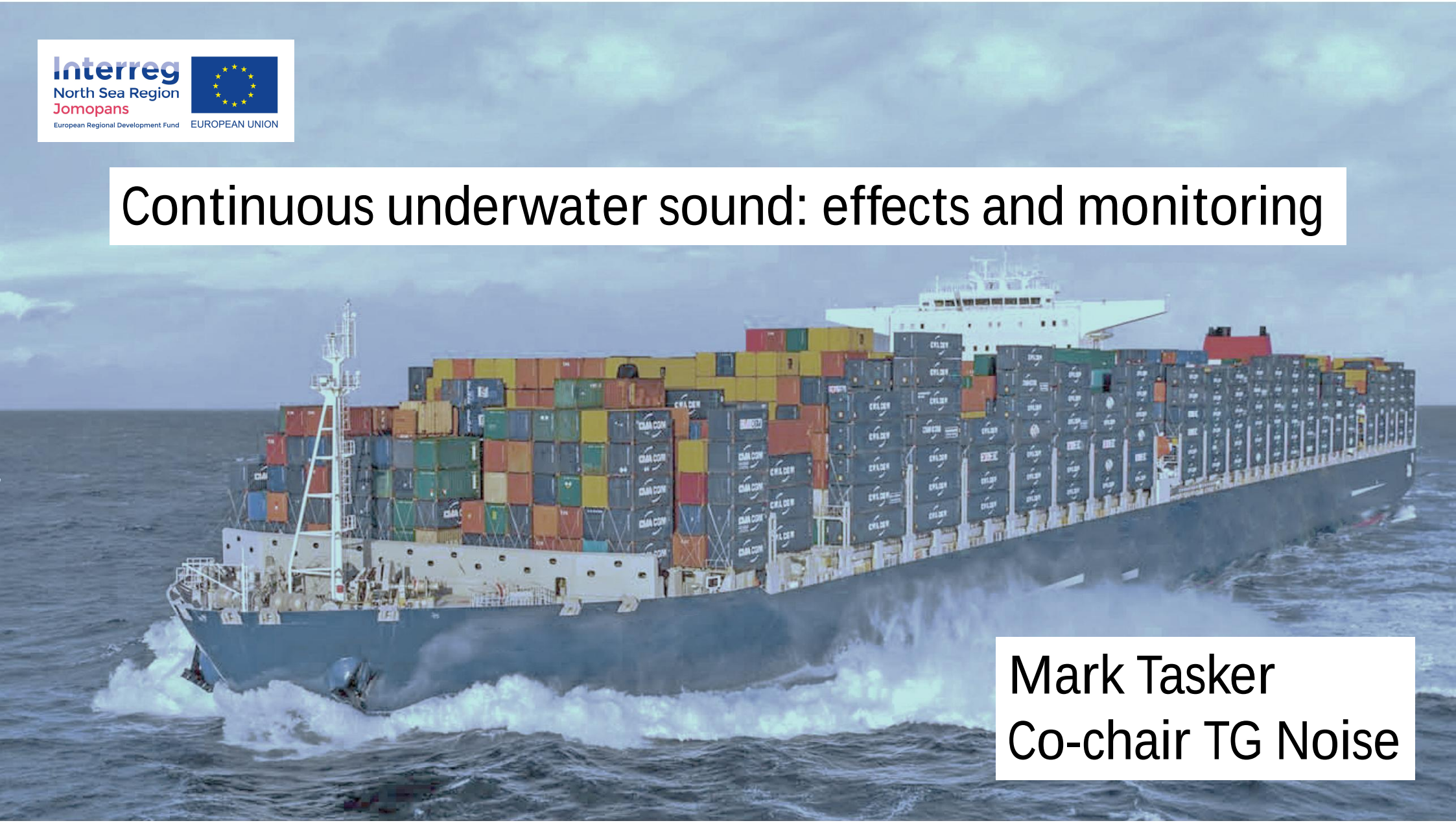
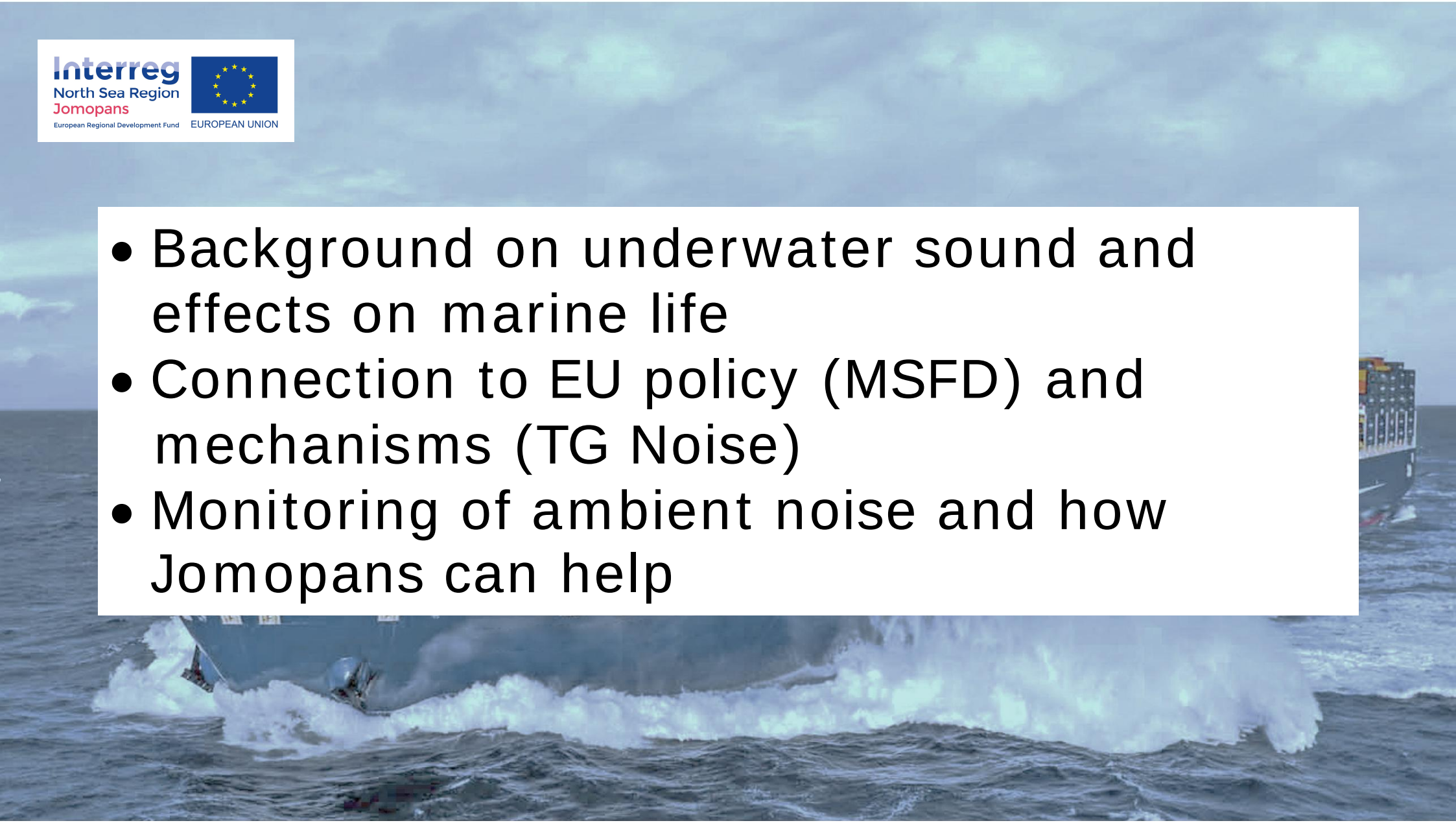
Interreg
North Sea Region
Jomopans
European Regional Development Fund

EUROPEAN UNION

Continuous underwater sound: effects and monitoring



Mark Tasker
Co-chair TG Noise



- Background on underwater sound and effects on marine life
- Connection to EU policy (MSFD) and mechanisms (TG Noise)
- Monitoring of ambient noise and how Jomopans can help

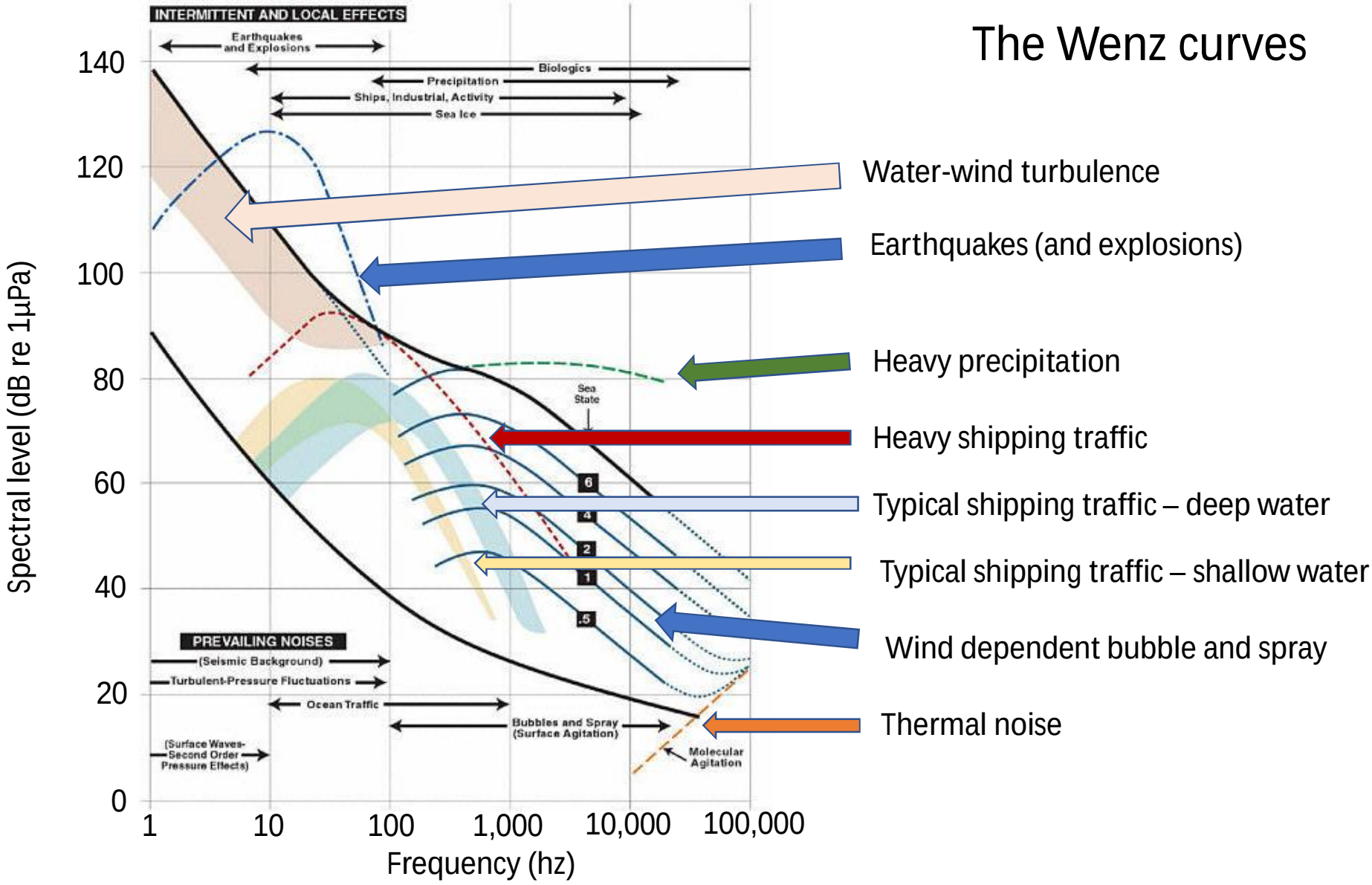
A traditional view is that the oceans are largely silent

Even before man's arrival many, if not most, marine animals were making sounds

Many physical sounds present as well

- Earthquakes
- Wind and waves

The Wenz curves



Water-wind turbulence

Earthquakes (and explosions)

Heavy precipitation

Heavy shipping traffic

Typical shipping traffic – deep water

Typical shipping traffic – shallow water

Wind dependent bubble and spray

Thermal noise

Aspects of sound

Descriptors of sound

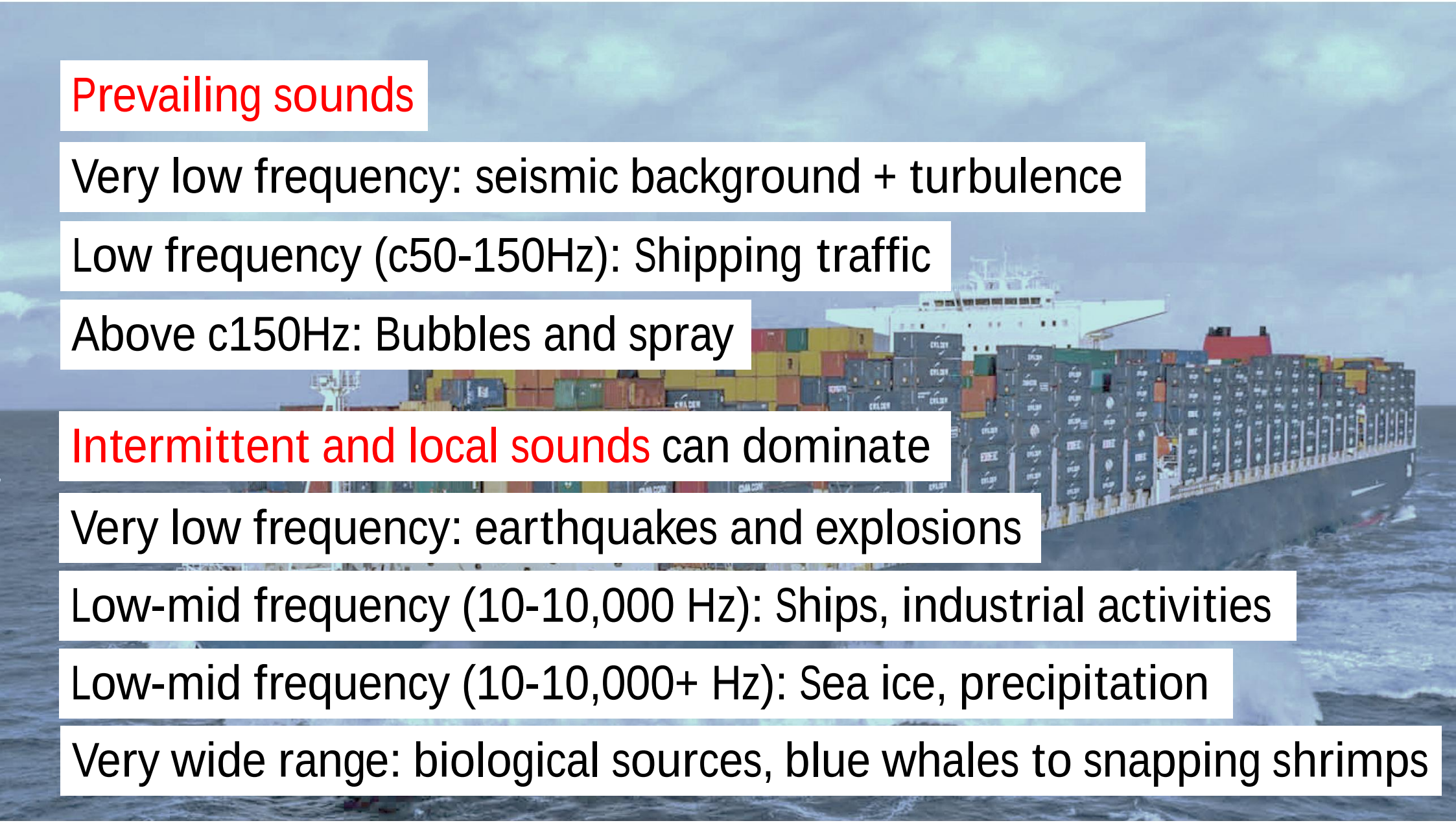
Source level
"Ping" energy
"Ping" duration
Duty cycle

Peak frequency
Band width
Directionality

Persistence
- temporal
- geographic

Low frequency sounds propagate further than high frequency sounds

"Loudness" depends on hearing capability of the receiver of the sound; sound intensity (or amplitude) used instead



Prevailing sounds

Very low frequency: seismic background + turbulence

Low frequency (c50-150Hz): Shipping traffic

Above c150Hz: Bubbles and spray

Intermittent and local sounds can dominate

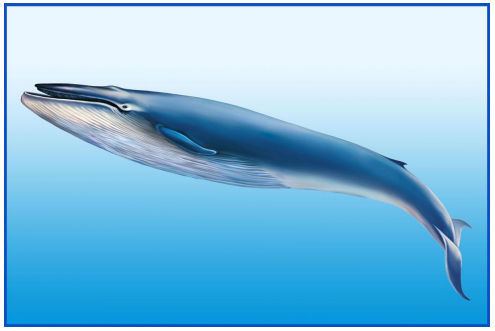
Very low frequency: earthquakes and explosions

Low-mid frequency (10-10,000 Hz): Ships, industrial activities

Low-mid frequency (10-10,000+ Hz): Sea ice, precipitation

Very wide range: biological sources, blue whales to snapping shrimps

Biological sounds



Blue whale
10-30 Hz
SL: 155-188 dB re 1µPa at 1m
Communication, ?navigation

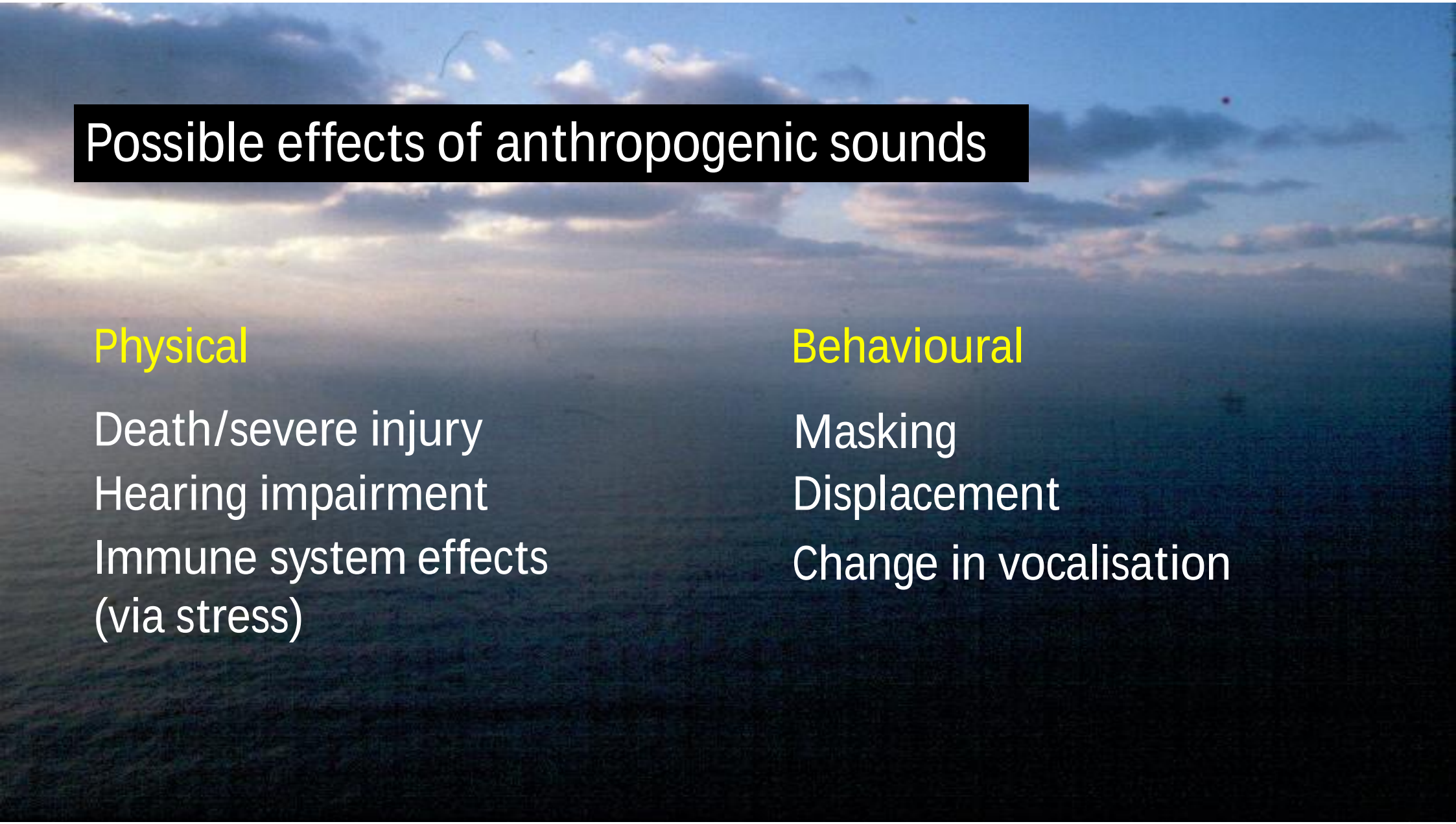
Haddock
<600Hz
SL: c100 dB re 1µPa at 1m
Courtship, communication

Snapping shrimp
2,000-5,000 Hz
SL: <189 dB re 1µPa at 1m
Communication, territoriality

Sperm whale (clicks)
15,000 Hz
SL: 180-230 dB re 1µPa at 1m
Communication, feeding

Dolphin (whistles)
2,000 – 40,000 Hz
SL: 125-173 dB re 1µPa at 1m
Communication, feeding

Harbour porpoise
110,000 – 150,000 Hz
SL: c150 dB re 1µPa at 1m
Communication, feeding



Possible effects of anthropogenic sounds

Physical

Death/severe injury

Hearing impairment

Immune system effects (via stress)

Behavioural

Masking

Displacement

Change in vocalisation

Possible effects of continuous anthropogenic sounds

Physical

Death/severe injury

Hearing impairment

Immune system effects (via stress)

Behavioural

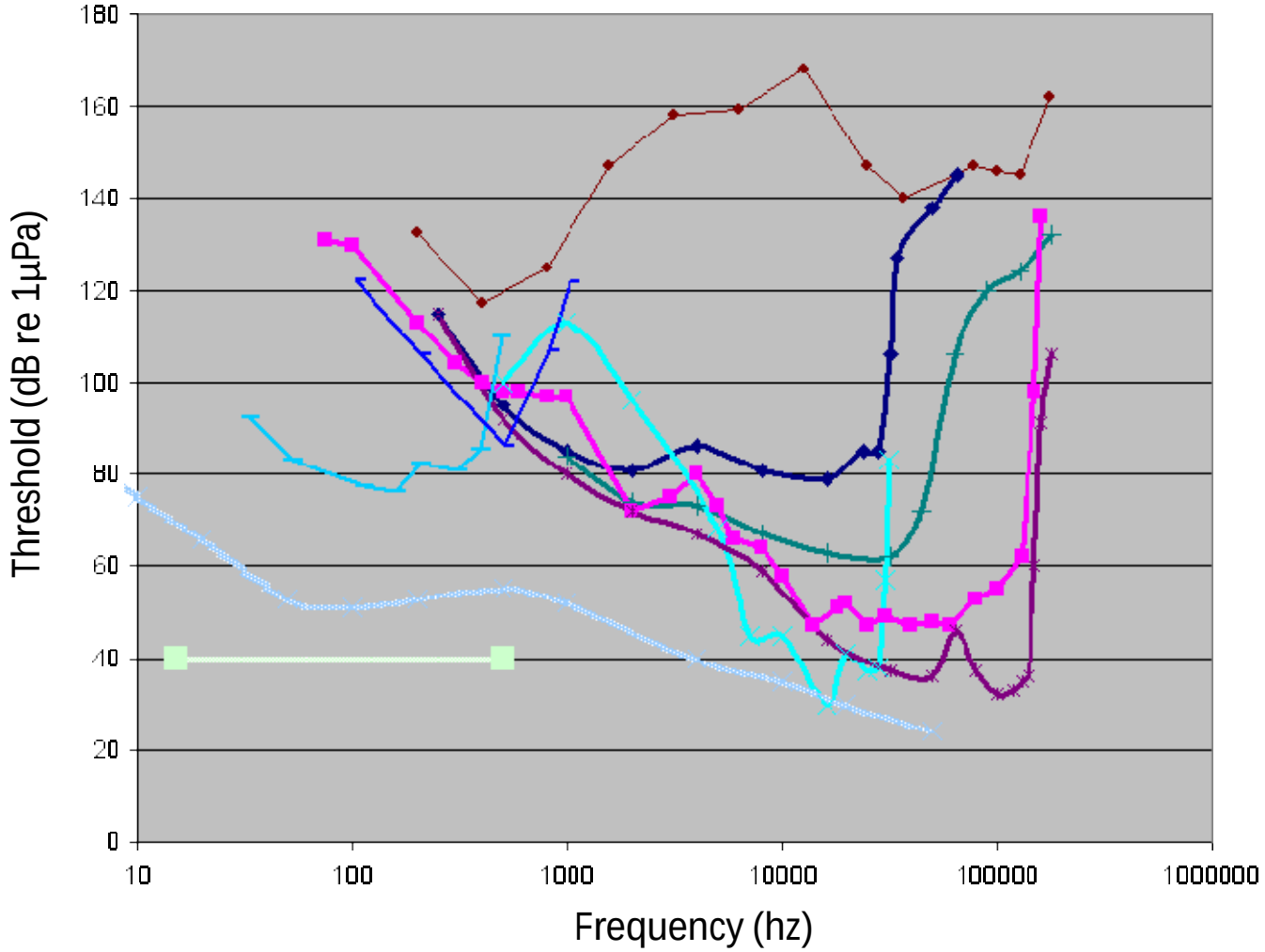
Masking

Displacement

Change in vocalisation

Applies to all marine animals that use sound to a greater or lesser extent

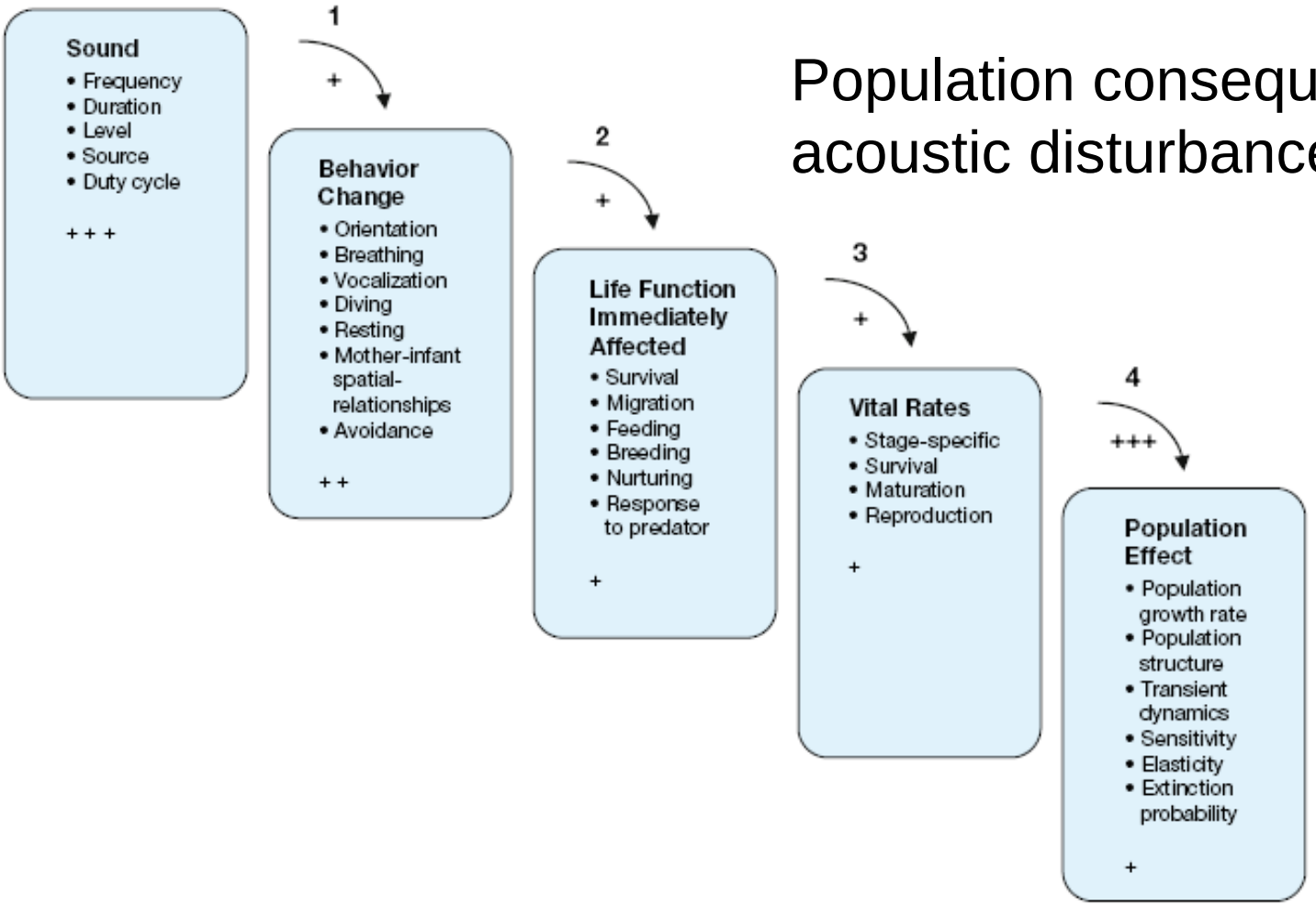
For any effect to occur, first need to sense the sound



Marine mammal and fish audiograms

Not all anthropogenic sounds will be sensed

Where we can observe a change in individual/group behaviour, it is difficult to link to population level



Population consequences of acoustic disturbance

Summary points

Continuous anthropogenic sounds made at most frequencies, but not at particularly high intensity

Better transmission of lower frequency sounds and wider prevalence of some natural sounds mean that anthropogenic sounds generally geographically predominate in the c50-150 Hz sound band

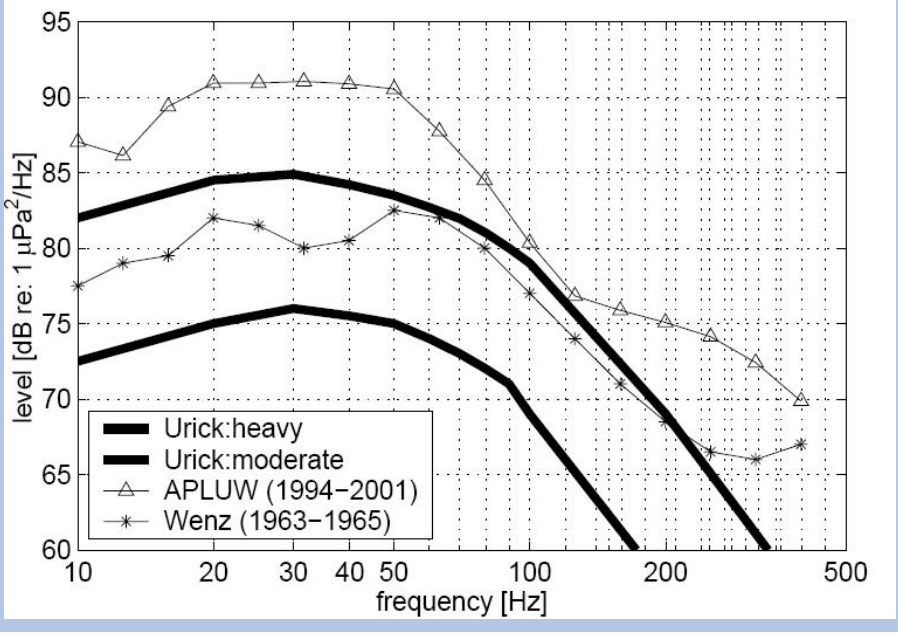
The hearing of most animals are not particularly sensitive at these low frequencies, but there is limited knowledge of frequency sensitivity in some groups, most notably the large whales

Knowledge of effects not good, knowledge of consequences of effects even worse

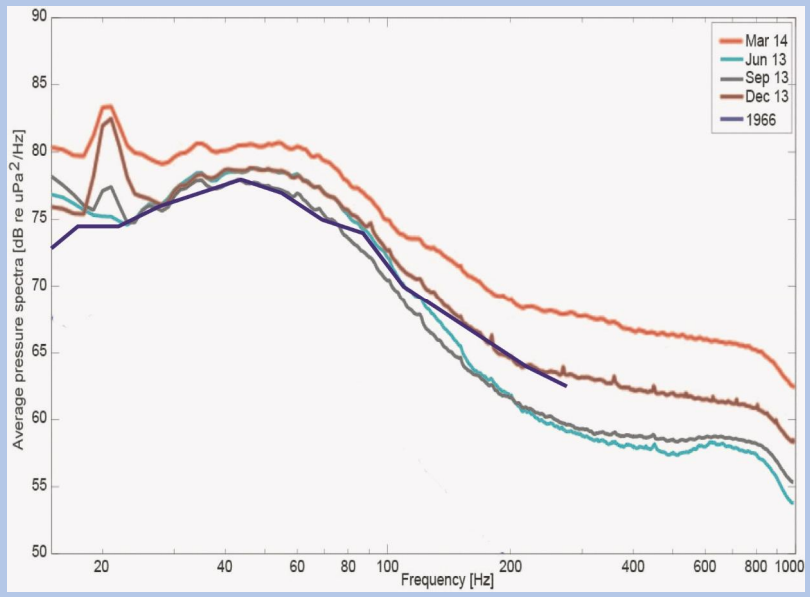
What has been happening with shipping noise?

Answer: Do not really know for sure; amount of shipping (tonnage) has increased, but size of ship increased and sound per tonne may have decreased

Increase in late 20th century off California (~3 dB per decade)



Increase also off Bermuda at max 0.5 dB per decade

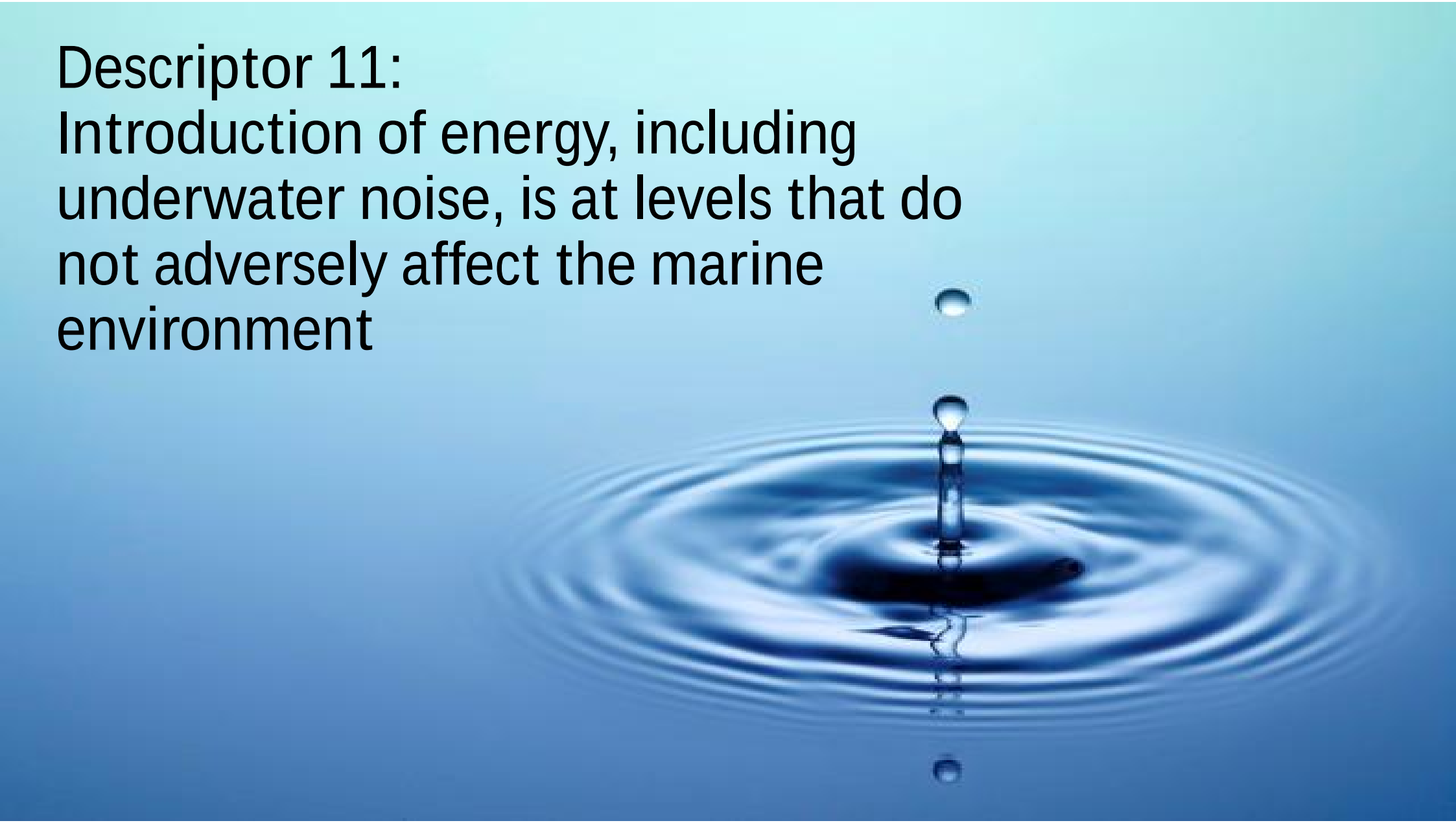


Marine Strategy Framework Directive

Overall aim: to ensure Europe's seas are in Good Environmental Status

Based on 11 descriptors covering the marine ecosystem and pressures on it

Descriptor 11:
Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment



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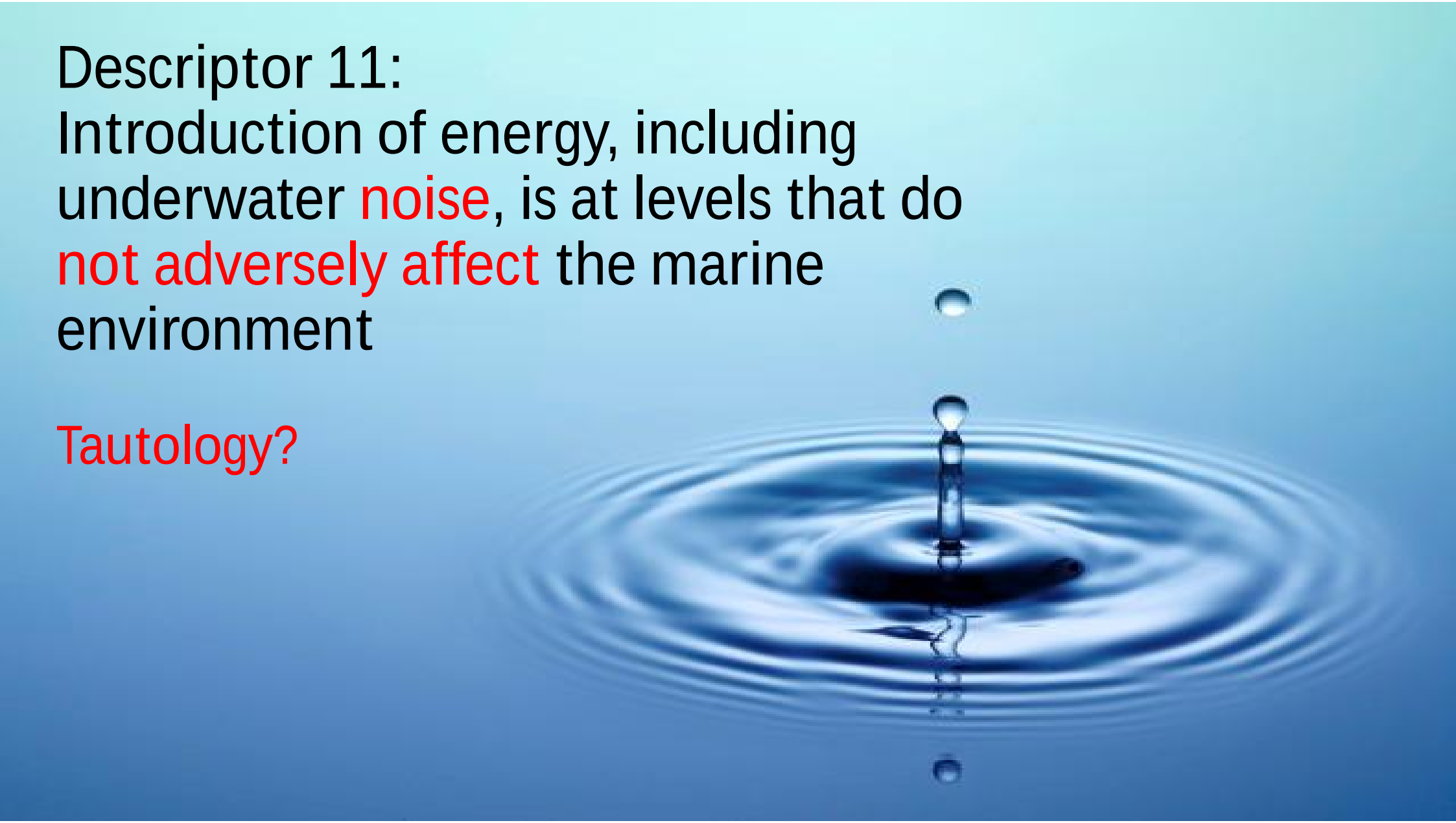
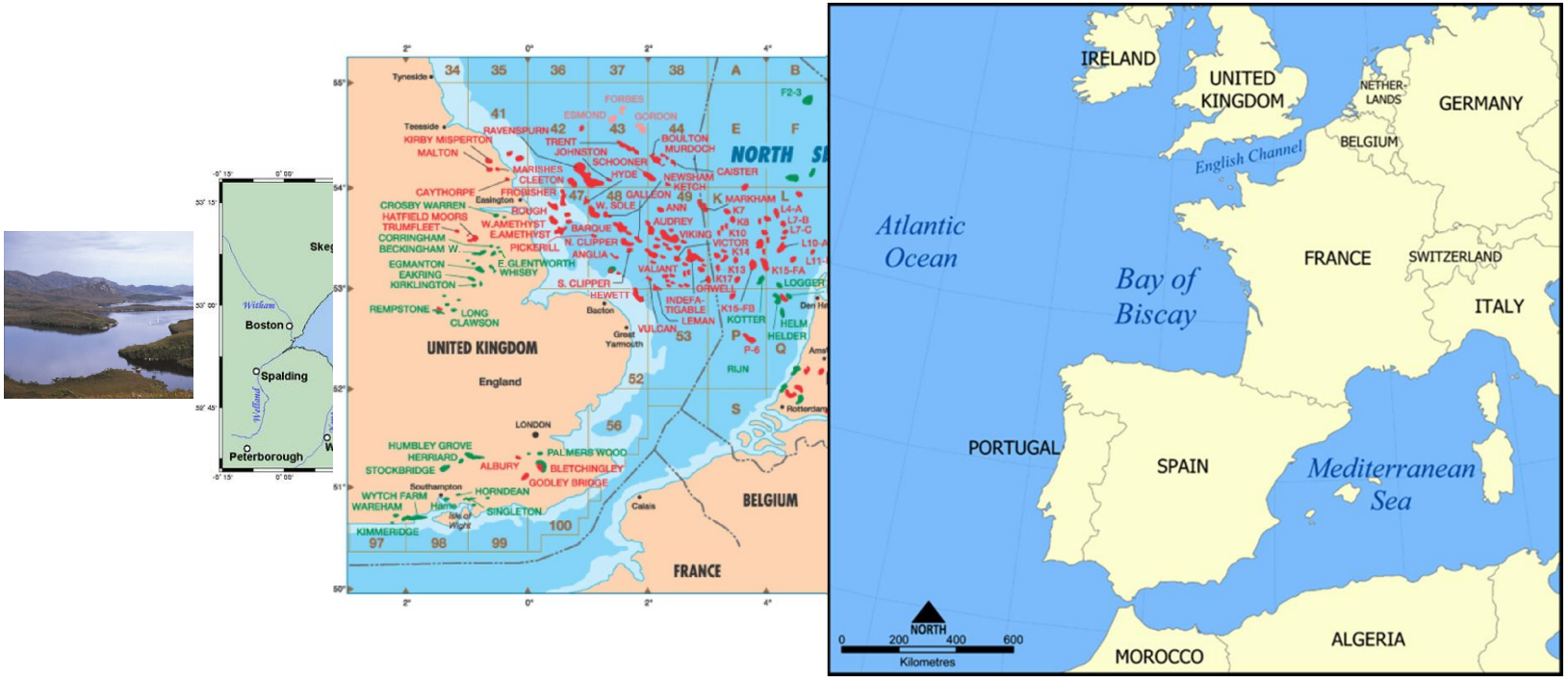
Tautology?



Marine environment

or components?

Adversely affect – what scale?



Temporal scale???

TG Noise

TG Noise

Been in existence in various guises since 2007

Currently chaired by Rene Dekeling and myself

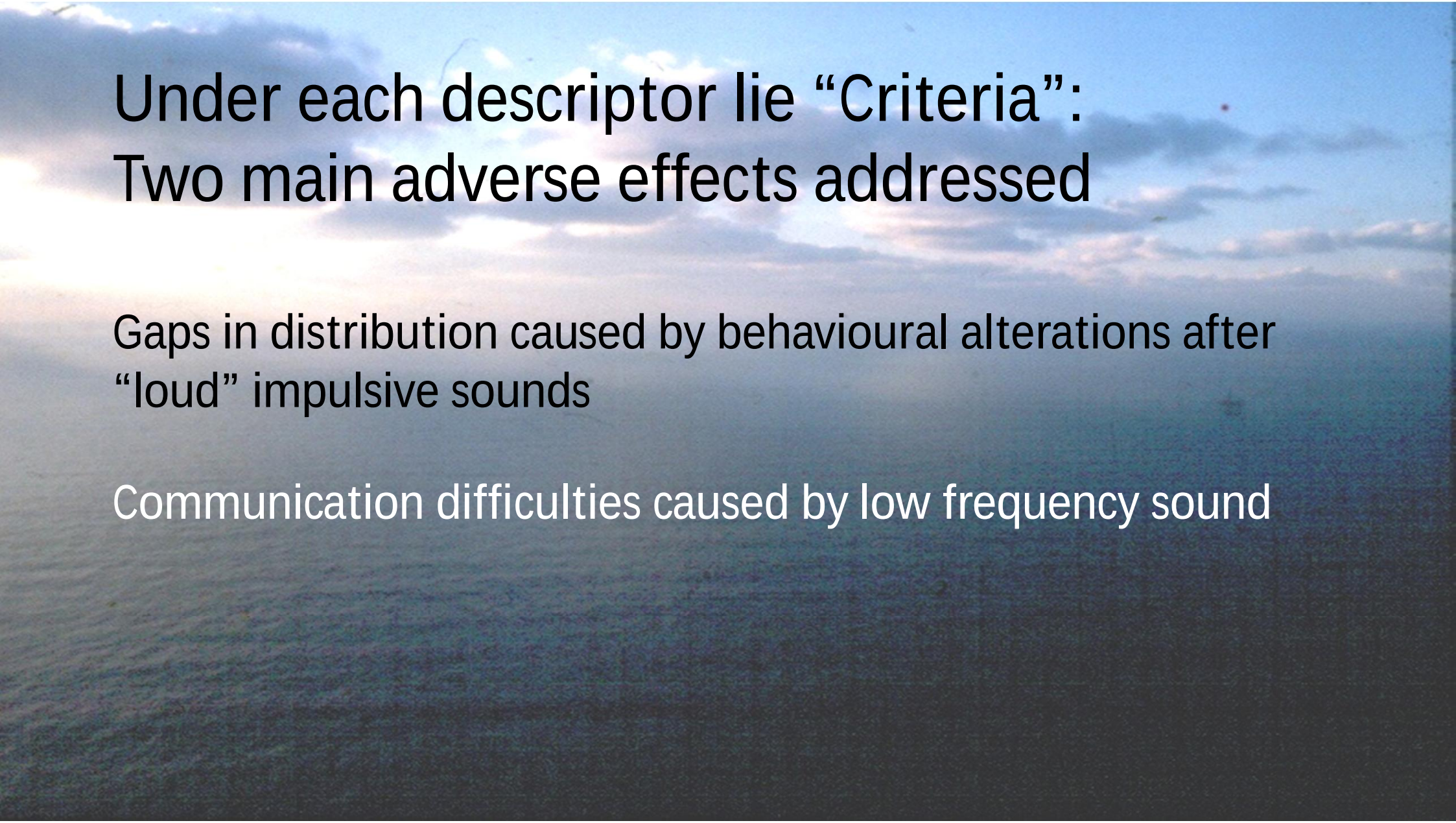
Provides technical advice to EU (and its Member States)

Advice includes technical interpretation of MSFD, monitoring guidance, co-ordination

Always keen to learn from experience of others, including globally

Made strong recommendations on implementation and research needs

Current work on setting thresholds



Under each descriptor lie “Criteria”: Two main adverse effects addressed

Gaps in distribution caused by behavioural alterations after “loud” impulsive sounds

Communication difficulties caused by low frequency sound

The spatial distribution, temporal extent and levels of anthropogenic continuous low-frequency sound do not exceed levels that adversely affect populations of marine animals.

Specification for monitoring and assessment

Annual average, or other suitable metric agreed at regional or subregional level, of the squared sound pressure in each of two ‘1/3-octave bands’, one centred at 63 Hz and the other at 125 Hz, expressed as a level in decibels in units of dB re 1 μPa, at a suitable spatial resolution in relation to the pressure. This may be measured directly, or inferred from a model used to interpolate between, or extrapolated from, measurements. Member States may also decide at regional or subregional level to monitor for additional frequency bands.

Unit of Measurement:
Annual average (or other temporal metric) of continuous sound level per unit area; proportion (percentage) or extent in square kilometres (km2) of assessment area with sound levels exceeding threshold values.

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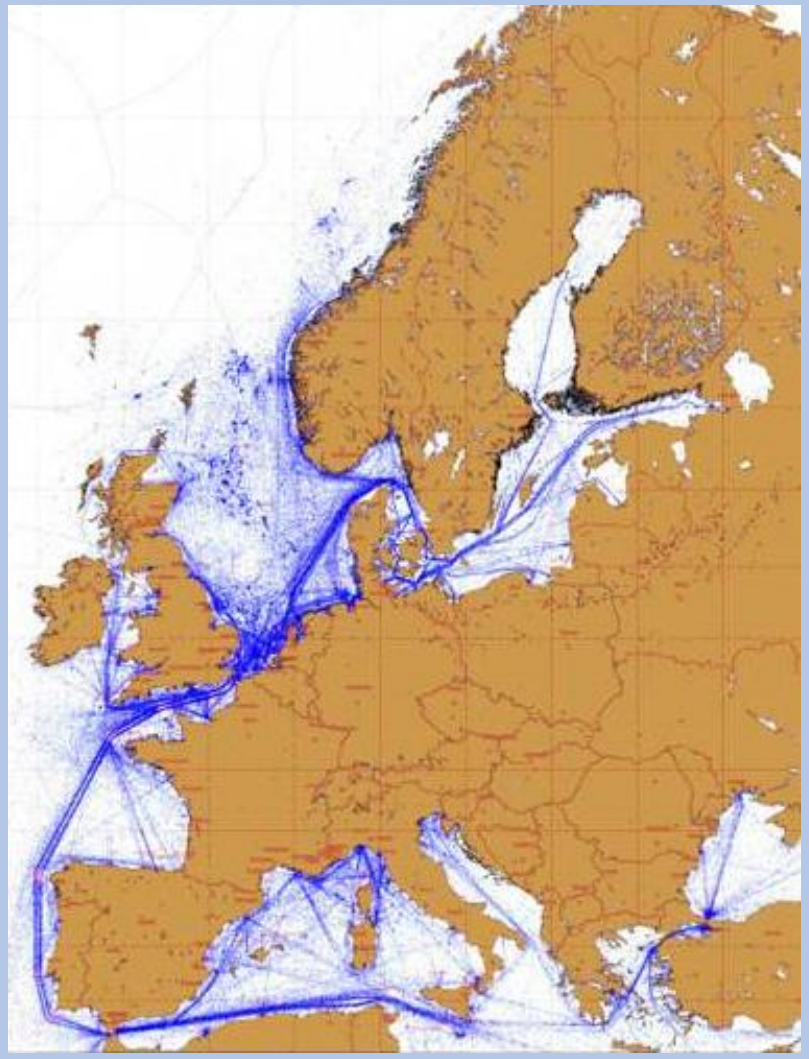
Monitoring of anthropogenic ambient (continuous) sound

Original thinking was to monitor trends in sound at frequencies dominated (on average) by anthropogenic sounds – mostly shipping – in wide areas

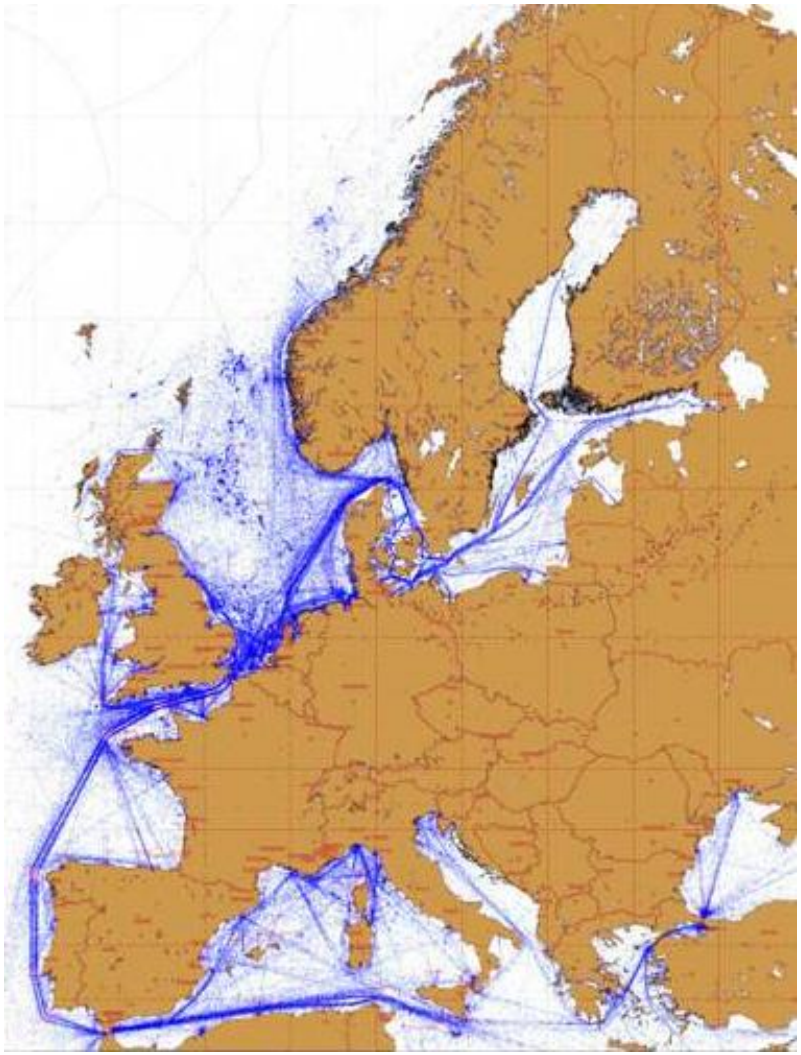
Original idea was not to describe all ship sounds at small scales, nor to determine effects



Obvious wide heterogeneity in shipping (and therefore of shipping sounds) geographically, with some temporal (seasonal) change also

Measuring and “averaging” therefore very challenging on an ocean basin scale

Variation in transmission of sound both geographically and seasonally



Setting of “thresholds” equally challenging

- Little existing information
- No agreement on scale (e.g. compare north and south North Sea)
- No real knowledge of “adverse effect”

BIAS

Baltic Sea Information on the Acoustic Soundscape

Interreg North Sea Region Jomopans

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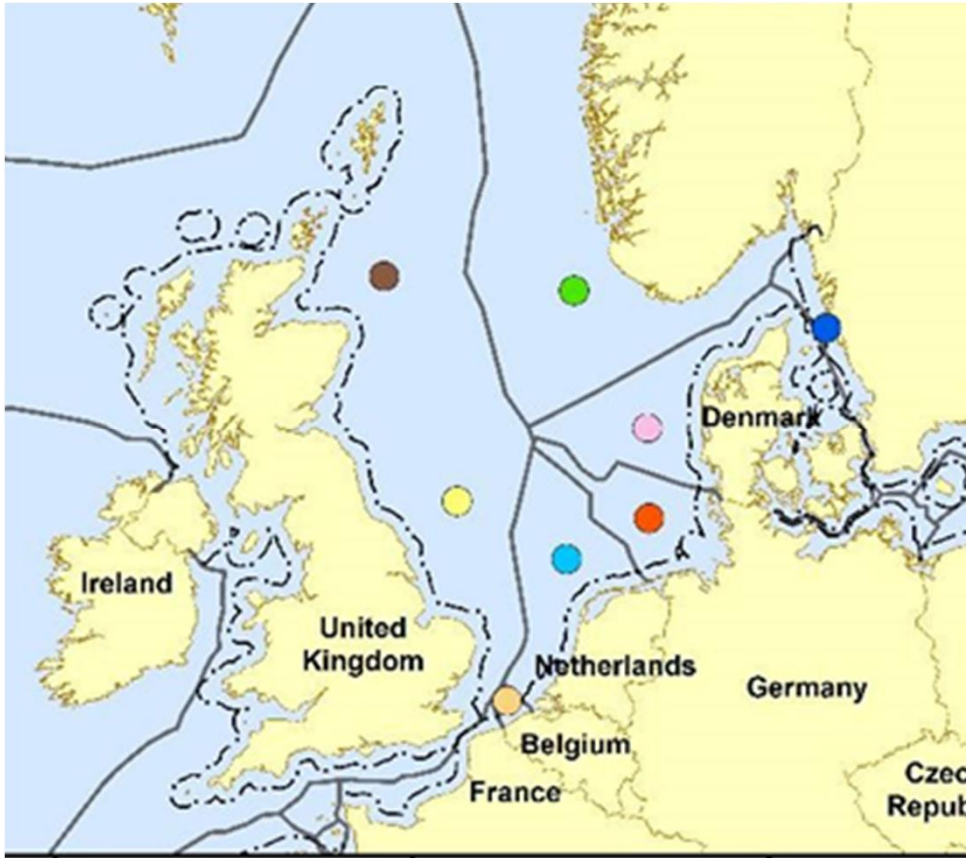
Learn from previous projects

Monitoring:

- goes beyond a project
- requires long-term sustainability
- design for North Sea
- keep it simple
- keep it cheap



Need also to consider two key issues

What effects are occurring, and do these occur at the population level?

What “management” is possible?

Monitoring schemes should be designed to provide evidence to take account of, or to support these

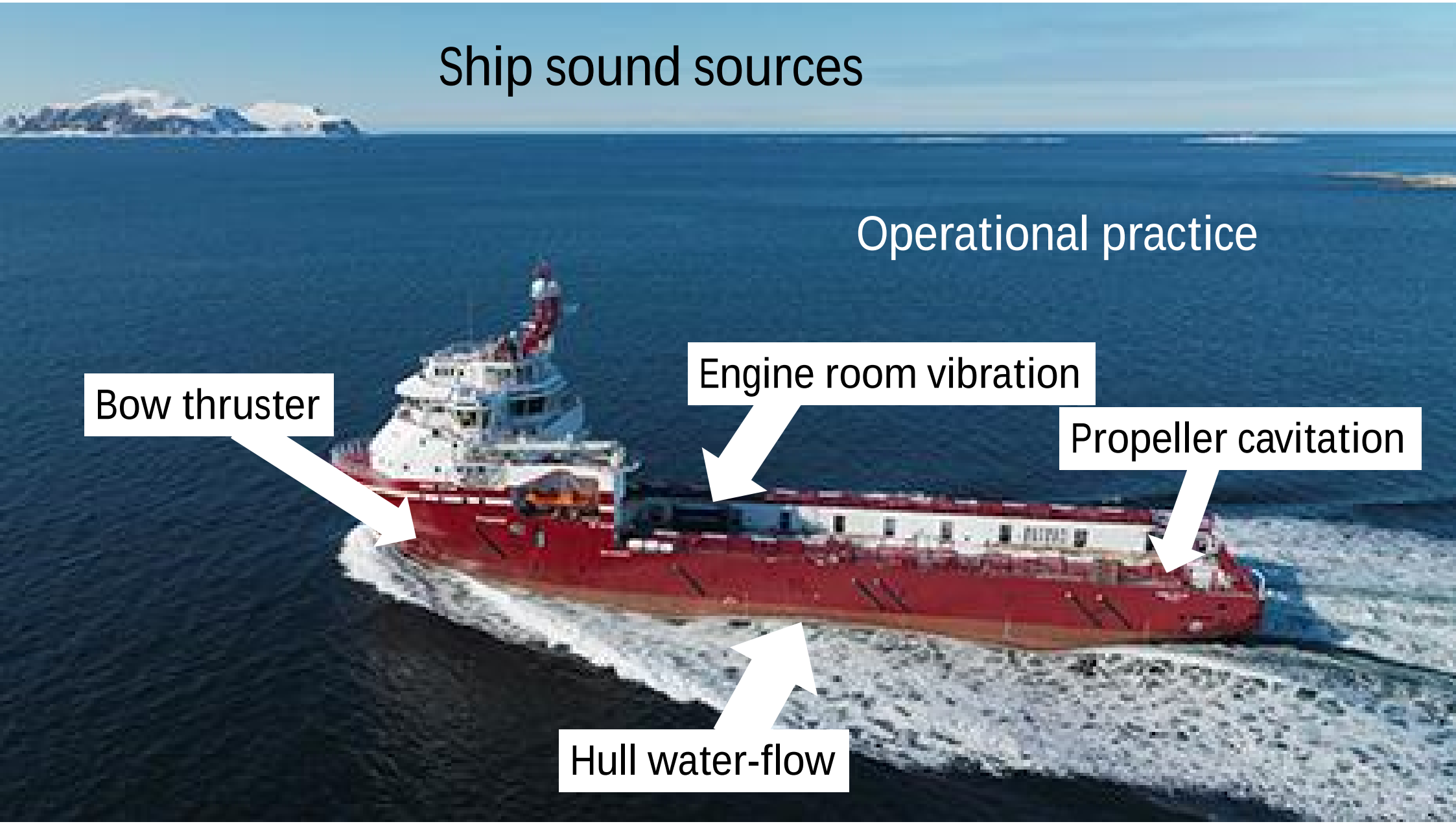
Impact studies at population level needed

Need to put any impact into context AND determine how it relates to other impacts

Effects are not necessarily additive, e.g. displacement may reduce effect of masking

Effects might though compound each other – population recovery following e.g. reduction caused by bycatch, may be inhibited if anthropogenic sound reduces breeding performance

Most obvious case is commercial fish – biggest human impact is fishing, but what role might ocean sound play in population dynamics (and in fishing?)


Ship sound sources
Operational practice
Bow thruster
Engine room vibration
Propeller cavitation
Hull water-flow


Reducing these sounds will require investment, that will need to be justified, and not just in Europe
Bow thruster
Engine room vibration
Propeller cavitation
Hull water-flow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