



ACCESS
Arctic Climate Change
Economy and Society



Project no. 265863

ACCESS
Arctic Climate Change, Economy and Society

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PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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This international workshop was originally planned at M24 (February 2013). It aimed at gathering the latest information on how the climate change will affect sound in the Arctic. The ACCESS results are expected to contribute to the necessary knowledge and the workshop cannot be celebrated before the main objectives are achieved, i.e. at the end of the project life. In addition, because of the increasing number of scientific meetings on underwater noise, it is important to make sure ACCESS schedules the workshop when the concerned community is available to come, so a true two-way exchange takes place and not only a presentation of ACCESS results. In Spring 2015, an international conference on ocean noise will be held in Vilanova i la Geltrú, Barcelona (Spain), hosted by the UPC, an ACCESS partner. In other words, the Deliverable consists of all the preparatory phases of the workshop and the final program that will include not only the conclusions of ACCESS but also the future challenges in the Arctic. ACCESS will be officially acknowledged during the workshop.

INTRODUCTION

The growing scientific and societal concern about the effects of underwater sound on marine ecosystems has been recently recognized through the introduction of several international initiatives aiming at measuring the environmental impact of ocean noise at large spatial and temporal scales.

OCEANOISE2015 will bring together international leading experts in noise measurement, modeling and mapping, physiological and behavioural effects as well as regulation and mitigation procedures.

OCEANOISE2015 format aims at favouring a dynamic exchange of the latest findings in the field of ocean noise in order to assist in providing ocean users with the best scientific knowledge and technical solutions to address operational and environmental issues.

Because the Arctic Ocean Noise issues cannot be isolated from the rest of the planet, we chose to include the ACCESS International Workshop within OCEANOISE2015 so it will benefit from the input of all experts in the field.

OCEANOISE2015 could not be held before the end of ACCESS but its programme is now almost complete, only awaiting for the conformation of a few speakers. Here, we present the structure and content of this unique conference, where for the first time, physical aspects of noise will share the same floor with the biological reality of the ocean ecosystems.

A NOVEL APPROACH

The format of OCEANOISE was designed to encourage dynamic discussions and exchanges amongst ocean acoustics experts, not as a platform to review published science. We are conscious that we face a challenge here: to move interesting discussions that usually take place at coffee-breaks or during dinners into plenary sessions. This was the essence of past

conferences where no fear to share experiences (and mistakes) with the community was the source of innovation.

OCEANOISE2015 is structured in three types of oral communications:

- keynote speakers
- invited speakers during chaired-sessions
- 5mn talks and associated posters (call for abstracts)

1. Five invited **keynote speakers** will address the perspective of the industry, NGO, academia, navy and regulation and present state-of-the-art lectures.

2. **Chaired-sessions** under specific themes shall cover most of ocean noise issues.

The chaired-sessions are aimed at favouring the presentation of novel data and ideas, not necessarily aimed at being published soon. No review presentation should be accepted.

The session Chairs are responsible of inviting speakers to their sessions. These speakers will be given 10mn to present their data. No time for questions will be allocated at the end of

the 10mn talks, but a 30mn round table composed by the session speakers and the Chairs will allow questions from the floor and most importantly to address key issues under the session theme. Please, note that the maximum number of speakers per session is 9 (2-hour session) to allow the 30mn round table.

Invited speakers must submit abstracts and specify they are invited.

The session chairs will report the conclusions of their session and round table to OCEANOISE science committee. These conclusions will be published as a peer-reviewed paper in a journal special issue. The session Chairs will be the leading authors of the paper and invite the session speakers to summarise their presentation to be included in the paper. Optionally, members of OCEANOISE Science Committee may be asked to join the authorship. The individual papers presented by the session speakers are not intended to be published.

3. In addition to the chaired-sessions, a **call for abstracts** was open until January 15. This call concerned the 5mn-talks that will be scheduled every day in the late afternoon. The call addressed the same themes as during the chaired-sessions and the authors were asked to pick-up one of them when submitting their abstract. Unlike the chaired-sessions, the 5mn-talks will not be chaired nor a round table will be organized. Instead, a general discussion will follow around the posters of the day (associated to the talks), where all participants will be invited to informally give their input or discuss with the speakers. Note that the posters will only be displayed the day of the presentation to focus the attention on the “daily speakers”.

The abstracts were reviewed by the session chairs, thus giving the opportunity to select a relevant contribution to the sessions or fill-in the gap if a session misses an invited speaker.

The criteria to review the abstracts were simple:

- an abstract must address the selected theme
- it must clearly present data (an abstract stating “results will be presented...” without describing these results should be rejected)
- no review should be accepted

The maximum number of abstracts that we can accept: 12 talks/day, 70/week, for a 1-hour session.

This means that we will have to make a selection of the top-five abstracts per theme to be included in the programme.

Based on the above, a total of 205 papers will be presented at the conference.

For the coherence of the programme, session Chairs must communicate the list of invited speakers (and their corresponding abstracts) under their sessions to OCEANOISE Science Committee for final validation, as well as a list of the top-ten abstracts selected for the 5mn-talk sessions. The Science Committee (SC) will review the top-ten list for each session (two SC members per session) and agree on the final top-five list with the session chairs.

THE PROGRAMME (as for February 18, 2015)

OCEANOISE2015

Vilanova i la Geltrú, BARCELONA 11-15 MAY

11-15 MAY	09:00	09:30	10:00	11:00	11:30	12:00	14:00	15:30	16:00	17:00	17:30	18:00	18:30	19:00
Monday		AMBIENT NOISE			*KN Indus	SHIPPING		SEISMIC			5MN Talks + Posters			
Tuesday	PILE-DRIVING				*KN Navy	RENEWABLE	SOUNDSCAPES			5MN Talks + Posters				
Wednesday	BEHAVIOUR				*KN Acad	SENSITIVITY	PATHOLOGY			5MN Talks + Posters				
Thursday	POLAR				*KN NGO	RIVERINE	MAPPING			5MN Talks + Posters				
Friday		*KN Regul	REGULATION			MITIGATION			5MN Talks + Posters					

* KN: Keynotes

SCIENCE COMMITTEE

Michael Ainslie (The Netherlands)
Tomonari Akamatsu (Japan)
Michel André, Chair (Spain)
Fabrizio Borsani (UK)
Christine Erbe (Australia)
Thomas Folegot (France)
Michele Halvorsen (USA)
Paul Lepper (UK)
Jennifer Miksis-Olds (USA)
Stephen Robinson (UK)
Peter Sigraay (Sweden)
Brandon Southall (USA)
Pete Theobald (UK)
Frank Thomsen (Denmark)
Manell Zakharia (France, India)

KEYNOTE SPEAKERS

John Hildebrand, *Scripps Whale Acoustic Lab*
John Campbell, *International Association of Oil and Gas Producers*
John Potter, *The NATO STO Centre for Maritime Research & Experimentation*
Sarah Dolman, *Whales and Dolphins Conservation*
Mark Tasker, *Joint Nature Conservation Committee*

SESSION CHAIRS

Here is the list of the session co-chairs:
Ambient & Natural Noise: Doug Cato & Mark Prior
Pile Driving: Stephen Robinson & Roberto Racca
Shipping: Christian Audoly & Christ de Jong
Seismic Surveys: David Hedgeland
Renewable Energy: Paul Lepper & Frank Thomsen
Riverine and Coastal: Tomonari Akamatsu & Satoko Kimura
Polar: Philippe Blondel & Hanne Sagen
Soundscapes: Jen Miksis-Olds & Kevin Heaney
Mapping: Christine Erbe & Thomas Folegot
Behavioural: Douglas Novacek & Patrick Miller
Pathology: Michele Halvorsen & Ursula Siebert
Sensitivity: Klaus Lucke & Aran Mooney
Mitigation: John Young & Jukka Pajala
Regulation: René Dekeling & Leila Hatch

SESSION CONTENTS

	session name	chairs	Invited speakers
NOISE MEASUREMENT	Ambient & Natural Noise	Doug Cato Mark Prior	Accepted: - Christine Erbe - Mike van der Schaar - Bruce Howe - Jen Miksis-Olds - Jerry Stanley - Mario Zampolli - Richard Dewey - Sasha Gavrilov - Rex Andrew - Craig Radford - Georgios Haralabus - Haru Matsumoto - Jeff Nystuen - Mike Buckingham - Peter Dahl - Ross Chapman - Stephen Robinson - Thomas Folegot - Whitlow Au

			<ul style="list-style-type: none"> - Frans-Peter Lam - Sander von Benda-Beckman - Láslo Evers
	Pile Driving	<p>Stephen Robinson Roberto Racca</p>	<p>Invited:</p> <ul style="list-style-type: none"> - Peter Dahl - Stefan Lippert - Alexander Gavrilov - Kevin Lee - Klaus Betke - James Miller - Christ de Jong - Jesse Spence - Michael Wood, - Stephen Robinson - Roberto Racca - Dick Hazelwood
	Shipping	<p>Christian Audoly Christ de Jong</p>	<p>Invited:</p> <ul style="list-style-type: none"> - Dietrich Wittekind - Cedric Gervaise - Christian Audoly - Alex Brooker / Victor Humphreys - Raul Salinas

			<ul style="list-style-type: none"> - Eric Baudin - Alex McGillivray - John Hildebrand - Mike Bahtiarian
	Seismic Surveys	David Hedgeland Mike Jenkersen	
	Renewable Energy	Paul Lepper Frank Thomsen	<p>Invited:</p> <ul style="list-style-type: none"> - Denise Risch - Monika Kosecka - Phillippe Blondel - M Halvorsen - Cristiano Soares - B Polagye - K Haikonen - T Gotz
NOISE HABITAT	Riverine and Coastal	Tomonari Akamatsu Satoko Kimura	<p>Invited:</p> <ul style="list-style-type: none"> - Songhai Li - Aran Mooney - Tzu-hao Lin - Chen Chifang - Tom Akamatsu - Saho Kameyama - Yuko Taga

			<ul style="list-style-type: none"> - Jonas Teilmann - Bayram Ozturk - Satoko S. Kimura
	Polar	Philippe Blondel Hanne Sagen	<p>Invited:</p> <ul style="list-style-type: none"> - Jaroslaw Tegowski - Dag Tollefsen - Erin C. Pettit - Hanne Sagen - Jeffrey A. Nystuen - Bruce Martin - Robert P. Dziak, - Olaf Boebel, - Kath Stafford, - Peter Worcester,
	Soundscapes	Jen Miksis-Olds Kevin Heaney	<p>Invited:</p> <ul style="list-style-type: none"> - Bruce Martin - Tony Hawkins - Ana Sirovic - Kevin Heaney - Jen Miksis-Olds - Kathy Heise - Maxwell B. Kaplan - Erica Staaterman,

			<ul style="list-style-type: none"> - Ilse Van Opzeeland - Leila Hatch - Dan Mennitt - Jeff Nystuen
	Mapping	Christine Erbe Thomas Folegot	Invited: <ul style="list-style-type: none"> - Nathan Merchant - David Barclay - Florian Aulanier - Bas Binnerts
NOISE EFFECTS	Behavioural	Douglas Novacek Patrick Miller	Invited: <ul style="list-style-type: none"> - Mike Noad - Wendy Dow-Piniak - Jenni Stanley - Denise Risch - Fleur Visser - Amanda Stansbury - Mathias Andersson - Douglas Nowacek - Patrick Miller
	Pathology	Michele Halvorsen Ursula Siebert	Invited: <ul style="list-style-type: none"> - Marta Solé - Maria Morell - Elisabeth Debusschere

			<ul style="list-style-type: none"> - Andreas Ruser - Christa Woodley - Dorian Houser - Christa Woodley (tentative – working on approval) - Loes Bolle (tentative – working on approval) - Lise Sivle (she is contemplating; waiting on decision) - Peter Wohlsein - Andreas Fahlman
	Sensitivity	Klaus Lucke Aran Mooney	<p>Invited:</p> <ul style="list-style-type: none"> - Tomonari Akamatsu - Michel André - Art Popper - Tony Hawkins - Amanda L. Stansbury - Andreas Ruser - Marc Lammers - Craig Radford - Brian Branstetter
NOISE SOLUTIONS	Mitigation	John Young Jukka Pajala	<p>Invited:</p> <ul style="list-style-type: none"> - Michael Bellman, ITAP, Germany, <i>Noise Mitigation in Pile driving operations</i> - Mark Wochner, AdBm Technologies - Tuomas Sipilä, Technical Research Center of Finland, <i>Propeller cavitation reduction studies with CFD</i>

			<ul style="list-style-type: none"> - Michael Jasny, Natural Resources Defense Council - JIP "ramp up" Study - Ludwig Houégnyan, Technical University of Catalonia, Spain, <i>Localization of cetaceans and anthropogenic sources: a didactic pattern recognition framework using neural networks</i> - Jean-Marc Mougemot, TOTAL, France, <i>Marine Vib Development Update</i> - Doug Cato, <i>Seismic airgun "ramp up" procedures</i> - David Hedgeland, BP, <i>Alternative Seismic Source</i> - Jack Belcher, HBW Resources Inc.
	Regulation	René Dekeling Leila Hatch	<ul style="list-style-type: none"> - Karen Trevino, Chief, Natural Sounds and Night Skies Division, US National Park Service. <i>Managing terrestrial soundscapes and lessons for sensitive or protected marine places</i> - Christ de Jong, TNO, Sonar and acoustics, The Netherlands, <i>Application of the Interim PCoD model in a Dutch assessment of the cumulative impact of pile driving sound associated with North Sea wind farm development</i> - Aylin Erkman, Rijkswaterstaat, The Netherlands, <i>International harmonization of approaches to define underwater noise exposure criteria</i> - Yvonne Mather, Underwater Group, dstl Naval Systems, UK. <i>The contribution of the UK Navy to the monitoring process needed for the EU Marine Strategy Framework Directive</i> - John V. Young, Director, Sound and Marine Life Business Line, CSA Ocean Science, US, <i>Considerations for Future Ocean Noise Management</i> - Leila Hatch, Stellwagen Bank National Marine Sanctuary, NOS-NOAA, US, <i>The NOAA Ocean Noise Strategy</i>

THE POLAR NOISE SESSION

Session co-Chairs: Philippe Blondel and Hanne Sagen

Speakers

PETTIT, Erin, Dept of Geology and Geophysics, University of Alaska Fairbanks, Fairbanks

SAGEN, Hanne, Nansen Environmental and Remote Sensing Center (NERSC), Bergen, Norway

TOLLEFSEN, Dag, Norwegian Defence Research Establishment (FFI), Box 115, 3191 Horten, Norway

TEGOWSKI, Jaroslaw, Institute of Oceanography, University of Gdansk, Poland

WORCESTER, Peter, Institute of Geophysics and Planetary Physics, Scripps Institution of Oceanography, UC San Diego, USA

MARTIN, Bruce, JASCO Applied Sciences, Halifax NS, Canada

MARTIN, Bruce, JASCO Applied Sciences, Halifax NS, Canada

THODE, Aaron, Marine Physical Laboratory, Scripps Institution of Oceanography, UC San Diego, USA

Abstracts

Characteristics of Underwater Noise Sources at the Glacier Ice-Ocean Boundary: Subglacial Discharge and Seiches

Passive underwater acoustics have revolutionized many fields including marine biology and physical oceanography, but have only recently been applied to explore glacier ice/ocean interactions. Sources of sound near glacier and ice-sheet margins include calving events and ice shelf rifting events, iceberg motion and collision, glacier ice melting, ocean surface-ice-cover conditions, ocean wave action (including seiches), rain and snow, and subglacial discharge. Among these, only ice melting and calving have been characterized through acoustic recordings combined with synchronous observations. The other sources are more difficult to characterize due to the difficulty of isolating the acoustic signal and/or collecting synchronous observations. For example, subglacial discharge is a subtle, yet important, tremor-like source that should have a diurnal and seasonal variability, punctuated by outburst flood events. Because it is a localized source along the glacier ice-ocean boundary, the geometry of the subglacial conduit and fjord relative to the position of hydrophones affect this noise characteristics making this source is difficult to infer. Seiche action, on the other hand, is a distributed surface source whose characteristics, while dependent on fjord geometry, are more distinct because they are primarily due to the seiche wave interacting with and reflecting off the coastline and ice terminal cliff. Here we present the theoretical and observed noise characteristics produced by subglacial discharge, seiche action, and surface-ice cover from Meares Glacier, Alaska; Icy Bay, Alaska; and Anvdord Bay Antarctica.

Passive acoustics from moorings and drifting ice stations in the Fram Strait

Recent results from acoustic measurements from drifting ice station in the marginal ice zone and from moorings in the Fram Strait will be presented. Focus is on describing the ambient noise characteristics in this very dynamic environment. As part of the WIFAR and UNDER-ICE projects passive acoustic recordings were obtained by an autonomous Integrated Ice Station (IIS). The IIS was drifting with the ice for several days in the Fram Strait marginal ice zone during late summer 2012 and 2013. The IIS was developed for NERSC, integrating components from Scripps Institution of Oceanography, Woods Hole Oceanographic Institution and Christian Michelsen Research. The recorded noise was analyzed in detail to separate and quantify different sounds. Spectral analysis of acoustic spectrograms was used to identify regularly varying sounds. This helped especially in the identification of man-made noise, which dominated noise levels at frequencies below 100 Hz. Furthermore, we will present preliminary results from analysis of low frequency passive acoustics from the multipurpose acoustic network implemented in the Fram Strait as part of the ACOBAR project. The system was operating for two years in the deep part of the Fram Strait. The hydrophones on the receiver mooring were recording 300 s every three hours for 2 years. Sample rate is 1000 Hz, and low frequency passive acoustic information is available.

Synoptic measurements of ambient noise in the Fram Strait Marginal Ice Zone

The marine soundscape of the Fram Strait has been subject to measurements since the mid-1980s. Increasing interest in Arctic operations initiated a recent series of acoustic experiments that included synoptic ambient noise measurements in the Marginal Ice Zone of the Fram Strait conducted over the years 2010-12. This presentation will give an overview of experiments where fields of sonobuoys were deployed over large (150 km x 150 km) areas under varying ice conditions in different seasons. Ambient noise spectra (20 Hz – 1 kHz) are presented and compared with historical data. The spectra are categorized by environmental parameters that include wind force and direction, ice concentration derived from satellite images, ocean wave and swell, and sound propagation conditions. Biological and anthropogenic components of the noise fields that are discussed include sound due to marine mammals, tomographic transmissions, and distant seismic exploration.

Broadband ambient noise and ice-related processes in the Arctic – Multi-year studies of Hans Glacier, Svalbard

The rapid climate warming observed in the last decades is strikingly noticeable in the Arctic, where ice cover and thickness decrease whilst the melt rates of individual glaciers increase. This translates into louder underwater noise at a range of frequencies. Starting in 2009, we have measured these levels in Svalbard fjords, contrasting different types of ice covers and glaciers. Hornsund Fjord, surrounded by glaciers, can be contrasted with Murchison Fjord, covered with marine ice floes. In 2010, we measured noise contributions from individual growlers in anechoic tanks, investigating melting, colliding, scraping and capsizing. The latest results from the 2013 and 2014 field surveys in Hornsund Fjord use long-term deployment of broadband hydrophones close to the glaciers: point measurements of broadband noise and its directionality, combined with time-lapse photography; and more tank measurements of fresh growlers and slabs of ice, simultaneously measuring noise and high-speed photography. Four frequency bands were identified and analysed: 20 Hz-200 Hz, 200 Hz – 800 Hz, 800 Hz – 4,000 Hz and 4,000 Hz – 16,000 Hz. They can be confidently associated with distinct geophysical phenomena, such as the noise generated by the bursting of air bubbles trapped in melting growlers and icebergs, waterfalls from glaciers and calving glacier noise. We observed significant fluctuations of Sound Pressure Level caused by changes in weather, waves and flows of noisy growlers and icebergs from the calving glacier. Specific signatures were identified with bespoke, advanced signal processing techniques and they will be presented in this paper. Long-term measurements over several years are continuing now, and because glaciers around Hornsund Fjord are typical of the

Atlantic sector of the Arctic, our results are applicable to many other, similar areas around the world. This work was supported by the National Science Centre of Poland (research projects no. UMO-2011/03/B/ST10/04275 and UMO-2013/11/N/ST10/01729), the US Office of Naval Research, Ocean Acoustics Program (grant no. N00014-14-1-0213) and the statutory activity of the Institute of Geophysics, Polish Academy of Sciences.

Ambient noise in the Arctic Ocean measured with a drifting vertical line array

In mid-April 2013 a Distributed Vertical Line Array (DVLA) with 22 hydrophone modules over a 600-m aperture immediately below the subsurface float was moored near the North Pole. The top ten hydrophones were spaced 14.5 m apart. The distances between the remaining hydrophones increased geometrically with depth. Temperature and salinity were measured by thermistors in the hydrophone modules and ten Sea-Bird MicroCATs. The mooring parted just above the anchor shortly after deployment and subsequently drifted slowly south toward Fram Strait until it was recovered in mid-September 2013. The DVLA recorded low-frequency ambient noise (1953.125 samples per second) for 108 minutes six days per week. Previously reported noise levels in the Arctic are highly variable, with periods of low noise when the wind is low and the ice is stable and periods of high noise associated with pressure ridging. The Arctic is currently undergoing dramatic changes, including reductions in the extent and thickness of the ice cover, the amount of multiyear ice, and the size of the ice keels. The ambient noise data collected as the DVLA drifted will test the hypothesis that these changes result in longer and more frequent periods of low noise conditions than experienced in the past.

Comparison of measured and modeled air-gun array in Baffin Bay, West Greenland

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Characteristics of air-gun array pulses and the ambient soundscape in Baffin Bay and Melville Bay, West Greenland

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Measurements of cumulative airgun survey activity in the Beaufort Sea during ice-free conditions, 2008-2012

Every year since 2007 a collection of at least 35 “Directional Autonomous Seafloor Acoustic Recorders” (DASARs) have been deployed across a 280 km swath of the Beaufort Sea continental shelf, in water depths between 15 and 50 m. The ability of these instruments to estimate the arrival azimuth of transient signals has facilitated the development of an automated algorithm for the detection of airgun survey activity, which has been applied to five field seasons of data. The contributions of airgun survey activity to the overall ambient noise background of the ice-free shallow-water Beaufort environment is quantified with a variety of metrics, in terms of both level (peak-to-peak, rms, sound exposure level), frequency, and time (intervals and fraction of time present). During some years, up to four airgun operations could be detected simultaneously, and a random one-second time sample yielded a 30% chance of containing an airgun signal, but the levels detected are generally within the bounds of natural wind-driven ambient noise levels. This dataset provides useful empirical insight into discussions about the cumulative contributions of anthropogenic noise to an environment extensively used by several marine mammal species. [Work sponsored by the Shell Exploration and Production Company.]

CONCLUSION

Each session chairs will gather summaries from invited talks and make a synthesis of them together with key issues addressing the specific challenge of ocean noise under their session theme. These papers will be published in a special issue of a peer-reviewed journal by the end of 2015.