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GUIDELINES

TO ADDRESS THE ISSUE OF THE IMPACT OF ANTHROPOGENIC NOISE ON MARINE MAMMALS IN THE ACCOBAMS AREA

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Guidelines to address the issue of the impact of anthropogenic noise on marine mammals in the ACCOBAMS area

Document prepared by Gianni Pavan for the ACCOBAMS Secretariat

Foreword

This document has been requested by the ACCOBAMS Secretariat to provide a concise summary of guidelines for setting up a permit system to regulate acoustic pollution that could be a threat to marine mammals in the Agreement Area. It is a follow up of the Report SC3/Doc 20 presented at the 3rd Scientific Committee meeting.

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Guidelines to address the issue of the impact of anthropogenic noise on marine mammals in the ACCOBAMS area.

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Executive Summary

Although we know that anthropogenic sound in the ocean is a serious threat, we do not have sufficient information at this time to understand the full extent of the problem. One of the biggest challenges faced in regulating the effects of noise is our ignorance of the characteristics and levels of sound exposures that may pose risks to marine mammals. Given the current state of our knowledge we must therefore take a precautionary approach in the regulation of noise.
We must also expand our efforts to protect and preserve marine mammals by instituting and using effective mitigation measures – such as geographic exclusion zones – now, to keep marine mammals at a distance from noise sources that have the potential to harm or kill them.
While most interest in anthropogenic noise has focused on marine mammals (mainly cetaceans and pinnipeds) and a few other vertebrates (sea turtles), there is increasing concern regarding the impact of such noise on fishes and marine invertebrates. This issue will need exploration in the future also taking into consideration the effects on the trophic web.

Acoustic impacts on marine environment need to be addressed through a comprehensive and transparent management and regulatory system. This should address chronic and acute anthropogenic noise, long-term and short-term effects, cumulative and synergistic effects, and impacts on individuals and populations.
Only through a combined approach based on precaution, mitigation, and research, we can assure that these very special resources will be here for the enjoyment of future generations.

Designated agencies should identify and implement mitigation measures that are effective for noise-producing activities as a part of research programs that includes systematic study of the effectiveness of various mitigation and conservation tools.
In addition, management should be extended to unaddressed sources and activities that have the potential to produce adverse effects (including, but not limited to, commercial shipping, recreational watercraft use, whale watching, and the development and use of acoustic harassment devices).

In the absence of specific laws, and given the fact that underwater noise is a transboundary pollutant, in the Mediterranean waters the EU Habitat Directive is probably the best framework for developing a permit system that complies with the opinions expressed by international organizations (ACCOBAMS Recommendation 2.7 and ACCOBAMS Resolution 2.16, the recommendations of the 56° and 58° IWC meetings (held in 2004 and in 2006), and the European Parliament Motion B6-0089/04).

The European Union Habitat Directive states that it is not permissible to deliberately disturb in the wild, any creature which is enlisted in Annex IV (a), where all Cetaceans (and several other marine mammals) are listed. In addition to species protection, the Habitats Directive also makes provision for the site-based protection of a range of marine mammal species (listed in Annex II), including bottlenose dolphins and harbour porpoises and all species of seal. To achieve this, Special Areas of Conservation (SAC), as well as Marine Protected Areas (MPA) should be proposed and designated as key tools for marine mammals protection.

Even though dedicated laws about underwater noise are not yet available yet, it is important to act in a precautionary way and give these animals, together with marine turtles and other zoological groups, protection against noise.

To create the basis for developing a permits system, it is necessary to promote an interdisciplinary and international approach based on the following actions:

- Create a suitable legislative framework where underwater noise is considered a real threat to marine life
- Develop international/worldwide databases on marine mammals and their habitats
- Develop international/worldwide databases on activities that may have an acoustic impact on marine mammals and/or on their habitat
- Review and evaluate available information on the impacts of human-generated sound on marine mammals taking into account all the features that may make an acoustic event a threat
- Identify research needs and make recommendations concerning priorities for research in critical areas to resolve uncertainties or disagreements
- Promote and support research and education
- Promote the involvement of stakeholders to find agreements on possible solutions, including voluntary implementation of risk reduction and mitigation procedures
- Create an Agency to manage a permit system aimed at avoiding or mitigating any possible adverse effect, either in the short or long term, of anthropogenic sounds on marine mammals and on other components of the marine environment

In this process it is important to involve all the subjects working in the sea environment to create a broad awareness of the acoustic pollution problem and of all the procedures and actions that can be adopted to mitigate negative effects.
As a first step all subjects should be urged to voluntarily adopt the basic mitigation procedures suggested here and develop the ability to carry out an environmental impact assessment (EIA) of their own activities.

In this context, the creation of Special Areas of Conservation (SACs) and Marine Protected Areas (MPAs) that take noise pollution into account should ensure protection of areas of critical and productive habitats, and particularly of vulnerable and endangered species.

The designation of SACs and MPAs can be used to protect marine mammals and their habitats from environmental stressors including the cumulative and synergistic effects of noise. In these areas, noise levels should not be allowed to exceed ambient levels of more than a given value, including the contributions from sources that are located outside of the MPA but whose noise propagates into MPA boundaries. This would require additional research to establish baseline noise data and evaluate thresholds for noise levels that can be considered acceptable; i.e. can be tolerated without any significant negative effect.

1. Introduction

In the ACCOBAMS area marine life is threatened by habitat degradation due to intense human activities such as fishery, ship traffic, pollution, and coastal development. In addition to being affected by chemical pollution, cetaceans can be affected by noise pollution.
At present, noise is an ubiquitous form of marine pollution, especially in areas of heavy maritime traffic and developed coasts. Intense underwater noise is generated by airguns widely used for geophysical explorations for the oil and gas industry as well as for academic and administrative purposes, by high power sonar, either military or civil, by ship traffic, by shoreline and offshore construction works, and by a series of other commercial, military and industrial sources. The knowledge that man-made noise can affect marine mammals and the need for a regulatory system to mitigate such effects has increased over the past few years, mainly within the context of military sonar and seismic surveys.

2. The noise issue

The underwater environment has its own acoustic peculiarities and cetaceans are extraordinarily well adapted to them. In these mammals acoustic communication and perception has acquired a privileged role compared with other sensory modalities. Marine mammals live in a medium which poorly transmits light but through which sound propagates very well, even over long distances and especially when frequencies are low or the sound is channelled. Marine mammals rely heavily on sound to communicate, to coordinate their movements, to navigate, to exploit and investigate the environment, to find prey and to avoid obstacles, predators, and other hazards.
In some cases anthropogenic sound sources radiate low- to high-frequency sound over relatively small areas and individual animals are exposed to high levels of sound (> 160 dB re 1 µPa) over relatively short periods of time (acute exposure), e.g. in some military sonar operations.
In other cases exposure to such high levels can occur for long periods, weeks and months, as in the case of seismic surveys or some military sonar. A further effect of seismic surveys and low-frequency naval sonar is that they radiate low-frequency sound over very large areas thereby exposing populations to lower sound levels (< 120 dB re 1 µPa) over relatively long periods of time (chronic exposure); this can be also the case for distant shipping noise, multiple distant seismic surveys or construction works (Tyack, 2003; Nieukirk et al., 2004; Pavan, personal observation). Regarding received levels, it is generally accepted that levels greater than 120 dB re 1 µPa may produce behavioral change (Richardson et al., 1995; Moore et al, 2002) and levels greater than 150 dB can lead to effects ranging from severe behavioural disruption to physical damage, including death in some circumstances. These numbers are still debatable, but represent current best guesses.
Noise pollution can cause marine mammals to abandon their habitat and/or alter their behaviour by direct disturbance or by masking their acoustic signals over large areas (Payne & Webb, 1971; Hildebrand, 2004, 2005); higher levels could directly affect their hearing capabilities by producing either temporary or permanent hearing losses (NRC 2000; NRC 2003; Gordon et al., 2004). All these effects may be critical for the survival of marine mammals. As previously indicated, some high energy sound sources can even trigger mortality events, as recently evidenced by several dramatic and well documented atypical mass strandings of beaked whales (e.g. Greece 1996, Bahamas 2000, Canary Islands 2002: References: Simmonds and Lopez-Jurado, 1991; D'Amico, 1998; Frantzis, 1998; Evans and England, 2001; Dep't of the Environment, 2002; Evans and Miller, 2004; Fernández 2005).
Although atypical mass strandings represent the most dramatic class of incidents related to acute sound exposure, at least for certain marine mammal species, it should be remembered that the effects of repeated non lethal exposures and of increased noise levels are generally unknown but may potentially have significant long term effects. Furthermore, the biology of "disturbance" and

the effect of noise on the fecundity of marine mammals and their prey species is not well understood. Fundamental research on marine mammal acoustics, on their habitats and habits, as well as on their prey, is thus needed to address this very complex issue.

Impacts on other marine organisms

While most interest in anthropogenic noise has focused on marine mammals (mainly cetaceans and pinnipeds) and a few other vertebrates (e.g. sea turtles), there is increasing concern regarding the impact of such noise on fishes and marine invertebrates. Despite increasing interest in the effect of sounds on fishes and its economic implications, this issue has only been addressed on a limited scale.

Although it is known that noise can deafen fish and otherwise seriously impact them (McCauley et al., 2003; Popper et al. 2004), little concern has been given to the ecological implications of such effects and few mitigation procedures address fish or spawning aggregations; despite ethical concern is rarely expressed, this issue will need exploration in the future also taking into consideration the effects on the trophic web.

3. Marine Mammals Risk Mitigation Policies

Because the occurrence and use of sources of potentially harmful anthropogenic noise are likely to increase in the coming years and new sound sources are continuously being introduced the question of how to mitigate the harmful effects of these noise sources is pressing. Acoustic Risk Mitigation procedures have been developed or are being developed by navies, administrations, and commercial companies. Generally these are concerned with avoiding exposing animals to sound pressures that can cause direct damage of their hearing system, or produce other types of physical damage that may lead to impairment of vital functions or to death, or that could disrupt their behaviour so that their survival could be threatened. Mitigation procedures, however, are not consistent between regions, and are often based on perceived “common sense” rather than real knowledge of risks, and may often be only applied sporadically.

Best current mitigation practices generally call for noise producers to 1) avoid areas with high density of marine mammals, 2) monitor the operational area to verify that no animals are present before starting acoustic emissions, and 3) observe the area while emitting sounds to check that no animals are within or are approaching the exposure area.

The implementation of these measures would require: 1) creation of databases of marine mammals’ spatial and seasonal distribution so that harmful activities can be planned in areas and periods where animals are less likely to be encountered, 2) visual and passive acoustic monitoring to ensure that marine mammals are distant enough from any active acoustic source(s) or to any source to be activated, 3) slow increase (ramp-up) of acoustic power to theoretically allow marine mammals sufficient opportunity to leave the ensonified area and 4) continuous research to improve monitoring and mitigation techniques.

The implementation of these points seems to be straightforward, though the efficacy of measures 2 and 3 are unproven and disputed in terms of their effectiveness (though passive acoustic monitoring holds some promise for certain species). With relation to ramp up it should be noted that in some cases this procedure can result in substantially more sound energy being produced in the marine environment making it important that its efficacy be measured and its costs balanced by efficacy.

One of the most common mitigation measures involves temporarily shutting off the acoustic source(s) if a marine mammal is sighted within a specified range. For example, the prohibition of exposing cetaceans to levels above 180 dB re 1 microPa, and a generalized shutdown range of 500m from the noise source. While this has been adopted in some cases, there is little scientific justification for both the 180 dB and the 500m criteria. More flexible models should be developed

to take into account differences among species and differences in sound propagation related to local oceanographic and bathymetric conditions (for example, the 180 dB safety range for a 3 airgun array can range from 80 to 600 meters for water depths of, respectively, 1000m and 100m) (Holst et al., 2005) and received levels can be as high as > 160 dB peak-to-peak to distance of 12 km from a seismic array (Turner, 2006).
A key point of any mitigation process is thus the ability to model, and to verify actual values, the emitted acoustic field (Holst et al., 2005; Turner et al., 2006) and to define a 3D range (exclusion zone, or EZ) where animals should not be present to avoid exposure to a harmful noise dose. Linked to this is the ability to detect animals within the EZ, or entering or approaching it, with sufficient time to apply mitigation measures such as shutting off the acoustic source(s). Although the effects of factors such as weather conditions, visual team size and animal behaviour on sightings probabilities for different species of marine mammals is well known the obvious impact that these will have on the risk of an animal being with the exclusion zone and not being detected is not considered in any current mitigation procedures.

One crucial and still open question is the definition of acceptable threshold levels, and thus related 3D ranges, for short-term exposure to sounds of high-intensity. Estimated threshold values for direct auditory damage differ by orders of magnitude from thresholds related to behavioural responses, such as those that have led to the atypical mass stranding of beaked whales in the Bahamas in 2000.
Once 3D ranges are established, trained Marine Mammal Observers (MMOs) and Bio-Acousticians (BAs) should be dedicated to the implementation of these monitoring and mitigation measures within a regulatory framework managed by a specific Agency.
Monitoring measures may include the survey of the area before, during and after the permitted activities to evaluate any possible effect, including changes in the population density, behaviour, or anomalous strandings. This could require establishing cooperation with local experts and organizations, such as stranding networks and other local authorities/agencies.
Mitigation measures may include: restriction of operations to daylight hours; a gradual increase (ramping up) of sound sources; cessation of emission (shut-down) if mammals are detected within the designated exclusion zone; shut-down or delay of operations if weather or sea conditions make monitoring impossible or unreliable; restrictions on boat traffic in the area; power limits; and seasonal or geographic restrictions based on the activities and distribution of the animals. Reducing the emission level (power-down) to reduce the ensonified area to that which can be monitored effectively in bad weather or limited visibility could be also considered.
Marine mammal mitigation measures currently in use worldwide show considerable variation and there are increasing numbers of studies that are relevant to monitoring and mitigation, suggesting the need for reconsideration of the rationale and effectiveness of existing methods.
Further, new detection technologies (e.g. thermal imagery, remote sensing, infrared, radar, etc.) including low-impact whale-finding sonar (themselves a source of noise), should be evaluated and developed for mitigation needs and as anti-collision tools.
No definitive methods currently exist for predicting or determining with high confidence whether there are marine mammals in a given area; spotting them at the surface and listening to their underwater sounds are currently the two most widely used techniques. But these techniques may fail: observers can only work in daylight with good weather conditions, and while acoustic monitoring can be done 24/24h, it requires suitable equipment and detects vocalizing animals only. Animals can be difficult to spot, some species can dive for long periods, of an hour or more, or they can be silent, at least in the observation period, or produce emissions out of the range of the detection equipment. Together with careful planning to avoid known key habitats and other areas of high marine mammal density, an integration of different techniques and proper observation periods

seems to be the most successful solution to date: trained and experienced MMOs equipped with suitable acoustic equipment can greatly improve the probability of detecting marine mammals.
Furthermore, passive acoustics is one of the tools to be used, with great potential for improvements, for (a) expanding knowledge about marine mammal distribution and habitat preferences (i.e. with surveys), (b) evaluating the effects of sound exposure on animals' behaviour, and (c) monitoring underwater noise levels.

Although no risk mitigation measures can completely eliminate the risks associated with high power sound sources, such as military sonars and airguns, a permit system to enforce thoughtful and prudent planning with mitigation actions can significantly reduce these risks. Pending the development of the permit system recommended in this document, one important interim step would be to develop and endorse uniform mitigation guidelines for noise producers in the ACCOBAMS area, and we urge the Scientific Committee to take up this task.

4. Towards a permit system in the ACCOBAMS area

The implementation of a permit system should be based on the best scientific knowledge about marine mammals sensitivity to noise, about the habitats they use for critical parts of their life cycle, and when scientific data are not available, on the implementation of the precautionary principle.

Marine mammals are difficult animals to study in the wild and relatively little effort has been directed towards understanding this problem. Consequently large data gaps exist in relation to both marine mammal populations and the effects of noise, which combined result is in substantial uncertainty in the effects of noise on marine mammal populations, especially in the long term. There is the potential for irreversible harm to occur before it is detected. The precautionary principle whose application is specifically required under the ACCOBAMS agreement, dictates that in the face of uncertain knowledge precautionary management measures should be implemented. Operationally, this might involve using pessimistic assumptions within the bounds of likely values for particular parameters of interest. However, these assumptions should become less restrictive as research is directed to reduce uncertainty in key areas.

In the US it is mandatory to comply with the Marine Mammal Protection Act (MMPA) and with the Endangered Species Act (ESA) for any action with a potential impact on marine life; for this reason the implementation of mitigation measures is designed to balance scientific, industrial and military needs with the protection of marine resources. The permit system is managed by NMFS and by other US Agencies, depending of the type of permit.
For an overview of how underwater sound is regulated, see McCarthy, 2004.

In the absence of specific laws, and given the fact that underwater noise is a transboundary pollutant, in the Mediterranean waters the EU Habitat Directive is probably the best framework for developing a permit system that complies with the opinions expressed by international organizations (ACCOBAMS Recommendation 2.7 and ACCOBAMS Resolution 2.16, the recommendations of the 56° and 58° IWC meetings (held in 2004 and in 2006), and the European Parliament Motion B6-0089/04).
The European Union Habitat Directive states that it is not permissible to deliberately disturb in the wild, any creature which is enlisted in Annex IV (a), where all Cetaceans (and several other marine mammals) are listed. In addition to species protection, the Habitats Directive also makes provision for the site-based protection of a range of marine mammal species (listed in Annex II), including bottlenose dolphins and harbour porpoises and all species of seal. To achieve this, Special Areas of

Conservation (SAC), as well as Marine Protected Areas (MPA) should be proposed and designated as key tools for marine mammals protection.
Even though dedicated laws about underwater noise are not yet available yet, it is important to act in a precautionary way and give these animals, together with marine turtles and other zoological groups, protection against noise.
In Europe, as far as military sonar operations are concerned, at least one policy exists, the NATO URC Marine Mammals Risk Mitigation Policy, and other protocols/guidelines are being developed by Navies about to the use of sonar and explosives during exercises.
Nevertheless, anthropogenic noise remains largely unregulated in the marine environment and thus both scientific research and new legislation are needed to address the current environmental concerns and to provide viable management and mitigation solutions.
Specific laws and the designation of organizations committed to overseeing their implementation are now required, along with support for research, education and training to build knowledge and expertise such that mitigation rules and technical tools can be designed, implemented, verified and improved.

The Italian situation
As specific national rules are lacking in Italy the legal reference framework is the Habitats Directive. The Office of Protected Marine Resources (Ministry of the Environment), is in charge for authorizing seismic surveys and for providing basic guidelines to minimize impact on marine fauna. But no office in charge of controls exists, and the effectiveness of the whole regulatory system is unclear.
In support of a stronger implementation of mitigation procedures, a recent law (L. 8 febbraio 2006, n. 61) allows extending Italian jurisdiction beyond the national waters, creating special Ecological Protection Zones.
The Italian Navy, concerned about the risk of sonars for marine mammals since 1995 (Nascetti et al., 1996) has recently developed and adopted a policy of mitigating the effects of sonar operations (Cerutti F., 2005).

The NATO approach
The NATO NURC (Undersea Research Center), located in La Spezia - Italy, runs an international research project named SOLMAR (Sound Oceanography and Living Marine Resources), that resulted in the development of the NATO Policy (NATO Staff Instruction 77-04); initially conceived for sonar research and development, the Policy is being considered a reference for NATO Navies.
The SOLMAR Project started in 1999 to support the NURC commitment to conduct marine research in an environmentally responsible manner and to provide guidelines and dedicated tools to the NATO Navies and to the scientific community.
One of the goals is the development and refinement of the tools and/or procedures to minimise the probability of marine mammals being within a zone near a sonar source prior to and during its use. It also seeks to improve the understanding of anthropogenic noise characteristics which are aversive and potentially harmful to animals. The project includes the development of a set of comprehensive databases of oceanography, ecosystem dynamics and living marine resources in the Mediterranean Sea to support the development of models for predicting the presence of marine mammals based on seasonal and environmental parameters.

5. A Mitigation strategy for the ACCOBAMS area

The primary objective of mitigation is to decrease environmental risk by reducing the likelihood of exposures that have the potential to lead to physical damage, and by promoting measures that minimize behavioural disturbance that could lead to effects on vital parameters such as growth, survival, or reproduction. A key goal is to protect at the population level. To this end, consideration needs to be given to defining strategies that address possible chronic, cumulative, and synergistic effects.

At present, there are no specific legal provisions to limit sound production underwater. Instruments such as the Habitats Directive lay down general prohibitions on deliberate disturbance which must be implemented through measures enacted at national level. Individual States are free – but not explicitly required - to adopt measures related to underwater noise and to justify these by reference to the principle of precaution (now enshrined in EC environmental policy). Such measures could, like any other legal measure, be challenged in the national administrative courts. The ministry involved would then have to demonstrate the reasonableness/lawfulness of the measure concerned by reference to the scientific case.
In practice, the limiting factor in the application of the Habitat Directive to the noise issue is that one is required to demonstrate that damage has occurred before intervention can take place.

A permit system should be implemented to develop a strategy based on prevention and on the precautionary principle.
The implementation of a permitting system requires a series of steps and synergistic actions to promote education, awareness and research. Much effort should be devoted to developing a legal framework where underwater noise is recognized and regulated as a real threat.

The need for a permit system has already been recognized and discussed by ACCOBAMS (Recommendation 2.7, the document presented to the Secretariat by Tyack (2003), the Resolution 2.16, the document prepared by G.Pavan for the 3rd meeting of the Scientific Committee), and by a number of international organizations, including the IWC (recommendations produced by the IWC Scientific Committee in 2004 and 2006) and the European Parliament (Motion B6-0089/04).

To create the basis for developing a permits system, it is necessary to promote an interdisciplinary and international approach based on the following actions:

- Create a suitable legislative framework where noise is considered a real threat to marine life
- Develop international/worldwide databases on marine mammals and their habitats
- Develop international/worldwide databases on activities that may have an acoustic impact on marine mammals and/or on their habitat
- Review and evaluate available information on the impacts of human-generated sound on marine mammals
- Identify research needs and make recommendations concerning priorities for research in critical areas to resolve uncertainties or disagreements
- Promote the involvement of stakeholders to find agreements on possible solutions, including voluntary implementation of risk reduction and mitigation procedures
- Create an Agency to manage a permit system aimed at avoiding or mitigating any possible adverse effect, either in the short or long term, of anthropogenic sounds on marine mammals and on other components of the marine environment

In this context, the creation of Special Areas of Conservation (SACs) and Marine Protected Areas (MPAs) that take noise pollution into account should ensure protection of areas of critical and productive habitats, and particularly of vulnerable and endangered species.

The designation of SACs and MPAs can be used to protect marine mammals and their habitats from environmental stressors including the cumulative and synergistic effects of noise. In these areas, noise levels should not be allowed to exceed ambient levels of more than a given value, including the contributions from sources that are located outside of the MPA but whose noise propagates into MPA boundaries. This would require additional research to establish baseline noise data and evaluate thresholds for noise levels that can be considered acceptable; i.e. can be tolerated without any significant negative effect.

5.1 Research and Education

Basic and applied research is required in several areas. Research on the effects of sound on marine mammals, and their biological significance is needed. Research to be able to predict spatial and seasonal distributions and abundances to support planning of activities in areas and times when impacts can be reduced, and research to improve and evaluate the effectiveness of operational mitigation measures (including visual and acoustic real time detection technologies) is also necessary. Specific research is required to identify and quantify the actual and potential risk for individual species, such as beaked whales.
It is also important to develop more effective ways to monitor the presence and behaviour of animals as part of current mitigation so that such monitoring data can be used for evaluating impacts and mitigation effectiveness. In this context, the interpretation of biological significance of null findings from impact assessments is problematic, and highlights the need for consideration of statistical power, experimental design and appropriateness of response variables.

Dedicated funding is required to support research, management and conservation issues as well as to continuously refine and update mitigation rules and tools.

Suggested priority actions include:

a) conduct more complete analysis of past and present stranding data, including obtaining more information on whether or not there were noise activities in the area at the time of the stranding, for both naval sonars and seismic surveys. Full disclosure of noise events by noise producers is necessary for a thorough analysis of such data.
b) create or improve regional and worldwide databases to model marine mammals' presence, distribution, density, as well as to map and model seasonal movements and habitat and seasonal specific behaviours.
c) develop an international/worldwide network of underwater noise monitoring stations, to collect baseline noise data, to keep track of the changes in the underwater noise levels, monitor cetaceans, and monitor for unusual events.
d) create datasets to assess the global extent of industrial, military and academic activities that use high power sound sources.
e) investigate acoustic exposure criteria by taking into account signal duration and repetition, energy, frequency, directionality, and bandwidth and behavioural and physical effects on animals. Exposure criteria designed to prevent injury should be based on well-defined measures for potential injury, including injury mediated by a behavioural response, and or hearing threshold shifts.

f) develop a “noise budget” model where the synergistic and cumulative effects of noise sources are taken into consideration.
g) develop an “acoustic comfort” model to define a range of noise levels above the natural background that can be tolerated with negligible effect.
h) clearly define a standard for measuring units and create equivalence tables, where applicable.
i) review and evaluate available information on the impacts of human-generated sound on marine mammals at the individual and population level and on other components of the marine environment, including the prey field.
j) collect baseline whale population and ecosystem data before any seismic/sonar operation has started. In case of field development and associated seismic surveys that may extend over decades, pre-exposure baseline data need to be assembled with a long-term focus.
k) create or improve stranding networks and involve related institutions so that monitoring for unusual events and the analysis of carcasses to reveal acoustic related trauma can be undertaken. This will involve substantial capacity building throughout the region in terms of necropsy facilities and techniques.
l) improve planning capabilities to more safely plan noisy activities (databases, geographical information systems, environmental models, habitat models, remote sensing technologies)
m) support education and training to produce qualified personnel such as marine mammal observers, marine biologists, bioacoustic experts, veterinarians, law officials, etc.
n) create specialist teams to examine problems related with the noise issue; in particular improve training for marine mammal observers and bio-acousticians to be employed for monitoring and mitigation in the field.
o) improve marine mammal detection tools to be used for (1) creating distribution databases, (2) assessing marine mammal presence, distribution and density in areas where surveys are to be planned, (3) detecting and monitoring marine mammal activity and movements for mitigation purposes during seismic/sonar operations.
p) investigate current mitigation techniques to evaluate and improve their effectiveness; develop new monitoring technologies (improved or new sensors: passive acoustic, thermal, radar, low power whale-finding sonars, remote sensing) and mitigation methods.
q) improve passive acoustic techniques, including towed arrays, bottom deployed hydrophones, sonobuoys, and acoustic recording tags.
r) improve data collection protocols and tools (e.g. specific software to assist in data collection, integration and processing, new tags and tracking/locating tools).
s) develop alternative sonar/seismic technologies with lower impact; design sound sources (sonar, airgun) to minimize the irradiated acoustic energy. For example, in seismic surveys, improve airgun design to better concentrate acoustic energy where it is required for geophysical needs, towards the seafloor, and reduce unnecessary long-range dispersion on the horizontal plane, for instance, by the reduction of unnecessary high frequencies and sharp transients.
t) reduce shipping noise by encouraging good maintenance of engines, better designed new ships, encouraging speed restrictions and alternative lanes, especially in sensitive habitat, etc.
u) create a funding/rewarding system to transparently support all the mentioned activities

5.2 Implementation of a permit program

Permits and authorizations should be required to conduct activities that may have an impact on marine mammals and on their habitat. The type and level of impact should be determined by the applicant using an Impact Evaluation Assessment (IEA) based on a standardized protocol. The IEA process should be transparent and should incorporate opportunities for public review and comment.

If there is no potential for serious injury or mortality or the potential for serious injury or mortality can be negated through mitigation measures that could be required under the authorization, the applicant should apply for a ***second level permit***.
If these requirements cannot be met, or in other words, if the potential for serious injury and/or mortalities exists and there are no mitigating measures that could be taken to prevent this from occurring, then the applicant requires a ***first level permit***.

Scientific research using sound intentionally directed at marine mammals should require a ***scientific research permit***. This type of permit concerns, for example, playback experiments and Controlled Exposure Experiments (CEE) as well as the testing of active sonar-based marine mammal detection systems. These types of research are aimed at studying how animals react to sound to better define those exposure levels on which mitigation measures are based.

After the type of authorization is determined, the applicant must submit a written request to the Agency designated by the Nation(s) where the specified activity is planned. In case of international waters the request should be addressed to the Agency designated by the Nation(s) whose coasts are closer to the activity area.
The request should be presented enough time in advance to allow the Agency to evaluate the request and release the permit. The Agency should adopt a very specific timeline for issuing a permit and should legally be required to adhere to this schedule.
There should also be an option for an “emergency” permit, primarily for scientific research, to address a situation that has suddenly arisen to offer a unique scientific research opportunity.

5.3 A permit program for the ACCOBAMS area

The development of a permit program in the European Union and in particular in the ACCOBAMS area could be a complex and difficult task.
The whole process can be summarized in six steps:

1) Identification of the legal framework and creation of new specific laws
2) Extension of jurisdiction over international waters
3) Creation of an Agency legally able to release a permit and to verify and prosecute any eventual violation of the permit in national and international waters
4) Identification of the activities that may require a permit
5) Identification of the subjects required to ask for a permit
    Any ACCOBAMS citizen/institution for operations everywhere
    Any ACCOBAMS citizen/institution for operations in the ACCOBAMS area
    Any citizen/institution for operations in the ACCOBAMS area
6) Adoption of guidelines for reducing impacts and for monitoring

In this context it is important to involve all the subjects working in the sea environment to create a broad awareness of the acoustic pollution problem and of all the procedures and actions that can be adopted to mitigate negative effects.
As a first step all subjects should be urged to voluntarily adopt the basic mitigation procedures suggested here and develop the ability to carry out an environmental impact assessment (EIA) of their own activities.

Concerning points 1-3, see the document presented by Clare Shine.

5.4 The Agency

A dedicated Agency, designated by interested Nations, should be in charge of managing the permits program. The Agency should have access to suitable knowledge bases to evaluate the permit requests, to evaluate the assessed impacts and the current impacts, to control the implementation of mitigation measures and their effectiveness, to approve Marine Mammal Observers which should include biologists and bio-acousticians, and to propose additional mitigation measures that may include additional Agency's approved MMOs. The Agency should also have an independent program to approve MMOs by releasing a license for Visual Observers, for Bio-Acoustician or for both. The Agency should also be able to provide funding for dedicated research, for training of Marine Mammal Observers and for promoting public awareness.
A special funding program should also be developed for sharing the cost of research with those applicants who invest in advanced research and actions to improve mitigation.

In this context, it is important to set up transparent safeguards and guidelines that aim to minimize the potential for bias or conflict of interest to occur. Transparency and credibility in research should be supported by allowing full public access to research data and by distributing funding with transparent criteria. Noise producers should preferably not directly fund research on the impacts of noise on marine mammals, but should contribute to a communal "pot" of funds, administered by an independent body which establishes priorities for the research, commissions it, and recommends regulations. In this way, the perception of bias is reduced, and the research is more credible.

5.5 Acoustic activities requiring a permit

In the marine environment many anthropogenic noise sources contribute to the overall noise level and it is thus important to identify which of those noise sources should be regulated through a permit system and which should merit attention for other types of mitigation.
Specific activities are known to have a strong impact on the marine environment, and those activities are the first to be regulated. But in the wide context of the noise issue, it is important to consider that all noise sources should require attention. Recent data (Green et al 1994, Andrew et al. 2002; McDonald et al., 2006) show that shipping noise has increased in the last decades to levels that may have an impact on marine mammal populations, and shipping industry should be encouraged, or regulated if necessary, to reduce the noise irradiated by engines and propellers and to modify shipping lines to avoid MPAs and sensitive areas such as breeding grounds, feeding grounds and migratory corridors.

To summarize, these are the sources and activities to be taken into consideration within the context of the ocean noise issue:

- Ship traffic (cargo ships, high speed ferries, any type of motorboat, whale watching boats)
- Military sonars
- Civil sonars
- Airguns and Sparkers, including arrays
- Explosives, including the blasting of residual war weapons, shipshock events to test hull integrity and other military exercises, decommissioning of offshore structures
- Construction/demolition works on harbours/coast, including pile drivers, jack hammers, etc.
- Offshore construction/demolition works
- Coastal industries
- Ports
- Drilling and oil/gas extraction offshore platforms

- Offshore wind farms
- Oceanographic instruments (bottom and sub-bottom profilers, side-scan sonars, current meters, underwater modems, acoustic thermometry experiments, etc.)
- Echosounders and other acoustic navigation aids and instruments
- Pingers (used on fishing nets) and Acoustic Harassment Devices (AHD)

Although all these sources should be evaluated and monitored individually for their acoustic emission features, for their contribution to the ocean noise budget and for any synergistic effects, a few major categories of noise producing activities are considered here as requiring a permit. This does not mean, however, that the others do not require attention and specific regulations (e.g. limits to ships' and motorboats' noise emission underwater).

A – sonar operations and sonar testing	Military operations (e.g. patrolling, training exercises) Civil operations (e.g. academic, research, testing)
B – geophysical surveys and experiments	Seismic surveys (academic) Seismic surveys (oil/gas exploration) Acoustic experiments (e.g. ATOC or similar)
C – Coastal and offshore construction works and activities	Coastal and offshore construction & demolition works (e.g. ports, bridges, offshore platforms, etc.) Use of explosives for decommissioning structures Use of explosives for testing ships/submarines
D – Resources exploitation	Gas/oil/minerals extraction platforms Drilling platforms Offshore windfarms
E – Scientific research on marine mammals	Playback experiments Controlled Exposure Experiments (CEE) Testing whale finding sonars
F – Other activities	Pingers and Acoustic Harassment Devices (AHD) to protect fisheries and water intakes Whale watching (touristic and scientific) Offshore races Blasting of residual war weapons

Table 1

For any of the listed activities a permit request should be submitted to the designated Agency.
The request must include detailed information regarding the planned activities, a specification of the anticipated acoustic emissions, the anticipated impact, and the mitigation measures to be used; it should include the following information:

- A detailed description of the specific activity or class of activities that can be expected to result in disturbance or damage to marine mammals:
  - Date, duration, geographical region and sub-areas where it will occur
  - Platform(s) to be used
  - Acoustic source(s) features (source level, type of sound or time-frequency structure, directionality or spatial emission pattern (3D field), signal duration, and duty cycle or repetition rate)
  - Time plan of the acoustic emissions in the area or in each sub-area
  - Physical and oceanographic features of the area(s)
  - Bathymetry, seafloor features and sound propagation models for the whole area(s)

  - Noise levels and main noise sources already existing in the area(s)

  - in case of scientific research on marine mammals additional data is required:
    - research protocol
    - expected exposure on individual targets
    - expected exposure on non-target individuals
    - expected exposure on other species
    - expected benefits of the research

- Environmental Impact Assessment
  - The species and numbers of marine mammals likely to be found within the activity area(s)
  - A description of the status, distribution, and seasonal distribution (when applicable) of the affected species or stocks of marine mammals likely to be affected by such activities
  - Exposure model for the expected species and the type and range of incidental impacts that are being expected, considering the worst cases (i.e., harassment only, injury and/or death) that may occur in case of unexpected conditions, and also considering the cumulative and synergistic effects of the proposed action together with past, present, and reasonably foreseeable future activities affecting the same populations or species
  - Presence of critical species, i.e. presence of endangered species or of species of known sensitivity to sound (e.g. beaked whales)
  - Presence of critical habitats, i.e. presence of habitats of key importance for marine mammal species or of habitats typical of critical species
  - The anticipated impact of the activity upon the habitat of the marine mammal populations, and the likelihood of restoration of the affected habitat, taking into account cumulative and synergistic effects of the proposed action together with past, present, and reasonably foreseeable future activities affecting the same habitat;
  - The anticipated impact on the ecosystem and on prey species

- The availability and feasibility (economic and technological) of alternative, lower impact equipment, methods, and manner of conducting such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks, or their habitat

- Mitigation procedures to be adopted
  - Rules (exposure criteria, monitoring protocol, mitigation protocol, reporting protocol)
  - Personnel (team of marine mammals observers (MMO and BA), which should include visual and acoustic observers)
  - Equipment (specific equipment for visual observers and for passive acoustic monitoring)
  - Expected effectiveness of monitoring in different weather and light condtions
  - Expected effectiveness of mitigation
  - Monitoring plans should include a description of the survey techniques that would be used to determine the movement and activity of marine mammals near the activity site(s) including migration and other habitat uses, such as feeding.

- Suggested means of learning of, encouraging, and coordinating research opportunities, plans, and activities related to reducing such incidental impacts and evaluating their long term effects.

This process implies that the applicant has the capability to produce an Environmental Impact Assessment, to setup suitable monitoring and mitigation procedures, to predict their effectiveness and, once the permit is obtained, to implement the mitigation with suitable personnel and equipment as well as to produce a complete final report.

This also implies that the Agency in charge of the permitting process is able to evaluate the documentation produced by the applicant, to judge the effectiveness of proposed mitigatioin measures, to eventually request additional measures, to control their implementation and then to evaluate the final reports on the activities carried out under the permit.

5.6 Issue of a permit

The Agency should evaluate the request, with an accurate evaluation of the EIA, proposed mitigation and expected effectiveness. In the case of permits for scientific research on marine mammals, the research protocol and the expected scientific and practical benefits should be carefully evaluated.
The Agency can then eventually request supplemental data and/or impose restrictions on activities or request additional mitigation measures on a case-by-case basis depending on the type of activity, its location, the impacted species, and other noise burdens and non acoustic factors (past, current and planned) that may impact the same populations of animals. Where appropriate, the concept of a "noise budget" may be employed to help evaluate permit applications. In the case of scientific research it could be requested to limit the exposure or trials on individual targets (e.g. limit the number of attempts/approaches on any individual whale).
Once the permit is issued, the Agency should have control over the planned activities and in particular on the implementation of the monitoring and mitigation protocols with the faculty of imposing agency assigned or agency-certified observers. During the permitted activities any change in the planned activities or in the implementation of monitoring and mitigation should be reported and authorized by the Agency, e.g. in case of unexpected marine mammal encounters or unexpected marine mammals reactions; in specific cases, continuous reporting could be requested.

A key point to be discussed is who should be charged with the mitigation costs. In the US, all costs are charged to the applicants, but government funding is available to support research aimed at improving mitigation.

Major costs to be taken into account are:

- The EIA, which may include surveys of the operative areas
- The production of documents for the permit request
- The onboard observer team and the equipment for monitoring and mitigating, including equipment for passive acoustic monitoring
- The cost associated with mitigation actions (delays in starting the operations, restrictions on areas, periods and duration of the operations, shut-downs and power-downs of the sources)
- The cost of reporting once the activities have been completed
- Any possible cost required for additional surveys during and after the operations
- Any possible cost required to monitor stranding events that may possibly be associated with the activities

All these costs, associated with the uncertainty of getting a permit and with all the restrictions and limitations eventually required by the permit, could be prohibitive for small institutions and for basic research programs not directly connected with important economic activities such as oil and gas research. To balance this, funding opportunities should be made available to research programs aimed at studying marine mammals, at improving mitigation procedures, and also at developing new less impacting techniques.
In the US this has boosted scientific research in support of mitigation needs.

5.7 Monitoring and Mitigation guidelines

A description of monitoring and mitigation procedures should be included in the permit request; though the permit could include additional or alternative measures.

Monitoring and mitigation measures should be adapted case by case; in particular, for all those activities for which scientific information is not available or for situations where uncertainties are high, measures should be more precautionary/restrictive and include multiple options.
In cases where the applicant is already required to adopt a mitigation policy, for example some Navies and US companies obliged by the US MMPA, the most restrictive rules should apply.

Mitigation guidelines fall into three main categories:

- Geographical & temporal restrictions
  - Year-round restrictions to avoid affecting MPAs or key marine mammals habitats
  - Seasonal restrictions to avoid affecting MPAs or key marine mammals habitats during sensitive/critical periods of the life cycle (breeding, feeding, nursing, etc.)
  - Site selection to identify low-risk areas where noise activities can be performed without affecting marine mammals
- Source-based mitigation
  - Technical and procedural modifications to reduce emitted level or other damaging noise characteristics such as rise time, wide beam pattern, long durations and duty cycles, etc.
  - Activity reduction
  - Sound containment
- Operational mitigation
  - Identification of exclusion zones (potentially adaptive according to visibility, propagation models, oceanographic conditions)
  - Restrictions to certain times of day or to duration of emissions
  - Dynamic modification of emitted power (e.g. power down rather than power off)
  - Spatial and operational modification (e.g. to avoid high density areas or to provide escape routes and avoid embayment of marine mammals)
  - Monitoring requirements
  - Reporting requirements
  - Other operational requirements – e.g. in case unexpected condition occurs

5.7.1 General guidelines

Mitigation procedures should be practical in that they should use data that can be readily collected by marine mammal observers, account for operating conditions and constraints, and, as far as possible, minimize disruption of operations while maximizing environmental protection.

Besides procedures for specific activities, the following guidelines and concepts should be taken into account for any activity carried out under a permit:

a) Consult databases of marine mammal spatial and seasonal distribution and habitats databases so that activities can be planned and conducted when and where animals are unlikely to be encountered or in non critical habitats

b) Avoid marine mammals' key habitats and marine protected areas, define appropriate buffer zones around them; consider the possible impact of long-range propagation
c) Closed areas should be avoided and surrounded by appropriate buffer zones
d) If required, organize surveys (shipboard and/or aerial) to assess the population density in the in the areas chosen for operation
e) Consider cumulative impacts over time and effects modeling; include consideration of seasonal and historical impacts from other activities (shipping, military, industrial, other seismic) in the specific survey area and nearby region. For these purposes, databases/GIS that track the history of sonar/seismic and other industrial activities should be developed
f) Modeling of the generated sound field in relation with oceanographic features (depth/temperature profile, sound channels, water depth, seafloor characteristics)
g) Safe and harmful exposure levels must be determined for any zoological group (e.g. mysticetes, odontocetes, pinnipeds, marine turtles) or critical species (e.g. beaked whales)
h) There should be a scientific and precautionary basis for the exclusion zone (EZ) rather than an arbitrary and/or static designation; exclusion zone should be dynamically modelled based on the characteristic of the source (power and directionality), on the expected species, and on the local propagation features (cylindrical vs spherical spreading, depth and type of sea bottom, local propagation paths related with thermal stratification)
i) In case of multiple EZ choices, the safest, most precautionary option should be adopted
j) Consider establishment of an expanded exclusion zone aimed at reducing behavioral disruption. This should be based on received levels much lower than those supposed to produce physiological and physical damage. Whenever possible, consider an expanded exclusion zone where exposure could be limited by reducing the emitted power (power-down) whilst maintaining acceptable operative capabilities
k) Marine mammal mitigation guidelines should be adopted and publicized by all operators, either military, industrial or academic.
l) A system of automated logging of acoustic source use should be developed to document the amount of acoustic energy produced, and this information should be available to noise regulators and to the public
m) Mitigation should include monitoring and reporting protocols to provide information on the implemented procedures, on their effectiveness, and to provide datasets to be used for improving existing marine mammal databases
n) During operations, existing stranding networks in the area should be alerted; if required, additional monitoring of the closest coasts and for deaths at sea should be organized
o) If required, organize post cruise survey to verify if changes in the population density or anomalous deaths occurred as a possible consequence of operations
p) In the case of strandings possibly related with the operations, any acoustic emission should be stopped and maximum effort devoted to understanding the causes of the deaths
q) In the case of abnormal behaviours observed in animals close to the operations, any acoustic emission should be stopped and maximum effort addressed at monitoring those animals
r) Trained and approved Marine Mammals Observers (visual and/or acoustic where appropriate) should be employed for the monitoring and reporting program including overseeing? implemented mitigation rules
s) Marine mammal observers and bio-acousticians in charge of the monitoring program must be qualified, dedicated and experienced, with suitable equipment
t) Marine mammal observers should report directly to the regulating Agency by using a standardized reporting protocol; any unexpected condition and/or change in applied protocols should be discussed with the Agency
u) Accurate reporting is required to verify the EIA hypotheses and the effectiveness of mitigation

v) Procedures and protocols should be based on a conservative approach that reflects levels of uncertainty. They should include mechanisms that create an incentive for good practice.
w) Take a precautionary approach every time uncertainties emerge; in the case of unexpected events or uncertainties refer to the regulatory Agency

Guidelines specific to the activities listed in Table 1 are reported in the following paragraphs.

5.7.2 Guidelines for military sonar and civil high power sonar

For military sonar operations and for civil high power sonars, the following guidelines and key concepts should apply in addition to the general guidelines (5.7.1):

a) Sonar surveys should be planned so as to avoid key marine mammal habitat and areas of marine mammal density, so that entire habitats or migration paths are not blocked, so that cumulative sonar sound is limited within any particular area, and so that multiple vessels operating in the same or nearby areas at the same time are prohibited.
b) Use of the lowest practicable source power
c) Adapt the sequencing of sonar lines to account for any predictable movements of animals across the survey area and avoid blocking escape routes
d) Continuous visual and passive acoustic monitoring (PAM) with a specialized team of marine mammals observers and bio-acousticians to ensure that marine mammals are not in the "exclusion zone" before turning on the acoustic sources and while sources are active.
e) Equipment for visual monitoring should include suitable binoculars, including big eyes, to be used according to the monitoring protocol
f) High power sources should be restricted at night, during other periods of low visibility, and during significant surface-ducting conditions, since current mitigation techniques may be inadequate to detect and localize marine mammals. Because of the impact of adverse weather conditions on the visual detection of mammals, emission during unfavourable conditions should be restricted as well
g) Passive acoustic monitoring (PAM) (towed array technology or other suitable technologies with enough bandwidth to be sensitive to the whole frequency range of marine mammals expected in the area) should be used to improve detection capabilities. PAM should be mandatory for night operations or when visibility is poor.
h) At least two dedicated Marine Mammal Observer should be on watch at every time on every operative ship; organize shifts to allow enough rotation and resting periods to MMOs. In case of acoustic monitoring, at least one operator should be on watch and shifts should be organized to allow 24/24h operation, unless automatic detection/alerting systems with proven effectiveness are available
i) Before beginning any emission there should be a dedicated watch of at least 30 minutes to ensure no animals are within the EZ
j) Extra mitigation measures should be applied in deep water areas if beaked whales have been seen diving on the vessel trackline or if habitats suitable for beaked whales are approached: in such a cases the watch should be prolonged to 120 minutes to increase the probability that deep-diving species are detected (e.g. Cuvier's beaked whales). Ideally, however, sonar exercises should not be done in areas that beaked whales are known to inhabit.
k) Every time sources are turned on, there should be a slow increase of acoustic power (ramp-up or soft start) to allow marine mammals sufficient opportunity to leave the ensonified area in the event that visual and passive searches are unsuccessful. Ramp-up should be at least 30 minutes (the effectiveness of this procedure is still debatable)

l) The beginning of emissions should be delayed if marine mammal species are observed within the exclusion zone (EZ) or approaching it. Ramp-up may not begin until 30 minutes after the animals are seen to leave the EZ or 30 minutes after they are last seen (120 minutes in case of beaked whales)
m) Avoid exposing animals to harmful acoustic levels by preventing them from entering into the EZ, by changing the ship course, if applicable, or by reducing (power-down) or ceasing (shut-down) the acoustic emissions
n) Shut-down of source(s) whenever a marine mammal is seen to enter the EZ and whenever aggregations of vulnerable species (such as beaked whales and sperm whales) are detected anywhere within the monitoring area

5.7.3 Guidelines for seismic surveys and airgun uses

Guidelines for mitigating the effects of seismic surveys have been experimented mostly in the context of academic seismic surveys conducted under NMFS permits (LGL, 2004; Richardson et al., 2004; Smultea et al., 2004; Holst et al., 2005; Tolstoy et al., 2004; Pavan, 2005; Turner et al., 2006). Most of the following guidelines are equivalent to those required for sonar operations and should apply in addition to general guidelines (5.7.1):

a) Seismic surveys should be planned so as to avoid key marine mammal habitat and areas of marine mammal density, so that entire habitats or migration paths are not blocked, so that cumulative seismic noise is limited within any particular area, and so that multiple vessels operating in the same or nearby areas at the same time are prohibited.
b) Use of the lowest practicable source power
c) Limit horizontal propagation by adopting suitable array configurations and pulse synchronization and eliminating unnecessary high frequencies.
d) Adapt the sequencing of seismic lines to account for any predictable movements of animals across the survey area and avoid blocking escape routes
e) Modelling of the generated sound field in relation with oceanographic features (depth/temperature profile, water depth, seafloor characteristics) to dynamically set the Exclusion Zone
f) Mitigation procedures should be practical in that they should use data that can be readily collected by marine mammal observers during offshore operations, account for operating conditions and constraints of sonar surveys and, as far as possible, minimize disruption of surveys while maximizing environmental protection
g) Continuous visual and passive acoustic monitoring (PAM) with a specialized team of marine mammal observers and bioacousticians to ensure that marine mammals are not in the Exclusion Zone before turning on the acoustic sources and while sources are active.
h) Equipment for visual monitoring should include suitable binoculars and big eyes to be used according to the monitoring protocol
i) Ideally, high power airgun configurations should be prohibited at night, during other periods of low visibility, and during significant surface-ducting conditions, since current mitigation techniques may be inadequate to detect and localize marine mammals. Because of the impact of adverse weather conditions on the visual detection of mammals, emission during unfavorable conditions should be restricted as well
j) Passive acoustic monitoring (PAM) (towed array technology or other suitable technologies with enough bandwidth to be sensitive to the whole frequency range of marine mammals expected in the area) should be used to improve detection capabilities. PAM should be mandatory for night operations or when visibility is scarce

k) At least two dedicated Marine Mammal Observer should be on watch at every time on every operative ship; organize shifts to allow enough rotation and resting periods to MMOs. In the case of acoustic monitoring, at least one operator should be on watch and shifts should be organized to allow 24/24h operation., unless automatic detection/alerting systems with proven effectiveness are available

l) Before beginning any emission there should be a dedicated watch of at least 30 minutes to ensure no animals are within the EZ

m) Extra mitigation measures should be applied in deep water areas if beaked whales have been seen diving on the vessel trackline or if habitats suitable for beaked whales are approached: in such a cases the watch should be at least 120 minutes to increase the probability that deep-diving species are detected (e.g. Cuvier's beaked whales).

n) Every time sources are turned on, there should be a slow increase of acoustic power (ramp-up or soft start) to allow marine mammals sufficient opportunity to leave the ensonified area in the event that visual and passive searches are unsuccessful (the effectiveness of this procedure is still debatable)

o) The beginning of emissions should be delayed if marine mammal species are observed within the exclusion zone (EZ) or approaching it. Ramp-up may not begin until 30 minutes after the animals are seen to leave the EZ or 30 minutes after they are last seen (120 minutes in case of beaked whales)

p) Avoid exposing animals to harmful acoustic levels by preventing entering them in the EZ, by changing the ship course, if applicable, or by reducing (power-down) or ceasing (shut-down) the acoustic emissions

q) Shut-down of source(s) whenever a marine mammal is seen to enter the EZ and whenever aggregations of vulnerable species (such as beaked whales) are detected anywhere within the monitoring area

r) Ensure that seismic survey vessels operating in the same area maintain a minimum separation distance to allow escape routes between sound fields.

s) Consider data sharing among surveyors to minimize duplicate surveying

5.7.4 Guidelines for coastal and offshore construction works

Coastal and offshore construction works, which may include demolition of existent structures, may produce high noise levels, even for prolonged periods, depending on the technologies used and on local propagation features that include propagation through the substrate.
Construction works on the coast or on the shoreline, including harbours, may propagate noise (e.g. from pile drivers and jack hammers) over wide areas in particular where the substrate is rocky (Tyack, 2003; Pavan, personal observation). Traditional percussive pile-driving produce vibrations that propagate well and can ensonify wide marine areas with ranges to more than 100km (David, 2006; Madsen et al., 2006; Pavan, personal observation); in such conditions alternative technologies should be used. In some cases mitigation can be achieved through the use of bubble screens (Wursig et al., 2000) or material screens that attenuate sound emitted from the source or other technical modification.

In case of prolonged activities, such as construction works of large structures, a scheduling of the most noisy activities could be evaluated as a measure to avoid continuous exposures especially during critical periods for marine mammals living or transiting in the area; concentration of noisy operations in short periods of time and alternative construction technologies should be also evaluated to minimize noise impact.

a) Modelling of the generated sound field in relation with geological and oceanographic features (depth/temperature profile, water depth, coastal and seafloor characteristics); define the area where animals could receive harmful noise levels (Exclusion Zone)
b) Schedule the noise producing activities according to the presence of marine mammals, if seasonal
c) Use alternative technologies or adopt countermeasures to reduce noise diffusion, i.e. bubbles curtains
d) Setup noise monitoring stations at given distances from the source area to monitor for both local and long range noise levels and verify if predicted levels are reached or not
e) Setup visual observation points/platforms to monitor for the presence and behaviour of marine mammals
f) Before beginning any noise producing action there should be a dedicated watch of at least 30 minutes to ensure no animals are within the EZ
g) In areas where water depths in the EZ exceed 200m the watch should be at least 120 minutes to increase the probability that deep-diving species are detected

It is also important to consider the noise that will be generated by the structures once they are operative. Bridges propagate vibrations related with the traffic; offshore wind-farms and oil extraction platforms produce their own noise and thus their environmental impact should be carefully evaluated and mitigated with dedicated rules.

5.7.5 Guidelines for offshore platforms

Offshore platforms may be used for a variety of different activities, such as seafloor drilling, oil/gas extraction, produce electricity (wind-farms), each one with its own peculiar impacts on the marine environment. Their placement should be carefully regulated; if their impacts include noise, they should require a specific permit with monitoring and mitigation rules to be defined case by case and separately for the construction phase and for the operative life. The growing number of windfarms in coastal areas may have an impact on cetaceans, in particular because of the noise they make (Madsen et al. 2006). They should be designed and operated to produce the lowest possible noise in both phases.

5.7.6 Guidelines for Playback & Controlled Exposure Experiments

CEEs are experiments in which animals in the wild are exposed to controlled doses of sound for purposes of assessing their behaviour or physiological responses.
CEEs introduce additional sound into the ocean and thus potentially expose not only the target species and/or individuals to be studied, but also additional ones. These considerations need to be balanced against the potential for CEEs to provide answers to management questions on a case by case basis.

Given the controversial nature of CEEs it is particularly important that when CEEs are used, they be carefully designed and their limitations acknowledged.

CEEs should use, as much as possible, sound exposures that are realistic and with the same characteristics of sound that the mammals are likely to be exposed to by ongoing sound operations. Further, for CEEs to be effective they must be preceded, as stated above, by baseline studies of behaviour and physiology that enable the results of the experiments to be interpreted as to their significance. To eliminate possible bias and arguments that will make the research valueless for regulatory purposes, if CEEs are conducted, there should be agreement, in advance, as to what constitutes a biologically significant effect.

As with all research, methods that can yield conclusive results with less risk of harm to the animals should be preferred. Systematic observations using ongoing sound-producing activities should be used in place of CEEs if they can provide similar information. It can be particularly difficult to conduct full programs of CEEs when large and expensive sound sources (such as airgun arrays or military sonar) are being investigated. Systematic studies of ongoing sound-producing activities can strengthen monitoring efforts required as mitigation, and have the benefit that such studies do not introduce additional sound directed at the mammals. The advantages of observational studies are increased as more attention is given to optimizing measurement methods and study designs with the greatest power to detect real effects and provide convincing results. In practice, research investigating the impacts of large sound sources has been most successful when it has utilised a suite of approaches including observations of controlled and uncontrolled sound exposures.
While conducting CEEs or Playback experiments, these guidelines should be taken into consideration:

- use sound exposures that are realistic and with the same characteristics of sound that the mammals are likely to be exposed to
- monitor target animal(s) and halt CEE if adverse response is observed
- limit repeated exposures on the same target(s) unless required by the research protocol
- monitored animals should be those exposed to highest levels
- monitor other individuals and species – which may require different methods but may provide additional information
- avoid CEEs/Playbacks in enclosed areas, avoid blocking escape routes
- avoid “chasing” animals during playback; if they move away don’t follow them with playback source
- CEE using animal sounds have been shown to elicit particularly strong responses. Avoid in particular playing back sounds of predators and distorted versions of animals’ own vocalisations

5.7.7 Guidelines for other mitigation cases

Any activity that produces noise above levels that may pose risks to marine mammals requires a permit.

Whale watching
Whale watching is an activity that is increasing every year and that may have an impact on marine mammals populations, stocks, and individuals. Rules and permits are already in force in many countries, but the noise issue is seldom taken into consideration. Noise irradiated by engines and propellers is an important component of the disturbance to animals (Erbe, 2002). Beyond complying with national rules and restrictions, whale watching operators should also comply with noise emission restrictions.
Boats should be as quiet as possible and noise controls should be made at the beginning of every field season. Noise limits should be set to reduce as much as possible the behavioural disturbance to animals.

Blasting of residual war weapons, use of explosives for testing or for decommissioning structures
In many areas of the Mediterranean Sea the blasting of residual war weapons is a recurrent activity that needs special care; also explosives are used widely for offshore decommissioning of structures and also for military trials, e.g. for testing ships and submarines.

In all such cases the definition of an Exclusion Zone is required, based on the power of the expected explosion(s) and on the oceanographic features; consequently the EZ area should be monitored to be sure no animals are inside. The watch before starting operations should be at least 30 min, it should be prolonged to 120 minutes in areas where deep divers could be present. Additional measures could include the use of absorbing materials, e.g. bubble curtains (Wursig et al., 2000), to attenuate the shock wave or at least to dampen the shock wave onset. The use of aversive sound devices to remove animals from the danger area for the relatively short period of blasting holds great promise for mitigation. However, further studies to develop and test such devices with the range of species of interest would be required before these could be relied on for mitigation.

Underwater acoustically active devices
Underwater acoustics is an expanding field and new acoustic techniques are continuously developed, tested and applied for a variety of uses, e.g. for searching/monitoring/exploiting environmental resources, for conducting scientific research, and for military purposes.
Examples of activities that may require a permit include: oceanographic experiments based on the use of high power acoustic sources, including the use of acoustic positioning devices, the use of deterrent devices (Pingers and Acoustic Harrassment Devices, in particular if used in array), e.g. to protect commercial fisheries or to protect industrial water intakes (cooling systems).

In all cases where high noise levels are expected in areas with the potential presence of marine mammals, at least the following guidelines should apply:

a) Modelling of the generated sound field in relation with oceanographic features (depth/temperature profile, water depth, coastal and seafloor characteristics); define the area where animals could receive harmful noise levels (Exclusion Zone)
b) Plan activities for areas with low marine mammal densities, avoiding wherever possible sensitive species, such as beaked whales
c) Schedule the noise producing activities according to the presence/absence of marine mammals, if seasonal
d) Setup noise monitoring stations to monitor for both local and long range noise levels and verify if predicted levels are reached or not
e) Setup visual observation points/platforms to monitor for the presence and behaviour of marine mammals
f) Before beginning any noise producing action there should be a dedicated watch of at least 30 minutes to ensure no animals are within the EZ
g) In areas where water depths in the EZ exceed 200m the watch should be at least 120 minutes to increase the probability that deep-diving species are detected.

5.8 Monitoring and Reporting

Monitoring and reporting are two key activities for the implementation of mitigation procedures and for evaluating their effectiveness. Standardized protocols and equipment should be defined in the permit request. The permit could eventually include additional monitoring and reporting requests.
Visual observations and acoustic monitoring data must be accurately collected during activities carried out under a permit.
Accurate and unbiased data is required to document any possible effect on the local fauna and to assess the effectiveness of the adopted mitigation rules. In case this can't be done adequately by observers undertaking mitigation, the Agency should be able to setup an independent monitoring program whose costs should be shared among the noise producer and the Agency.

A monitoring program to investigate such effects could look for changes (or lack of changes) in behaviour, spatial distribution, abundance, and reproductive success.
Baseline and control data are very helpful in understanding changes that may, or may not, occur during seismic/sonar surveys or during times when mitigation actions are in place. Control data include a wide variety of types of data. This could mean data obtained in a control area, that is, an area similar to the area being used in the surveys but not affected by the noise or data collected before and after the noise exposure.
To document such changes, the program may have to look at a variety of scales: small and large temporal and spatial scales; and look for changes that may be temporary or permanent. Another aspect of such a monitoring program would be to collect data necessary to distinguish between changes due to a seismic/sonar survey (or mitigation measure) and changes due to natural factors (such as environmental shifts) or due to other human-related factors (such as fishery interactions).
Examples of methods to monitor small spatial temporal scale changes include using focal follows and swim directions of the cetaceans and detailed telemetry e.g. using suction cup devices such as D-tags. Examples of methods to monitor medium spatial temporal scale changes include using satellite telemetry, or determining spatial distributions or relative abundances. A method used to monitor large spatial and long temporal scale changes for some baleen whales is to use autonomous seafloor-mounted instruments to monitor selected areas.

- Procedures for collecting observational data should be based on a standardized protocol
- All whale observational data should be made available in the public domain and concur to improve existing datasets and knowledge bases
- Monitoring data should be integrated with specific studies designed to investigate changes in distributions of whales with respect to seismic/sonar operations
- Monitoring data should be integrated with oceanographic data and with an automatic logging of ship tracks and acoustic source use
- If required, independent monitoring stations could be used to monitor noise levels at different ranges from the source

6. Selected references

This list provides an overview of the scientific literature concerned with the underwater noise and its impact on the marine environment. It is not exhaustive, but includes the most relevant reviews on the topic and some papers that address specific issues cited in the present paper.

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