Institution: University of Bath

Unit of Assessment: B9 Physics

Title of case study: Commercial success of Seiche Ltd and new standards for offshore acoustic monitoring

Period when the underpinning research was undertaken: 2007 - 2020

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Philippe Blondel	Senior Lecturer, previously Lecturer	September 1999 – present

Period when the claimed impact occurred: 1/8/2013 to 31/12/2020

Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact

Offshore acoustic surveys are subject to strict regulations, but sound propagation underwater is complex, making it challenging to define safe ranges for marine animals exposed to loud sounds. Collaborative research with Seiche Ltd (a UK-based SME) defined new surveying strategies to monitor sound levels and to minimize their impact on marine life. This significantly improved the performance of the company, through the development and sale of new products, enhancement of its capacity and services, and a training programme for professionals in the field. This has culminated in new sales of GBP[text removed for publication] during the REF period [text removed for publication] from contracts with the offshore industry and environmental organisations.

Additional impacts of the research include a new code of practice incorporated into UK regulations, and the definition of four new international standards (BS ISO 17208-1:2016, BS ISO 17208-2:2019, BS ISO 18405:2017, BS ISO 18406:2017) in underwater noise pollution.

2. Underpinning research

Offshore surveys that use acoustic methods and general shipping both produce loud sounds underwater. Regulations prohibit activities likely to endanger marine life, at potentially great cost to the industry. Acoustic surveys must be stopped when marine animals are within the "mitigation range", and speed restrictions may be considered in dense shipping lanes. Source variability (with sea conditions or operations) and ocean variability (with range, depth and time) both change the required mitigation range. Simple models cannot take these effects into account and, depending on the margin of error applied, either risk harm to marine life, or unnecessarily restrict operations. Measurements are constrained by time, costs and safety. How to measure these sounds, where to measure them cost-effectively, and implementation into industrial practice are therefore fundamentally important for appropriate protection of the marine environment.

Blondel's research to address these challenges covers the entire range of underwater acoustic techniques, specialising in passive monitoring of sounds, sound propagation in complex environments across the world, and bioacoustics.

Starting in 2007, Blondel researched whale habitats of Canada [1], showing how higher frequencies (> 1 kHz) associated with shipping and weather processes might affect whale behaviour. This research was combined with passive monitoring of shipping in other settings (Strait of Georgia, Canada [2], Falmouth Bay, UK [3]), which addressed the lack of consensus over how to average local shipping noise levels for environmental assessment purposes. The

research culminated in the publication of a highly cited method and software to systematically measure and compare sound levels and frequencies associated with different offshore activities [4].

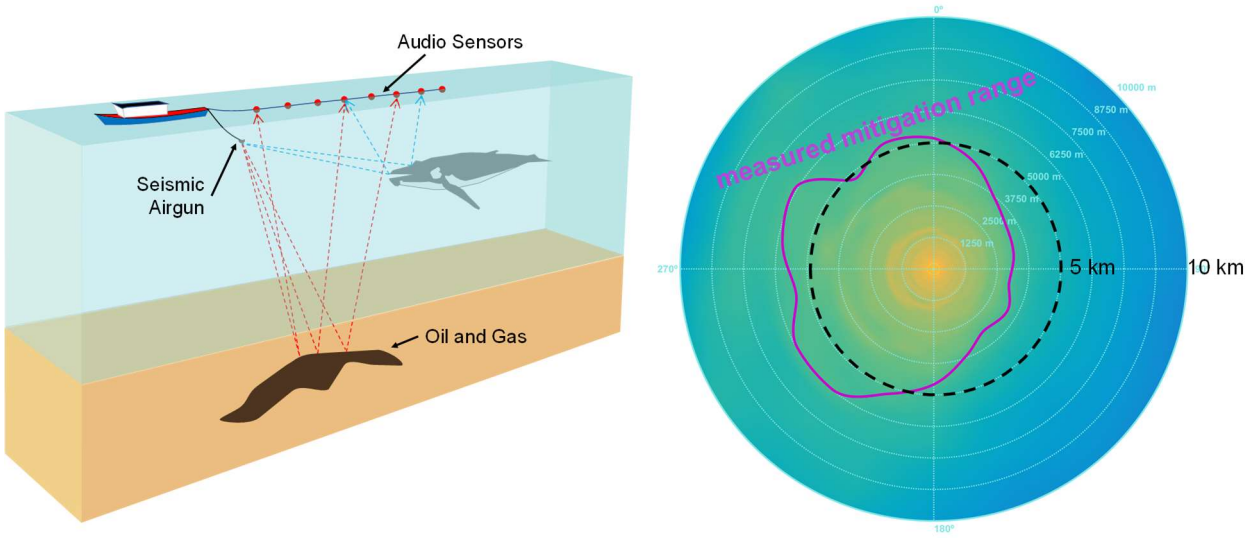

Figure 1. Loud blasts of sound propagate in the water and in the seabed, reflecting from interfaces but also potentially affecting marine life (left, red lines). Production of loud sounds must be stopped if protected animals are detected within the mitigation range. Blondel's research showed that the actual shape of the mitigation range (solid line) depends on ocean properties (right [5]). The research also showed that high frequencies in the sound blasts can be used to detect animals [6] (left, blue lines).

This methodology and software has underpinned Blondel's research collaboration with Seiche Ltd, that has been supported by three Knowledge Transfer Partnerships: KTP 9203 - To develop a methodology for verifying propagation models for predicting sound in complex and dynamic underwater environments for implementing within marine seismic surveys and piledriving (2013-2016); KTP 9670 - To improve marine mammal mitigation and to provide 3D/4D visualisation of cetacean movements in response to seismic survey activity (2015-2018); KTP 11898 - Design, develop and commercialise the next generation of Digital Thin Line Array capable of detection, localisation and classification of acoustic contacts, suitable for deployment from unmanned surface and underwater vehicles (2020-2023).

In KTP 9203 and KTP 9670, Blondel combined field measurements with simulations of propagation underwater. The research identified the optimal surveying strategies to monitor sound levels underwater, comparing simulations and measurements with a variety of platforms, in order to define effective and evidence-based mitigation ranges adapted to each offshore survey and each environment [5] (deep or shallow water, coastal or abyssal, Fig. 1). This conclusively showed that seismic airgun arrays produce most of their energy between 1 Hz and 1 kHz, but also contain significant contributions extending between 1 kHz to 100 kHz. Field measurements also showed how seismic mitigation ranges vary with the marine environment. Informed by knowledge of the high-frequency signatures of other offshore processes [2,3], these results were used to consider the use of seismic airguns as "sources of opportunity" to detect marine animals present in the mitigation range but not detectable with traditional approaches [6]. In comparison to conventional methods using spotters, this approach allows detection of marine mammals in poor visibility and also when they remain below the surface. Blondel's research collaboration with Seiche Ltd continues with KTP 11898.

Blondel's expertise in acoustic measurement has been central to his membership of the British Standards Institution (BSI) committee EH/1/7 "Underwater acoustics" (throughout the REF period). He contributed to defining several international standards for measuring underwater sounds, in particular from ships and pile driving (BS ISO 17208-1:2016, BS ISO 18405:2017, BS ISO 18406:2017, BS ISO 17208-2:2019) [A].

3. References to the research

[1] Merchant, ND, Blondel, P, Wladichuk, JL & Megill, WM 2011, 'Acoustic interaction of humpback whales and recreational fishing vessels in a temperate fjord : Measurements in Rivers' Inlet, British Columbia' in J Papadakis & L Bjorno (eds), *Proceedings of the 4th International Conference and Exhibition on Underwater Acoustic Measurements: Technologies and Results.* Kos (Greece), pp. 715-722, 4th International Conference and Exhibition on Underwater Acoustic Measurements: Technologies & Results, Kos, Greece, 20/06/11. https://www.uaconferences.org/docs/Past_proceedings/UAM2011_Proceedings.pdf

[2] Merchant, ND, Blondel, P, Dakin, DT & Dorocicz, J 2012, 'Averaging underwater noise levels for environmental assessment of shipping', *Journal of the Acoustical Society of America*, vol. 132, no. 4, pp. EL343-EL349. https://doi.org/10.1121/1.4754429

[3] Merchant, ND, Witt, MJ, Blondel, P, Godley, BJ & Smith, GH 2012, 'Assessing sound exposure from shipping in coastal waters using a single hydrophone and Automatic Identification System (AIS) data', *Marine Pollution Bulletin*, vol. 64, no. 7, pp. 1320-1329. https://doi.org/10.1016/j.marpolbul.2012.05.004

[4] Merchant, ND, Fristrup, KM, Johnson, MP, Tyack, PL, Witt, MJ, Blondel, P & Parks, SE 2015, 'Measuring acoustic habitats', *Methods in Ecology and Evolution*, vol. 6, no. 3, pp. 257-265. https://doi.org/10.1111/2041-210X.12330

[5] Blondel, P, Jimenez, G & Wyatt, R 2016, 'Seismic surveys in complex environments: effects of environmental variability on sound propagation and mitigation practice' in *Acoustics & Environmental, Variability, Fluctuations & Coherence - 12-13 December 2016 - The Moller Centre, Cambridge.* vol. 38, Institute of Acoustics Proceedings, no. 3, vol. 38, Institute of Acoustics, pp. 16-23, Acoustics & Environmental, Variability, Fluctuations & Coherence, Cambridge, UK United Kingdom, 12/12/16. https://www.ioa.org.uk/catalogue/article/seismic-surveys-complex-environments-effects-environmental-variability-sound

[6] Banda, N & Blondel, P 2016, 'Identifying mid-water targets using the higher frequencies emitted by seismic sources of opportunity' in *MTS/IEEE Oceans'2016 Conference Proceedings.* IEEE, Monterey, U. S. A., pp. 1-7. https://doi.org/10.1109/OCEANS.2016.7761172

4. Details of the impact

Improved Performance of Seiche Ltd

Seiche Ltd is a UK SME that provides equipment and services in marine technology and environmental solutions to offshore marine industries, enabling compliance with environmental regulations to protect marine life from the effects of sound. With offices in the UK, USA and South Africa, Seiche has a track record based on over 20 years' experience across the 7 continents.

Increased sales: Blondel's research collaboration with Seiche has fed into new commercial products and services with the company [B], including a suite of new modelling and diagnostic products. These products have generated GBP[text removed for publication] of sales for Seiche in the assessment period. [text removed for publication]

[text removed for publication]

Products include the Source Pressure Level software SPL-Toolbox [text removed for publication], Sound Source Verification Modelling (SSV), Sound Source Measurement, and Soundscape Calculations. [text removed for publication]

Enhanced services and capability: Bath research has increased Seiche's international credibility as a scientific company as well as an equipment provider. [text removed for publication]

[text removed for publication]

Three Research Associates, funded by the completed KTPs and employed by the University, have subsequently been hired by Seiche (a company of approximately 25 employees in total). The new employees have grown Seiche's skill base and assist with: (i) the completion of new commercial projects using the products and services that they developed with Blondel; (ii) demonstrating the software based on Blondel's methodology to current and potential customers; (iii) participating in international trade shows and conferences to talk to customers using their in-depth research knowledge of the products developed with Bath. To further embed Seiche as a research-based company, Blondel reshaped the professional courses run by Seiche Training Ltd. These courses draw on his articles and books; they are attended by industry, defence, governmental and regulatory organisations from around the world [text removed for publication]. [text removed for publication]

New contracts and environmental protection: Based on the new products developed with Bath's research, Seiche has attracted new business. [text removed for publication]

Impacts on Standards and Guidelines
Blondel made significant contributions to the National Physical Laboratory's "Good Practice Guide for Underwater Noise Measurement" (Crown Estate, 2014) as an expert reviewer [F]. This guide has been adopted as a mandatory requirement by UK marine regulators for use by offshore consultants, and has had significant impact on the quality of the in-situ acoustic measurements made in support of marine licensing for UK renewable energy developments. It has been downloaded 1,000s of times [F].

By membership of the BSI committee EH/1/7, Blondel's research and experience was [text removed for publication] [F] in informing international standards (listed in [A]) on measuring noise from ships in deep water (BS ISO 17208-1:2016; BS ISO 17208-2:2019) and from pile driving (BS ISO 18406:2017), and acoustic definitions (BS ISO 18405:2017[text removed for publication]

Summary of impact

- Bath research has led directly to new products with aggregated sales of GBP[text removed for publication] for Seiche Ltd in the REF period, growing to [text removed for publication]% of total sales in 2019/20 [B,C].
- Close interaction with Bath research has enabled Seiche to gain a unique position in the market, increasing visibility and reputation of the company [B].
- Seiche Training courses built on Blondel's research have trained more than [text removed for publication] professionals in underwater acoustics [D].
- Blondel's research has substantially informed codes of practice and standards [A], including ones which now form part of the UK regulatory framework [F].

5. Sources to corroborate the impact

[A] International standards:

a) BS ISO 17208-1:2016 Underwater acoustics – Quantities and procedures for description and measurement of underwater sound from ships – Part 1: Requirements for precision measurements in deep water used for comparison purposes
https://www.iso.org/standard/62408.html

b) BS ISO 18405:2017 Underwater acoustics – Terminology
https://www.iso.org/standard/62406.html

c) BS ISO 18406:2017 Underwater acoustics – Measurement of radiated underwater sound from percussive pile driving https://www.iso.org/standard/62407.html

d) BS ISO 17208-2:2019 Underwater acoustics – Quantities and procedures for description and measurement of underwater sound from ships – Part 2: Determination of source levels from deep water measurements https://www.iso.org/standard/62409.html

[B] Letter from [text removed for publication], Seiche Water Technology Group, 11 November 2020.

[C] Financial information from [text removed for publication], Seiche Water Technologies Group: Table with additional explanations, up to 31 December 2020.

[D] Letter from [text removed for publication], Seiche Training, 1 December 2020.

[E] Observing 'Wilson': Environmental Monitoring of the Ocean Cleanup System, Environment Coastal & Offshore (ECO) magazine, November-December 2019, 40-43 https://www.seiche.com/wp-content/uploads/2019/12/AutoNaut-Eco-Magazine-NovDec-2019.pdf

[F] Letter from [text removed for publication], 25 November 2020.