

# Regulatory Approaches to Underwater Noise

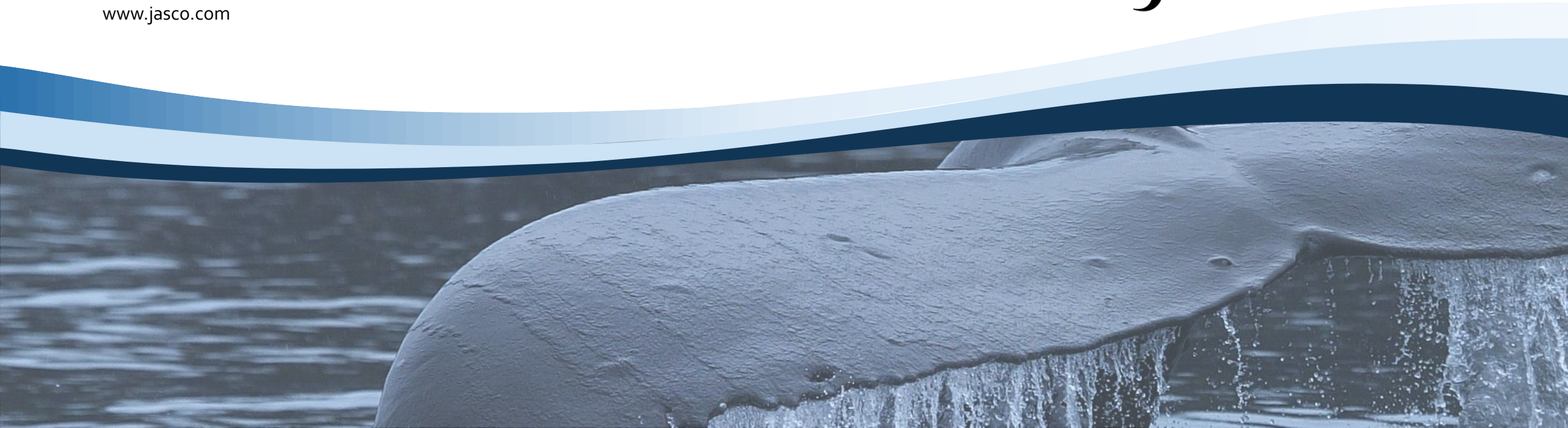
## An International Comparison

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DOSITS Webinar Series

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[www.jasco.com](http://www.jasco.com)



# Before we start...

- Marine mammals  
- focus on cetaceans only
- 35+ minute presentation  
and Q & A session
- Moderated site under 'DOSITS –  
Resources for decision makers' with  
links to national regulations
- Interviews with regulators  
and experts in the field
- Basic knowledge is assumed

# Outline

1. Terminology
2. General Aspects of Noise Regulations
3. Country Specific Regulation
4. Harmonisation and Diversity, Uncertainty
5. Ecological Consequences and Regulatory Frameworks
6. Summary



# 1. Terminology

# Important terminology

Term	Meaning
Sound vs. noise	Noise is any form of unwanted sound
Noise exposure criterion	A criterion contains the noise exposure <u>threshold</u> + other parameters (such as weighting functions)
Behavioural response, disruption, and disturbance	Any altered behaviour is a response; <u>disturbance</u> and disruption describe a change from one behaviour to another
Acoustic injury	There is no medical definition other a description of symptoms; injury is defined and used differently in regulatory regimes based on their statutes
Impulsive vs. non-impulsive	Vague definitions exist
Cumulative exposure	Usually accumulated up over a day or duration of activity; not considering separate activities



## 2. General Aspects of Noise Regulations

Including mitigation and frequency weighting

# Why regulate underwater noise?

- Marine fauna is sensitive to sound
- Sound is a pollutant and stressor
- **Ultimate concern:**  
Ecological consequences of noise exposure for marine fauna
- **Currency:**  
Fitness reduction for individuals and population consequences

# Governance of Underwater Noise

## Governing entities

- Countries – at Perhaps say at national/federal or state/province level
- Regional and multinational agreements or organisations

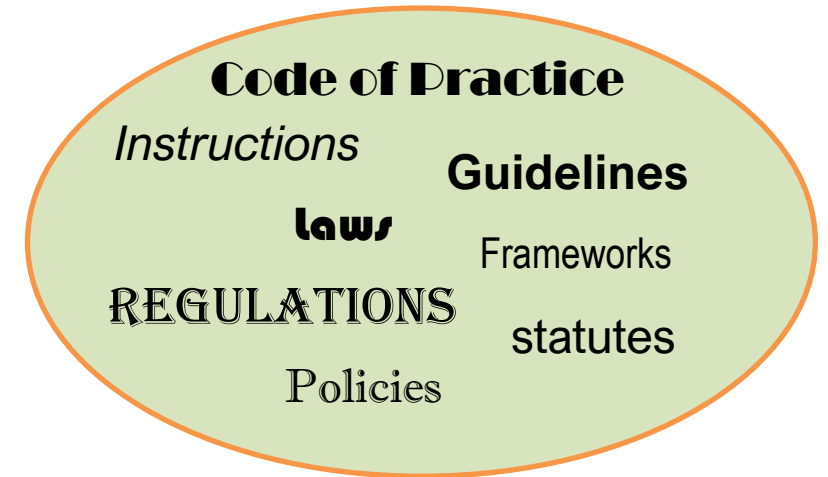
## Noise regulations can\*

- Be prescriptive or non-prescriptive;
- Be mandatory
- Recommend actions in a non-binding way

Policies – set by authorities to carry out their plans

Regulations – restriction imposed by authorities  
– rules made to obtain compliance  
– aiming at implementing the policies

## Governance instruments



\*complementary properties -  
not mutually exclusive terms



# Different approaches

- Source-centric/ activity-centric
- Habitat centric
- Species centric – indicator species; e.g., harbour porpoise
- Prescriptive – operational noise exposure limits that can/should not be exceeded (without permit); e.g., USA and Germany
- Non-prescriptive – no prescribed operational noise exposure limits; EIA must provide justification; e.g., Australia and Denmark

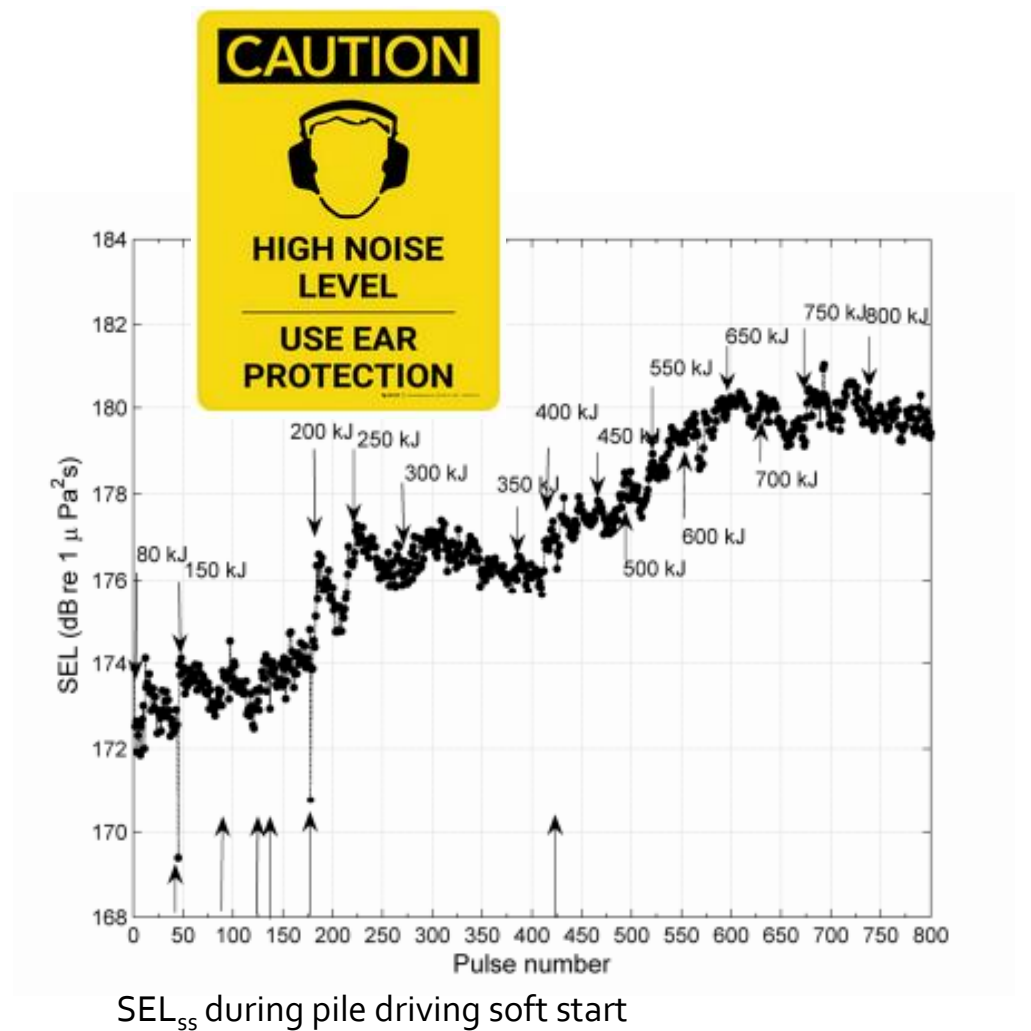
Aim	Goal	Regulation type
Identify predicted received levels, so that noise effects can be considered under national regulatory regime	Assess/ reduce	Prescriptive or non-prescriptive
Protect species	Reduce/ limit	Prescriptive

# Mitigation

Noise mitigation (operational and procedural) to reduce unwanted effects

## Mitigation measures

- Ramp-up/ soft start
- Safety zone and implementation of shut-down or power down; detection through monitoring
- Temporal and/or spatial closures
- Sound reduction
- Deterrence



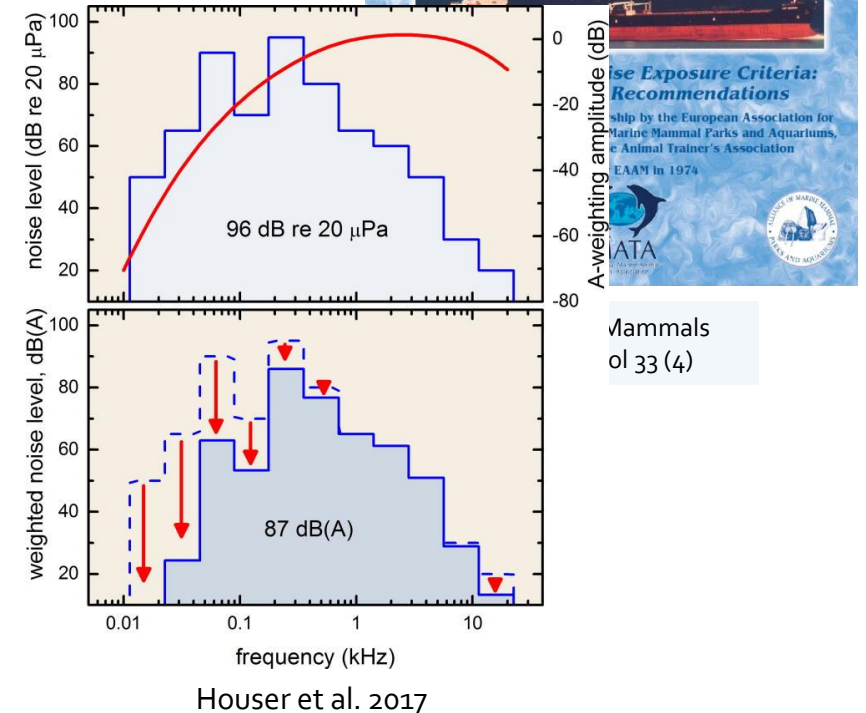
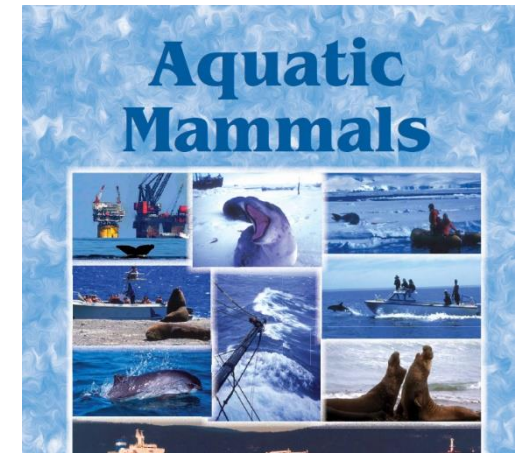
*Robinson et al. 2007 Oceans 2007-Europe. IEEE, pp. 1-6.*

Mitigation requirements can be mandatory, as part of a permit  
Mitigation can be the only way of preventing exceedance of noise exposure thresholds

# Southall et al. (2007/2019) Initial & Updated Scientific Recommendations

## Purpose

- Review existing scientific information
- Propose criteria for exposure of marine mammals to anthropogenic sound
- Dual criterion: PK + SEL  
Differentiation between single and multiple pulses and non-pulses
- Auditory frequency weighting functions (M-weighting / Type II)
- Noise exposure thresholds for onset of auditory impairment (TTS/PTS)
- Severity scaling and summary of existing behavioural data but no criteria [work in progress!]



Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene, Jr., D. Kastak, D.R. Ketten, J.H. Miller, et al. 2007. Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. *Aquatic Mammals* 33(4): 411-521.

Southall, B.L., J.J. Finneran, C.J. Reichmuth, P.E. Nachtigall, D.R. Ketten, A.E. Bowles, W.T. Ellison, D.P. Nowacek, and P.L. Tyack. 2019. Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. *Aquatic Mammals* 45(2): 125-232. [doi.org/10.1578/AM.45.2.2019.125](https://doi.org/10.1578/AM.45.2.2019.125).



### 3. Country Specific Regulation

Highlighting the most prominent and relevant ones

# Underwater noise regulations worldwide

## Existing *national* regulations:

- Australia
- Belgium
- Brazil
- Canada
- Denmark
- European Union
- Germany
- Ireland
- Mexico
- New Zealand
- Taiwan
- The Netherlands
- United Kingdom
- United States of America

## Existing *regional* regulations:

- ACCOMBAMS
- ASCOBANS
- CBD
- CCAMLR
- European Union
- HELCOM
- IMO
- IWC
- NATO
- OSPAR

## Regulations in development/ Initiatives:

- Chile
- China

## Noise considered:

- Saudi Arabia
- Qatar

# United States of America

Jolie Harrison and Amy Scholik Schlomer's DOSITS webinar

## **Review of NMFS Regulatory Approach to Underwater Noise**

Archived recording (23 Jul 2020) [[dosits.org/decision-makers/webinar-series/2020-webinar-series](https://dosits.org/decision-makers/webinar-series/2020-webinar-series)]

30+ marine mammal species in US waters

### Legislative background

Marine Mammal Protection Act [MMPA]:

Protect and conserve all marine mammals

Endangered Species Act [ESA]:

Protect, conserve, and recover marine species listed as endangered or threatened, as well as critical habitat

### Primary Regulatory Mechanisms for Noise Impacts

ESA: Section 7 Consultations

MMPA: 101(a)(5)(A&D) Incidental Take Authorizations

### Diverse Range of Activities, including:

Underwater geophysical exploration,  
active sonar, explosive detonations, pile  
driving, offshore drilling, etc.

# United States of America cont...

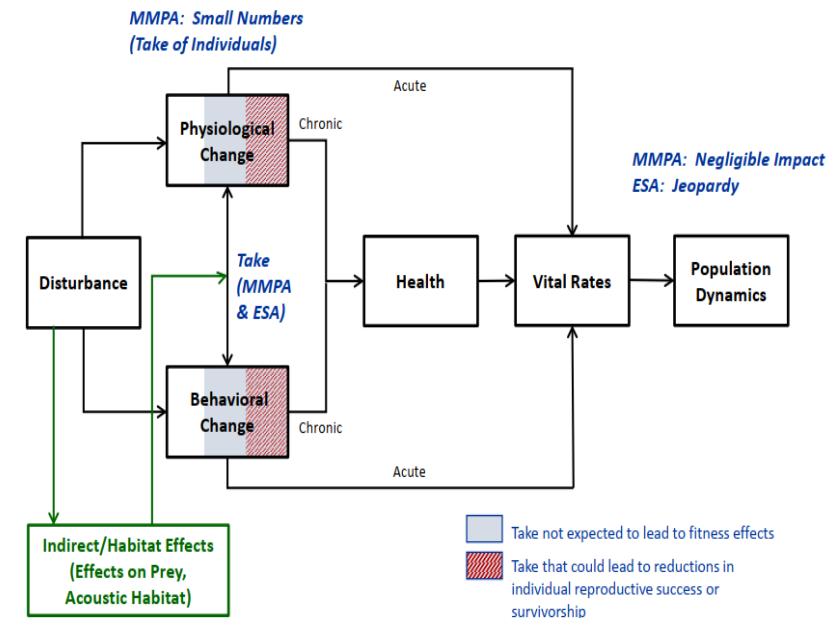
## MMPA Instruments

- Prohibition on “take” of listed species (to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal), with exceptions
- Level A and B harassment: Injury vs. behavioural effects
- Permits (research, enhancement) and incidental take authorisations (IHA)

## Issuance criteria

- Negligible impact on affected species/stocks
- Small Numbers: allowable amount of authorised take
- Mitigation, monitoring and reporting required

IHA must include assessment of effects on individual fitness + population level consequences



# United States of America cont...

First thresholds: National Marine Fisheries Service (NMFS) 1995

Latest update: Technical Guidance 2018 (*link below*) – auditory effects only

## Auditory Impairment (TTS/PTS)

- Different level for impulsive + non-impulsive sounds
- Specific for functional hearing classes
- Dual criterion for impulsive sound (SEL + PK)
- Frequency weighted SEL

## Behavioural Disturbance

- Impulsive + intermittent sounds :  
160 dB re 1  $\mu$ Pa (SPL)
- Continuous sounds:  
120 dB re 1  $\mu$ Pa (SPL)

Hearing group	PTS onset thresholds* (received level)		TTS onset thresholds* (received level)	
	Impulsive	Non-impulsive	Impulsive	Non-impulsive
Low-frequency (LF) cetaceans	$L_{pk}$ , flat: 219 dB $L_{E, LF, 24h}$ : 183 dB	$L_{E, LF, 24h}$ : 199 dB	$L_{pk}$ : 213 dB $L_{E, LF}$ : 168 dB	$L_{E, LF}$ : 179 dB
Mid-frequency (MF) cetaceans	$L_{pk}$ , flat: 230 dB $L_{E, MF, 24h}$ : 185 dB	$L_{E, MF, 24h}$ : 198 dB	$L_{pk}$ : 224 dB $L_{E, MF}$ : 170 dB	$L_{E, MF}$ : 178 dB
High-frequency (HF) cetaceans	$L_{pk}$ , flat: 202 dB $L_{E, HF, 24h}$ : 155 dB	$L_{E, HF, 24h}$ : 173 dB	$L_{pk}$ : 196 dB $L_{E, HF}$ : 140 dB	$L_{E, HF}$ : 153 dB
Phocid pinnipeds (PW) (underwater)	$L_{pk}$ , flat: 218 dB $L_{E, PW, 24h}$ : 185 dB	$L_{E, PW, 24h}$ : 201 dB	$L_{pk}$ : 212 dB $L_{E, PW}$ : 170 dB	$L_{E, PW}$ : 181 dB
Otariid pinnipeds (OW) (underwater)	$L_{pk}$ , flat: 232 dB $L_{E, OW, 24h}$ : 203 dB	$L_{E, OW, 24h}$ : 219 dB	$L_{pk}$ : 226 dB $L_{E, OW}$ : 188 dB	$L_{E, OW}$ : 199 dB

- Prescriptive
- Impact- and habitat-centric
- IHA including population effect assessment to obtain take permit

NMFS: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (2018 Revision)

<https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-acoustic-technical-guidance>



# European Union

- Marine Strategy Framework Directive (MSFD)
  - 2008/56/EC – established a framework for community action in the field of marine environmental policy
  - Descriptor 11: Underwater Noise
  - Aim: to improve the condition of all European seas and ensure that human use of and activity within these seas is sustainable
  - Directive requires Member States to take necessary measures to achieve or maintain good environmental status (**GES**) in the marine environment by the year 2020 at the latest

Marine Strategy Framework Directive does not qualify as underwater noise regulation yet as it is not prescriptive (lacks impact threshold criteria) and does not include a control/permitting mechanism (EIA)

# European Union cont...

## Two Indicators

- 11.1. Distribution in time and place of loud, low and mid frequency impulsive sounds

Proportion of days and their distribution within a calendar year over areas of a determined surface, as well as their spatial distribution, in which anthropogenic sound sources exceed levels that are likely to entail significant impact on marine animals measured as Sound Exposure Level (in dB re  $1\mu\text{Pa}^2\cdot\text{s}$ ) or as peak sound pressure level (PK, in dB re  $1\mu\text{Pa}$ ), measured over the frequency band 10 Hz to 10 kHz (11.1.1)

- 11.2. Continuous low frequency sound

Trends in the ambient noise level within the  $1/3$  octave bands 63 and 125 Hz (centre frequency) (SPL, re  $1\mu\text{Pa}$ ); average noise level in these octave bands over a year measured by observation stations and/or with the use of models if appropriate (11.2.1).

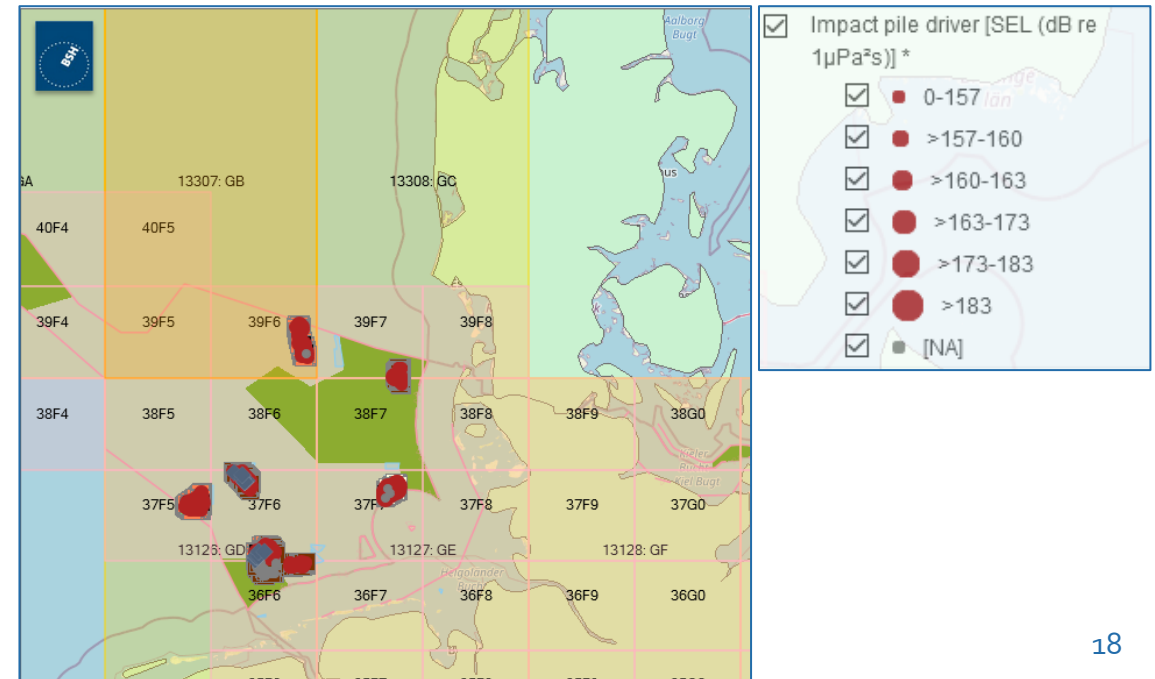
## EU Impulsive Noise Registers (11.1)

ICES – northern Europe (HELCOM/OSPAR), 2015  
ACCOBAMS – Mediterranean

## EU Continuous Noise Registers (11.2)

ICES – northern Europe (HELCOM), 2020

- Source- and habitat-centric



# European Union cont...

Commission Decision (EU) 2017/848 of 17 May 2017

- *"laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment"*

Technical Group (TG) Noise now developing noise criteria for GES

- "GES" thresholds, not noise-induced effect thresholds

Expert statements:

- No perceived conflict with national regulation of underwater noise
- Balance between best available science and practicable policy needed
- Ways forward to suggest threshold values is still debated
- Some member states waiting for EU criteria to define their own

# Germany

Regulator:	Federal Maritime and Hydrographic Agency (BSH)
Legislative background:	Offshore Wind Energy Law and Marine Installation Ordinance
First rule:	2008
Activity specific:	Focus on offshore pile driving
Injury definition:	Onset of TTS
3 marine mammal species normally occurring in German waters	
Species-specific	
Key- / Indicator species:	Harbour porpoise

# Germany cont...

Instrument: 'Standarduntersuchungskonzept'  
(latest version: StUK4, 2013)

Monitoring / mitigation measures:

- 750 m exclusion / observation zone
- Demonstrate that per-pulse levels at 750 m from the pile are below:
  - 160 dB re 1  $\mu\text{Pa}^2\cdot\text{s}$  SEL, and
  - 190 dB re 1  $\mu\text{Pa}$  PK
- Noise prognosis required
- Acoustic monitoring throughout installation
- Additionally online real-time acoustic monitoring
- ADDs mandatory

German concept (160 dB SEL in 750 m) adopted in Taiwan

- Stronger focus on marine mammal presence monitoring
- Real-time feedback

# Germany cont...

Sound Protection Concept (2013): *'Protection of Harbour Porpoises from Sound Exposures during the Construction of Offshore Wind Farms in the North Sea'*

Developed by German Federal Environment Ministry (BMU)

*Appropriate Assessment of projects' environmental impacts under the Habitats Directive provided for in Section 34(1) of the Federal Nature Conservation Act (BNatSchG)*

Considers habitat loss for harbour porpoises induced by disturbance

Effect range of disturbance assumed to be 8 km based on perceived level of 160 dB at 750 m

Disturbance range allows calculating and regulating cumulative effects

German EEZ:	<10% exposed above disturbance level
Nature conservation areas (SAC):	<10% of SAC areas
Sylt Outer Reef (calving ground):	<1% from 01. May to 31. August

- Prescriptive
- Impact- and habitat- based regulation
- Species centric
- EIA with modelling and plan to reduce impact required to obtain permit

# United Kingdom

Devolved responsibility for offshore marine area or offshore marine installations: Each country in the UK has their own regulation and regulatory body:

- England: Natural England
- Wales: Natural Resources Body for Wales
- Scotland: Scottish Natural Heritage
- N. Ireland: Department of Agriculture, Environment and Rural Affairs

Geophysical activities (oil & gas) centrally regulated for all of UK by  
Department for Business, Energy & Industrial Strategy (BEIS)

Scientific Advisory to the Government: Joint Nature Conservation Committee (JNCC)

Legislative background:

- The Conservation of Habitats and Species Regulations 2017  
[www.legislation.gov.uk/ukxi/2017/1012/contents/made](http://www.legislation.gov.uk/ukxi/2017/1012/contents/made)
- Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001  
[www.legislation.gov.uk/ukxi/2001/1754/contents/made](http://www.legislation.gov.uk/ukxi/2001/1754/contents/made)

- Non-prescriptive
- Activity-centric
- Focussed on disturbance and injury

# United Kingdom cont...

Five harbour porpoise Special Areas of Conservation (SACs) in UK were designated in 2019 [excl. Scotland]

Conservation Objective of SACs:

Maintaining Favourable Conservation Status (FCS) for harbour porpoise in UK waters

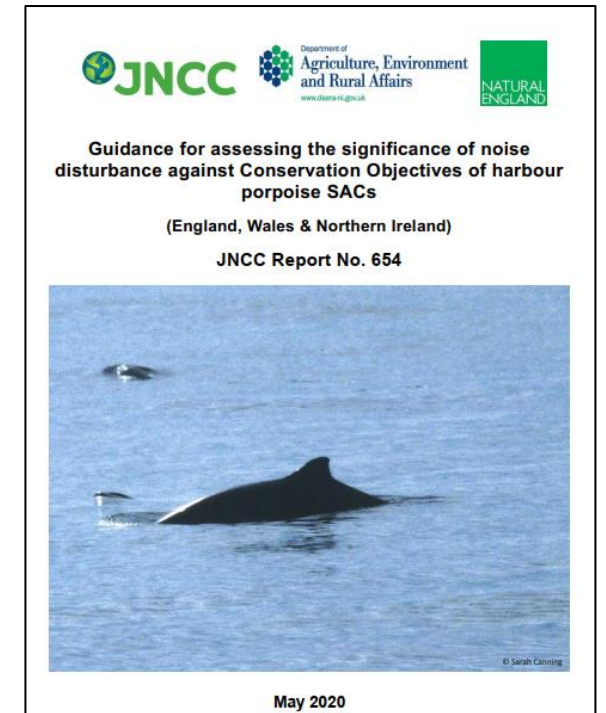
No significant disturbance allowed

Noise disturbance is considered to be significant if it excludes harbour porpoises from more than:

1. 20% of the relevant area of the site in any given day, or
2. An average of 10% of the relevant area of the site over a season

- New regulation is habitat- and species-centric
- Noise regulation is under revision

<https://data.jncc.gov.uk/data/2e60a9a0-4366-4971-9327-2bc409e09784/JNCC-Report-654-FINAL-WEB.pdf>





# The Netherlands

Current noise regulation tailored for installation of offshore wind farms

Regulator: Rijkswaterstaat, Ministry of Infrastructure and Water Management

Legislative background: Nature Conservation Act

Key species: Harbour porpoise

Instrument: Framework for Assessing Ecological and Cumulative Effects (KEC; 2015/2019)

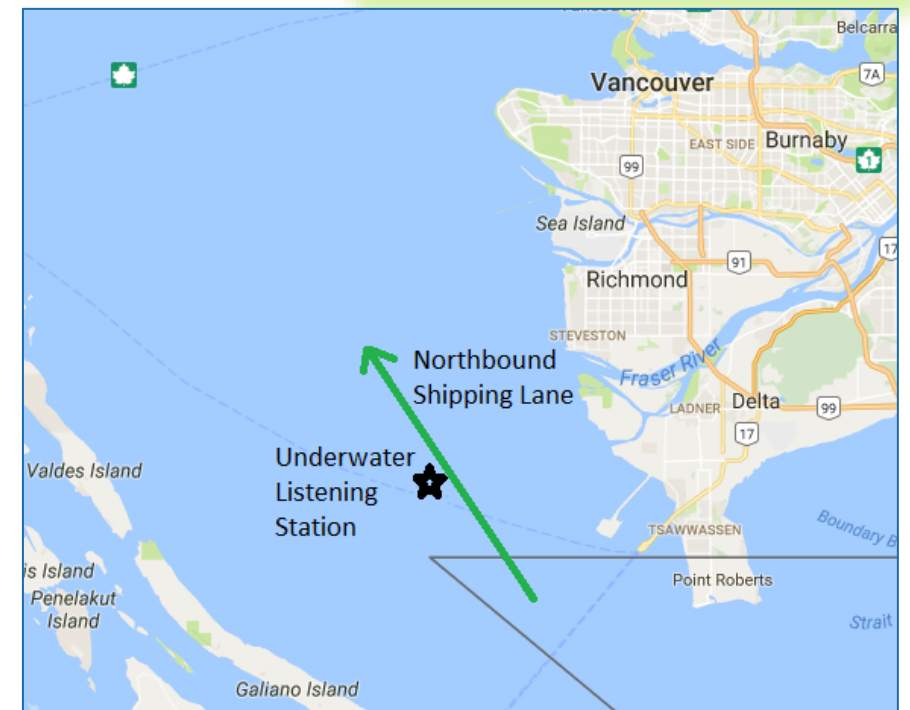
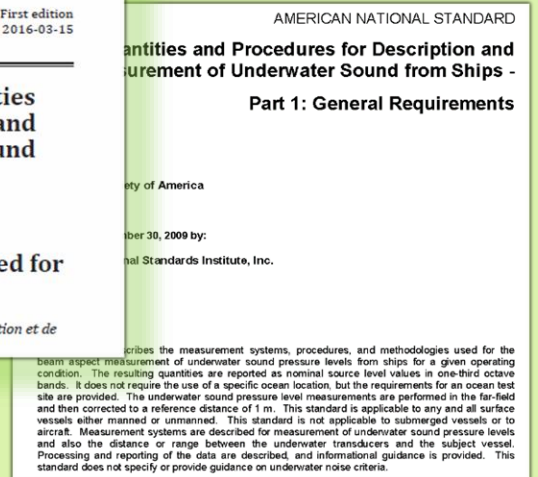
## Staged process

1. Sound propagation
2. Disturbance area,  $SEL_{SS} = 140$  dB SEL unweighted, broadband
3. Number of disturbed harbour porpoises
4. Harbour porpoise disturbance days
5. Population level effects  
Effect assessment

- Species-specific
- Activity-centric
- Prescriptive
- Population-based

# Canada... Ship noise measurements

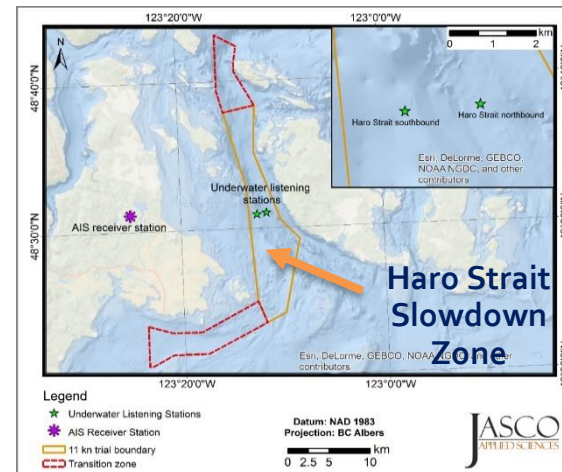
- Enhancing Cetacean Habitat and Observation (ECHO) program
  - Collaborative project: Port of Vancouver, Transport Canada, JASCO Applied Sciences, and Ocean Networks Canada
- 
- Measure noise emission levels of commercial vessels for assessing effects on marine mammals
  - Track ambient noise levels over several years
  - Automatically detect marine mammals and send notifications of detections



# Canada...

## Haro Strait Vessel Slowdown Trial (ECHO)

- Targeted mitigation measure; study to quantify the reductions in noise emission levels by slowing vessels (summer 2017)
- Port of Vancouver requested voluntary slowdowns of shipping traffic in critical habitat of Southern Resident Killer Whales



Category	Speed reduction (trial vs. control)	Noise level reduction (trial vs. control)
Containerships	7 kn	9.2 dB
Vehicle Carriers	5 kn	9.2 dB
Passenger Ships	6 kn	8.1 dB
Bulkers & Gen. Cargo	2 kn	4.7 dB
Naval Vessels	5 kn	8.1 dB
Tankers	3 kn	3.6 dB

Approach is:

- Habitat- and species-centric
- Source centric
- Voluntary

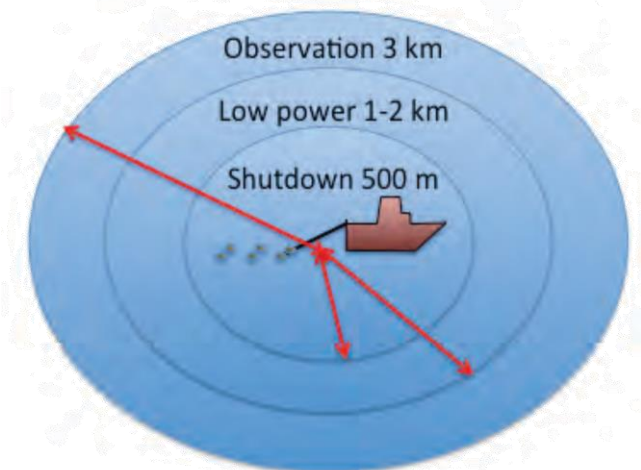
# Australia

- Policy maker: Department of Agriculture, Water and the Environment (DAWE)
- Legislative background: Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) + Offshore Petroleum Greenhouse Gas Storage Act 2006 (OPGGGS Act)
- OPGGGS Act Regulator: National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA)
- Expectations: Impacts and risk evaluated and managed to as low as reasonably practical and acceptable (ALARP approach) levels; criteria to be based on best available science

- Non-prescriptive
- Activity-and habitat centric
- Objective-based

## Required measures for seismic surveys:

- Observation zone, low power and shutdown zones defined:
  - 3 km / 2 km / 500 m if per pulse SEL >160 dB re 1  $\mu\text{Pa}^2\cdot\text{s}$  at the source
  - 3 km / 1 km / 500 m otherwise
- Require acoustic modeling to support zone selection
- Soft start and MMOs required, PAM recommended
- Consideration of species-specific conservation management plans
- Adaptive management





## 4. Harmonisation and Diversity, Uncertainty

# Diversity or Harmonization in Noise Regulation

## Pro Diversity

- Regulation of underwater noise is still in development, we need to learn from each other
- Large data gaps; constant updates required
- Gaps in understanding ecosystem relationships
- Diversity in approaches useful to determine the best way

## Pro Harmonisation

- Animals (cetaceans) do not respect national/regulatory boundaries
- End-users/proponents require practicable regulation – different jurisdictions problematic
- Least common denominator will provide comparable level of conservation

## Common requirement

- Communication and collaboration between all stakeholders:
  - Science – Industry – Regulators
  - Industry – Regulators (e.g., co-funding research)
  - Among Regulators
- Re-examine concepts and definitions

# Uncertainty

Statistical uncertainty, natural variability, and true uncertainty

Data available from a limited number of:

- Individuals within a species
- Species
- Sound sources

Extrapolations across species, functional hearing groups

Simplified regulatory processes  
(scientifically problematic but more practical)

Precautionary principle vs. proportionality principle

Regular updates to include latest science and new understanding



## 5. Ecological Consequences and Regulatory Frameworks



# Ecological relevance of noise exposure

## Initial focus of noise regulation

- Noise-induced hearing impairment (TTS/PTS)

## Recent trend

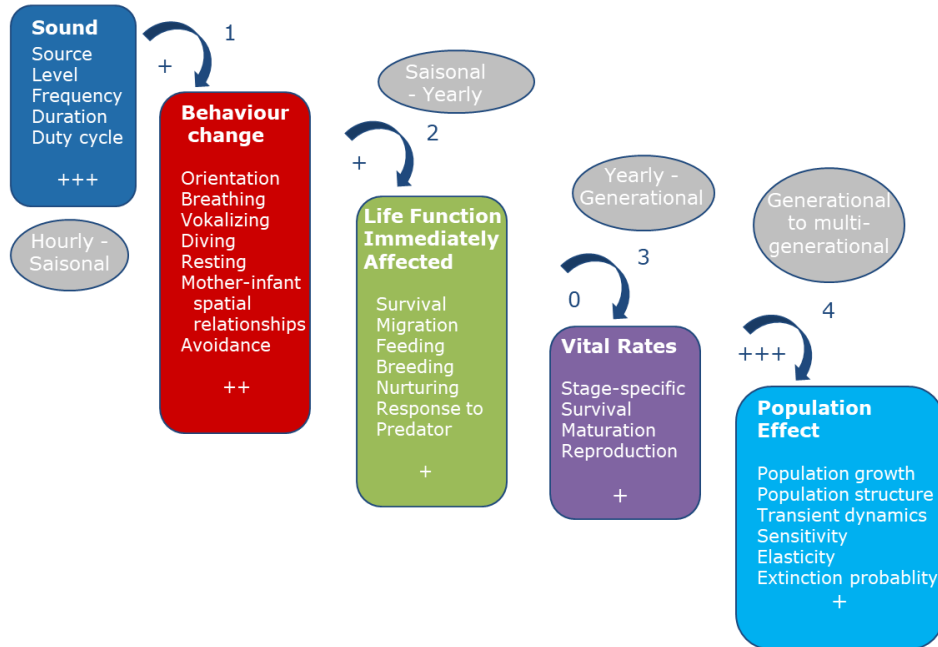
- Increased focus on sub-lethal or sub-injurious effects
- Integrating physiological and behavioral response studies
- Auditory and behavioral response studies using realistic (full-scale) sources [BRAHSS, 3S, SOCAL]

## Frameworks developed to understanding the ecological consequences of noise-exposure

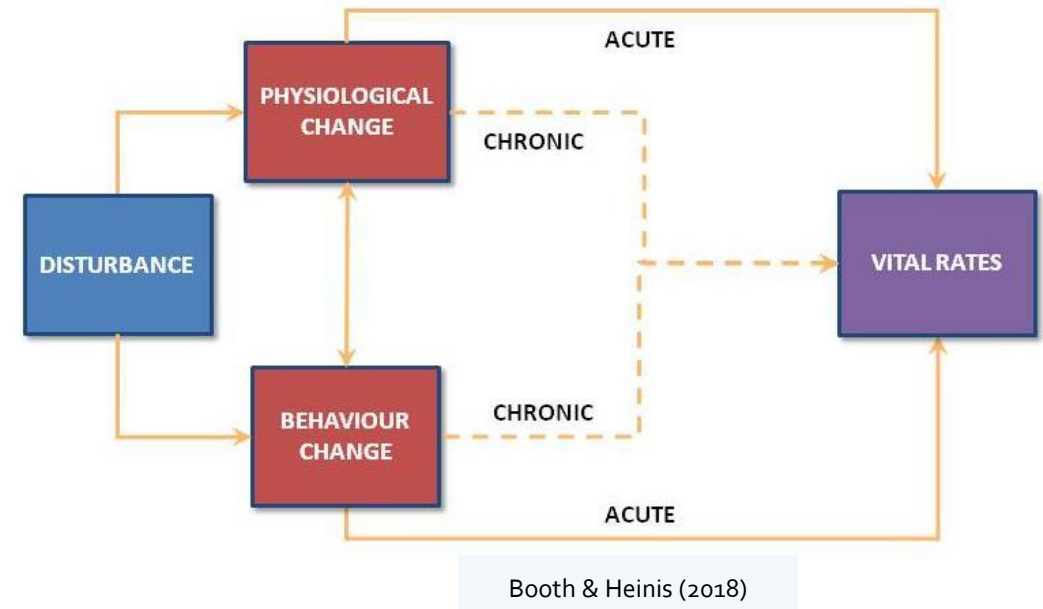
- PCAD / PCoD / iPCod
- Risk Assessment Framework (RAF)

# Regulatory frameworks

Scaling the effects of behavioural disturbance from an individual's vital rates to population consequences



Population Consequences of Acoustic Disturbance (PCAD), developed by NRC (2005)



Population Consequences of Disturbance (PCoD), developed by ONR Working Group (2009), adapted by Harwood et al. (2014)

NRC. 2005. *Marine Mammal Populations and Ocean Noise: Determining When Noise Causes Biologically Significant Effects*. Washington DC, The National Academies Press.

Harwood, J., S. King, R. Schick, C. Donovan, and C. Booth. 2014. *A draft protocol for implementing the interim population consequences of disturbance (PCoD) approach: assessing the effects of UK offshore renewable energy*.

Booth, C.G. & Heinis, F. 2018. *Updating the Interim PCoD Model: Workshop Report – New transfer functions for the effects of permanent threshold shifts on vital rates in marine mammal species*. Report Code SMRUC-UOA-2018-006.

# Risk assessment framework

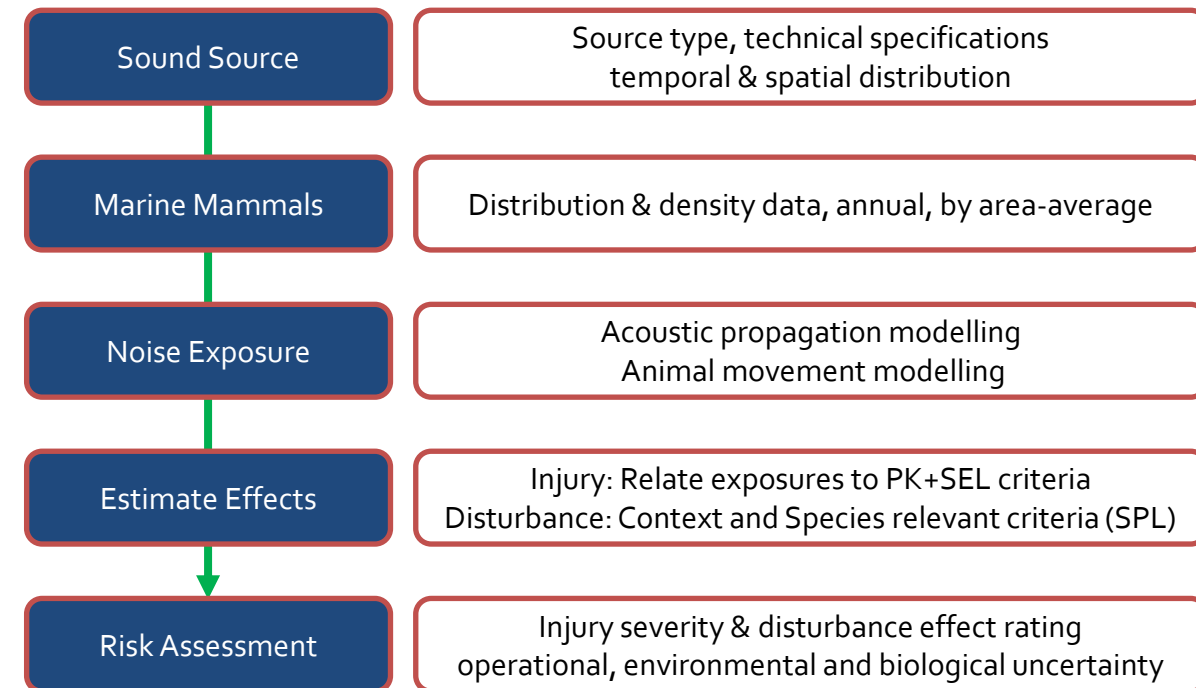
Five Stage Approach to Integrate Risk Assessment with PCAD/PCoD Model

Contextualising the impacts: Considering behavioural disturbance, auditory injury on population level

Direct validation of PCoD assumptions as basis of Magnitude-Duration curves

Assessment includes:

- Different behavioural patterns (incl. aversion)
- Region-specific density estimates
- Frequency weighting
- Latest science on TTS/PTS
- Considers lost opportunities and acoustic masking
- Mitigation
- Chronic effects
- Uncertainty
- Modelling of aggregate exposures





## 7. Comparison Summary

# International comparison

## Parallels

- Shared jurisdiction and non-centralised administrative responsibilities can be problematic
- Majority requires EIA (or comparable) to obtain permit/take authorisation
- Few regulations are focused on impact only, most often habitat is included too
- Focus on few sound sources
- Details of regulations often carry 'fingerprints'
- Cumulative effects considered, but difficult to quantify

## Common shortcomings

- Continuous noise sources mostly not regulated
- Shipping not included in regulation
- Acoustic masking and stress not considered

## Differences

- Focus on key species vs. entire megafauna
- Per-pulse vs. cumulative assessment
- Definition of injury – TTS vs PTS
- Definition of sound types
- Complexity of regulation
- Implementation of regulatory framework
- Behavioural disturbance – considered in a few regulatory regimes; thresholds set in 2 countries and GER
- Administrative boundaries (3 nm vs. EEZ)

## Needs

- Need for practicable metrics
- Clear and harmonised definitions
- Population- / ecosystem frameworks

# Acknowledgments

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Sónia Mendes

## Additional slides



# Habitats Directive (EU)

- Directive on the conservation of natural habitats and of wild flora and fauna (Council Directive 92/43/EEC of 21 May 1992)
  - Transposed into national law in all European countries
  - Under the Directive, marine mammal species normally occurring in national waters must be given protection
  - Two cetacean species (harbour porpoise, bottlenose dolphin) and two pinniped species (grey seal, harbour seal) requiring designation of Special Areas of Conservation (SAC) [Annex II]
  - Cetaceans (all species of whales, dolphins, and porpoises) as species requiring strict protection [Annex IV]

Regulation of underwater noise in several EU member states driven by Habitats Directive

*Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora*

<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31992L0043>



## Other EU – Member States

**Belgium:** 'Actualisatie van de initiële beoordeling voor de Belgische mariene wateren, 2018'

Threshold: Lz-p (level zero to peak) of max. 185 dB re 1  $\mu$ Pa at 750 m distance

Restrictions [\* variable]:

- seasonal pile driving restriction from January 1st - April 30th (local seasonal peak in porpoise density)
- use an ADD and soft start procedure are obligatory\*
- pile driving is to be delayed or stopped if a porpoise is observed\*

<file:///G:/docs/Literature/Guidelines%20%20Laws%20%20Directives/BEL/322240.pdf>

**Denmark:** no central regulation, activity-dependent, non-prescriptive, PTS criterion suggested as indicator for population consequences, species-centric, PTS – unweighted cumulative SEL thresholds harbour seal: 200 dB re 1  $\mu$ Pa<sup>2</sup>s, harbour porpoise: 183 re 1  $\mu$ Pa<sup>2</sup>s.  
Guidelines in revision.

**Ireland:** Guidance document issued in 2014, metrics based on Southall et al. 2007  
Focusing only on licensable activities  
Secondary or indirect effects must be considered in risk assessment

**Greenland:** Seismic surveys

'Offshore Seismic Surveys in Greenland; Guidelines to Best Environmental Practices, Environmental Impact Assessments and Environmental Mitigation Assessments';  
[https://naalakkersuisut.gl/~media/Nanoq/Files/eamra/Guidelines\\_UK\\_2\\_Dec.pdf](https://naalakkersuisut.gl/~media/Nanoq/Files/eamra/Guidelines_UK_2_Dec.pdf)

# Canada

- Effects of underwater sound on marine fauna regulated under the Species at Risk Act (SARA)
- Current regulations focus on monitoring and mitigation measures during offshore seismic surveys
- Mitigation requirements for seismic activity
- Current regulations: Statement of Canadian Practice (SOCP) with respect to mitigating seismic airgun impulses in the marine environment (DFO 2008) and the Fisheries Act (DFO 1985)

- Source-centric
- Non-prescriptive
- currently under review

# New Zealand

Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations (2012)

- Prescriptive
- Recommends no surveys in ecologically important areas when species are present

Marine Mammal Impact Assessments:

- Must include sound propagation modeling for surveys in ecologically important areas
- Two thresholds for shutdown based on Southall's single pulse thresholds"
  - SEL(24h) > 171 dB re 1  $\mu\text{Pa}^2\cdot\text{s}$  at a specified radius (depends on airgun array size)
  - SEL(24h) > 186 dB re 1  $\mu\text{Pa}^2\cdot\text{s}$  at 200 m
- Require MMOs and PAM on duty for all surveys >427 in<sup>3</sup>

Revised Code of Conduct (unpublished, review still ongoing)

- New Code suggests a single -20 dB step is applied as a weighting function below 1 kHz
- Noise exposure levels are defined for impulsive and non-impulsive sounds, and cumulative exposure is accounted for

# Brazil

Joint Normative Instruction IBAMA/ICMBIO No. 2, 21 Nov 2011:

Establish permanent restriction areas and periodic restriction areas for **seismic data acquisition activities** for oil and gas exploration in priority areas for the conservation of aquatic mammals on the Brazilian coast

National Action Plans for the Conservation of Endangered Species (PANs):

1. Marine cetaceans
2. Amazon aquatic mammals
3. Porpoises

Implementation of PANs managed by the National Aquatic Mammals Research and Conservation Center (CMA), coordinated by ICMBio [Brazilian Ministry of the Environment]

<https://www.icmbio.gov.br/cma/legislacao.html>

# Mexico

Regulator: Agencia de Seguridad, Energía y Ambiente (ASEA)

Legislative background:

“General Administrative Arrangements to Establish the Guidelines on Industrial Safety, Safety and Operating Environment Protection Activities for Surface Exploration, Oil Exploration and Extraction” (2016)

Activity-centric: seismic surveys (airgun)

Prescriptive

Exclusion zone of 2,000 meters

Permitted sound levels of up to 180 dB re 1 $\mu$ Pa (RMS) PAM operators and visual monitoring (PSO) mandatory.

No restrictions for pile driving other than the use of MMOs in some protected areas

# Kingdom of Saudi Arabia



THE DESTINATION

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protect, preserve and enhance the local environment; and



set a new standard in sustainable development;



<https://www.theredsea.sa/en/project>

# People's Republic of China

Current initiatives to develop noise-related regulations

Focus on:

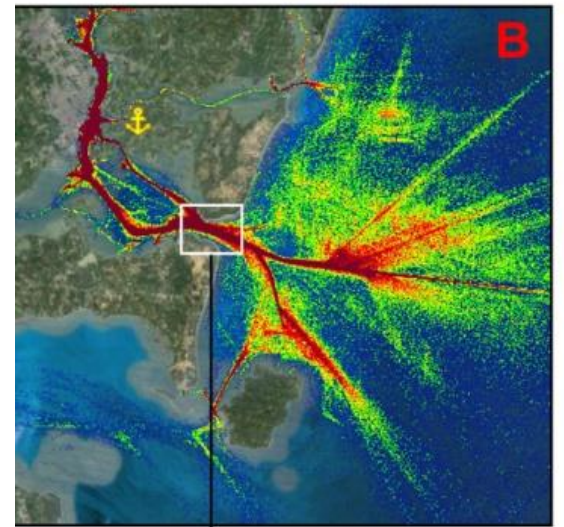
Indo-Pacific humpback dolphins (*Sousa chinensis*)

Yangtze finless porpoise (*Neophocaena phocaenoides*)

Example:

Initiative to develop regulations to mitigate shipping effect on Indo-Pacific humpback dolphins

- Mitigation: reduction
- Suggested Regulation: Creating marine protected areas (MPAs) in Indo-Pacific humpback dolphin habitats



Li et al. (2018)

Li, S., M. Liu, L. Dong, J. Dong, and D. Wang. 2018. Potential impacts of shipping noise on Indo-Pacific humpback dolphins and implications for regulation and mitigation: a review.

*Integrative Zoology* 13(5): 495-506. [doi.org/10.1111/1749-4877.12304](https://doi.org/10.1111/1749-4877.12304).  
DOSITS webinar series: Regulatory Approaches to Underwater Sound - An International Comparison

Li, S. 2020. Humpback dolphins at risk of extinction. *Science* 367(6484): 1313-1314. [doi.org/10.1126/science.abb5744](https://doi.org/10.1126/science.abb5744).

# Noise-Induced Effects

Marine animals use sound in a variety of contexts, including sending and receiving signals, prey localisation, environmental eavesdropping, navigation, social cohesion, and parental care

## Possible Effects:

- **Increased stress** – acute/chronic – increase susceptibility for diseases (reduced immunosuppression)
- **Altered behaviour** – reduced parental care; stranding of cetaceans, particularly beaked whales
- **Acoustic/ auditory masking** – reduced communication or listening space; prevent marine animals from hearing important sounds
- **Auditory impairment** – temporary or permanent hearing loss (TTS/PTS)
- **Non-auditory effects** – damage tissue
- **Death** – direct or indirect



## ... and what is regulated

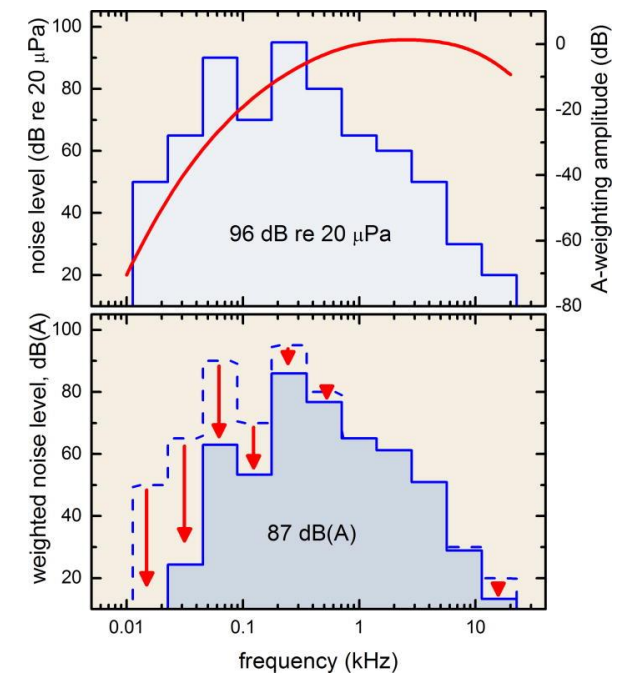
- Behavioural disturbance
- Auditory effects



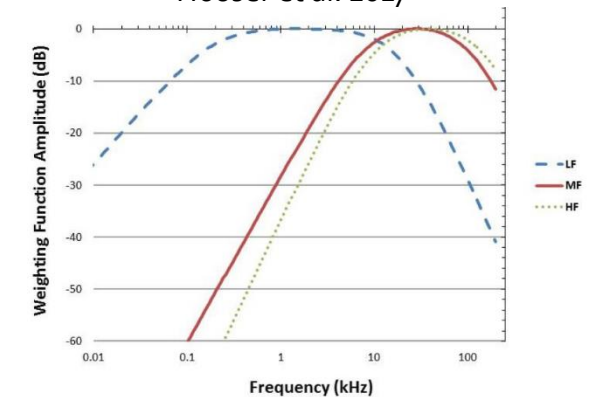
# Auditory frequency weighting functions

- Functions account for frequency-dependent differences in auditory sensitivity and hearing group's susceptibility to noise-induced hearing loss
- Used to predict the auditory effects of anthropogenic sound on marine mammals
- Species-specific, but merged for functional hearing groups

- Complex functions considered in one regulation so far
- Simple step-function considered in some countries
- Not considered in most regulations



Houser et al. 2017



NMFS 2018

Houser et al. 2017. A review of the history, development and application of auditory weighting functions in humans and marine mammals. *Journal of the Acoustical Society of America* 141(3): 1371-1413. [doi.org/10.1121/1.4976086](https://doi.org/10.1121/1.4976086).

Erbe et al. 2016. Communication masking in marine mammals: A review and research strategy. *Marine Pollution Bulletin* 103(1): 15-38. [doi.org/10.1016/j.marpolbul.2015.12.007](https://doi.org/10.1016/j.marpolbul.2015.12.007).

Tougaard and Dähne, 2017. Why is auditory frequency weighting so important in regulation of underwater noise? *Journal of the Acoustical Society of America* 142(4): EL415-EL420. [doi.org/10.1121/1.5008901](https://doi.org/10.1121/1.5008901).

# Acoustic Metrics

Metric	NMFS (2018) and Southall et al (2019)	ISO 2017		Unit
		Abbreviation in main text	Symbol in equations/ tables	
Sound pressure level	n/a	SPL	$L_p$	decibel (dB) re 1 micropascal ( $\mu\text{Pa}$ )
Peak sound pressure level	PK	PK	$L_{pk}$	dB re 1 $\mu\text{Pa}$
Sound exposure level (per pulse)	n/a	Per-pulse SEL	$L_E$	dB re 1 $\mu\text{Pa}^2 \cdot \text{s}$
Sound exposure level (accumulated over time), $SEL_{\text{time-period}}$	$SEL_{\text{cum}}$	$SEL_{24\text{h}}$	$L_{E,24\text{h}}$	dB re 1 $\mu\text{Pa}^2 \cdot \text{s}$
Source level	SL	SL	$L_{S,pk}$ $L_{S,p}$ $L_{S,E}$	dB re 1 $\mu\text{Pa} \cdot \text{m}$ (Peak source pressure level, SPL source level) or dB 1 $\mu\text{Pa}^2 \text{m}^2 \text{s}$ (Per-pulse source SEL)
Particle acceleration (not accumulated)	n/a	n/a	n/a	$\text{m/s}^2$ , $\mu\text{m/s}^2$ , and $\text{nm/s}^2$ , and logarithmic scale (dB) relative to these units