

Overview of the Fifth International Conference on the Effects of Noise on Aquatic Life

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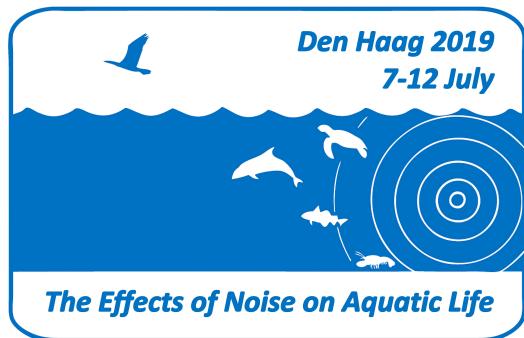


5th International Conference on the Effects of Noise on Aquatic Life

Den Haag, The Netherlands

7-12 July 2019

Meeting Overview: AN2019



Overview of the Fifth International Conference on the Effects of Noise on Aquatic Life

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The Effects of Noise on Aquatic Life took place in Den Haag, the Netherlands, in July 2019. The potential effects on animals ranging from plankton, shrimps, crabs, and lobsters, to fishes, seals, dolphins, and whales were discussed. Reported effects include behavioral responses, auditory masking, cardiac rate changes, stress, a temporary loss of hearing, and perhaps more serious tissue and organ damage. Short-term and long-term, individual and population-level effects were portrayed. Several studies also looked at the fundamentals of animal sound production and perception. One session dealt with the regulation and management of underwater noise. Another integral part of the meeting focused on the sounds and sound sources that might affect aquatic life. As a consequence, underwater noise from pile driving, seismic surveying, shipping, and sonars, as well as from non-anthropogenic sources such as wind and waves was examined. The social program was intended to encourage more leisurely discussions amongst conference participants in order to facilitate networking and the strengthening of relationships. The feedback from conference delegates (submitted via an online survey after the meeting) was very positive.

1. INTRODUCTION

The Effects of Noise on Aquatic Life is a topic of growing international concern and research. Underwater noise originates from marine traffic, port construction, offshore petroleum and mineral exploration and production, marine renewable energy plants, fisheries, defense operations, surveying, scientific research, etc. The potential impacts on marine life range from none or mere detectability of associated sound, to acoustic masking, behavioral responses, stress, temporary hearing loss, and more severe physical and physiological effects such as organ and tissue injury that may lead to death.

Anthony D. Hawkins, Arthur N. Popper, and Magnus Wahlberg initiated a conference series on the effects of noise on aquatic life in Nyborg, Denmark in 2007 (Hawkins et al., 2008). The striking success of this meeting led to additional meetings on the same topic. The second such meeting, organized by Hawkins and Popper, was in Cork, Ireland in 2010 (Popper and Hawkins, 2012), and the third in Budapest, Hungary in 2013 (Popper and Hawkins, 2016). The fourth meeting, organized by Christine Erbe, Anthony D. Hawkins, Arthur N. Popper, Joseph Sisneros, and Frank Thomsen, took place in Dublin, Ireland in 2016 (Erbe et al., 2016). Den Haag was selected for the fifth meeting for a number of reasons: 1) It is located somewhat in the center of European activity surrounding the effects of noise on aquatic life; 2) it is easily accessible from anywhere in the world (via a brief train ride from Schiphol international airport); 3) the Kurhaus, in particular, met all the requirements for this meeting's venue, in addition to being quite stunning and right at the beach; and 4) there were ample opportunities for evening outings at the end of a busy day at the conference, daytime activities for accompanying persons, and vacation destinations for families.

This conference series continues to bring together scientists, regulators, environmentalists, and industry representatives to learn about and discuss the potential effects of man-made noise on aquatic organisms. Emphasis is on cross-fertilization of ideas and findings across species and noise sources. This kind of sharing of material is of exceptional value since there are many commonalities in issues that never get appreciated except at meetings that cross disciplines and ideas. Participants learn about matters that they normally do not encounter. For example, scientists learn about the concerns of regulators, while industry representatives learn about the latest data, etc.

The number of participants at the conferences continues to be strong. There were 202 delegates and 134 presentations in Nyborg: 244 delegates from 22 countries and 111 presentations in Cork; 243 delegates from 24 countries and 125 presentations in Budapest; 323 delegates from 23 countries and 229 presentations in Dublin; and 312 delegates from 29 countries and 214 presentations in Den Haag.

This POMA volume contains articles based on several of the papers presented at the Den Haag meeting. There also is a special issue in *The Journal of the Acoustical Society of America* (JASA) on *The Effects of Noise on Aquatic Life*, selected by some authors for the benefit of peer-review. Submission to either POMA or JASA was not a requirement unless presenters received funding from the conference to attend. Fifty-nine people, including all students and postdocs who requested support, were funded thanks to our generous supporters (see Acknowledgements).

2. SCIENTIFIC SESSIONS

Presentations were a mixture of 15-minute oral presentations, 4-minute speed talks (with posters), and posters. Each speed talk presented the highlights of an accompanying poster of the same title. There were also four 40-minute keynote presentations. The following sections give brief summaries of oral and poster presentations by themes.

A. KEYNOTE PRESENTATIONS

Brigitte Schulte-Fortkamp (Technical University of Berlin, Germany) opened the meeting with her keynote about the concept of soundscape from the human and terrestrial perspective. She reminded us that in studies on humans, soundscape is a perceptual construct: Humans "create" soundscapes in their brain from the various acoustic stimuli they receive. This is not fundamentally different from what animals do but it imposes interesting challenges when studying the topic in marine life. Georg Klump (University of Oldenburg, Germany) gave an interesting insight into perception and acoustic ecology. He gave examples from his long-term research on birds and mammals to understand how signal processing has been optimized in the acoustic background provided by the environment. Tim Leighton (University of Southampton, UK) talked about ultrasound impacts on humans and described how sounds you cannot hear can still harm you. Finally, Jill

Lewandowski (Bureau of Ocean Energy Management, USA) took us on a tour around the globe when describing harmony and discord in international regulation of underwater sound.

B. SOUNDSCAPES

This topic covered riverine, estuarine, coastal to offshore, and submarine canyon soundscapes. We heard about soundscapes ranging from the Arctic to the Antarctic. While most soundscapes were impacted by anthropogenic activities, we also discovered some pristine soundscapes. Soundscapes were not only recorded, monitored, analyzed, and quantified, but also modeled, mapped, and planned. Some presentations were based on impressively long-term monitoring of ambient noise to identify trends in Europe and beyond, useful for management (e.g., for the EU Marine Strategy Framework Directive, MSFD). Soundscapes were also analyzed for biological purposes, for example to investigate biodiversity in specific habitats.

C. ACOUSTICS

Several presentations focused on underwater acoustics and the characteristics of anthropogenic sound. While we're continuing to learn about commonly studied sound sources such as pile driving, seismic surveying, shipping, and sonar usage, we also had presentations on less-common sources such as tidal turbines, seal scarers, acoustic deterrence devices, pipeline installation, explosives, vibroseis, hydroelectric dams, and weirs. Some sound features, such as kurtosis (roughness), were demonstrated to be useful in classifying anthropogenic sounds and in estimating sound exposure. More measurements of particle motion from human activities such as offshore wind farm construction and shipping were presented than previously. Finally, there were talks on important acoustic concepts such as damped cylindrical spreading when studying the impacts from offshore wind farms and seismic surveys.

D. HEARING, MASKING, AND EFFECTS ON SOUND COMMUNICATION

This category covered hearing anatomy in cetaceans including mysticetes. New data from experimental hearing studies in fishes, seabirds, and seals were presented as well. Estimating communication range and echolocation range was a common topic. Masking, including the Lombard effect, was studied, for example in minke whales and bowhead whales. We further learned more about self-mitigation capabilities such as animals adjusting their hearing thresholds in expectation of strong sound exposure.

E. EFFECTS ON BEHAVIOUR AND PHYSIOLOGY

With 22 oral presentations and a large number of speed talks and posters, studies covering the effects of noise on behavior and physiology made up the largest theme at AN2019. This is in line with the focus of the meeting on biological effects of aquatic noise. Effects were studied in a wide range of taxa, from pearl oysters to humpback whales. Stimulus sounds included well-known sources such as naval sonars, impact pile driving, and airguns. Less-studied sources such as underwater blasts and vibratory piling were also discussed. Reported animal reactions included startle responses, avoidance, TTS, injury, stress, and metabolic changes, and no apparent reaction to underwater noise at all.

F. IMPACTS AND LONG-TERM EFFECTS

Building on the previous topic, the presentations in this category attempted to answer the "so what?" question about, for example, the population consequences of behavioral responses. New ways to inform population models were presented, such as Agent Based Modeling (ABM). It is promising that some of the datasets now used for such studies are very comprehensive. We heard that noise may push predator-prey relationships out of balance or affect symbiotic relationships. One presentation addressed synergistic versus antagonistic impacts of acoustic and non-acoustic (i.e., chemical) stressors. Potentially long-term stress responses were investigated in fishes and marine mammals.

G. REGULATION, MONITORING, AND MANAGEMENT

Talks and posters under this theme introduced regulation and management of noisy activities in different countries. The updated NOAA guidelines on assessing noise impacts were presented, as were initiatives in Canada to set new frameworks and management measures to reduce shipping sound, such as at the Port of Vancouver, B.C. Sound mitigation techniques for pile driving and other activities were studied and reviewed, and standards for auditory threshold experiments discussed.

3. RODNEY COATES AWARD

The Rodney Coates award for the best student presentation was made through the generosity of his family. This initiative was first launched at AN2016 in Dublin. The late Rodney Coates attended several of our meetings and he was avidly interested in the whole discipline and spent a lifetime supporting early career researchers.

In 2019, 29 entries were received from around the globe on subject matters including underwater sound sources and propagation, animal underwater hearing and masking, animal behavioral responses, acoustic ecology, and others, covering a wide diversity of aquatic species. Candidates for the Coates award either had to be registered graduate students or had to have received their doctorates in 2019 from a recognized college or university in any country. Each candidate was assessed for presenting both a speed talk (4 minutes) and a poster on their work. A team of eight expert judges drawn from the scientific community at the conference were asked to judge both the talk and poster. The 2019 judges were Giacomo Giorli, Vincent Janik, Nathan Merchant, Mirjam Müller, Vanesa Reyes, Amy Scholik-Schlomer, Hans Slabbekoorn, and Kathy Vigness-Raposa.

The standard of the work presented was agreed by all to be extremely high and praise was raised on all of the presentations and posters. Both poster and oral presentations were very well attended and received. The judges did have a very hard time separating winners because of this consistently high standard. As a result, one overall winner was selected as well as three joint second places.

The winner of the cash prize of £1000 was:

Annebelle Kok from the Institute of Biology, Leiden University, the Netherlands, with her work titled “Does local variation in acoustic experience affect noise impact on anti-predator behavior in sand gobies?”

In joint second place each receiving a cash prize of £250 were:

Steffen De Vreeze from the Department of Comparative Biomedicine and Food Science, University of Padova, Italy, and the Laboratory of Applied Bioacoustics, Technical University of Catalonia, Spain, with his work titled “Comparative morphology of the external ear canal in several species of odontocete”.

Tobias Schaffeld from the Institute for Terrestrial and Aquatic Wildlife Research, Germany, for his work titled “Effects of multiple exposure to pile driving noise on harbor porpoise hearing during simulated flights – a risk evaluation tool”.

Katherine Whyte from the University of St Andrews, UK, for the work titled “Behavioral responses of seals to pile driving during offshore wind farm construction”.

The awards were made during the conference closing session on Friday 12th July by Damion Coates, Rodney’s son, on behalf of the Coates family.

4. SOCIAL PROGRAM

On Sunday night before the conference, a welcome reception was held in the Kurzaal of the Kurhaus. A hot and cold buffet dinner was served, accompanied by a local pianist. The conference opened on Monday morning with live music by our colleague Christ de Jong and his wife Jorina. At the end of the day, a personal trainer got us running, hopping, and pumping on the beach. On Tuesday, a public evening was held to which the wider Den Haag community (including school pupils and tourists) was invited. In the tradition of this conference, we finished early on Wednesday afternoon, so that delegates could network or enjoy the local sights with their families. On Thursday evening, the Kurhaus set up a disco and bar under the stars in the glass house. The conference concluded with the banquet in the gorgeous Kurzaal, accompanied by a local chamber orchestra of which Christ de Jong is a member.

5. PARTICIPANT FEEDBACK

An online survey was set up at the end of the conference and 103 participants (32%) responded within two weeks. As seen in Figure 1 (left), there were about equal numbers of males and females attending. Figure 1 (right) shows that the majority of attendees were 30-50 years old, suggesting a significant attendance by active investigators and others. A goal of the meeting was to involve younger people, and this has been successful as shown by over 15% being under the age of 30. Also, Figure 2 indicates that 38% of attendees were students or

postdocs. Attendance of young investigators at our conference series is enabled by strong external grant support.

Figure 2 shows the distribution of positions of responders. Academics, which would include undergraduate students, graduate students, postdocs, and faculty, made up about 50% of attendees. Another goal of the meeting was to attract a diversity of stakeholders, which was achieved as indicated by the large number of individuals from areas outside of research.

Attendees who responded to the survey came from 24 countries (Table 1). Registered attendees came from 29 countries, with Chile, Greece, Ireland, Israel, and South Africa not represented in the survey responses. Table 2 summarizes attendees' scores of a number of specific aspects of the meeting. Based on the percentages of scores 4 or 5 (liked or liked greatly) awarded, there was broad satisfaction with the meeting including accommodations (76%), oral presentations (91%), poster organization and space (over 90%), etc. We are very pleased that VenuesWorld, who handled the logistics of our meeting, received strong support from attendees. Table 3 lists attendee feedback on the scientific content of the meeting. As can be seen, there is a strong consensus that the scientific content was excellent, as further supported by the responses to several of the questions in Table 2.

Figure 1. Left: Gender of survey attendees. Right: Age distribution of responders.

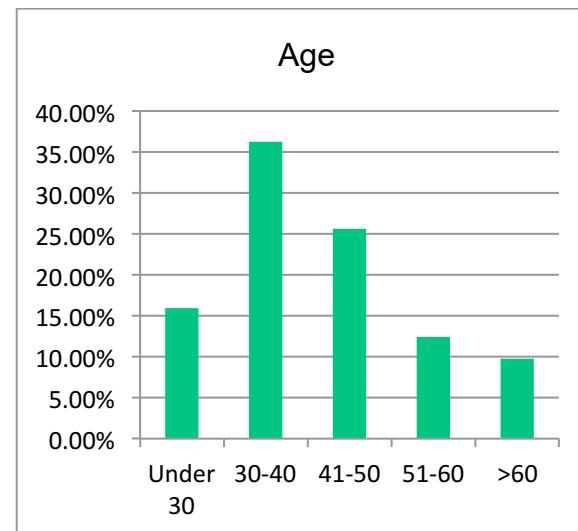
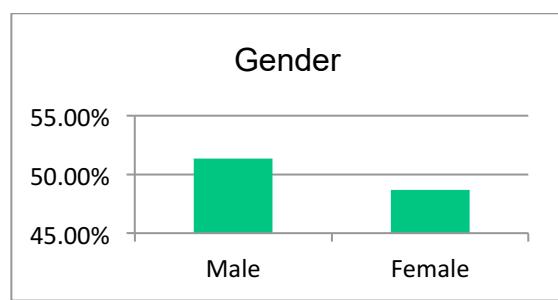


Figure 2. Position of responders.

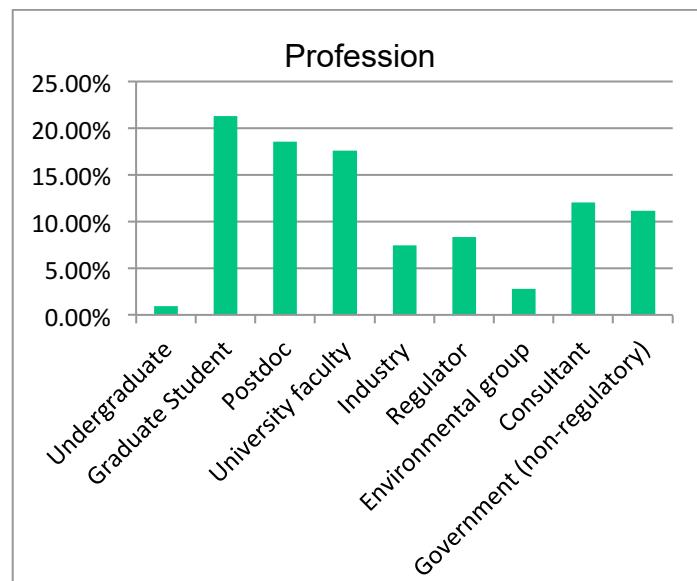


Table 1. Country of origin of 103 responders.

Country	% and Number of Responders		Country	% and Number of Responders	
Argentina	3%	3	Iran	1%	1
Australia	6%	6	Italy	8%	8
Belgium	1%	1	Japan	1%	1
Brazil	5%	5	Netherlands	9%	9
Canada	7%	7	New Zealand	3%	3
China	1%	1	Norway	1%	1
Colombia	1%	1	Portugal	3 %	3
Denmark	1%	1	Russia	3%	3
Estonia	1%	1	Spain	1%	1
France	6%	6	Taiwan	4%	4
Germany	9%	9	United Kingdom	11%	11
India	1%	1	United States	30%	30

Table 2. Scores for different aspects of the meeting (103 responders).

	1 (not liked)	2	3 (neutral)	4	5 (liked greatly)
Accommodations	1%	6%	18%	26%	49%
Lunches	4%	14%	23%	37%	22%
Oral presentations (15-minute talks)	1%	1%	8%	39%	51%
Keynote talks	0%	6%	23%	31%	41%
Poster space	1%	8%	9%	38%	45%
Poster organization	1%	4%	14%	38%	43%
Poster quality	0%	1%	12%	42%	45%
Meeting (lecture) room	2%	1%	14%	31%	52%
Breaks	0%	5%	21%	44%	30%
Social meeting space (bars, seating areas, etc.)	2%	4%	18%	40%	37%
Den Haag as a meeting venue	0%	4%	15%	31%	49%
Services provided by VenuesWorld	0%	0%	13%	35%	53%
Meeting web site	0%	3%	14%	42%	41%
Meeting registration (and its ease of use)	1%	1%	10%	36%	52%
Information provided prior to the meeting	0%	2%	10%	41%	47%
Lightening rounds (speed talks)	0%	2%	4%	39%	55%
Closing banquet	6%	15%	52%	14%	12%
Abstract submission method and site	0%	0%	18%	42%	40%
Time for discussion after groups of papers	3%	10%	22%	42%	23%
Sunday night reception	0%	2%	20%	33%	46%
Your hotel	0%	8%	15%	28%	49%
Coates Award	2%	1%	24%	33%	40%

Table 3. Verbatim responses (unedited other than spelling corrections and removal of duplicate responses from different delegates) to a question asking about the scientific content of the meeting.

Very inspiring.	I learned a lot!
It was superb.	Getting better every year!
The best!	It really went well.
One of the best meetings in a long time.	Excellent.
I thought it was excellent.	Fantastic conference for updates on sound science!
The scientific level of the conference is very high.	Fantastic level of science
Great contents!	Excellent best yet.
Superior!	Outstanding
Very good!!	Very high.
I learnt a lot. Thank you.	Level of the talks could be higher
Excellent meeting!	Outstanding. Thank you!
Excellent content.	Progressive, exciting & thorough.
Excellent standard overall	The content was really interesting.
Great!	Absolutely excellent!
It was great and very helpful.	Average, could be better
It is one of the best conferences I've ever attended.	Generally the content was very good
I think it was great and gets better every year.	Very high quality.
Wonderful. It has been incredibly useful conference.	Not sufficiently "leading edge" due to much of the content already being published.
Really good and accurate, the peak knowledge of the field I would say.	It really inspired me and I came back with new ideas!!
Good, but not fantastic. Some of it is getting old. Need to focus on quality and novelty of findings.	With each conference the level of scientific reports increases.
Excellent content, well organized, thoughtfully presented.	Excellent. AN has become The Meeting to get the idea of the present state of the science in this field.
I like it very much :) Thanks to all for making it an enjoyable experience	High amount of content compared to other conferences.
The relative specificity of the conference mean we get to the edge of the current understanding - this is great!	Overall, I thought it was an excellent meeting with broad, well-balanced content of a very high quality.
I think it was very very interesting and i will be glad to attend the next AN22.	I think the scientific content was quite good and addressed topics, issues, and methods that are at the forefront of our field.
Most talks were highly interesting with good presentation. I would be nice to have a key findings summary by taxa or issue.	Really really good, only the age of some of the studies being presented (see above) I guess, but that might just be me! Thanks for a great meeting!
Again, the conflict-of-interest by the noise producers is the single greatest factor that diminishes the scientific merit of the meeting.	As noted in 12. above, I didn't think I got as much new information as at prior meetings, but nonetheless I am glad that I came.
Interesting and generally good quality. The focus could have been more on impact and (reducing) effects of noise.	I think the quality of presentations was generally very high and provided me with a lot of Input for my own work.
It was a great meeting, Thanks to the organizing committee and to Terry and her team, they have been really great.	The topics are very diversified. It is challenging, but I think the sessions should be more coherent and sequential.

Broad! "Aquatic noise" seems a very specific topic but I was surprised by the variety of talks on this subject! I truly learned so much, thank you for that.	Overall, my impression was positive. I thought the assignment of some talks to the session headings was a bit awkward. Better alignment between the two, if feasible.
I think the scientific content was broad and of high quality. It's good to see more people from developing countries attending the meeting and conducting research on noise topics.	Excellent as always. But, as always, it was very marine-mammal heavy, and I look forward to less of this and more fish/invertebrate work in the future (I know that this is not the organizers' fault though!!)
Great, really liked that invertebrates were included. Was surprised at how many were pile driving and seismic focused and how little sonar was discussed but maybe that is just my bias.	Overall I think it was good, but there were definitely some talks that seemed questionable. I think the discussion session after the talks helps to clear some things up and is good.
The scientific content was of very high level, I learnt a lot, I could discuss with colleagues about different topics of the aquatic noise, it was a really enriching experience. Many thanks to all the organizers for the excellent meeting you organized. I am very happy to have had the possibility to assist and be part of it. Hope to see you in 2022.	As a starting scientist, working in projects for monitoring the Baltic Sea harbor porpoise subpopulation, mostly marine mammals and anthropogenic sounds are interesting for me. This was covered quiet good and a lot possibilities to connect to people having same interests.
This is perhaps almost an inherent comment, but I found some of the research topics difficult to translate the research to a practical setting. I can imagine that policy makers have a hard time slotting these findings into legislation and guidelines which I think is a shame as the research can be of real value. It could also be nice to have a little more feedback from industry on what the current (best) practices are and identify areas which are in need of scientific expansion.	Oral presentations differed a lot in their quality. Student presentations were often better. Too much focused on marine systems and mammals... with many presentations on the same topic. That's boring... Some hot topics (freshwaters, the ecological effects of noise) have not been put forward enough. For instance, there was a poster on the effect of noise on a whole food web. This would have deserved an oral presentation or at least a speed talk!

6. CONCLUSION

At the five-day conference in Den Haag we heard about new research on the effects of noise on marine fauna, and sometimes the lack of effects. Our understanding of potential impacts is steadily growing. More and more sources of noise are being investigated, and more and more animal species are being studied. We are well on our way to assess the potential effects on marine ecosystems. Many sound monitoring projects have been going on for years now, and we are beginning to be able to look at long-term effects.

In Den Haag, we had the opportunity to discuss underwater noise and its potential impacts with fellow scientists, government representatives and regulators, industry representatives, defense staff, and members of non-government organizations. Some presentations pointed out communication problems between stakeholders—not just hurdles, but real barriers at times. We have all had different pathways into the field of underwater noise impacts, and we all have different expectations and motivations. It is through conferences like this one, that we grow our understanding of each other's concerns and needs, and have an opportunity to build relationships and grow as a community.

In conclusion, the organizers were very pleased with the outcome the meeting and look forward to planning for the next meeting in 2022. The venue of the meeting will not be selected for at least a year or 18 months. Please keep an eye on www.an2022.org for updates.

ACKNOWLEDGMENTS

The conference could not have taken place were it not for generous funders and numerous colleagues who graciously provided help as the meeting developed and during the meeting.

Foremost, we are indebted to our funders and sponsors, who enabled us to support the attendance of so many younger colleagues and colleagues from developing countries. We thank our funding organizations: The Aquatic Noise Trust (UK), the Bureau of Ocean Energy Management (USA), the Marine Mammal Commission grant MMC18-164 (USA), the National Marine Mammal Foundation (USA), the National Oceanographic and Atmospheric Administration grant NA15OAR4320063 (USA), the National Science Foundation grant OCE1833337 (USA), the U.S. Office of Naval Research award N00014-18-1-2398 (USA), the Office of Naval Research – Global (UK), the Naval Facilities Engineering Command (USA), and the U.S. Navy Living Marine Resources Program grant N39430-16-C-1865 (USA).

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Our media committee, consisting of Marta Bolgan (University of Liège, Belgium), Ben Colbert (U.S. Navy, USA), Sarah Marley (University of Portsmouth, UK), and Renee Schoeman (Nelson Mandela University, South Africa) organized the public lecture night and kept the community up-to-date via Facebook and Twitter.

Jeneil Lagassé (University of Washington, USA) handled much of the grant income and all of the finance reimbursements on our behalf.

Last but certainly not least, we thank Terri Cullinane of VenuesWorld for her expert help with all conference logistics, venue, accommodations, social functions, registration, website, lunches, and coffee breaks. This was the fourth of these meetings that Terri and her colleagues organized and much of the non-scientific success of the meeting is due to the outstanding and thoughtful work of this group.

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APPENDIX

The following pages show photos from the meeting. Additional images can be found in the photo albums on our Facebook page: <https://www.facebook.com/pg/AquaticNoise2019/photos/>













