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PRACTICAL APPROACHES FOR REDUCING OCEAN NOISE ASSOCIATED WITH OFFSHORE RENEWABLE ENERGY DEVELOPMENT

GLOBAL ALLIANCE FOR MANAGING OCEAN NOISE (GAMeON)

JULIETTE A. LEE, BRANDON L. SOUTHALL

A REPORT ABOUT QUIETING WORKSHOP ONE

Practical Approaches for Reducing Ocean Noise Associated with Offshore Renewable Energy Development

Global Alliance for Managing Ocean Noise
Juliette A. Lee,[1] Brandon L. Southall,[2,3]

[1]*Nicholas School of the Environment, Duke University Marine Laboratory*
[2]*Southall Environmental Associates, Inc.*
[3]*Institute of Marine Sciences, Long Marine Laboratory, University of California Santa Cruz*

Executive Summary

Workshop One: 'Practical Approaches for Reducing Ocean Noise Associated with Offshore Renewable Energy Development' fostered a productive setting for stakeholders across international governing bodies, industry leaders, non-governmental organizations, and academia to debate, break down barriers, and ultimately develop data-informed and technologically advanced solutions. The workshop culminated by identifying and proposing opportunities for actionable next steps. GAMeON recommends the following actions: (1) develop a noise abatement technology decision aid; (2) establish a risk assessment protocol which evaluates potential impacts, guides informed monitoring approaches, identifies outstanding research questions, and meets legal requirements; and (3) build robust regulatory standards for noise reduction and attenuation.

Approach

Multi-sectoral dialogues provide the capacity to address ocean quieting in a way that initiates actionable steps. Through multi-sectoral implementation of principal ocean management tools, we have an opportunity to achieve the United Nations Sustainable Development Goals (SDG). SDG14 is about "Life below water" and is one of the 17 Sustainable Development Goals established by the United Nations in 2015. Multi-sectoral mechanisms are the most effective at reconciling the ecological, governance, and social dimensions of an ocean challenge, in this case ocean quieting (Reimer et. al, 2020). While implemented more broadly for SDG14, constructive dialogue must be implemented for ocean noise.

The blue-acceleration, i.e., the growth in ocean-based economic activity, must be balanced with conservation of marine resources. Use of marine resources leads to conflicts between sectors, such as industry versus government, at different levels of organization, and at multiple spatial and temporal scales (Klinger et al., 2018). The continued growth of offshore renewable energy, shipping, and geophysical exploration will likely lead to an increase in cross-sector conflicts. In the European Union, a new strategy has been adopted that seeks to achieve both sustainable marine resource use and economic expansion. Multi-sector management of ocean noise is complicated by the spatial and temporal scales of marine mammal life functions (Schupp et al., 2019). Single sector and multi-sector management frameworks must be used in concert to maintain pace with changing ecological, governance, and social conditions (Schupp et al., 2019).

By providing a setting for multi-sectoral dialogues, participants can overcome obstacles to multi-sectoral management by addressing the lack of information and how decisions made in one sector can impact another sector. Multi-sectoral dialogues build connectivity between sectors "in spatial, temporal, provisional, and functional dimensions" (Schupp et al., 2019) to collaboratively solve ocean noise.

The Global Alliance for Managing Ocean Noise (GAMeON) is an international partnership of proactive and action-minded scientists, managers, policy makers, and industry representatives fostering inclusive dialogues to fuel creative, workable solutions that will transform ocean noise management (GAMeON, 2022). GAMeON is developing responsible, modern, integrated, and informed solutions for

managing anthropogenic ocean noise with three key actionable goals:

- Scan horizons to proactively identify emerging concerns and solutions;
- Map existing and emerging knowledge on ocean noise, technology, and policy;
- Create inclusive dialogues and networks to collaboratively solve ocean noise issues globally.

The GAMeON Quieting Workshop Series intends to foster collaborative conversations among key, multi-sectoral attendees. Workshops focus on three key topics around the theme of practical approaches for reducing ocean noise: (1) offshore renewable energy development; (2) geophysical exploration; and (3) shipping. The sequential series will culminate with a symposium that will synthesize the current state of science and technology from the three workshops and will develop strategic, actionable next steps.

Primary Research Questions:

1. How can multi-sectoral dialogues be used as a tool to drive noise reduction from anthropogenic sources, including offshore renewable energy, shipping, and seismic exploration?

2. What barriers exist between sectors to implementing ocean quieting approaches for offshore renewable energy development?

Methods

A group of stakeholders were selected based on a criterion of having equal representation across sectors: government, private, non-governmental organization, and academia (Table 1). Recruiting experts across these different sectors to be informants was not even, thus there is an uneven number of participants for the panel across sectors, as shown in Table 1. Having additional representation across different levels of organization (e.g., between and among individuals, groups, nations, etc.) and operating at multiple spatial scales was important to gain a holistic understanding. Thus, participants were recruited from a global network of ocean noise and offshore renewable energy experts.

Table 1. Stakeholder entities were invited to represent their sectors during the workshop's panel discussion. (Source: Lee, Juliette 2022)

Public / Governmental Organization	Private	Non-Governmental Organization	Academia / Research
Department of Energy (DOE)	SMRU Consulting	International Fund for Animal Welfare (IFAW)	Bioacoustics Research Program, Cornell University
Department of Interior: Bureau of Ocean Energy Management (BOEM)	Heerema Marine Contractors Nederland SE	Wildlife Conservation Society	Bioacoustics and Engineering Laboratory, Duke University
National Oceanic and Atmospheric Administration (NOAA): Office of National Marine Sanctuaries	Orsted	International Union for Conservation of Nature (IUCN)	Southall Environmental Associates
Joint Nature Conservation	Shell Renewables	Natural Resource Defense	Marine Acoustics Inc.

Committee		Council (NRDC)	
	Shell	Ocean Conservation Research	Institute for Technical and Applied Physics (ITAP)

Informants were invited to participate as either a panelist or a presenter. A preliminary research survey was administered to the workshop participants (n = 13, Figure 1), both presenters and panelists, with the intention of gaining their initial perspective on practical approaches for reducing ocean noise associated with offshore renewable energy. The survey also provided an opportunity for those who may typically be less likely to voice their perspective in a panel discussion. The survey questions addressed both the primary research as well as specific topic interest for the panel.

The workshop agenda was developed to reflect pressing challenges and opportunities:

Presentations (60 minutes)
Theme: Local to global

- Baseline Monitoring with Wildlife Conservation Society (10 min)
- Noise mitigation engineering solutions (20 min)
- Wildlife and Offshore Wind (5 min)
- New Risk Assessment Methods (10 min)

Discussion (60 minutes)
Theme: Synthesis assessment with actionable solutions

- Noise mitigation and management lessons learned (20 min)
- Pairing noise monitoring and mitigation requirements for ongoing developments of noise management (10 min)
- Creating action items (10 min)

Results

Survey Results

Survey participants were asked to provide their perspectives on (a) what barriers they think exist between sectors to implementing ocean quieting approaches for offshore renewable energy development, (b) what action(s) can be taken to best manage ocean noise associated with offshore renewable energy development, and (c) what are the most promising solutions to minimize ocean noise associated with offshore renewable energy development. Questions (a) and (b) were coded with the meeting minutes and workshop transcript in NVivo to explore opportunities and barriers. Regarding (c), out of all of the surveys (n = 13), ten identified direct noise mitigation approaches during discrete phases of the development process as the most promising area for minimizing ocean noise associated with offshore renewable energy development, as shown in Figure 1. This was closely followed by mitigation hierarchy or other risk assessment tools and engineering solutions.

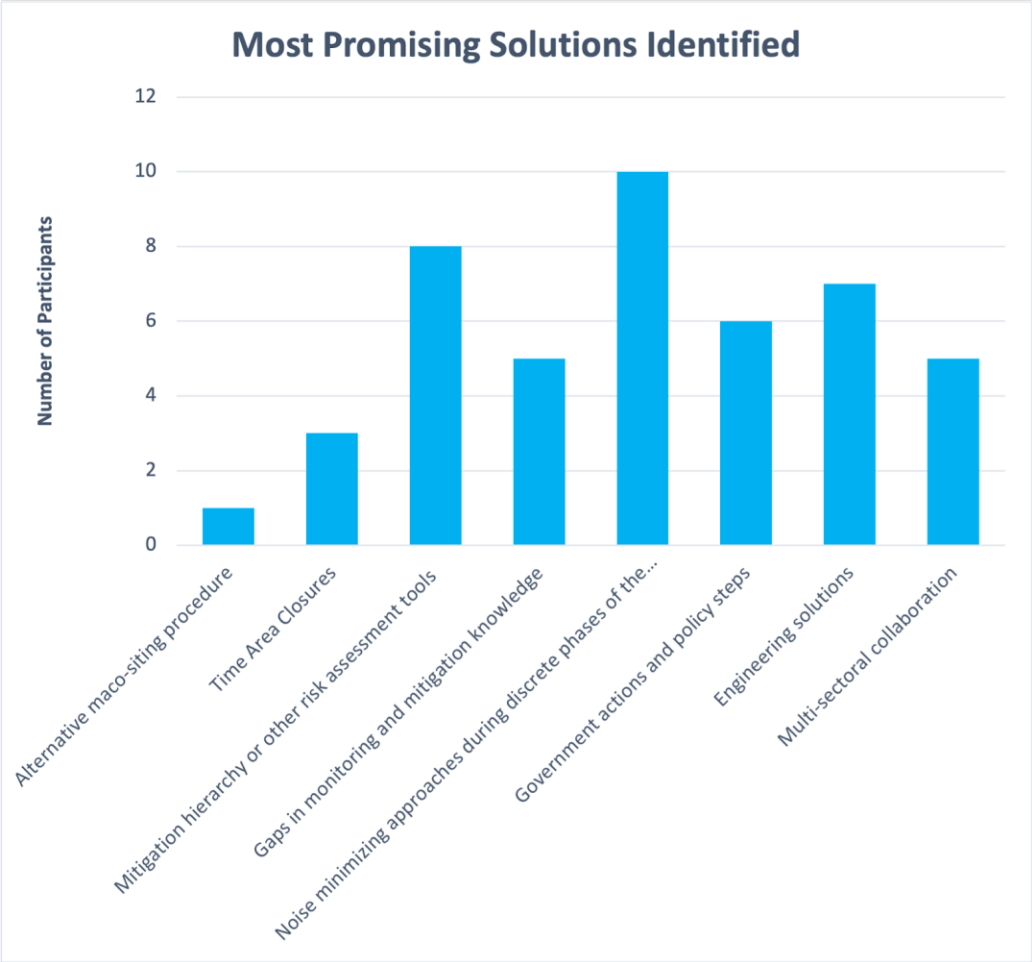

Figure 1. Solutions selected by survey participants (n = 13) as the most promising to overcome the challenge of ocean noise as it relates to offshore renewable energy development. (Source: Lee, Juliette 2022)

Quieting Workshop One

Workshop One: 'Practical Approaches for Reducing Ocean Noise Associated with Offshore Renewable Energy Development' fostered a productive setting for multi-sectoral dialogues. Stakeholders across sectors debated, broke down barriers, and developed data-informed and technologically advanced solutions. The focal topics of the workshop included lessons learned from different projects and experiences and pairing monitoring and mitigation requirements for ongoing developments in science and research. This workshop culminated by identifying and proposing opportunities for actionable next steps.

The workshop attracted a large number of registrants (n = 438), a significant number of audience attendees (n = 266), and expert participants (n = 20) on March 3, 2022. A total of 44 questions were asked by audience attendees of the expert participants, and several attendees requested information regarding subsequent GAMeON workshops.

Social Impact Analysis

From the workshop, opportunities and barriers were analyzed using NVivo, a qualitative data analysis software, to code the survey's long-answers, workshop meeting minutes, and workshop transcript. The following barriers and opportunities were identified as nodes: sectoral conflicts, ecological interventions, governance

interventions, social interventions, and technology. Sub-nodes were identified within each, as seen in Figure 2. The following social impact analysis of the workshop can be used by the GAMeON Sounding Board to facilitate discussion during subsequent workshops and the synthesis symposium.

The framework used identifies three distinct ocean quieting approaches: (i) ecological interventions, (ii) governance interventions, (iii) social interventions or behavior change. These categories and conservation interventions were adapted from IUCN's CMP Conservation Actions Version 2.0 and Brooke et al. 2020.

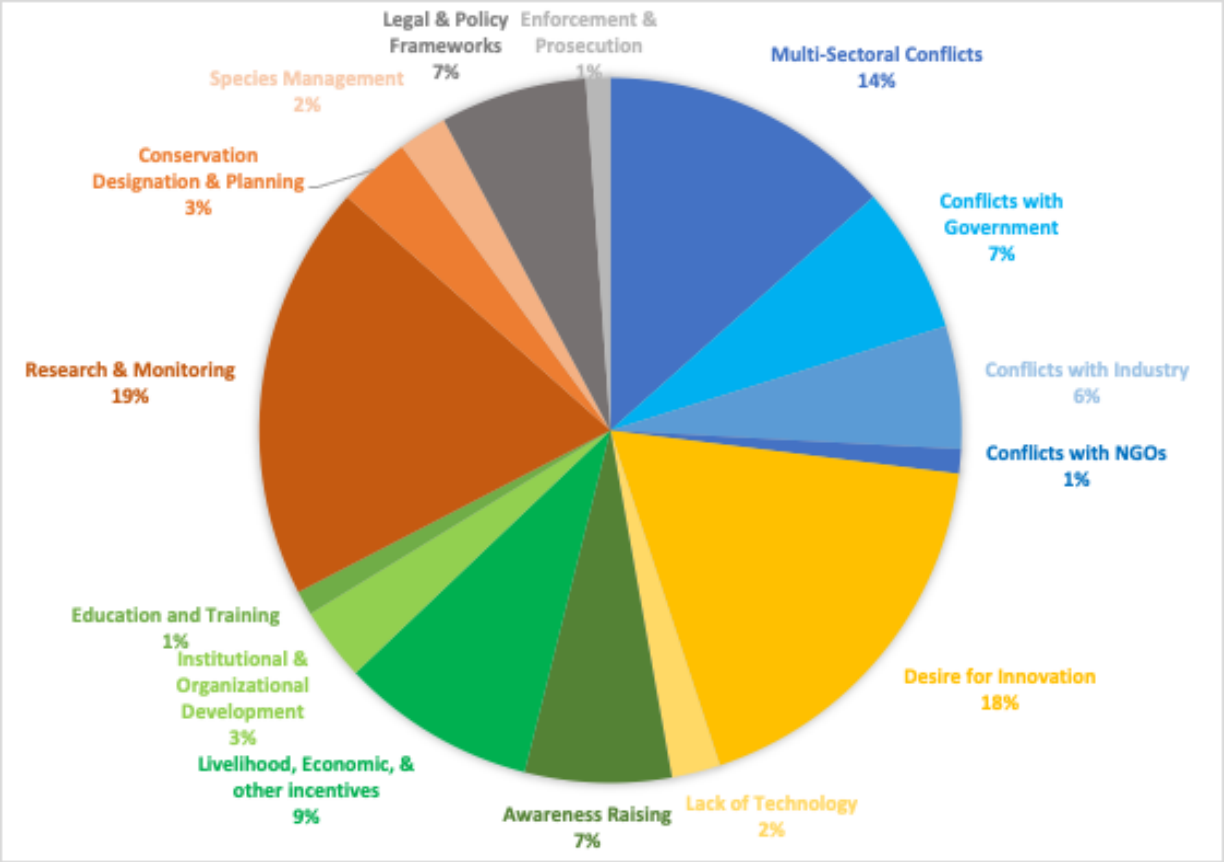

Figure 2. Pie chart of identified barriers and opportunities compared by the percentage of the number of times they were coded. The chart is color coded by identified nodes: sectoral conflicts are blue, technology is yellow, social interventions are green, ecological interventions are orange, and governance interventions are grey. (Source: Lee, Juliette 2022)

Certain barriers and opportunities that arose regarding sectoral conflicts included unilateral conflicts with government, industry, and NGOs, as well as multi-sectoral conflicts. Regarding conflicts with the government (n = 6 references), a participant identified "a lack of dialogue between contractors and regulators to ensure regulations can be implemented practically during operations." Several participants stated that regulations are often strict but not realistic or practical. Additionally, an industry participant said that the United States' Bureau of Ocean and Energy Management (BOEM) was easy to work with while other US government agencies struggled to provide "information and regulations on mitigations." Another challenge identified was how many non-governmental stakeholders experience reluctance in reaching out to government stakeholders– a government participant encouraged non-governmental participants to reach out. Regarding conflicts with industry (n = 5), several participants pointed

out that industry members are eager to implement technologies as soon as possible so that they may "come into revenues [as soon as possible]." Industry participants were encouraged by other participants to disassociate energy development from economic growth. Conflicts with NGOs were limited (n = 1), yet industry participants argued that environmental NGOs are the "counter drivers" to rapid development. Conflicts with academia did not arise in this data.

Multi-sectoral conflicts were the most common (n = 12), where no specific sector was targeted as the culprit of "mistrust, lack of communication, lack of coordination, different goals, [and] different 'languages'" and "over-conservatism." While participants identified offshore renewable energy development as a positive outcome, stakeholders across sectors identified different challenges to the implementation. While multiple participants identified these conflicts as barriers to ocean quieting, many also identified the exact opposite as a clear opportunity. One participant emphasized: "There needs to be buy-in, collaboration and understanding from all sectors in order to successfully implement effective mitigation and noise reduction strategies." Knowledge sharing and confidence building were seen as opportunities for all stakeholders. By sharing a common understanding of each other's concerns, stakeholders may be able to compromise or come to a consensus on quieting capabilities.

Barriers and opportunities arose around ecological interventions, including conservation designation and planning, research and monitoring, and species management. Participants suggested opportunities around conservation designations: time area closures and mitigation hierarchy. Research and monitoring were the most frequently coded area (n = 17). A participant emphasized the importance of "gathering *in situ* empirical data and not just relying on [acoustic] model predictions" and had support from others. Risk assessment was identified as an important aspect that must be conducted prior to development. Monitoring of species was identified as imperative through the entire development and operations process. Species management was considered (n = 2) in conjunction with risk frameworks and applying the precautionary principle. There was additional emphasis on the importance of continued research and development around technological interventions, such as noise abatement, mitigation, and other alternatives.

Regarding governance interventions, barriers and opportunities were considered about both enforcement and prosecution (n = 1) and legal and policy frameworks (n = 5). Regarding enforcement, a participant emphasized the importance of being strict, yet also emphasized the importance of being realistic with the challenges of implementing quieting methods. Regarding legal and policy frameworks, one participant encouraged a restriction of "harmful sound generating activities during times of higher marine mammal presence," such as seasonal closures to construction. A participant suggested a specific regulatory measure, such as a noise cap. A pattern of barriers arose about how regulations are not clear. A consistent opportunity arose in response: transparency throughout policy and legal procedures at all government levels. Another barrier identified in this area is that regulations may be too focused on per-project scales and should be more holistic for longer term success.

For the barriers and opportunities of the social interventions, the following were considered: awareness raising (n = 6), education and training (n = 1), institutional and organizational development (n = 3), and livelihood, economic, and other incentives (n = 8). Participants emphasized the importance of increasing awareness to drive a commitment to good practices of noise mitigation. Increasing awareness is not only important at the stakeholder level, but one participant pointed out that "grass-root community engagement" could provide opportunities to generate consensus on the importance of reducing noise. Technology awareness was identified as important to regulators. A disconnect exists between new and emerging technology and what regulators are aware of– a regulator suggested that due to their workload, "information needs to be spoon fed" to

them to be implemented. Additionally, an emphasis on "centralized, standardized, accessible, transparent data" was paired with a suggestion for a "repository of information." Several participants are dissatisfied with the current data streams. A barrier that arose multiple times was the challenge of cost feasibility but was also paired with the opportunity to use economic incentives to push industry toward quieting. One participant pointed out that there is technical readiness yet cost limitations. An industry participant was in favor of a cost incentive for developers to expedite the development timeline, effectiveness, and resources. Additionally, a government representative offered the idea of federal funding opportunities to justify this.

Technology was discussed as both a lack of (n = 2) and a desire for innovation (n = 16). A common theme of lack of technology arose, specifically regarding quieting around installation, maintenance vessels, and construction. Yet, this theme was often paired with a strong desire for increased technological innovation. Several participants suggested alternative foundations to reduce the noise impacts of pile driving, as shown in Figure 3 and others suggested a required use of current noise-abatement technologies such as bubble curtains and resonant curtains. There was a desire to bring new noise mitigation technologies to market, including direct drive turbines that eliminate the gear-box noise and vibration-isolation of moving parts such as the mast, stanchions, and bases. Others suggested considering the difference between protecting high-frequency species, such as harbor porpoises, and low-frequency species, such as North Atlantic right whales. This was particularly important as there was some push-back against simply taking lessons-learned from the European examples, where high-frequency species might be more of a concern. While lessons learned from Europe are important, the marine mammals present may differ from those that reside on the US Atlantic coast. The low-frequency great whales have not yet been not considered in Europe given the current location of wind leases, which are mainly North Sea., but instead a short list of cetaceans and phocids were, as listed in Annex II and IV of the European Union's Habitats Directive, as shown in table 3.

Figure 3. Offshore wind foundation types. Left to right: monopile, jacket, twisted tripod, floating semi-submersible, floating tension leg platform, and floating spar. (Source: Illustration by Josh Bauer at the National Renewable Energy Laboratory, 2021)

Table 3. Marine mammal species included in Annex II and IV of the Habitats Directive in Europe. (Source: European Environment Agency, 2019)

Species	Common Name	Annex II (Natura 2000)	Annex IV (strictly protected)
Cetacea			
Phocoena phocoena	Harbour Porpoise	Y	Y
Tursiops truncatus	Bottlenose Dolphin	Y	Y
Cetacea (all other species)	Whales, dolphins, porpoises	N	Y
Phocidae			
Halichoerus grypus	Grey seal	Y	N
*Monachus monachus**	Mediterranean monk seal	Y	Y
Pusa hispida botnica	Baltic ringed seal	Y	N
*Pusa hispida saimensis**	Saimaa	Y	Y
Phoca vitulina	Harbour seal	Y	N

*priority species, for the conservation of which the EU has particular responsibility because of the proportion of their natural range which falls within the European territory of the Member States to which the treaty establishing the European Economic Community applies.

Action Items and Recommendations

Workshop One: 'Practical Approaches for Reducing Ocean Noise Associated with Offshore Renewable Energy Development' created a space for constructive dialogue. Through the survey results and social impact analysis many barriers and opportunities surfaced that provide the GAMeON Sounding Board with direction, as shown in table 4. Additional conversations, specifically relating to offshore renewable energy development is advisable since this first workshop provided only a short period of time to explore this complex challenge. Yet, clear patterns of barriers, such as sectoral conflicts and regulatory transparency, and clear patterns of opportunities, such as knowledge sharing and technology advancements, shows like-minded perspectives amongst the stakeholders.

Constructive dialogue creates ample opportunity to explore sectoral conflicts, ecological, governance, and social interventions, and technology. Implementing the action items and recommendations provided below, combined with innovative technology as shown in table 5, creates opportunities for stakeholders across sectors to reduce ocean noise throughout the entire development process.

Table 4. Action items and recommendations for reducing ocean noise. (Source: Juliette Lee, 2022)

Intervention Category	Action Items	Recommendations
Ecological Interventions		
Conservation Designation and Planning	• Time-Area Closures	• Use of mitigation hierarchy
Land / Water Management		
Research and Monitoring	• Gather in-situ empirical measurements • Perform a noise risk assessment prior to development • Monitor sound production and impact radius through all phases of development	• Research and development incentives, e.g. interagency prize opportunities
Species Management	• Update risk framework for protected species and habitats	• Apply the precautionary principle
Governance Interventions		
Enforcement & Prosecution		• Ensure regulations are strict but realistic and practical
Legal and Policy Frameworks	• Seasonal restrictions • Noise reduction and attenuation standards: species-dependent noise mitigation values (behavior/injury), site-specific transmission loss, frequency-depending weighting functions, piling sequence including soft-start and blow rate	
Social Interventions		
Awareness Raising	• Industry guidelines	• Increase awareness of technology innovations • Engage communities • Additional opportunity for multi-sectoral dialogue
Education and Training		• Educating regulators on the availability of mitigation technologies
Institutional / Organizational	• Repository of information	

development	with centralized and transparent data	
Livelihood, Economic, and other incentives		• Market-based incentive programs for industry • Bringing new noise mitigation technologies to market • Innovative funding mechanisms e.g. prizes

Table 5. Noise abatement technology options for reducing ocean noise, with gaps in information where measures have not been explored. (Source: Michael Bellman, 2022)

Noise Mitigation Measures	Details	Advantage	Disadvantage
Reduced impact pile-driving energy		State-of-the art; HiLo Procedure incl. latest hammer type and hammer used by 50 to 70% capacity	
Vibro-piling	Continuous Noise		Continuous Noise Limited knowledge regarding impact assessment and currently not a proven installation method; not viable for all projects
Suction Buckets			Not viable for all projects
Gravity foundations			Not viable for all projects
Blue Piling Hammer			Prototype, currently not available
New hammer technologies: PULSE / MNRU			First offshore tests in 2022
Noise Abatement Systems (NAS)			
Bubble Curtain System			
Guided & Unguided Small Bubble Curtain	Only prototypes available	Will be used for jacket installations in post-piling. Air will be delivered to grouting lines in the gap between pile sleeve and pile Grout Annulus Bubble Curtain (GABC)	Not proven technique for Monopiles; requires project specific design for Jacket foundation; limited noise reduction in unguided conditions due to current

Small Bubble Curtain (Menck)			Prototype, currently not available
Double Big Bubble Curtain	Far-from-pile NMS; impedance shifts (water vs. water-air mixture) Water Depth: ≤ 45 m (UXO clearance ≤ 70 m) Pile Diameter: ≤ 8 m Components: Compressed air, nozzle hose on sea bed	Has been applied; independent of foundation design; independent of installation vessel (pre-laying) Measured Noise Reduction: Δ SEL = 15 to 16 dB	Separate vessel and compressors required; coordination with installation vessel and nozzle hoses; noise reduction depends on water depths, current, direction, shape, distance between foundation and nozzle hose, number, length, and distance between nozzle hoses, used air flow and pressure distribution, used hole configuration, maintenance of used nozzle hoses
Shell-in-Shell System			
Noise Mitigation Screen (IHC)	Close-to-pile NMS Water Depth: ≤ 40 m Pile Diameter: ≤ 8 m (sizeable shells)	Has been applied; pile guiding system integrated; inclination measurement tool integrated; independent of water depth and direction Measured Noise Reduction: Δ SEL = 13 ≤ 15 ≤ 17 dB Latest generation 15 to 17 dB	Weight; dimensions; ground coupling effects; application at varied depth; increased safety risks during deployment; requires re-design for floating installation vessel
Cofferdam & shell-in-shell constructions			Prototype, currently not available
BeKa shell (Weyres Offshore)			Prototype, currently not available
Fire Hose Method (Menck)			Prototype, currently not available
Other Systems			
Pile wrapped with foam			Prototype, currently not available
Hydro Sound Damper (HSD)	Resonator System and Close-to-Pile NMS Water Depth: ≤ 45 m Pile Diameter: ≤ 8 m	Has been applied; light-weight; HSD-elements taunable (frequency > 500 Hz); independent of water depth and current	Ground coupling effects; Ballast box includes lifting tool; lifetime of HSD elements is 20-30 times; requires project

	Components: Net, HSD elements, ballast box	Measured Noise Reduction: Δ SEL = 10 ≤ 11 ≤ 12 dB	specific design
Resonator system			Prototype, currently not available
HydroNas			Prototype, currently not available
AdBm System by AdBM Technologies	Resonator System and Close-to-Pile NMS Water Depth: ≤ 30 m Pile Diameter: ≤ 8 m Components: Vertical shape blocks and lifting tool	Light-weight; block shapes partly tunable (frequency < 500 Hz); independent of water depth and current Measured Noise Reduction: Δ SEL = < 10 dB (1st application)	Ground coupling effects; only prototype available (not much experience); lifting tool; requires project specific design

Call to Action

Moving forward, the Global Alliance for Managing Ocean Noise (GAMeON) recommends the following three concrete and specific deliverables for specific parties, as identified by participants during the workshop:

1. *Develop a noise abatement technology decision aid* for industry members and governing bodies to use to identify which of the following four Noise Abatement System (NAS): Double Big Bubble Curtain, Noise Mitigation Screen (IHC), Hydro Sound Damper (HSD), or AdBm System by AdBM Technologies, or a combination should be used for a particular lease area. This decision aid will incentivize technological advancements and streamline implementation during all stages of development.

2. *Establish a risk assessment protocol* which evaluates potential impacts, guides informed monitoring approaches, identifies outstanding research questions, and meets legal requirements established by the governing body. The risk assessment protocol will drive informed monitoring, such as in the U.S. for species protected under the Marine Mammal Protection Act (MMPA) of 1972 and the Endangered Species Act of (ESA) 1973.

3. *Build robust regulatory standards* for noise reduction and attenuation which can be used internationally to increase the transparency and consistency of requirements. The regulatory standards will assist in overcoming some of the multi sectoral conflicts identified during the workshop.

Contact Us

Should you have questions or interest in getting involved with GAMeON, reach out to GAMeON Secretariat Juliette Lee at Juliette.Lee@boem.gov.

Citations

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