Wind Propulsion 2023 Conference

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Wind Propulsion and Underwater Radiated Noises Mitigation

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International Windship Association

THE ROYAL INSTITUTION OF NAVAL ARCHITECTS

"Imagine you live in a dark place, and you must rely on your hearing the same way you would rely on your vision. And that space is loud and getting louder. It's certain to cause you stress." Statement from CLEAR SEAS Centre for Responsible Marine Shipping (Canada)

Reduce URN and impacts on Marine Life with Wind Propulsion

IMO INTERNATIONAL MARITIME ORGANIZATION

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New revision 2023

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MEPC.1/Circ.833
7 April 2014

GUIDELINES FOR THE REDUCTION OF UNDERWATER NOISE FROM COMMERCIAL SHIPPING TO ADDRESS ADVERSE IMPACTS ON MARINE LIFE

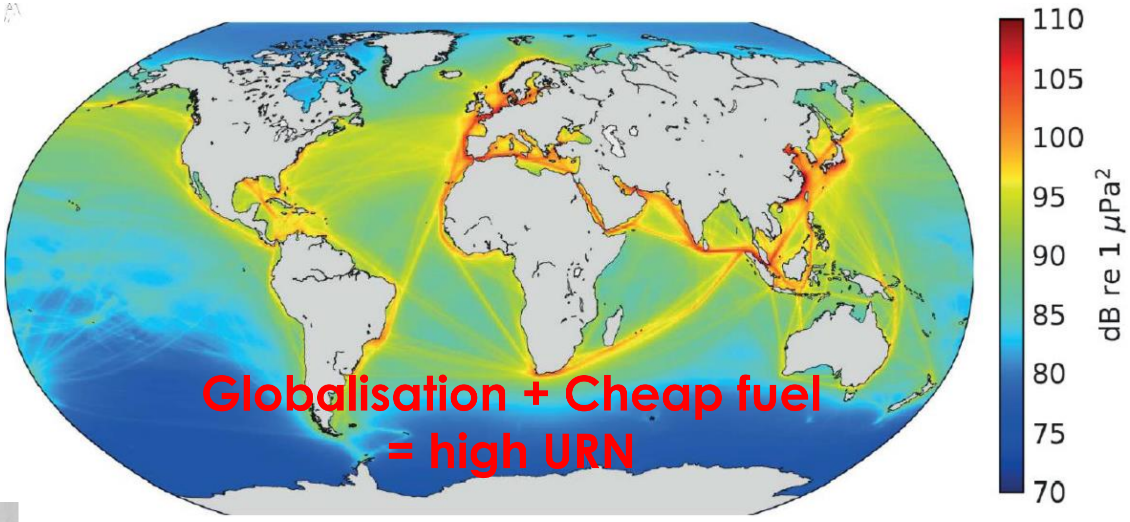
IMO resolution on URN from ships will come in force soon

Wind Propulsion and Underwater Radiated Noise Mitigation

Underwater Radiated Noises (URN) in the oceans never stopped increasing :

- Worldwide shipping fleet x 3 between 1948 and 2008 (1)
- Measured noise increased by 20 dB since 1950’s (2)

Average sound level due to shipping in 2014 at 100 Hz



From Duarte et al. 2021

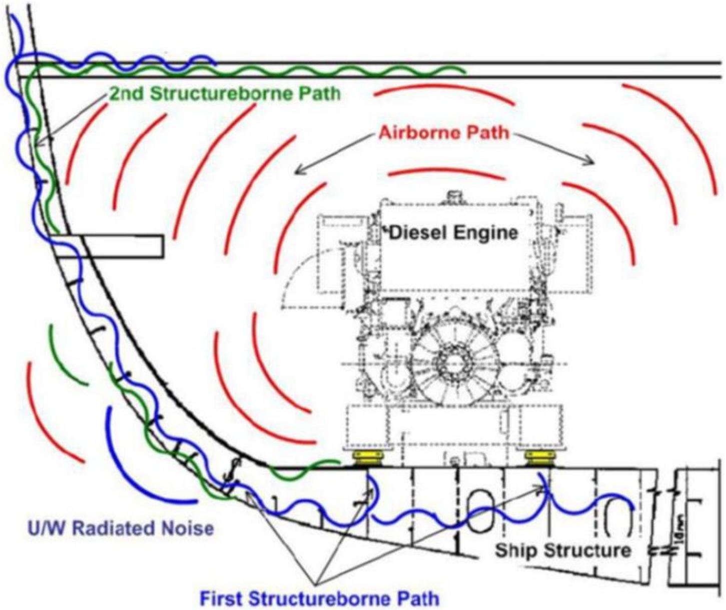
- Cargo sail ships (clippers) almost disappeared at the end of the 19th century
- There were however the most silent ships
- Now Wind Propulsion is back !

(1) Hildebrand, 2009
(2) Frisk, 2012

Main sources of ship emitted URN & Mitigation

Machinery equipment :

- Structure borne => resilient mountings
- Airborne => Hull and bulkheads isolation



From Spence & Fischer 2017

Research vessels, Navy Ships, Cruise vessels => Designed to be pretty quiet …. With expansive measures

Propeller Cavitation :

- Depression on the outer side of the blade => water vaporization
- Depends on hull & blade design
- Disappears below a certain rpm limit

From The Shipyard Blog

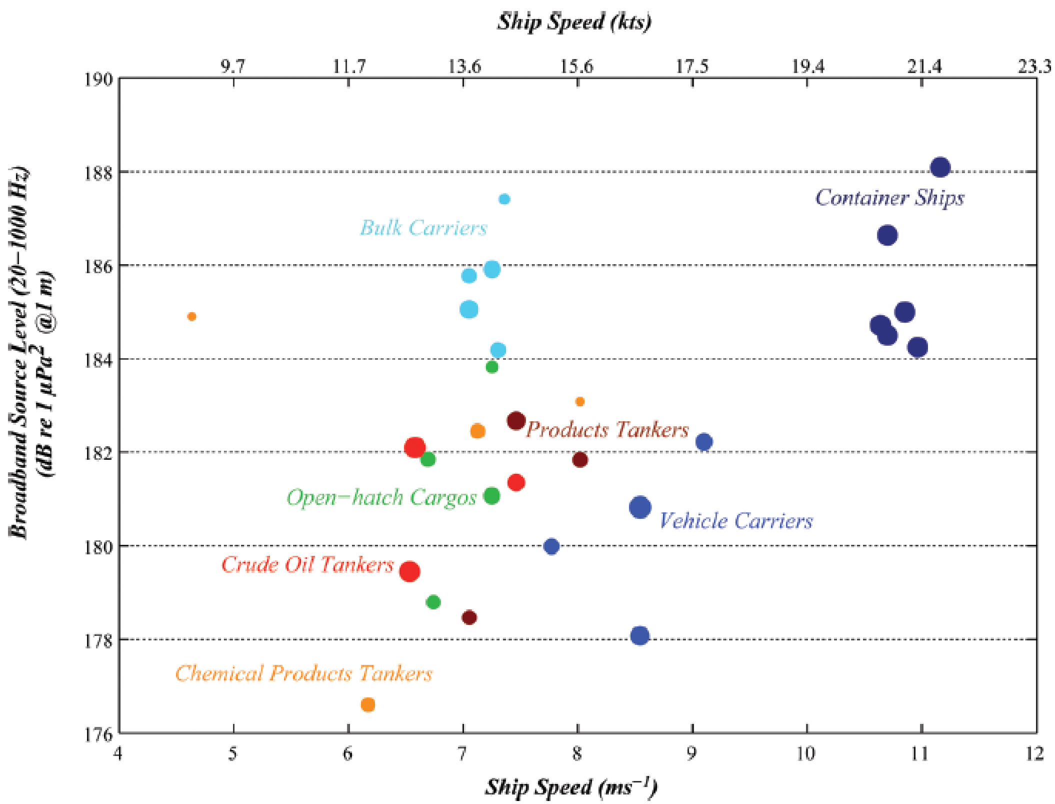
URN mitigation by vessel speed reduction

Speed and URN for major part of the fleet

- Tankers, bulk carriers and container ships : major contributors
- The fastest are the noisiest
- Difference of about 10 dB between the slowest and fastest
- Existing fleet not designed for URN reduction => Expansive refit

URN propagation loss factors

- URN levels and frequencies at the source
- Depth of the source
- Water depth / seabed nature
- Sea water characteristics
- Distance Source – Receiver
- Directionality : Bow vs Stern propagation



From M F Mc Kenna et al. 2012

Underwater Radiated Noises (URN) emitted by vessels disturb the marine life

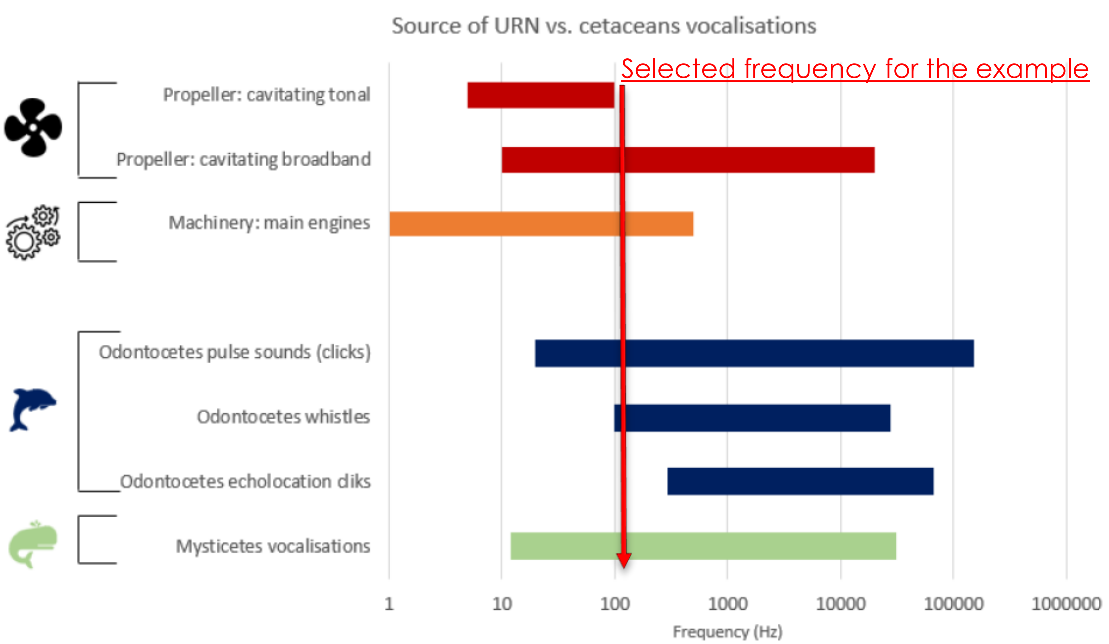
- Vessels' URN frequency ranges overlap marine mammals' communication frequencies
- They increase the Ambient Noise Level and reduce the communication distance

Main impacts on cetaceans

- Vocal behaviour
- Diving and swimming patterns
- Reduction in communication range
- Foraging behaviour
- Physiological responses

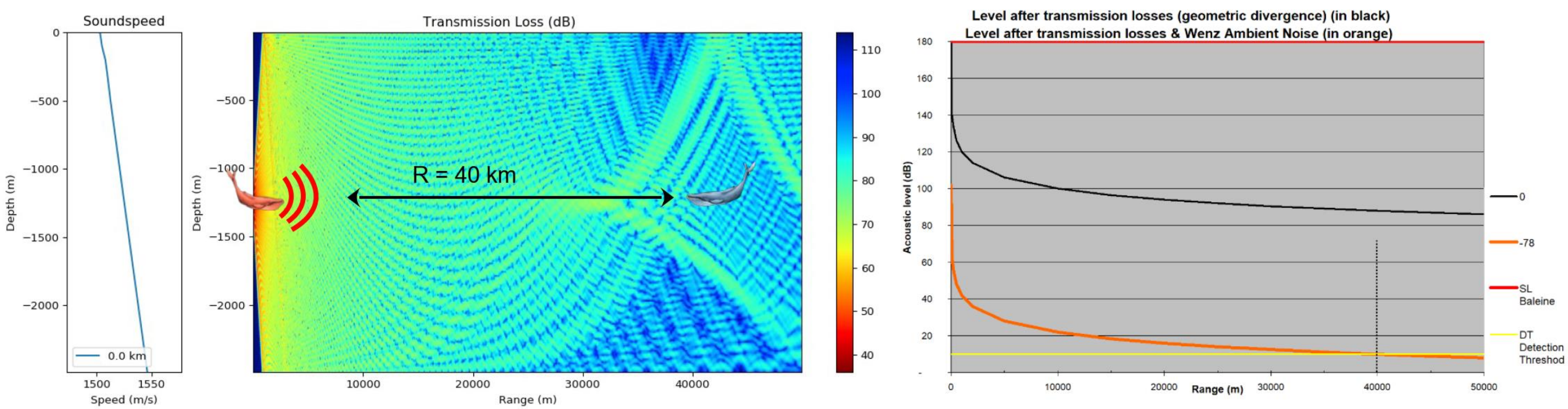
➢ **May compromise their lives**

➢ **Fishes and invertebrates are also impacted**



From EMSA SOUNDS report 2021

Communication distance between two individuals reduces as the Ambient Noise Level (ANL) increases



Example with a maximum communication distance of 40 km, an ANL of 78 dB, and whale emission level of 180 dB

From Semantic TS 2023

When a ship comes across the zone :

- First cetaceans increase the emission level up to a maximum
- Then communication distance reduces which disturb their social life

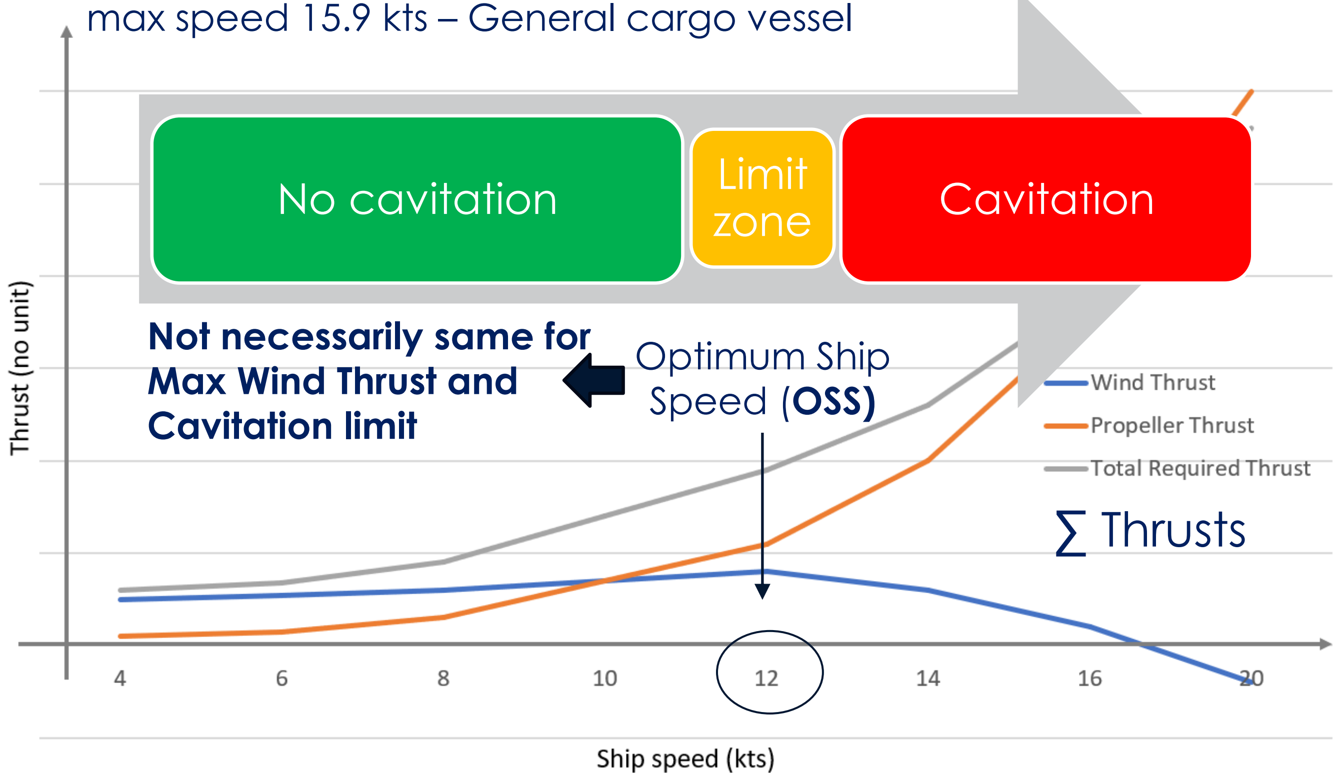
Benefit of wind propulsion contribution
Example of a conventionally propelled vessel fitted with WASP (not defined)

Wind data:
- TWS = 15 kts
- TWA = 60 deg

Wind contribution increases up to the OSS (12 kts):
- AWS = 23 kts
- AWA = 35 deg

Above the OSS :
- Wind thrust ↘
- Propeller rpm ↗
- URN ↗

M/V OVERSEAS HARIETTE, DWT 25 515 tons, L 172.9 m, B 22.8 m, max speed 15.9 kts – General cargo vessel



From XP Sea 2023

Wind Propulsion and Underwater Radiated Noise Mitigation

Comparison between 2 cases at the same speed of 12 kts (OSS):

- Case A : **100%** conventional propeller propulsion (no WASP)
- Case B : **60%** conventional / **40%** wind propulsion (WASP)

Parameter	CASE A 100% Conventional Propulsion	CASE B 60% Conventional 40% Wind	Difference
Ship speed (knots)	12.0	12.0	
Thrust form conventional propulsion	100%	60%	
Thrust form wind propulsion	0%	40%	
Propeller rotational speed (rpm)	105	68	-37
URN maximum levels	Values in dB from Figure 5 except (*)		(dB)
10 – 31.6 Hz	178	165 (*)	-13
31.6 Hz – 100 Hz	179	165 (*)	-14
100 Hz – 316 Hz	170	161	-9
316 Hz – 1000 Hz	164	161	-3
> 1000 Hz	159	156	-3

XP Sea analysis of Arveson Vendittis 1999 data

(*) Noise levels from machinery equipment which are usually isolated, URN therefore capped to 165 dB

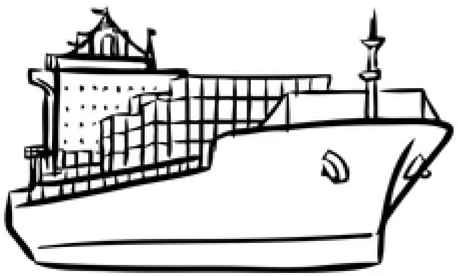
URN source

- Case A = Blade Cavitation
- Case B = Diesel Generator (no cavitation)

Selected frequency of 100 Hz (max URN)

- Case A = 169 dB
- Case B = 155 dB => **-14 dB**

Equivalence in terms of URN generation in the same area for -14 dB offset at 100 Hz



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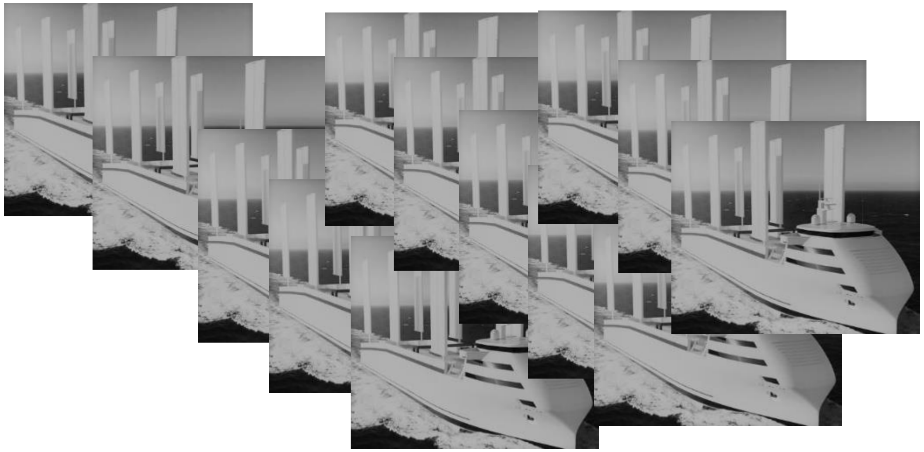


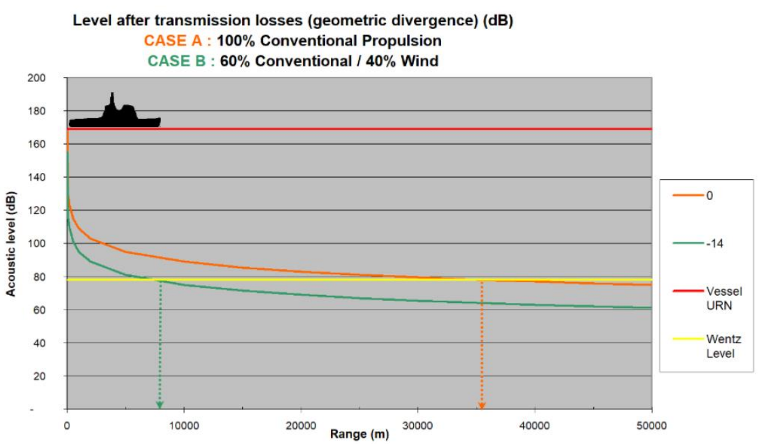
1 CASE A Vessel 100% conventional propulsion

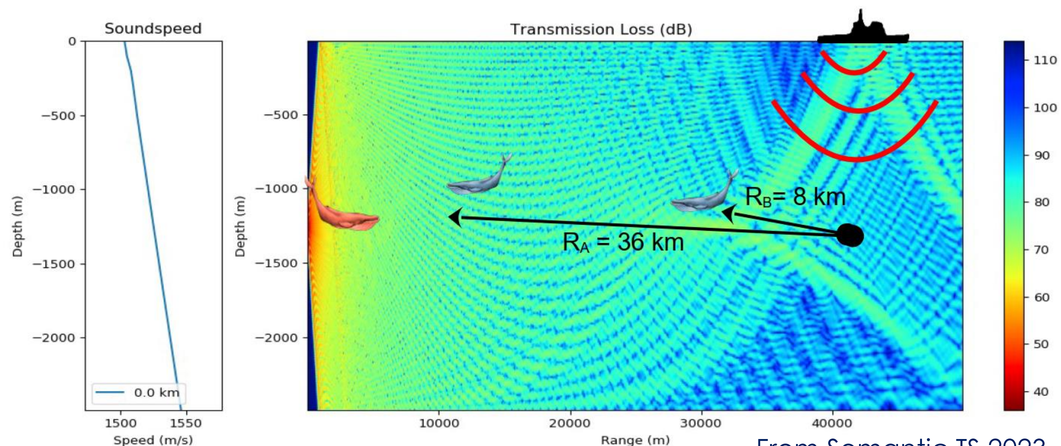
25 CASE B Vessels 40% Wind Propulsion

$$10^{\frac{14}{10}} = 25$$

Communication range reduction / Gathering distance increase

- Reference maximal communication distance is R= 40 km in our example
- When a vessel comes close to one of two individuals (or groups)
  - The communication distance is then reduced by R_n
  - They need to gather by a range R_n to communicate





From Semantic TS 2023

Minimum required gathering distances

- Case A : R_A = 36 km
- Case B : R_B = 8 km

Wind Propulsion reduces the disturbance distance by 28 km

Macro estimating the impact of wind propulsion benefits based on a reference low Ambient Noise Level (ANL)

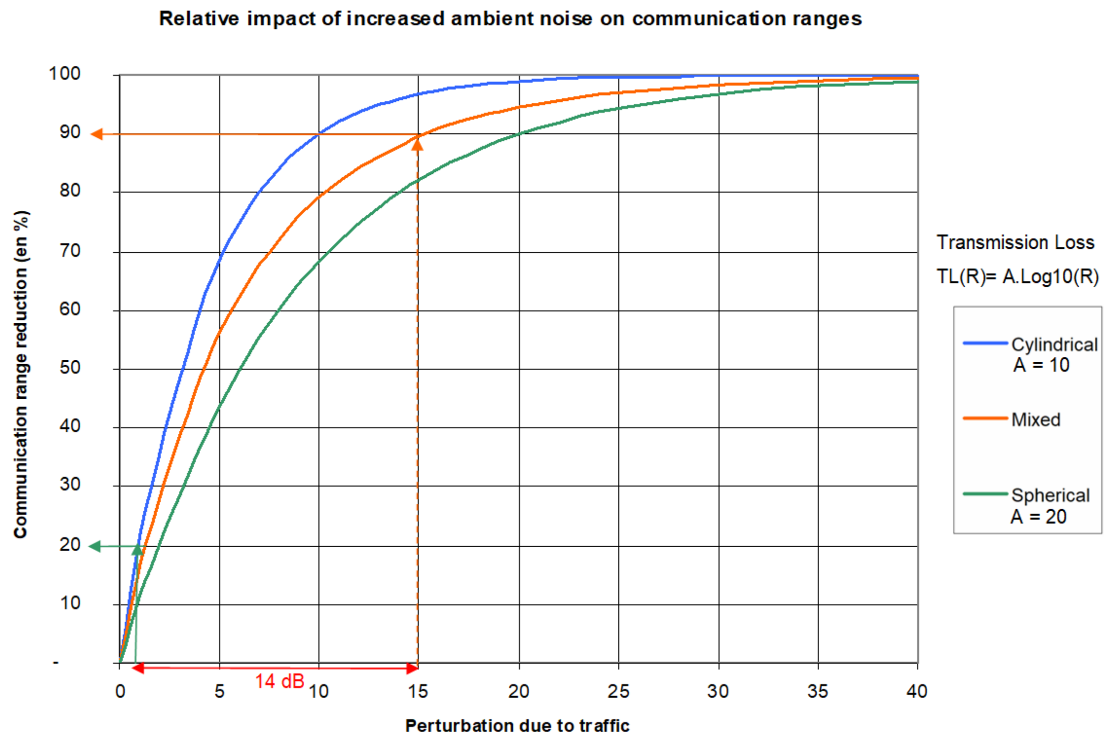
ANL increase

- Case A : by **15.3 dB**
- Case B : by **1.3 dB**

Communication distance decrease

- Case A : by **90%**
- Case B : by **20%**

Wind Propulsion has the potential to drastically reduce URN and disturbance of marine life for only 40% of wind contribution



WAY FORWARD

Obtain more measurements to build graphs combining conventional and wind propulsion. For any vessel fitted with a WASP system :

- Thrust vs Speed graphs to determine the OSS for various wind conditions (TWS/TWA) and % of each contribution
- URN graphs vs frequencies for various ship speeds / rpm
- Cavitation point depending on the wind propulsion contribution (propeller unloading) and rpm

On-board live monitoring :

- Display locations of sensitive species (detection systems)
- Display URN levels vs rpm
- Set maximum allowable URN vs distance to species
- Real-time calculation of the OSS to maximize wind contribution

Ship speed reduction is good for:

- **URN reduction**
- **Maximizing wind thrust**
- **Carbon footprint**
- **Pollutant emissions**
- **Fuel consumption**

From Zéphyr et Borée Website