

Università di Trieste
LAUREA MAGISTRALE IN GEOSCIENZE
Curriculum Esplorazione
Curriculum Geologia applicate e ambientale

Anno accademico 2021 – 2022

Geologia Marina

Parte II

Modulo 7.1

Effetti del rumore sull'ambiente marino

Angelo Camerlenghi

acamerlenghi@inogs.it

OUTLINE

Introduction

Sound in the marine environment

Anthropogenic Sound in the marine environment

- sources

- impacts

- mitigation

Legislation and policies

Introduction

Noise has major negative impacts on

- Communication
- sleep and mood
- children's school learning skills
- cardiovascular system
- hearing loss.



Introduction

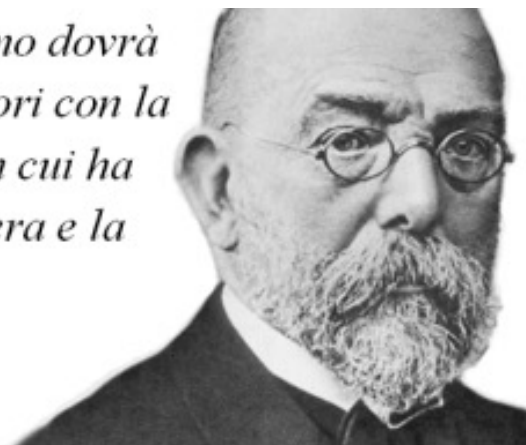
The World Health Organization (WHO) has declared that in Europe traffic noise is an environmental problem second only to air pollution:

some 30 million Europeans would be exposed to decibel levels that are hazardous to their well-being.

living on busy streets or near an airport increases the risk of heart attacks and strokes by 20 to 25%

*“Un giorno, l'uomo dovrà
combattere i rumori con la
stessa tenacia con cui ha
combattuto il colera e la
peste”*

(Robert Koch 1843-1910)



1905 Nobel Price in Medicine

Introduction

APPROACH

RESEARCH



THRESHOLDS



MITIGATION MEASURES

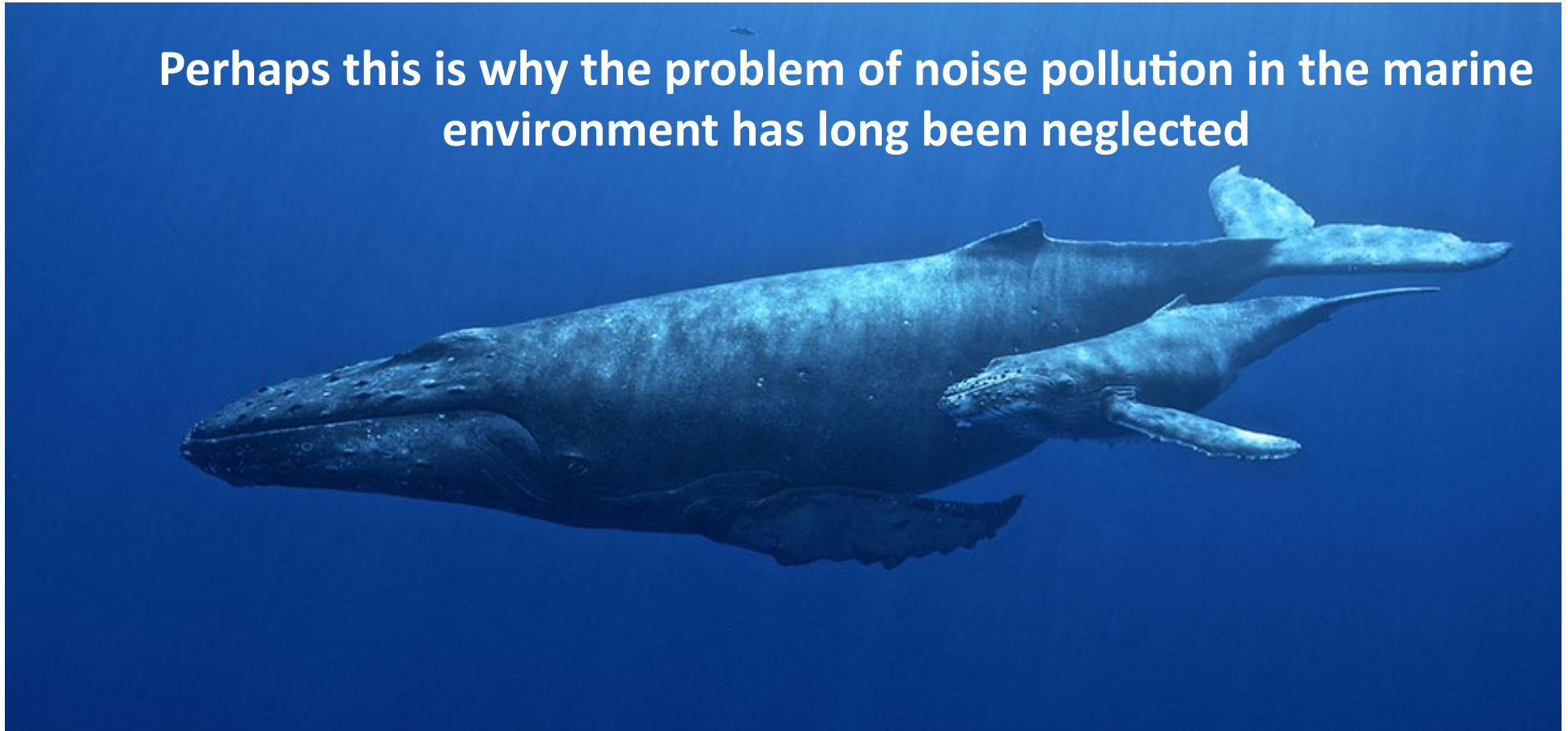


Sound in the marine environment

And in the marine environment? (70% of the earth's surface)

No human beings live there

Perhaps this is why the problem of noise pollution in the marine environment has long been neglected



Humpback whales swimming underwater. Photo credit: Ed Lyman/NOAA, under NOAA permit #14682

Sound in the marine environment

SOUND PROPAGATION

AIR**VELOCITY** ~ 340 m/s = 1230 km/h**STRONG ATTENUATION**

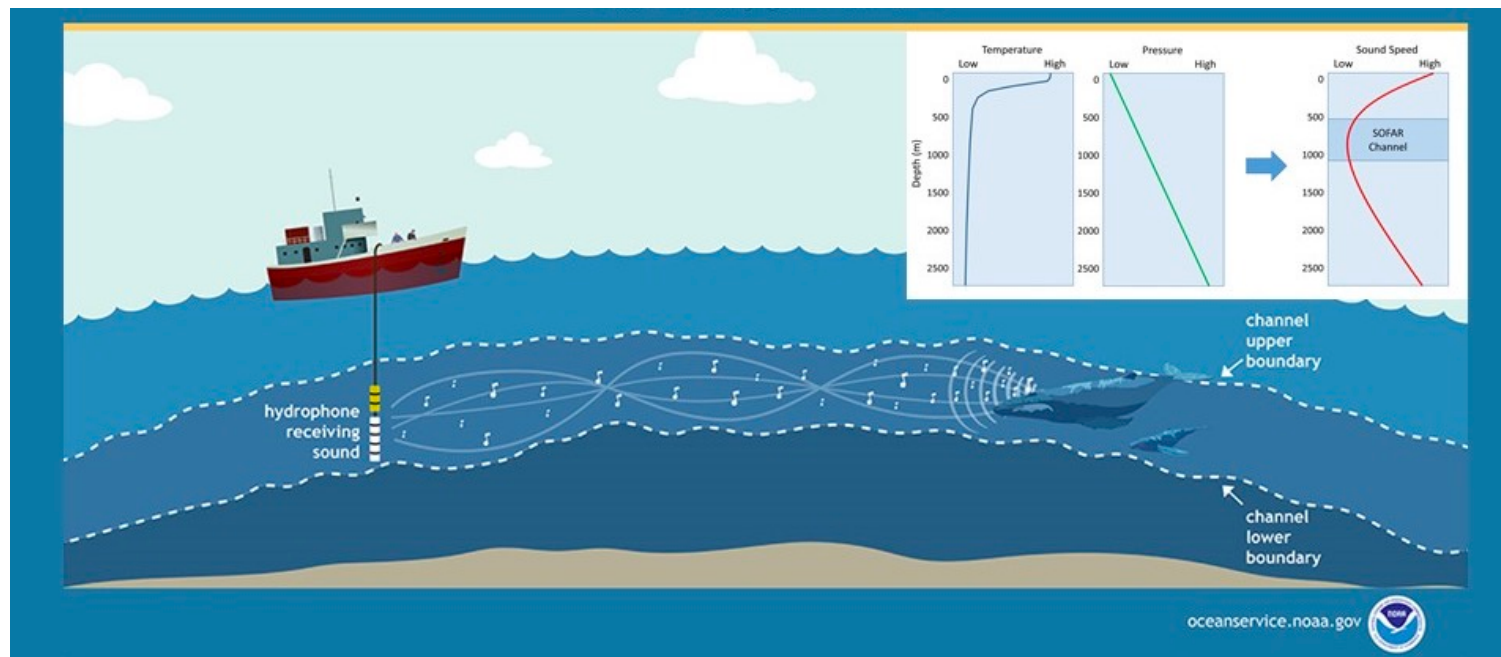
$$c = \sqrt{\frac{K}{\rho}} = \sqrt{\frac{1}{\chi \rho}}$$

c = velocity*K* = Bulk Modulus [*N* · *m*-2]*ρ* = Density [*kg* · *m*-3]*χ* = Compressibility = 1/*K***WATER****VELOCITY** ~ 1500 m/s = 5400 km/h**WEAK ATTENUATION**

Sound in the marine environment

SOund Fixing And Ranging Channel

Low-frequency sound waves within the channel can travel thousands of miles before dissipating



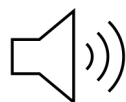
SOFAR CHANNEL

Sound in the marine environment

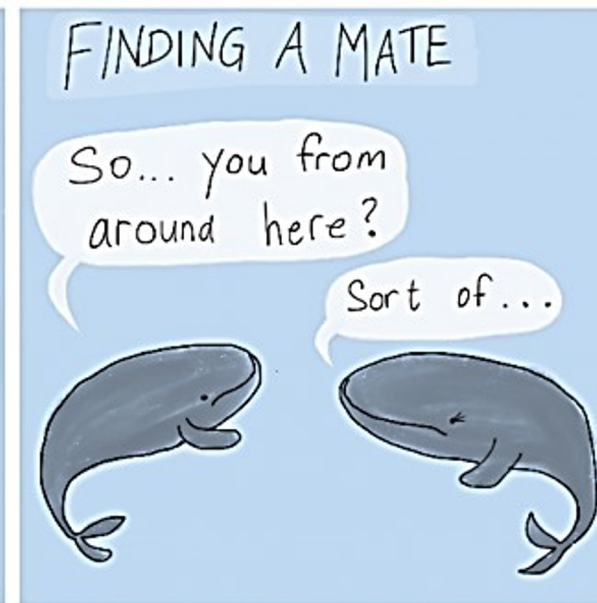
USE OF SOUND BY MARINE ANIMALS



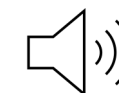
"CLICKS" Odontoceti (Orcas, Dolphins, Porpoises, Sperm Whales) to detect the size and nature of objects



"MOANS", "TONES" - communication, navigation mysticetes (Fin Whales, Humpback Whales)



"VOCALIZATIONS" Humpback whales only by males and only during the mating season



Communication, Find food, Find a mate

<https://dosits.org/galleries/audio-gallery/marine-mammals>

Whales and dolphins

Odontocetes – whales and dolphins with teeth

impulsive clicks – echolocation

whistles + other sounds – communication



Mysticetes – whales with baleen moans and tones – communication and navigation

Sound in the marine environment

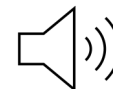
OTHER ANIMALS



INVERTEBRATES

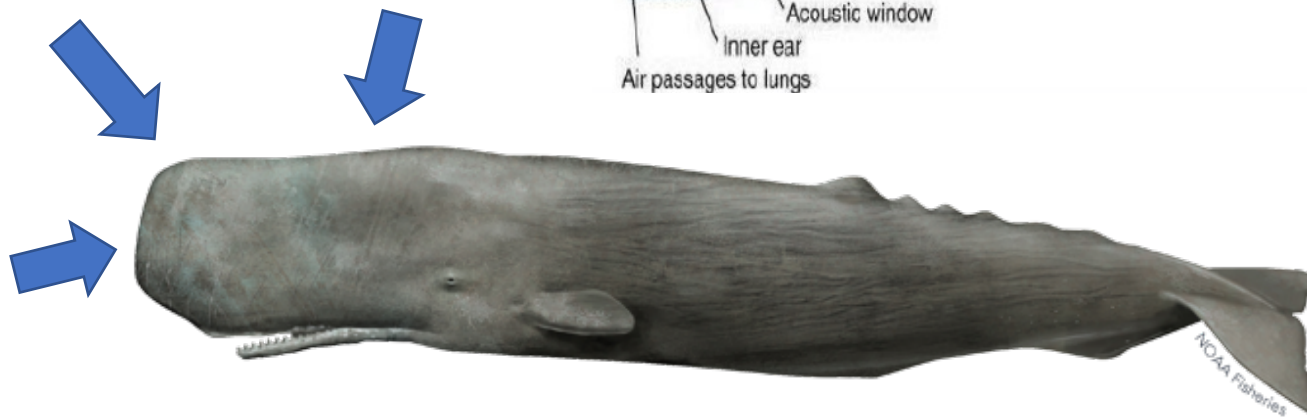
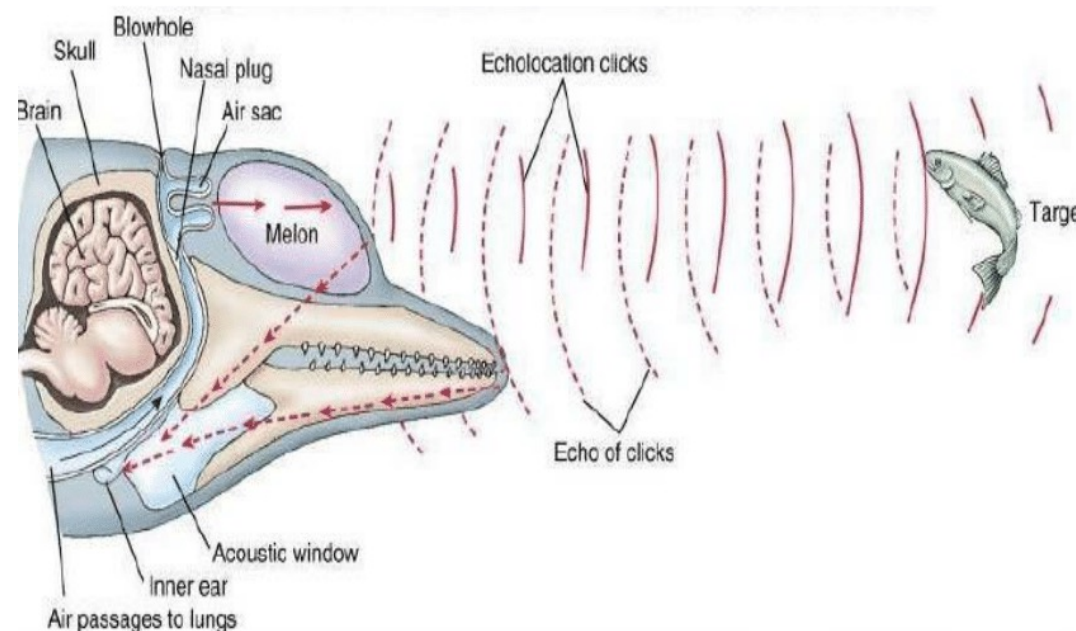


FISH !



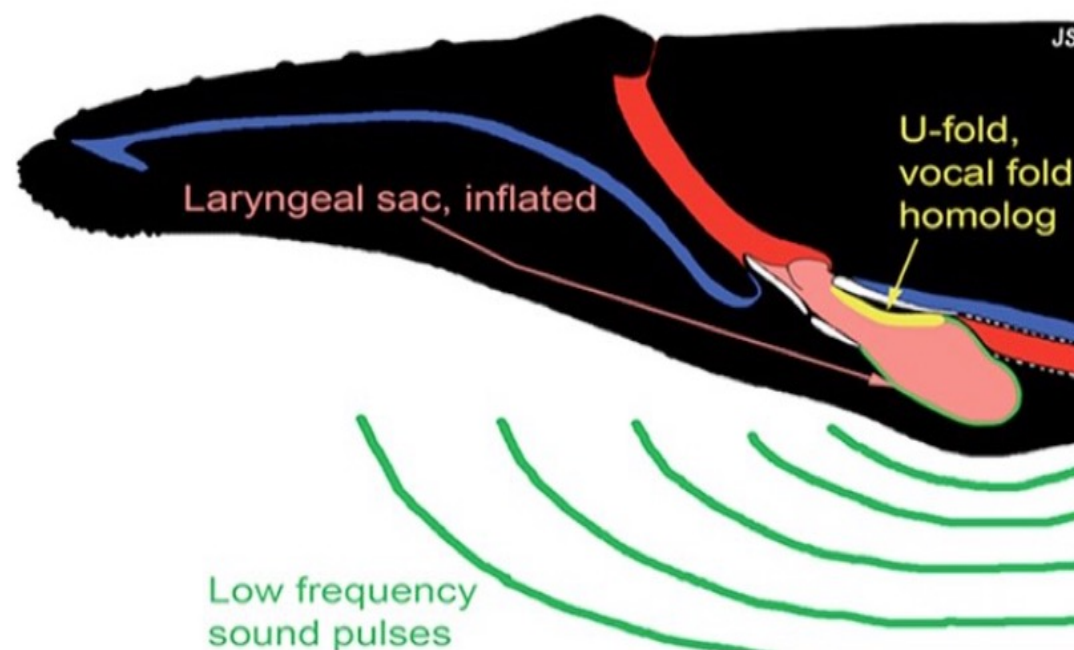
Sound production

Odontocete head anatomy and acoustic beam



Sound production

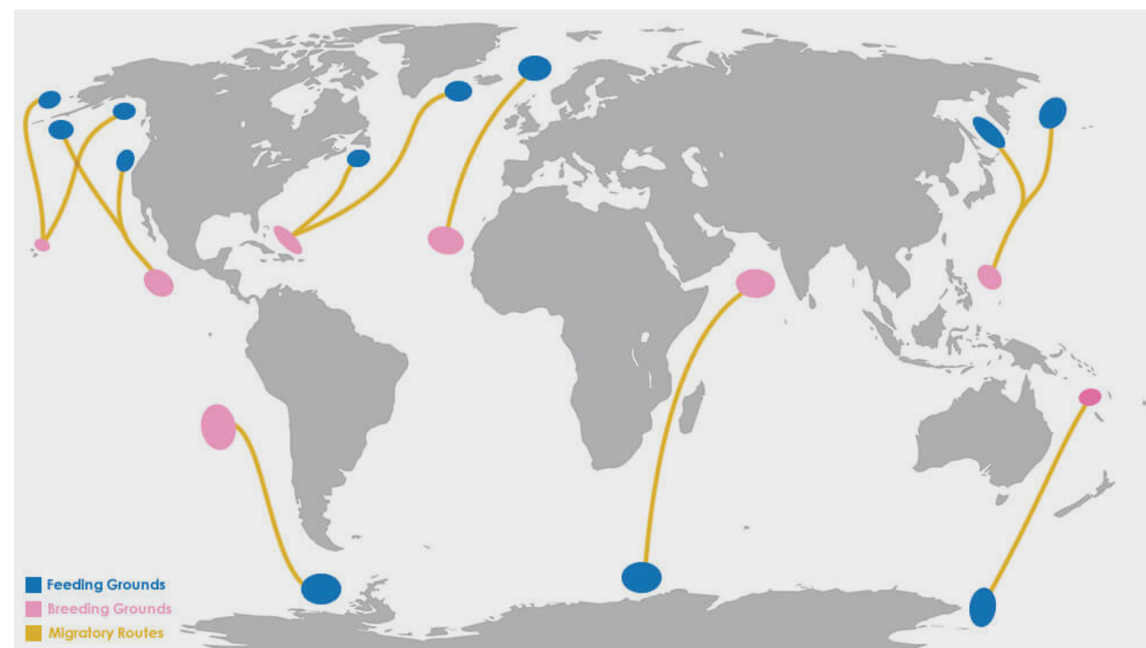
Mysticete head anatomy



Sound in the marine environment

Why do whales sing?

- We don't know for sure
- To mark the territory
- To communicate with the little ones
- To coordinate the migration
- To attract females
- Why do they have fun (?)



Sound in the marine environment

MEASURING UNDERWATER SOUND

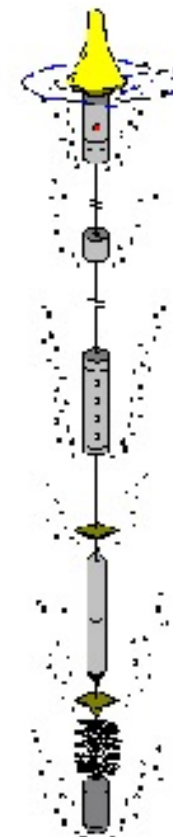
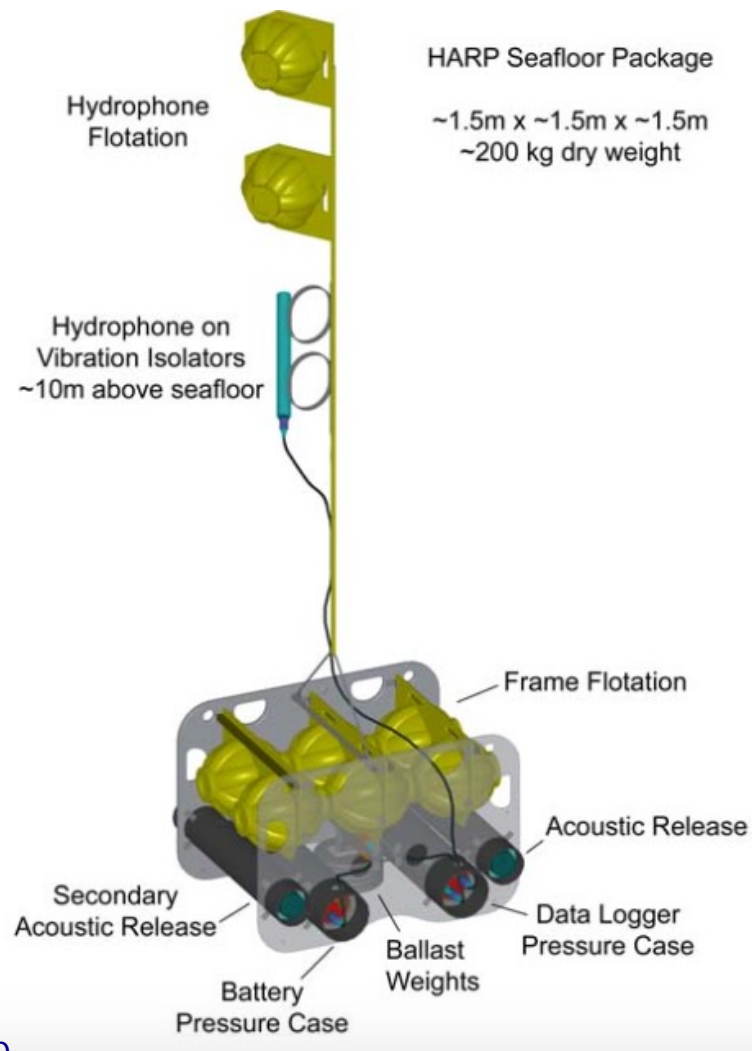


Deployment of an acoustic recorder in Florida
Keys National Marine Sanctuary. NOAA



Sound in the marine environment

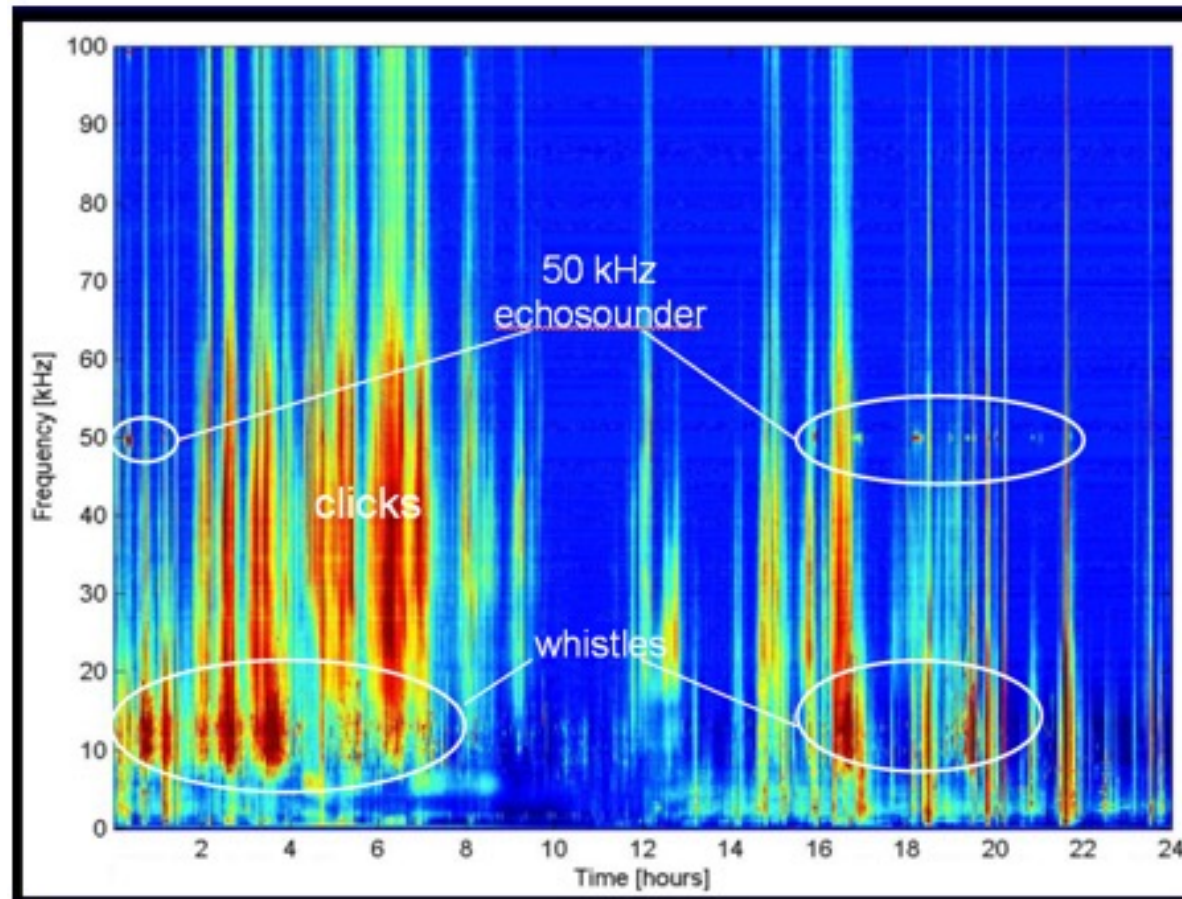
Recording equipment



Sound in the marine environment

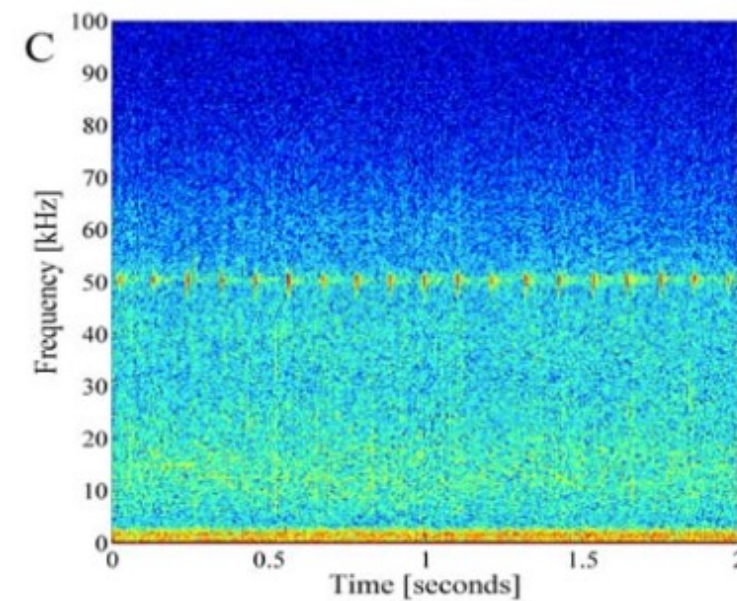
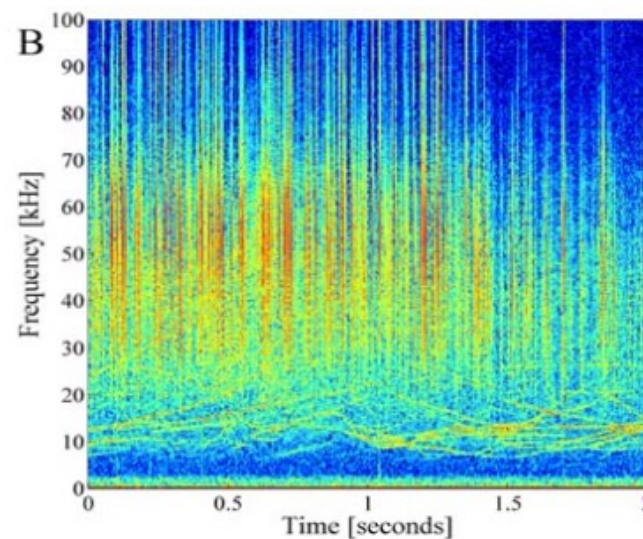
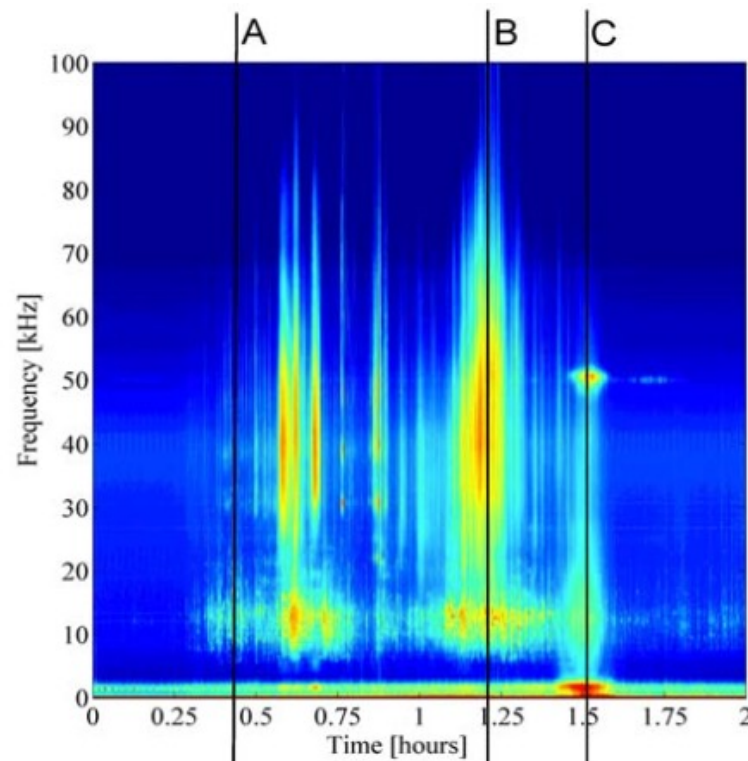
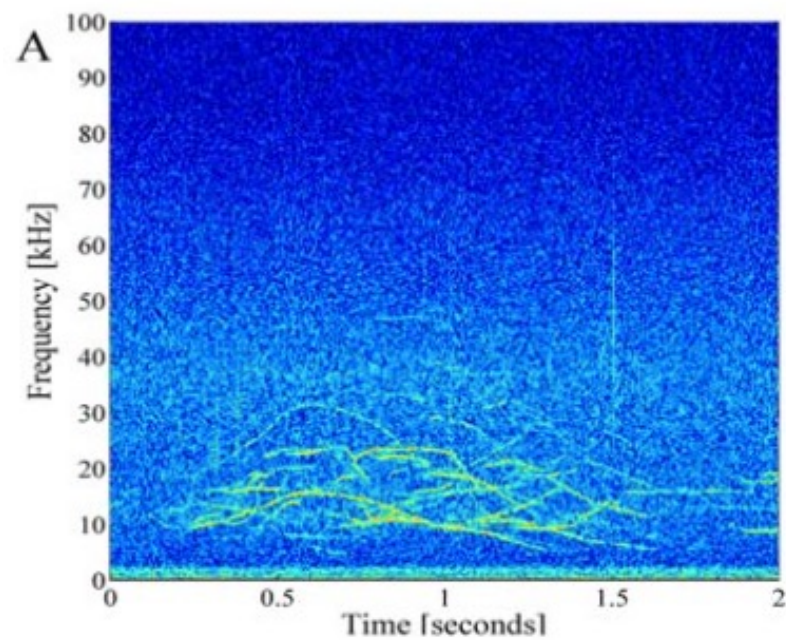
Sound spectral analysis -LTSA

- Visual representation of sound.
- Horizontal dimension is time, vertical dimension is frequency.
- Intensity of the sound is the colour.

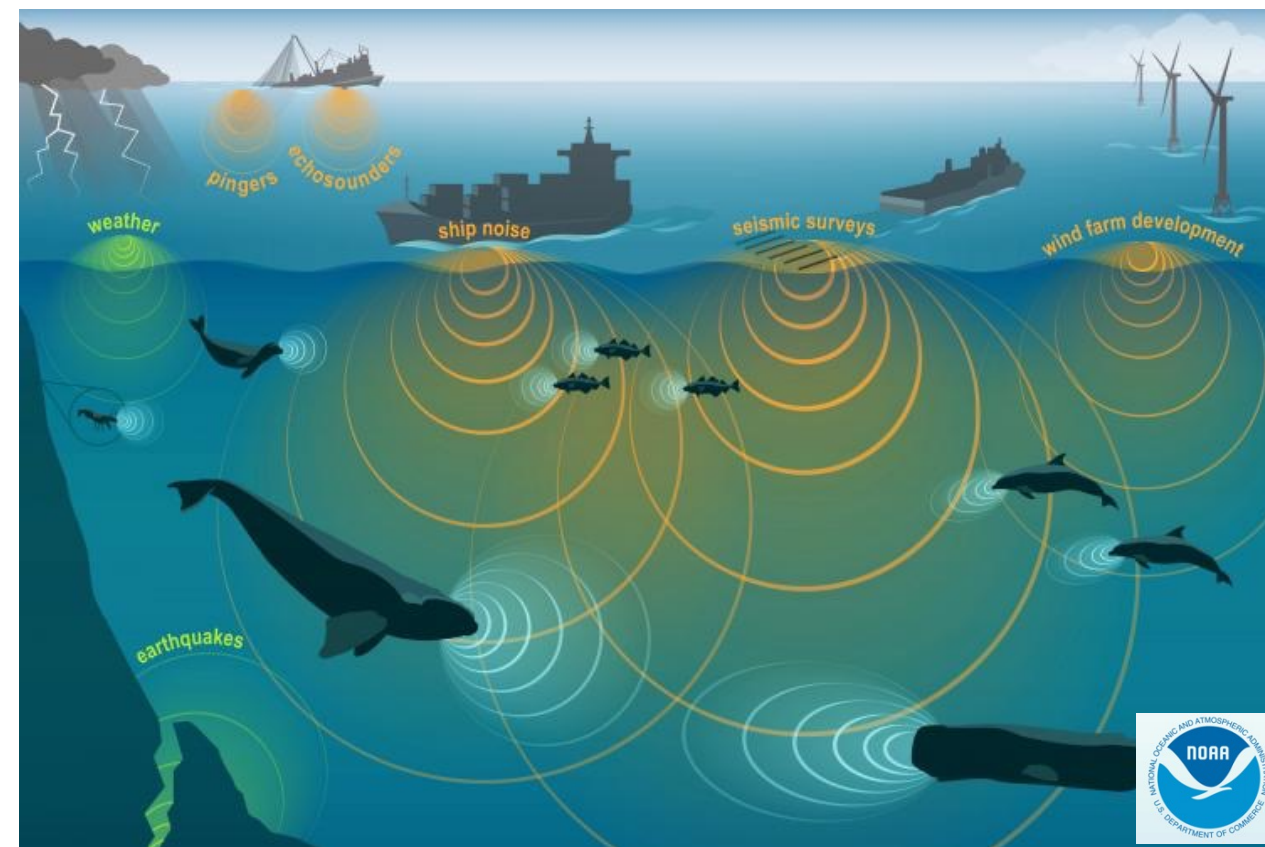
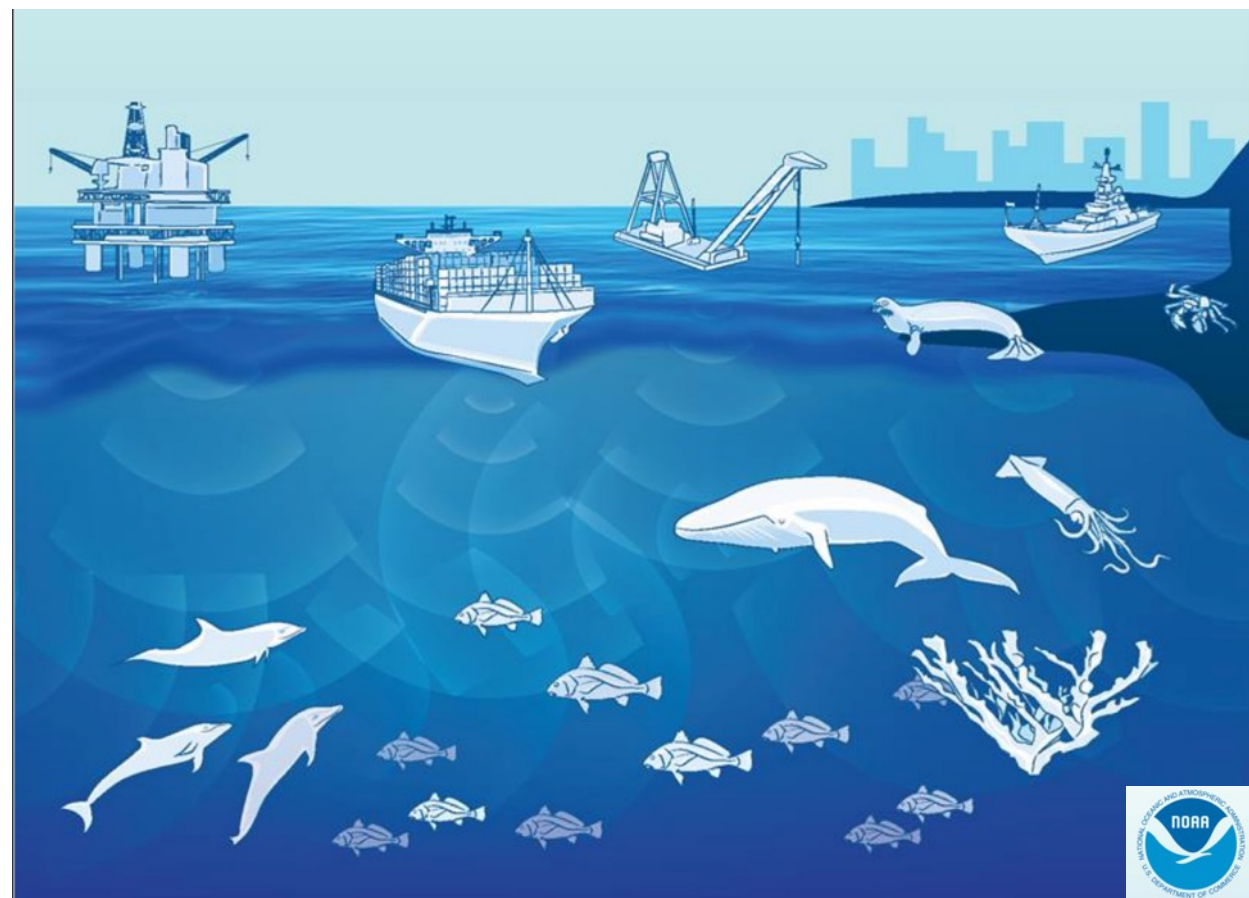


Courtesy of Scripps Whale Acoustic Lab

Sound in the marine environment



Anthropogenic Sound in the marine environment Sources

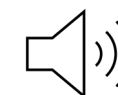
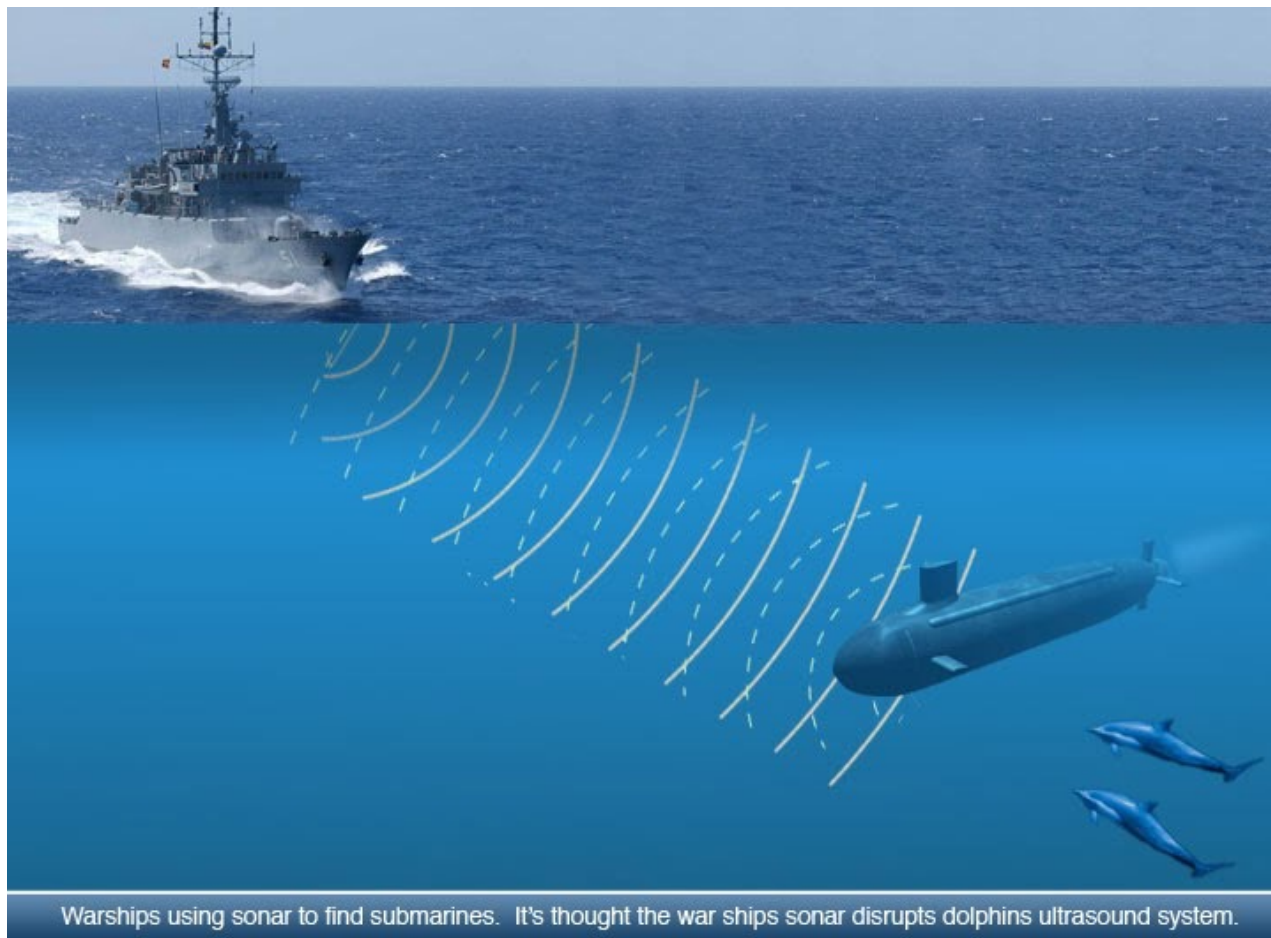


THE BIG FIVE!

Anthropogenic Sound in the marine environment

Sources

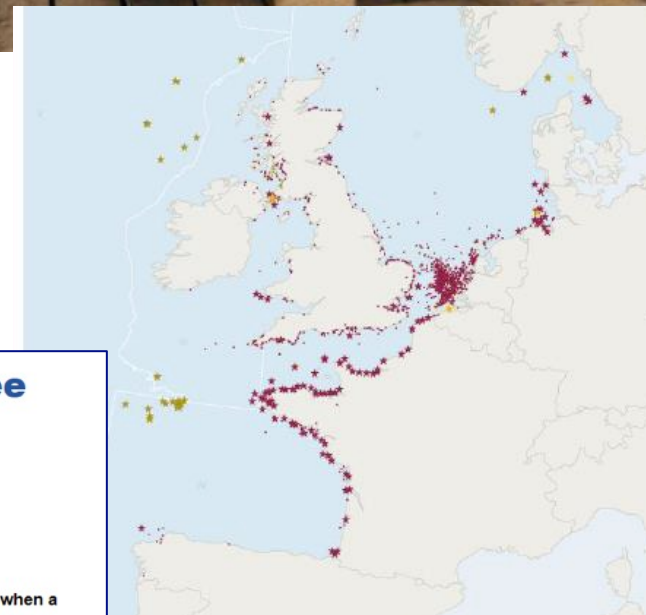
1.(military) Sonar



Anthropogenic Sound in the marine environment

Sources

2.Explosions



World War II bomb kills three fishermen

AFP

Friday, April 08, 2005

Like Share 0

Tweet

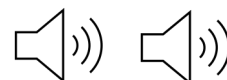
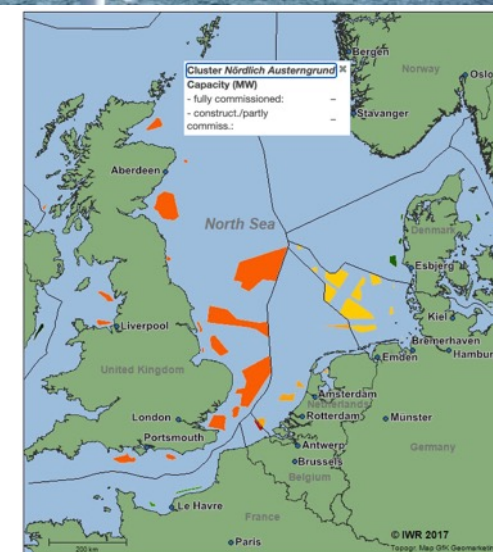
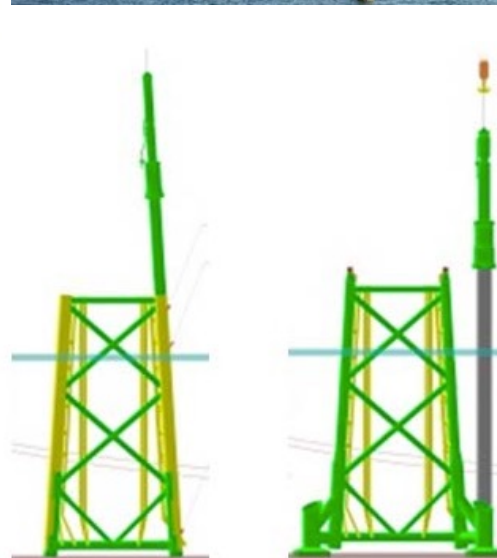
Print Email

THE HAGUE (AFP) - Three Dutch fishermen were killed yesterday when a suspected World War II bomb they picked up in their nets exploded on board the vessel, the ANP news agency reported.

Anthropogenic Sound in the marine environment

Sources

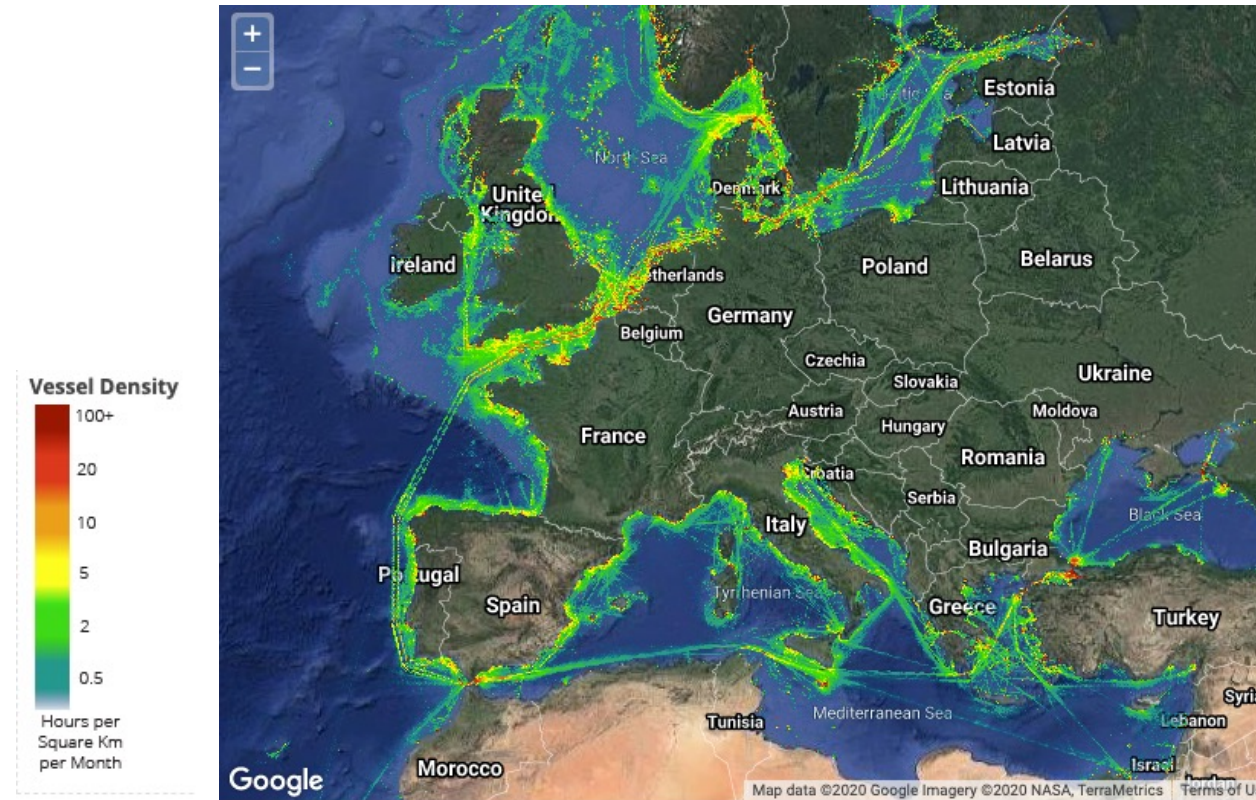
3. Offshore activities, pile driving (offshore wind farms)



Anthropogenic Sound in the marine environment

Sources

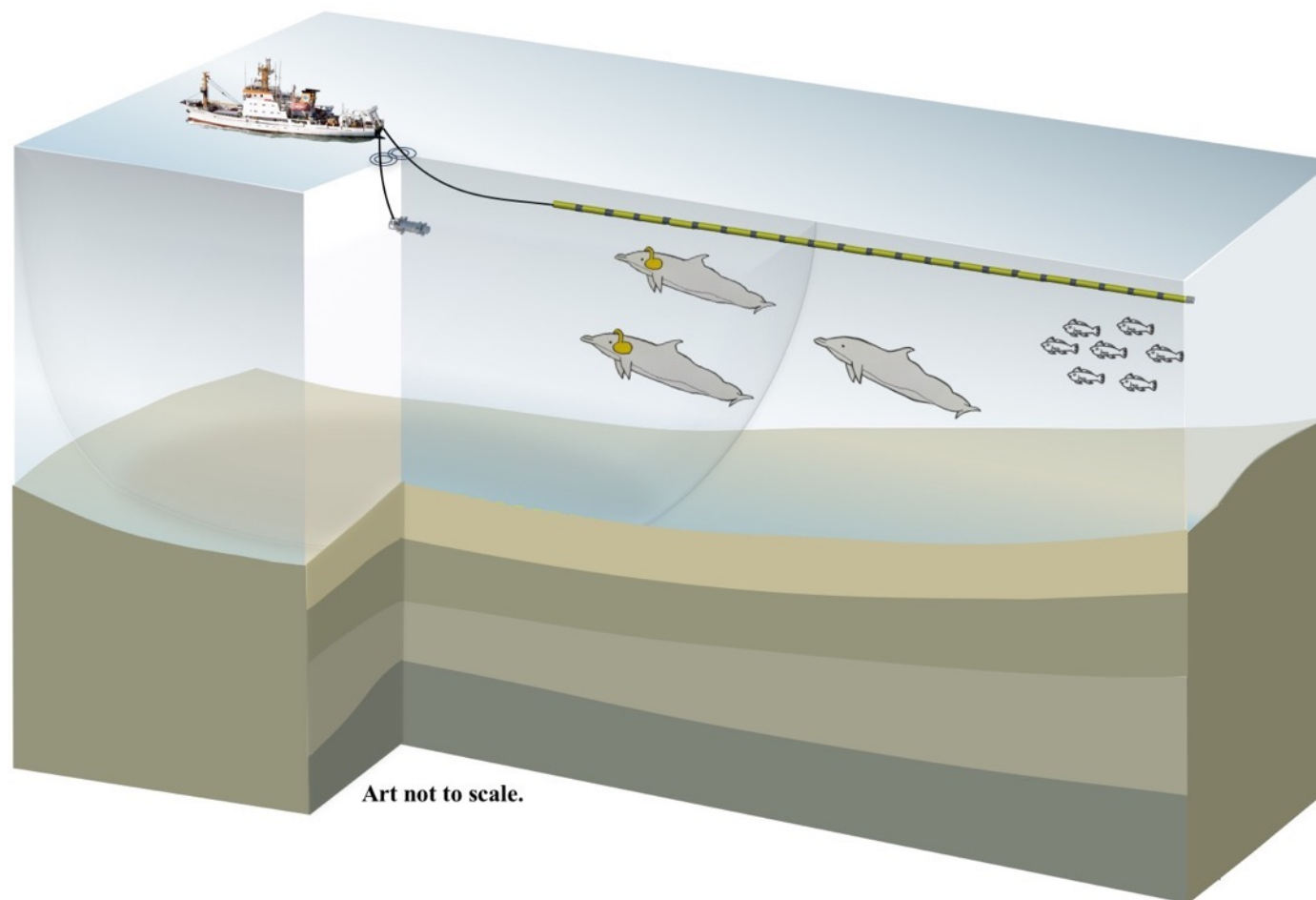
4. Shipping



Anthropogenic Sound in the marine environment

Sources

5. Seismic exploration



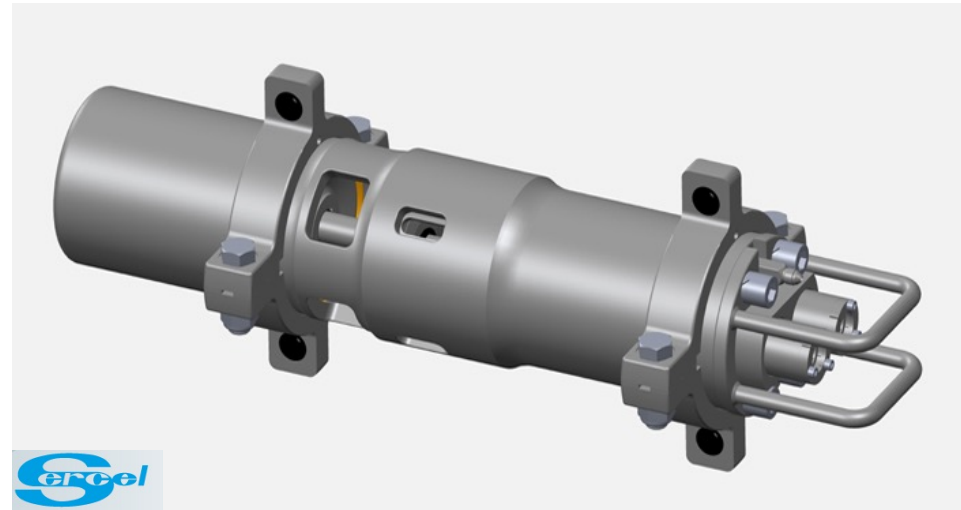
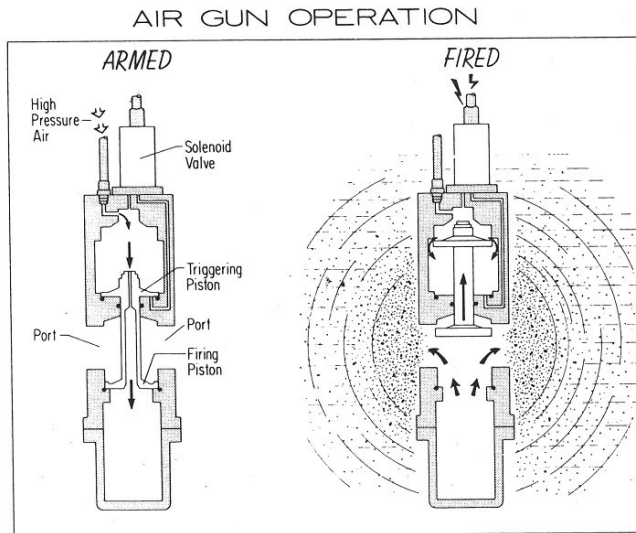
Anthropogenic Sound in the marine environment Sources



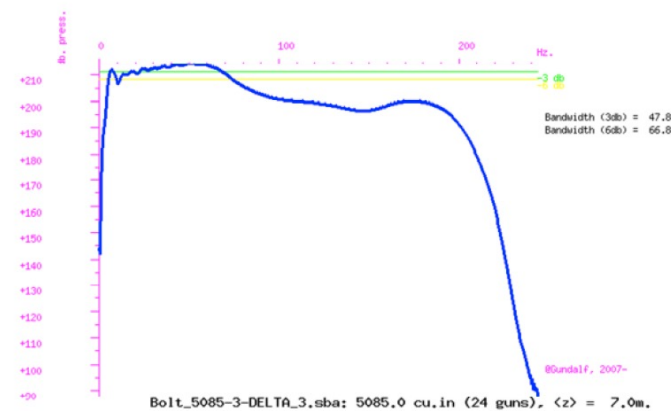
Anthropogenic Sound in the marine environment

Sources

Cannoni ad aria (*air guns*)



	intervallo di frequenza
Sismica naturale	0.1 - 5 Hz
Sismica convenzionale a bassa frequenza <i>Deep scientific / industrial exploration</i>	5 - 80 Hz
Sismica ad alta risoluzione <i>Fluid escape, gaz hydrates, reservoir modelling</i>	50 - 400 Hz
Sismica a risoluzione molto alta <i>Site survey, sedimentary models, reservoir modelling</i>	300 - 2000 Hz



Spettro di frequenza (near field) di un array industriale

Anthropogenic Sound in the marine environment

Sources

Google Search: airgun

Google

airgun

Tutti Shopping Immagini Video Maps Altro Impostazioni Strumenti

Raccolte SafeSearch

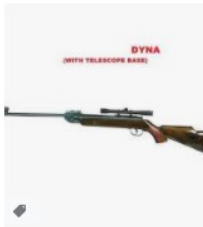
gamo break barrel uragan king air pistol airgun technology royal airgun compressed air

 Air gun - Wikipedia
en.wikipedia.org

 Bond Sports Air Gun at Rs 1450/piec...
indiamart.com

 Buy Precihole Athena NX20...
10kya.com · Disponibile

 Airgun World | WHSmith
whsmith.co.uk · Disponib...

 Air Gun Dyna at Rs 9500/...
indiamart.com

 Pack PCP Cometa's airguns. Model Lynx v10 natural
aceros-de-hispania.com

 Airgun Technology Uragan Synthetic .177: A...
airgunsofarizona.com · Disponibile

 Pin on Guns & ammo
pinterest.com

 AIR RIFLE AIRGUN TECHNOLOGY...
mundilar.net · Disponibile

 Umarex - Airgun IWI Jericho - 4,5 mm - 5.8...
specshop.pl · Disponibile

 ESA 200 Pistol Grip Break Barrel...
theairgunstore.com · Disponibile

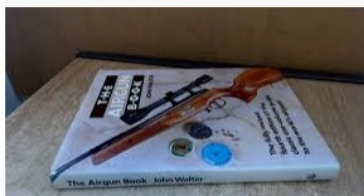
 SDB 95 Model 0.177 Cal (4.5m...
airgunhubindia.com

 Airgun Power Source Pro's & Con's — Replica Air...
replicaairguns.com

 Buy Charismacart Metal And Wo...
shopclues.com · Disponibile

 Taurus co2 review.... - YouTube
m.youtube.com















Anthropogenic Sound in the marine environment

Sources



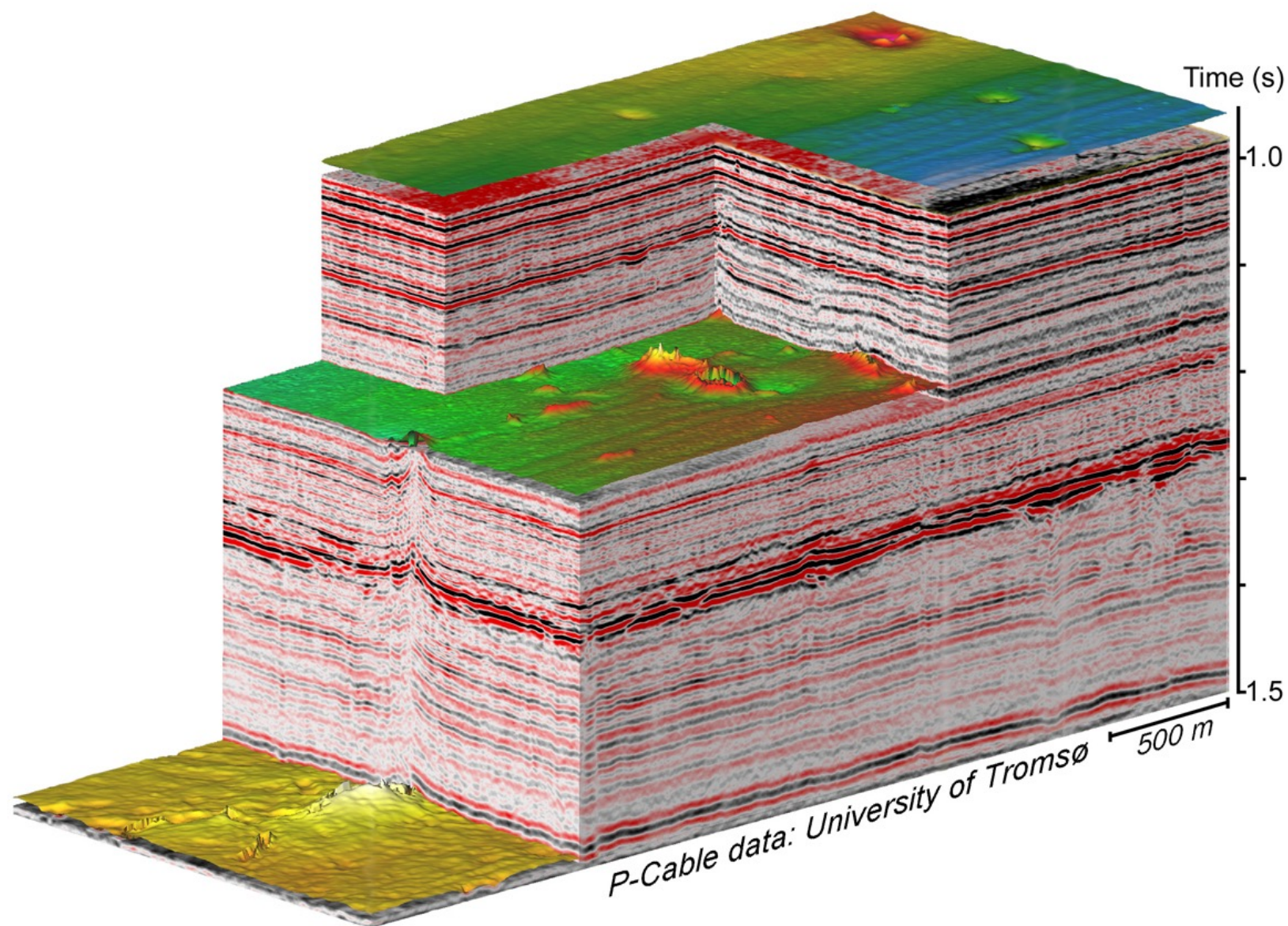
Anthropogenic Sound in the marine environment

Sources



[Geophysical Surveys - International Association of Geophysical ...](#)
www.iagc.org1100 × 733Search by image

Anthropogenic Sound Sources



Anthropogenic Sound in the marine environment

Sources

Early phase of geophysical prospecting at sea: Explosives were commonly used.

Today, this is forbidden

Airguns are pneumatic impulsive seismic sources

They do not generate any explosion underwater

www.cgg.com

1958 CGG's first dual vessel marine survey, with one boat as source, initially using an underwater dynamite charge. A second boat towed the streamer recording the seabed reflections.



Anthropogenic Sound in the marine environment impacts

5 EFFECTS ON MARINE FAUNA



✓ Injury

Damage to tissues (rupture, internal bleeding)

Gas embolism or decompression symptoms

✓ Hearing Loss

Irreversible damage to the hearing apparatus

Permanent lowering of the hearing threshold (PTS)

Temporary lowering of the auditory threshold (TTS)

Anthropogenic Sound in the marine environment impacts

5 EFFECTS ON MARINE FAUNA



✓ Masking

Masking of intraspecific communications

Masking of interspecific communications

Interference with the ability to analyse the environment

✓ Behavioural Disturbance

Temporary Interruption of normal behaviour

Partial modification of natural behaviour

Moving from an area normally occupied (for short or long term)

Temporary interruption of social ties

Anthropogenic Sound in the marine environment impacts

5 EFFECTS ON MARINE FAUNA



✓ Other indirect effects

Less availability of prey

Increased vulnerability to predation or other risks (eg stranding)

Behavioral changes that cause physical damage (eg collisions with boats)

Anthropogenic Sound in the marine environment impacts

Rilevamento sonoro:

Modifica comportamento, vocalizzazione, ricerca di cibo.

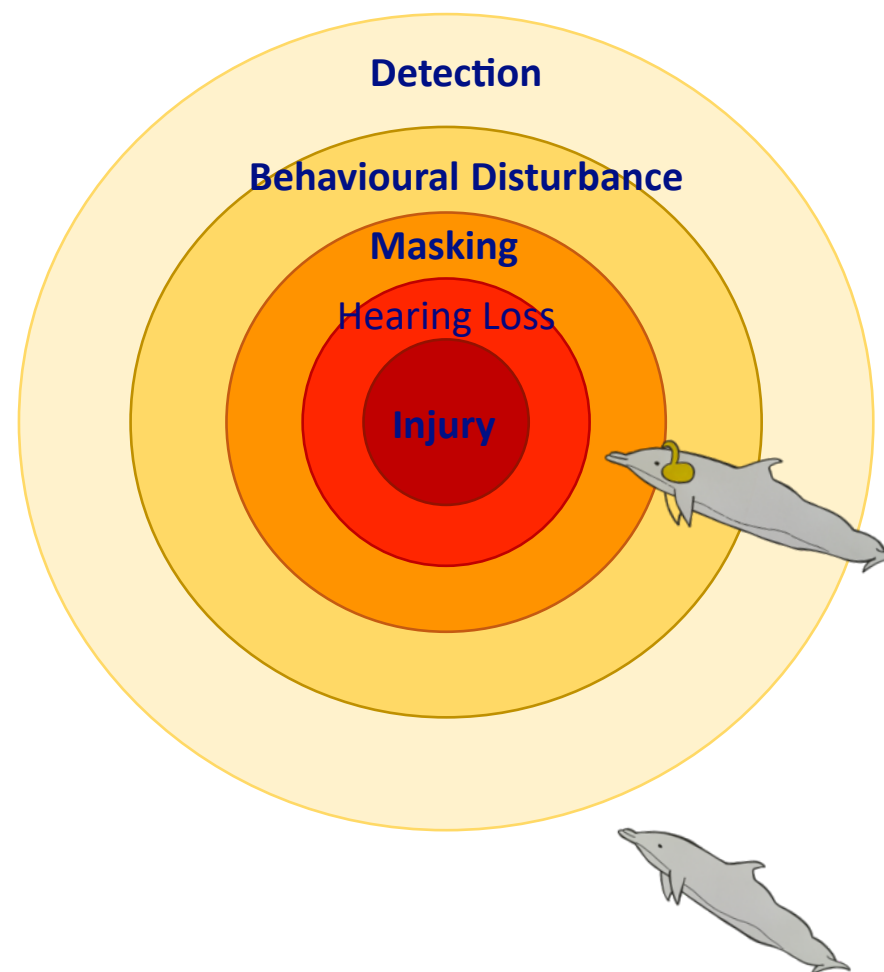
‘Masking’: suono interferisce con rilevamento segnali biologici. Comunicazioni, ecolocalizzazione, navigazione.

Reattività: modifiche comportamentali (evitamento o fuga).

TTS, PTS: danno udito. Abbassamento permanente/temporaneo della soglia uditiva.

Lesioni: effetti fisici (danni ai tessuti, sintomi di decompressione)

Zones of influence



modificato da Richardson et al., 1995

Anthropogenic Sound in the marine environment Mitigation

Airgun Mitigation

Planning:

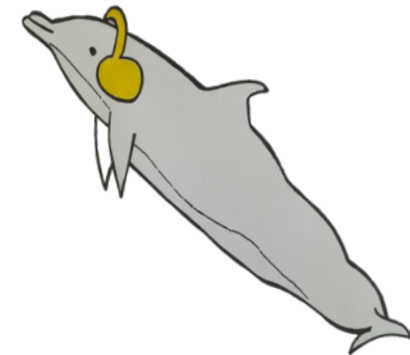
avoid sensitive areas, exclusion zone.

Animal Detection:

passive visual monitoring (MMO)

passive acoustic monitoring (PAM)

interruption of operations



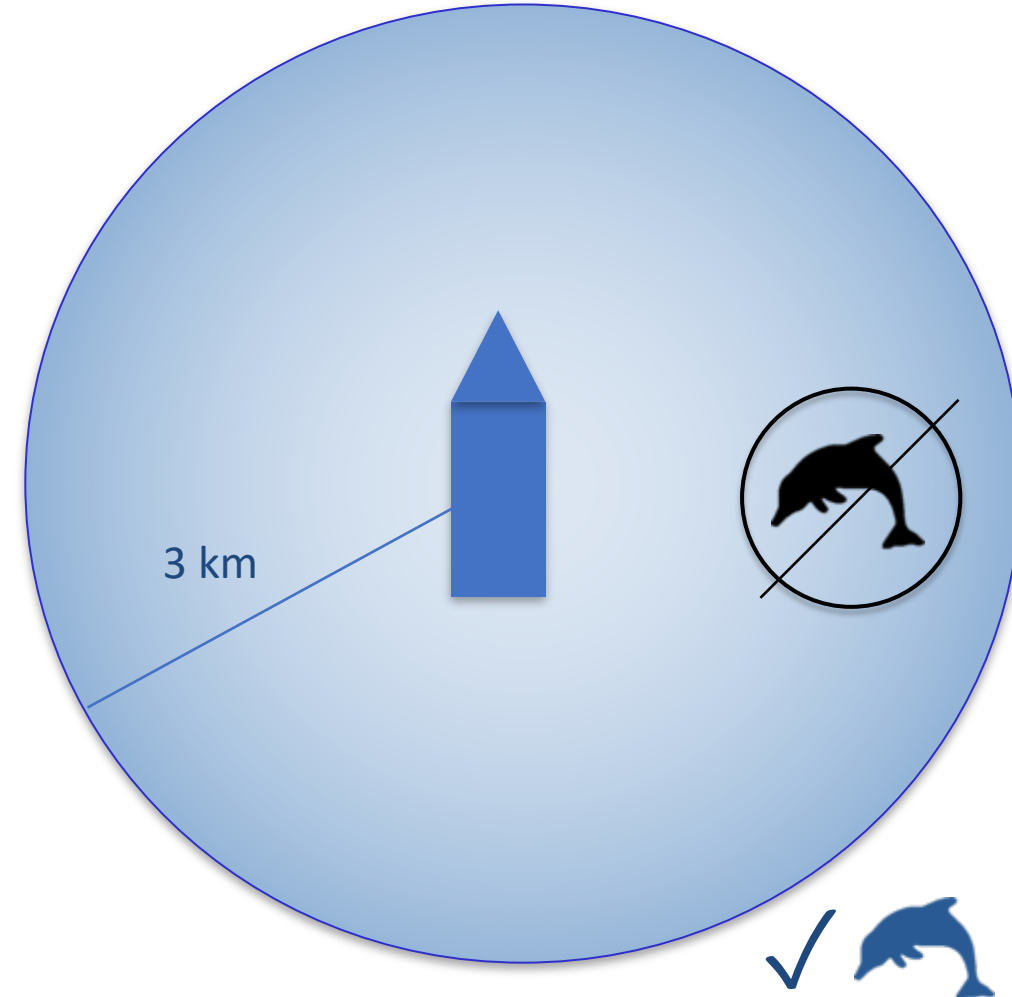
Operating procedures:

'Ramp up' 'soft start' = gradual increase in the sound pressure level.

Anthropogenic Sound in the marine environment Mitigation

Exclusion Zone

- Limit of 180 dB - 160 dB
re 1 μ Pa RMS
- To be defined before the survey using a
sound propagation modelling software
- To be monitored and verified during the
survey with Marine Mammal Observers
(MMO) and Passive Acoustic Monitoring
(PAM)



Anthropogenic Sound in the marine environment Mitigation

MARINE MAMMALS OBSERVERS (MMO)



Anthropogenic Sound in the marine environment Mitigation

PASSIVE ACOUSTIC MONITORING (PAM)



EU INTRODUCES THE MARINE STRATEGY FRAMEWORK DIRECTIVE



To maintain the good environmental status of our seas member states should guarantee that

“Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment”

Concerns for UW sound impacts

- Lack of standardized methodologies to measure and analyse UW noise
- Difficult to compare results
- Need for policy for standardised emissions
- **Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA) proposes guidelines**
 - Environmental impacts to sea creatures
 - Noise thresholds
 - Mitigation measures



ISPRA

Istituto Superiore per la Protezione
e la Ricerca Ambientale

Rapporto tecnico

Valutazione e mitigazione dell'impatto acustico dovuto alle prospezioni geofisiche nei mari italiani

Maggio 2012

7. Raccomandazioni e conclusioni

Servirsi di personale tecnico altamente specializzato, in particolare per ricoprire il ruolo di osservatore-*Marine Mammal Observer* (MMO) e di tecnico per il PAM - monitoraggio acustico passivo;

assicurarsi che tutti i dati validi dal punto di vista scientifico derivanti da linee sismiche esistenti vengano, quando possibile, riutilizzati;

pianificare almeno una visita ispettiva a bordo della nave sismica (il numero di controlli può variare in base alla durata dell'attività di prospezione) da parte del Ministero vigilante o di ISPRA;

assicurarsi che il *reporting* di fine attività sia propriamente svolto e spedito al Ministero vigilante e ISPRA. Ciò può rivelarsi estremamente utile per l'individuazione di eventuali *lessons learnt* circa le misure di mitigazione adottate ed il loro possibile perfezionamento.

Documenti:

EUROPEAN PARLIAMENT

2004



2009

Session document

B6-0089/2004

European Parliament resolution on the environmental effects of high-intensity active naval sonars



Address:

**JNCC, Marine Advice,
Dunnet House, 7 Thistle Place,
Aberdeen, AB10 1UZ, United
Kingdom**

Telephone:

+44(0)1224 655720

Email:

seismic@jncc.gov.uk

**ANNEX A - JNCC guidelines for minimising the risk of
disturbance and injury to marine mammals from seismic
surveys**

June 2009

Documenti:

16th ASCOBANS Advisory Committee Meeting

Brugge, Belgium, 20-24 April 2009

Document AC16/Doc.47 (O)

Dist. 25 March 2009

Agenda Item 5.5.1

Implementation of the ASCOBANS Triennial Work Plan (2007-2009)

Review of New Information on Pollution,
Underwater Sound and Disturbance

Anthropogenic noise

Document 47

Noise Pollution

Essenza dei documenti internazionali:

- **L'utilizzo degli Air Guns deve essere strettamente regolamentato**
- **l'utilizzo deve essere approvato dall'autorità competente dietro presentazione di dettagliato rapporto di impatto ambientale**
- **a bordo devono essere presenti MMO e PAM**
- **deve essere definita una Distanza di Esclusione sulla base del livello degli impulsi acustici**
- **l'inizio delle operazioni deve essere effettuato con modalità ramp-up**

Future European Policy

According to the **Mission Board Healthy Oceans, Seas, Coastal and Inland Waters (2020)** one of the four targets to achieve a status of Zero Pollution of the sub-aquatic environment is to reduce underwater acoustic emissions by at least 50% by the year 2030 and to define noise impact mitigation measures in each European marine region. The approach to this challenge is two-fold: 1) reduce the emissions at the source; 2) implement impact mitigation measures.

The **Technical Group on Underwater Noise (TG Noise) of the European Union** has the task to facilitate the development by Member States of their own strategies and regulations for the mitigation of impacts, always in order to achieve the Good Environmental Status (GES) addressed by the EU Marine Strategy Framework Directive (MSFD).

Future European Policy

the **Joint Programming Initiative Healthy and Productive Seas and Oceans (JPI Oceans)**, an intergovernmental platform with the objective to promote coordination on marine and maritime research activities, launched a new Joint Action “Underwater Noise in the Marine Environment” (<https://www.jpi-oceans.eu/underwater-noise-marine-environment>) with Italian and German coordination, with the overarching objective to decrease the high level of uncertainty about the impact of noise through the promotion of specific lines of scientific research at regional and sub-basin scale. Among the urgent actions needed are the implementation of deep-sea sound observing systems and new numerical modeling tools for prediction of the anthropogenic sound propagation in the near and far field.

Present policy in Italy

In Italy, the relevant authority for the implementation of the MSFD is the **Ministry of the Environment (MATTAM)**, in collaboration with other national and local authorities. The scientific and technical support is provided by the **Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA)**, who is also co-leading the European Union TG-Noise. Both the MATTAM and the **Ministry of Economic Development (MISE)** have created technical committees to address the effect of the noise by seismic exploration on the marine ecosystems. In 2015 the MATTAM created a Working Group with the task of monitor and collect all available information about national and international initiatives aiming at understanding the impact of '*airguns*' on marine ecosystems, and suggest initiatives to contribute to the implementation of guidelines at a national level. In 2017, in the framework of the implementation of the European Directive 2013/30/UE for the safety of offshore oil and gas operations created a Working Group with the task of releasing, in 2018, a Report on Eco-Sustainable Techniques for Seismic Exploration Offshore (TESEO).

Present policy in Italy

The **National Institute of Oceanography and Applied Geophysics (OGS)** has published in 2020 a Decalogue stating the institutional position with respect of the noise in the marine environment emitted during oceanographic expeditions, including research vessel's noise and sonars, stating the ethical necessity to reduce the impacts and to promote new scientific and technological research aimed at an environmentally sustainable use of oceanographic instruments for scientific research (Affatati, 2020).

Un caso italiano: proposta di emendamento al ddl sugli Eco-reati (2015)

Marzo 2015. approvazione in Senato di un emendamento al ddl sugli ecoreati proposto da Gal e Fi che introduce il divieto di esplosioni in mare per attività di ricerca e ispezione dei fondali: «Art. 452-*undecies*. - (*Ispezione fondali marini*) - **Chiunque, per le attività di ricerca e di ispezione dei fondali marini finalizzate alla coltivazione di idrocarburi, utilizza la tecnica dell'*air gun*, o altre tecniche esplosive è punito con la reclusione da uno a tre anni**».

Dalla trascrizione del dibattito in Senato:

*Si tratta di una tecnica **esplosiva**, per la quale noi riteniamo di dover prevedere la pena della reclusione da uno a tre anni. Altrimenti non si spiegherebbe come mai tutti coloro che utilizzano **sistemi di esplosione** per la pesca vengono condannati e perseguiti dalla legge e non lo si fa per questa che sostanzialmente è sovrapponibile.*

*...Attenzione, l'utilizzo di queste tecniche potrebbe **creare dei terremoti** pari al grado 3,6 della scala Richter. In un territorio vicino alla Sicilia o in altri luoghi dove già si è soggetti normalmente a processi di movimento del terreno, questo potrebbe costituire un rischio.*

L'emendamento ha provocato una risposta di Assomineraria ed una di tutti gli Enti Pubblici di Ricerca che si occupano di Oceanografia (OGS, CNR, INGV, Stazione Zoologica di Napoli, INFN) CONISMA, Società Geologica Italiana, ISPRA Sezione Italiana EAGE/SEG (Geofisica Applicata)

Quest'ultima ha generato una replica da parte di WWF, Greenpeace e Legambiente.

L'emendamento è stato cancellato in Senato durante l'approvazione finale della legge.

Attualmente in Italia

L'utilizzo di «airguns» prevede l'autorizzazione tramite una procedura di VIA
Valutazione di Impatto Ambientale

Dal 2017 di fatto, qualsiasi attività di prospezione geofisica in mare, sia per scopi industriali che scientifici è stata azzerata

Serve una disciplina dettagliata che valuti non solo la tipologia dell'emissione sonora, ma l'energia e la modalità di emissione

Sorgenti *Sparker* e *Watergun* non sono considerate

Il volume e la durata temporale delle sorgenti non sono considerate

Reading:

Review by Alice Affatati: Rumore subacqueo in ambiente marino: fonti, effetti sulla fauna e misure di mitigazione.

Bollettino di Geofisica teorica ed applicate, Vol. 61 – Supplemento 1 Marzo 2020.

http://www3.inogs.it/bgo/provapage.php?id_articolo=836

and references herein