

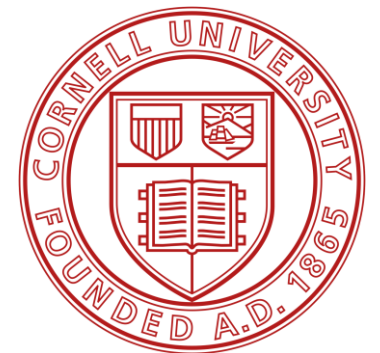
# Ruido submarino y su efecto en la fauna. Un enfoque para el licenciamiento ambiental



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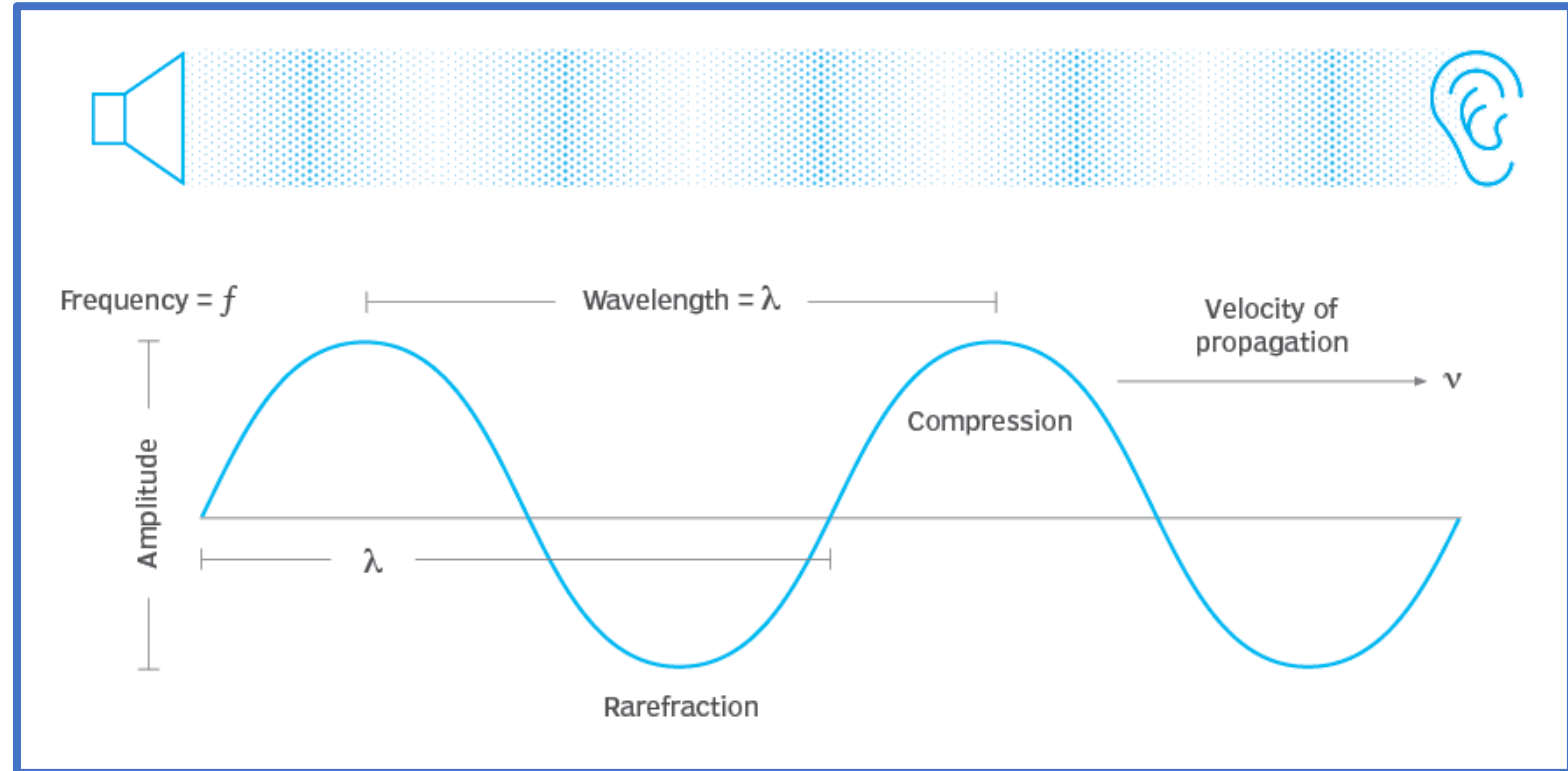
# Contenido

- Principios del sonido submarino
- Propagación del sonido
- Paisajes sonoros
- Ruido y sus efectos
- Mediciones de ruido
- Estudios de caso
- Monitoreo y regulación



# Principios de Acústica submarina

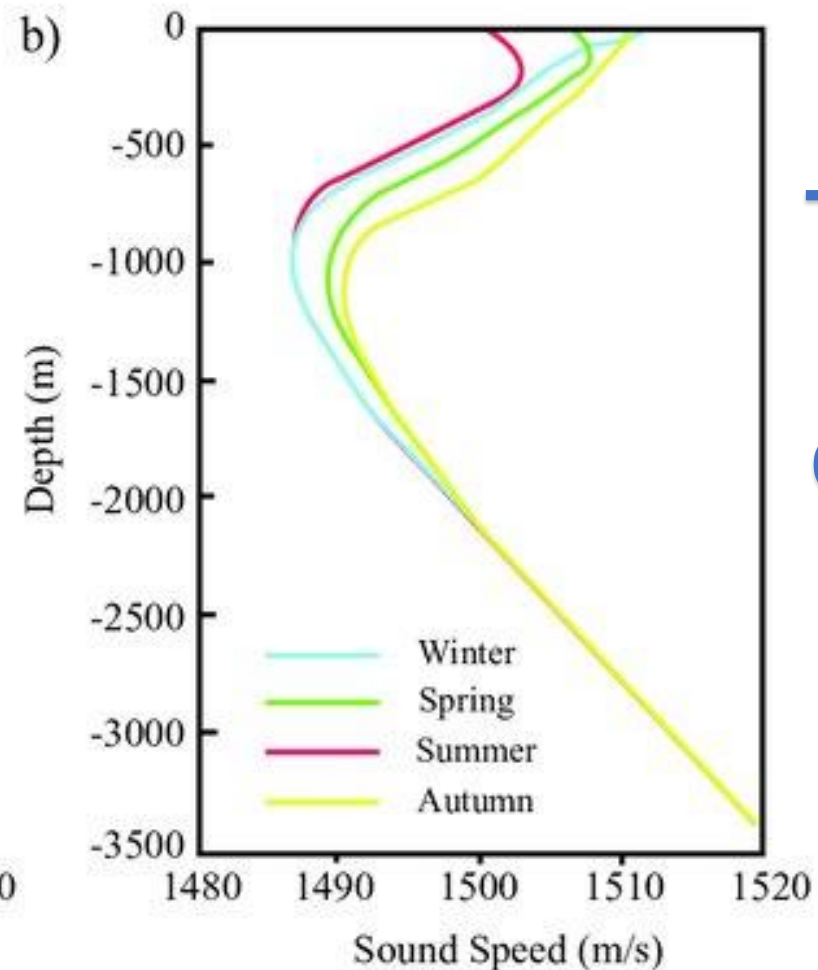
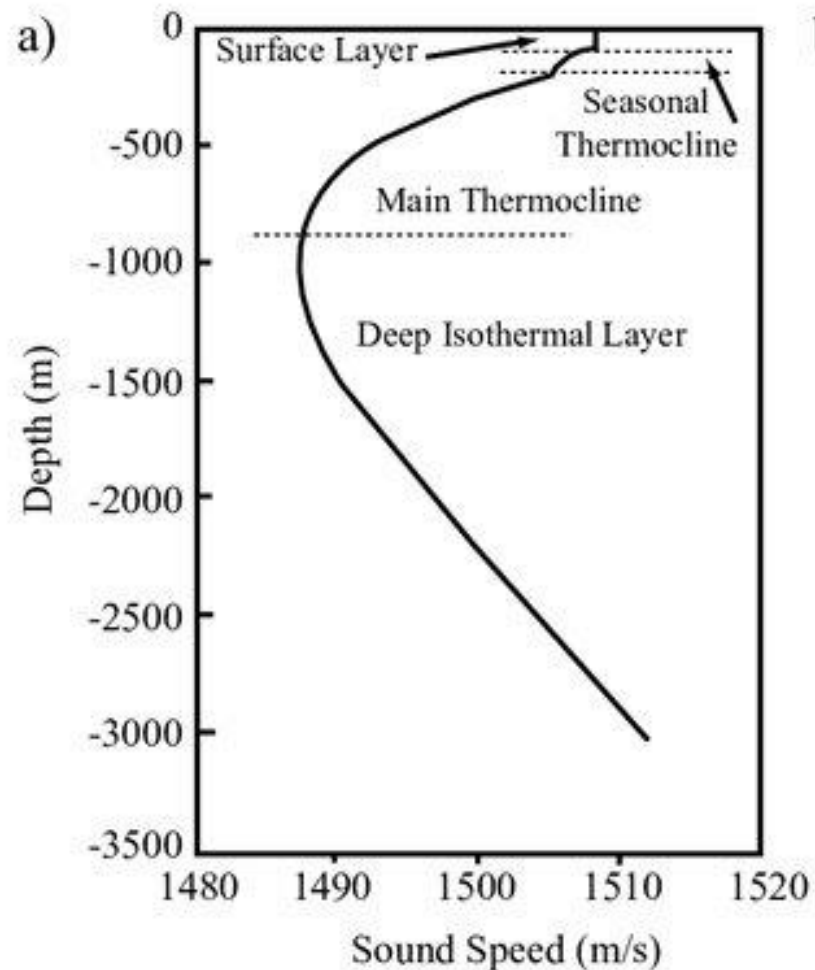
- **Sonido**  
Onda mecánica longitudinal



- El sonido viaja diferente en agua y en aire.
- 4.3x más rápido:  $343\text{m/s} \ll 1482\text{m/s}$



# El sonido en el mar – perfil de velocidad



→ SOFAR  
Autopista  
de sonido!

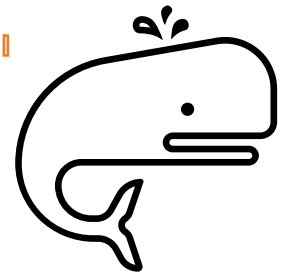
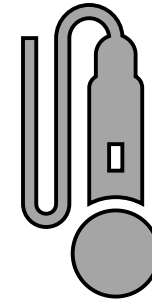
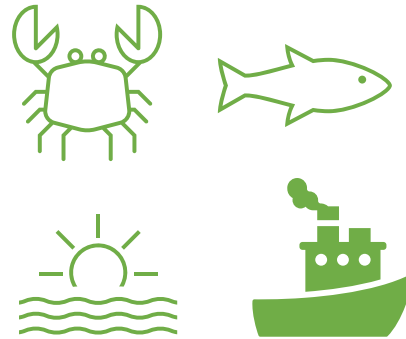
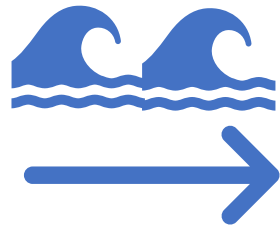
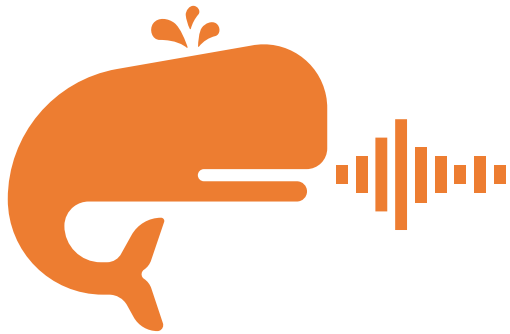


(Simao, 2009)

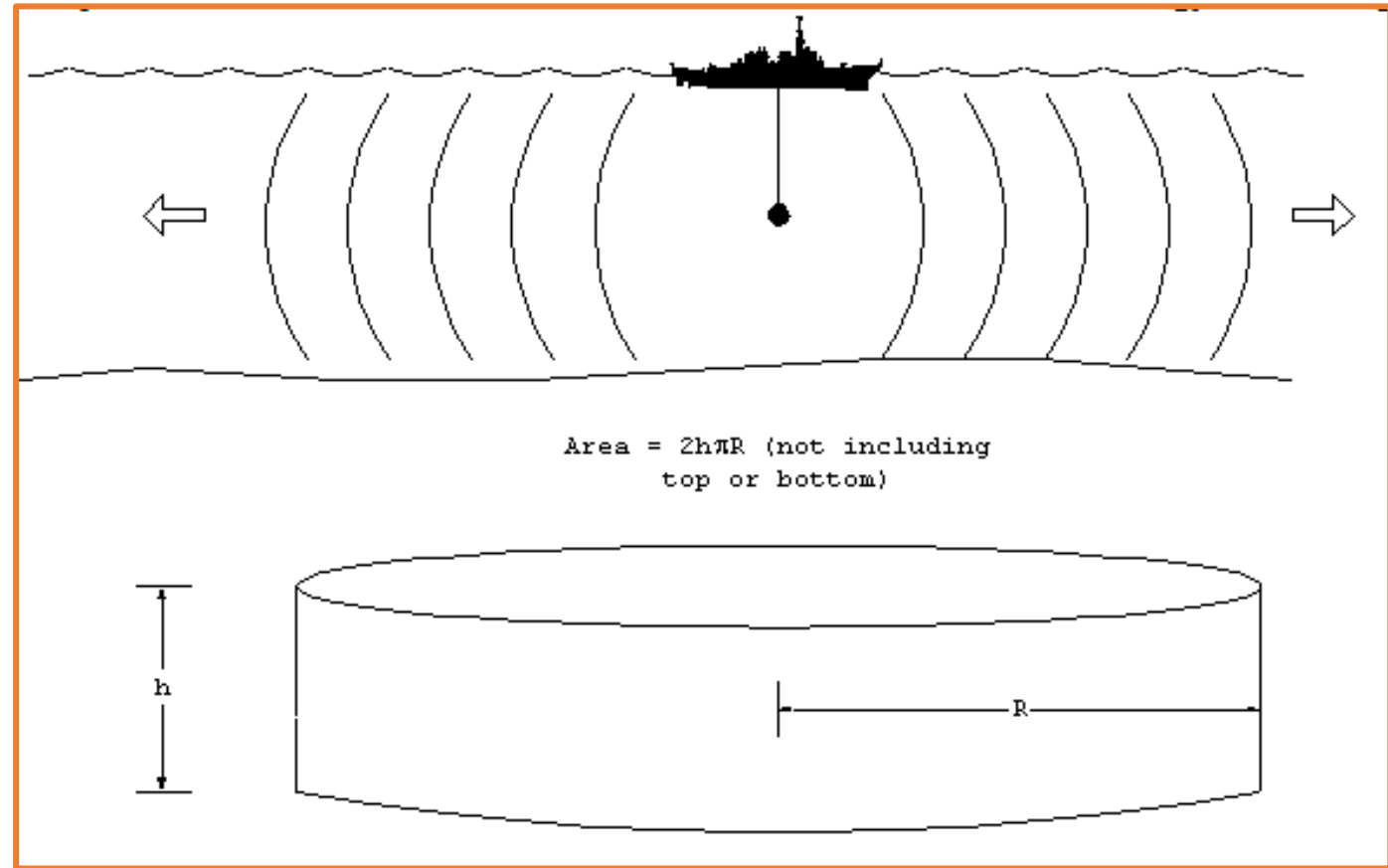
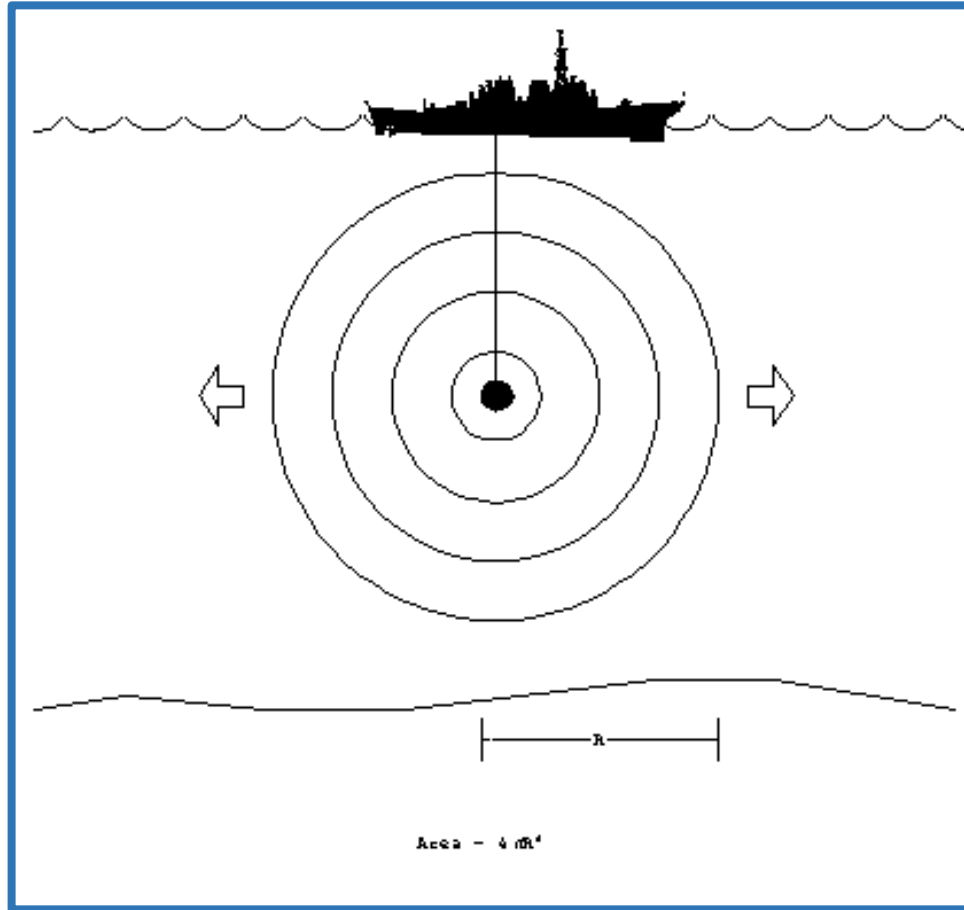
# Ecuación del SONAR -pasivo

Propagación del sonido debajo del agua

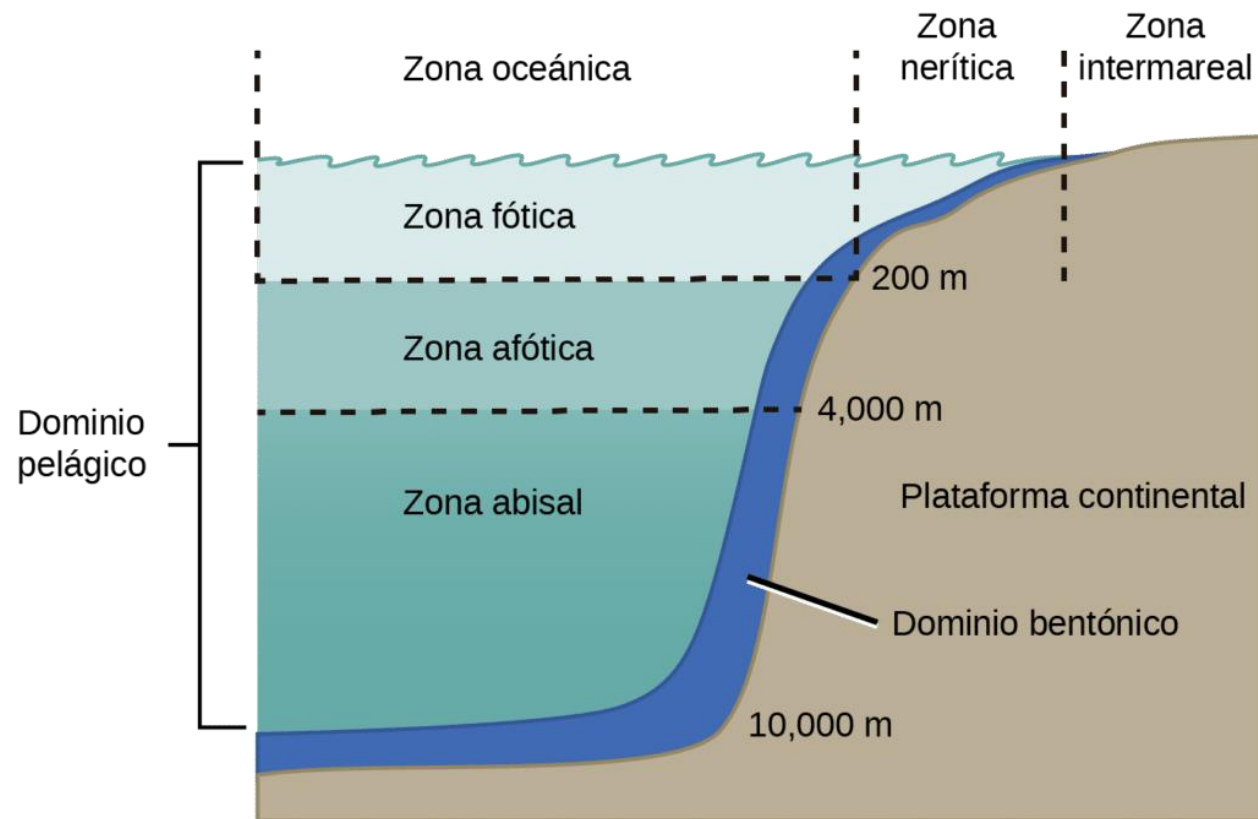
$$SL - TL - (NL - PG) \geq DT$$



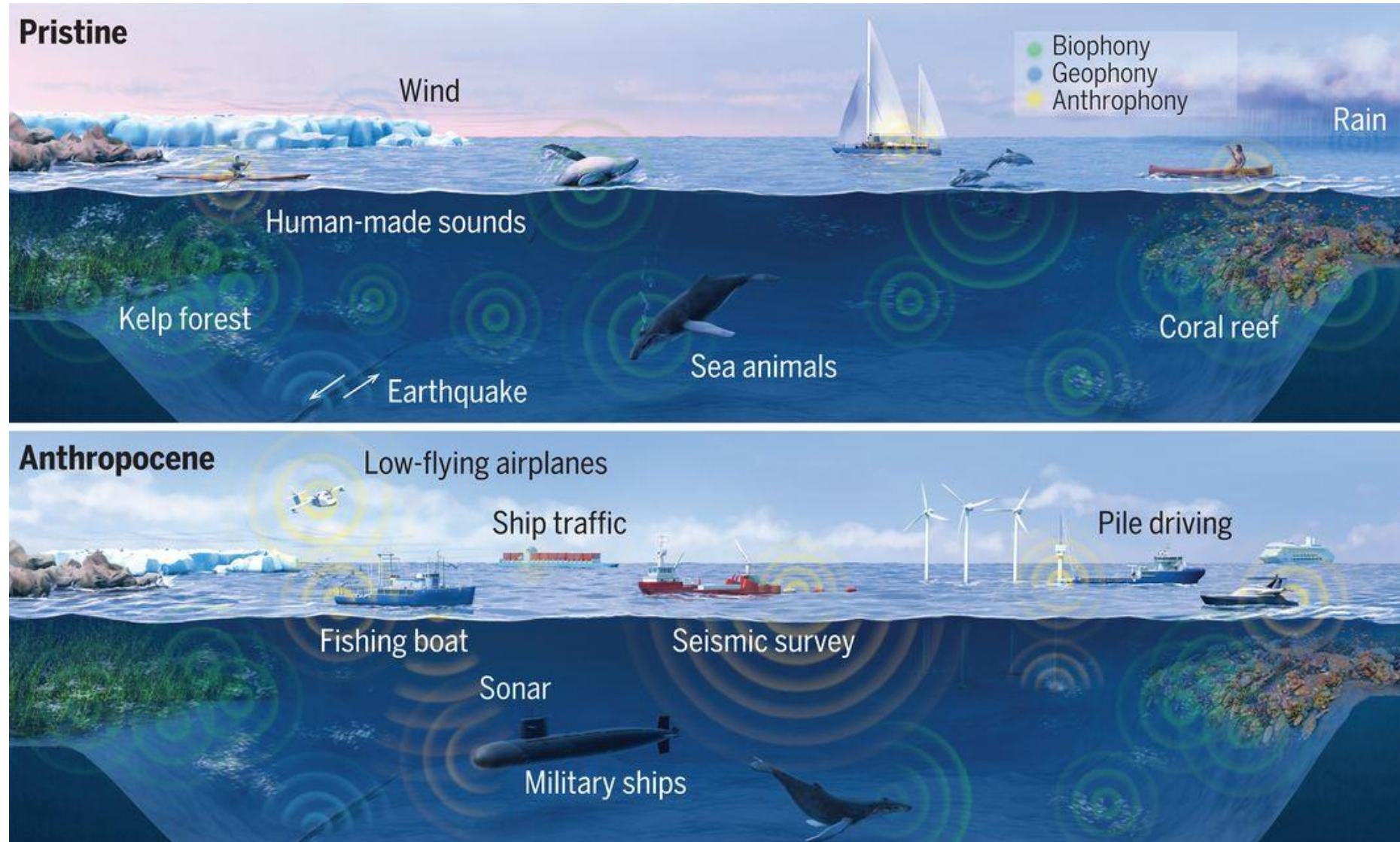
# Tipos de propagación acústica submarina



El sonido es fundamental en el océano, ya que es el principal medio de comunicación entre los organismos.

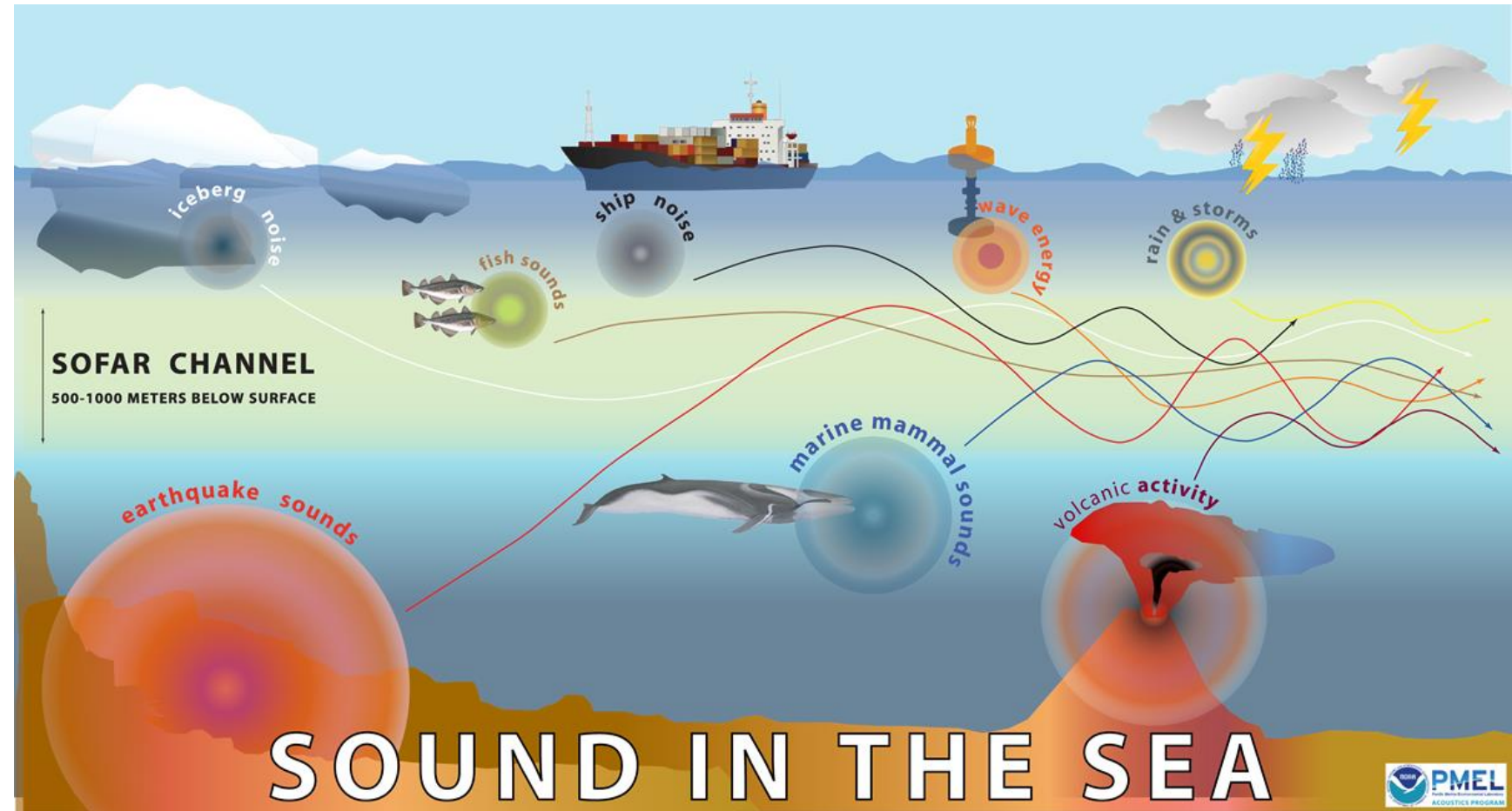


# Paisaje acústico

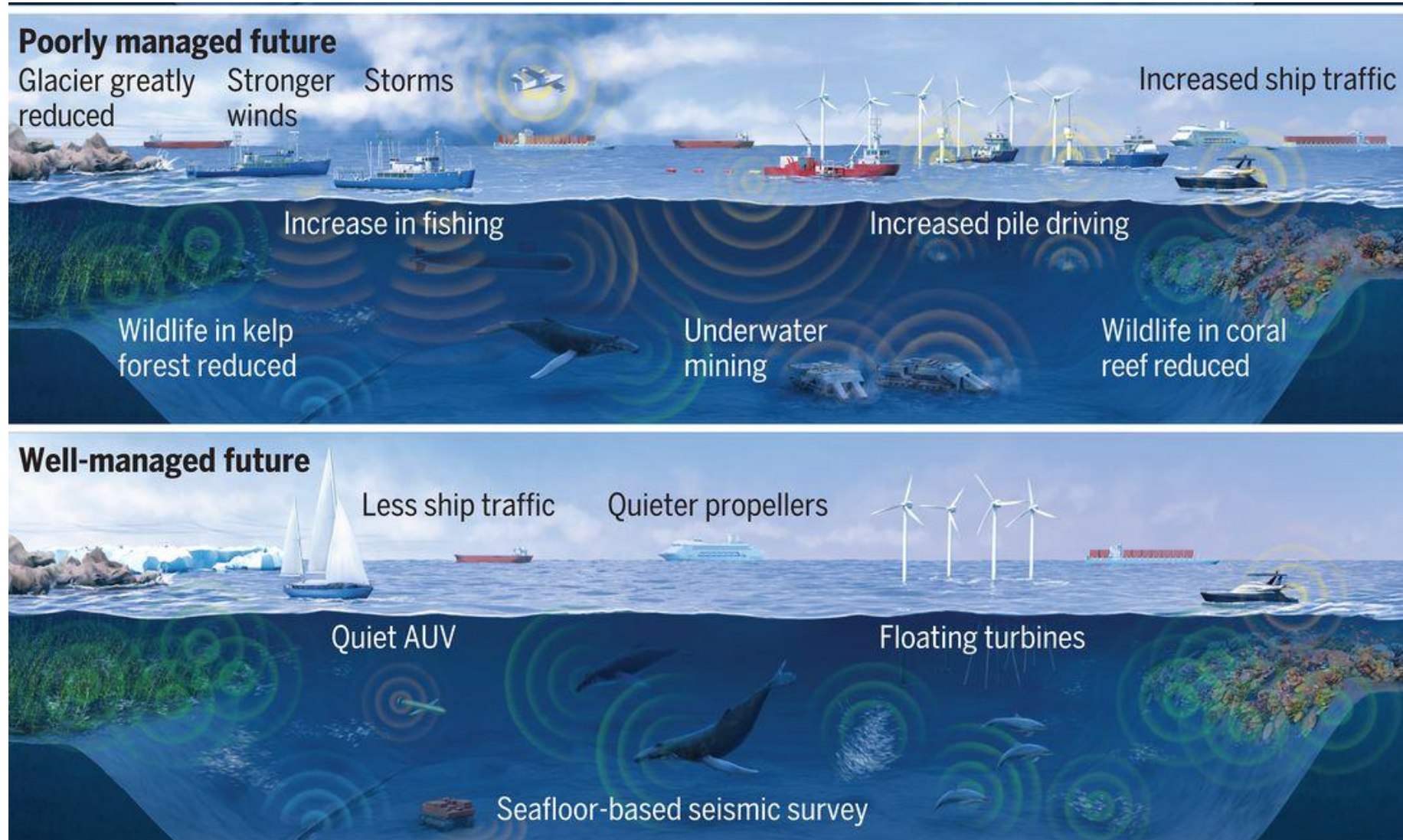


# Fuentes de ruido submarino

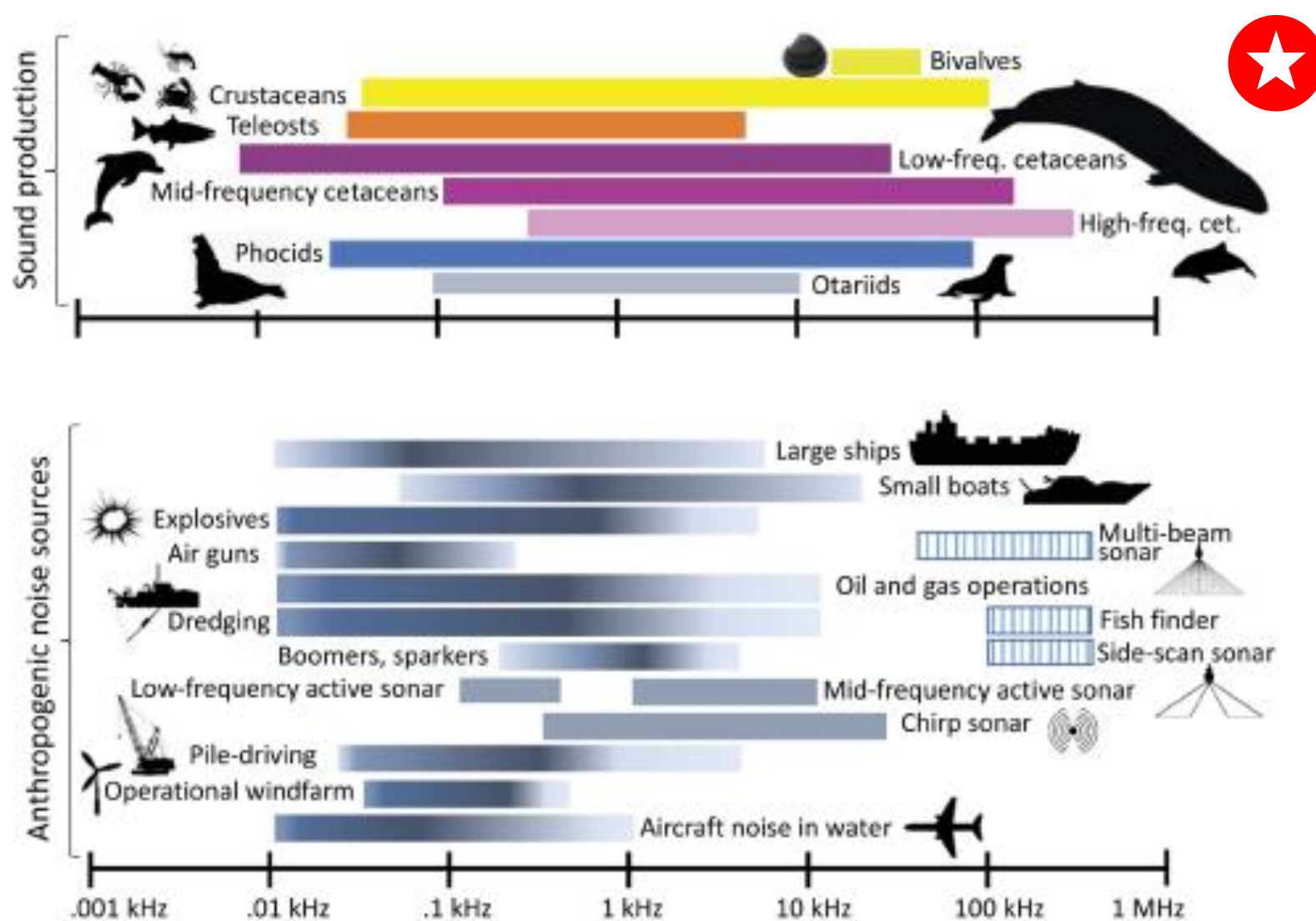
- **Categorías de fuentes de ruido** (Shannon et al. 2016)
  - Ambiental
  - Transporte (vehículos, embarcaciones, aeronaves no militares)
  - Industrial (estudios sísmicos, Instalación de estructuras)
  - Militar (explosiones, disparos, aviones, sonares)
  - Recreación (barcos para avistamiento de ballenas, recorridos aéreos en helicópteros)
  - Otros (sintético, indefinido)



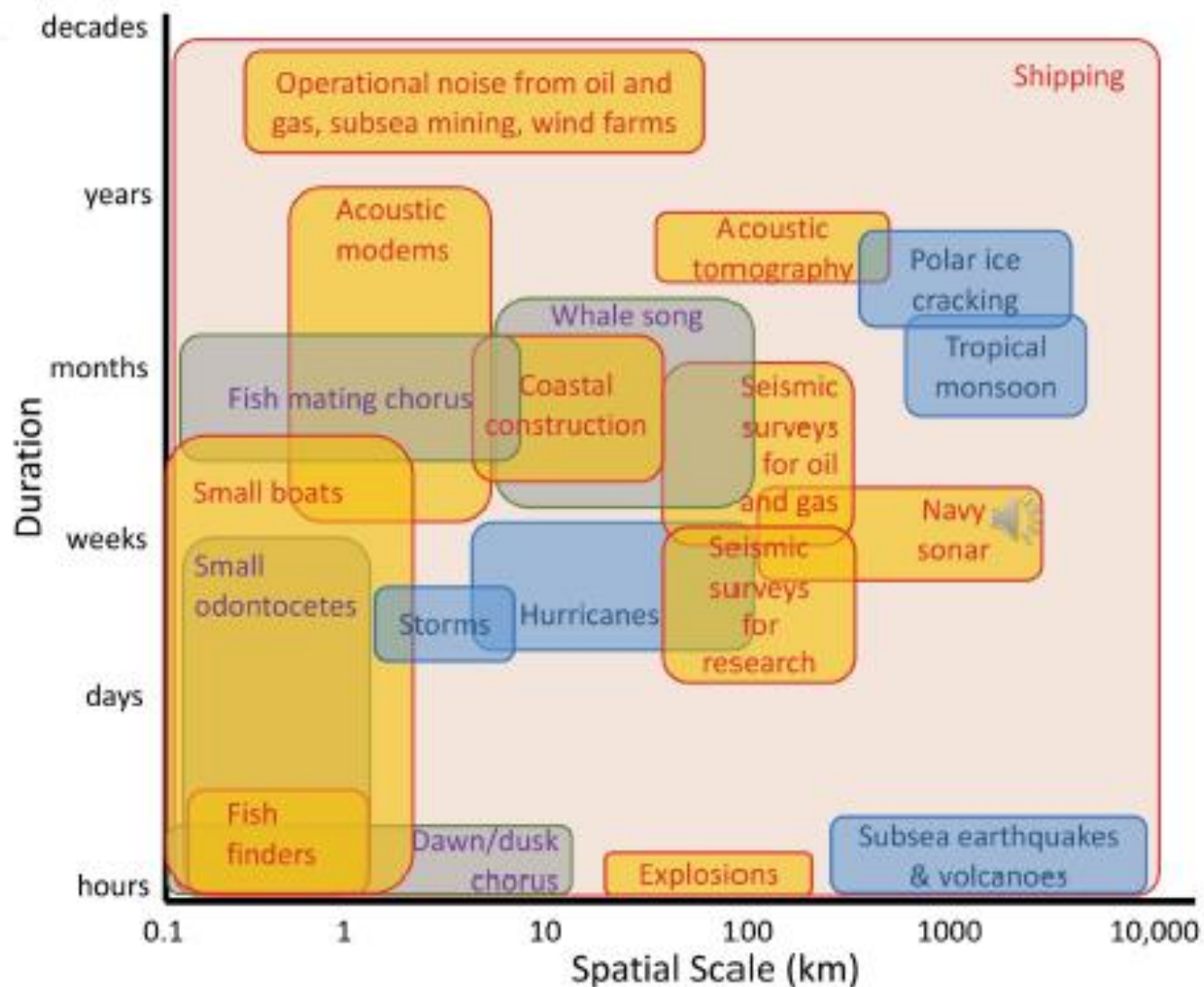
# Viendo hacia el futuro



# Interferencia del ruido en frecuencia



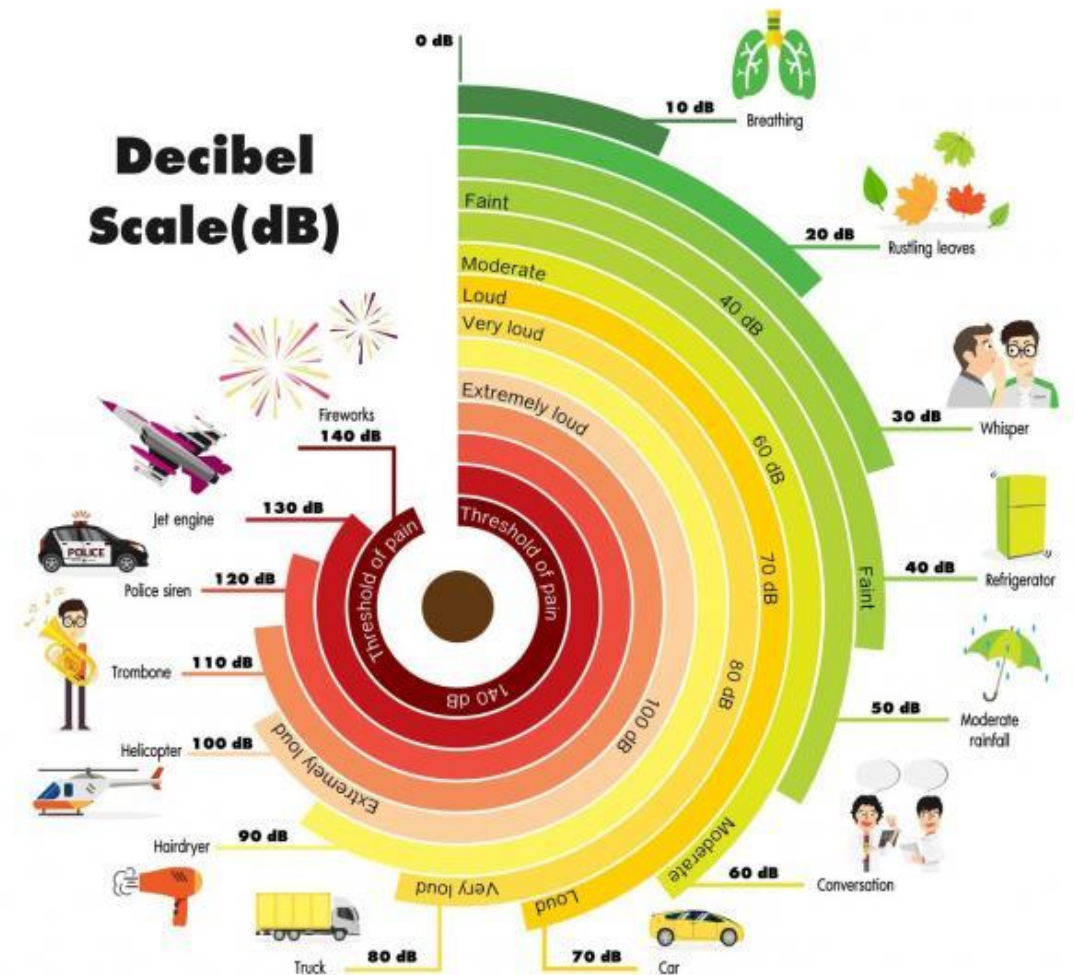
# Interferencia del ruido en escala espacio-temporal



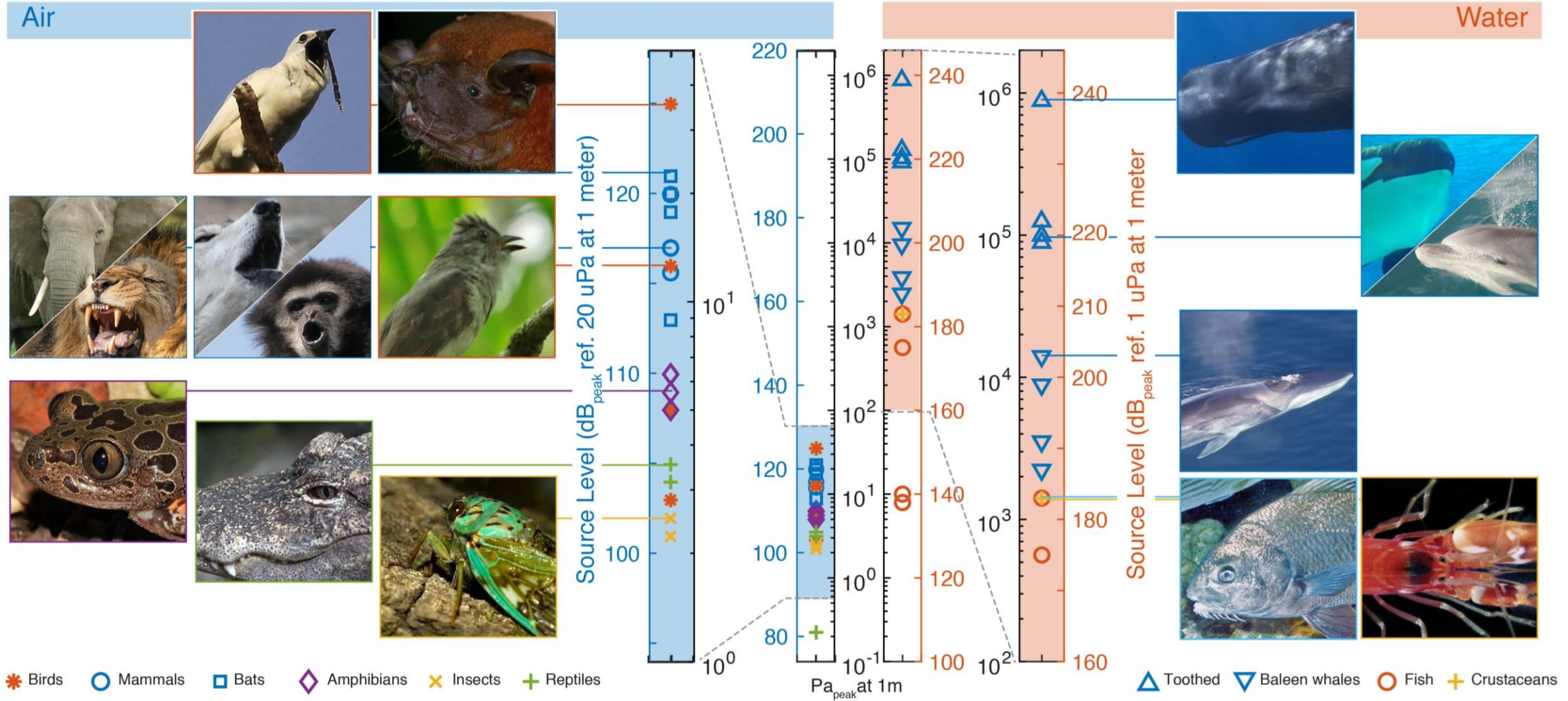
Cómo se mide el ruido?

# Presión Sonora y decibelios

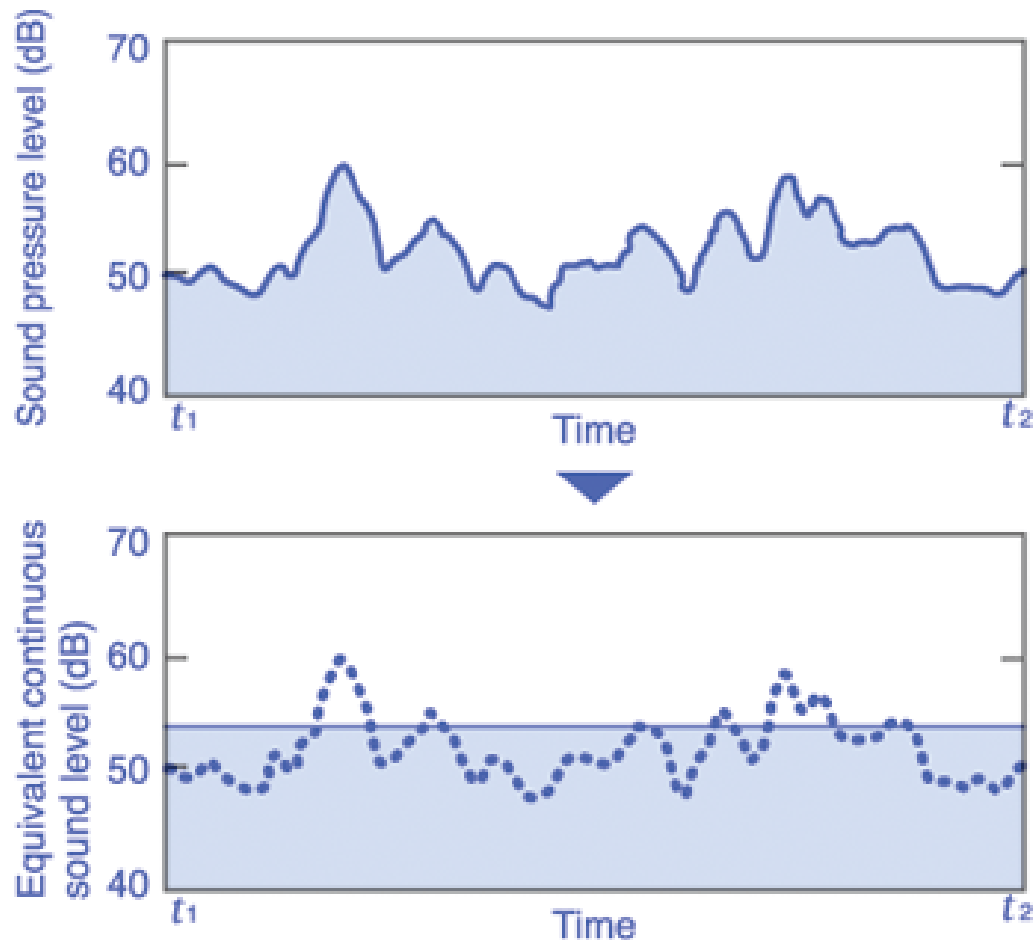
- Fuerza por unidad de area. → Con que fuerza se mueven las particulas en el medio.
- Depende de la Fuente
- Escala logaritmica – decibelios
  - 1uPa referencia
- dBs en agua y en aire NO SON lo mismo (61x mas en agua)



C

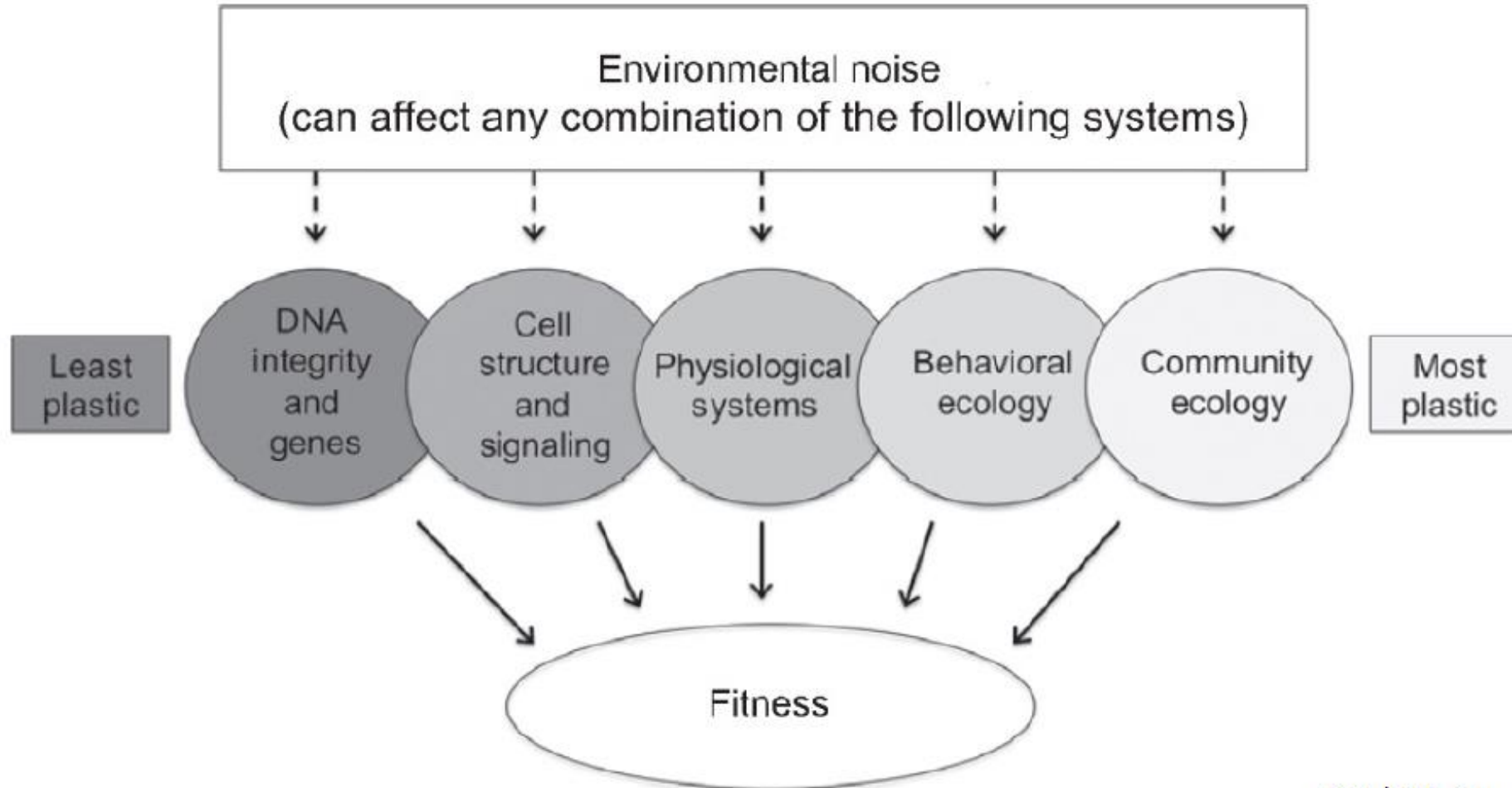


# Leq y SEL (no todos los dB son iguales)



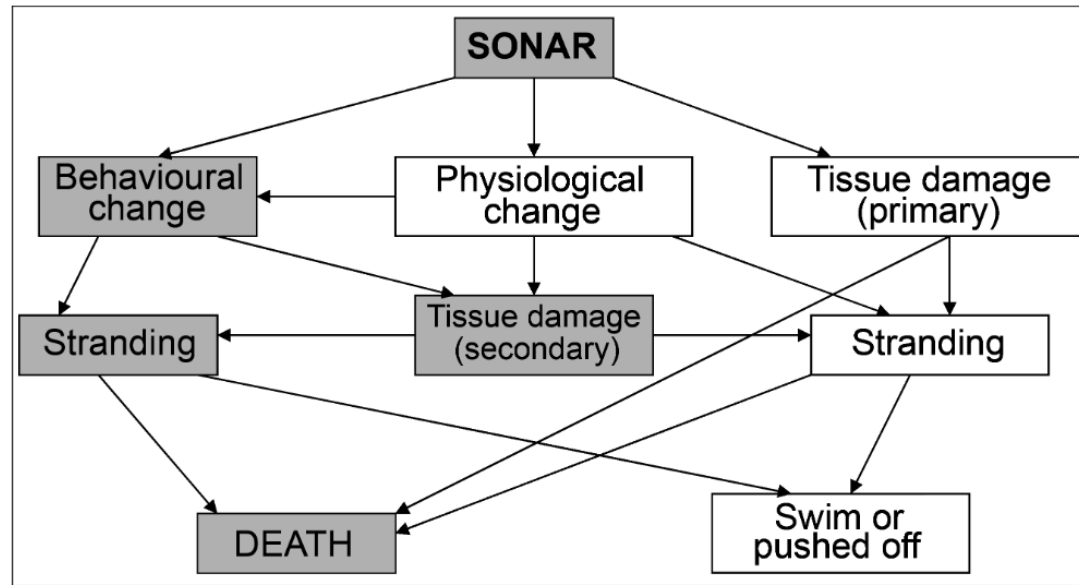
Sound pressure level and equivalent continuous sound level

# Impacto de ruido en animales



(Kight & Swaddle 2011)

# Ballenas picudas o Zífidos



# Ballena Franca Atl. Norte

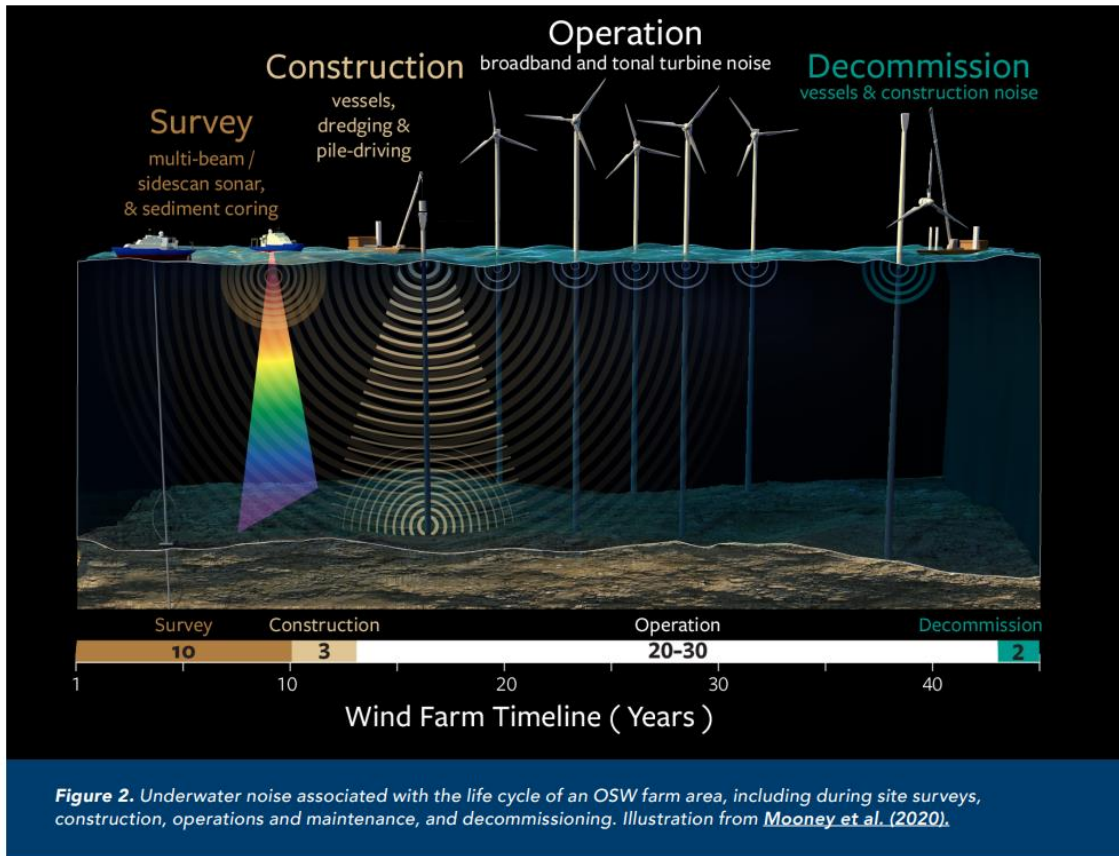
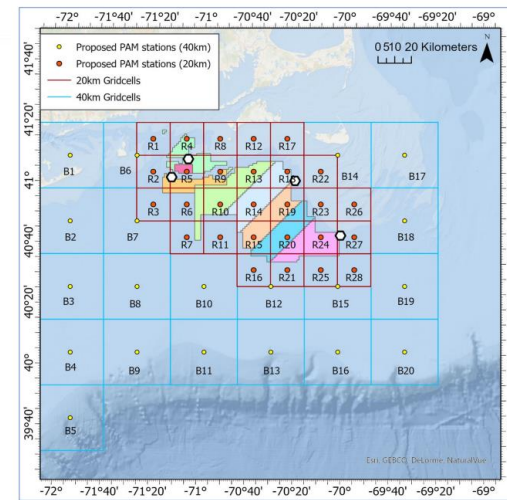
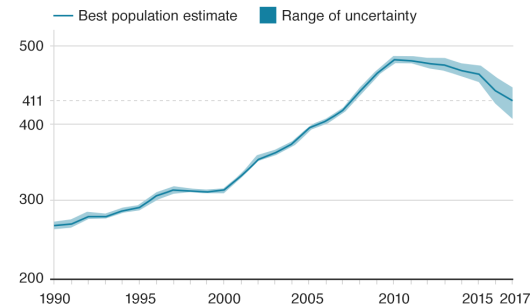


Figure 2. Underwater noise associated with the life cycle of an OSW farm area, including during site surveys, construction, operations and maintenance, and decommissioning. Illustration from Mooney et al. (2020).



Study area for the POWERON effort in the Massachusetts and Rhode Island Wind Energy Areas to understand potential pre- and post construction impacts.

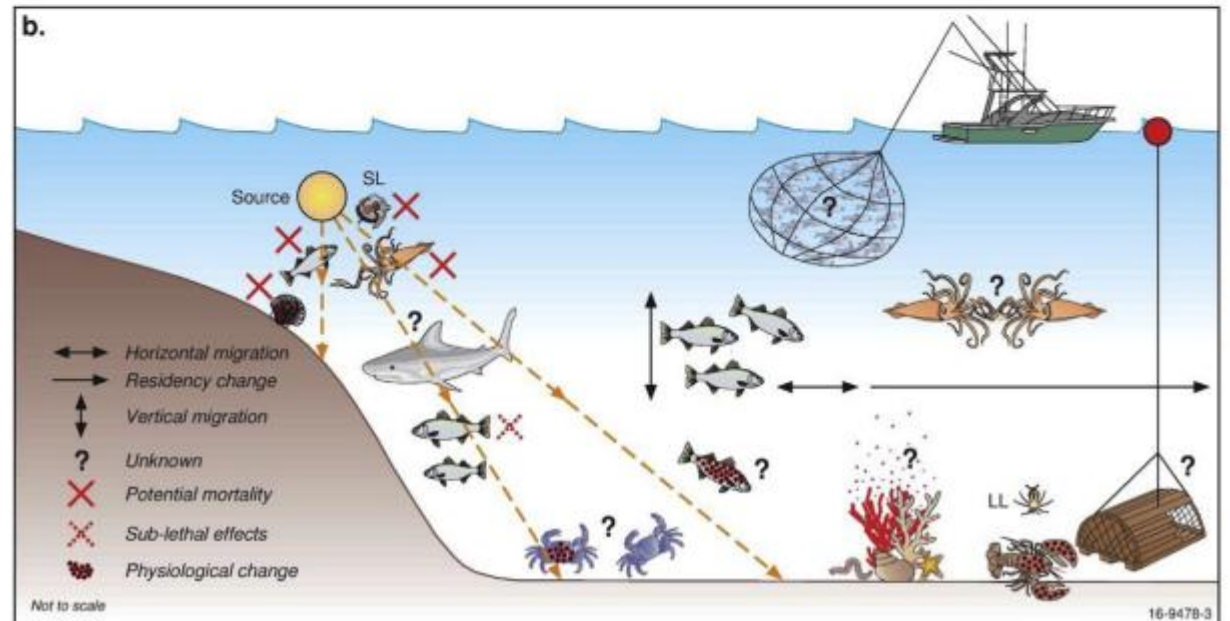
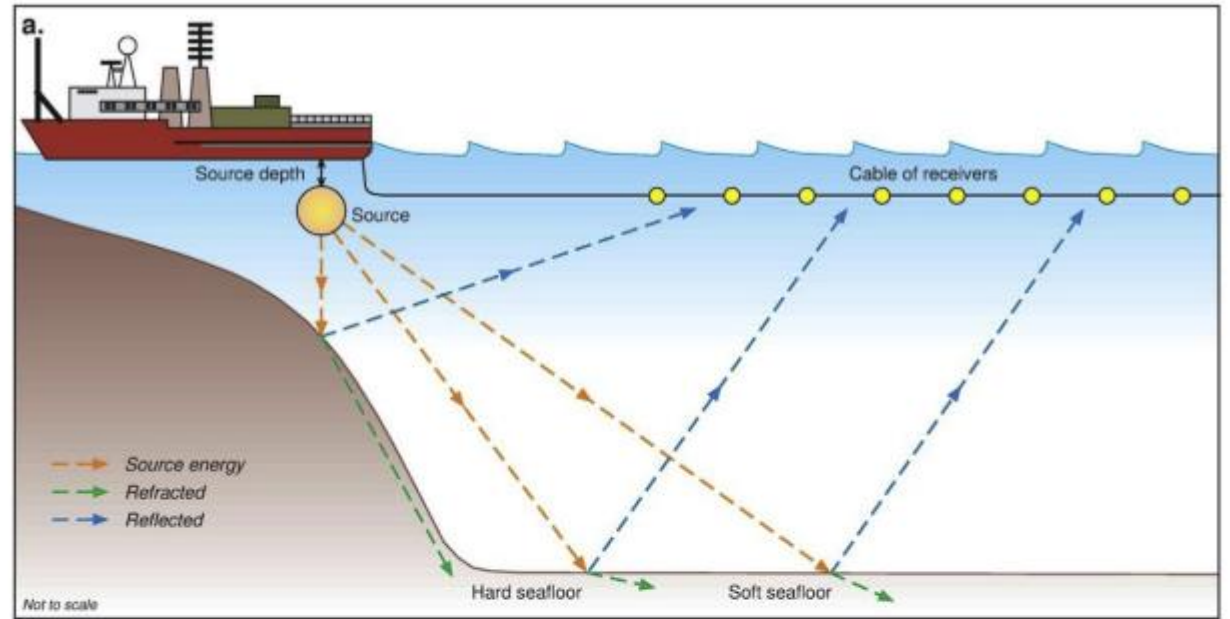
**Downturn in right whale population**  
North Atlantic right whale population 1990-2017



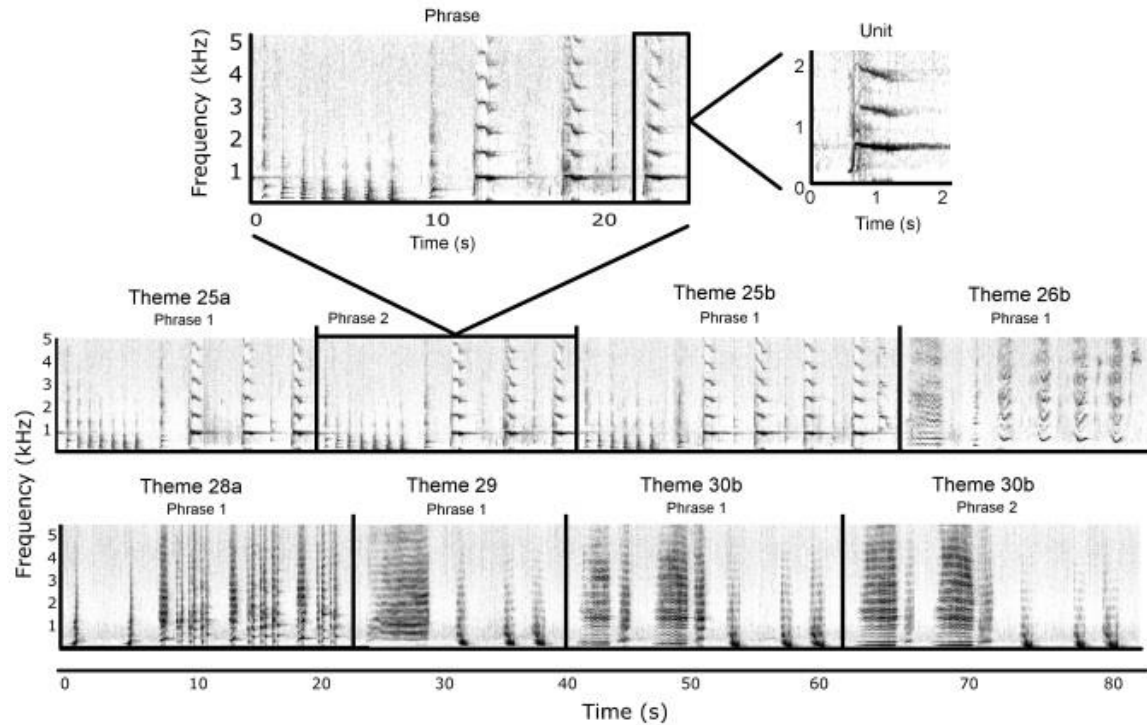
Source: NARWC



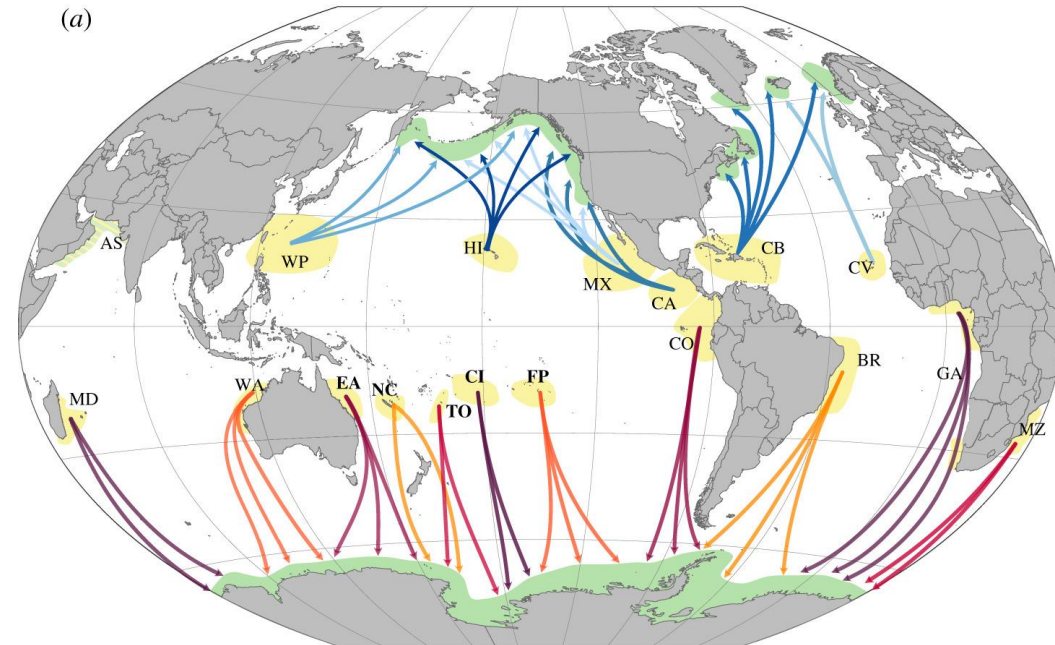
# Peces e invertebrados



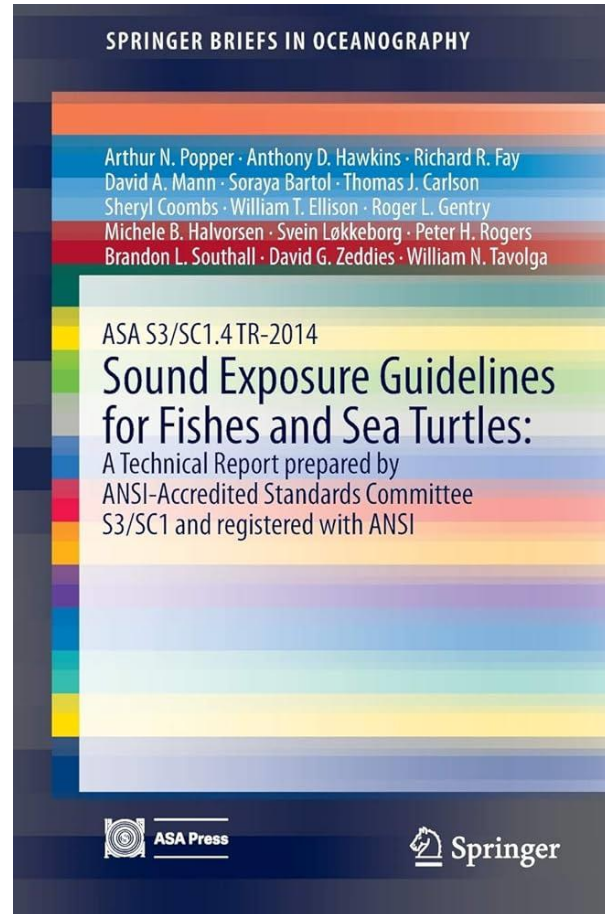
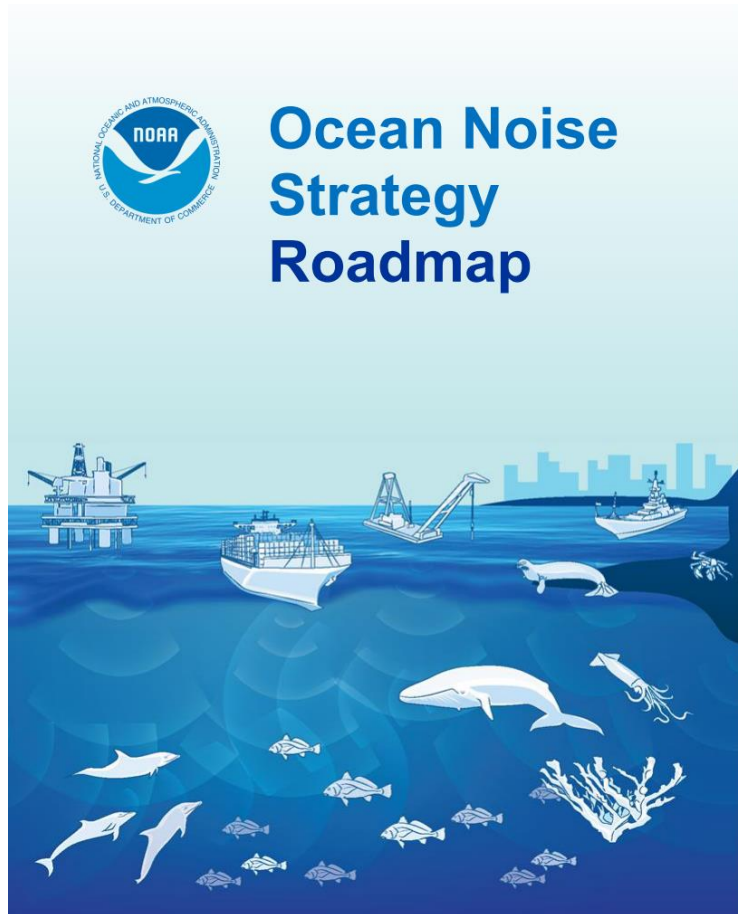
# Ballenas jorobadas



- Menos interacción social
- Menos cantos.
- Patrón de buceo y forrajeo alterado



# Regulación USA



Onset of Permanent Threshold Shift (PTS) (NMFS 2018)

PTS Onset for Impulsive and Non-impulsive Sources (NMFS 2018)

Hearing Group	PTS Onset Acoustic Threshold (Received Level) for Impulsive Sources*	PTS Onset Acoustic Threshold (Received Level) for Non-impulsive Sources*
Low-Frequency (LF) Cetaceans	<i>Cell 1</i> $L_{\text{pk},\text{LF}}$ : 219 dB $L_{\text{E},\text{LF},24\text{h}}$ : 183 dB	<i>Cell 2</i> $L_{\text{E},\text{LF},24\text{h}}$ : 199 dB
	Mid-Frequency (MF) Cetaceans	<i>Cell 3</i> $L_{\text{pk},\text{MF}}$ : 230 dB $L_{\text{E},\text{MF},24\text{h}}$ : 185 dB
High-Frequency (HF) Cetaceans		<i>Cell 5</i> $L_{\text{pk},\text{HF}}$ : 202 dB $L_{\text{E},\text{HF},24\text{h}}$ : 155 dB
	Phociid Pinnipeds (PW) (Underwater)	<i>Cell 7</i> $L_{\text{pk},\text{PW}}$ : 218 dB $L_{\text{E},\text{PW},24\text{h}}$ : 185 dB
Otariid Pinnipeds (OW) (Underwater)		<i>Cell 9</i> $L_{\text{pk},\text{OW}}$ : 232 dB $L_{\text{E},\text{OW},24\text{h}}$ : 203 dB

\* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.

# Union Europea

## Zero pollution and Biodiversity: First ever EU-wide limits for underwater noise

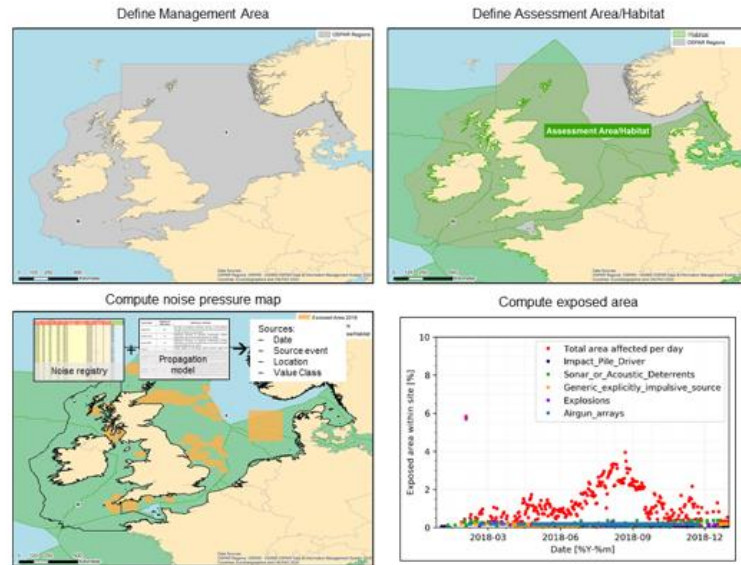


Figure 2: Illustration of the assessment procedure applied to the North Sea. The practical implementation (see Figure 2) is as follows:

- Definition of the Management Area
- Determination of the assessment area/habitat of the indicator species
- Evaluation of completeness and quality of the data
- Consideration of Level of Onset of Biological adverse Effect (LOBE)



Underwater noise due to human activities at sea can harm marine biodiversity, leading for example to hearing impairment and behavioural disturbances. EU experts have adopted recommendations on maximum acceptable levels for impulsive (for example from oil and gas exploration and extraction) and continuous (such as from shipping) underwater noise.

**Commissioner** for the Environment, Oceans and Fisheries, Virginijus Sinkevičius, said:





# Gracias!

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