



CONFERENCE REPORT

THE EFFECTS OF NOISE ON THE AQUATIC
ENVIRONMENT

(Nyborg Denmark from 13th – 17th August)

by

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Executive Summary

The Nyborg Conference represented a meeting that was devoted to the objective of examining the current understanding of the effects of noise on aquatic organisms (marine mammals to invertebrates). The conference program, almost entirely in plenary, comprised:

- Invited presentations, which dealt with topics on specific themes, notably:
 - How animals use sound;
 - The detection of sound by aquatic organisms;
 - Sources of underwater sound;
 - Anthropogenic sources;
 - Effects of anthropogenic sound on aquatic animals; and
 - Regulatory issues.
- Poster paper sessions, during which about 100 poster papers were on view, with opportunity to meet and discuss each poster with the author(s). There were also plenary sessions at which select posters were presented and discussed.
- A final wrap-up session with rapporteurs giving feedback on select focus areas, notably:
 - a. Regulation;
 - b. Detection and use of sound;
 - c. Effects of sound; and
 - d. Sources.

Delegates were provided with a CD containing abstracts of all the invited presentations and poster papers. It is envisaged that two major publications will emerge from the meeting. The first will be an edited monograph based on the major invited talks. The second will be a series of extended abstracts, to be published in the journal *Bioacoustics*.

More than 200 people were registered, representing many countries throughout the world. There was a predominance of representatives from Europe and North America with a low presence from regions such as the Middle East, Africa and Asia. Although most of the delegates were from the academic and research sector, there was a good representation from industry (oil and gas), government, non-government and consultant sectors. Canada was well-represented with 26 persons attending, 14 of whom are situated in the Atlantic Provinces.

In general, the Nyborg conference achieved most of its objectives, and can be regarded as being extremely successful. On the basis of what was observed at the conference, some thoughts and impressions, relevant to the emerging OEER invertebrate program, are given. These relate to:

- The importance of noise as a regulatory issue
- The relative global priority and activity in invertebrate research
- The value of gaining experience from traditional research activity on other organisms
- A research framework for the OEER invertebrate research program
- The complexity of conducting meaningful and transferable field experiments
- The relative high level of invertebrate research experience in Atlantic Canada
- The value of networking
- Issues raised by some of the Canadian conference participants.

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1. Introduction

Over the last few decades, anthropogenic noise has been identified as an important stressor of marine organisms. This has led to a general recognition that noise, and its impacts, requires attention within a variety of activities, including amongst others:

- Development planning;
- Marine construction activities;
- Management of marine organisms, especially endangered species and fishery organisms;
- Science and technology;
- Human resource development and training;
- Environmental risk assessments; and
- Policy and regulation practice, particularly regarding permits for a wide range of developments and activities in the marine environment.

There is a diverse array of stakeholders (industry, academia, government, NGOs, community organisations, etc.) who have a high level of interest in understanding noise and its impact on marine organisms. This is reflected by the number of international conferences that have included sessions on “noise” in their programs. The Nyborg Conference, represented a conference that was devoted entirely to the topic of “the effects of noise on aquatic organisms”. It was, therefore, important that the OEER, with its developing research program on the impacts of seismic exploration on invertebrates, have a presence in Nyborg. Accordingly, the OEER supported the attendance of two persons at the conference (Mr Jay Lugar, a member of the OEER Research Advisory Committee, and Dr Danny Walmsley, the OEER invertebrate research program manager). This report provides feedback relevant to the developing OEER invertebrate research program, and also provides some specific comments (pertinent to Atlantic Canada) that were generated by a group of Canadians who attended the conference.

2. The Conference

2.1 Conference Objectives

The conference, which was open to all interested individuals and organizations, had the main objective of examining the current understanding of the effects of noise on aquatic organisms (marine mammals to invertebrates). More specifically, the conference organizers had the objectives of:

- Defining the major research questions, both basic and applied, that must be answered to enhance our understanding of the effects of noise upon aquatic life;
- Enabling scientists, regulators, and industry to meet and to start to come to a shared understanding of what is actually known about the effects of noise on aquatic life;
- Helping scientists understand how their findings can be applied in a regulatory and industry context;
- Enabling regulators and representatives of industry to play a part in developing research projects for the future; and
- Improving networking between individuals concerned with noise and aquatic life.

2.2 Conference Program

The conference program (see [Annex 1](#)), almost entirely in plenary, comprised the following elements:

- **An introductory opening session** with two keynote addresses by Tony Hawkins (ex-Director of Scottish Fisheries Research) and John Richardson of LGL (Canada).
- **Session 1 with a series of important generic topics**, notably noise standards, masking, noise exposure and experimental design for research.
- **Follow-on sessions with invited presentations, which dealt with topics within specific themes.** These included:
 - How animals use sound;
 - The detection of sound by aquatic organisms;
 - Sources of underwater sound;
 - Anthropogenic sources;
 - Effects of anthropogenic sound on aquatic animals; and
 - Regulatory issues.
- Each session was concluded with a plenary session involving questions to the presenters from the floor.
- **Two poster paper sessions** (see [Annex 2](#)), during which about 100 poster papers were on view, with opportunity to meet and discuss each poster with the author(s). There were also plenary sessions at which select posters were presented and discussed.
- **A final wrap-up session** with rapporteurs giving feedback on select focus areas, notably:
 - Regulation;
 - Detection and use of sound;
 - Effects of sound; and
 - Sources.

Delegates were provided with a CD containing abstracts of the invited presentations and poster papers. It is envisaged that two major publications will emerge from the meeting. The first will be an edited monograph based on the major invited talks. The second will be a series of extended abstracts, to be published in the journal *Bioacoustics*. This will be done to extend knowledge of the material beyond those attending the meeting in Nyborg.

2.3 Attendance

More than 200 people were registered, representing many countries throughout the world. There was a predominance of representatives from Europe and North America with a low presence from regions such as the Middle East, Africa and Asia. Although most of the delegates were from the academic and research sector, there was a good representation from industry (oil and gas), government, non-government and consultant sectors.

Canada was well-represented with 26 persons attending, 14 of who are situated in the Atlantic Provinces (see [Annex 3](#)).

3. Impressions and Thoughts

The conference, attracted most of the world's scientific authorities, and was well-organized, allowing for coverage of topics such that non-specialists could get a good overall appreciation of how noise works over the wide spectrum of aquatic organisms. In general, the Nyborg conference achieved most of its objectives, and can be regarded as being extremely successful.

On the basis of what was observed at the conference, it is considered useful to present some thoughts and impressions which are of relevance to the emerging OEER invertebrate program.

3.1 Importance of Noise as a Regulatory Issue

Sound and noise are important environmental stimuli and, therefore, require regulatory attention for all activities that might generate potentially harmful noise in the marine environment. This is supported by the topics in the conference program, and the relatively high level of attendance by many government, non-government, industry and regulatory representatives. Improvement in regulation can only be achieved through supportive and directed research programs. This is exemplified by the long-term approach that was needed to develop scientific noise exposure criteria for marine mammals in the USA (presentation by Gentry *et al.*). Similar approaches might be needed for other organisms.

3.2 Relative Priority and Activity in of Global Invertebrate Research

The main focus of experience (regulation, research, capacity development) on sound in the marine environment has been devoted to and directed towards marine mammals and fish. This is supported by the number of conference presentations and poster papers on mammals (52% of conference contributions) and fish (38%). Within the overall mammal contributions at the conference, almost 85% dealt with knowledge and impacts of noise on cetaceans. This priority has the support of most governments and industries throughout the world (with the exception of some in Atlantic Canada). There is a relative paucity of global knowledge and current research activity on noise and its impacts on invertebrates (<6% of conference contributions), reptiles (2%) and birds (0%).

The programmed overview keynote paper on invertebrates was not presented as the author was not in attendance due to poor health. However, the abstract indicates that the author dealt only in a very general way with how certain invertebrates detect and react to natural sound in the marine environment (mainly for feeding and predator evasion). Other invertebrate contributions at the conference included:

- **“The effects of vibrations on the behaviour of cockles (bivalve molluscs)”** by Ronald Kastelein (Sea Mammal Research Company – Seamarco, Netherlands). Research has shown that substratum vibrations led to shell closure of the organism and threshold levels for frequency and amplitude were determined. Seismic exploration, if it causes vibrations in the sediment, could potentially play a role in shell closure of filter feeding molluscs.
- **“Do seismic surveys pose an important risk factor for fish and shellfish?”** by Jerry Payne *et al.* (DFO, Newfoundland). In laboratory tank studies the researchers showed that exposure of lobster to “low” (~ 202 dB peak-to-peak) and “high” (~227 dB peak-to-peak) sound levels had no effects on delayed mortality up to 8 months post-exposure, mechano-balancing systems (as demonstrated by lack of effects on righting ability), or loss of appendages. However, sub-lethal effects were observed with respect to feeding

and serum biochemistry, with statistically significant effects sometimes being retained weeks to months after low-level exposures. Because of the laboratory conditions under which the work was carried out, the findings are considered to be only exploratory and require follow up.

- **“Orientated swimming behaviour of crab post-larvae in response to reef sound”** by Craig Radford *et al.* (University of Auckland, New Zealand). Five species of crab post-larvae demonstrated a consistent and significant response toward an artificial source of reef sound, with more post-larvae choosing to move toward than away from the artificial sound source regardless of the position of the artificial sound source. This demonstrates that pelagic crab larvae do exhibit a response to natural sound.
- **“Establishing the boundary conditions for experiments on the effects of anthropogenic sound on fish and invertebrate animals”** by Carl Schilt (LGL Ltd). The author recognizes that fish and invertebrates present advantages as experimental organisms as they can be (1) caged for replicated and controlled sound exposure at known ranges from sources and exposed to sound treatments; (2) observed before, during, and after exposure by various methods for behavioural, auditory, or anatomical responses to sound exposure; (3) observed by a variety of underwater imaging methods (video and sonar) and telemetry; and (4) sampled for abundance and distribution at sound-exposure test sites before, during, and after experimental sound-exposure treatments. In all cases, appropriate data on both scalar and vector components of the sound treatment at the animal can be collected. He states that it would be most helpful for researchers to present the most thorough discussion possible of prevailing boundary conditions and their possible implications for the data's interpretation and generalization to other physical environments.
- **“Marine invertebrates, intense anthropogenic noise, and squid response to seismic survey pulses”** by Rob McCauley and J Fewtrell (Curtin University, Western Australia). The authors exposed caged squid to experimental seismic noise. It was observed that squid showed an avoidance response, but this was inconsistent. Conducted more than 5 years ago, these research observations, can be considered to be exploratory.

From a scientific perspective, the dedicated OEER research program on invertebrates is a timely and welcome initiative to the global science and research scene on noise and its impacts on aquatic organisms. However, just as in the business world where any new product requires considerable effort to “break into the market”, progress on this new OEER venture will be dependent on its ability to successfully compete against traditional interests. There are always factors that can accelerate market penetration (money, immediate tangible benefits etc), but of particular concern at this stage is the relative lack of exploration activity that is envisaged by the oil and gas industry in marine areas of Atlantic Canada where invertebrates are important. The Joint Industry Initiative (JIP), the large-scale research program supported by the international Oil and Gas Industry, does not currently perceive invertebrate research as being a high priority (Smies and Gentry, poster at conference).

3.3 Experience from Traditional Research Activity on Other Organisms

There are many lessons to be learnt from work that has been, or is being, done on other organisms, particularly regarding experimental approaches, and aspects that need to be covered. In the selection of research priorities, and the design of any research program or project, there are many things to consider. However, not all of them need necessarily be considered to be priority

aspects – indicating that there has to be contextualisation of issues and concerns. This is illustrated by a simplistic diagram (**Figure 1**) presented initially by Dr Tony Hawkins, but widely used by other speakers in follow up sessions.

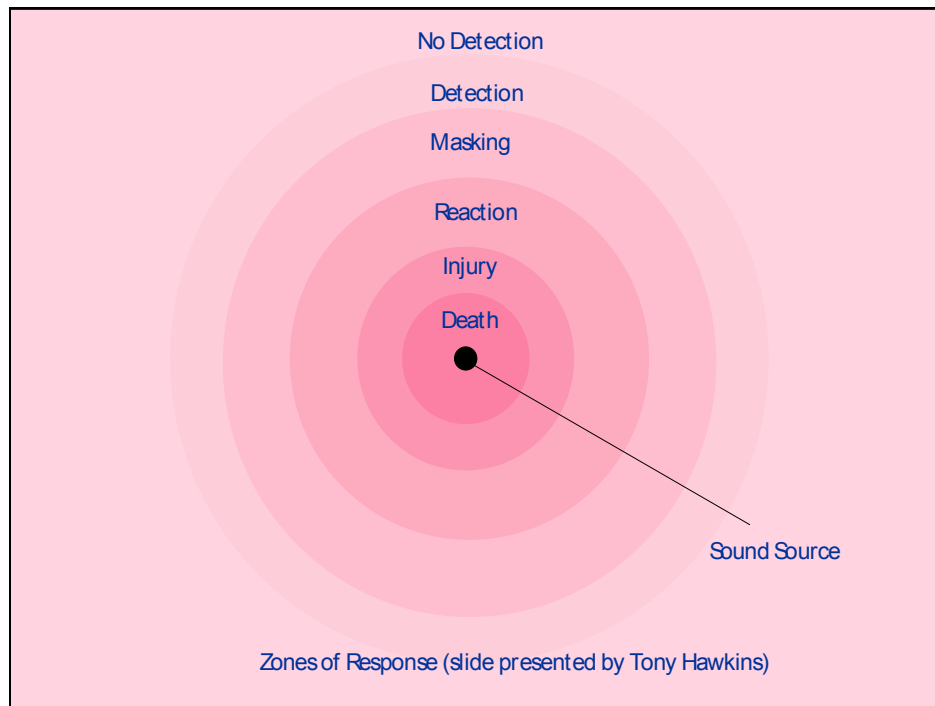


Figure 1: Schematic diagram to illustrate range of possible organism response to sound sources.

The diagram demonstrates that sound (depending on its characteristics and the organism) can have numerous effects, all of which can be important from a resource management perspective. Ideally, one would like to develop a profile for each target organism that relates response to sound source characteristics.

3.4 An OEER Invertebrate Research Framework

Conceptual modelling provides a useful tool for assessing responses, risk and designing research and monitoring programs. One useful example is the conceptual Population Consequences of Acoustic Disturbance model (PCAD) which was developed by the USA National Research Council to relate acoustic disturbance to effects on a marine mammal population. There were several presentations in Nyborg which discussed PCAD and its applications. The PCAD model defines several levels of potential effects ranging from behavioural effects, effects at a life function (e.g. feeding, breeding, migrating), a vital rate level (e.g. adult survival, reproduction), and the population level effect). The overall model can possibly be used to provide a framework for the emerging OEER invertebrate research program (see **Figure 2** below).

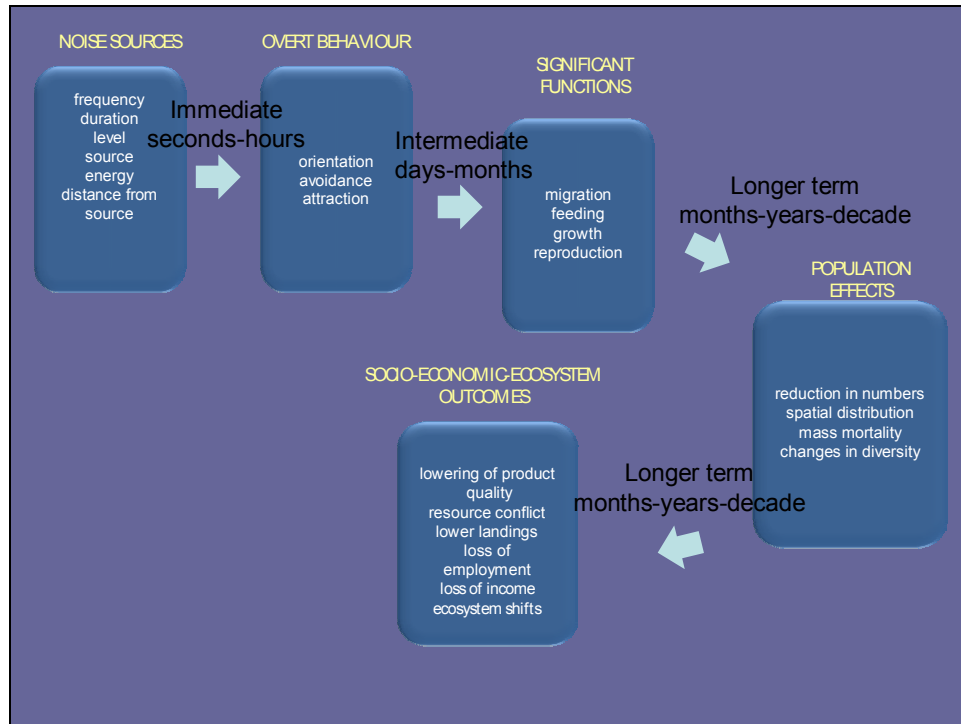


Figure 2: Adapted PCAD model framework approach to illustrate research areas for the OEER invertebrate program which require attention and the relative time-scales.

The PCAD framework approach does emphasize that research programs should primarily follow the track of the arrows – focusing initially on seismic noise source characteristics and the impacts on overt behaviour and significant functions. Most population effects and outcomes will require research approaches on a longer time scale before delivery of meaningful findings.

3.5 Complexity of Conducting Meaningful and Transferable Field Experiments

Experimental field research is extremely complex and there is no easy route to associating absolute responses to specific noise levels. This fact was highlighted by the presentation by Peter McGregor (Duchy College, UK) on “Designing experiments to test for behavioural effects of sound”. He highlighted the numerous factors (e.g. season, lifecycle stage, breeding condition, ecosystem condition, food availability, environmental conditions, biological variability etc.) that can influence the behaviour and response of marine organisms and the need to ensure that there is a rigorous approach to experimental research design. Results from one day might not necessarily be the same on another, nor do those for one area apply to another.

3.6 Invertebrate Research Experience in Atlantic Canada

Collectively, Atlantic Canada-based researchers already have more seismic exploration/invertebrate research experience than other parties elsewhere in the world. On the basis of what was presented at the Nyborg conference (as compared to activity in the Atlantic Provinces over the last 5 years), it is evident that Atlantic Canada researchers have a considerable amount of scientific material and experience that has not yet been presented to the wider global community. We perhaps have missed a promotional opportunity. For example, it would have been useful to

have seen more detail on Canadian experiences at the conference (e.g. the 2003 Cape Breton Corridor seismic shoot or the DFO overview on seismic). A good indicator of a successful research program is the presence of its researchers giving keynote presentations at conferences such as Nyborg. Such activity has numerous benefits such as attracting funding support, recruitment of researchers, stimulating cooperative activities, and receiving advice and evaluation. It also emphasizes the need for research and management findings to be published in independent, peer-reviewed journals, thereby gaining acceptance by the global community.

3.7 Networking

A new program requires considerable collective networking effort in order to achieve synergistic outcomes. The Nyborg conference was extremely useful in observing and learning about the wider issues associated with noise and the marine environment. It also gave opportunity for parties to exchange and share ideas. The notion that it would be useful to establish good interaction between Canadian delegates at the conference was partially successful. Pre-conference enquiries yielded the names of 10 persons who were known to be attending the Nyborg conference – the actual attendance was 26. The absence of a delegates list in Nyborg did not allow for all the other Canadian parties to be identified and systematically approached during the conference (a post conference semi-confidential list has subsequently been made available by the organizers). However, those who were able to be contacted were invited to a final interactive discussion session convened directly after the closure of the conference. This was attended by:

Bruce Cameron	Nova Scotia Department of Energy
Camille Mageau	DFO
Danny Walmsley	OEER
Dave Burley	Canada-Newfoundland Offshore Petroleum Board
Dave Millar	DFO
Dave Taylor	ESRF
Eric Theriault	Canada-Nova Scotia Offshore Petroleum Board
Jay Lugar	SPANS
Scott Carr	JASCO
Urban Williams	PetroCanada

They were asked to contribute some “take home” points that might merit follow up. The following useful points were noted (these don’t all specifically relate to invertebrates):

- The OEER program appears to be on the right track and there was wide consensus within the conference that the initiative is a much-needed addition to the development of global knowledge on sound and its impact on the marine environment.
- Maps and 3-D animation products which predict expected noise outputs from propagation models (from airgun array sources) would be useful – particularly in relation to actual key fishery/oil and gas areas. Consideration should be given to scoping out a project on this, particularly for snow crab. This concept could perhaps be expanded to incorporate a risk-type model for the Scotian Shelf that helps to assess the potential volume of space that is impacted during, and by, a seismic shoot.
- It is important for the OEER invertebrate program to continue nurturing and developing an active network involved in research, regulation, management and funding of activity involving anthropogenic noise and its impacts on the marine environment. There is much to be gained from this. There is opportunity for the OEER to become involved in the support and convening of international workshops and conferences in Nova Scotia. A possible suggestion is a meeting on field experimental methodology.

- Funding sources for invertebrate research will require a partnership/leverage approach and there is a need to explore new and wider sources than those that are currently active.
- The preliminary observation and suggestion that shellfish might close their shells when exposed to seismic energy needs to be explored, particularly for scallops.
- Reefs and coral hotspots, which might be impacted by noise, need to be assessed.
- The significance of seismic noise and its impacts on invertebrate eggs and larvae needs to be explained and communicated in a more clear and concise way.
- There is a need to develop standardized observation protocols that can be used for noise in relation to marine mammals. This could follow the same approach that has been developed for seabirds by the ESRF.
- An investigation might be useful on the practice and efficacy of the start-up/ramp-up/shut-down process during seismic surveys when cetaceans are observed.
- The OEER website should be widely promoted and used as a means of communicating useful information.
- There is a need to ensure that the aspect of noise receives an appropriate profile in forthcoming and planned societal meetings; e.g. the 3rd Biennial Nova Scotia Energy and Research Development Forum to be held in May 2008.
- Literature reviews on seismic noise and marine organisms appear to be extremely repetitive, and much of the literature is somewhat dubious - there is a need to develop a rating system for rate papers (*apropos* of their value).
- Sound budgets need to be developed and monitored in Nova Scotian/Newfoundland/Labrador waters.

4. Acknowledgements

The OEER is gratefully acknowledged for providing support to attend this extremely valuable conference. Canadian delegates who provided comment and opinion are thanked for participating in the interactive session at the end of the conference. Jay Lugar is thanked for his useful comments and ideas in the development of this report.

Annex 1

Programme of Oral Presentations

Day One

08:30 Opening of the meeting – *Arthur N. Popper*

08:40 Welcome to Denmark – *Axel Michelsen*

08:50 Effects of noise on aquatic life: the key issues – *Anthony D. Hawkins*

09:10 Keynote Talk: Effects of noise on aquatic life: much known, much unknown – *W. John Richardson*

Session One: Background on Hearing and Effects of Sound on Marine Mammals

Chair: *Arthur N. Popper*

09:40 Creation of noise standards for man: 50 years of research – *Donald Henderson*

10:10 Break

10:30 Masking – *Robert J. Dooling*

11:00 Auditory scene analysis – *Richard R. Fay*

11:30 Designing experiments to test for behavioural effects of sound - *Peter K. McGregor*

12:00 Marine mammal noise exposure criteria: initial scientific recommendations – *Roger L. Gentry, Brandon L. Southall, Ann E. Bowles, William T. Ellison, James J. Finneran, Charles R. Greene Jr., David Kastak, Darlene R. Ketten, James H. Miller, Paul E. Nachtigall, W. John Richardson, Jeanette A. Thomas, and Peter L. Tyack*

12:30 Lunch

Session Two: How animals use sound – Chair: *Roger Gentry*

13:30 How do marine invertebrates detect and use acoustic stimuli? - *Hans Erik Karlsen*

13:50 Acoustic communication in marine fishes – *David A. Mann and James V. Locascio,*

14:10 Sound communication in fishes and the influence of ambient and anthropogenic noise - *Friedrich Ladich*

14:30 Hearing and acoustic communication underwater in the clawed frog *Xenopus l. laevis* - *Andreas Elepfandt*

14:50 The effects of noise on echolocating odontocetes - *Whitlow W. L. Au*

15:10 Acoustic communication in mysticetes - *Susan E. Parks and Christopher W. Clark*

15:30 Break

16:00 Discussion and questions

17:00 Poster Session One

19:15 Dinner

Day Two

Session Three: The detection of sound by aquatic organisms – Chair: *Robert Gisiner*

08:30 Anthropogenic sound sources and the lateral line system - *Sheryl Coombs*

08:50 A review of auditory function of sea turtles - *Soraya Moein Bartol*

09:10 Amphibian underwater hearing: biophysics and neurophysiology - *Jakob Christensen-Dalsgaard and Taffeta M. Elliott*

09:30 Detection of sound by fish: a mini-review - *Olav Sand*

09:50 Hearing in marine carnivores – *Colleen Reichmuth*

10:10 Recent directions in odontocete cetacean hearing - *Paul E. Nachtigall*

10:30 Break

10:50 Discussion and questions

Session Four: Sources of underwater sound – Chair: *Mardi Hastings*

11:20 Ambient noise and its significance to aquatic life - *Douglas H. Cato*

11:40 The contribution of biological sound sources to underwater ambient noise levels - *Magnus Wahlberg*

12:00 Ocean noise budgets - *James H. Miller, Jeffrey A. Nystuen and David I. Bradley*

12:20 Discussion and questions

12:30 Lunch

13:30 Poster Session One continued

Session Five: Presentation of selected posters and discussion of posters

Chair: *Soraya Moein Bartol*

15:00 Presentation of selected posters: to be announced

15:30 General discussion of all posters

Day Three

Session Six: Anthropogenic sources – Chair: *Lee Miller*

08:30 Metrics - *Charles R. Greene Jr.*

09:00 Underwater Sound from Marine Pile Driving – *Richard B. Rodkin and James A. Reyff*

09:20 Criteria for assessing ship noise and other broadband pseudo-random noise - *Richard A. Hazelwood*

09:40 Underwater noise from construction and operation of offshore wind farms - *Jakob Tougaard, Peter T.Madsen, and Magnus Wahlberg*

10:00 The marine seismic airgun - *Robert M. Laws and David Hedgeland*

10:20 Break

10:40 Airgun arrays as noise sources: output, impact zones and frequency content - *Peter T. Madsen*

11:00 Active sonar acoustics - *David M. Fromm*

11:20 Discussion and questions

12:00 Break

12:30 Lunch

Session Seven: Effects of anthropogenic sound on aquatic animals

Chair: *Lidia Eva Wysocki*

13:30 Underwater ears and the physiology of impacts: Comparative liability for hearing loss in sea turtles, birds, and mammals – *Darlene R. Ketten*

13:50 Auditory effects of intense sounds on odontocetes: continuous, intermittent and impulsive exposures – *James J. Finneran*

14:10 Effects of underwater sound fields on tissues containing gas – *Diane Dalecki*

14:30 Barotrauma in aquatic animals – *Mardi Hastings and Thomas Carlson*

15:00 Break

15:20 Discussion and questions

16:00 Excursion

Day Four

Session 8: Effects of anthropogenic sound on aquatic animals – Chair: *Mark Tasker*

08:30 Marine invertebrates, intense anthropogenic noise and squid response to seismic survey pulses – *Robert D. McCauley and Jane Fewtrell*

08:50 Effects of anthropogenic sounds on fish – *Arthur N. Popper and Svein Løkkeborg*

09:10 Valuable lessons from studies evaluating impacts of cetacean-watch tourism - *Lars Bejder and David Lusseau*

09:30 Assessing effects of anthropogenic noise on the behaviour of marine mammals - *Douglas P. Nowacek and Peter L. Tyack*

09:50 Elaboration of the NRC Population Consequences of Acoustic Disturbance (PCAD) Model – *Douglas Wartzok and Peter Tyack*

10:10 Break

10:30 Discussion and questions

11:30 Poster Session Two (see page 13)

12:20 Lunch

Session Nine: Regulatory issues – Chair: *Peter Madsen*

13:30 Mitigation - *Susanna B. Blackwell*

14:00 Overview of regulations for the conservation and protection of organisms in European seas - *Mark L. Tasker*

14:20 U.S. regulation of the effects of sound on marine life: NOAA's mandates and use of scientific information – *Brandon Southall, Craig Johnson, Amy Scholik, Tammy Adams, Jolie Harrison and Ken Hollingshead*

14:40 Environmental compliance by the Royal Australian Navy – *Stephen Cole*

15:00 Break

Session Ten: Presentation of selected posters and discussion of posters

Chair: *Olav Sand*

15:20 Presentation of selected posters; to be announced

3:50 Discussion of all posters and regulatory issues

19:15 Banquet

Day Five

Final discussion session – Chair: *Darlene Ketten*

08:30 Regulation: Rapporteur – *Anthony D. Hawkins*

Detection and use of sound: Rapporteur – *W. John Richardson*

Effects of sound: Rapporteur – *Douglas H. Cato*

Sources: Rapporteur – *Sarah Dolman*

10:30 Break

11:00 Final discussion, questions and thoughts – *Chaired by Magnus Wahlberg*

11:40 Closing remarks by organizers

12:30 Lunch

13:30 Depart

Annex 2

Poster Papers

Session A

1. **Acebes, J.M., Darling, J. & Aca, E.Q.** Dynamite blasts in a humpback whale (*Megaptera novaeangliae*) breeding ground, Babuyan Islands, Philippines.
2. **André, M., Månuel, A., Danobeitia, J-J., Rolin, J-F. & Person, R.** Biological and anthropogenic sound sources: effects and control in the European seas observatory network (ESONET).
3. **Arbelo, M., Bernaldo de Quirós, Y., Sierra, E., Méndez, M., Godinho, A., Ramírez, G., Caballero, M.J. & Fernández, A.** Atypical beaked whale mass stranding in Almería's coasts: pathological study.
4. **Boebel, O., Kindermann, L. & El Naggar, S.** PALAOA: Broadband recordings of the Antarctic coastal soundscape.
5. **Codarin, A., Spoto, M. & Picciulin, M.** One-year characterization of sea ambient noise in a coastal marine protected area: a management tool for inshore MPAs.
6. **Codarin, A., Wysocki, L.E. Ladich, F. & Picciulin, M.** Hearing under ambient and ship noise conditions: a case study on fishes from a protected area in the Adriatic Sea.
7. **Cowan, D.F.** Pathological assessment of acoustic noise effects in stranded dolphins.
8. **Cranford, T. Krysl, P. & Hildebrand, J.** Sound pathways revealed: simulated sound transmission and reception in Cuvier's beaked whale (*Ziphius cavirostris*) using the vibroacoustic toolkit.
9. **Di Iorio, L.** Potential masking of blue whale calls through seismic air gun noise.
10. **Doksæter, L., Kvadsheim, P.H., Godø, O.R., Benders, F.P.A., Miller, P.J.O., Lam, F-P., Handegard, N.O. & Hjellvik, V.** Observations of the behaviour of herring exposed to low- (1-2 kHz) and mid- (6-7 kHz) frequency sonar signals.
11. **Elepfandt, A.** Lateral line scene analysis.
12. **Holt, M.M., Veirs, V. & Veirs, S.** Noise effects on the call amplitude of southern resident killer whales (*Orcinus orca*).
13. **Jensen, F.H., Wahlberg, M., Bejder, L. & Madsen, P.T.** Noise levels and masking potential of small whale watching and research vessels around two delphinid species.
14. **Kastak, D.** Effects of noise on seals and sea lions: laboratory approaches.
15. **Kastelein, R.A.** Effects of vibrations on the behavior of cockles (bivalve molluscs).

16. **Langård, L., Øvredal, J.T., Johannessen, A., Nøttestad, L., Skaret, G., Fernö, A. & Wahlberg, M.** Sound production in pre-spawning herring, cod and haddock in a naturally enclosed ecosystem.
17. **Lemon, M., Cato, D., Lynch, T. & Harcourt, R.** Short-term behavioural response of bottlenose dolphins (*Tursiops aduncus*) to recreational powerboats.
18. **Lucke, K., Lepper, P., Blanchet, M-A. & Siebert, U.** Testing the acoustic tolerance of harbour porpoise hearing for impulsive sounds.
19. **Luczkovich, J.J. & Keusenkothen, M.A.** Can longspine squirrelfish hear bottlenose dolphin?
20. **Lugli, M.** The role of ambient noise as selective factor for frequencies used in fish acoustic communication.
21. **McCauley, R.D., & Fewtrell, J.** Experiments and observations of fish exposed to nearby seismic.
22. **Mountain, D.C., Zosuls, A., Newburg, S. & Ketten, D.R.** Predicting cetacean audiograms.
23. **Mulow, J. & Reichmuth, C.** Amplitude-vs-rate transfer functions to tone burst stimuli in the California sea lion (*Zalophus californianus*).
24. **Murphy, M.** Seismic survey: promoting co-existence between the fishing and petroleum industries in Newfoundland and Labrador.
25. **Parks, S.E., Clark, C.W. & Tyack, P.L.** Long and short-term changes in right whale acoustic behavior in increased low-frequency noise.
26. **Picciulin, M., Codarin, A. & Spoto, M.** Characterization of small-boat noises compared with the chorus of *Sciaena umbra* (Sciaenidae).
27. **Popper, A.N., Comeau, L.A. & Campana, S.** Determination of the effects of seismic exploration on fish (project SEIfish).
28. **Radford, C.A., Jeffs, A.G., Tindle, C.T. & Montgomery, J.C.** Ambient noise in shallow temperate waters around north-eastern New Zealand.
29. **Robinson, N.E., Chaudry, F., Clark, N.M., Duguid, G. & Walker, R.N.** Is passive acoustic monitoring during seismic surveys a valuable tool for mitigation?
30. **Schack, H.B., Malte, H. & Madsen, P.T.** Effects of intense ultrasound on Atlantic cod, *Gadus morhua*.
31. **Simard, Y., Roy, N. & Gervaise, C.** Masking of blue and fin whales low-frequency vocalizations by shipping noise in the Saguenay—St. Lawrence Marine Park.
32. **Simpson, S.D.** The sounds of the reef: can we learn to listen before it is too late?

33. **Smies, M. & Gentry, R.L.** Oil and gas activities and sound and marine life: an international joint industry research and development programme.
34. **Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene, C.R.Jr., Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A. & Tyack, P.L.** Marine mammal noise exposure criteria: initial scientific recommendations.
35. **Spinks, J.A.L., Stead, S.M., Downie, J. & Bentley, M.G.** Perceptions of underwater noise from offshore wind farms and effects on the environment and local communities.
36. **Stage, B., Stæhr, K.-J., Nielsen, R. & Lundgren, B.** Observed reactions of fish in captivity to replayed vessel noise sounds from the fisheries research vessel Dana.
37. **Stimpert, A.K. & Au, W.L.** Humpback whale (*Megaptera noveangliae*) social sounds in Hawai'i.
38. **Streever, B., Angliss, R.P., Suydam, R., Ahmaoga, M., Bailey, C., Blackwell, S.B., George, J.C., Greene, C.R.Jr., Jakubczak, R.S., Lefevre, J., McDonald, T.L., Napageak, T. & Richardson, W.J.** Progress through collaboration: a case study examining effects of industrial sounds on bowhead whales.
39. **Stummer, M. & Ladich, F.** How does aquaria and pond noise affect hearing in different fish species?
40. **Thomsen, B.** An experiment on how seismic shooting affects caged fish.
41. **Thomsen, F., Luedemann, K., Piper, W., Judd, W. & Kafemann, R.** Potential effects of offshore wind farm noise on fish.
42. **Tsoflias, S.L. & Young, J.** Marine seismic operations.
43. **Tun, T.** Sound signals used in castnet fishing with the help of Irrawaddy dolphins.
44. **Vasconcelos, R.O., Amorim, C.P. & Ladich, F.** Ship noise affects acoustic communication in the Lusitanian toadfish.
45. **Vigness Raposa, J.J., Scowcroft, G., Knowlton, C. & Worcester, P.F.** The *Discovery of Sound in the Sea website*: an educational resource.
46. **Von Lüders, S. & Gill, A.** Marine mammal observers: real time mitigation of anthropogenic noise.
47. **Winsor, M. & Mate, B.R.** Seismic survey activity and the proximity of satellite-tagged sperm whales (*Physeter macrocephalus*) in the Gulf of Mexico.
48. **Nøttestad, L., Brehmer, P., Josse, E., Doksæter, L., Pavan, G., Sancho, G., Gosselin, J.F., Lebourges-Dhaussy, A., Georgakarakos, S., Aumeeruddy, R. & Dalen, J.** Do whales really care about conventional fisheries acoustics?

Session B

1. **Babaran, R., Anraku., K. Ishizaki, M., Watanabe, K. & Matsuoka, T.** Comparison of auditory sensitivity of pelagic fish with the sound generated by a fish aggregation device.
2. **Borsani, J.F., Clark, C.W. & Scarpiniti, M.** Fin whales avoid loud rhythmic low-frequency sounds in the Ligurian Sea.
3. **Burkhardt, E., Boebel, O., Bornemann, H. & Ruholl, C.** Risk assessment of scientific sonars.
4. **Cameron, B., Mageau, C. & Smyth, R.** Canada's approach to mitigation of seismic sound in the marine environment.
5. **Carr, S.A. & Erbe, C.** Assessing the impact of underwater noise on marine fauna: a software tool.
6. **Coers, A., Bouton, N; Vincourt, D. & Slabbekoorn, H.** Fluctuating noise conditions may limit acoustic communication distance in the rock-pool blenny.
7. **Dolman, S.J., Jopling, B.C. & Simmonds, M.P.** The worldwide extent of seismic exploration, 1994-2004.
8. **Götz, T. & Janik, V.** The acoustic startle response in phocids: an initiator of extreme behavioural responses to anthropogenic noise.
9. **Halvorsen, M., Carlson, T. & Popper, A.N.** Effects of exposure to pile-driving sounds on fish.
10. **Hastings, M.** Sound exposure metrics for aquatic animals.
11. **Heise, K. & Barrett-Lennard, L.** The calm before the storm: the need for baseline acoustic studies off the central and north coasts of British Columbia, Canada.
12. **Houser, D.S., Dankiewicz, L.A., Stockard, T.K. & Ponganis, P.J.** Ultrasound inspection for intravascular bubbles in a repetitively diving dolphin.
13. **Kastelein, R.A., Van der Heul, S., Verboom, W. & Reijnders, P.** Acoustic dose-response effects in marine fish.
14. **Knudsen, F.R., Gammelsæter, O.B., Kvadsheim, P.H. & Nøttestad, L.** Evaluation of fisheries sonars for whale detection in relation to seismic survey operations.
15. **Lavender, A.L., Avery, H.W., Bien, W.F., Spotila, J.R. & Standora, E.A.** The behavioural and physiological effects of anthropogenic sound on the diamondback terrapin, a model estuarine vertebrate.
16. **Lzauski, C. & Mitchell, G.** Use of Monte Carlo methods to determine the sensitivity of acoustic exposure simulations.

17. **Li, S., Akamatsu, T., Wang, D., Wang, K., Dong, S., Zhao, X., Wei, Z., Zhang, X., Taylor, B., Barrett, L.A., Turvey, S.T., Reeves, R.R., Stewart, B.S., Richlen, M. & Brandon, J.R.** Indirect evidence of boat avoidance behaviour of Yangtze finless porpoises.
18. **Luczkovich, J.J. & Sprague, M.W.** Does boat noise affect spawning sound production of soniferous fish in shallow estuarine systems?
19. **Ludwig, S., Nissen, I. & Knoll, M.** The German sound propagation model MOCASSIN: Integration of a marine mammal database for improving protection measures.
20. **Martin, J.S. & Rogers, P.H.** Sound exposure chamber for assessing the effects of high intensity sound on fish.
21. **Mate, B.R.** Technical instrumentation issues related to the design and execution of a controlled exposure experiment (CEE) for large cetaceans to assess possible behavioural responses and potential impacts.
22. **McCauley, R.D., Rennie, S.R., Hughes, J.R. & Duncan, A.J.** Transmission of marine seismic signals in Australian waters.
23. **Miksis-Olds, J.I.** The effect of environmental noise on the Florida manatee (*Trichechus manatus latirostris*).
24. **Millar, D.** Monitoring, mitigating and managing acoustic affects on at-risk whales on the Scotian Shelf, Canada.
25. **Mitchell, G.H., Lazauski, C.J., Lange, N., Damon, C.P. & Frederickson, J.M.** Assessing risk from underwater sound using simulation of live-fire/anti-submarine warfare naval exercises in the presence of protected marine species.
26. **Mueller-Blenkle, C., Jones, E., Reid, D., Lüdemann, K., Kafemann, R. & Elepfandt, A.** Reactions of cod (*Gadus morhua*) to low-frequency sound resembling offshore wind turbine noise emissions.
27. **Payne, J.F., Andrews, C.D., Fancy, L.L., Guiney, J., Cook, A. & Christian, J.R.** Are seismic surveys an important risk factor for fish and shellfish?
28. **Polglaze, J.F.** Understanding sonar as a precursor to understanding its environmental risks.
29. **Prahl, S., Ketten, D.R. & Siebert, U.** Examinations of ears in harbour porpoises (*Phocoena phocoena*) from the North and Baltic Seas.
30. **Radford, C.A., Jeffs, A.G. & Montgomery, J.C.** Orientated swimming behaviour of crab postlarvae in response to reef sound.
31. **Rollo, M.M., Sayuri Iwai, F. & Mazinini Rosa, J.** Evaluating the effects of anthropogenic noise on estuarine dolphins (*Sotalia guianensis*) from Cananeia, southeastern Brazil.
32. **Schilt, C.** Establishing the boundary conditions for experiments on the effects of anthropogenic sound on fish and invertebrate animals.

33. **Siderius, M., Porter, M. & Mountain, D.** Modelling alternative sonar waveforms to determine risk factors for marine mammals.
34. **Smies, M. & Gentry, R.L.** Oil and gas activities and sound and marine life: an international joint industry research and development programme.
35. **Smith, M.E. & Gilley, R.R.** Testing the equal energy hypothesis in noise-exposed fishes.
36. **Southall, B., Boyd, I., Tyack, P.L. & Wartzok, D.** Deep-diving odontocetes behavioural response study (BRS).
37. **Stæhr, K.-J., Stage, B. & Lundgren, B.** Vessel-noise measurements of the fisheries research vessel *Dana*. A simplified cost-effective method.
38. **Stocker, M., Reuterdahl, T., Horn, L. & Hurley, G.** A simple acoustical exposure metric based on naturally occurring noise levels and biological thresholds.
39. **Supin, A. & Popov, V.V.** Directional sensitivity and sound-receiving windows in dolphins.
40. **Terhune, J.M.** Variation in harp seal underwater acoustic communication range estimations.
41. **Tsoflias, S.L. & Young, J.** Marine seismic operations.
42. **Van der Woude, S.** Assessing effects of an acoustic marine geophysical survey on the behaviour of bottlenose dolphins, *Tursiops truncatus*.
43. **Wahlberg, M., Schack, H.B., Wilson, M., Bejder, L. & Madsen, P.T.** Particle acceleration noise generated by boats.
44. **Wilson, M., Hanlon, R.T., Tyack, P.L. & Madsen, P.T.** Big bang? Intense ultrasound does not have any detectable effects on the squid *Loligo pealeii*.
45. **Wilson, C.D., De Robertis, A., Hjellvik, V. & Williamson, N.J.** Inter-vessel comparison of walleye pollock acoustic backscatter recorded by a noise-reduced and a conventional research vessel.
46. **Woodbury, D.P. & Stadler, J.H.** A proposed method to assess physical injury to fishes from underwater sound produced during pile driving.
47. **Yamato, M., Ketten, D.R., Arruda, J. & Cramer, S.** Biomechanical and structural modeling of hearing in baleen whales.

Annex 3

List of Canadian delegates who attended the Acoustic Conference in Nyborg Denmark (12-17th August). Please note this list of persons contains details provided by the conference organizers. It does not provide complete contact details.

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