Report of the Workshop on International Harmonisation of Approaches to Define Underwater Noise Exposure Criteria

(Budapest, Hungary 17th August 2013)

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Contents

1. Summary

This international workshop funded by the Netherlands Ministry of Infrastructure and the Environment was held in August 2013 with a group of 102 participants, comprised of scientists, regulators and other stakeholders. The workshop consisted of short presentations on key topics followed by group discussions focused on how new scientific information related to the effects of underwater noise on marine life influences permitting practices for human activities at sea. Also discussed were how individual countries regulate underwater noise (and grant permits) and opportunities for harmonising approaches between neighbouring countries, as well as on an international scale. The workshop was intended to build momentum towards an international exchange of information and to potentially establish a network for the regulation community.

Most of the discussions during the workshop, and consequently reported herein, are focussed on effects related to marine mammals, while aspects referring to other animal groups will be specifically indicated. Current research on noise-induced effects focuses on behavioural changes, population level outcomes, increasing the number of species for which there is existing data, and finding the best metric to describe temporary threshold shift (TTS) in animal hearing.

Large gaps in knowledge still exist. Filling these gaps is of primary importance in order to provide regulators with the necessary scientific knowledge and understanding about cause-effect relationships and noise thresholds. In particular, hearing sensitivity in baleen whales remains an unsolved, but highly relevant question. New results on long-term effects of TTS raise new questions about the definition of impairment and injury. Other taxa, such as bony fishes, sharks, or invertebrate species, need to be considered as well, with many of the same questions as those raised for marine mammals. Fishes, sharks, and invertebrates are generally sensitive to particle motion, although some species are also sensitive to sound pressure. Little is known about particle motion detection by fishes, and even less is known about responses of other organisms. It is important to determine relevant thresholds for the detection of particle motion in relation to behavioural effects, as well as pressure-related physiological effects and masking in these animals.

The needs of regulators from different countries are comparable: they need reliable and understandable baseline information on cause-effect relationships. This information could be partially provided through targeted training material for regulators (and other stakeholders). These materials are not currently available. Another critical regulator need is for opportunities to speak with each other and share knowledge across wide geographic regions. Identifying the questions common among the countries/parties could help raising funds from various countries and help increasing efficiency by reducing redundancy.

Additional keys to future success were identified, including the needs to obtain commitments from the regulatory senior management and politicians, ensuring that their nations will participate (by pointing out the benefits of participating in this discussion) and will encourage participation by regulators from their agencies or institutions; invite nations who were not represented in the Budapest discussions to participate in future meetings; and raise awareness of this topic across a broad audience, including the public. In order to keep the momentum up, there are attempts underway to launch a platform for information exchange, and follow-up meetings are planned to discuss more concrete measures, as well as scientific aspects.

2. Introduction

The potential negative effects of high levels of underwater noise on marine life have been identified and acknowledged, and this issue has been incorporated into various international agreements over the past decade. Several countries have already issued regulations to limit the incidence and level of anthropogenic noise in the oceans. The development of regulations on noise exposure in marine environments has to date focused on two groups, marine mammals and, to a lesser extent, fishes. In the absence of sufficient data and a comprehensive understanding of all relevant dose-response functions, existing regulations are based on extrapolation from the limited data available (especially for fishes), expert judgement and a precautionary approach, or a mix thereof.
Nevertheless, our understanding of the complexity of acoustic and behavioural effects is improving, and it might be possible to develop existing noise-exposure criteria with scientific knowledge evolving. More importantly, new regulations, or at least the approaches taken toward regulations, could be internationally harmonised to provide better protection for marine fauna.

Workshop

To facilitate such a process, a workshop on 'international harmonisation of approaches to define underwater noise-exposure criteria' was organised and held on 17th August 2013, in conjunction with the *Third International Conference on the Effects of Noise on Aquatic Life*, Budapest (11-16th August 2013). The workshop, attended by 102 people, was funded by the Ministry of Infrastructure and the Environment, the Netherlands , and organised by IMARES Wageningen UR in cooperation with TNO.

Goals

The workshop provided a platform for in-depth discussions of the regulatory aspects of anthropogenic underwater noise and the science that is currently available to inform the regulations community. Its specific aims were:

- *Science input for the regulations*, i.e. harmonising methods and threshold values to assess impact ranges for the effects of anthropogenic sound sources on marine life.

  Questions addressed:
  1. What progress has been made since Southall, et al. 2007 for marine mammals and for other taxa (turtles, bony fishes, sharks, invertebrates)?
  2. How can recent scientific findings be implemented?
  3. What research needs to be done next (prioritization)?

- *International understanding of regulatory approaches*.

  Questions addressed:
  1. What are the differences between current national approaches?
  2. What is the rationale behind the national approaches?
  3. Are there possibilities and willingness for harmonisation?

3. Workshop

Presentations

A. Three presentations covering current scientific understandings were given at the workshop by experts in their respective fields:

1. James Finneran, US Navy Marine Mammal Program, Space and Naval Warfare Systems Center Pacific, San Diego, CA USA: *Most Relevant Results on TTS in Marine Mammals – An Update.*
Additional species have been tested over the last six years (since the publication of Southall et al. 2007), and in terms of sensitivity for TTS, significant differences across species have been found. Also, higher levels of TTS have been induced in TTS studies in order to achieve a dose-response function and better predict permanent threshold shift (PTS). Moreover, the frequency dependency of TTS, auditory weighting functions, the effect of various types of sound, and self-mitigation of noise effects have been investigated. An important aspect is the right metric to describe TTS: sound exposure level (SEL) and the equal energy hypothesis are good as SEL captures both sound pressure level (SPL) and duration, but longer duration exposures will produce more TTS than shorter exposures with same SEL. Therefore, multidimensional models might be the best way forward.

2. Arthur N. Popper, University of Maryland, College Park, MD USA: *Guidelines for Sound Exposure for Fishes and Turtles.*
A working group started by the U.S. National Oceanic and Atmospheric Administration (NOAA) is working on a revised version of suggested exposure guidelines for fishes and turtles from different sources. They divided possible effects into mortal and potentially mortal effects, impairment (including recoverable injury, TTS, and masking) and behavioural changes. Exposure guidelines for effects will be based on five different animal 'groups': 1) Fishes without a swim bladder (only detect particle motion), 2) fishes with a swim bladder (primarily detect particle motion, and probably also pressure), 3) fishes with swim bladder "connected" to the ear (physostomes) – detects particle motion but also pressure, 4) sea turtles, 5) fish eggs and larvae. The results will be published in early 2014.

3. Anthony Hawkins, Loughine Limited, UK: *Effects of Noise on Fish, Fisheries, and Invertebrates in the U.S. Atlantic and Arctic from Energy Industry Sound-Generating Activities: Gap Analysis - Research Priorities.*
The U.S. Bureau of Ocean Energy Management (BOEM) convened a workshop to identify gaps in our understanding of the effects of noise on marine fishes, fisheries, and invertebrates (Normandeau Associates, 2012). Some of the most relevant gaps are:

- to determine more fully the characteristics of the sounds generated by different sources and those features that are most harmful
- derive thresholds for response, or noise exposure criteria, with respect to death and mortal injury
- measure hearing abilities for a wider range of species, using behavioural techniques
- distinguish between sensitivity to sound pressure and particle motion
- determine the levels of sound pressure and particle motion that physically damage the inner ear or other parts of the auditory system
- examine the masking effects of background noise
- describe behavioural changes in response to sounds for animals in the wild

- examine soundscapes; refine biological, source and procedural mitigation (e.g. ramp-up) of sound exposure.

BOEM will use the results of this workshop to better inform decision-making and environmental analysis processes.

B. Three presentations on regulatory issues were given by representatives of regulatory agencies from the Netherlands, the United States, and Germany. The approaches taken in these countries represent different philosophies and strategies in regulating underwater sound:

1. Suzanne Lubbe, Rijkswaterstaat, Ministry of Infrastructure and the Environment, NL: *Regulation of Underwater Noise in the Dutch North Sea*.

2. Jolie Harrison, U.S. NOAA/National Marine Fisheries Service, Office of Protected Resources (OPR): *U.S. Approach to the Management of Underwater Noise Impacts and Revision of Acoustic Thresholds for Marine Mammals.*

3. Thomas Merck, German Federal Agency for Nature Conservation: *German Regulatory Approach to Underwater Noise.*

C. Following the presentations, workshop attendees formed break-out groups of 20-30 people to discuss aspects related to the science or regulatory related issues with regard to the harmonisation of noise criteria. For both aspects, a set of partly overlapping topics was prepared as a template, covering issues identified beforehand as relevant for the final plenary discussion and workshop report. The break-out groups were moderated by Gail Scowcroft, Aylin Erkman, Kathleen Vigness-Raposa and Frans Peter Lam. The topics were:

1. Science
The Way Ahead (scientific aspects):

- *Where are the gaps in current scientific knowledge regarding the effects of underwater noise on marine fauna?*
- *What are the priorities to address to support regulation and which research would yield the most scientific benefit with regard to effects of underwater sound on marine fauna? Where do priorities and benefits intersect?*
- *The Way Ahead (regulatory aspects)*
- *Based on the current/latest scientific evidence, what kind of regulations should be implemented?*
- *What would regulatory agencies/governments have to do to achieve a level of protection for marine fauna, where sound exposure does not have an impact upon populations?*
- *Methodology*
- *Is terminology harmonised? Do we also need to harmonise experimental procedures? If so, how can we do this effectively (through ISO or ANSI workshops?)*
- *General*
- *What is the overall advice of scientists for the regulators? (not just "more research funding")*

2. Regulations
Current Situation

- *What are the commonalities and differences between regulatory/permitting processes in various countries? (Using concrete examples: offshore pile-driving, shipping, sonar, airguns etc.)*
- *What is the logic behind the various regulatory approaches (e.g. source level vs. received level and stand-off distance, temporal vs. spatial planning, buffering etc.)?*
- *The Way Ahead (scientific aspects)*
- *How can scientific research aid in achieving better and more harmonised regulations? What are the questions for the scientists?*
- *The Way Ahead (regulatory aspects)*
- *Can we learn from each other (between different countries/regulatory agencies) and adjust regulations accordingly, or are all regulations carved in stone due to national/regional (e.g. EU) legislation?*
- *Do we need to harmonise regulations and procedures? What are the opportunities and challenges for harmonising regulation and permitting procedures?*
- *How could intergovernmental cooperation be implemented?*

This list of topics and questions was intended as a template for the discussions in the break-out groups, but was not exclusive; and groups were invited to review the topics and change or add to them. Not all topics/questions were addressed by each group within the given time frame. The main outcomes of the discussions are delineated below.

Regulatory Issues

Is there a need for harmonisation?

As a starting point for the discussion of regulatory issues, the aim of the workshop was reviewed and more clearly defined: the focus should be the potential for harmonisation of approaches to regulating underwater sound, not the harmonisation of the regulations themselves. It is inherent in this topic that specific regulations will commonly reflect each country's legal background (its statutes and provisions) and thus the cultural perspectives of the cultures that develop them. However, is there a need for harmonisation at all? Some areas are logical for harmonisation, especially for animals, which cross national barriers. It was suggested that there may be a need to harmonise approaches and procedures, but it was also recommended that decisions should be based on costs and benefits.

What are the goals of regulation?

Regarding generic regulation, it was proposed that the approach should focus on goal setting legislation, rather than common regulations. As an example, one approach would be for the international regulation community to agree on what good habitat status means (see *European Union Marine Strategy Framework Directive*). Another suggestion was to utilize adaptive management in existing regulations. This is not often implemented, and a major problem so far is that new information is not always integrated efficiently into the regulatory system. The degree of regulation and protection for any chosen indicator (species/group/taxon) considered to be necessary is of course influenced by the interest of each stakeholder; and as concerns, such as over-protection of sensitive populations, were discussed. It was suggested that regulatory efforts should strike a balance between protecting species and ecosystems and the economic interests of industry and other regulated parties. Caution was advised regarding the conflicting effects of a mitigation strategy. For example, making ships quieter might increase the risk of collisions with whales. Also, since underwater noise regulation is unlikely to become globally harmonised, it was suggested that underwater noise regulation should rather be based on regional considerations.

With regard to the analytical frameworks applied in different countries, there should be no concern about differences, but an overview would be useful and appreciated. There was consensus that regulations should not be confined to one taxonomic group and that injury/disturbance characteristics should be considered. However, it is important to note that regulations, or at least criteria, need to differ by taxa, and that different issues need to be addressed for different taxa – such as particle motion for fishes, turtles, and invertebrates, but not for mammals.

What do regulators need from scientists?

An important topic in the discussion was the question 'what do regulators and industry need from scientists – and vice versa?' There was clear consensus that regulatory requirements need to be updated as the science evolves. At the moment, the state of knowledge has improved compared to before the Southall et al. 2007 study, but it is still insufficient for the decisions regulators have to make.

Dedicated education and training

Another important aspect is education and training of all parties involved: regulators, industry representatives, and other stakeholders must have access to and understand the science. They must also see the need for and appreciate a manual of guiding materials based on relevant research (e.g., the scientific presentations given prior to the break-out group discussions) and/or regular updates from scientists on the latest research findings for relevant taxonomic groups, which can be achieved through national and international meetings. It was suggested that such updates should be provided on a regular basis, either on a yearly basis, or at least at regular intervals – compiled by a widely accepted scientific review panel (thus creating an 'update' of Southall et al. 2007 on a regular basis). The benefit of such meetings on an international basis would be to ensure the same level of quality of information for all participating countries and avoid multiplication of research efforts. Such initiatives can be international, but can also be useful on a regional scale.

Another tool suggested to improve the exchange and provision of information is a catalogue of basic foundational science tools (or links to them) that may include tutorials on bathymetry, population data, soundscape data, biological data, distribution maps, and density maps. Training material, as provided by some oil companies for their staff or through existing websites (e.g., the Discovery of Sound in the Sea project resources at www.dosits.org and the Tethys-Database at http://mhk.pnnl.gov/wiki/index.php/Tethys_Home) were recommended as well as an international database of research and monitoring results, regional protocols and standards, strategy documents that outline research needs, and models.

Exchange between agencies and involvement of higher management

Besides providing training opportunities, the opportunity for regulators to speak with each other and share knowledge across wide geographic regions was considered as a priority for the best way forward. Keys to success would be to obtain commitment of regulatory senior management that their nations will participate in these international dialogues, make the benefits clear to their regulators, and encourage participation by their agencies and institutions. Also, other nations who were not represented in the Budapest discussions should be invited to future meetings. Finally, there was general consensus that awareness of these topics should be raised across a diversity of audiences, including the public.

Avoiding redundancy by international collaboration

A clear economic benefit for common regulatory guidelines is that scientists and interested parties from various countries may be able to work/research collaboratively to answer questions that are common among the countries/parties. For example, does a seismic airgun ramp-up procedure work? By leveraging research funds from the various countries, one could answer questions that each country/party needs without having to have multiple efforts.

State of knowledge and major uncertainties

Scientists should not only provide relevant information. Instead, the scientific community needs to provide a clearer understanding of what is currently known and unknown. They need to highlight major uncertainties as well as the priorities for future research and funding. Moreover, scientists should also be informed about goals and regulations in order to increase the reach of their own research results, as well as the efficiency of regulations.

Coherent and predictable regulation

For offshore industry (underwater sound producers of all types of industry) and other stakeholders, it is important to have clear, simple, coherent regulatory requirements that are based on sound, scientific evidence. It is important for industry to have some predictability of the future regulations, i.e. regulators should send advance notification and inform industry about their procedures in updating regulations so that they can cope with new regulations in a timely manner. It was suggested that industry as well as NGO's should even participate in the formation of new guidelines or frameworks. The regulatory requirements could, for example, be tailored to particular ocean basins or river systems. Also, guidelines or frameworks should be developed in a way that allows industry to employ them even in unregulated areas.

Communication between all parties involved

Communication was identified as one of the core factors for a successful harmonisation of approaches to underwater noise regulation. In order to accomplish this task, mechanisms are needed for communicating the science to the regulatory bodies, industry, stakeholders, media, and the public. Moreover, such mechanisms are also needed for communicating regulatory approaches to regulatory bodies that have not yet focused on acoustic issues, thereby bringing nations unrepresented (from the regulatory side) into the general discussion (e.g., China, Brazil, etc.).
In order to improve the communication between all parties involved, the use of existing (international) infrastructure was recommended rather than creating new information structures. There is already a plethora of potential platforms, such as the World Ocean Council, Environmental Regulators Platform, International Petroleum Environmental Regulators Forum as well as multi-national companies and their associations (Oil& Gas, Shipping, Construction, Fishing, Dredging), which present the opportunity to use existing structures. However, the ideal forum for information exchange and discussions between all parties involved remains to be determined.

Main Regulatory Issues

- Definition of the goal of regulation
- Education and training of all parties involved
- Regular updates on latest research findings
- Including more species and taxonomic groups into regulation
- Opportunity for regulators to communicate and share knowledge across wide geographic regions
- Identification of questions common among countries/parties to avoid redundancy and increase efficiency
- Obtaining commitment of regulatory senior management
- Regulation needs to be coherent and predictable
- Mechanisms for communicating the science to all parties involved as well as to the media and the public.

Scientific Issues

Unresolved Issues and Approaches to solve them

The discussion of the scientific issues revealed that there are numerous aspects that are not yet or are insufficiently investigated and understood. Subsequently, a long list of research gaps was developed by the scientific break-out groups, covering the entire marine fauna from marine mammals to invertebrates. The topics included behavioural responses (studies in the field vs. captive studies or laboratory studies), the influence of masking in general, and background noise levels (pre, during, post exposure). In particular, the need for long-term studies was identified as a critical need to establish an understanding of what noise induced effects mean to an animal/population and population level effects in general. It was stressed that peer-reviewed information on these topics was lacking. Also, a better standardization of methods is required to improve/provide consistency and comparability of studies.
One way of achieving the information most efficiently could be by using an integrative approach: sharing information, bringing together large groups of data (raw data, meta data), and conducting a meta-analysis from teams that already have the data (oceanographers, military navies, industries, etc.). This should also include the coordination of causal links between behaviours/responses such as how fish behaviour affects cetaceans.

Increasing the Range of Species and Taxonomic Groups

An important shortcoming is the lack of data on noise-induced effects on a wide range of species from all taxa. In order to get access to data from more animal species, international collaboration and coordination between countries would be required. The same could be beneficial in studying cumulative impacts of noise, including other parallel activities.
Basic information on how to group animals can be drawn from not only their hearing capabilities (functional hearing groups), but also from their morphology; and it was suggested that species should be grouped by frequency response categories rather than by taxa. It was noted that effects on different age classes, sizes, and life stages play an important role in this context too. At the moment, the regulatory focus is placed on marine mammals, but it was questioned if the right ("mega"-) fauna species are used as indicators for ecosystem health; there might be a need to look at invertebrates, trophic relationships, and food chains.

Behavioural Response

With regard to achieving behavioural response thresholds, controlled exposure and field experiments seem to be the best approach. These studies are complicated by the context dependence of reactions and individual variability in reaction thresholds (some animals might react to the beat frequency rather than the carrier frequency of a duty-cycled or FM signal). Consequently, there is a need to understand behavioural mechanisms before a dose-response relationship is used for predicting behavioural effects and consequences. Put another way, defining behavioural threshold criteria has to go beyond SPL. Even a lack of behavioural reaction might be relevant as an animal that stays put in the presence of a sound stimulus might still be affected, while currently this might be interpreted as 'not impacted.' Other parameters, such as stress indicators and motivational state, might add value to such studies. Another important aspect is the energetic consequence of behavioural reactions (cost or success) in the field. The key aspect for choosing a behavioural as well as any other noise-related criterion is its significance for the animal/species (in the U.S. for example, experiments must be designed to show effects upon fitness). While it is often difficult to study this in the field, the PCAD/PCoD[1] models seem to be the best conceptual models to approach this problem.

[1] PCAD: Population Consequences of Acoustic Disturbance (National Research Council 2005)
PCoD: Population Consequences of Disturbance (see Lusseau et al. 2012)

Fishes and Particle Motion

With regard to fishes (and invertebrates and perhaps marine turtles), a main problem is that Environmental Impact Assessments and Statements for tidal generators, pile-drivers, seismic airguns, etc. are commonly dealing with effects upon specific species in terms of only sound pressure – for physical damage that might be feasible, but it is ignoring the fact that the behavioural responses of these species are especially sensitive to particle motion. Therefore, a better understanding for when large particle motions are likely to be present in a sound field is required as well as studies on the particle velocity amplitudes generated by sources like pile drivers and seismic airguns. In addition, ground roll which may reach high amplitudes should be measured as they might have effects on behaviour especially of bottom dwelling fish. As ground roll can be composed of both P-waves and shear waves a recording of a multi-component receiver would be important. At the same time, it is important to make sure that the questions asked are from the perspective of the animals, i.e. knowledge of particle motion per se is irrelevant and useless unless more is known about what is relevant for the individual species. If an animal does not detect particle motion, or if the particle motion levels are below those detectable to an animal, it is irrelevant. The problem is that apart from the physical sensory system, very little is known about particle motion detection by fishes and even less by other organisms. Moreover, little is known on detection capabilities in specific species and effects on other tissues. The issue here is not the response of the sensory system to particle motion (as measured by AEP), but the behavioural responses as a result of detection and processing of sounds by the brain.

It was suggested that there should be an obligation in environmental impact assessments, especially of behavioural effects upon fishes, to model the particle motion, and to validate these models by means of actual measurements. Otherwise the assessments would be seriously deficient. However, it was stressed that actual measurements of particle velocity, over long periods could place a huge compliance burden on relatively small projects, especially since measuring particle velocity in the water column is complicated and there is no state-of-the-art system/technique to measure this parameter e.g. in high energy environments.

Standardisation and Best Practice

There is need for standards of measurement methods and metrics for all aspects of underwater sound. It was recommended that the design of behavioural data collection should be standardised/consistent to make results comparable. This could be done by developing a 'best practice' protocol for behavioural studies, which should also include provisions for the characterisation of background noise and information on the sound source. Measurements standards were also requested for particle motion, of sound in the near field, and of ground transmission of sound. Moreover, terminology and metrics need to be standardised in units and frequency bands of sounds have to be clearly defined. The rise time and absolute peak pressure of signals also has to be measured and reported. It needs to be clear if signals are impulsive, transient, or intermittent (see definitions suggested by Southall et al. 2007). There is a continuum between pulse and continuous signals and the question arises at what distance does a pulse become a non-pulse? In the absence of knowledge regarding which sound parameter is critical for behavioural responses, sound should be characterized and described by different parameters in a standardized way. This ensures that current studies yield optimal comparison with future studies and are robust enough to advances in insights.

An important unit in the current discussion is SEL, as it has diverted into two different metrics (SELcum cumulative and SELss per pulse). It was suggested in the discussion that SEL should be one measurement, as it is just the integration of energy over a certain period of time. Both units (SELcum and SELss) can be used, but they need to be defined precisely (see Normandeau 2012). In this context, it might be necessary to advise regulators that SPL is not a magic quantity, but only part of the picture. Other acoustic characteristics have to be taken into account as well when grouping of signals types: explosive blasting and pile-driving should not be grouped together because of their acoustic differences. There are current efforts to achieve definition and standardisation of metrics (ISO, ANSI, MSFD, and others), and the ISO is expected to publish the results of their efforts in 2014.

However, the number of classes of sound should be limited to 2-3, as otherwise, the regulations get too complicated and specific, and there will never be sufficient data for too many classes. Any additional specifics of the sound characteristics can be captured by quantities describing the sound (which had already been started by Southall et al., 2007). Also, the experimental design should be standardised (at least at a minimum level), and a defined list of minimum measures that need to be reported agreed upon.

Strategies for Future Research

In terms of strategic planning for research related to noise effects, it was stated that scientists often guide their studies toward what regulators need, instead of getting the best information. Instead, it would be more sensible to collect data logically and use that information to help regulators guide their own regulatory paradigms.
A noise criterion is a level of impact risk and not a protective act per se. Regulators can choose to be very precautionary or accepting a certain level of risks for populations counterbalanced against other considerations. At the moment, regulatory metrics tend to be conservative (e.g. distance of animal from source) and often assume worst case scenarios for at least new marine activities, whereas for existing marine activities this varies.

Research Prioritisation

How should priorities be set amongst the diverse set of relevant research topics? Currently budgets often drive the priority, i.e. limited funds are available and some specific studies are funded, while much research has ideally to be done in parallel or important information will be missed. Better communication between groups might improve the efficacy of research funding. In principle, priority should be given to studies investigating the effect of noise exposure on biologically significant parameters and finally related to fitness.
In order to understand and predict the effects of sound on marine life and inform regulators in the best possible way, it is necessary to understand the receiver (animal) as well as the noise sources and propagation.
Some types of anthropogenic noise are not studied at all (at the moment explosives are used to remove offshore structures, but insufficient data exist on their impacts – on the physics or the biology), and other sound-producing activities, like shipping, are not regulated at all.

Scale of approach

Whether or not effects should be investigated on an individual or a population level depends on the national legislation and philosophy behind it, but there is clearly a need to understand effects on populations over large spatio-temporal scales. Even though the value of long time series was acknowledged, it is also clear that there are no pristine environments anymore. Rather than trying to look back in time, it was suggested that the current status should be set as a bench-mark or bar, and then observations should be made over time.

Monitoring and Data Archives

As a recommendation to regulators, it was proposed that regulatory requirements should include a research requirement, or at least a monitoring component, that contributes to (peer-reviewed) scientific knowledge. The quality of the data depends directly on the quality of the design of the monitoring program. In order to achieve data that are of sufficient quality for science, the monitoring requirements have to be defined accordingly. It would also be good to have a repository/archive for the data, not just for regulators, but also for use by scientists. Creating a commonly shared data archive could also serve as a mitigation measure with regard to seismic surveys in order to avoid redundant surveys in marine areas of interest. One year was suggested as a minimum duration for baseline monitoring, to cover seasonal variability, and for reporting standards. Another approach would be to determine the duration by a definition of a healthy soundscape, i.e. the probability of energy in certain bands at certain times. In this case, sound budgets would need to be monitored.

It was stressed that monitoring data formats should be standardised in order to be useful for research and regulation (e.g. some studies collect terabytes of data that is useless because of a lack of metadata). The value of monitoring studies is that they allow patterns to be seen, but obtaining the most value from such data requires that they can be joined across projects and are publicly accessible. In general, scientists might have to advise regulators on how to run these monitoring studies as well as how to incorporate new science into regulations (see EU Noise Task Group Monitoring Guidance which will be available soon).

Funding

To overcome the limitations to research on noise-induced effects due to limited funding, several ways forward were suggested. For example, regulators could put a levy on permits and then use these funds for research and/or accumulate part of the levy to fund large-scale experiments. Canada's Environment Studies Research Fund (ESRF), that supports research via industry (Oil and Gas) that have leases offshore Nova Scotia was suggested as a good example for such a funding scheme. Payment into the ESRF fund is proportional to the amount of oil and gas production offshore Nova Scotia.

Regular Updates

Further advice from scientists for regulators is to provide sufficient flexibility in a regulatory framework for incorporation of new findings. This, as it became clear in the discussions of the regulatory aspects, is in accordance with the view of many regulators. An update of regulations should be done/sought every three to five years. It was recommended to keep to the big picture (the elements of the ecosystem which are important) for regulation, i.e. to regulate on a population level instead of the single animal level, if applicable. With regard to TTS being one of the key criteria used in regulation of underwater noise so far, a definition is needed of when TTS is actually an injury, rather than the cause of a behavioural shift. In the U.S. for marine mammals, the PTS is currently set in regulations, but the results presented by Charles Lieberman at the Budapest conference shed some new light on this topic, and the current definition(s) might require a revision.

Main Scientific Issues and Gaps in Knowledge

- Increasing the range of species and taxonomic groups investigated
- Behavioural responses to sound
- Influence of masking
- Long-term effect of noise of individuals and populations
- Chronic and multi-source impacts
- Fishes and particle motion
- Standardisation or metrics and best practice
- Data archives and data sharing

Next steps

Almost all regulations of underwater sound rely on action-specific approaches, making it challenging to address chronic and multi-source impacts that co-occur across longer time periods and larger areas, and from multiple activities. Additionally, some activities that contribute significantly to background noise levels, such as large commercial shipping, are challenging, if not impossible, to regulate case-specifically. Filling the gaps in knowledge is probably the most important requirement to improve the regulation on underwater noise. While the request for funding more research is valid, the logical next steps from this workshop should be to look for short-term goals and proceed in small, achievable steps. One step would be to implement a forum for regulators to exchange information and to provide them with basic scientific content, training materials, and scientific updates. A first step towards this would be to identify the best platform or international organisation where such a forum could be based and to invite more nations to join the discussion.

Another important step would be to convince the regulatory senior management of the benefits of a direct exchange of information and of heading towards harmonising approaches in noise regulation. Otherwise, the regulators effectively working on the issues will have difficulties to actively participate in future meetings and even devote time to communicating relevant topics within an international network. Identifying the research question which are common among countries/parties would allow leveraging research funds from multiple sources to collectively work on these common issues.

There are already on-going discussions about follow-up meetings to keep the momentum going, and besides discussing regulatory issues, there is a strong need to provide more information to regulators about the effects of underwater sound on fishes and invertebrates. These topics are currently almost completely neglected in regulations, but the central regulatory agencies play a key role in triggering some overall studies on the effects of particle motion on these taxonomic groups.

With regard to monitoring and mitigation, it seems important to review and share knowledge about those measures that are effective, and those which are not. In any case, mechanisms to check the efficacy of mitigation methods have to be developed and implemented when necessary.

When it comes to exchanging information, this need is a basic requirement, not only between different regulatory agencies, but also within the scientific community and between both groups. A minor, but probably important, role is the need to overcome the language barrier and to provide monitoring reports not only in the national language but also in English. Otherwise, potentially useful information made available will still not be accessible internationally.

Finally, objective agreements need to be reached on sound exposure criteria, recognising that this will require a matrix of different effects (injury, hearing deficiencies, behavioural changes, masking) against a range of animal groups and for different sound sources.

4. Review of national regulation/permitting process

As background information for workshop attendees, a 'white-paper' was compiled and distributed to provide workshop participants with the necessary information to actively contribute to the discussions during the workshop. The white paper comprised contributions from national regulatory agencies from several countries where offshore renewables or other noise-emitting human activities have been a major issue in recent years. Based on a list of relevant questions (in red below), contributions were made by several countries. These are analysed and collated in this report, in a comprehensive, but not exclusive way. Contributions were received from Australia, Belgium[2], Denmark, France, Germany, Netherlands, U.K. and the U.S. (Lucke et al. 2013). Later, additional contributions were made by the U.K., and information was gathered from other sources on regulations in other countries (Ireland, Sweden) as well as international organisations and treaties.

1. What kind of regulation is in place for underwater noise? On which law is this regulation based?

There is a great variety in legal regulations of human activities at sea, in general, and of underwater sound emission in particular. A survey of existing regulations on underwater sound revealed that most countries bordering the sea have no such regulations in place. However, in many countries the emission of sound into the marine environment can be indirectly addressed under the umbrella of more generic regulations, most often in regard to Environmental Impact Assessments. In some countries, relevant regulations are focussed on specific anthropogenic activities (such as hydrocarbon exploration and exploitation or offshore pile-driving), few countries have specific laws and regulations in place, which deal with the underwater sound emissions.

In Australia and Canada, legal regulations are focussed on the offshore petroleum industry.
The Australian National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) came into effect on 1 January 2012 and is responsible for regulation of the offshore petroleum industry in relation to safety, well integrity, and environmental management in Commonwealth waters and state waters, but only where functions have been conferred. The environmental management regulations that apply to offshore petroleum activities are the *Offshore Petroleum and Greenhouse Gas Storage* (OPGGSA) Environment Regulations (2009). These Environment Regulations are given effect by the O*ffshore Petroleum and Greenhouse Gas Storage Act* 2006 and only apply to petroleum and greenhouse gas storage activities in Australia's Commonwealth waters (or coastal waters where functions have been conferred by state and Northern Territory governments). Other legislation will apply to noise generating activities outside of the petroleum sector and outside of Commonwealth waters (i.e. in state and Northern Territory waters within 3 nm of the mainland).
The Environment Regulations do, however, require consideration of other Australian legislation, and this will include the provisions of the *Environment Protection and Biodiversity Conservation Act* (EPBC) (Australian Government, Department of Environment, Water, Heritage and the Arts, 1999). This legislation applies to all activities that are likely to have a significant impact on Matters of National Environmental Significance (MNES), which includes listed threatened and migratory species and is administered by the Department of Sustainability, Environment, Water, Population and Communities (SEWPaC). Where a petroleum operator deems that an activity is likely to impact on MNES, they are required to refer the activity to SEWPaC for determination as to whether the activity requires assessment and approval under the EPBC Act 1999.

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[2] The Belgian regulatory approach is basically represented in the position paper published by the Central Dredging Association (CEDA 2011; Bob Rumes, pers. comm.). The information on the Belgian regulation is taken from this publication and supplemented by further sources.

This may apply to petroleum activities in Commonwealth waters and in these cases, a petroleum activity may be subject to the requirements of both the OPGGSA (Environment) Regulations and the EPBC Act 1999. SEWPaC has developed a policy statement on the interaction between offshore seismic exploration and whales, EPBC Act Policy Statement 2.1 (further information can be sought from www.environment.gov.au or directly from SEWPaC).

Belgian legislation does not relate directly to underwater noise, but it requires an environmental impact assessment (EIA) for every offshore wind farm in its Exclusive Economic Zone (EEZ) waters to be conducted by the Management Unit of the North Sea Mathematical Models and the Scheldt estuary (MUMM). The EIA is based on an environmental impact study (EIS) submitted by the applicant. In the framework of its evaluation the MUMM can, if necessary, carry out, or order additional studies and research. Based on this EIA and on the results of the public consultation, the MUMM advises the federal Minister responsible for the marine environment. In this advice the MUMM gives an opinion on the acceptability of the project concerning the marine environment and on the conditions, which the project must fulfil to be acceptable. The Minister decides whether the environmental permit should be granted. For every new permit the conditions might be different, based on latest scientific data. (Jan Haelters, pers. comm.).

All activities related to the exploration, development and production of offshore petroleum resources on the east coast of Canada require authorization (permits) from either the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB), the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) or the National Energy Board (NEB). For offshore oil and gas activities the mitigation in the environmental assessment is made a condition of authorization of the activity under either the N*ewfoundland Offshore Area Petroleum Geophysical Operations Regulations*, the *Nova Scotia Offshore Area Petroleum Geophysical Operations Regulations* or the *Canada Oil and Gas Geophysical Operations Regulations*.
For offshore seismic activities the federal and some provincial governments of Canada, with advice from the Boards, developed the *Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment*[3]. This statement provides guidance during the preparation of the project specific environmental assessment. It specifies the mitigation requirements that should be met during the planning and conduct of marine seismic surveys, in order to minimize impacts on life in the oceans. These expectations are set out as minimum standards. For the use of explosives in the marine environment, Fisheries and Oceans Canada has developed and published *Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters*[4]. The federal *Fisheries Act* includes provisions for the protection of fish, shellfish, crustaceans, marine mammals and their habitats. The detonation of explosives in or adjacent to fish habitat has been demonstrated to cause disturbance, injury and/or death to fish and marine mammals, and/or the harmful alteration, disruption or destruction of their habitats.
The purpose of this guideline is to provide information to proponents who are proposing activities that involve the use of confined or unconfined explosives in or near Canadian fisheries waters, and to which the *Fisheries Act*[5], Sections 32 and 35 in particular, may apply. Guidelines are provided on methods and practices for the conservation and protection of fish, marine mammals, and fish habitat from impacts arising from the destructive forces of explosives.

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[3] http://www.cnsopb.ns.ca/sites/default/files/pdfs/statement-of-canadian-practice.pdf
[4] http://www.dfo-mpo.gc.ca/habitat/role/141/1415/14155/explosives-explosifs/index-eng.asp
[5] http://laws-lois.justice.gc.ca/eng/acts/F-14/index.html

The report describes the suggested application and review procedures and processes for proponents whose use of explosives may result in the destruction of fish, or the harmful alteration, disruption or destruction of fish habitat.
For the use of explosives in the marine environment, Fisheries and Oceans Canada has developed and published Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters. The federal Fisheries Act includes provisions for the protection of fish, shellfish, crustaceans, marine mammals and their habitats.
Canada's ESRF (Environment Studies Research Fund). It is a program that supports research via industry (Oil and Gas) that have leases offshore Nova Scotia. Payment into the fund is proportional to the amount of oil and gas production offshore Nova Scotia.

Denmark and France have, like Belgium, no laws or regulations in place, which specifically address underwater noise issues.
In Denmark, underwater noise is indirectly regulated through the Promotion of Renewable Energy Act. This act regulates the necessary licenses/permits needed when erecting a wind turbine park. The permits have articles concerning the environment and nature, including articles relating to noise-related activities. The license for erecting wind turbines in Danish waters is partly based on an environmental impact assessment that specifies the necessary need for regulation for the specific project.

In France, underwater noise is covered by the more generic term "pollution" linked to anthropogenic noise sources which appears in the Environment Law in 2010 (Article L219-8, July 12th 2010). This means that any projects or activities, which are likely to disturb marine environment, must include an environmental impact study that will be assessed by the competent State Administrative Authority who will then allow or not these projects (Article L122-1).

Construction of offshore wind turbines is the main driver behind underwater noise related regulations in Germany. In the waters of the German EEZ, such installations are regulated by the Federal Maritime and Hydrographic Agency (Bundesamt für Seeschifffahrt und Hydrographie, BSH) based on the *Marine Facilities Ordnance* (See-Anlagenverordnung) and the Environmental Impact Assessment Act (UVPG), which requires an EIA for wind farm projects comprising more than 20 wind turbines.

In the Netherlands, the principal anthropogenic sources of underwater sound in the North Sea are regulated by licensing within various legal frameworks, by codes of conduct, or by international conventions. Provision is made within the regulatory licensing frameworks for the environmental impact of underwater noise. Up to now, the effects of underwater noise pollution (UNP) were subject to the provisions of the *Water Act* (Offshore Wind farms).
The construction and operation of oil & gas platforms is regulated in the 2002 Mining Act. For seismic exploration however, a license is not required but it needs to be reported after the survey to the Ministry of Economic Affairs (EZ). During seismic surveys, measures must be taken to prevent disturbing effects of sound on marine mammals. In this case, only a soft-start is required, and no further measures are compulsory. Currently, the authorities are examining if the provisions of the *Mining Act* in relation to the impacts of underwater noise on the marine environment need adjustments. The Dutch UNP regulatory framework relating to activities that are subject to licensing has been mainly 'indirect', i.e. regulations tackling the (significant) negative effects on populations of protected species and habitats. The adverse effects on protected species are provided for under the *EU-Habitats and Birds Directives*. In the Netherlands, the provisions of these Directives have been incorporated in the Nature Conservation Act and in the Flora and Fauna Act. In the Dutch EEZ, the provisions of the *Nature Conservation Act* and the *Flora and Fauna Act* have yet to be implemented. Until then, the Habitats and *Birds Directive* will apply.

In Sweden, marine construction related activities (including construction, alteration, repair and removal of dams or other water structures in water areas, filling and piling in water areas, the removal of water from or digging, blasting, and cleansing in water areas, as well as other measures in water areas whose purpose is to change the depth or position of the water, is regulated by the Environmental Code (Regeringskansliet 2000). The only environmental concern is that activities are not detrimental to fishing. However, no direct link to underwater sound is made in this regulation.

There are no specific regulations for pile-driving in the United Kingdom (UK). However, the construction of offshore wind turbines, which usually involves pile driving, is regulated in the UK with regard to noise monitoring and mitigation.

Effective legal regulations are:

- FEPA (F*ood and Environmental Protection Act* 1985)
- Joint Nature Conservation Committee (JNCC) protocol (Joint Nature Conservation Committee 2010a), consolidating all the various amendments made to the Conservation Regulations 1994 (i.e., the *Habitats Regulations*, HR) in respect of England and Wales
- *Offshore Marine Conservation (Natural Habitats) Regulations* 2007 (the Offshore Marine Regulations, OMR) 2007
- *Coast Protection Act* 1949 (CPA, Section 34); despite some differences in legal aspects, data requirements for CPA and FEPA are for all intents and purposes identical.

The JNCC has issued guidelines specifically dealing with offshore pile driving (Joint Nature Conservation Committee 2010b).

In the context of marine conservation (and permitting in particular), the U.S. does not have any Federal statutes or regulations in place that are specifically designed to address underwater noise. However, the U.S. currently regulates the impacts of underwater noise (among other impacts) on trust resources through multiple Federal statutes, such as *Marine Mammals Protection Act* (MMPA), *Endangered Species Act* (ESA) and *National Marine Sanctuaries Act* (NMSA). These trust resources are co-managed by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Fish and Wildlife Service (USFWS).

2. What noise related activities need a permit, i.e. fall under the national regulation? Is the national regulation focussed on sound types (e.g. impulsive vs. continuous) or types of activities (offshore pile-driving, seismic surveys etc.)? Please define the relevant types.

Anthropogenic sound emitted into the marine environment can be divided based on its duration into two main categories: continuous and impulsive sound, with all sounds shorter than one second in duration considered being impulsive. Ship noise is almost ubiquitous and in terms of the acoustic energy emitted into the water one of the strongest anthropogenic contributor to the underwater sound scape. Underwater explosive detonations are the strongest anthropogenic sound sources producing short impulses as well as a shock wave. Pile driving and airguns are also impulsive sources, but lack the potential for shock wave generation and have to be treated differently. Sonars and other active acoustic sources fall in between these two categories as normal depth- or fish finders emit brief impulses whereas military sonars typically emit signals longer than one second.

In Australia and Canada, where regulations are mostly concerned with offshore hydrocarbon exploration and exploitation, the most relevant acoustic activity is of course the use of airguns. Other generating activities such as seismic surveys, drilling, vertical seismic profiling, vessel movements, and geophysical surveys, however, are also considered in these countries.

In Canada the use of explosives is also regulated. The federal *Fisheries Act* includes provisions for the protection of fish, shellfish, crustaceans, marine mammals and their habitats and Fisheries and Oceans Canada has developed and published *Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters*[6]. The purpose of this guideline is to provide information to proponents who are proposing activities that involve the use of confined or unconfined explosives in or near Canadian fisheries waters, and to which the *Fisheries Act*[7], Sections 32 and 35 in particular, may apply. No specific guidelines for pile driving in aquatic environments per se are in place in Canada, as potential sources of sound associated with proposed activities in aquatic environments are assessed on a site-specific, project-by-project basis.

The Danish regulations mainly aim at pile driving, transport corridors, while in France a focus is put on wind turbine related sounds and seismic surveys. In Belgium, Germany, and the Netherlands, regulation related to underwater sound is almost entirely restricted to offshore pile driving (for offshore constructions such as wind turbines, transformer platforms, research/ measurement platforms etc.).

In the U.S., no distinction between different sound sources is made, but basically all anthropogenic activities, which could cause a disturbance or injury to marine mammals or fish (or other protected species) are regulated. The following are the broad activity types for which authorizations/permits/exemptions for impacts from noise are most commonly issued: military training (active sonar and explosives); seismic surveys (oil and gas exploration and research); coastal construction (impact or vibratory pile- driving; dynamic thrusters/positioning); drilling; ice-breaking; explosive rig removal; and rocket launches. For naval activities, special Navy regulations have been developed dealing explicitly with the naval related emissions of underwater sound (and shock waves), their potential negative effects on the marine fauna and the appropriate mitigation measures.

3. Which taxonomic groups are to be protected through regulation (marine mammals, fish, invertebrates, diving birds or specific species)? Are certain species prioritised?

Sound propagating through the water can be perceived as a change in pressure or through the particle motion, and marine fauna, from invertebrates to marine mammals, have developed different sensors and different degrees of sensitivity for either or both of these physical properties. The focus of scientists, regulators, and the informed public lies in this context with marine mammals, but recently awareness is shifting also to fishes and invertebrates.

Australia's environmental regulations do not prescribe or prioritise which taxonomic groups or species must be protected – all relevant environmental receptors must be considered in the Environment Plan (EP). In Canada, all species listed under Species at Risk Act are illegal to kill, harass, capture or harm it in any way. This accounts for fishes, marine mammals, and fish habitats.

In the European countries, the focus is put on marine mammals. In most of these countries, the harbour porpoise and harbour seals are the key species in this context. In Germany and the Netherlands fishes and marine birds are also considered with regard to underwater noise. In Sweden, the focus is put entirely on effects on fishes.

6 http://www.dfo-mpo.gc.ca/habitat/role/141/1415/14155/explosives-explosifs/index-eng.asp

7 http://laws-lois.justice.gc.ca/eng/acts/F-14/index.html

The MMPA in the U.S. applies to all marine mammal species, which include cetaceans, pinnipeds, manatees, polar bears, and sea otters. Many taxa are listed as threatened or endangered under the ESA, however, the assessment of noise exposure is primarily applied to cetaceans, pinnipeds, polar bears, sea otters, manatees, fishes, sea turtles, and birds.

4. What are the specific regulations for the different noise-related activities, i.e. what is regulated in the permit (installation procedures, exposure criteria, temporal closure of areas, mitigation requirements)?

In Australia, regulations require that all impacts and risks, including those associated with underwater noise, are managed to as low as reasonably practical (ALARP) and acceptable levels. The regulatory regime is objective-based and, as such, does not prescribe a specific approach to environmental risk reduction (e.g. noise exposure criteria). The Regulations require that the Environment Plan (EP) includes appropriate environmental performance objectives, environmental performance standards and relevant control measures to demonstrate the measures that will be taken to manage impacts and risks to ALARP and acceptable levels. The objective, non-prescriptive nature of the regulations ensures that emerging technologies are considered as they do not prescribe a minimum standard.
The EPBC Act Policy Statement 2.1 (Australian Government, 2008) regulates seismic activities in Australian waters with respect to offshore seismic exploration and its potential effect on whales. It includes requirements specific for this activity such as observer requirements, observation technique and a set of mitigation measures: a source exclusion zone (EZ), soft start/ramp-up including a delay or shut-down for animals within the EZ, pre-shoot watch, special provision for night-time airgun use and the use of passive acoustics. A time/area closure applies only for the Great Australian Bight for southern right whales and Australian sea lions.
The following precaution zones are recommended for proposed seismic surveys that can demonstrate through sound modelling or empirical measurements that the received sound exposure level for each shot will not likely exceed 160 dB re 1μPa^{2}s, for 95% of seismic shots at 1km range,:

- Observation zone: 3+ km horizontal radius from the acoustic source.
- Low power zone: 1 km horizontal radius from the acoustic source.
- Shut-down zone: 500m horizontal radius from the acoustic source.

For all other proposed seismic surveys:

- Observation zone: 3+ km horizontal radius from the acoustic source.
- Low power zone: 2 km horizontal radius from the acoustic source.
- Shut-down zone: 500m horizontal radius from the acoustic source.

Seasonal restrictions apply in Belgium: pile-driving is not permitted between 1 January and 30 April, given that this is the period with the highest density of harbour porpoises in Belgian waters. Moreover, the use of at least one Acoustic Deterrent Devices (ADD) (pinger or seal scarer) with a source level of 170 to 195 dB re 1μPa is required during offshore pile-driving operations for wind farms; it should start working one hour before the start of pile-driving and continue until pile-driving has started, at a distance of less than 200 m from the piling location. Moreover, a soft-start procedure is taken up in the permit – it is however not standardized. The most recent conditions require a maximum energy output of the piling hammer at least 10 minutes after the first stroke. The soft-start procedure has to be agreed upon by MUMM as well.

In Canada, potential sources of sound associated with proposed activities in aquatic environments are assessed on a site specific, case-by-case basis. However, underwater noise is assessed during the environmental assessment process for a project or activity, and mitigation is developed to minimize any likely significant adverse environmental effects. On-board seismic vessels are marine mammal observers that are trained to identify different species of marine mammals and turtles that may reasonably be expected to be present in the area where the seismic survey will take place. If marine mammals are

observed within a pre-defined distance from the seismic source, the air-guns are shut down as specified in the project specific environmental assessment and the *Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment*.

In Denmark, permits for constructing offshore wind turbines granted by the Danish Energy Agency (DEA) include articles about monitoring during construction, safety regulations and requirements for deconstruction, environmental regulations, including noise regulations, and regulations about other activities on the sea. A detailed project description must be sent to the DEA before construction begins to document that the requirements of the DEA's permit is fulfilled.

The EIA required in France for offshore activities which are likely to disturb marine environment include an analysis of the initial state of the area and the community may be affected by the project, an analysis of the positive and negative effects, both direct and indirect temporary and permanent, in the short, medium and long term, of the project on the environment, and analysis of the cumulative effects of the project with other projects known. However, no specific requirements related to underwater sound are decreed. Avoidance of or compensation for any negative effects have to be considered, but are not mandatory.

In contrast, a noise exposure criterion is mandatory part of the licence for offshore pile driving when building offshore wind turbines in German waters. A dual criterion has been defined by the BSH in 2003 (updated in 2011): emitted sounds have to be limited to a received level of 160 dB re 1 μPa^2s SEL and a sound pressure level of 190 $dB_{peak\text{-}peak}$ re 1 µPa at a distance of 750 meters, which has to be achieved by appropriate measures. These levels were developed taking into consideration results from several research projects, after consultations with experts and are based on a recommendation of the Federal Environmental Agency (UBA). The levels are mandatory and strict. They have been selected following the precautionary principle, to account for multiple exposures to pile driving impulses and to keep disturbance as low as possible. With regard to noise mitigation, several conditions are in effect comprising noise reduction, noise mitigation as well as deterrence measures.

In the Netherlands, seasonal and geographical restrictions apply in the EEZ: pile driving is not permitted in the period 1 January through 30 June to mitigate the food chain effects while also sparing the highest porpoise densities. Excessive cumulative effects are prevented by licensing the construction of only one offshore wind farm per season. In addition to the conditions in the permit, most developers usually will use a 'soft start' and 'acoustic harassment devices' during the construction of offshore wind farms. For seismic exploration in Dutch waters of the EEZ, however, a license is not required, but it needs to be reported after the survey to the Ministry of EZ. During seismic surveys, measures must be taken to prevent disturbing effects of sound on marine mammals. In this case, only a soft-start is required and no further measures are compulsory.

In Sweden, pile driving operators must, at their own expense, make and in the future maintain any arrangements that are necessary for the passage of fish or the sustainability of fishing, comply with any other conditions that may be necessary in the context of the operations to protect fishing in the water in which the water operations are carried on or in adjacent water areas. If the benefit of a disputed installation or a condition cannot reasonably be considered to justify the expense incurred by the operator for compliance, the operator may be discharged from such an obligation (Regeringskansliet 2000).

In the UK, the JNCC has revised their guidelines for conducting seismic surveys (Joint Nature Conservation Committee 2010b), which were widely adopted by regulators in several European countries before with regard to managing various anthropogenic sound sources at sea. JNCC has also written a best practice guidance document for explosive use (Joint Nature Conservation Committee 2010c). Detailed requirements for construction of wind farms:

- Development license from Crown Estate/Department of Energy and Climate Change (DECC).
- FEPA license issued by the Department for Environment, Food and Rural Affairs (Defra); as part of this licensing process Defras seek advice from other bodies: Centre for Environment, Fisheries and Aquaculture Science (Cefas, an Agency of Defra), JNCC, Natural England.

A FEPA license is required for the deposit of any substance or articles in the sea or under the sea bed in UK waters, UK controlled waters or from UK vessels. When making applications for FEPA construction licenses, applicants are required to provide specific details about the project. With regard to the noise emissions a typical FEPA license (Round 2) comprises the following requirements:

- Construction: The License Holder must undertake measurements of the noise generated by the installation of foundation pieces. Measurements will need to be taken at various distances for the first few foundation pieces (minimum of four) including during the 'soft start' procedure. The specification for these measurements should be agreed with the Licensing Authority, consultation with Cefas and Natural England at least four months before the construction work commences. The results of these initial measurements should be processed and the report submitted to the Licensing Authority within six weeks of the installation of the first foundation piece. Assessment of this report by the Licensing Authority will determine whether or not any further noise monitoring is required. Should noise levels be significantly in excess of those predicted during the Environmental Impact Assessment process then further pile installation will not occur without the consent of the Licensing Authority.
- Operation: The License Holder must develop plans for subsea noise and vibration from the turbines to be assessed and monitored during the operational phase of the wind farm. Before completion of the construction phase the License Holder must supply specification to the Licensing Authority of how it proposes to measure subsea noise and vibration. These measurements must be taken various frequencies across the sound spectrum at a selection of locations immediately adjacent to, and between turbines, within the array and outside the array at varying distances.

To obtain these licenses developers are required to undertake an Environmental Impact Assessment (EIA) and submit an Environmental Statement (ES) at the planning stage. Noise monitoring, as well as mitigation measures to reduce the impact on marine mammals, are required during the construction phase. There are, however, no limits regarding the noise emissions during any of the construction or operational activities in UK waters.

A soft-start (i.e., the gradual increase of emitted sound energy over a given period of time) is required, but not specified by the regulator. Marine mammal observers are required, as well as passive acoustic monitoring. There must be no marine mammals detected within a 500 m zone around the piling vessel/ platform for at least 30 min prior to the onset of piling. Visual observation must continue throughout the piling. Piling must be stopped if a marine mammal is observed within the 500 m zone.

A typical underwater sound measurement plan comprises:

- Measures as a function of range to estimate the 'source level' along predetermined transects
- Different directions for each pile often measured
- Transects ideally chosen with relatively flat bathymetry
- Sometimes toward protected areas, etc.
- Place fixed noise monitoring buoys to measure entire piling sequence
- A range independent measurement–used for 'level calibration'
- Necessary because of soft-start
- Measurements of ambient noise in the area–before and/or after
- Logged metadata (Water depth at each measurement location, CTD measurement in the survey area, Wind speed/sea-state, GPS position at each measurement location)

In the U.S., NOAA uses acoustic criteria for marine mammals as well as (even though less widely applied) for fishes and sea turtles. These provide received level exposure thresholds above which animals may be either injured or behaviourally harassed, two specific effect types that align well with statutory definitions of some components of "take" in MMPA, ESA, and "injury" under the NMSA. These thresholds have predominantly been presented in the form of single received levels (RL) for particular source categories (e.g., impulse, continuous, or explosive) above which an exposed animal would be predicted to incur auditory injury or be behaviourally harassed; generically, RL's of 180/190 dB re 1 µPa are used as criteria for acoustic injury of cetaceans/pinnipeds and RL's of 160/120 dB re 1 µPa for behavioural harassment from impulse/continuous sources. However, NOAA also uses dose-response-type curves to quantify behavioural harassment from Navy tactical sonar activities.
Due to the activity-specific structure of the current regulatory framework in the U.S. there is no standard required set of mitigation to apply to noise-producing activities.
The following mitigation measures are commonly required or recommended:

- Power-down/shutdown zones to minimize the likelihood of injury, or the behavioural harassment of large groups of animals or mother/calf or pup pairs
- Day time operations only or use of night-time specific technology to enhance detection (see below)

- Seasonal/Area Limitations
  - Avoidance/minimization of operations in seasons and/or areas of biological importance
  - Avoidance of sanctuaries

- Source level manipulation
  - Ramp-up procedures with airguns (and sometimes pile-driving)
  - Sound reduction and mitigation methods for pile-driving (bubble curtains, wood blocks, etc.)

5. Is monitoring requested as part of the permitting procedure/requirements? How is this regulated, i.e. who is responsible for the monitoring?

The Australian regulations do not prescribe any specific approaches to managing risk, however, monitoring is one option that may be considered and implemented by petroleum operators to meet the requirements of the regulations. Petroleum operators need to demonstrate in the Environment Plan (EP) how monitoring is, or in some cases is not, relevant to the management of the impacts and risks of their activity.

If monitoring provisions are included in an EP, they are assessed by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) as part of the Environment Plan submission. When monitoring is included in the accepted EP, it is the petroleum operator's responsibility to implement monitoring in compliance with the accepted EP. However, NOPSEMA has a role in monitoring the performance of the operator in complying with the commitments in an accepted EP through regular reporting and compliance inspections.

For seismic surveys in Canadian offshore waters , monitoring is required as part of the authorization (permit) requirements. Monitoring may take two forms: compliance monitoring and, on occasion, environmental effects monitoring. For seismic activities, the operator is responsible for monitoring requirements, which are submitted to the Boards for review and oversight.

In Denmark, the DEA monitors that the Promotion of Renewable Energy Act is upheld and the Environmental Protection Agency monitor the environmental issues in connection with construction and performance of the wind turbine park. For bigger turbine parks, it has been custom to set up an Environmental Monitoring Program that runs for several years. If such a program is requested, it will be included in the permit. The results of the program are made available on the DEA webpage.

Monitoring is not required for any offshore activities in French waters. However, the French environmental law specifies that projects of construction or marine planning must include an environmental impact study based on criteria and thresholds established by the Environment Law. The acoustic impact of the project or activity on marine environment is detailed in this impact study, and is focused more precisely on marine mammals. However, there are no strict regulations regarding standard procedures to measure underwater noise, nor even allowable sound exposure levels.

The German BSH is the responsible authority for instructing and supervising operators on both noise-level compliance and noise monitoring during construction. Offshore wind farm projects comprising more than 20 turbines require an environmental impact assessment based on the UVPG (Environmental Impact Assessment Act). UVPG requires that applicants investigate the marine environment in the project area and predict the impact of the projected wind farm. The BSH has issued regulations specifying the required scope of the environmental investigations to be carried out by the applicants with respect to each of the features to be protected (so-called 'Standards for the Environmental Impact Assessment'). On the basis of the environmental studies, the applicant prepares an Environmental Impact Assessment (EIA), which is reviewed by the BSH and other stakeholders prior to a decision on the permit.

Companies that are granted a license in the Netherlands to build an offshore wind farm are obliged to follow a monitoring and evaluation program. The aim of the monitoring is to validate the assumptions made in the Environmental Impact Assessment/ Appropriate Assessment in order to reduce the uncertainties predicted impacts. Its object is also to measure the effectiveness of the measures. The licensing conditions together with the measures will be re-evaluated by the permitting authority on the basis of the new findings and adjustments made where necessary.
In the monitoring program accompanying the licensing process for offshore wind farms, the underwater noise instructions include the following:

- Measure underwater noise during pile driving of mono-piles
- Measure effects of pile driving on presence of marine mammals

Due to the activity-specific structure of the current regulatory framework in the U.S. there is also no standard required set of monitoring to apply to noise-producing activities.

The following monitoring activities are commonly required or recommended in correlation to the mitigation measures listed above:

- Real time detection and action
  - Protected species visual observers (shore, ship and aerial)
  - Passive acoustic technicians (increasingly common)

6. Are data made available (freedom of information) or intellectual property of operator?

Freedom of information laws allow access by the general public to data held by national governments. They establish a "right-to-know" legal process by which requests may be made for government-held information, to be received freely or at minimal cost, barring standard exceptions. Also variously referred to as open records, or sunshine laws (in the U.S.), governments are also typically bound by a duty to publish and promote openness. In many countries there are constitutional guarantees for the right of access to information, but usually these are unused if specific support legislation does not exist. Over 90 countries around the world have implemented some form of freedom of information legislation[8]. Most freedom of information laws exclude the private sector from their jurisdiction. Information held by the private sector cannot be accessed as a legal right.

In Australia, a petroleum operator is not required by the Environment Regulations to make data publicly available. However, they are required to store and maintain records for a period of 5 years. If marine mammal observation data is collected to meet requirements of the EPBC Act 1999, the data is submitted to SEWPaC.

In Canada, Denmark, and France, environmental effects monitoring data are publically available (in Canada, compliance monitoring is typically confidential for a period of 5 years). However, the public cannot have access to data.

The results of the efficiency control and monitoring have to be included in the final reports for each project in Germany. Final reports (construction monitoring) are be available to all public authorities involved. Third parties have to apply to receive this information from the operating company. Research reports, however, are publically available. Acoustic raw data are classified for reasons of military interest and national security.

In The Netherlands, all monitoring reports must be submitted to the competent authority for approval and they are then made public (website www.noordzeeloket.nl). The intention is to have most study reports published in English in order to facilitate the exchange of information at an international level. In addition, the raw data is made available to the government.

In contrast to the other countries listed above, transparency and sharing of raw data has increased through time in the U.S., and data may now largely be obtained, if requested, with the exception of acoustic data that may implicate national security concerns (acoustic signal or locational data) or proprietary energy lease information (locational data). Of note, both ever-increasing data holdings and the need to address noise issues more comprehensively across multiple permitted activities support the need for a permanently maintained, standardized, web-accessible database/portal for acoustic and marine mammal data.

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[8] Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters. This convention has been ratified by 45 states and the EU and provides for open access to all environmental data held by governments.

7. How are the regulations implemented and enforced?

The Australian Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 require that all petroleum activities in Commonwealth waters (and NOPSEMA jurisdiction) be carried out in accordance with an accepted EP. The operator must develop an EP for assessment and acceptance by NOPSEMA prior to operations. It is an offence under the Environment Regulations for a petroleum operator to carry out an activity in Commonwealth waters (or NOPSEMA jurisdiction) with no EP in force or contrary to the accepted EP. The requirements of the Environment Regulations are enforced by NOPSEMA through the assessment of EPs, inspection of activities against the commitments of the in-force EP and investigations of reported incidents. A range of graduated enforcement actions is available to NOPSEMA to enforce compliance, including and up to formation of a brief for prosecution by the Commonwealth Department of Public Prosecutions.

In Canada, the C-NLOPB and CNSOPB have in place an effective monitoring program to evaluate operator compliance with environmental regulatory requirements while conducting authorized petroleum related work activities. Operators are required to submit reports detailing the status of their work programs on an ongoing basis, along with other documentation to demonstrate compliance with regulatory requirements. Operational status reports are provided on a daily basis for drilling and production activities, and on a weekly basis for other activities, such as seismic programs. Reports filed with the CNSOPB and C-NLOPB are reviewed by staff to identify environmental compliance issues, and such issues are addressed accordingly.
Marine mammal observers on-board seismic vessels are authorised to shut down seismic operations upon a sighting of marine mammals within a pre-defined safety zone (see mitigation). C-NLOPB and CNSOPB staff also regularly conduct environmental compliance audits and inspections at offshore work sites and operator offices. C-NLOPB and CNSOPB staff may investigate environmental incidents that occur at offshore worksites, depending upon their nature and severity. An investigation is normally conducted using conservation officer powers granted by the Accord Act legislation. However, in cases where a conservation officer has reasonable grounds to believe an offence has been committed, the investigation is conducted taking into account limitations imposed by the Canadian Charter of Rights and Freedoms. The C-NLOPB and CNSOPB have an established compliance and enforcement policy to address situations of regulatory noncompliance. Enforcement actions may include:

- voluntary compliance;
- issuance of orders, directives or notices;
- suspension or revocation of approvals and authorizations; and
- prosecution in the court system

At an early stage in the permitting process, the German BSH requests a sound mitigation concept from the operator. Within the further permitting process 'jour fixe' are conducted on a regular basis, involving also the German Federal Agency for Nature Conservation (Bundesamt für Naturschutz, BfN) and the Federal Environmental Agency (Umweltbundesamt, UBA). The implementation of noise mitigation measures is monitored by the BSH:

- the implementation of the sound reduction and mitigation measures have to be reported from the construction site on a daily basis.
- the efficiency of the measures is recorded for each pile-driving event (by means of underwater sound measurements and passive acoustic monitoring of harbour porpoise echolocation activity).

In the Netherlands, both the construction and operation of offshore wind farms are subject to licensing. All monitoring reports must be submitted to the competent authority for review and approval.

For seismic exploration, a license is not required but it needs to be reported after the survey to the Ministry of EZ.

Regarding enforcement in the U.S., permit-holders are typically required to self-report activity levels, their implementation of required mitigation and monitoring, and when and if there are any observable effects of their activity on a protected species.

Philosophy of Approach

8. What is the aim of the regulation (species/animal protection, Good Environmental Status)?

The aim or object of the Environment Regulations in Australia is to ensure that any petroleum activity or greenhouse gas storage activity carried out in an offshore area is conducted in a manner consistent with the principles of ecologically sustainable development and is in accordance with an environmental plan. In Canada, the aim of regulating sound in the marine environment is for environmental protection and minimising the possibility of significant impacts, while in Denmark the aim of the promotion of Renewable Energy Act is to promote production of renewable energy and reduce CO2 emissions. In Germany, all requested measures aim at protecting the marine environment from excessive sound. The Netherlands' aim is to prevent significant effects on the ecosystem resulting from specific activities such as pile-driving and seismic surveys. The purpose of the Swedish Environmental Code is to promote sustainable development, which will assure a healthy and sound environment for present and future generations. The aims of noise related regulations in the U.S. are as manifold as the relevant regulations: the primary objective of the MMPA related management should be to maintain the health and stability of marine mammals and their ecosystems and efforts should be made to protect essential habitats. The purposes of the ESA include providing a means to conserve the ecosystems of endangered species and threatened species (those threatened with extinction) and to provide a program for the conservation of the species themselves. The NMSA allows for the designation and protection of national marine sanctuaries.

9. What is the "philosophy" behind the regulation (i.e. regulation based precautionary principle, societal debate/consensus, legislation, conceptual framework): Why regulate (underwater-) noise related activities, for what purpose?

There are a number of core philosophies within the Australian Environment Regulations. The overarching philosophy is for petroleum activities to be carried out in a manner consistent with the principles of ecologically sustainable development, one of which relates to the precautionary principle. The principles of ecologically sustainable development include consideration of environmental, social, and economic considerations. At the same time, the Australian *Offshore Petroleum and Greenhouse Gas Storage Act* (OPGGSA) (2006) provides for an objective-based regime, which means that the focus is on safety, environment, and (oil-/gas-) well integrity outcomes, rather than prescribing minimum standards for industry compliance. This embraces the variety of activities that are covered by the regime and ensures that operators, who carry the risk from those activities, have flexibility to tailor management solutions to best suit their particular circumstances and location of their activity.

The philosophy behind the Canadian and also the Dutch regulation is a precautionary approach to minimize the possibility of or to prevent significant impacts, while in Sweden, regulation is based on recognition of the fact that nature is worthy of protection and that our right to modify and exploit nature carries with it a responsibility for wise management of natural resources.

The regulatory approach in the U.S. is based on an ecosystem/conservation-based philosophy, recognising that that marine mammals and other protected species are resources of great international significance and should not be permitted to diminish beyond the point at which they cease to be a significant functioning element of the ecosystem.

10. Are there trans-boundary issues, i.e. is there a need for harmonisation between neighbouring countries/ countries sharing trans-boundary habitats of a migratory species?

The Convention on Environmental Impact Assessment in a Trans-boundary Context (informally called the *Espoo Convention*) is a *United Nations Economic Commission for Europe (UNECE) convention* (signed in Espoo, Finland, in 1991) that entered into force in 1997. The Convention sets out the obligations of Parties — that is States, which have agreed to be bound by the Convention — to carry out an environmental impact assessment of certain activities at an early stage of planning. It also lays down the general obligation of States to notify and consult each other on all major projects under consideration that are likely to have a significant adverse environmental impact across boundaries. As of May 2013, the treaty had been ratified by 44 states and the European Union[9].

In addition to any commitment arising from the *Espoo Convention*, Australia and the U.S. provided more information on this topic.
The legislation and regulatory approaches are similar between state and Commonwealth jurisdictions within Australia, meaning that few transboundary issues exist, particularly in the context of species protection within Australia. Outside of Australia, the legislation can be quite different and often affords less protection to migratory species. There are many initiatives worldwide to improve species protection legislation, but this is mostly within the remit of SEWPaC. NOPSEMA actively engages with international regulators to harmonise environmental regulation and measures of environmental performance where possible for the offshore industry.

In the U.S., NOAA's efforts to conserve and protect trust resources are multi-faceted, including (among other things) coordination with international efforts to minimize the impacts of noise on aquatic resources (e.g., International Quiet Ocean Experiment, EU Marine Strategy Directive). Additionally, NOAA recognizes that the risk assessment tools it is using ultimately require multi-lateral partnerships to characterize noise impacts accurately, and the U.S. intends to work with partners to share data and ideas.

Future development

With growing awareness of underwater sound related issues and increasing scientific insight into the causal relationships underlying them, specific regulations are considered (e.g., in Ireland), or existing regulations are under revision (e.g., in Germany, the Netherlands, U.K., and U.S.).

[9] Several parties signatory to the convention have made declarations and reservations (Austria, Bulgaria, Canada, European Union, France, Liechtenstein, Netherlands and United Kingdom) and two countries (Spain and Sweden) have reacted with objections to the Canadian reservation (United Nations Treaty Collection 2013).

5. International Regulations: Conventions and Agreements on the Effects of Underwater Sound

Underwater sound and its potential negative consequences for the marine environment are also subject to numerous international treaties and regional or global organisations.

European Union

- In the European Union, anthropogenic ocean noise is now considered a form of pollution that, depending on source and intensity, may degrade habitat and have adverse effects on marine life, ranging from disturbance of communication or group cohesion to injury and mortality. Underwater noise has been listed as one of 11 descriptors for the assessment of a good environmental status (GES) of the European waters under the European Marine Strategy Framework Directive (MSFD). However, none of the abovementioned parties have put a binding regulation, with regard to underwater noise, in place. Nor have they established authority to do so.
- In European waters, for most offshore construction activities, an environmental impact assessment (EIA) must be carried out. The EIA Directives on Environmental Impact Assessment of the effects of projects on the environment (Directive 85/377/EEC 1985, amended 1997/2003 and Directive 97/11/EC) set out rules on what information an EIA must provide to comply. The development of common guidelines for mitigation in relation to acute noise sources is highly recommended. Increased cooperation between EU Member States will be required by the MSFD through the application of an ecosystem-based approach to the management of human activities.
- Under the European Habitats and Species Directive (92/43/EEC) the Harbour Porpoise has been awarded the highest protective status as it is listed on Annex II (species for which protected sites need to be selected by Member States conserving their habitats) and IV (species that have to be strictly protected) of the EU Habitats and Species Directive (92/43/EEC). The EU Habitats and Species Directive is relevant in the framework of offshore wind farms and marine pile driving in several aspects. The Habitats Directive requires that Member States undertake surveillance of the conservation status of species of Community interest, with the aim to maintain or restore species at a Favourable Conservation Status (FCS). The conservation status of species will be taken as 'favourable' when: (a) population dynamics data on the species concerned indicate that it is maintaining itself on a long term basis as a viable component of its natural habitat; (b) the natural range of the species is neither being reduced nor likely to be reduced for the foreseeable future; and (c) there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long term basis. The protection of cetaceans from the impact of anthropogenic noise can form part of the strict protection awarded to them. There is increasing consensus on the view that noise should be considered a form of pollution and is covered in general terms in current international legislation regulating the emission of energy into the marine environment. According to this generally accepted view, deliberate or incidental emission of noise is clearly an issue in cases where it would likely be significant in relation to the objectives of the Directive, which include the maintenance of the protected species at a favourable conservation status.

- One of the products of the European Integrated Maritime Policy, launched by the European Commission in October 2007, is the Roadmap for Maritime Spatial Planning: achieving common principles in the EU. According to Gilliland and Laffoley (2008), marine spatial planning is an essential tool for conducting ecosystem-based sustainable development of the marine environment. One of the applications mentioned in the EU Directive 2002/49/EC for noise in air is generating strategic noise maps, which are useful for spatial planning in relation to sound exposure.

Agreement on the conservation of small cetaceans of the Baltic, North East Atlantic, and Irish and North Seas

The parties to the Agreement on the conservation of small cetaceans of the Baltic, North East Atlantic, and Irish and North Seas (ASCOBANS) have prepared several Resolutions with recommendations on underwater noise. In the Resolution on Adverse Effects of Underwater Noise on Marine Mammals during Offshore Construction Activities for Renewable Energy Production, adopted by ASCOBANS Parties in 2009, parties recommend that:

- A strategic approach in marine renewable developments should be taken;
- The precautionary approach should be followed;
- Guidelines should include an appropriate location of devices; measures for avoiding construction activities with high underwater noise source levels during the periods of the year with the highest densities of small cetaceans; measures for avoiding construction activities with high underwater noise source levels when small cetaceans are present in the vicinity of the construction site; measures for alerting small cetaceans to the onset of potentially harmful construction noise; and technical measures for reducing the sound emission during construction works.

ASCOBANS further promotes the development of effective mitigation measures, guidelines and technological adaptations, an assessment of the effectiveness of guidelines, a continued monitoring of effects, and the exchange of information.

Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea, and contiguous Atlantic area

For the waters of the Mediterranean and Black Seas the potential impact of noise on the marine environment, especially on cetaceans, is regulated by the Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS). ACCOBAMS aims to reduce threats to cetaceans in Mediterranean and Black Sea waters and improve the knowledge of these animals. It was concluded in the auspices of the Convention on Migratory Species in 1996 and entered into force in 2001.
On request by the ACCOBAMS Secretariat, Pavan (2006) provided a concise summary of guidelines for setting up a permit system to regulate acoustic pollution that could threaten marine mammals in the Agreement Area. The ACCOBAMS Scientific Committee had noted that:

- Noise is a significant threat to marine mammals and other marine wildlife;
- Underwater noise should be regulated and reduced;
- Underwater noise should be included in Environmental Assessments; and
- Underwater noise levels should be considered a quality parameter when assessing habitats, MPAs (Marine Protected Areas) and other issues related to marine life.

According to Pavan (2006) construction/demolition works on harbours/coast, including pile drivers, jack hammers, etc., are activities to be taken into consideration within the context of the ocean noise issue and a permit request should be submitted to a designated Agency.

However, no guidelines have yet been implemented, and no agency has been designated with responsibility for granting these permits.

Convention for the Protection of the Marine Environment of the North-East Atlantic

Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) recognized noise as a form of pollution in 2004, which was confirmed by the OSPAR-Commission in 2005. OSPAR (2009) states:

It is currently difficult to provide an evaluation of the effectiveness and adequacy of the measures taken and planned for the protection of the marine environment against effects from underwater noise. In order to improve our understanding of the effects of underwater sound on marine life, research including behavioural and auditory studies, monitoring of the distribution (both of the noise sources and of relevant species), and investigation of anthropogenic sound budgets will be needed.

Furthermore, there is an urgent need for standardization of methodologies to study the impact of sound on marine species over larger spatial scales. Increased efforts should be made to develop and apply effective mitigation measures to reduce the impacts of underwater noise (of any source) on marine life. The most effective mitigation measures are geographical and seasonal restrictions to avoid ensonification of sensitive species and habitats. Sound-producing activities may be designed to avoid areas and/or times where/when sensitive marine mammals and other species are usually engaged in susceptible activities such as mating, breeding, feeding, or migration.

In a background document (OSPAR, 2009) the effects of offshore pile driving on marine fauna are discussed along with other marine construction and industrial activities.

North Atlantic Treaty Organization

In reaction to a series of mass stranding events of cetaceans, mostly beaked whales, which have been linked to military sonar operations (Simmonds and Lopez-Jurado 1991, Frantzis 1998, NOAA and U.S. Navy 2001, Jacobs and Hall 1972, Fernández et al. 2005), the North Atlantic Treaty Organization (NATO) has developed and implemented regulations with regard to intense acoustic emission from vessels, especially with respect to the operation of Low and Mid-Frequency Active Sonar (LFAS/MFAS) systems operated by the NATO Undersea Research Centre (NURC).

Even though LFAS und MFAS signals are not considered impulsive sounds, but transient tonal sounds, the NURC guidelines are listed here, as the U.S. Office of Naval Research has funded numerous studies on the effects of noise on marine mammals over the past decades. The results of these studies were partially implemented into the NURC guidelines.

The NURC Staff Instruction 77 (SI-77) is updated continuously (e.g., within the Marine Mammal Risk Mitigation Project, NURC 2006) and comprises procedures and marine mammal risk mitigation protocols. The guideline requires an Environmental Scoping Study (ESS), mitigation procedures, and monitoring together with an associated audit trail. An important basis for the ESS is spatial modelling to predict areas of primary importance for marine mammals. Specific prediction tools like 'SAKAMATA' (TNO, The Netherlands) have been developed to help sonar operators to check which marine mammals are likely to be in the operating area and how sensitive their hearing is. The advice from this program includes a 'ramp-up scheme' that accounts for the sonar specifications, the environmental conditions, and the types of marine mammals present in the operating area. Using a ramp-up of noise gives marine mammals the opportunity to seek quieter areas during sonar operations (see Von Benda-Beckmann et al. 2013).

World Association of Dredging Associations

In Technical Guidance on Underwater Sound (World Association of Dredging Associations 2013), the World Association of Dredging Associations (WODA) recognises the sound emissions made by offshore dredging activities, and WODA advises its members to identify, assess, and manage the risk following a risk-based approach. In conclusion, assessments of dredging sound-induced impacts may require different approaches depending on the organisms and effects of concern and the type and location of the dredging activity. If the assessment concludes that there is a high risk of an adverse effect, the risk management could involve mitigation measures.

Convention on Migratory Species

The Convention on Migratory Species (CMS) Resolution 9.19 (United Nations Environment Programme/CMS 2009), on adverse anthropogenic marine/ocean noise impacts on cetaceans and other biota, noted that in case of doubt, the precautionary approach should be applied. Parties are further encouraged to facilitate:

- Regular collaborative and coordinated temporal and geographic monitoring and assessment of local ambient noise (both of anthropogenic and biological origin);
- The compilation of a reference signature database, to be made publicly available, to assist in identifying the source of potentially damaging sounds;
- Characterization of sources of anthropogenic noise and sound propagation to enable an assessment of the potential acoustic risk for individual species in consideration of their auditory sensitivities; and
- Studies reviewing the potential benefits of 'noise protection areas', where the emission of underwater noise can be controlled and minimized for the protection of cetaceans and other biota.

United Nations

Resolution A/RES/60/30 (2005) of the United Nations adopted by the General Assembly on March 8 2006, Paragraph 84 demands further studies and consideration of the impacts of ocean noise on marine living resources.

International Union for Conservation of Nature

The International Union for Conservation of Nature (IUCN) states that, when there is a reason to expect that harmful effects on biota may be caused by such ocean noise, lack of full scientific certainty should not be used as a reason for postponing measures to prevent or minimize such effects (UNEP/CMS 2009).

International Whaling Commission

Resolution 1998-6 of the International Whaling Commission (IWC) identified the impacts of anthropogenic noise as a priority topic for investigation within its Scientific Committee, and that the Scientific Committee, in its report to the 56th meeting of the IWC, concluded that military sonar, seismic exploration, and other noise sources such as shipping pose a significant and increasing threat to cetaceans, both acute and chronic.

United Nations Environment Programme

The United Nations Environment Programme (UNEP) recognizes the lack of data on the distribution and migration of some populations of migratory cetaceans and the adverse human-induced impacts on cetaceans (UNEP/CMS 2009). Therefore, the Conference of the Parties to the Convention on the Conservation of Migratory Species of Wild Animals urged Parties and invited non-Parties to endeavour to control the impact of emission of man-made noise pollution in habitats of vulnerable species and in areas where marine mammals or other endangered species may be concentrated, and where appropriate, to undertake relevant environmental assessments on the introduction of systems that may lead to noise associated risks for marine mammals.

United Nations Convention on the Law of the Sea

The fundamental obligation to protect and preserve the marine environment is reflected in Part XII of the United Nations Convention of the Law of the Sea (UNCLOS). Article 194 (1) obliges parties to take measures that are necessary to prevent, reduce, and control pollution of the marine environment from any source using the best practicable means at their disposal and in accordance with their capabilities. Pollution is broadly defined in Article 1 (4) and includes the term 'energy'. As interpreted in accordance with its ordinary meaning in the context of the objects and purposes of UNCLOS, energy should encompass noise within its remit. According to Art 208 (1) and (2), under part XIII of UNCLOS, all activities relating to the exploitation and exploration of the seabed must be carried out with due regard to the protection of the marine environment and, in particular, the prevention and control of pollution. Accordingly, parties must take measures to prevent and control the emission of noise associated with seismic surveys, drilling, pile driving, and other associated activities. Article 211 of UNCLOS seeks to prevent, reduce, and control the pollution of the marine environment from vessels.

Helsinki Convention

Regulation 2 of Annex VI of the 1992 Helsinki Convention on the Protection of the Marine Environment Area (HELCOM) stipulates that parties must use the best available technology and best environmental practice to prevent and eliminate pollution, including noise, from offshore activities.

European Science Foundation

In a position paper (Boyd et al. 2008), the European Science Foundation (ESF) lists pile driving as a type of anthropogenic sound source that could affect marine mammals. The effects of greatest concern caused by pile driving are physical trauma, hearing loss, behavioural change, and behaviourally-mediated effects (see Nowacek et al. 2007). Within its 'Risk Assessment Framework' the ESF applies a five step analytical process consisting of hazard identification, dose-response assessment, exposure assessment, risk characterization, and risk management. An important aspect of the risk assessment is to question if the effects of anthropogenic sound on marine mammals result in changes in species viability. This aspect is handled in the Population Consequences of Acoustic Disturbance (PCAD) model (Figure 1) presented in a U.S. National Research Council (NRC) report (National Research Council, 2005). This model provides a rationale for prioritization of research. It is represented by a flow diagram showing research topics in areas ranging from sound production, through behaviour change and effects on life function, to impacts on vital rates, and by implication, the effects on populations. To construct a full risk assessment, it is necessary to make the linkages among each of these aspects.

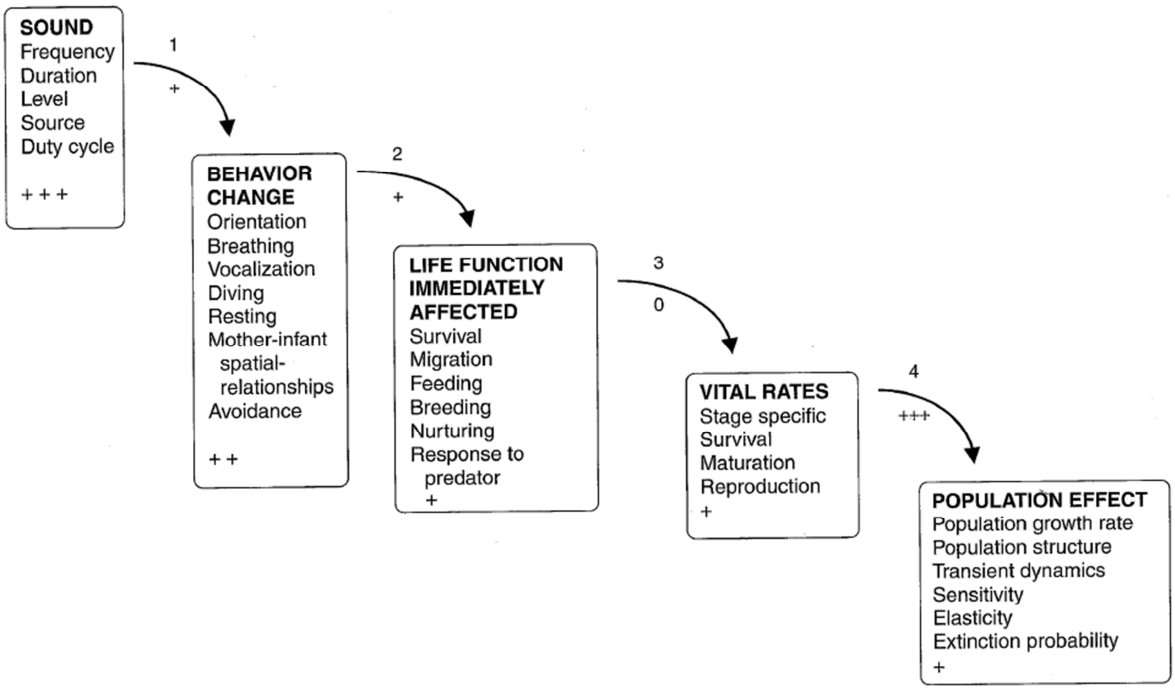

Figure 1: The conceptual Population Consequences of Acoustic Disturbance (PCAD) model describes several stages required to relate acoustic disturbance to effects on marine mammal population (from: National Research Council 2005).

Following this model, it is an extremely complex process to translate behavioural changes into population level effects. Current data are insufficient to allow the PCAD model to serve as more than a conceptual model (National Research Council, 2005). Recent studies on northern elephant seals (Mirounga angustirotris) provided sufficient data for the first time to develop a bioenergetics approach in parameterising the transfer functions developed in the PCAD model. This approach allowed the identification of species and/or particular life history characteristics that are likely to be sensitive or resilient to acoustic disturbance (Costa et al., 2011). The problem is that such data are not available for other species, including the harbour porpoise. In order to assess the potential effects on species, e.g., harbour porpoises, a simpler, mechanistic model was developed which provides a mechanistic approach to predict potential impact of offshore activities. This model, named "Population Consequences of Disturbance" (PCOD) model (Figure 4), can therefore be integrated as part of an adaptive management scheme to advise on future anthropogenic use/ future detonations of underwater explosives (Lusseau et al,. 2012).

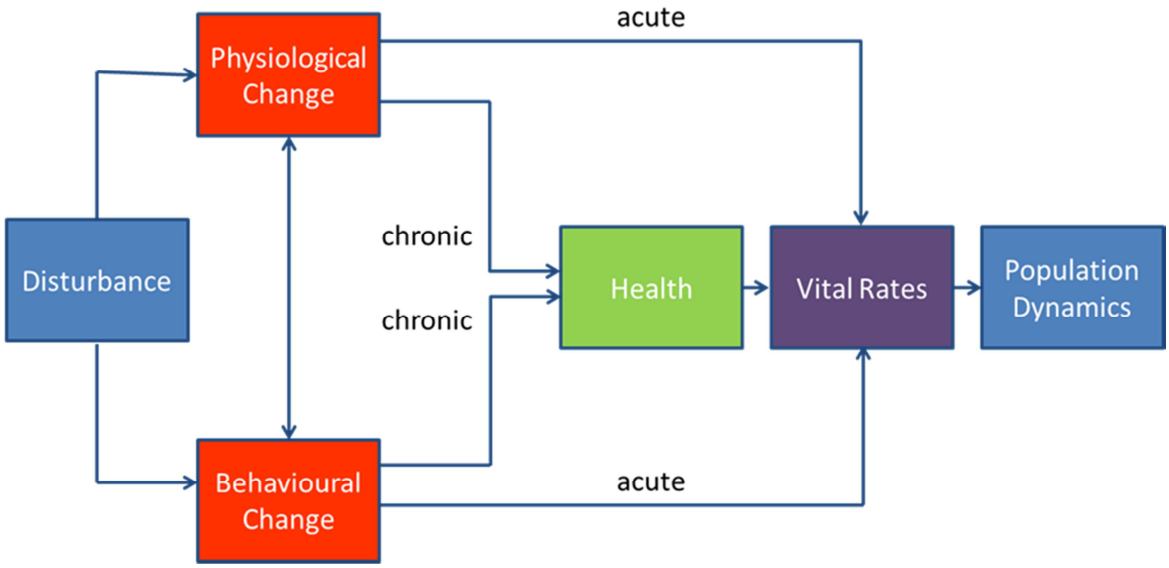

Figure 2: The PCOD framework for modelling the population consequences of disturbance developed by the ONR working group on PCAD (Anon. 2012). The term "Health" is used to describe all aspects of the internal state of an individual that might affect its fitness. These include, for example, the extent of its lipid reserves and its resistance to disease. "Vital rates" refers to all the components of individual fitness (probability of survival and producing offspring, growth rate, and offspring survival).

6. Quality Assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 124296-2012-AQ-NLD-RvA). This certificate is valid until 15 December 2015. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Fish Division has NEN-EN-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 27 March 2013 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

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Justification

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The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of IMARES.

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