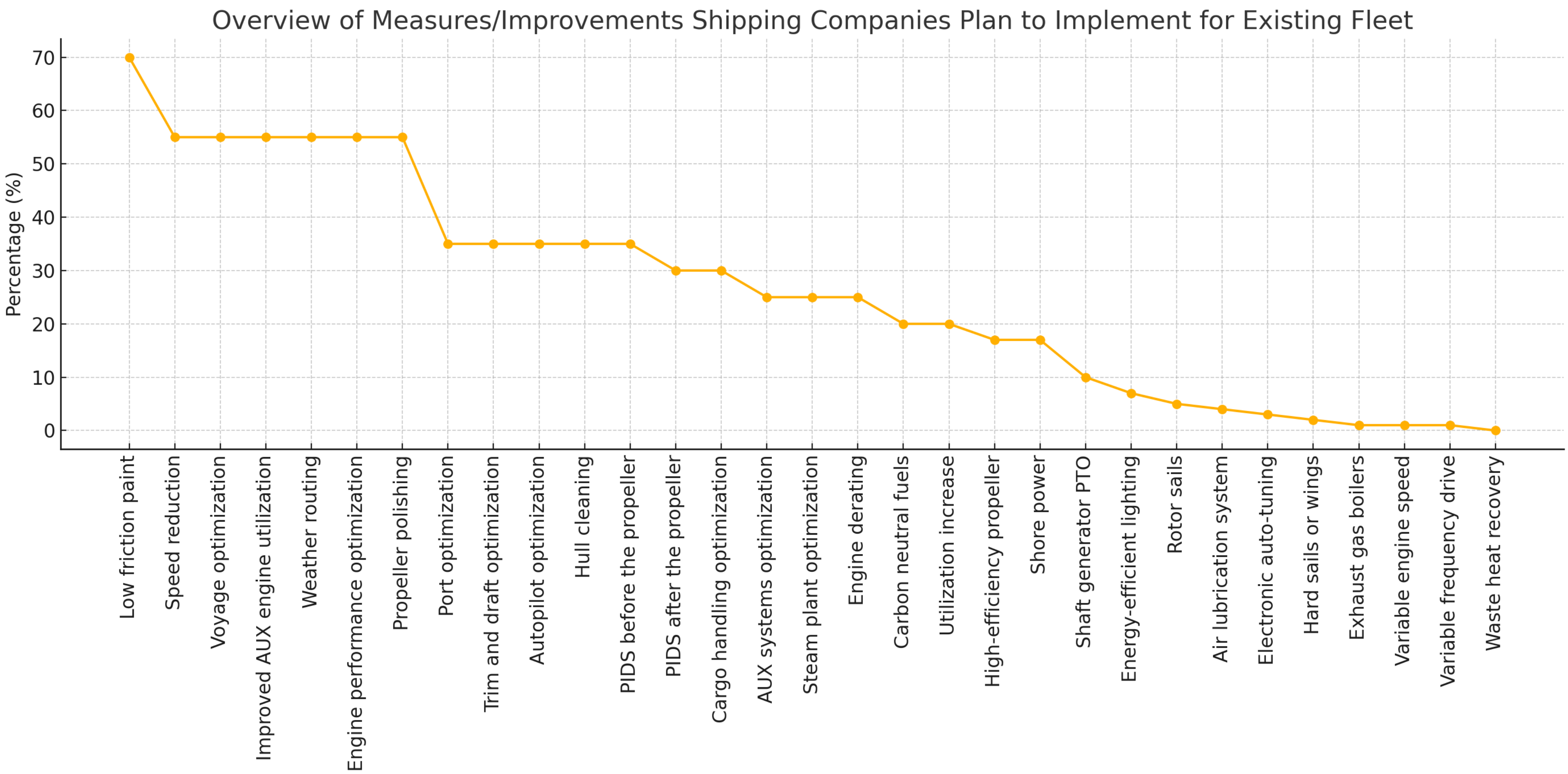
$$\frac{\left(\prod_{j=1}^{n} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)}\right) + \left(P_{AE}\cdot C_{FAE}\cdot SFC_{AE}*\right) + \left(\left(\prod_{j=1}^{n} f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)}\cdot P_{AEeff(i)}\right) C_{FAE}\cdot SFC_{AE}\right) - \left(\sum_{i=1}^{neff} f_{eff(i)}\cdot P_{eff(i)}\cdot C_{FME}\cdot SFC_{ME}**\right)}{f_i\cdot f_c\cdot f_l\cdot Capacity\cdot f_w\cdot V_{ref}\cdot f_m}$$

$$\text{Attained CII} = \frac{CO_2\ \text{emissions}}{(\text{Deadweight or Gross tonnage}) \times \text{Distance sailed}}$$



Source: (IMO, 2018)

Trends in Implementation of Energy Efficiency Measures



Source: Adopted from (Klima- og miljødepartementet, 2023)

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Shipping Decarbonisation Technologies' GHG Emissions Reduction Potential.

3-20%
Machinery
Machinery efficiency improvements
Waste heat recovery
Engine de rating
Battery hybridisation
Engine Vs Fuel cell
Enhance fuel injection system

5-15%
Vessel design and hydrodynamic
Optimum ship size and dimension
Energy Saving Device
Air lubrication system
Hull form optimisation
Hull coating
Hull and propeller cleaning

0-100%
Energy
LNG, LPG
Hydrogen
Ammonia,
Methanol
Electrification
Renewable energy (Wind, Solar)
Biofuels

>20%
Voyage optimization
Speed reduction and Just In Time
Advance port logistic
Optimise vessel utilisation
Power demand optimisation
Weather routing

Source: (Vakili et al., 2024)

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Source: (Vakili et al., 2024)

Carbon neutral fuel
Energy efficiency
Logistic

0-100%
Energy
LNG, LPG
Hydrogen
Ammonia,
Methanol
Electrification
Renewable energy (Wind, Solar)
Biofuels

>20%
Voyage optimization
Speed reduction and Just In Time
Advance port logistic
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URN & Commercial Vessels

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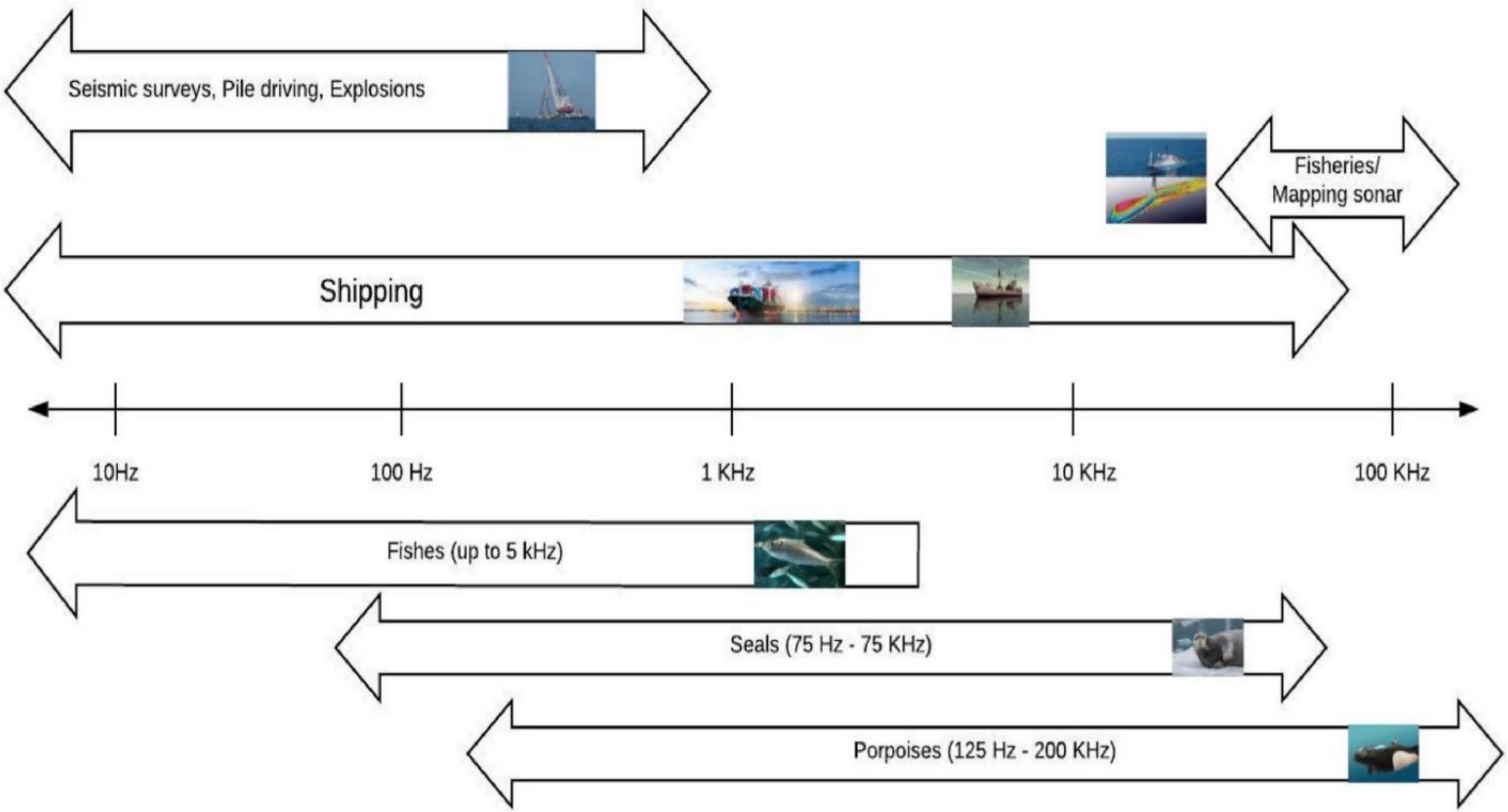
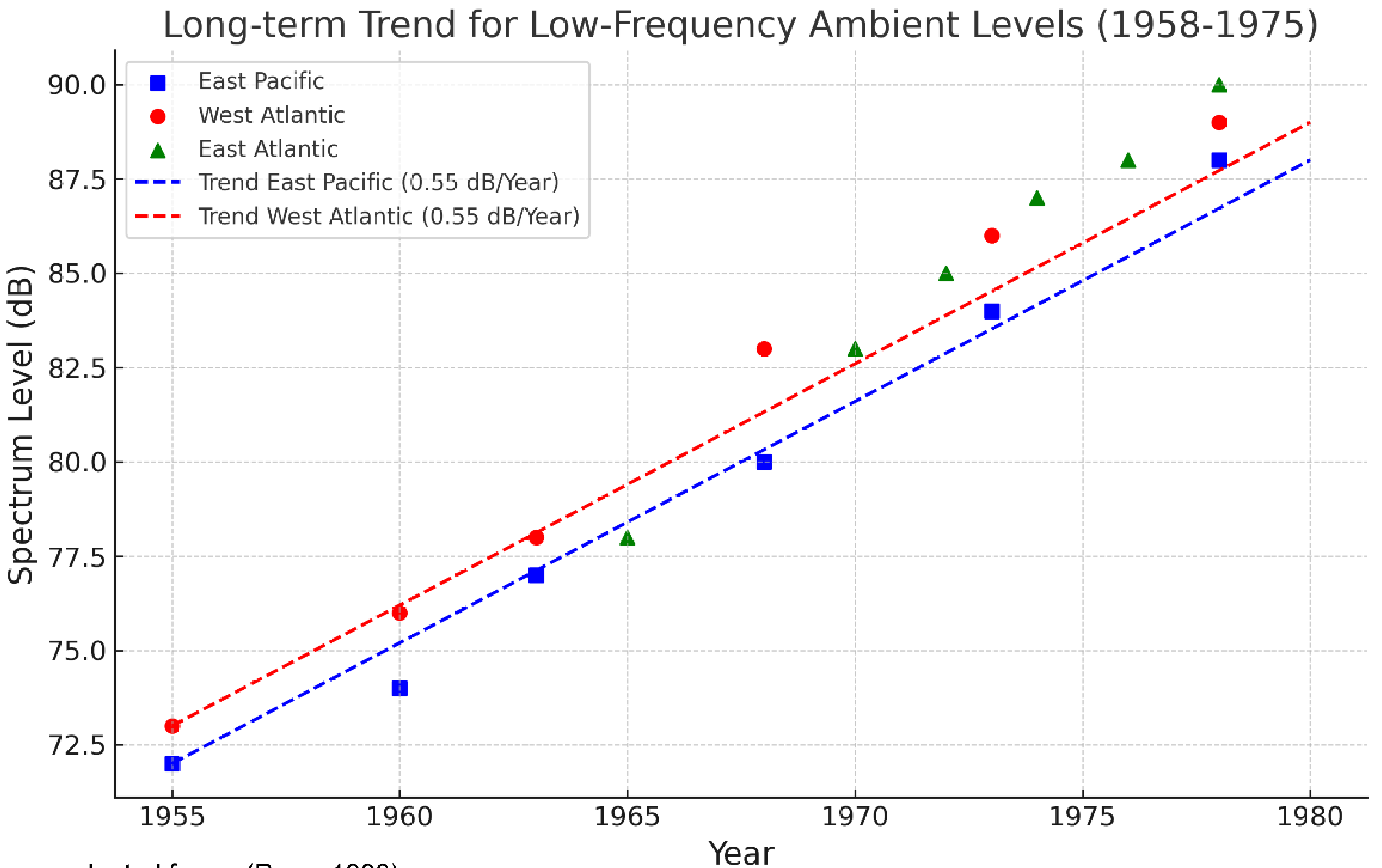
The URN



Source: adopted from : (Vakili et al., 2020)

Global Noise Level



Source: adopted from : (Ross ,1993)

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The Ambient Noise Level in dB

$$Ln = Ls - 95 + 10\log\delta + 10\log\frac{1}{\alpha H}$$

Ln: is the ambient noise,
Ls: is the average sound source level per ship,
δ: represents the density of ship traffic,
α: is the attenuation factor, and
H: denotes the water depth.

Source: (Ross, 1993)

Ambient Noise Level & Seaborne Trade Growth

- The transport work growth ranging from 40% to 100% from 2020 to 2050, translating to an average annual growth rate of approximately **1.21% to 2.33%.**
- Worst case scenario: **2.33%** the transport work growth:

2033: **26%** growth in transport work

- **1 dB** increase in ambient noise.
- **3 dB reduction by Okeanos target in every decade:**

  4 dB reduction in the source level per ship is required.

2050: **73.5%** growth in transport work

- Approximate **2.38** dB increase in ambient noise.
- **10 dB reduction by Okeanos target in 30 years:**

  11.38 dB reduction in the source level per ship is required.

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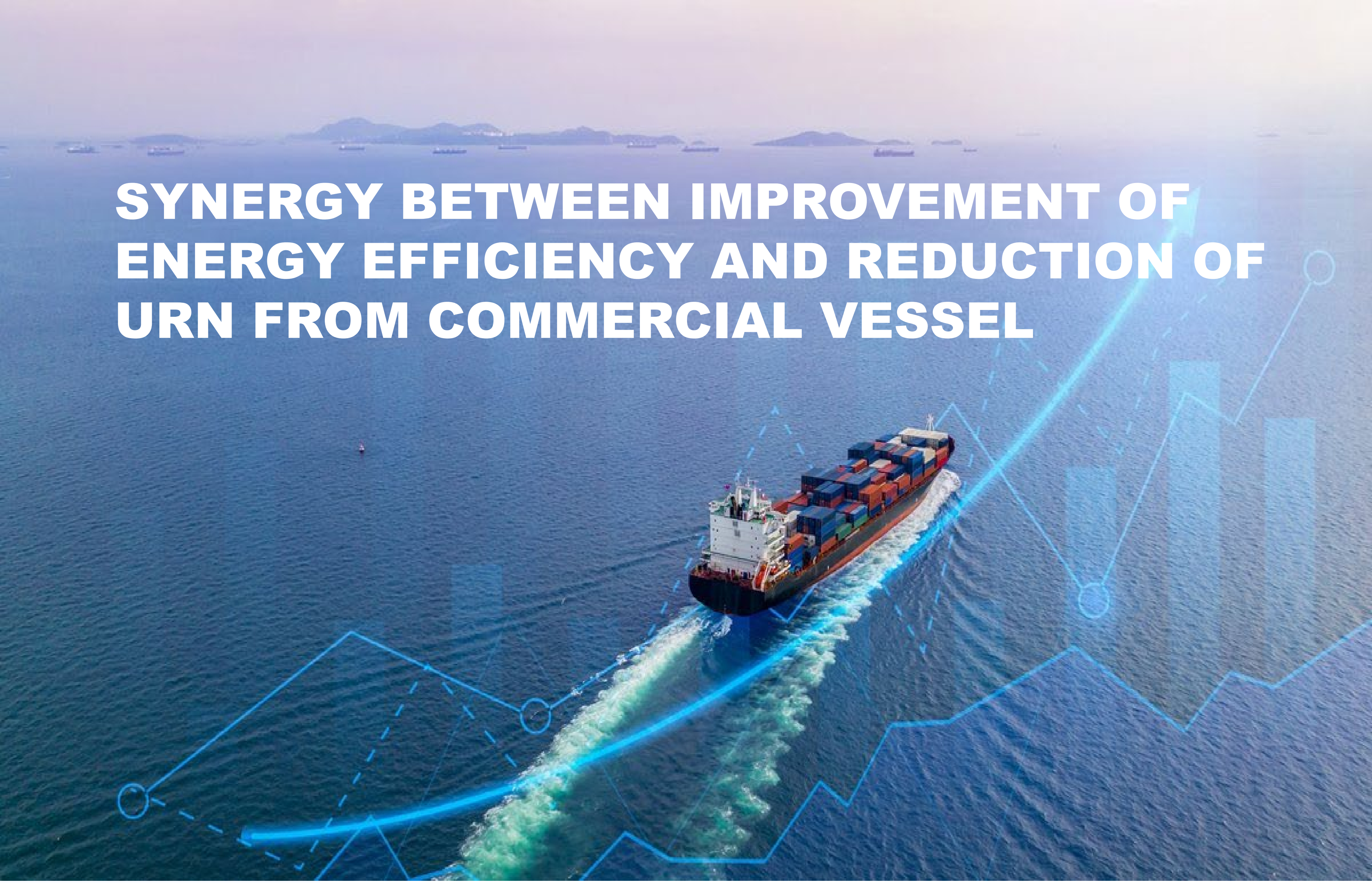
SYNERGY BETWEEN IMPROVEMENT OF ENERGY EFFICIENCY AND REDUCTION OF URN FROM COMMERCIAL VESSEL



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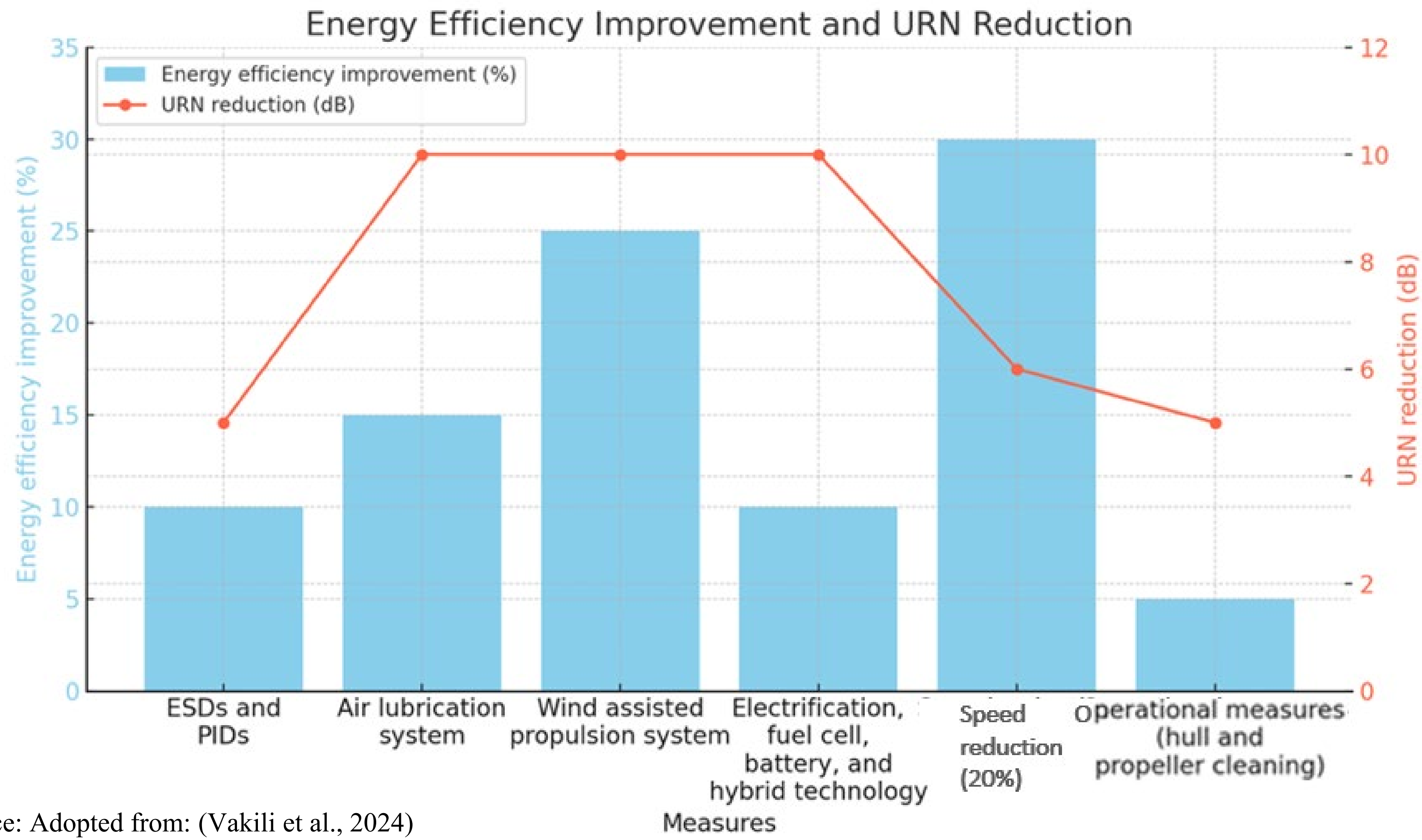
Synergy Between Improvement of Energy Efficiency & Reduction of URN from Commercial Vessels



Source: Adopted from: (Vakili et al., 2024)

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Synergy Between Improvement of Energy Efficiency & Reduction of URN from Commercial Vessels

	Impact on fuel consumption	Impact on URN
Hull cleaning	Up to 5%	Up to 5 dB
Flow straightening e.g. Swirl fins and propeller boss cap fins	Up to 10%	Up to 10 dB
Propeller cleaning	Up to 4%	Up to 5 dB
Contra rotating Propeller	Up to 5%	Up to 10 dB

Source: Adopted from: (Vakili et al., 2024)

Discussion & Conclusions

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Discussion & Conclusions

- There exists a **synergy between improving energy efficiency and reduction of URN** from commercial vessels (Vakili et al., 2023).

- It is predicted that **speed reduction, wind-assisted propulsion systems, ESDs, and air lubrication systems** will play crucial roles in realizing the IMO GHG reduction strategy (Vakili et al., 2023).

- The maritime sector transitions towards vessel **electrification**, the adoption of **fuel cells, batteries, or hybrid technologies**, especially in short sea shipping, holds significant promise for **improving energy efficiency** and accelerating progress in alignment with the IMO's GHG reduction strategy (Vakili and Ölçer, 2023).

Discussion & Conclusions

- Operational measures such as **vessel hull and propeller cleaning** and **maintenance, optimizing vessel handling, meticulous passage planning, and utilizing weather routing strategies**, provide opportunities to **improve energy efficiency and URN reduction** in commercial vessels (Vakili et al., 2021).

- The trend in increasing the ambient noise of **approximately 3 dB per decade is not consistent** across all areas, with some regions experiencing a **plateau** or **even a decrease** in noise levels. Furthermore, **discrepancies** in the forecasts of underwater noise levels in different regions necessitate **nonlinear models** that can accommodate **long-term cyclic dynamics** (Vakili et al., 2023).

- **By 2033**, to achieve the targeted 3 dB reduction proposed by Okeanos, an average reduction of **4 dB per ship** in source level would be necessary and this would be **11.38 dB** per ship in source level for **2050** (Vakili et al., 2024).
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Discussion & Conclusions

- Considering **32% contribution from energy efficiency** measures to decarbonisation of the shipping industry can be a **counteract the impact of seaborne trade growth**, effectively **mitigating ambient noise** even in challenging scenarios (Vakili et al., 2023).

- It is important to underscore the importance of focusing on the **deep sea** for more precise predictions of URN on a global scale.

- The **coastal enhancement** effect needs consideration when examining factors influencing ambient noise, as it amplifies URN from coastal sources, making them audible in the deep ocean.

- **Ports** play a crucial role in controlling, monitoring, and mitigating URN from commercial vessels, through the use of appropriate **technologies** such as **OPS** and the adoption of **policy measures**, such as **speed reduction** and **incentive** schedules (Vakili et al., 2020; 2020a).

ELSEVIER

Marine Pollution Bulletin

Volume 171, October 2021, 112687

The development of a transdisciplinary policy framework for shipping companies to mitigate underwater noise pollution from commercial vessels

ELSEVIER

Marine Policy

Volume 118, August 2020, 104004

Full length article

The development of a policy framework to mitigate underwater noise pollution from commercial vessels

ELSEVIER

Marine Policy

Volume 120, October 2020, 104132

The development of a policy framework to mitigate underwater noise pollution from commercial vessels: The role of ports

Institution of MECHANICAL ENGINEERS

Case Study

The trade-off analysis for the mitigation of underwater noise pollution from commercial vessels: Case study – Trans Mountain project, Port of Vancouver, Canada

Southampton Marine & Maritime Institute

University of Southampton

The impact of shipping's energy efficiency measures on reduction of underwater radiated noise, and opportunities for co-benefit

Version 4- 02.11.2023

Schlüter Foundation shipping environment

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Thank you for you attention
Any Question Please?

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