Solutions to reduce vessel noise impacts to marine mammals

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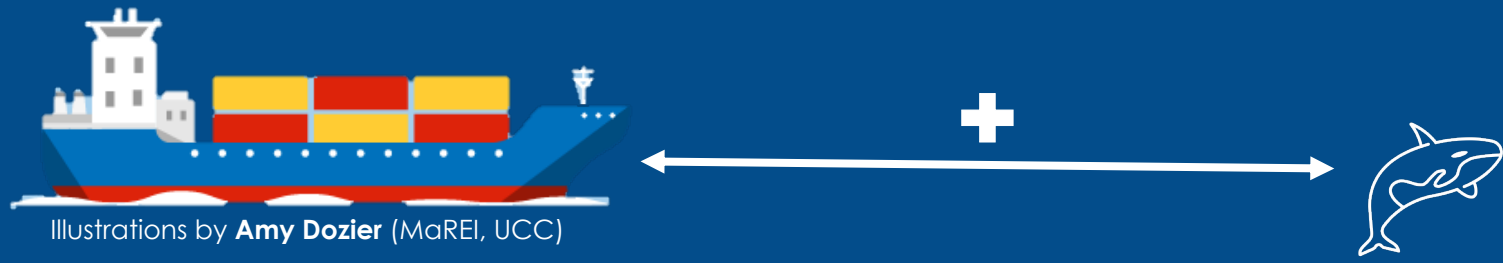
Saturn
Developing Solutions for Underwater Radiated Noise

SATURN has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101006443.

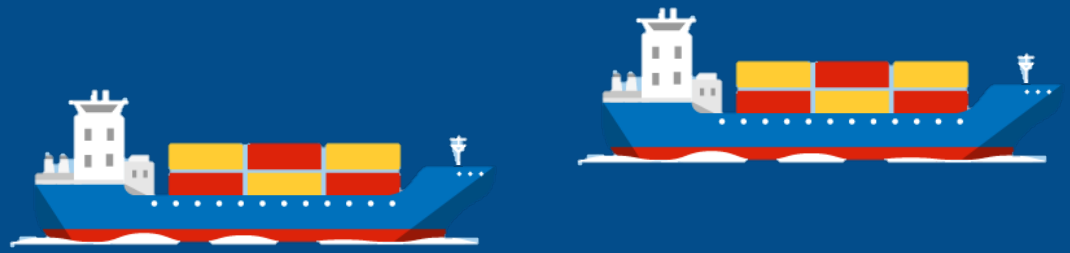
How can we reduce vessel Underwater Radiated Noise (URN)?

1. Increase distance

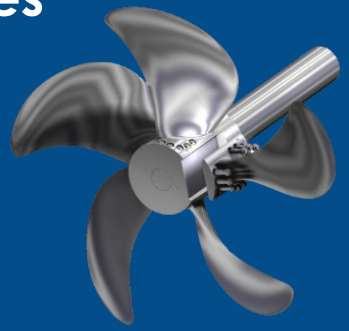


Illustrations by **Amy Dozier** (MaREI, UCC)

2. Maintenance & Operational measures



3. Technological measures



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Key Knowledge Gaps

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- How do source level reductions affect the area exposed to URN?
- By how much can slowdowns reduce source levels?
- How effective are these approaches at reducing noise impacts to marine mammals?
- Are slowdowns a ‘zero-sum game’ approach?
- Can we combine these mitigation approaches to reduce URN?

How do source level reductions affect the area exposed?

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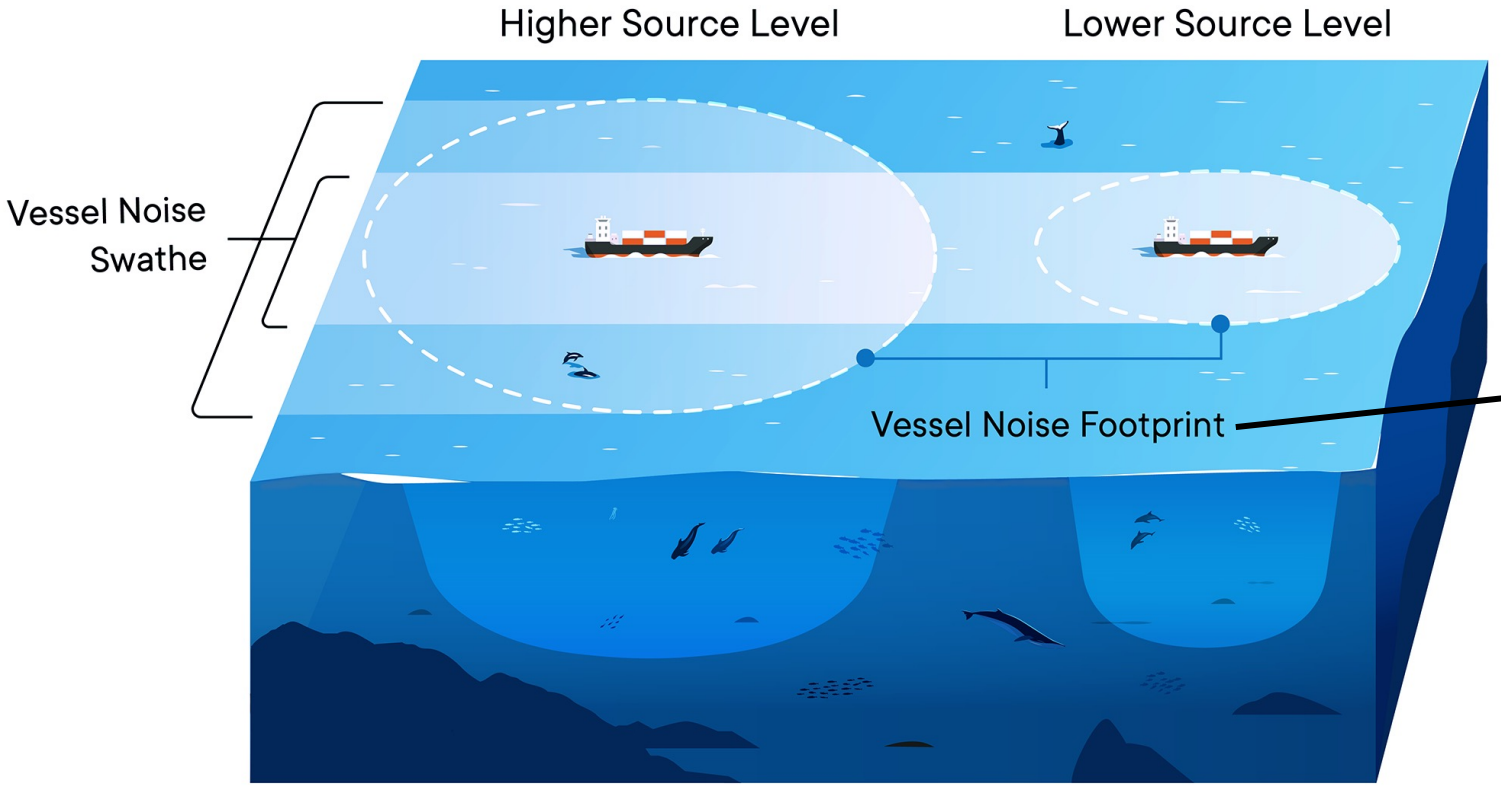

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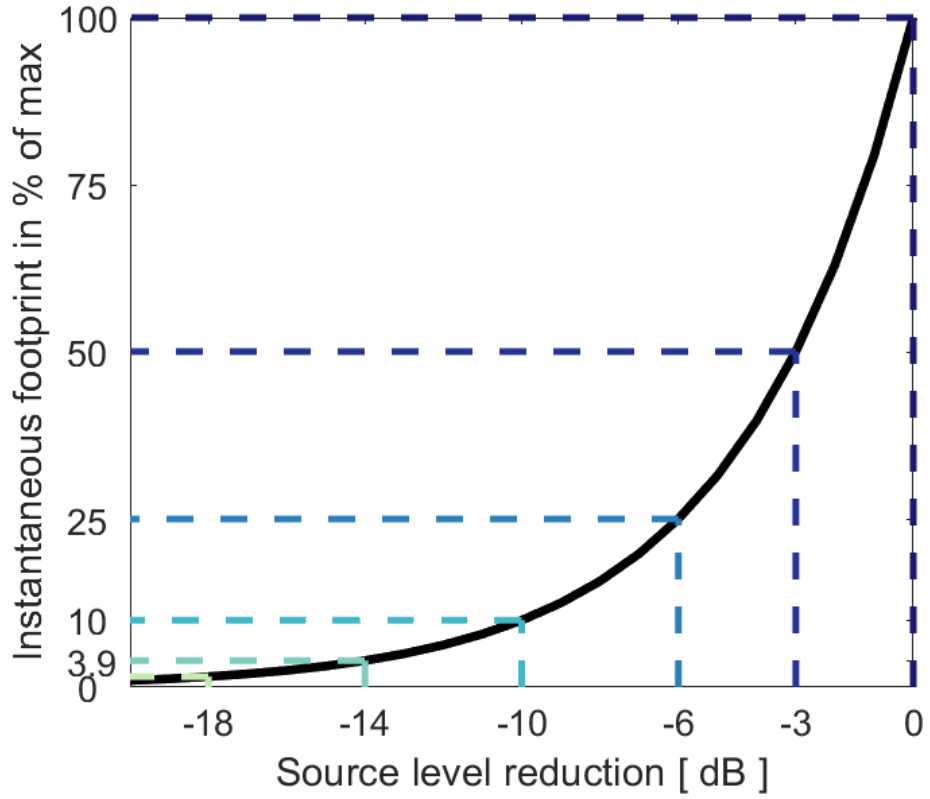

By how much do slowdowns reduce source levels?

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Containership

Photo by Venti Views on Unsplash

20 knots

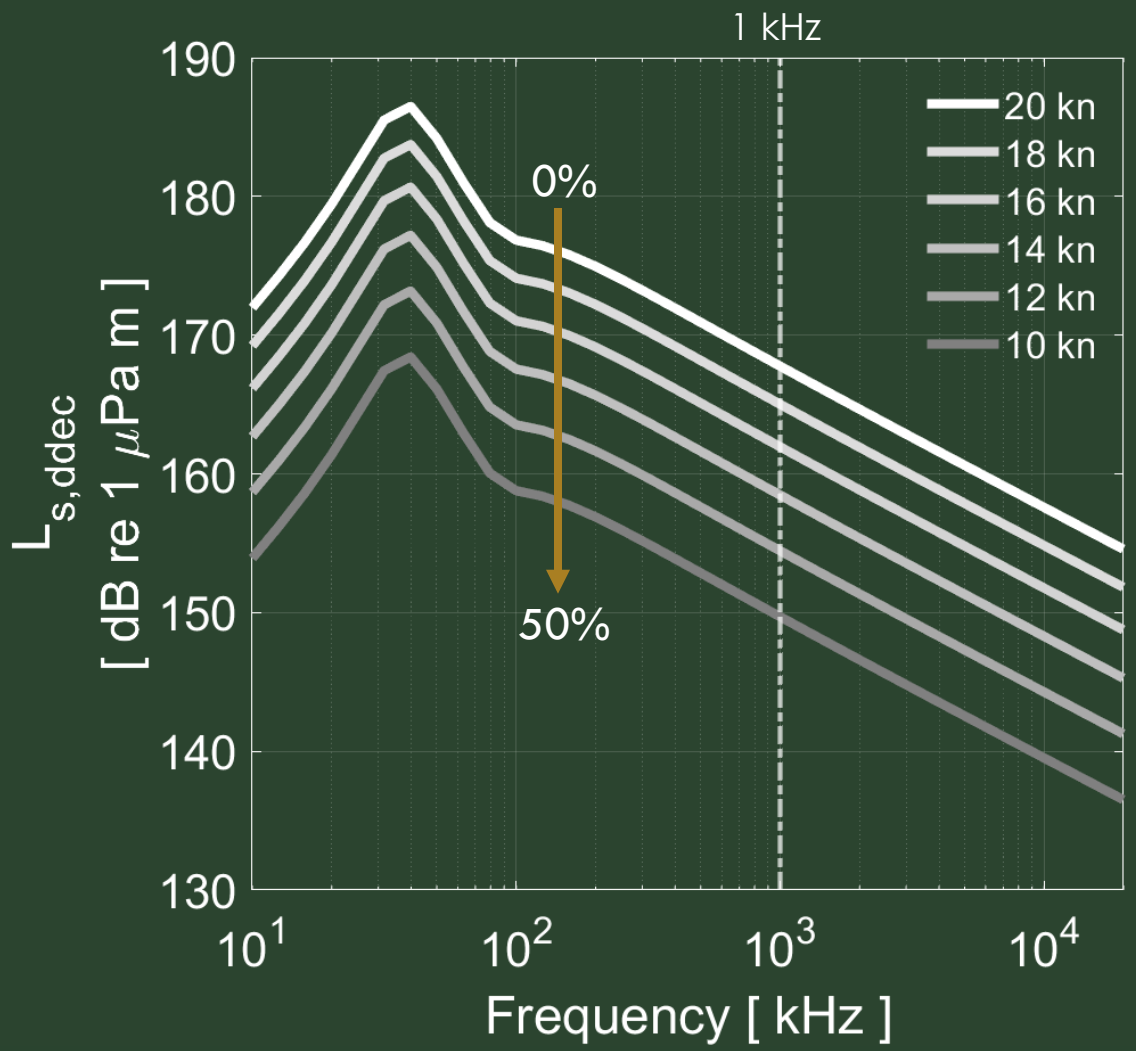
Source Level ?

Slowdown: 10 – 50%

10 knots

JOMOPANS-ECHO reference spectrum model

MacGillivray & de Jong, 2021



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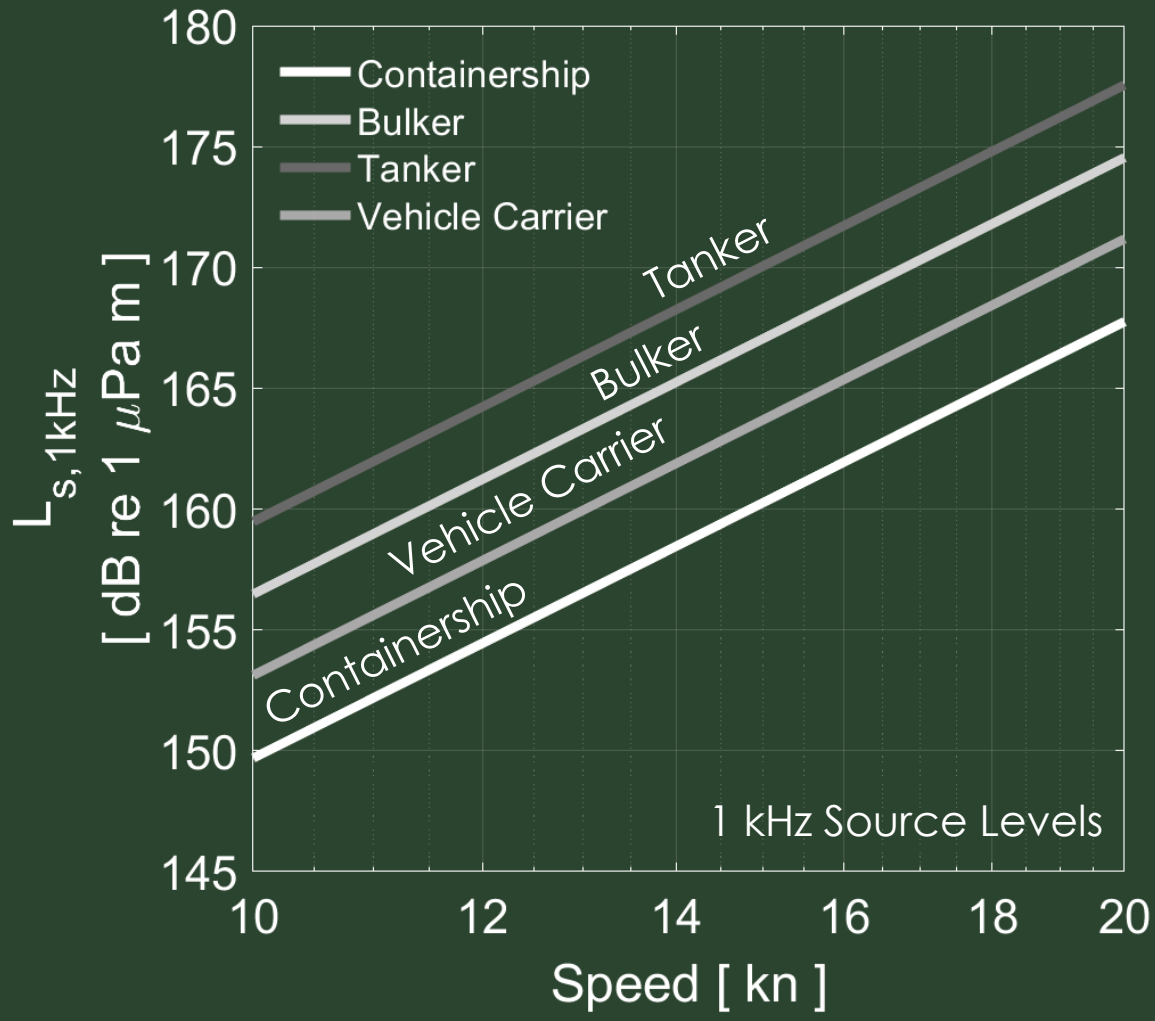

Do speed reductions reduce impacts to marine mammals?

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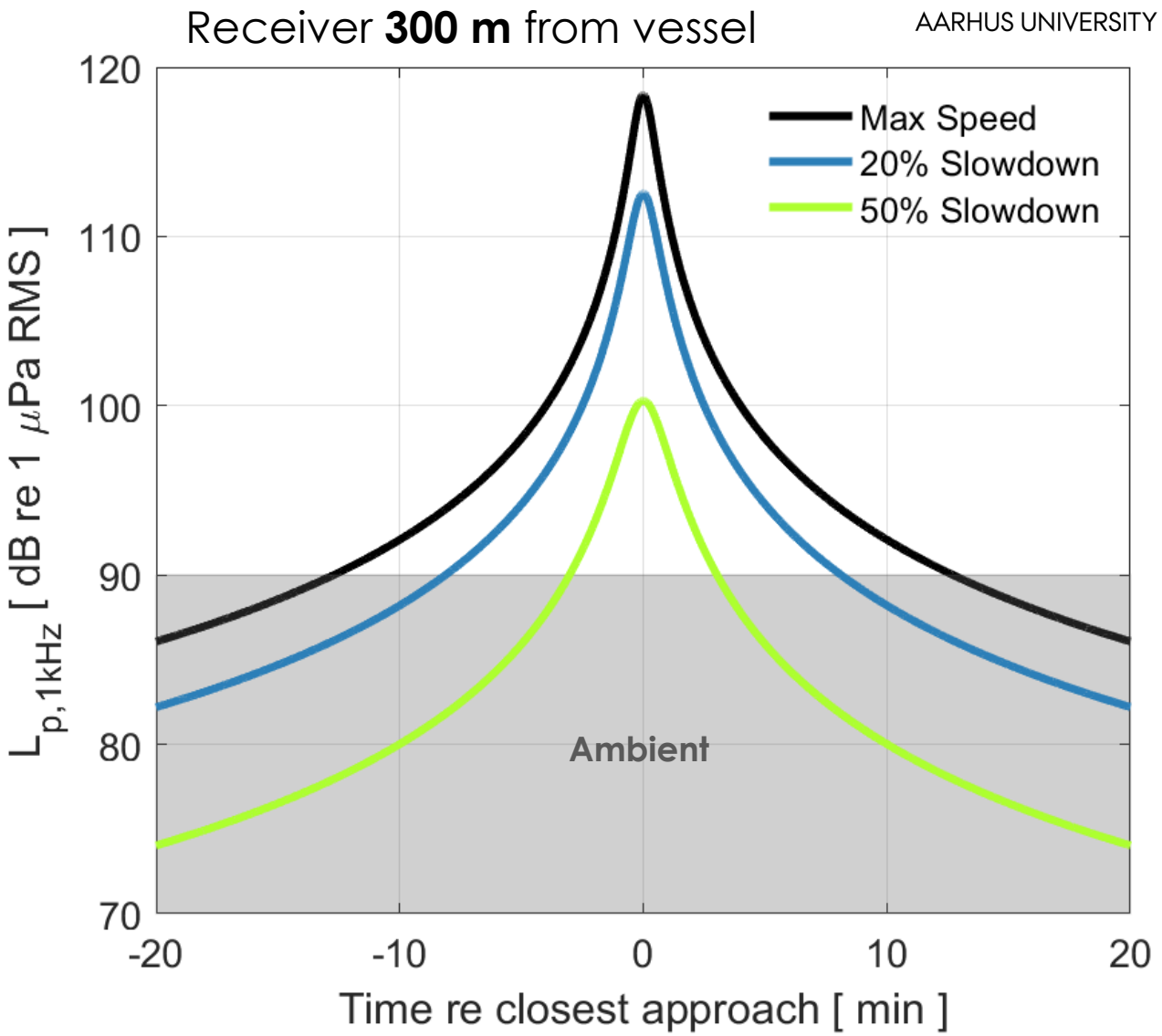
- **Proxies for noise impact:**
  - Maximum received level (dB re 1 µPa)
  - Exposure duration (min)
- **Max received levels ↓**
  - 20% (16 kn) = 6 dB
  - 50% (10 kn) = 18 dB
- **Exposure duration ↓**
  - 20% (16 kn) = 36%
  - 50% (10 kn) = 76%
- **Slowdowns ↓ all noise impacts**
- Supported by **ECHO programme**
  (Joy et al. 2019; Burnham et al. 2021)



Are slowdowns a zero-sum game approach?

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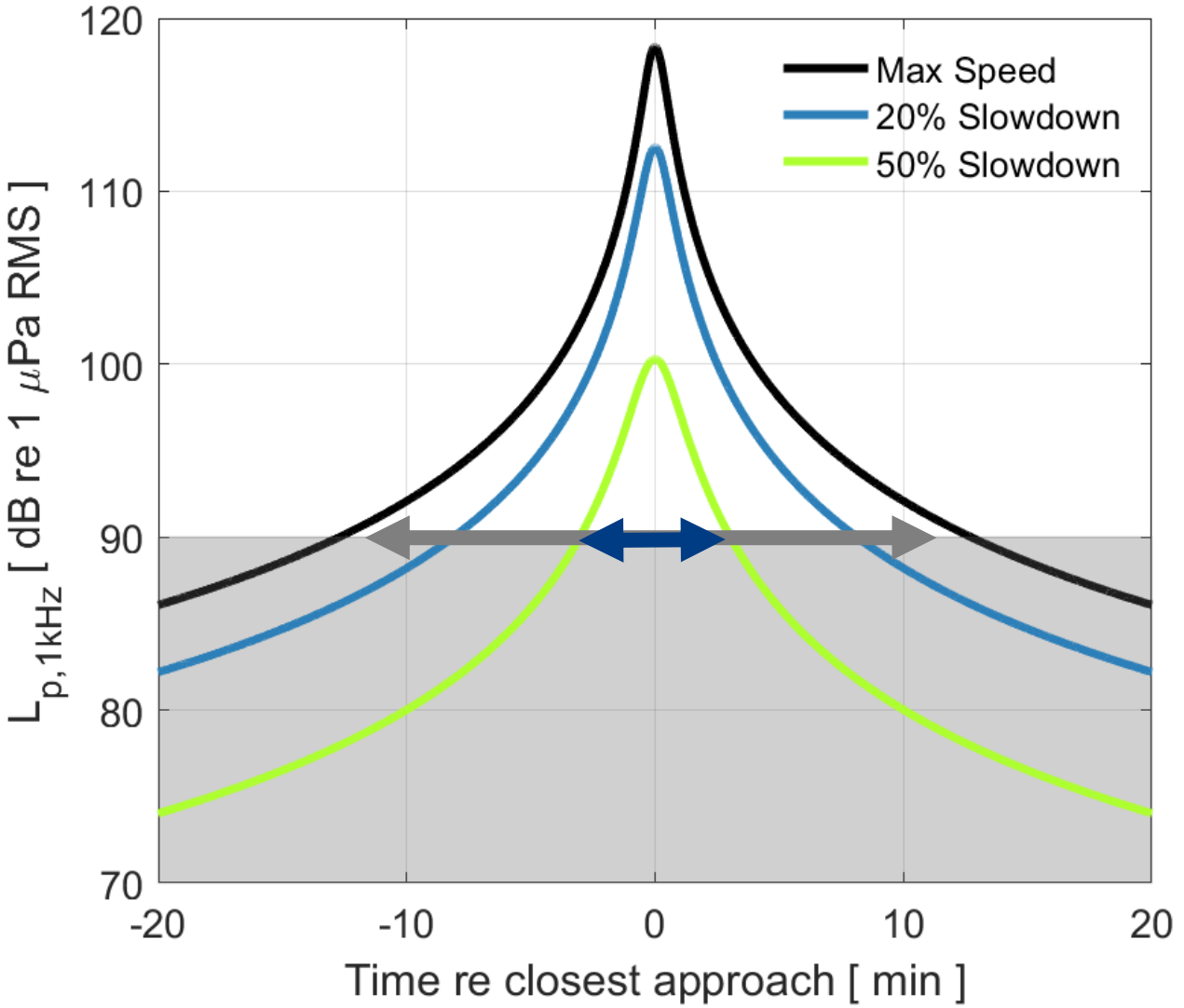
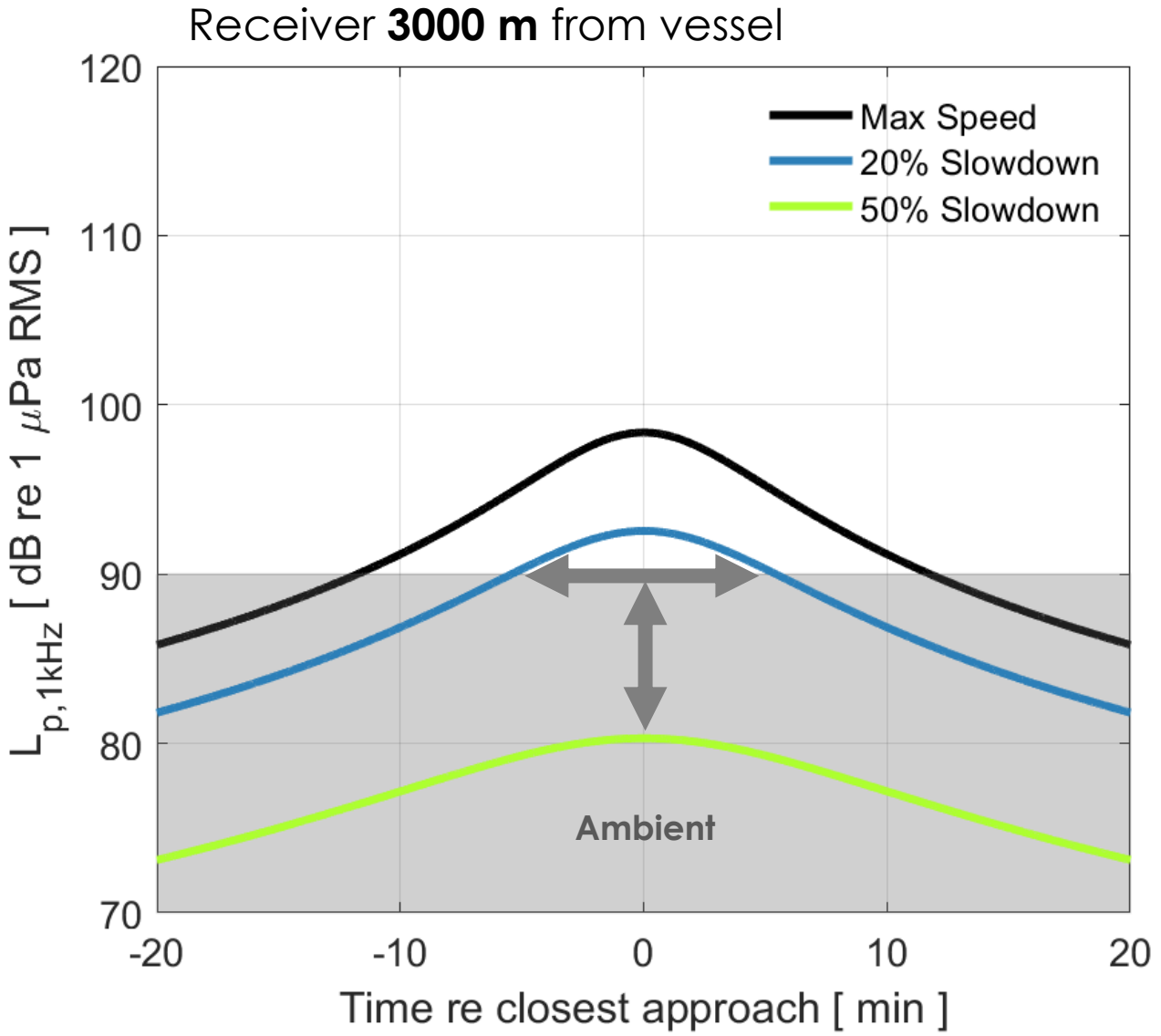
- Slower vessels in habitat for longer – more noise exposure?
- **Slowdowns ↓ time impacted**
- Supported by field measurements of cargo vessels (ZoBell et al. 2021)
- **Not a zero-sum game approach!**



Can we combine slowdowns with increased distance?

- Move our vessel further from animals & protected sites?
- **Max received levels ↓**
- Can we combine with slowdowns?
- **Exposure duration ↓**
- Very slow & distant vessel not audible as below ambient!



Can we combine slowdowns with increased distance?

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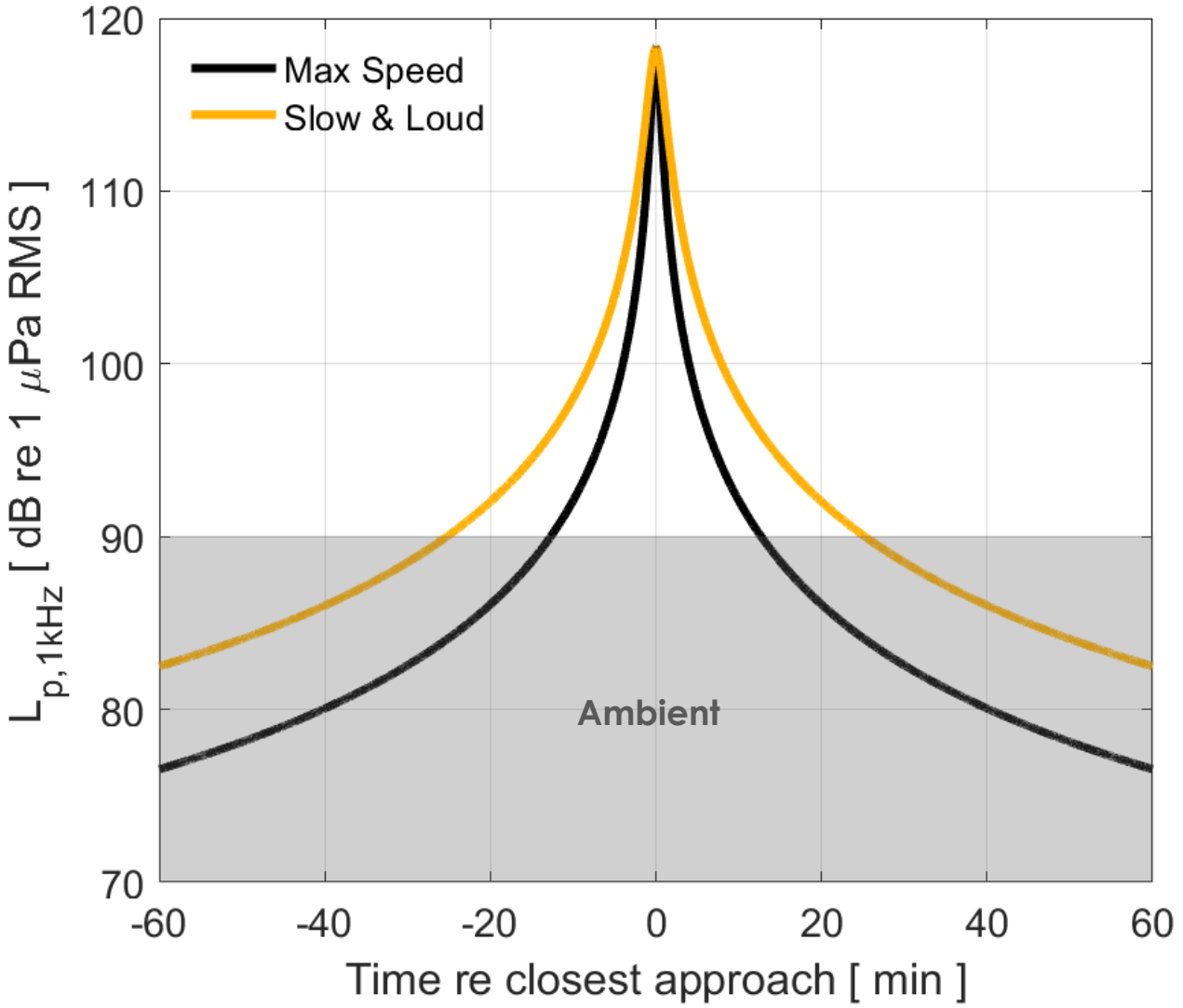
- Move our vessel further from animals & protected sites?
- **Max received levels ↓**
- Can we combine with slowdowns?
- **Exposure duration ↓**
- Very slow & distant vessel not audible as below ambient!
- **Reduce noise & lethal ship strike risk**
  (Laist et al. 2014)

Photo taken from: https://pressnewsagency.org/california-whales-are-being-killed-by-ships-but-ai-might-be-able-to-save-them/

Do slowdowns always work?

- Slow (10 knots) and Loud (+18 dB)?
- **High max received levels**
- **2 x longer exposure duration**
- Should we **target for maintenance, modification** or **remove** from the global fleet?
- Additional considerations:
  - **Optimum speed ranges for ship engines**
  - **Controllable Pitch Propellers**



Co-benefits of speed reductions

↓ Greenhouse Gas Emissions, NOx, SOx, Particulate Matter & Black Carbon

e.g., Khan et al. 2012; Cullinane & Cullinane, 2013; Faber et al. 2017; Leaper, 2019

↓ fuel consumption & port wait times
↑ reliability of deliveries & price of bulk goods

e.g., Cullinane & Cullinane, 2013; Lee et al. 2015; Leaper, 2019; Jalkanen et al. 2018; Leaper & Renilson, 2021; Elkafas et al. 2023

↓ risk of lethal ship strikes with cetaceans

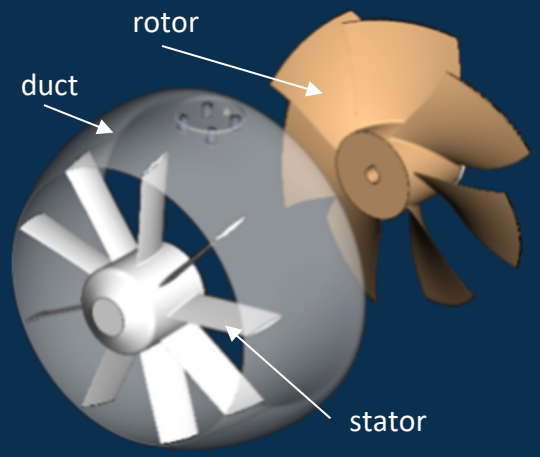
e.g., Silber et al. 2012; Conn & Silber, 2013; Laist et al. 2014; Leaper, 2019; Morten et al. 2022

Photo by Kinsey on Unsplash

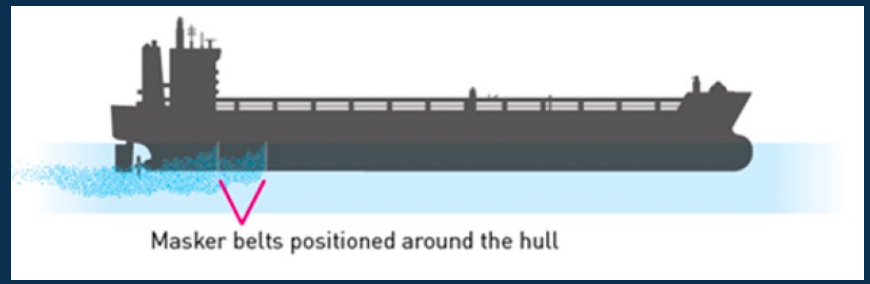
Examples of technology being trialled in SATURN

TROCHOIDAL PROPELLER

PUMPJET



AIR BUBBLE MITIGATION



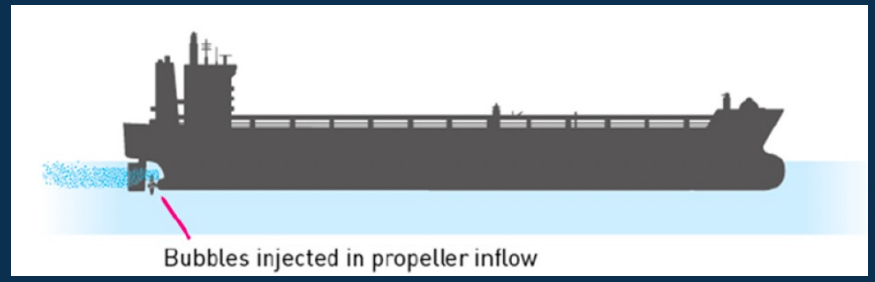
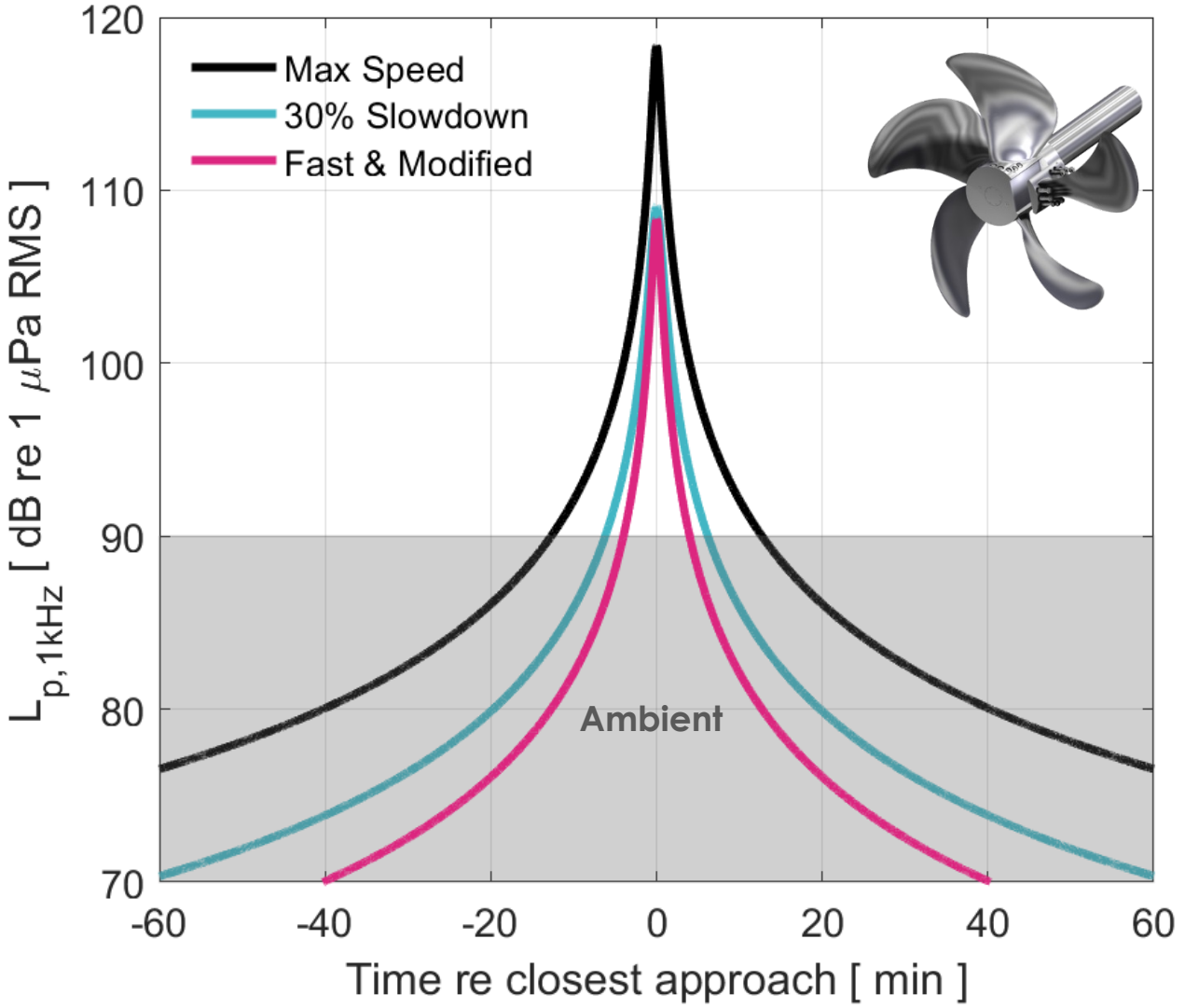


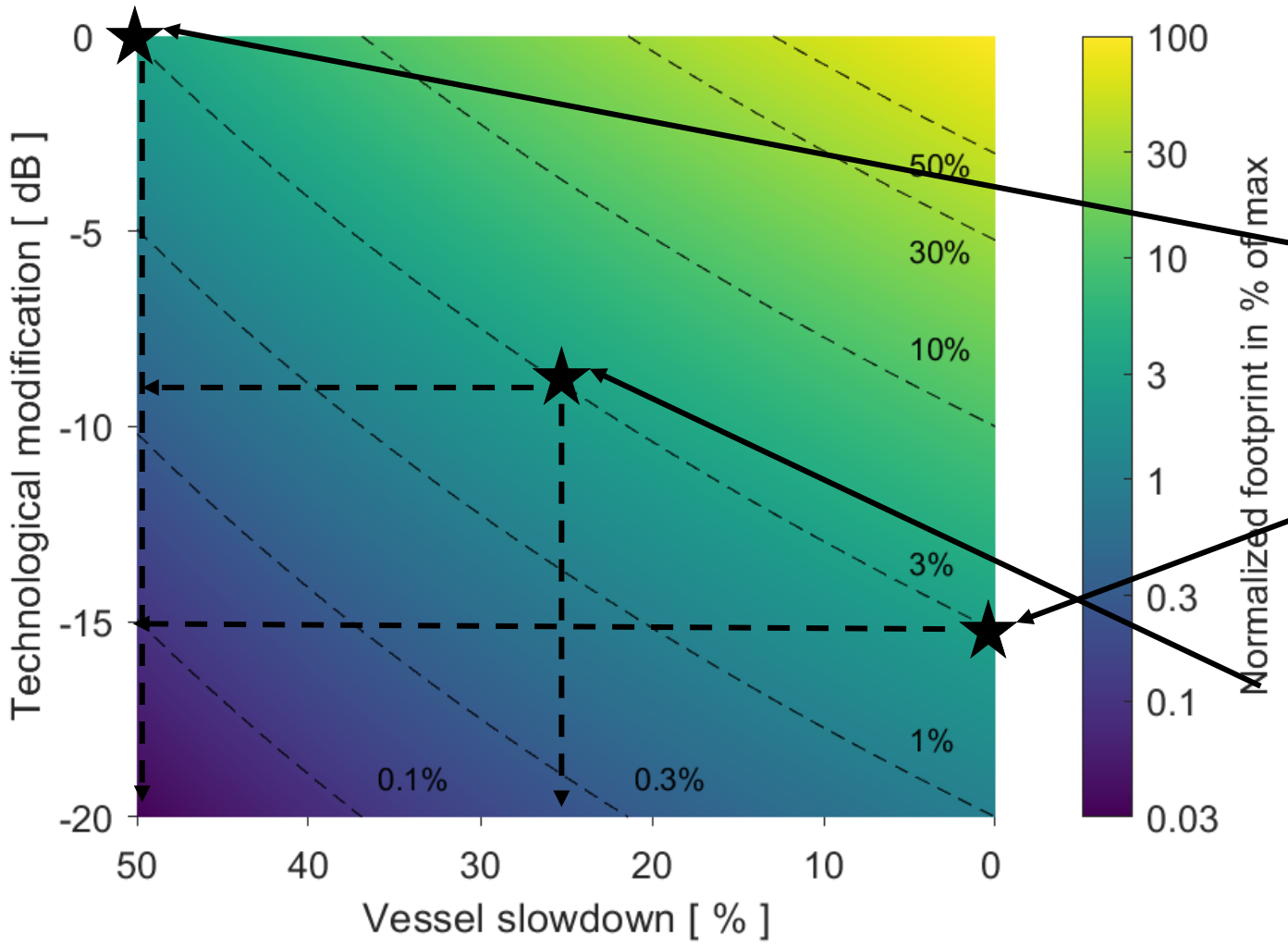
Photo credits: SIREHNA, NAVAL-GROUP, ADV-PROPULSE, FORMES&VOLUMES

What if we modify vessel technology?

- Fast (20 knots) & Modified (-10 dB)?
- **Max received levels ↓**
- **Exposure duration ↓**
- **A lot of tech solutions** to consider
- **Expensive** beyond design stage
- Option for **new vessels** in global fleet?
- Are they harder to detect?



Can we combine approaches?



97% Reduction in Area Exposed?

50% reduction in vessel speed

15 dB technological modification

25% slowdown &
8 dB technological modification

Conclusions

- Marine mammals **regularly exposed to vessel URN**
  - ↑ **data** on vessel URN exposure in **key species**
  - Different **tools available** to study exposure/impacts
- What **aspects of vessel URN cause response**?
- URN may have **fitness consequences for marine mammals**
  - **Short term changes in behaviour** affect **energetic budgets** of individuals = **long term consequences for populations**
  - Focus on **responses with fitness consequences**
  - **Inform population models** e.g., DEPONS

SCAN ME

Findlay et al. 2023

SCAN ME

Nachtsheim et al. 2023

BIOSPHOTO / Alamy Stock Photo

Conclusions

- Source level ↓ substantially ↓ **area exposed to URN**
- **Moderate speed reductions = large source level ↓**
- Speed reductions ↓ **all noise impacts to marine wildlife**
- Speed reductions ↓ **time soundscape impacted**
- **Combined approaches** achieve ↑ reductions in URN
- **Slowing down is effective, scalable** & **quickly implementable** solution to URN

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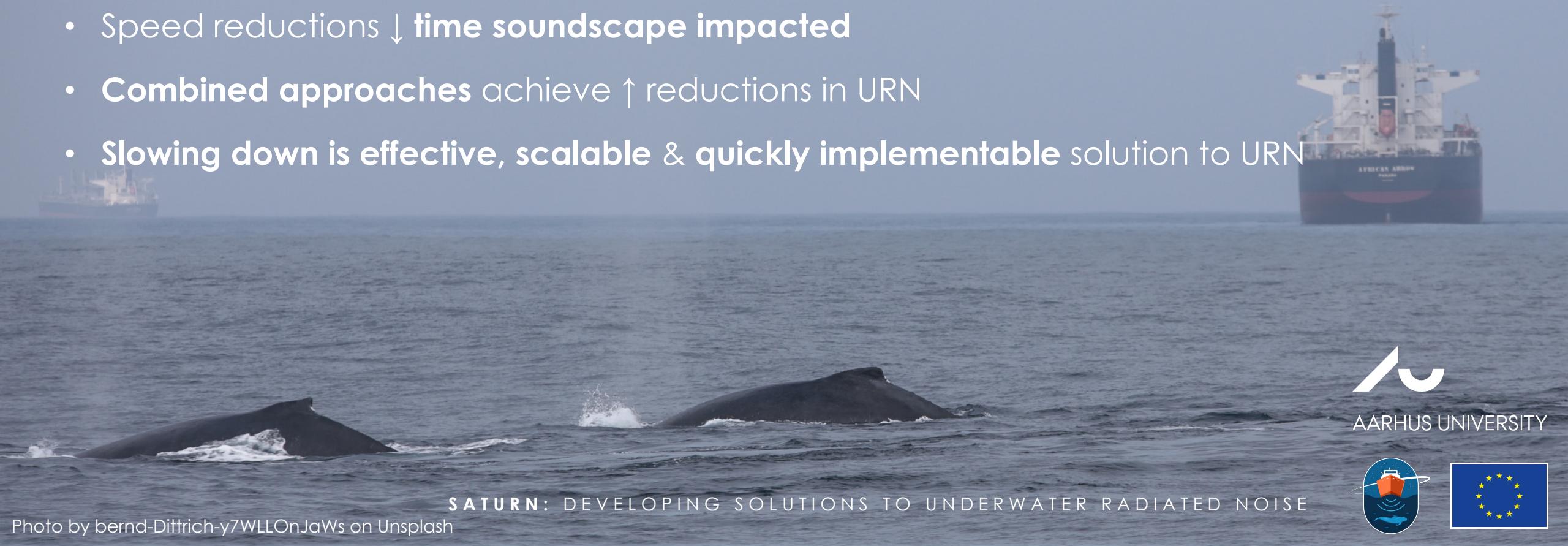
Findlay et al. 2023

SCAN ME

Nachtsheim et al. 2023



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Thank you!

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