OceanCare

Environmental Impact Assessment of anthropogenic marine noise in European waters

The ocean environment is filled with natural sound, but the last century has introduced many anthropogenic activities that have increased levels of noise. Anthropogenic marine noise has doubled in at least some areas of the world, every decade, for the past 60 years.^[1, 2] This is a life-threatening trend for marine species.

Many marine species rely on sound in some form for vital life functions, including communication, prey and predator detection, orientation and for sensing surroundings.^[3, 4] While the ocean is certainly a sound-filled environment and many natural (or biological) sounds are very loud, wildlife are not adapted to anthropogenic noise.

The main noise producing marine activities are commercial shipping, defence-related operations, hydrocarbon exploration and development, research and recreational activities. Levels of threat caused by these activities are now well defined.^[3]

Mitigation and monitoring of marine noise has become a primary focus of marine mammal research, but is also of concern to the public and policy makers. Guidelines for marine operations exist in many parts of the world, with mitigation efforts primary directed at reducing the risk of injury from exposure to intense noise during activities. ^[3] There are almost no guidelines available for what should be assessed prior to approving these intense noise industries.^[5]

OceanCare has worked for the protection of marine species and the oceans since 1989. In this time, the organisation has developed international recognition as a research, advocacy and education nongovernmental organisation (NGO) that champions the protection of marine flora and fauna. OceanCare maintains a focus on reducing the impact of anthropogenic marine noise on marine species through the Silent Oceans campaign. The organisation promotes the requirement for comprehensive Environmental Impact Assessments (EIAs) prior to any intense noise generating activities, and the exclusion of these activities from the critical habitat of protected species.

EIAs for any noise producing industries in European waters must be thorough, comprehensive and mandatory. This paper will explain that at a minimum, EIAs should:

1. collect baseline biological and environmental information to describe the area being impacted;^[5-8] 2. fully characterise operations, including describing the sound source in some detail, professionally modelling the sound propagation features and spatial area that will experience anthropogenic noise above natural ambient sound levels, and verifying this modelling in the field;^[5] 3. assess the impact to species within this area and consider the potential cumulative effects from other sound sources as well as other human activities that add to the pressures on wildlife;^[5-8] 4. describe how the impacts will be monitored before, during and after the operation;[5-8]

5. provide an objective consideration of the





risk posed by the proposed activity against alternatives.

Marine wildlife and anthropogenic noise.

Wildlife exposed to elevated or prolonged anthropogenic noise levels can suffer permanent or temporary hearing threshold shifts, compromising their communication and their ability to detect threats.^[2, 9]

Noise can mask important natural sounds, such as the call of a mate, the sound made by prey or the noise made by a predator. These mechanisms, as well as factors such as stress, distraction, confusion, and panic, can affect reproduction and growth rates, in turn influencing the long-term welfare of the population.^[2, 10-12]

The most commonly measured wildlife responses to noise fall into three main categories: behavioural, acoustic and physiological.

 Behavioural responses include changes in surfacing, diving and heading patterns and changes in feeding behaviour.
Acoustic responses include changes in type or timing of vocalisation and communication relative to the noise source. 3. **Physiological** responses or impacts include physical damage, hearing threshold shifts and 'stress' in some species. Noise can also mask natural sounds the animal relies on.

These impacts are experienced by a wide range of species including fish, crustaceans and cephalopods,^[13-20] pinnipeds (seals, sea lions and walrus),^[9, 10, 21-24] sirenians (dugong and manatee),^[25] sea turtles^[26-28] and cetaceans (whales, dolphins and porpoises)–the most studied group of marine species when considering the impact of marine noise. ^[2, 29-35]

Environmental Impact Assessments providing defensible information.

Many jurisdictions have developed national and regional operational guidelines about the mitigation of anthropogenic noise on marine fauna while activities are being conducted. These began with the United Kingdom's Joint Nature Conservation Committee guidelines in 1995. Similar guidelines have been iteratively developed in the United States of America, Brazil, Canada, Australia and New Zealand since. ^[5, 36, 37] In many jurisdictions these guidelines are provided for industry guidance and are not specifically regulated.

Few jurisdictions have articulated what detail should be provided at the assessment stage to provide decision makers with defensible information before approvals are given for a noise generating activity to proceed.

It is broadly accepted the basic intent of EIAs is to anticipate the significant environmental impacts of development proposals before any commitment to a particular course of action. The purpose of EIAs for anthropogenic noise industries should determine the level of impact on populations of marine wildlife and the wider ecosystem,^[4] yet many EIAs are insufficiently researched, drawing heavily from previous assessments. Topics are dealt with by dismissal, often ignoring recent scientific literature, perpetuating misconceptions and containing analytical flaws. Discussions about wildlife often focused on lethal impact, with little or no consideration of sublethal impacts. Professional modelling of sound transmission is very rarely provided.



The complexities of sound in water

Sound in the marine environment behaves differently to sound in air. The extent and way that sound travels (propagation) is affected by the frequency of the sound, water depth and density differences within the water column. These vary with temperature, salinity and pressure. Moreover, the ocean bottom substrate affects propagation as well.^[38–41] Consequently, assessing noise propagation is complex.^[40, 42–44]

The temperature of seawater at different depths is important to sound propagation^[45-47] as is the way sound propagates. Seawater is roughly 800–1500 times denser than air and sound travels around five times faster in this medium. ^[40] Sound waves moving through water, at 22°C, travel at around 1484ms-1.^[45-47] Transmission loss-the decrease in the sound intensity levels-happens uniformly in all directions during spherical spreading. In cylindrical spreading the sound waves are effectively contained between the sea surface and the sea floor, while the radius still expands uniformly. As the height is now fixed, the sound intensity level decreases more slowly.^[40, 48] Horizontal layers of water in the ocean at which depth, the speed of sound is at its minimum-Sound Fixing and Ranging Channels (SOFAR) or deep sound channels (DSC)-are created through the interactive effect of temperature and water pressure (and, to a smaller extent, salinity). The speed gradient above and below the sound channel axis-the depth where the sound speed is at a minimumacts like a lens, bending sound towards the depth of minimum speeds. Sound within the channel meets no acoustic loss from reflection of the sea surface and sea floor and travels very long distances with little transmission loss.^[40, 48] The seabed is rarely, if ever, flat and parallel to the sea surface, and so modelling propagation in the marine environment is complex.



Modelling must accommodate the water depth as well as the rise and fall of the seabed.^[40]

All of these complexities require professional modelling to fully understand noise propagation characteristics. It is not acceptable for any noise producing industry to provide generalised assurances.

The specific importance of modelling

While noise modelling is common for land-based anthropogenic noise producing activities, modelling and indeed robust EIAs for marine noise generators are failing this base need.^[5] EIAs for any significant noise generating activity should provide a clear indication of the sound propagation features across the full area the noise will impact.^[5]

To illustrate this need, two examples of professionally modelled sound propagation (dB re 1µPa2.s) are presented below for a 3090in3 seismic survey airgun, proposed to operate in water depth of $2000m^{[49]}$ These illustrations are limited to a radius of 200km.

The significant difference of propagation from the same noise source being transmitted from two separate locations, less than 50km apart, demonstrates clearly why generalized statements of propagation are inappropriate.



Proponents should be required to present professional noise propagation modelling of their proposed activity within their EIA. This modelling should specific to the proposal, the region and under the conditions they plan to operate. They should be required to verify this modelling in the field. Using the modelling to define the area they will impact, their documentation should demonstrate a clear understanding of the species present and any necessary species exclusion zones or measures that will need to be accommodated.

Given the strong commitment of governments to reducing anthropogenic marine noise, this information, if





decisions have already determined the

direction for regulating anthropogenic

European Union Directive

the following:

States:

marine noise. The most recent of these are

The 2014/52/EU Directive introduction

now directs European Union Member

"[w]ith a view to ensuring a high level of

protection of the marine environment,

especially species and habitats, environmental impact assessment and

transparently supplied, will provide regulators and decision makers with robust, defensible and impartial information on which to base their decisions. Only with this level of information can the risks of the proposed noise generating activity be weighed against alternatives.

The existing EIA commitment of European Member States

These suggestions are not without precedent and governmental commitment. A series of important intergovernmental screening procedures for projects in the marine environment should take into account the characteristics of those projects with particular regard to the technologies used (for example seismic surveys using active sonars)."^[50]

ACCOBAMS

The Agreement on the Conservation of Cetaceans in the Black Sea Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) 'Resolution 5.13: Conservation of Cuvier's beaked whales in the Mediterranean'^[51] and 'Resolution 5.15: Addressing the impact of anthropogenic noise'^[52] reinforces the commitments made in 'Resolution 4.17: Guidelines to Address the Impact of Anthropogenic Noise on Cetaceans in the ACCOBAMS Area (ACCOBAMS Noise Guidelines)' that urges ACCOBAMS Parties to:

"[r]ecogniz[e] that anthropogenic ocean noise is a form of pollution, caused by the introduction of energy into the marine environment, that can have adverse effects on marine life, ranging from disturbance to injury and death."^[53]

This Resolution also encourages ACCOBAMS Parties to:

"... address fully the issue of anthropogenic noise in the marine environment, including cumulative effects, in the light of the best scientific information available and taking into consideration the applicable legislation of the Parties, particularly as regards the need for thorough environmental impact assessments being undertaken before granting approval to proposed noiseproducing activities."^[53]

The ACCOBAMS Noise Guidelines provide further comprehensive detail relating to each of the marine noise producing activities.

Espoo (EIA) Convention

Principle 17 of the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo (EIA) Convention) states that: "Environmental impact assessment[s], as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority."^[54]

CBD

The Convention on Biological Diversity (CBD) 'Decision XII/23: Marine and coastal biodiversity: Impacts on marine and coastal biodiversity of anthropogenic underwater noise' encourages CBD Parties: "... to take appropriate measures... to avoid, minimize and mitigate the potential significant adverse impacts of anthropogenic underwater noise on marine and coastal biodiversity."[55] In Decision XII/23, CBD Parties have agreed to a significant list of technical commitments, including gathering additional data about noise intensity and noise types; and building capacity in developing regions where scientific ability can be strengthened.

Decision XII/23 urges the transfer to quieter technologies and applying the best available practice in all relevant activities. The CBD Parties advocate for mapping spatial and temporal distribution of sound through EIAs and combining this acoustic mapping with habitat mapping of soundsensitive species with regard to spatial risk assessments to identify areas where species may be exposed to noise impacts. They also advocate the use of spatio-temporal management of activities.

CMS

The Convention on Migratory Species (CMS) 'Resolution 10.24: Further Steps to Abate Underwater Noise Pollution for the Protection of Cetaceans and Other Migratory Species' encourages CMS Parties to:

"... prevent adverse effects on cetaceans and on other migratory marine species by restricting the emission of underwater noise, understood as keeping it to the lowest necessary level with particular priority given to situations where the impacts on cetaceans are known to be heavy" and "[u]rges Parties to ensure that Environmental Impact Assessments take full account of the effects of activities on cetaceans and to consider potential impacts on marine biota and their migration routes ..."^[56]

Resolution 10.24 further articulates that CMS Parties should ensure that EIAs take full account of the impact of anthropogenic marine noise on marine species; apply Best Available Techniques (BAT) and Best Environmental Practice (BEP); and to integrate the issue of anthropogenic noise into the management plans of marine protected areas.

EIAs for any noise producing activities in the European waters must be thorough,



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comprehensive and mandatory. At a minimum, EIAs should: 1. collect baseline biological and environmental information to describe the area being impacted; [5-8] 2. fully characterise operations, including describing the sound source in some detail, professionally modelling the sound propagation features and spatial area that will experience anthropogenic noise above natural ambient sound levels, and verifying this modelling in the field;[5] 3. assess the impact to species within this area and consider the potential cumulative effects from other sound sources as well as other human activities that add to the pressures on wildlife;[5-8] 4. describe how the impacts will be monitored before, during and after the operation;[5-8] and 5. provide an objective consideration of the risk posed by the proposed activity against alternatives.

Anything less that these measures do not meet the obligations that European governments have already committed to.

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