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EXPERT WORKSHOP ON UNDERWATER NOISE
AND ITS IMPACTS ON MARINE AND
COASTAL BIODIVERSITY
London, 25–27 February 2014

# REPORT OF THE EXPERT WORKSHOP ON UNDERWATER NOISE AND ITS IMPACTS ON MARINE AND COASTAL BIODIVERSITY

## INTRODUCTION

1. At its eleventh meeting, the Conference of the Parties to the Convention on Biological Diversity, in its decision XI/18 A, requested the Executive Secretary to collaborate with Parties, other Governments, and competent organizations, including the International Maritime Organization (IMO), the Convention on Migratory Species (CMS), the International Whaling Commission, indigenous and local communities and other relevant stakeholders, to organize an expert workshop with a view to improving and sharing knowledge on underwater noise and its impacts on marine and coastal biodiversity, and developing practical guidance and toolkits to minimize and mitigate the significant adverse impacts of anthropogenic underwater noise on marine and coastal biodiversity, including marine mammals, in order to assist Parties and other Governments in applying management measures, as appropriate, and to make the report of the workshop available for consideration by a meeting of the Subsidiary Body prior to the twelfth meeting of the Conference of the Parties. The decision further noted that the workshop should cover issues such as the development of acoustic mapping of areas of interest, among other things.

2. Pursuant to this request, the Executive Secretary convened an Expert Workshop on Underwater Noise and its Impacts on Marine and Coastal Biodiversity at the headquarters of the International Maritime Organization, London, United Kingdom of Great Britain and Northern Ireland, from 25 to 27 February 2014, with financial support from the European Commission.

3. With the financial support of the European Commission, the CBD Secretariat commissioned a consultancy to support the scientific and technical preparation for the workshop. The results of this technical preparation were made available in the background document on the development of practical guidance and toolkits to minimize and mitigate the significant adverse impacts of anthropogenic underwater noise on marine and coastal biodiversity (UNEP/CBD/MCB/EM/2014/1/INF/1).

4. The workshop was attended by experts from Argentina, Azerbaijan, Bangladesh, Canada, Costa Rica, Croatia, Democratic Republic of the Congo, Japan, Mexico, Republic of Korea, Senegal, Togo, United Kingdom of Great Britain and Northern Ireland, United States of America, International Maritime Organization, ACCOBAMS/ASCOBANS/CMS Noise Working Group, IUCN-Global Marine and Polar Programme, Animal Welfare Institute, BP International, Quiet Oceans, World Ocean Council, and WWF-Canada.

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## ITEM 1. OPENING OF THE MEETING

5. On behalf of Mr. Koji Sekimizu, Secretary-General of the International Maritime Organization (IMO), Mr. Stefan Micallef, Director of the Marine Environment Division of the IMO, welcomed participants to London, to the IMO headquarters and to the workshop. He expressed his appreciation to the CBD Secretariat for organizing and to the invited experts for attending this workshop. Mr. Micallef explained that the impact of anthropogenic noise from a human safety perspective had been on IMO's agenda for many years, and that, in 1981, IMO adopted the code of noise levels on board of ships, which was further updated in 2012. He explained that when the code was originally adopted, it was recognized that marine life could also benefit from the adoption of these instruments. However, IMO did not address the potential adverse impacts on marine life of underwater noise emanating from ships until some years later. In 2008, following various reports from 2004 to 2007, the IMO's Marine Environment Protection Committee (MEPC) commenced in-depth discussions on the potential harmful impacts of underwater noise on marine life from ships. This work was to culminate in April 2014, when MEPC would consider draft guidelines for minimizing underwater noise from commercial ships with a view to approval and dissemination as an MEPC circular. But this was only a first step, and it was envisaged that the scope and timing of future work would also be considered, such as progress on quantifying and understanding in advance the potential impact of noise on marine species; identifying the types of areas and situations where waterborne noise was potentially most disruptive for marine life; setting specific noise reduction targets; and setting operating guidelines for sensitive marine areas, to name a few possible issues. Mr. Micallef expressed his hope that this workshop would help to clarify technical aspects that were still uncertain and that the workshop would help participants to focus on what further practical guidance was needed to minimize and mitigate adverse effects on marine life from all sectors contributing to noise in the marine environment. He wished participants the best of success in their discussions.

6. On behalf of the Executive Secretary of the Convention on Biological Diversity, Mr. Braulio Ferreira de Souza Dias, Ms. Jihyun Lee delivered an opening statement. In his statement, Mr. Dias welcomed the meeting participants and thanked the Government of the United Kingdom of Great Britain and Northern Ireland for hosting, the International Maritime Organization for collaborating, and the European Commission for their kind financial support for the organization of this workshop. In the statement, he highlighted the importance of the oceans to sustainable development and healthy global ecosystems. He noted that the dynamics of sound in the ocean were intimately linked to the well-being of many marine species and the healthy functioning of marine ecosystems, pointing out that sound played a key role in communication, navigation, orientation, feeding and the detection of predators. He indicated that anthropogenic underwater noise could potentially cause notable effects on a wide range of marine biodiversity, ranging from mild behavioural responses to serious physical injury or death. Mr. Dias noted the increasing concerns about the long-term, cumulative effects of underwater noise on marine biodiversity, which were largely unknown. He expressed the need for adequate policy action to address these potential impacts and noted that there existed some knowledge and experience upon which to build in developing policy approaches to minimize and mitigate them. He pointed to two recent documents produced by the Secretariat of the Convention on Biological Diversity, *Scientific Synthesis on the Impacts of Underwater Noise on Marine and Coastal Biodiversity and Habitats*, 2012; and the background document produced for this workshop (see paragraph 3, above), which reviewed various approaches used to minimize and mitigate the significant adverse impacts of anthropogenic underwater noise.

7. On behalf of the Secretariat, Ms. Jihyun Lee introduced the workshop participants to the Convention's work on marine and coastal biodiversity, the Strategic Plan for Biodiversity 2011-2020 and its Aichi Biodiversity Targets, and the objectives and expected outputs of the workshop, highlighting relevant decisions of the Conference of the Parties to the Convention on the issue of underwater noise and its impacts on marine and coastal biodiversity. She reiterated the call by the Conference of the Parties to the Convention, at its eleventh meeting, to convene this workshop to improve and share knowledge on underwater noise and its impacts on marine and coastal biodiversity, and to develop practical guidance and toolkits to minimize and mitigate the significant adverse impacts of anthropogenic underwater noise on marine and coastal biodiversity, including marine mammals, in order to assist Parties and other

Governments in applying management measures. She then explained the future steps, including the submission of the workshop results to the forthcoming eighteenth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice for consideration prior to the twelfth meeting of the Conference of the Parties to the Convention.

8. On behalf of the IMO, Mr. Edward Kleverlaan provided background on the work that had been undertaken by IMO on the issue of underwater noise from commercial shipping and its adverse impacts on marine life. It was highlighted that noise from shipping had been under consideration in the IMO Marine Environment Protection Committee (MEPC) since 2008, in particular with regard to a number of factors, including ship type, size, loading conditions, method of propulsion and speed. This noise mainly originated from propeller cavitation and onboard machinery, and formed a chronic source of sound below 300 Hz. MEPC would consider draft non-mandatory guidelines for the reduction of underwater noise from commercial shipping, with a view to approval at the forthcoming meeting scheduled for April 2014, and possible future work related to this issue.

## ITEM 2. ELECTION OF THE CO-CHAIRS, ADOPTION OF THE AGENDA AND ORGANIZATION OF WORK

9. Mr. Mark Tasker (UK) and Ms. Carmen Bazúa-Durán (Mexico) were elected to serve as the workshop co-chairs.

10. Participants considered the provisional agenda, as contained in document UNEP/CBD/MCB/EM/2014/1/1, and the proposed organization of work, as contained in annex II of document UNEP/CBD/MCB/EM/2014/1/1/Add.1, and adopted them without any amendments.

11. The workshop was organized in plenary session and break-out group sessions.

12. The co-chairs nominated Mr. Simon Harding and Mr. Arthur Popper as rapporteurs for Agenda items 3 and 4, respectively, taking into consideration their expertise and experience, in consultation with the Secretariat of the Convention on Biological Diversity.

## ITEM 3. IMPROVING AND SHARING KNOWLEDGE ON UNDERWATER NOISE AND ITS IMPACTS ON MARINE AND COASTAL BIODIVERSITY

13. Mr. Simon Harding presented the first background study on the subject, prepared by the Secretariat for the sixteenth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice in 2012, as contained in UNEP/CBD/SBSTTA/16/INF/12.

14. Mr. Yvan Simard provided a theme presentation on monitoring and assessing noise source variability and trends in ocean areas in Canada.

15. Mr. Arthur Popper delivered a theme presentation on the importance of sound to aquatic animals and the potential impacts of underwater noise on fish and invertebrates.

16. Ms. Linda Weilgart provided a theme presentation on the potential impacts of underwater noise on marine mammals.

17. Summaries of the above presentations are provided in annex II.

18. In both plenary and break-out sessions, the meeting participants shared their global, regional and national experiences on activities and further action needed to improve and share knowledge on underwater noise and its impacts on marine and coastal biodiversity, building upon the theme presentations.

19. The discussions focused on the following issues:

- Major sources, and trends in the prevalence and magnitude of underwater noise;
- Role of sound in the behaviour and well-being of marine species and ecosystems;

- Impacts of underwater noise on various types of species, as well as broader impacts on marine and coastal biodiversity, including implications of cumulative impacts of multiple sources of noise; and

- Major knowledge gaps regarding the short- and long-term consequences for marine animals and other biota in the marine environment.

20. Results of the workshop discussion under this agenda item are contained in annex III.

## ITEM 4. DEVELOPING PRACTICAL GUIDANCE AND TOOLKITS TO MINIMIZE AND MITIGATE THE SIGNIFICANT ADVERSE IMPACTS OF ANTHROPOGENIC UNDERWATER NOISE ON MARINE AND COASTAL BIODIVERSITY, INCLUDING MARINE MAMMALS, IN ORDER TO ASSIST PARTIES AND OTHER GOVERNMENTS IN APPLYING MANAGEMENT MEASURES

21. Mr. Simon Harding presented the background study prepared by the Secretariat for this workshop, as contained in UNEP/CBD/MCB/EM/2014/1/INF/1.

22. Mr. Arthur Popper presented a theme presentation under this agenda item, discussing gaps and research priorities regarding the effects of anthropogenic noise on fish and invertebrates.

23. Mr. Yanis Souami delivered a theme presentation in which he discussed the work of the ACCOBAMS/ASCOBANS/CMS Joint Working Group on Underwater Noise.

24. Mr. Frank Thomsen delivered two consecutive presentations in which he highlighted the relevance of the work being undertaken within the EU Marine Strategy Framework Directive, and technical guidance on underwater sound in relation to dredging, respectively.

25. Mr. John Young delivered a theme presentation on the role of risk assessments in planning marine operations.

26. Mr. David Hedgeland provided a theme presentation on this agenda item in which he highlighted the work of the International Association of Oil and Gas Producers (OGP) Joint Industry Programme (JIP) on Sound and Marine Life.

27. Summaries of the above presentations are provided in annex II.

28. In both plenary and break-out sessions, the participants shared their views and suggestions on developing practical guidance and toolkits to minimize and mitigate the significant adverse impacts of underwater noise on marine and coastal biodiversity, including marine mammals, in order to assist Parties and other Governments in applying management measures. The discussion focused on the issues below.

- Gaps and limitations in existing guidance, including the need to update it in the light of improving scientific knowledge, and recognizing a range of complementary initiatives under way;

- Development of acoustic mapping of areas of interest;

- Means to promote research with a view to further improving understanding of the issue;

- Means to promote awareness of the issue among relevant stakeholders, both nationally and regionally;

- Potential measures, as appropriate, to minimize the significant adverse impacts of anthropogenic underwater noise on marine and coastal biodiversity, including the full range of best available technologies and best environmental practices, where appropriate and needed, drawing upon existing guidance;

- Indicators and frameworks for monitoring underwater noise for the conservation and sustainable use of marine biodiversity;

- Best management practices and capacity-building needs, particularly in data-poor regions.

29. Results of the workshop discussion under this agenda item are contained in annex VI.

## ITEM 5. OTHER MATTERS

30. There were no other matters discussed under this agenda item.

## ITEM 6. ADOPTION OF THE REPORT

31. Participants considered and adopted the report of the meeting with some changes on the basis of a draft report prepared and presented by the co-chairs.

## ITEM 7. CLOSURE OF THE MEETING

32. On the final day of the workshop, Mr. Jeremy Eppel, Deputy Director, International Biodiversity, Ecosystems and Evidence, UK Department for Environment, Food and Rural Affairs (DEFRA), delivered closing remarks. Mr. Eppel expressed thanks to the workshop participants for addressing such a key issue and welcomed the attention of the Convention on Biological Diversity on the important emerging area of underwater noise and its potential impacts on marine biodiversity. He highlighted the work being undertaken in the EU and by DEFRA in the development and implementation of the Marine Strategy Framework Directive (MSFD) in addressing underwater noise. He also noted promising developments in knowledge on this key area, but stressed the need to fill critical knowledge gaps in support of policy approaches. As a member of the Bureau of the eleventh meeting of the Conference of the Parties to the CBD, Mr. Eppel noted the key importance of the Convention in addressing issues related to underwater noise and biodiversity and the opportunities inherent in addressing underwater noise to contribute to the achievement of the Aichi Targets.

33. The co-chairs thanked all participants for their valuable contributions, rapporteurs for their excellent support in preparing the draft report, IMO staff for their valuable technical inputs and kind logistical support, and the staff of the Secretariat for their hard work in servicing the meeting.

34. The meeting was closed at 6 p.m. on Thursday, 27 February 2014.

*Annex I*

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*Annex II*

## SUMMARY OF THEME PRESENTATIONS

### ITEM 3

***Scientific synthesis on the impacts of underwater noise on marine and coastal biodiversity (by Mr. Simon Harding, CBD Secretariat Resource Person)***

Mr. Harding presented the initial background study, produced in 2012, on the scientific synthesis on the impacts of underwater noise on marine and coastal biodiversity, as contained in document UNEP/CBD/SBSTTA/16/INF/12. He began by noting that water was an excellent medium for sound propagation, a property which was utilized by both humans and marine animals. He noted that many marine species used sound as an important sensory medium, including for reproduction, communication, feeding, avoidance of predators, navigation, and habitat detection. He also highlighted that expanding human presence in the oceans was contributing to increased anthropogenic sound levels in many areas due to activities such as shipping, oil and gas exploration, fishing, military sonar, and marine construction, among others. He described the potential impacts of elevated sound levels on marine species, including physical damage to tissues and organs, temporary or permanent hearing loss, behavioural effects ranging from subtle changes in normal behavior to strong adverse reactions, masking of important sounds, and mortality. He noted that the main categories of approaches to mitigate these impacts were: (1) isolation from the noise-generation activity (including through spatio-temporal restrictions); (2) reduction of the noise level at the source; and (3) prevention of the exposure of marine animals to noise through real-time mitigation measures as activities were underway. He also outlined some key areas in need of greater research, including further characterization of underwater noise and properties of emitted sound in a changing marine environment; baseline data on the biology, distribution, abundance and behaviour of marine species; detailed information on the potential impacts of sound on marine animals at the individual, population and ecosystem level; and an assessment and improvement, and of the use of, mitigation measures.

***Monitoring and assessing noise source variability and trends: Experiences from Canada (by Mr. Yvan Simard, Canada)***

Mr. Simard delivered a presentation on the monitoring and assessment of underwater noise in marine and coastal areas around Canada. Mr. Simard emphasized that many areas, both in shallow and deep waters, were becoming increasingly affected by human activities that temporarily emitted strong impulsive transients or chronically radiated substantial levels of low- to mid-frequency noise, which could impact marine biodiversity in different ways. The diversity of underwater habitats in the oceans was likely paralleled by a wide range of soundscapes, in both natural and anthropogenically altered environments, and considerable data acquisition and modelling efforts were required to understand the sound dynamics of these areas and how they may affect marine life. Mr. Simard outlined how, in the last decade, long-term acoustic observatories had been deployed at several sites in Canada's three bordering oceans, including in pristine Arctic and subarctic waters, and in anthrophogenically altered southern Canadian environments. The annual time-series in both anthrophogenically altered and pristine environments showed a large variability in both "ambient" noise and acoustic transients, in response to natural and anthrophogenic (shipping and boating) sources. A 2013 year-round high-resolution detailed shipping traffic atlas was developed for all southern Canadian waters using the Canadian Coast Guard Automatic Identification System (AIS) network. This was done in combination with a seaway acoustic observatory for establishing the actual source levels (SL) of a sample of several hundreds of ships composing the present merchant fleet. This traffic density and ship SL information would be used to develop a shipping noise mapping tool in southern and northern Canadian waters.

***Sound and aquatic animals (by Mr. Arthur Popper, United States of America)***

Mr. Popper presented on basic concepts associated with the potential effects of sound on aquatic (and all)

animals. He began with a discussion of the importance of hearing to animals and humans and then gave a general overview of how fish and invertebrates hear and use sound. He described how the underwater soundscape can be characterized into three types of sound: (1) Sound produced by the physical environment (geophony); (2) Sound produced by non-human organisms (biophony); and (3) Sound produced that results from human activity (anthrophony). He noted that different types of marine animals can detect, and are affected very differently by, various types of sound and that, when thinking about mitigation, there needs to be a clear understanding of how animals are impacted by a given type of sound. He also addressed how anthrophogenic sounds may affect animals and what we actually know and don't know about these potential effects. He then concluded by noting that very little was known about the effects of anthrophogenic sound on fish and invertebrates and outlined a number of areas in need of further research, including: baseline data on soundscapes; data on sound pressure, particle motion, and substrate vibration; changes in the marine soundscape as a result of human activities; and the responses of marine biodiversity to different types of sound.

***Underwater noise impacts on marine mammals: Recent research results (by Ms. Linda Weilgart, Animal Welfare Institute)***

Ms. Weilgart discussed the potential impacts of underwater noise on marine mammals, characterizing underwater noise as pervasive, dominant and increasing in the marine environment. She outlined potential impacts on marine mammals, including increase in stress hormones, displacement, changes in communication and diving, disruptions in foraging efficiency, hearing damage, higher entanglement, loss of muscle control, and a decrease in species diversity. She highlighted that military sonar, and perhaps seismic surveys, could cause fatal mass stranding in some marine mammals, and especially in beaked whales. She also outlined how underwater noise could have population-scale impacts and cause reduced fitness through the displacement of species from their habitats. She highlighted recent studies that pointed to potential evidence of population-level effects, specifically from the use of military sonar, but noted that population-level impacts from underwater noise were particularly difficult to detect and required long-term research. She also noted that marine protected areas and noise buffer zones had shown promise in reducing impacts from underwater noise on marine mammals.

**ITEM 4**

***Development of practical guidance and toolkits to minimize and mitigate the significant adverse impacts of anthropogenic underwater noise on marine and coastal biodiversity (by Mr. Simon Harding, Secretariat Resource Person)***

Mr. Harding provided an outline of the draft background document produced for this workshop. He began by noting the three ways to mitigate the impacts of noise: isolation of the noise; reduction at source; and prevention of exposure. He then went on to discuss mitigation measures and procedures both for impulsive and non-impulsive (continuous) noise. In the case of the former, they included mitigation frameworks, mitigation measures and protocols during operations, noise-reduction technologies (for both pile driving and seismic surveys), and noise-quieting technology (for both pile driving and airguns). For the latter, they included ways to reduce the sound emanating from commercial vessels, the main source of which was the propeller. He noted the various operational solutions to achieve this, as well as design solutions for commercial vessels, and draft guidelines for commercial vessels produced by IMO, to be considered for adoption at the next meeting of the IMO Marine Environment Protection Committee. He went on to outline some monitoring and mapping tools that could aid in the understanding and measurement of sound and animal distributions. He then identified a number of management frameworks that could be used, as well as some national and international standards for sound measurement. He then offered some preliminary conclusions and recommendations.

***Effects of anthropogenic noise on fishes and invertebrates: Gap analysis-research priorities (by Mr. Arthur Popper, United States of America)***

Mr. Popper discussed gaps in knowledge and key research priorities regarding the effects of anthropogenic noise on fish and invertebrates. He explained that investigation of the possible effects of anthropogenic sounds on fishes and invertebrates demonstrated that there were, in fact, very few useful data. As a consequence, there were large gaps in the knowledge of potential effects, and even uncertainty as to whether there were, in fact, any effects at all on many types of marine animals. In support of a recent workshop conducted by the Bureau of Ocean Energy Management (BOEM) in 2012, Mr. Popper and colleagues conducted an analysis to identify the most critical knowledge gaps and suggest the types of research needed to address them. The analysis revealed that the gaps were enormous, and that defining them, and then doing the research necessary to fill them, was a major task. In this presentation, he outlined a number of priorities for research that would fill the most critical gaps and provide the greatest insight to answer the most critical questions. These gaps include the need to develop common terminology and metrics for underwater sounds, and the need to better understand: the sounds generated by different sources; mortality and injury from sound exposure; hearing abilities of a wider range of species; the impacts of masking of biologically important sounds; and behavioural responses to sounds.

***ACCOBAMS/ASCOBANS/CMS Joint Noise Working Group contribution to the Expert Workshop on Underwater Noise and Its Impact on Marine and Coastal Biodiversity (Mr. Yanis Souami, ACCOBAMS/ASCOBANS/CMS Joint Noise Working Group)***

Mr. Souami explained that the Joint Noise Working Group (Joint NWG) was established with members and observers of the scientific and advisory bodies of the Convention on Migratory Species (CMS), Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) and Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS). External experts (such as industries) were also invited to participate in the Working Group in order to ensure the best possible advice be generated for the Parties. Mr Souami presented the ACCOBAMS Guidelines and the work of the Joint NWG. He outlined the different stages for environmental impact assessments, including 1) a planning stage: assessment, evaluation of risk and development of plans; 2) implementation stage: mitigation and monitoring; 3) and a post-operation stage: evaluation and improvement. At the end of the presentation he invited participants to attend the Joint NWG at the ECS on 6 April 2014 in Liege: "Introducing noise into the marine environment: what are the requirements for an impact assessment for marine mammals?"

***Role of risk assessments in planning marine operations (by Mr. John Young, World Ocean Council)***

Mr. Young delivered a presentation addressing the conceptual aspects of risk assessment in planning marine operations. He discussed how risk was perceived differently by different individuals, depending on the context and also reviewed different types of risk often faced by industries, including environmental risk, regulatory risk, risk related to public perception, social/political risk, and operational risk (such as working in remote areas). He described a risk assessment process aimed at building an understanding of both the probability and ultimate consequences of potential impacts as a way to adequately assess risk. He noted that, as the impact of sound on marine life was largely unknown, this often hindered the ability to conduct well-informed risk assessments. Therefore, it was very important to identify, analyze and prioritize risks. Due to individual perception of risk, the lack of scientific data and the often emotional nature of the issue, the risk assessment process could be a valuable tool enabling productive dialogue about risk with relevant stakeholders and how best to manage it.

***International Association of Oil and Gas Producers (OGP) - Sound and Marine Life Joint Industry Programme (JIP) (by Mr. David Hedgeland, BP International)***

Mr. Hedgeland explained that the overarching objective of the JIP was to identify specific, operationally focused questions that related to the effects of sound generated by the offshore E&P industry on marine

life, and to pursue a research programme that would test scientific hypotheses and produce the data needed to address these questions. The scope of this programme reflected the diverse interests of the JIP partners and the global nature of their operations. The taxa of concern included marine mammals, fish (all life stages) turtles and invertebrates. The JIP supported research in any nation. The primary scope of the programme's research was to describe industry sources, the known or potential effects of these sources on animals and ways to mitigate these effects. The research programme in three funding phases had made in excess of $50 million available for fundamental and applied research. Over 50 studies had been commissioned in North America, Europe and Australia. The JIP participants encouraged publication of all studies in the peer–reviewed literature.

***The EU Marine Strategy Framework Directive and underwater noise (by Mr. Frank Thomsen, DHI Group)***

Mr. Thomsen explained that the EU Marine Strategy Framework Directive (MSFD) was published in 2008 and became law in EU member States in 2010. The aim of the MSFD was to protect, conserve, and where possible, restore the marine environment in order to maintain biodiversity and provide diverse and dynamic oceans and seas that were clean, healthy and productive. The Directive required Member States to achieve Good Environmental Status (GES) in their marine environment by 2020 at the latest. There were 11 qualitative descriptors for GES, one of which stated that "the introduction of energy, including underwater noise, was at levels that did not adversely affect the marine environment." Based on advice from an expert group, it had decided on two indicators that further specified GES. Indicator 1 addressed the distribution in time and place of loud, low- and mid-frequency impulsive sounds. The second indicator dealt with continuous low-frequency sound. Whereas indicator 1 would perhaps require only an annual desk-based assessment of activities generating low-frequency pulses, such as pile driving and seismic surveys, indicator 2 would most likely involve measuring ambient noise, perhaps at a regional level, which would represent significant progress in identifying trends in existing pressures, such as those from shipping. Details of requirements for such monitoring had been recently published in a 2013 European Commission report, *European Marine Strategy Framework Directive Working Group on Good Environmental Status (WG-GES) - Guidance for setting up underwater noise monitoring in European Seas*.

***WODA: Technical guidance on underwater sound in relation to dredging (by Mr. Frank Thomsen, DHI Group)***

Mr. Frank Thomsen explained that the World Organization of Dredging Associations (WODA) had identified underwater sound as an environmental issue that needed further consideration. A WODA Expert Group on Underwater Sound (WEGUS) was established to provide a guidance paper on dredging sound, impact on aquatic biota and advice on underwater sound monitoring procedures (*Technical Guidance on: Underwater Sound in Relation to Dredging*). The paper recommended the application of a risk-based process as this would result in a more systematic approach to sound impact studies. The paper provided suggestions to meet the critical need for standardization of acoustic terminology and methods. It was further noted that underwater acoustic models, in combination with measurements, provided a pragmatic approach for the assessment of sound distribution. Dredging sounds could be associated with dredging excavation, dredging vessels during transport, and dredged material placement. Existing data indicated that source levels associated with most dredging processes were not intense in comparison with other anthropogenic sources. Some cetaceans had been observed avoiding areas of dredging activity on a temporal basis. No information existed about effects of dredging-induced sound on seals or fish. While it was clear that dredging sound had the potential to affect the behaviour of aquatic life in some cases, there appeared to be minimal risk of injury. Yet, information on impacts was necessary to further identify risks and support informed decisions about the necessity of sound mitigation measures.

*Annex III*

## SUMMARY OF DISCUSSION ON IMPROVING AND SHARING KNOWLEDGE ON UNDERWATER NOISE AND ITS IMPACTS ON MARINE AND COASTAL BIODIVERSITY[1]

*Under agenda item 3, the workshop discussed the role of sound in the behaviour and well-being of marine species and ecosystems, major sources and trends in the prevalence and magnitude of underwater noise, impacts of underwater noise on marine and coastal biodiversity (including implications of cumulative impacts of multiple sources of noise), and major knowledge gaps regarding the short- and long-term consequences for marine organisms and other biota in the marine environment.*

*With regard to these topics, the workshop noted the following:*

### *Role of sound in the behaviour and well-being of marine species and ecosystems*

1. Underwater sound around marine species can be called their "soundscape" and provides animals with sensory information about the surrounding marine environment in three dimensions. This information is important for the detection of predators, prey, conspecifics, critical habitats and the environment in general, cues for activities such as navigation and migration, and allowing communication between individuals. Sound is particularly important since it provides information from distances well beyond any visual range. Disrupting the ability to hear and use the soundscape has the potential to affect the fitness and survival of an individual. If a sufficient number of individuals or significant parts of their habitat are affected, then adverse effects could occur at the population scale.

2. As well as detecting sounds, the ability to use information about the soundscape also requires that an organism is able to discriminate among acoustic signals, determine the location of the sound source (localisation), and perceive biologically important sounds in the presence of "masking sounds." Although communication among organisms is an important use of sound, detection of the overall soundscape is of great importance. Indeed, while marine mammals use sound for communication among individuals of species, according to present knowledge most fishes and invertebrates do not. However, sound is still important to fishes and invertebrates for gleaning environmental information.

3. Sounds that are not perceived by an organism cannot affect them behaviourally. However, sounds that are not perceived by an organism may still have a physiological impact. The complexity of terminology related to underwater acoustics, as well as recognition of the differences between some of the terms (e.g., source level vs. received level) was noted as being important to understanding the relationship between sound and potential impacts.

### *Major sources and trends in the prevalence and magnitude of underwater noise*

4. Underwater sound could be conceived as comprising three components:

- Geophony—sounds produced by the physical environment (e.g., wind, waves, tidal actions, ice, lightning strikes, earthquakes);
- Biophony—sounds produced by non-human organisms (e.g., fishes, marine mammals, invertebrates); and
- Anthrophony—sounds that result from human activity (or produced by humans).

5. There are no baseline datasets for noise levels in the marine environment before humans affected soundscapes, although estimates of natural ambient soundscapes as they may have been prior to human activity have been undertaken in some areas. The dramatic reduction in large whale populations caused by whaling could potentially have reduced the biophony from these animals greatly.

[1] In this document, the words "noise" and "sound" are used interchangeably, unless defined otherwise. "Noise" may or may not have a detrimental effect. There were various views at the meeting regarding the use of these terms.

6. Sources for anthropogenic noise can be divided into two general categories: *impulsive* and *continuous*. There is, however, some overlap between the two categories. A given sound field in any region can be comprised of continuous and originally impulsive sounds that have stretched over time due to complex sound propagation patterns. Sounds also attenuate with distance. For example, the repetition of impulsive sounds from seismic surveys can be low-level continuous at several thousand kilometres.

7. Impulsive noise should be subdivided into four main groups according to operational activity: seismic surveys (mainly airgun arrays), marine construction (mainly pile driving), naval sonar and other higher frequency sonar (e.g., echo sounders, fish finders, multi-beam sonar), and sounds that accompany explosions. This subdivision will aid management activities. For each of these subcategories, there was a discussion on past (within the last decade) and possible future trends in noise emissions by these activities:

- **Seismic surveys (mainly airgun arrays)**: In some regions, seismic surveys have increased, while in others they have decreased. There are distinct seasonal patterns of seismic surveys in some regions but not in others. If more seismic data-sharing occurred, there would likely be a reduction in the amount of surveys needed. Seismic surveys occur predominantly in waters less than 200 m deep, but also in deeper waters up to 2000 m. A future upward trend in noise emissions was also suggested for the Arctic region, given the predicted increase in future hydrocarbon exploration.

- **Marine construction (mainly pile driving)**: Construction in coastal (e.g., port construction) and offshore waters less than 50 m deep for marine renewables has increased in some areas and is likely to continue to do so.

- **Military low- and mid-frequency sonar**: Sonar use is concentrated in naval ranges and exercise areas.

- **Higher frequency sonars** (e.g., navigation echo sounders, fish finders, multi-beam and oceanographic survey sonar): These sonars are predominantly used in coastal areas. In some parts of Europe, heavily used by recreational craft, echo sounders can comprise a notable portion of the soundscape at the frequencies at which they operate. Trends in recreational usage seem likely to be increasing. Higher frequency sonar is also routinely used for many industrial activities for initial research investigations prior to the construction/operational phase.

8. Trends in continuous noise emissions:

- **Commercial Shipping**: Although individual ships represent point sources, the primary concern is likely to be the overall contributions of many vessels to increasing background noise. While there is no comprehensive data on trends for noise emissions from ships, some data on low-frequency shipping noise that was measured in the Northeast Pacific Ocean show a gradual increase in background levels of approximately 19 dB (decibels *re* 1 $\mu$Pa$^2$/Hz) during the period 1950–2007.[2] A study along the North American West Coast suggests that since 2000 a leveling off (or even a decrease at some locations) in noise levels has occurred.[3] This may be explained by the fact that newer ships are often constructed to higher standards for energy efficiency, and a by-product of that are technical advances such as better propeller design, better routing and optimal choice of speed may all contribute to reducing the average sound footprint of individual vessels.

  With regard to shipping trends, the world commercial fleet has doubled since 2001 and had reached 1.63 billion dead-weight tons by January 2013.[4] The growth in the fleet for the next decade is difficult to project as a turning point in the shipbuilding cycle occurred recently as a result of deteriorating economic conditions. This is evidenced by declining orders for new builds

[2] Frisk, G.V., 2012. Noiseonomics: The relationship between ambient noise levels in the sea and global economic trends, Scientific Reports. 2012; 2

[3] Andrew R. K., Howe B. M. & Mercer J., 2011. Long-time trends in ship traffic noise for four sites off the North American West Coast. J. Acoust. Soc. Am.129, 642–651 (2011).

[4] UNCTAD, 2013 - Review of Maritime Transport 2013 - Trade Logistics Branch of the Division on Technology and Logistics, UNCTAD.

from 2009 onwards with the current schedule providing output of close to recent levels for 2013 and a little less for 2014. The amount of cargo carried increased from 2000 to 2013 from approximately 6000 to 9165 million tons loaded.[5] Trends in shipping volume for the future are likely to be closely tied into economic trends, with wide regional variation. An increase in shipping in the Arctic region is likely as sea ice in this region continues to decrease, opening up potential shipping routes.

- **Drilling** was also mentioned briefly as a source of continuous sound but general trends were not discussed. The major source of noise associated with drilling operations is a result of using a ship-based drill platform equipped with a bow thruster.

***Impacts of underwater noise on marine and coastal biodiversity, including implications of cumulative impacts of multiple sources of noise***

9. The functional hearing groups devised for marine mammals and those proposed for fish can be used to separate out impacts on marine species. In the past, the focus has been on the physical impacts of underwater noise, but it is now widely perceived that behavioural impacts of underwater noise could be as important or more so, noting that some behavioural changes can lead to physical impacts and mortality. Physical injury caused by noise is rare but the effects on the overall population will be greater for a species that has fewer individuals.

10. Cumulative and synergistic impacts are very likely to be important, but are very difficult to measure and assess at this time, particularly as the detail of the sound exposure (and the "recovery" time between exposures) can determine its impact. Longer gaps between exposures can result in tissue recovery and decrease the degree of masking experienced by an organism.

11. The degree of cumulative effects will also depend on the mobility of marine organisms (and also of the sound source). Highly mobile species may be able to avoid stationary sounds, while more sedentary or sessile species will not be able to move away from a stationary sound source. Migratory species may be subjected to multiple impacts along their migration route.

12. It is possible to model and calculate cumulative sound exposure, although it is still difficult to identify cumulative acoustic impacts. When there are multiple sources, it is important to identify the dominant noise contributor, as this may have the greatest impact on the species of concern.

13. The behavioural context of the organism also needs to be considered with respect to cumulative effects, as this can affect the type of behavioural response to the noise.

14. The cumulative and synergistic impacts of multiple noise sources and other stressors (e.g., habitat loss, pollution, bycatch, illegal, unregulated, and unreported fishing, ocean acidification) on marine animals in a given area need to be considered.

15. Detection of long-term consequences of noise impacts on marine organisms may require systematic studies of populations, noise characteristics, and other environmental effects acting upon them over decades.

***Major knowledge gaps regarding the short- and long-term consequences for marine organisms and other biota in the marine environment***

16. There has already been a significant amount of research into the effects of noise on aquatic life over the last decade. There still remain significant questions that require further study. The largest gaps in knowledge relate to the following taxa: fishes, invertebrates, turtles and birds. Additional knowledge gaps include characteristics of major sound sources, trends in the prevalence and magnitude of underwater noise and on the potential population and ecological impacts of underwater noise, including implications of cumulative and synergistic impacts of multiple sources of noise and other stressors. Specific areas of

[5] *Ibid*

research are further discussed in documents UNEP/CBD/SBSTTA/16/INF/12 and UNEP/CBD/MCB/EM/2014/1/INF/1.

*Annex IV*

## SUMMARY OF DISCUSSION ON DEVELOPING PRACTICAL GUIDANCE AND TOOLKITS TO MINIMIZE AND MITIGATE THE SIGNIFICANT ADVERSE IMPACTS OF ANTHROPOGENIC UNDERWATER NOISE ON MARINE AND COASTAL BIODIVERSITY, INCLUDING MARINE MAMMALS, IN ORDER TO ASSIST PARTIES AND OTHER GOVERNMENTS IN APPLYING MANAGEMENT MEASURES

*Under agenda item 4, the workshop discussed practical guidance and toolkits to minimize and mitigate the significant adverse impacts of anthropogenic underwater noise on marine and coastal biodiversity, including marine mammals, in order to assist Parties and other Governments in applying management measures and focused on the following topics, in particular:*

***Gaps and limitations in existing guidelines, including the need to update them in the light of improving scientific knowledge, and recognizing a range of complementary initiatives under way***

1. The workshop did not consider this item in detail. The workshop also noted gaps and limitations described in the background document (UNEP/CBD/SBSTTA/16/INF/12), suggesting that this document needs to be updated. Monitoring and mitigation measures are in place at the national level, sometimes regional, and globally via best practices for certain industries. There is variation in the application of these measures, and a need for more information on their effectiveness.

***Development of acoustic mapping in priority areas***

*With regard to this topic, the workshop identified the following needs:*

2. The key need for standardization and harmonization of research outputs so that results can be compared.

3. The need for ship identification systems for a broader range of vessels was addressed, particularly with regard to:

- Automatic identification systems (AISs) that could be extended to small vessels so that information on them can feed into more complete shipping noise mapping; and
- The need for improved quality of AIS broadcasting by ships and improved coverage by AIS receivers.

4. Further information is needed on sound characteristics for a greater number of types of vessels within the present merchant fleet. Standards to measure source levels of ships based on opportunistic observation are also needed. The workshop noted that IMO is considering further work in this area.

5. With regard to the selection of areas for acoustic mapping, the inclusion of areas that are affected at different levels of sound in order to build a coherent and complete picture of the spatial and temporal distribution of sound

6. In spatial risk assessments, acoustic mapping should be combined with habitat mapping of species of concern to identify areas where particular species are at risk from noise impacts.

- Existing work under the Convention on Biological Diversity (CBD) on the description of ecologically or biologically significant marine areas (EBSAs) and IMO's work on Particularly Sensitive Sea Areas (PSSAs) can provide useful scientific information (e.g., feeding, breeding, spawning and nursery habitats, and migratory routes) for States or competent intergovernmental organizations to identify areas of priority concern, with regard to linking relevant scientific information on the impacts of underwater noise.

7. There is a need to consider appropriate time and geographic scales on which to monitor, taking into account the length of time the organism is exposed to the sound and based on biological processes (e.g., migration) to be able to determine if there is no noise effect.

***Means to promote research with a view to further improving understanding of the issue***

*With regard to this topic, the workshop noted the following:*

8. Issues related to underwater noise and biodiversity are subject to prioritization against other important issues on biodiversity conservation and sustainable use.

9. Building political awareness and understanding is essential to inform prioritization and build support for research.

10. Building national-level political awareness and policy commitment to address this issue would be a prerequisite to tap into any possible international or regional funding initiatives.

11. Potential means to promote research and awareness-building of the issue include, among others:

- Knowledge exchange;
- Workshops at the national and regional level;
- Web-based tools;
- Policy briefs drawing upon scientific syntheses or other relevant technical documents, and made available in United Nations languages;
- Noting that awareness on the issues of underwater noise is low in some regions; and
- Noting that major research funds have been provided by some, but not all industries, and encouraging other industries and companies to work together to support common research needs.

***Means to promote awareness of the issue among relevant stakeholders, both nationally and regionally***

*With regard to this topic, the workshop identified the need to undertake the following:*

12. Provide scientific advice to relevant international and regional organizations, national governments, scientific groups, and industry organizations to ensure that the relevant scientific information is distributed widely and in ways that will help these stakeholders understand such scientific information and advice.

13. Engage industry, particularly the international construction industry and recreation industry, to increase awareness of noise issues and enable them to develop a feeling of ownership so that they appreciate the importance of addressing this issue within the context of their responsible business practices, in collaboration with relevant scientific and technical partners and other stakeholders.

14. Facilitate the use of online awareness-building activities; develop social media for communicating information on this issue; engage scholarly societies in communicating more broadly about the issues of sound and biodiversity; and develop an information portal web site where all scientific materials can be placed, and perhaps additional materials on regulation and related topics, regarding the impacts of anthropogenic underwater noise on aquatic life, so as to make this material widely and easily available.

***Potential measures, as appropriate, to minimize the significant adverse impacts of anthropogenic underwater noise on marine biodiversity, including the full range of best available technologies and best environmental practices where appropriate and needed, drawing upon existing guidance***

*With regard to this topic, the workshop noted the following:*

15. This issue was well-covered by the 2013 United States Bureau of Ocean Energy Management (BOEM) mitigation and quieting workshops for shipping, seismic surveys, and pile driving.[6] Other industries were not covered in the BOEM workshop report, but should be addressed in future workshops.

[6] The report of this workshop will be made available to the eighteenth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice.

In summary, quieter technologies presently exist or are under development for airguns and pile-driving. Ship quieting measures are also promising. Regulators have an important role in incentivizing such development.

16. In addition, the ACCOBAMS/ASCOBANS/CMS Noise Working Group has developed guidelines for mitigation approaches for marine mammals.[7] This could serve as a toolbox for what is available to mitigate sound. The measures can be applied dependent on the sensitivity of the area. Similar approaches might be taken for fishes, turtles, and invertebrates. The meeting suggested making the summary available to the eighteenth meeting of SBSTTA.

17. The cost of various mitigation methods (cost-effectiveness approach) should be taken into consideration along with all other issues. The costs are considered in the BOEM workshop report for each of the various mitigation methods. Cost effectiveness is not considered in the ACCOBAMS ASCOBANS/CMS Noise Working Group guidelines.

18. There is a the need to compile various toolboxes developed in different countries, and tailor them for countries that are just starting to address noise issues, considering their socio-economic and cultural contexts as well as available scientific and technical capabilities. This ensures that the toolboxes, while generally standardized, fit the needs and capabilities of each place using them.

19. The idea of developing marine protected areas with appropriate buffer zones for addressing the impacts of anthrophogenic noise on key species groups using known locations during critical life cycle stages (e.g., migration corridors) was discussed. However, there was no agreement that this is the most effective approach since many of the participants thought that it would be very hard to develop areas protected from sound since sound propagates so far and so well that no area can be pristine from sound. This is an area that needs further study and consideration in the future.

20. Existing marine protected areas might have a noise consideration added to the management plan. However, the same challenges of controlling sounds getting into the areas exist. Areas that are particularly critical for a short period of time can be protected from underwater noise spatially and/or temporally. Such areas might include a spawning site for haddock or seasonal feeding site for whales. During these sensitive periods, efforts should be made to lower anthropogenic noise and to avoid interference with the organisms. These spatial and temporal tools for specific situations may be used at different times and places to accommodate different events.

21. Guidelines for fish and turtles will be released by mid-2014 from the Standards Working Group of the Acoustical Society of America.[8] There are no guidelines or criteria for invertebrates. Developing such material will need far more research information on these organisms than exists at present. The IMO is drawing up the "Guidelines for the Reduction of Underwater Noise from Commercial Shipping."[9] This work will culminate in April 2014, when the IMO's Marine Environment Protection Committee (MEPC) will consider draft guidelines for minimizing underwater noise from commercial ships with a view to approval and dissemination as an MEPC circular. Based on this progress made by the IMO, the group acknowledges that the IMO, as the recognized competent body for international commercial shipping, is the appropriate forum to address the reduction of underwater noise from commercial shipping. But this is only a first step, and it is envisaged that the scope and timing of future work will also be considered, such as progress on quantifying and understanding in advance the impact of noise on marine species; identifying the types of areas and situations where waterborne noise is most disruptive for marine life and setting specific noise-reduction targets; and setting operating guidelines for sensitive marine areas, to name a few possible issues.

[7] These guidelines will be made available to the eighteenth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice.

[8] *Ibid*

[9] *Ibid*

***Indicators and frameworks for monitoring underwater noise for the conservation and sustainable use of marine biodiversity***

*With regard to this topic, the workshop noted the following:*

22. The EU Marine Strategy Framework Directive (MSFD) provides the only known statutory indicators and framework for underwater sound, in its Directive 11.

23. The indicators for underwater noise under MSFD cover only low- and mid-frequency impulsive sounds, and low frequency continuous sounds (see UNEP/CBD/MCB/EM/2014/1/INF/1 for precise definitions).

24. MSFD monitoring of these sounds will be international, at the regional sea scale, which is appropriate for such sound.

25. Further development to understand and measure/model the impact of the sounds at the population level is in progress.

26. Consideration is being given to adding further indicators, for example for higher frequency impulsive sounds.

***Best management practices and capacity-building needs, particularly in data-poor regions***

*With regard to this topic, the workshop identified the need to undertake the following*

27. Build capacity in developing regions, where the awareness and scientific capacity on addressing this issue are yet to be strengthened, and, in particular:

- Increase awareness on EIAs and related guidelines in countries/regions where relevant legislations and/or guidelines addressing this issue are not available;
- Guidance can be provided through the Convention, building upon its existing work on voluntary guidelines on biodiversity-inclusive EIA/SEA, on how to undertake impact assessment and/or take advantage of existing training material on impact assessments Additional guidelines on marine mammals are reviewed in the background document produced for this workshop;
- Assist developing countries to set in place a mechanism to require industries to help them build local capacity to understand and control anthropogenic noise; and
- Countries can require industries to involve their academic or research institutions in their processes of addressing noise, in order to help build in-country capacity.
- Engage NGOs and other civil society organizations, as appropriate, to help build local capacity to address underwater noise issues.

28. Make relevant training or information documents available in different United Nations languages.

29. Encourage organizations to develop academic courses that can deliver information and train people so that they learn the complex knowledge associated with anthropogenic underwater noise, its impacts and appropriate management measures.

30. Develop best management practices (BMPs), while also making sure to:

- Recognize that industries have their own best practices;
- Recognize that BMPs can differ from country to country, depending on the legislation in the countries; and
- Be cognizant that industries often have best practices across different countries, which depend on legislation within each country.

31. Engage industry when developing guidelines to increase their ownership and participation in the implementation of the guidelines. Develop incentives for minimizing the impacts of noise at the sources, such as rewarding programmes for lowering noise levels. This could include reducing fees for minimizing the production of anthropogenic noise.

32. Develop approaches to standardization of metrics and sound measurements, so that there are similar measures and approaches for all sounds and in all places. Support standards by the American National Standards Institute (ANSI) and the International Organization for Standardization (ISO).

33. Encourage collaboration and communication among relevant international bodies for synergies in addressing this issue.

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