

Attachment 4.4: Risk Assessment for Annex IV Species (EU Habitats Directive)

A MISSING-Link between continental shelves and the deep sea: Addressing the overlooked role of land-detached submarine canyons.

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1. Introduction

This attachment assesses the potential impact of the proposed project on species listed under Annex IV of the Habitats Directive (92/42/EEC), which are identified as possibly being present in the project areas. Our discussions with the National Parks and Wildlife Service indicate that there may be a requirement for derogation for use of acoustic sources in the marine environment; hence, we have applied for a derogation licence for completeness.

This report was prepared by Dr Michael Clare, Dr Isobel Yeo, Professor Veerle Huvenne, Dr Rob Hall, Mr Alan Evans and Mr Dale-Smith.

Dr Michael Clare is a Principal Researcher and the Mission Network Lead for Hazards and Pollution at the National Oceanography Centre, Southampton, where he has worked since 2015, before which he was a specialist in Offshore Survey and Marine Geohazards for FUGRO. His work focuses on sediment-transport dynamics, submarine geohazards and deep-sea systems. He has served as Marine Scientific Adviser to the International Cable Protection Committee since 2020. Dr Clare has led and co-led offshore monitoring campaigns in submarine canyon settings, including work in Congo and Whittard canyons that deployed moorings instrumented with Acoustic Doppler Current Profilers (ADCPs) to record turbidity currents and bottom-current variability. He is also an expert in the acquisition, processing and integration of multibeam bathymetry, side-scan-style acoustic seafloor mapping and sub-bottom profiling with moored and seabed sensors to characterise seafloor processes and risks to infrastructure.

Dr Isobel Yeo is a Senior Researcher at the National Oceanography Centre, specialising in Marine Geohazards, with over 15 years experience working in Marine Geology research. Her work has focused on using hydrographic survey methods and bottom sampling to map hazardous phenomena and sampling of rocks and sediments to characterise hazards and recreate timelines. She has extensive experience working with Autonomous Underwater Vehicles (AUVs) and Remotely Operated Vehicles (ROVs) to acquire data and samples across all seafloor depths. She has worked closely with AUV teams, including on mission design and execution. She has been the Chief Scientific Officer on three expeditions (two onboard British Vessels) and has participated in 20 scientific seagoing expeditions.

Professor Veerle Huvenne is a Principal Researcher at the National Oceanography Centre, Southampton. She has over 25 years of experience in marine habitat mapping and benthic ecology, her work spans cold-water corals, submarine canyon systems and deep-sea benthic communities. She has participated in more than 40 international expeditions—often acting as Chief Scientist or scientific lead—and has spent in excess of 900 days at sea. Her work uses multidisciplinary approaches to integrate geological, geophysical and biological methods (e.g., ROV/AUV video imagery, sediment cores, multibeam bathymetry, sidescan sonar and habitat classification) to characterise complex deep-sea ecosystems and the dynamic processes that govern them. She has studied the Whittard Canyon system since 2007, and has extensive expertise of the benthic ecology of the Porcupine Seabight. Prof Huvenne also acts as Chief Scientist of the Marine Autonomous and Robotic Systems facility at NOC, part of the UK's National Marine Facilities. For this, she draws on her extensive expertise working with marine robotic systems (ROVs, AUVs, gliders), often acting as scientific liaison to the technical teams and developing new observing capabilities with them.

Dr Rob Hall, Principal Investigator in Physical Oceanography at the Scottish Association of Marine Science and Scientific Lead of the Scottish Marine Robotics Facility. Dr Hall has 20 years of experience in shelf-sea and deep-ocean fluid dynamics, specifically internal tide and wave processes, sediment transport and mixing, drawing on both observational deployments (including autonomous underwater vehicles and gliders) and numerical modelling. He has expertise in marine hydrodynamics, sediment transport and benthic-habitat interactions in the

Celtic Sea. He has participated in more than 10 research expedition including as Chief Scientist for recent survey of hydrodynamic processes at the Celtic Sea shelf break.

Mr Alan Evans serves as Head of Marine Policy at the National Oceanography Centre (NOC) in the UK and acts as a Marine Science Policy Adviser, bringing over two decades of experience in marine science, technology, and policy underpinned by a strong geoscientific background. At NOC, he leads the organisation's engagement with the global marine community through participation in international fora, bilateral partnerships, collaborative projects, and interactions with national governments—including UK Overseas Territories—and regional institutions. His expertise includes extensive application of the United Nations Convention on the Law of the Sea (UNCLOS), covering baseline and maritime-zone definition, continental-shelf delineation beyond 200 nautical miles, the mandate of the International Seabed Authority (ISA), and the enabling of marine scientific research and technology transfer. Internationally, Alan serves as the Alternate Head of the UK delegation to UNESCO's Intergovernmental Oceanographic Commission (IOC-UNESCO), where he chairs the Group of Experts on Capacity Development. He also contributes as a technical expert on the ISA Partnership Fund Board and previously advised the ISA/UN-OHRLLS "Women in Deep-Sea Research" initiative. Additionally, he represents NERC-UKRI at the European Marine Board, where he is vice-Chair.

Mr Guy Dale Smith serves as Head of Research Ship Operations at the National Oceanography Centre (NOC) in the UK, where he leads the planning, execution and oversight of marine research vessel campaigns and associated infrastructure, drawing on extensive maritime and operational experience. With a deep background in ship-based science support, Guy manages not only the logistics and safety of ocean-going missions but also the strategic alignment of NOC's fleet with scientific goals, ensuring that vessel operations maximise research impact while adhering to rigorous standards of marine safety and efficiency. His role spans coordination across multidisciplinary teams, vessels and international collaborations, forging strong relationships with science teams, engineering groups and external stakeholders to support downward-looking research in challenging marine environments.

2. Legislation

Article 12 of the EU Habitats Directive states:

1. Member States shall take the requisite measures to establish a system of strict protection for the animal species listed in Annex IV (a) in their natural range, prohibiting:

- (a) all forms of deliberate capture or killing of specimens of these species in the wild;
- (b) deliberate disturbance of these species, particularly during the period of breeding, rearing, hibernation and migration;
- (c) deliberate destruction or taking of eggs from the wild;
- (d) deterioration or destruction of breeding sites or resting places.

1. For these species, Member States shall prohibit the keeping, transport and sale or exchange, and offering for sale or exchange, of specimens taken from the wild, except for those taken legally before this Directive is implemented.
2. The prohibition referred to in paragraph 1(a) and (b) and paragraph 2 shall apply to all stages of life of the animals to which this Article applies.

3. Member States shall establish a system to monitor the incidental capture and killing of the animal species listed in Annex IV (a). In the light of the information gathered, Member States shall take further research or conservation measures as required to ensure that incidental capture and killing does not have a significant negative impact on the species concerned

3. Scope of Works

3.1. Proposed Project Rationale

This application is in relation to offshore activities as part of a scientific research project called MISSING LINK funded by the United Kingdom's Natural Environment Research Council (NERC) to conduct systematic scientific monitoring surveys in the deep-sea Whittard Canyon (which includes work in the Southern Canyon SAC) and Gollum Channel, to perform a first of its kind characterisation of the transport of natural particles, nutrients, organic carbon and pollutants from the continental shelf to the deep-sea. The overarching aim of this proposed work is to acquire new scientific data into better understanding: 1) the natural processes that occur within deep-sea submarine canyons - namely the Whittard Canyon (overlapping with the Southern Canyon cSAC) and Gollum Channel - through detailed monitoring of seafloor currents, characterisation of seafloor sediments, measurement of water column properties, remote mapping of the seafloor; and 2) the distribution of pollutants (particularly litter and microplastics) through video surveys and seafloor sampling.

This project will enable a step change in understanding of the sporadic but large flows of sediment, climatically-important organic carbon, and pollutants through submarine canyons, which connect continental shelves worldwide to the deep-sea. >9000 large submarine canyons occur on all the world's submerged margins, often dwarfing river systems in scale. Such canyons can transfer large quantities of natural sediments, organic carbon and nutrients that sustain important ecosystems, and are increasingly recognised as hotspots for seafloor pollution that threatens the enhanced biodiversity they host. The sediment flows that travel along canyons can be fast and dense, breaking cables that underpin global communications. It is therefore important to understand when and how such flows are triggered, the amount and type of material that is transported, and crucially, how these vary between types of canyon.

Recent measurements in Whittard Canyon (in the Celtic Sea, 250 km from shore) have revealed that such land-detached canyons can feature frequent sediment flows. This project aims to understand how frequent sediment flows can occur if a canyon head lies far from present day sediment supplies. We plan to deploy an array of short moorings within the Whittard Canyon and Gollum Channel, to measure the conditions before and coincident with turbidity currents, and repeatedly map the seafloor to identify how and where sediment is transported to/from the canyon head. We will then make the first source to sink measurements along a land-detached canyon, and the second of any major deep sea canyon worldwide, hence in itself this will represent a significant scientific milestone. Global budgets exist for particulate transport to and across the ocean, but none include land-detached canyons such as these. We will provide a first order calculation to assess the global significance of land-detached canyons, first assessing the contribution to deep sea transport across the Celtic Margin, and then up-scaling our results to determine what is missing from existing global budgets. The project will assist with providing a more detailed environmental characterisation in these key deep-sea sites in Irish waters and will increase the understanding of environmental marine conditions within ecologically-important, but poorly understood deep sea sites, characterise the transport pathways of pollutants such as microplastics into the deep-sea, and will aid in the wider understanding of similar sites that exist worldwide.

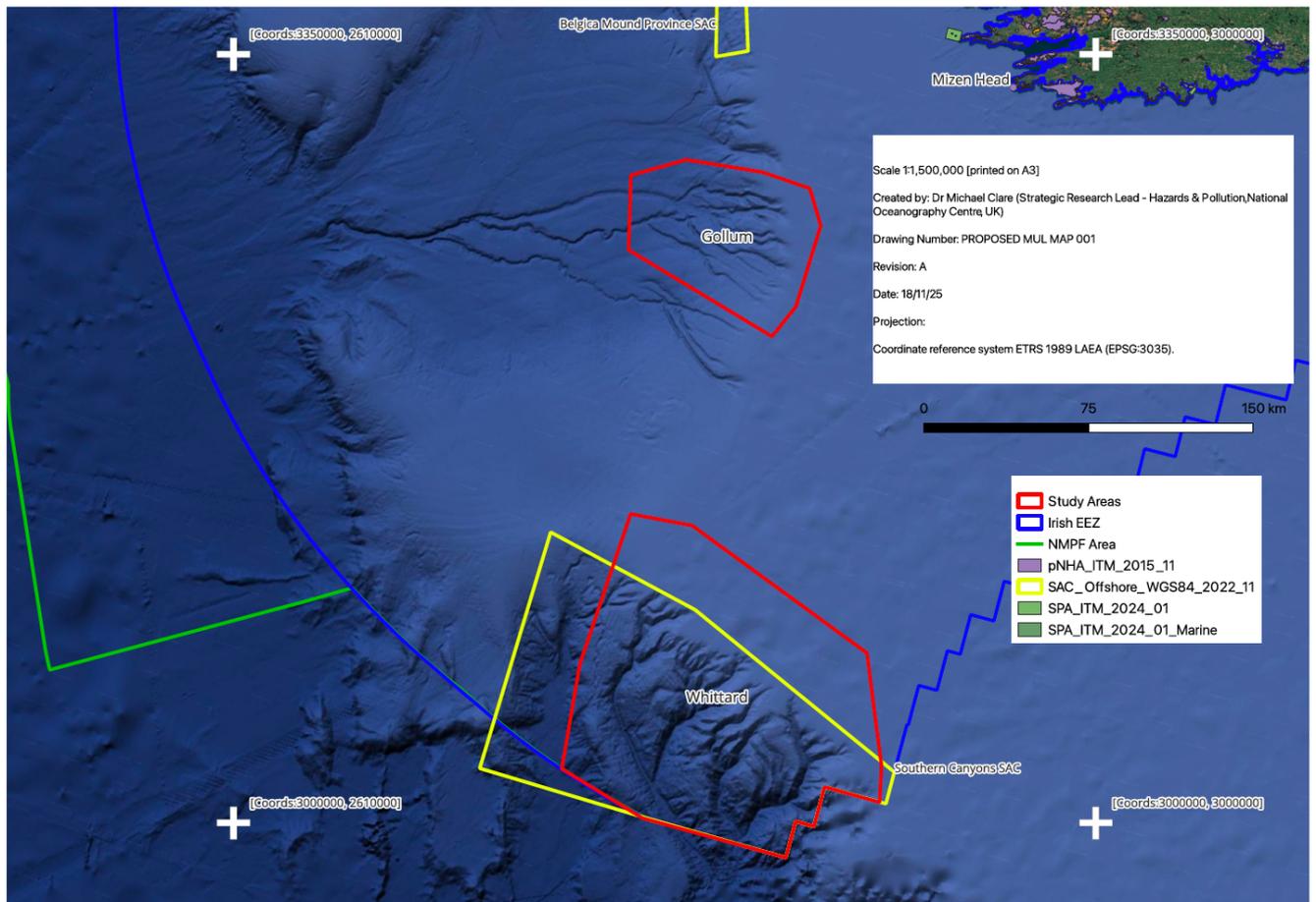


Figure 1: Overview map. Red lines define limits of study areas for the proposed project. Yellow lines indicate locations of SACs and cSACs.

3.2. Overview of Planned Activities

The proposed project activities include:

- i) temporary deployment of short oceanographic moorings (with no sea surface expression) to monitor near-seafloor currents and sediment transport, which will be recovered after a period of approximately 12 months. Seafloor moorings to be deployed at five locations in Irish waters between water depths of 1500m and 3400m.
- ii) sampling of seafloor sediments using scientific coring equipment. For each offshore campaign we proposed to use an OSIL megacorer (0.5 m deep x 0.06 m diameter cores – 30 sampling locations proposed, at each sampling location 4 cores to be acquired, so a potential total of 120 cores), NIOZ box cores (0.5 m deep x 0.5 wide sampler – 15 cores proposed), and Standard Gravity Piston coring (up to 6 m deep x 0.1 m diameter cores – 16 cores proposed) along transects within the canyon systems.
- iii) seafloor video surveys acquired using Modular Platform Underwater System (MPUS), which is a modular, versatile, robotic underwater vehicle (RUV) capable of reaching depths of 6,000 metres, developed and operated by the National Oceanography Centre.
- iv) short-term (4 weeks maximum) deployment of an autonomous underwater glider (Kongsberg Seaglider owned and operated by the National Oceanography Centre) to monitor

ocean currents using an integrated Nortek 1 MHz ADCP and measure temperature and salinity using a SeaBird Electronics CTD sensor.

v) short-term (24 hour maximum) deployment of Autonomous Underwater Vehicle (AUV – Autosub5) to map the seafloor and shallow subsurface using multibeam echosounder (Norbit WBMS 400kHz multibeam echosounder), side scan sonar (Edgetech 2205 Dual Frequency Sidescan Sonar - 420 kHz and 120 kHz), sub-bottom profiler (Edgetech 2205 Sub Bottom Profiler, 2-16 kHz), photograph the seafloor using a camera system (AESA 2.5 Camera System), and characterise the water column using a Conductivity, Temperature and Density (CTD) sensor (Seabird CTD9+), characterise suspended sediments using a Hydroptic UPV6 and Fluidion Deep Water Sampler, and is also equipped with an Acoustic Doppler Current (ADCP) profiler to assist with navigation (Syrinx SprintNav, 600 kHz). The AUV will be deployed and recovered multiple times during the two offshore campaigns, and aside from launch and recovery will move beneath the sea surface with no surface expression and will not involve any contact with the seafloor, instead flying above it for seafloor surveys.

vi) vertical profiling of the water column to characterise temperature, salinity, current velocity and turbulent mixing. This will include vertical profiles made using a CTD package and Lowered ADCP (two RDI 300 kHz Workhorse) mounted on a conventional CTD/Carousel frame. This will be deployed off the side of the vessel using a heave-compensated winch. A Vertical Microstructure Profiler (VMP-2000) will also be used for the measurement of turbulence kinetic energy dissipation rate through the water column. The VMP-2000 is equipped with cm-scale velocity probes (shear probes), high-resolution temperature sensors (fast thermistors), and a high-accuracy Seabird CTD.

vii) shipboard measurements to be made while vessel is underway, which include single beam echosounding (Kongsberg EA640 10/12 kHz), multi beam echosounding (Kongsberg EM122 12 kHz and EM710 70 to 100 kHz), sub-bottom profiler (Kongsberg SBP27 Sub-bottom profiler 2-9 kHz) and AML Micro-X Sound Velocity probe.

See Table 1 for details pertaining to the proposed equipment and specifications.

Table 1: Acoustic and sampling equipment proposed to be operated on board the RRS James Cook during the MISSING-Link expedition. Note: In the event of equipment failure a similar alternative may be used/deployed if available.

Equipment	Model	Deployment	Company	Sound Pressure Level @ 1 μ PA in water @ 1m from source	Reference
Acoustic Survey Equipment					
Multibeam Echosounder	Norbit WBMS 400kHz	AUV	Norbit	Typically 200-220	No information from manufacturer – range presented is based on typical values for such systems https://naturalresources.wales/media/694743/underwater-acoustic-survey-evidence-review_nrw-evidence-report-448.pdf
Sidescan Sonar	Edgetech 2205 Dual Frequency (420 kHz and 120 kHz)	AUV	Edgetech	~226	Geo-matching (n.d.) <i>EdgeTech 2205 AUV/ROV/ASV Sonar – Product Specification.</i> Available at: https://geo-matching.com/
Sub Bottom Profiler	Edgetech 2205 (2-16 kHz)	AUV	Edgetech	~226	Geo-matching (n.d.) <i>EdgeTech 2205 AUV/ROV/ASV Sonar – Product Specification.</i> Available at: https://geo-matching.com/
ADCP	Syrinx SprintNav, 600 kHz	AUV	Syrinx	217	Sonardyne https://www.sonardyne.com/product/syrinx-dvl/#:~:text=Need%20help%20with%20your%20product,UI%20for%20setup%20and%20configuration.
ADCP	RDI 300 kHz Workhorse	CTD Frame	Teledyne	~215	Teledyne RD Instruments (2011) <i>Source Level of Teledyne RDI ADCP Transducers (Technical Note FST-054).</i> Teledyne Marine. Available at: https://www.teledyne-marine.com/

ADCP	RDI 600 kHz Workhorse	Mooring	Teledyne	~217	Teledyne RD Instruments (2011) <i>Source Level of Teledyne RDI ADCP Transducers (Technical Note FST-054)</i> . Teledyne Marine. Available at: https://www.teledyne-marine.com/
ADCP	RDI 75 kHz Ocean Surveyor	Vessel mounted	Teledyne	~227	Teledyne RD Instruments (2011) <i>Source Level of Teledyne RDI ADCP Transducers (Technical Note FST-054)</i> . Teledyne Marine. Available at: https://www.teledyne-marine.com/
ADCP	RDI 150 kHz Ocean Surveyor	Vessel mounted	Teledyne	~226	Teledyne RD Instruments (2011) <i>Source Level of Teledyne RDI ADCP Transducers (Technical Note FST-054)</i> . Teledyne Marine. Available at: https://www.teledyne-marine.com/
ADCP	1 MHz AD2CP	Seaglider	Nortek	214-215	
Single Beam Echosounder	Kongsberg EA640 10/12 kHz	Vessel mounted	Kongsberg	~222	Kongsberg Maritime (2022) <i>Sound levels from Kongsberg multibeam systems</i> . Kongsberg Discovery. Available at: https://www.kongsberg.com/
Multibeam Echosounder	Kongsberg EM122 12 kHz and EM710 70 to 100 kHz	Vessel mounted	Kongsberg	~210 (122) ~210 (710)	Kongsberg Maritime (2022) <i>Sound levels from Kongsberg multibeam systems</i> . Kongsberg Discovery. Available at: https://www.kongsberg.com/
Sub-bottom profiler	Kongsberg SBP27 (2-9 kHz)	Vessel mounted	Kongsberg	~209	Kongsberg Maritime (2022) <i>Sound levels from Kongsberg multibeam systems</i> . Kongsberg Discovery. Available at:

					https://www.kongsberg.com/
Ultra-short baseline (USBL)	Ranger 22-34 kHz	AUV	Sonardyne	187 - 196	Sonardyne International Ltd (2021) <i>Wideband Sub-Mini 6+ (WSM 6+) Type 8370-1111/4112</i> . Available at: https://www.sonardyne.com/wp-content/uploads/2021/06/Sonardyne_8370_WSM6-1.pdf
Sensors					
CTD	SBE9+	AUV	Seabird Electronics	N/A	
Sound Velocity probe	AML Micro-X	Cable (from Vessel) or CTD frame	Alm Oceanographic	N/A	
Vertical Microstructure Profiler	VMP-2000	Cable (from vessel)	Rockland Scientific International	N/A	
CTD	SBE 37 MicroCAT	Mooring	Seabird Electronics	N/A	
Sampling equipment					
Megacorer	Multi-Corer	Cable (from Vessel)	OSIL	N/A	
Optical Imaging Sensor	Hydroptic UPV6	AUV	Hydroptic	N/A	
Water Sampler	Deep Water Sampler	AUV	Fluidion	N/A	
Rosette Sampler	Niskin Bottles	CTD Frame	N/A	N/A	
Box Core	NIOZ box core	Cable (from Vessel)	N/A	N/A	
Standard Gravity Piston Corer	Standard Gravity Piston coring	Cable (from Vessel)	N/A	N/A	
Sediment Traps	McLane sediment trap	Mooring	McLane	N/A	
Other Survey Equipment					
Camera System	AESA 2.5	AUV	Blackfly, adjusted by NOC	N/A	

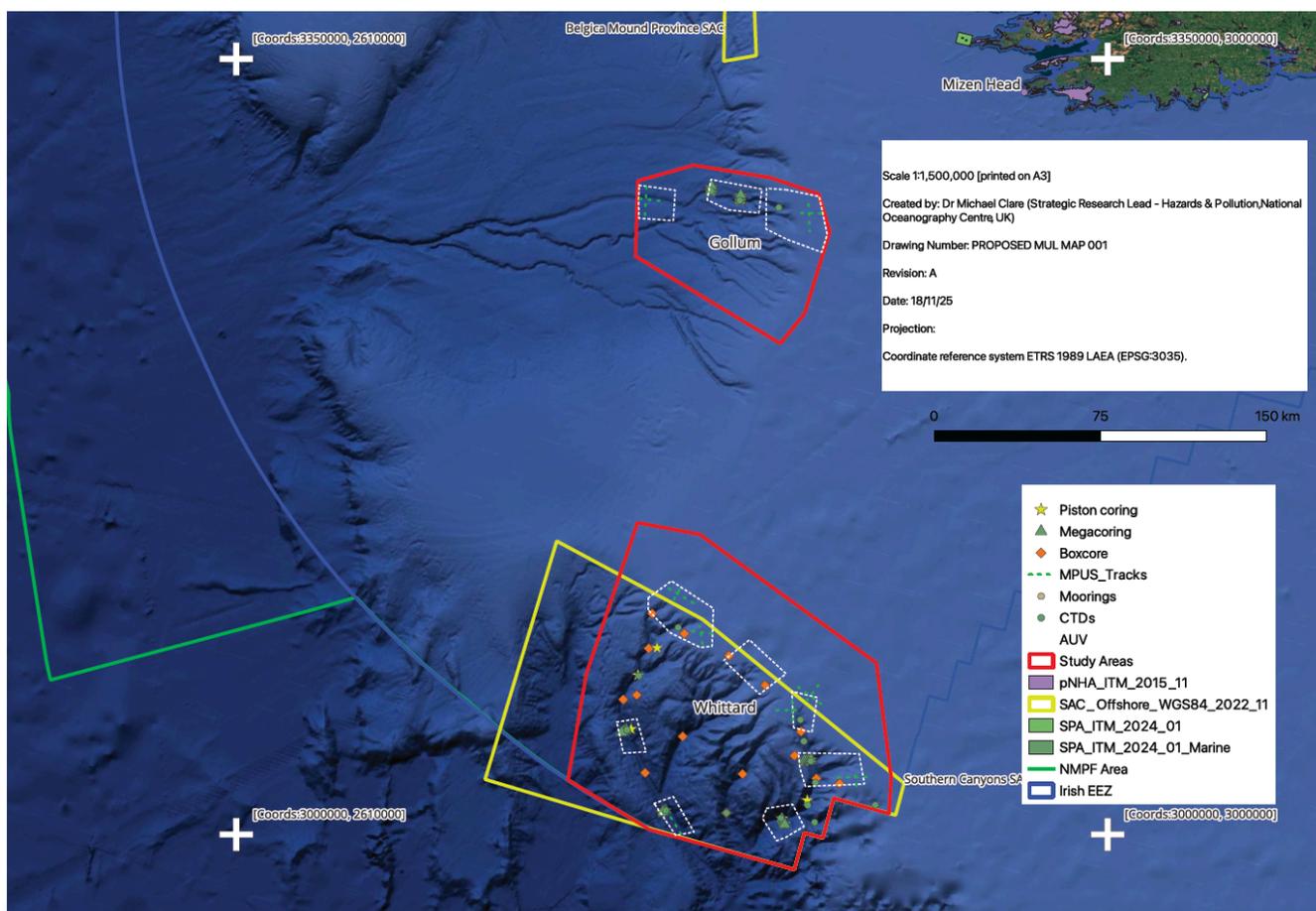


Figure 2: Proposed locations of sampling and survey locations – ship-board equipment will be run while the vessel is underway and glider deployments are planned within the red study areas. White dashed areas represent proposed locations within which AUV dives will be performed but are unlikely to include the full extent of what is presented.

3.2.1 Vessels and Platforms

3.2.1.1 RRS James Cook/RRS Discovery

The expedition in 2026 will be carried out aboard RRS James Cook, however, as the 2027 expedition is not yet scheduled that may occur on either RRS James Cook or RRS Discovery, hence specifications for both vessels are included (Table 2).

The RRS James Cook (2006) and RRS Discovery (2013) are UK global-class oceanographic research vessels with overlapping but distinct technical capabilities. James Cook provides approximately 278 m² of fixed laboratory space supplemented by multiple ISO container laboratories, including facilities for trace-metal-clean sampling. Its deck machinery includes high-capacity stern and mid-ships A-frames and a broad winch suite enabling deep-ocean coring, heavy trawling, towed-instrument operations, and ROV deployment. The vessel carries a comprehensive hydroacoustic system comprising multibeam and single-beam echosounders, ADCPs, and sub-surface positioning sensors for full-ocean-depth water-column and seabed measurements. Discovery incorporates a modular laboratory configuration designed for rapid reconfiguration between cruises, as well as dual deployment stations that allow independent or simultaneous use of winches and handling systems. Its acoustic and geophysical systems include multibeam bathymetry, sub-bottom profiling and seismic capability integrated with precision navigation and timing systems. Both vessels support full-ocean-depth CTD and rosette operations, clean seawater supply, and the

deployment and recovery of moorings, landers and autonomous platforms. Together they provide the UK marine science community with capacity for physical, chemical, biological and geological measurements in open-ocean and high-latitude environments under extended-duration operating conditions.

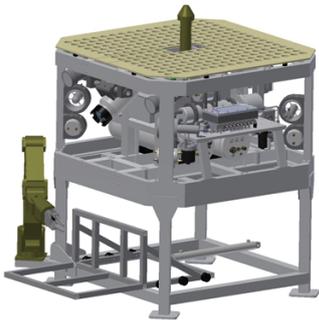
Table 2: Vessel specifications for the RRS James Cook (2026 vessel) and the RRS Discovery (2027 vessel may be either RRS James Cook or RRS Discovery)

	RRS James Cook	RRS Discovery
Length	89.20 m	100 m
Beam	18.60 m	18 m
Draught	6.315 m	6.6 m
Displacement	5,800 tonnes	6,075 tonnes
Gross Tonnage	5,401 tonnes	5,952 tonnes
Maximum endurance	50 days	50 days
Year built / delivered	2006 / service 2007	Delivered 2013
Propulsion / Engines	Four Wärtsilä 9L20 diesel engines driving alternators, giving a total available generating capacity of 6,840 kW	Four Wärtsilä 8L20 diesel-generator sets, each rated ~1,770 kW generating capacity ~7,080 kW
Crew / Scientist capacity	22 crew + 32 scientists	24 crew + 28 scientists
Lab & deck space	278 m ² labs; 7 containers	389 m ² labs; 7 containers
Image		

3.2.1.2 Modular Platform Underwater System (MPUS)

The Modular Platform Underwater System (MPUS) is a deep-rated, highly adaptable tethered underwater vehicle engineered for 6,500-meter operations. Its architecture is based on a modular payload and control framework, enabling rapid reconfiguration between command, imaging, and sampling missions. The system integrates a high-capacity hydraulic actuation suite, vectored thruster arrangement for precise maneuverability, and a multi-camera imaging stack optimized for both scientific observation and pilot situational awareness. With a 12 kVA subsea power system, fiber-optic multiplexed communications, and ROS-based control software with fault-tolerant thrust allocation, MPUS provides a robust and future-proof platform for deep-ocean intervention and research tasks.

Table 3: Specifications for the Modular Platform Underwater System (MPUS). Note the system is currently under construction at NOC and will be deployed only during the 2027 expedition.

	Specification
General	NOC in-house built; Modular design (Command, Camera, Sampling modules)
Depth Rating	6500 m
Structure	Welded & heat-treated Aluminium Alloy 6082-T6
Payload Capacity	Up to 1200 kg (module & depth dependent)
Hydraulics	12-function bi-directional SubAtlantic hydraulic valve pack (proportional control)
Thrusters	4 × vectored Innerspace 2 HP thrusters
Manipulator	Kraft Predator manipulator (TBC)
Primary Cameras	1 × 1080i HD stills & video camera
Pilot Camera	1 × 1080p HD camera
Additional Cameras	2 × PAL cameras
Power Unit	Jetpower JPT4 Power Unit
Power Input	Three-phase 2800 V, 400 Hz
Power Output	~12 kVA expected
Telemetry / Comms	MOOG Focal Fiber-Optic Mux
Electronics	In-house designed PCBs; EMC compliant
Science Bus	12 V & 24 V
Control Software	In-house developed; ROS-based; node-based modular architecture
Control Features	Fail-safe vectoral thrust distribution algorithm
User Interface	Qt-based responsive GUI
Image	

3.2.1.3 Kongsberg Seagliders

The Seaglider is a buoyancy-driven autonomous glider designed for long-duration, low-power oceanographic missions. It achieves propulsion through controlled buoyancy changes, enabling efficient gliding in a saw-tooth vertical profile with endurance spanning months and ranges of several thousand kilometres. Its modular payload architecture supports physical,

chemical, and biological ocean sensors, while satellite telemetry enables remote mission updates and data retrieval. With no external moving parts and a streamlined isopycnic pressure hull, the Seaglider provides a robust, low-logistics platform for sustained open-ocean and boundary-layer observations.

Table 4: Specifications for the Kongsberg Seagliders.

	Specification
Platform class	Buoyancy-driven glider-type AUV
Deployment duration	Up to ~10 months (mission dependent)
Range / travel distance	Up to ~4,600 km (~650 dives to 1 km depth)
Operating depth	50–1000 m (configuration dependent)
Length	1.8–2.0 m (configuration dependent)
Diameter	0.30 m excluding wings
Dry weight	~52 kg
Wing span	1.0 m
Glide / forward speed	Typical ~0.25 m/s (~0.5 kt)
Variable buoyancy volume	~850 cc
Energy store	~17 MJ (Lithium primary batteries)
Sensor payloads	CTD, ADCP, dissolved oxygen, fluorometer/optical backscatter, PAR, active and passive acoustics
Communications	Iridium satellite telemetry when surfaced
Navigation & control	Surface GPS fixes, underwater dead-reckoning, digital compass, Kalman filter
Mechanical design	Isopycnic pressure hull, composite fairing, no external moving parts
Image	

3.2.1.4 Autonomous Underwater Vehicle Autosub 5

The Autosub 5 is a high-power, work-class autonomous underwater vehicle (AUV) developed by the National Oceanography Centre (NOC) for deep-ocean survey, mapping, and under-ice missions. Engineered for operations to depths of up to 6,000 metres, the vehicle integrates a modular payload architecture supporting multibeam sonar, sidescan, sub-bottom profilers, and imaging systems. Its enhanced navigation suite provides high-accuracy dead-reckoning and bottom-lock tracking, while a dual-thruster propulsion system with X-configuration control surfaces offers robust manoeuvrability and redundancy. Designed for deployment using a dual-winch davit LARS system, Autosub 5 delivers a reliable platform for long-range, high-fidelity oceanographic data acquisition.

Table 5: Specifications for the Autosub 5 AUV.

	Specification
Platform class	Work-class AUV, length ~6 m, mass ≈2 tonnes
Maximum depth rating	Up to 6,000 m
Cruise speed	Approx. 1.1–1.4 m/s
Endurance / Sensor range	Typical mission lengths 250–300 km depending on depth and payload
Propulsion / Control surfaces	Dual thrusters; four X-configuration control planes enabling thruster-loss redundancy
Buoyancy / Structure	Syntactic foam centre section (2000 m or 6000 m rated); free-flooded nose and aft sections
Payload architecture	Modular forward and aft payload tubes supporting sonar, cameras, CTD/DO, magnetometer, and scientific sensors
Navigation accuracy	Enhanced navigation package with <0.1% distance-travelled positional error in bottom-lock surveys
Launch & Recovery	Dual-winch davit LARS system; deployable in sea state up to 4
Command & Control	Onboard autonomous mission executive, ROS-based controls, acoustic modem + Iridium comms
Use-cases	High-resolution seabed mapping, under-ice missions, benthic surveys, scientific sensor deployment
Image	

3.2.2 Multibeam echosounders, sidescan sonars and sub-bottom profiling

The project involves multibeam echosounder surveys, sidescan sonar surveys and sub-bottom profiling of the seafloor and sub-seafloor with both the vessel hull-mounted echosounders and with a similar suite of echosounders mounted on the AUV. The details of these surveys are below.

3.2.2.1 Vessel Operations

Shipboard measurements will be made while vessel is underway, including single beam echosounding (Kongsberg EA640 10/12 kHz), multibeam echosounding (Kongsberg EM122 12 kHz and EM710 70 to 100 kHz), sub-bottom profiler (Kongsberg SBP27 Sub-bottom profiler 2-9 kHz) and AML Micro-X Sound Velocity probe, which will be acquired within the proposed study areas, ranging from water depths between 170 and 3400 m.

3.2.2.2 AUV Operations

Short-term (30 hour maximum) deployment of Autonomous Underwater Vehicle (AUV – Autosub5) using multibeam echosounder (Norbit WBMS 400kHz multibeam echosounder), side scan sonar (Edgetech 2205 Dual Frequency Sidescan Sonar - 420 kHz and 120 kHz), sub-bottom profiler (Edgetech 2205 Sub Bottom Profiler, 2-16 kHz). The AUV will be deployed and recovered multiple times during the two offshore campaigns, and aside from launch and recovery will move beneath the sea surface with no surface expression and will not involve any contact with the seafloor. The approximate survey altitudes are 50-75 m for multibeam echosounder, and 15 m for sidescan sonar and sub-bottom profiler.

3.2.3 Moorings

The project involves the temporary deployment of short oceanographic moorings (with no sea surface expression) to monitor near-seafloor currents and sediment transport, which will be recovered after a period of approximately 12 months (Figure 3). Seafloor moorings to be deployed at five locations in Irish waters between water depths of 1500m and 3400m. Each mooring will comprise: an anchor (1000 kg weight comprising chain or train wheels) connecting to a vertical wire (approximately 30 m long) that connects to buoyancy (provided by glass spheres and/or syntactic foam buoy). Scientific instruments will be attached to the vertical mooring line as detailed below, and an acoustic release link that will enable recovery of the mooring. These moorings follow a very similar design that has been deployed and recovered previously elsewhere in the Whittard Canyon (as previously agreed with MARA).

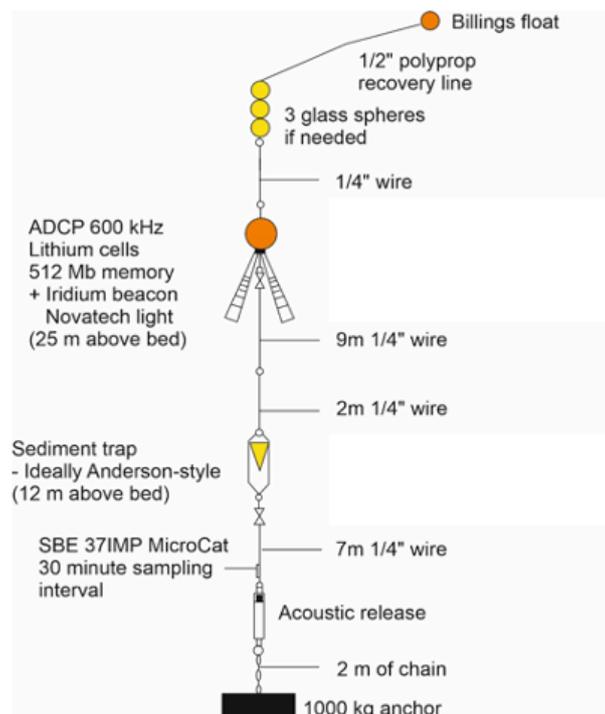


Figure 3: Schematic diagram of the proposed mooring setup.

3.2.3.1 ADCP

The Teledyne RDI Sentinel 600 kHz Acoustic Doppler Current Profiler (ADCP) is used to measure ambient and sediment laden currents. It operates by transmitting acoustic pulses through four slanted beams and measuring the Doppler shift of sound scattered back from particles suspended in the water. By sampling the returning echoes in a series of depth cells, the instrument constructs vertical profiles of current speed and direction throughout the water column. Integrated tilt, compass, and pressure sensors allow the ADCP to correct measurements for its orientation and depth during deployment. Data can be stored internally or transmitted in real time, and the system can operate in various modes, including current profiling, bottom tracking, and directional wave measurement, depending on the platform and mission requirements. The ADCP will be mounted approximately 25 m above the seabed in down-looking configuration.

3.2.3.2 Sediment Trap

The McLane Sediment Trap is deployed on a mooring or vertical array and features a large funnel that captures particles settling through the water column. Prior to deployment the instrument is programmed with a sample schedule, either at fixed intervals or adaptive based on sensors (e.g., pressure or tilt). As particles accumulate in the funnel they are directed into one of a carousel of sample bottles that contain a solution of HgCl₂, which is dense and the bottle will be sealed when not in use (so will not be released); each bottle is sequentially sealed off once its turn is complete and the mechanism rotates to the next bottle. The instrument logs time, date, battery voltage and optional tilt/pressure data throughout the deployment to support post-recovery analysis. Upon recovery the collected bottles provide discrete time slices of particulate flux, which are then analyzed for sediment composition, organic carbon, radionuclides or other parameters. The sediment trap will be mounted approximately 12 m above the seabed.

3.3.3.2 Seabird Electronics 37 MicroCAT

The SBE 37 MicroCAT is a compact, low-power oceanographic recorder that measures conductivity, temperature, and pressure to derive high-accuracy temperature, salinity and depth time series. It uses a stable, pumped or unpumped conductivity cell paired with a precision thermistor and a high-resolution pressure sensor to capture seawater properties at user-defined intervals. During deployment, the instrument autonomously logs data to internal memory while maintaining extremely low energy consumption, making it suitable for long-term moorings, gliders, profiling floats, or fixed observatories. Its internal firmware applies calibration coefficients, timestamps each sample, and performs basic quality checks. Once recovered, the recorded dataset is downloaded via serial or inductive modem interface, processed with calibration corrections, and used to derive water column structure, mixing processes, and long-term oceanographic trends. The SBE 37 MicroCAT will be mounted approximately 3-5 m above the seabed.

3.2.4 Sampling

The project involves the sampling of seafloor sediments using scientific coring equipment (Table 6). For each offshore campaign we proposed to use an OSIL megacorer (0.5 m deep x 0.06 m diameter cores – 30 sampling locations proposed, at each sampling location 4 cores to be acquired, so a potential total of 120 cores), NIOZ box cores (0.5 m deep x 0.5x 0.5 m wide sampler – 15 cores proposed), and Standard Gravity Piston coring (up to 6 m deep x 0.1 m diameter cores – 16 cores proposed) along transects within the canyon systems. On the basis of this plan, we anticipate a total volume of 0.7 m³ of megacorer samples, 1.9 m³ of box cores to be sampled, and 3.0 m³ of Standard Gravity Piston cores – equating to a total of 5.6 m³ of seafloor sampling, for each campaign; hence an anticipated recovery of 11.1 m³ of sediment.

Table 6: Overview of physical sampling requirements for the MISSING-Link expedition.

Type of sample	Type of gear	Water column	On or in seabed	Below seabed	Number Stations	Water depths	Distance from coast
Box core	NIOZ box core	No	Yes	Yes	15	170-3400 m	12-200 NM
Mega-corer	OSIL mega-corer	No	Yes	Yes	30	170-3400 m	12-200 NM
Standard Gravity Piston coring	Standard Gravity Piston coring	No	Yes	Yes	16	170-3400 m	12-200 NM
Water sample	Fluidion Deep Water Sampler and from CTD rosette to calibrate salinity measurements	Yes	No	No	<100 (sampled while AUV is underway and from CTD rosette)	170-3400	12-200 NM

3.2.4.1 Box Coring

The NIOZ box corer is a seabed sampling instrument designed to collect relatively undisturbed sediment blocks and their overlying bottom water. During deployment, the corer is lowered to the seafloor with its sampling box held open and its spade and doors locked in position. When the frame makes contact with the seabed, the instrument's weight allows the sampling box to penetrate the sediment vertically. As the corer is lifted, a mechanical trigger closes the spade beneath the sample and swings the top doors shut, sealing the sediment and preserving its stratification and water-sediment interface. Once recovered on deck, the box insert is removed for sub-sampling, allowing researchers to extract intact vertical profiles of sediments, pore waters, biological communities, and geochemical gradients with minimal disturbance.

3.2.4.2 Mega Coring

The OSIL Mega-Corer is a multi-core seabed sampling system designed to recover multiple high-quality, undisturbed sediment cores in a single deployment. During descent, each core tube is held open with its core catcher and sealing mechanisms restrained to prevent premature closure. When the frame lands on the seabed, the system's weighted structure allows the core tubes to penetrate vertically into the sediment under their own mass. As the corer is lifted, each tube's core catcher engages to retain the sediment, and an upper sealing

valve closes to preserve the overlying water and maintain the sediment–water interface. On deck, the tubes are removed individually for sub-sampling, providing a consistent suite of parallel sediment cores ideal for geochemical, biological, and sedimentological analyses.

3.2.4.3 Gravity Piston Coring

A standard gravity–piston corer is designed to collect long, relatively undisturbed sediment cores from the seabed. During deployment, the core barrel—fitted with a piston and a core catcher at the lower end—is suspended beneath a weighted head that provides the driving force. As the system free-falls through the water, the weight and momentum allow the barrel to penetrate deeply into the sediment. When the barrel enters the seabed, the piston remains at the sediment surface, creating suction that reduces internal friction and allows the sediment column to enter the liner more cleanly. As the corer is retrieved, the core catcher engages to retain the sample, preventing loss from the bottom of the tube. Once on deck, the liner is removed and sectioned for sedimentological, geochemical, and paleoenvironmental analyses, providing a continuous vertical record of seabed deposition.

3.2.4.4 Water Sampling

The Fluidion Deep Water Sampler is an autonomous, pressure-tolerant water sampling system designed to collect discrete seawater samples during underwater missions. When mounted on an AUV, the sampler receives a trigger from the vehicle’s mission controller at predefined depths or waypoints. Upon command, the system activates an internal pumping and valve mechanism that draws 100 ml of water into one of its sterile sampling chambers, isolating the sample by sealing the chamber immediately after filling to prevent contamination or mixing. The sampler records metadata such as depth, temperature, time, and system diagnostics for each collection event. Because it is compact and electrically efficient, the unit integrates cleanly with AUV payload power and communication systems, allowing high-quality chemical, biological, or microbiological samples to be captured at targeted locations without interrupting the vehicle’s mission. Once the AUV is recovered, the 14 sealed sample cartridges are removed for laboratory analysis.

3.2.5 AUV Camera System

The Autosub 5 camera system is an integrated imaging payload designed to capture high-resolution seabed and mid-water imagery during autonomous missions. The system consists of a downward-looking 20 Mpix digital stills camera paired with a synchronized LED strobe or high-intensity lighting array to ensure consistent illumination under low-light deep-sea conditions. The camera is mounted in a pressure-rated housing and triggered automatically by the vehicle’s mission controller at predefined altitudes, waypoints, or time intervals. An onboard altitude sensor, collision avoidance system and navigation data stream allow the vehicle to maintain stable flight height of 3-5 m above the seabed, ensuring uniform image scale and overlap for photogrammetric processing. All imagery is stored to high-capacity solid-state memory within the camera module, along with metadata such as depth, position, pitch, and roll. After recovery, the dataset provides detailed visual records of seabed habitats, geological structures, and anthropogenic features, supporting quantitative analysis and habitat characterization.

3.2.7 Ultra-Short-Baseline (USBL)

A USBL system determines the underwater position of a vehicle or instrument by measuring the travel time and angle of arrival of acoustic signals exchanged between a transceiver mounted on the surface vessel and a transponder or responder mounted on the subsea asset. The Ranger 2–class configuration provides mid-range tracking capability, typically supporting reliable positioning over several kilometres with high update rates. During operation, the vessel-mounted transceiver emits short acoustic interrogation pulses; the subsea transponder

receives these pulses and replies with its own acoustic signal. The USBL processor measures the return signal's travel time to determine slant range, while an array of closely spaced hydrophones in the transceiver determines the horizontal and vertical arrival angles through phase-differencing techniques. By combining angle-of-arrival and range information, the system computes a real-time 3D position fix relative to the vessel. Motion sensors and GPS on the surface platform provide corrections for pitch, roll, heave, and heading, ensuring accurate and stable tracking of the underwater target even in dynamic sea states. USBL will be used for positioning of the AUV, gliders and of over-the side sampling deployments.

3.2.8 CTD and turbulence profilers (except mooring mounted, see 3.3.3.2)

3.2.8.1 *Sea-Bird SBE 9plus CTD*

The Sea-Bird 911plus is a ship-deployed, real-time oceanographic CTD system engineered for high-accuracy profiling from the surface to full ocean depth. It uses a pumped-flow conductivity and temperature measurement path to ensure rapid sensor response and stable alignment between channels, while a precision quartz pressure sensor provides accurate depth determination. The instrument transmits data continuously through a sea cable to the surface, where the deck unit handles power distribution, real-time data acquisition, and system control. Typically integrated with a rosette water sampler, the 9plus supports coordinated bottle firing using auxiliary channels and altimeter input. Its fast sampling rate and robust pump-controlled flow enable the high-resolution vertical structure of temperature, salinity, and density to be measured even in sharp thermohaline gradients. The system is designed for repeatability and long-term calibration stability.

3.2.1.2 *Rockland Scientific VMP-2000 Vertical Microstructure Profiler*

The Rockland Scientific VMP-2000 is a free-fall, high-resolution microstructure profiler designed to measure small-scale turbulence and mixing processes throughout the water column. During deployment, the instrument is released to descend through the water at a controlled fall speed, typically between 0.5 and 0.8 m/s. Cable is spooled out to ensure that the instrument is freefalling and so unaffected by ship movement. As it falls, the profiler's microstructure sensors—piezoelectric shear probes and fast-response thermistors—capture fine-scale velocity shear and thermal gradients at kilohertz sampling rates. These signals are used to estimate turbulent kinetic energy dissipation and vertical eddy diffusivity with very high spatial resolution. The profiler also carries standard CTD sensors, accelerometers, and tilt sensors to correct for motion and to provide contextual hydrographic data. Data is transmitted up the cable in real time to a logging computer on deck and when the instrument approaches the seabed, it is winched back to the surface. To ensure robust scientific result, profiling is repeated multiple times while the ship is moving slowly through the water.

3.2.9 ADCPs (except mooring mounted, see 3.2.3.1)

3.2.9.1 *Teledyne RDI 300 kHz Workhorse ADCP (CTD Mounted)*

The Teledyne RDI 300 kHz Workhorse is a mid-frequency Acoustic Doppler Current Profiler designed for versatile oceanographic current measurements from fixed moorings, mobile platforms, or vessel-mounted configurations. Operating at 300 kHz, it provides a balance of profiling range and vertical resolution, making it suitable for shelf-sea deployments, coastal studies, and moderate-depth current surveys. The instrument uses a four-beam Janus configuration to transmit acoustic pulses and measure the Doppler shift of backscattered sound from particles in the water column, generating vertical profiles of current magnitude and direction across user-defined depth cells. Integrated sensors—such as tilt, temperature, and optional pressure—allow the ADCP to correct for instrument orientation and provide context for current structure. The Workhorse series is known for its robust build, low power consumption, and reliable long-term operation, and can store data internally or stream it in real time depending on platform requirements. Two RDI 300 kHz ADCPs will be attached to

the CTD rosette, in down-looking and up-looking configurations. They are synced acoustically to avoid cross-contamination of the signals.

3.2.9.2 Syrinx SprintNav 600 kHz (AUV mounted)

The Syrinx SprintNav is a compact, high-frequency 600 kHz Doppler Velocity Log (DVL) and inertial navigation system designed for precise near-bottom and mid-water velocity measurements. Using a four-beam Janus configuration, it transmits short acoustic pulses and measures the Doppler shift of echoes returning from the seabed or suspended particulates, producing high-precision velocity-over-ground or water-tracking data. Its 600 kHz operating frequency provides excellent resolution for low-altitude AUV flight, enabling accurate dead-reckoning and stable control in challenging terrain or during close-proximity survey operations. The SprintNav integrates the acoustic DVL with an onboard high-grade IMU, allowing tightly coupled inertial-acoustic navigation that maintains accurate state estimates even during brief periods of acoustic dropout. This makes the system well suited for complex missions such as pipeline inspection, habitat mapping, detailed seabed surveys, and manoeuvring in cluttered or variable environments.

3.2.9.3 Teledyne RDI 75 kHz and 150 kHz Ocean Surveyor ADCP (Vessel Mounted)

The Teledyne RDI 75 kHz and 150 kHz Ocean Surveyor are low-frequency Acoustic Doppler Current Profilers optimised for vessel mounting. They provide real-time profiles of current velocity under the ship down to >700 m (75 kHz) and >400 m (150 kHz). Ship motion is removed from the data using the vessels high-accuracy GPS.

4. Receiving environment: Annex IV Species

This section details information relevant to those species identified as requiring consideration in Table 4.1 and with relevance to the proposed study areas.

Table 7: Overview of Annex IV Species requiring consideration

Group	Common name	Scientific name	Notes
Cetaceans	All cetacean species		All whales, dolphins, and porpoises in EU waters
Pinnipeds	Mediterranean monk seal	<i>Monachus monachus</i>	Only Annex IV seal species in EU marine waters
Marine turtles	Hawksbill turtle	<i>Eretmochelys imbricata</i>	Very rare vagrant
	Loggerhead turtle	<i>Caretta caretta</i>	One of the most common nesting and foraging marine turtles in EU waters (Mediterranean, occasional Atlantic)
	Green turtle	<i>Chelonia mydas</i>	Primarily an Eastern Mediterranean nester (e.g., Cyprus)
	Kemp's ridley turtle	<i>Lepidochelys kempii</i>	Very rare vagrant
Fish	European sturgeon	<i>Acipenser sturio</i>	Anadromous, uses marine waters
	Allis shad	<i>Alosa alosa</i>	Anadromous
	Twaite shad	<i>Alosa fallax</i>	Anadromous

Invertebrates	Date mussel	<i>Lithophaga lithophaga</i>	Mediterranean
	Noble pen shell	<i>Pinna nobilis</i>	Mediterranean
Otters	Eurasian otter	<i>Lutra lutra</i>	Freshwater, estuarine, and some coastal/marine environments.

4.1. Cetaceans

All cetaceans occurring within the Exclusive Economic Zone are strictly protected under Article 12 of the EU Habitats Directive and are primarily listed as Annex IV species. Twenty-six cetacean species have been recorded in Irish waters. Distribution data held by the National Biodiversity Data Centre's Marine Mammal Database—drawing on multiple sources such as the Irish Whale and Dolphin Group—indicate that the waters within and around the proposed project areas are used by a variety of cetacean species. Their presence, density, and spatial distribution vary seasonally and over time.

Those that are known to have been sighted in the study areas and a conservatively assumed 20 km Zone of Influence of the study sites include: Common dolphin (*Delphinus delphis*), Common Porpoise (*Phocoena phocoena*), White-beaked Dolphin (*Lagenorhynchus albirostris*), Bottle-nosed Dolphin (*Tursiops truncatus*), Risso's Dolphin (*Grampus griseus*), Fin Whale (*Balaenoptera physalus*), Humpback Whale (*Megaptera novaeangliae*), Minke Whale (*Balaenoptera acutorostrata*), Killer Whale (*Orcinus orca*), False Killer Whale (*Pseudorca crassidens*), Blue Whale (*Balaenoptera musculus*), Sperm Whale (*Physeter macrocephalus*).

Based on documents from the National Parks & Wildlife Service (NPWS), we understand that the Belgica Mound Province Special Area of Consideration (that lies within 50 km of the Gollum Channel study site) is designated with respect to two cetacean species — Bottlenose Dolphin (*Tursiops truncatus*) and Harbour Porpoise (*Phocoena phocoena*). Although infrequent, there are live cetacean recordings within the Belgica Mound Province SAC including Common dolphin (*Delphinus delphis*), Common Porpoise (*Phocoena phocoena*), False Killer Whale (*Pseudorca crassidens*), Fin Whale (*Balaenoptera physalus*), White-beaked Dolphin (*Lagenorhynchus albirostris*), and Bottle-nosed Dolphin (*Tursiops truncatus*). Regarding cetaceans, this region qualifies as an SAC for Annex II listed species including Bottle-nosed Dolphin (*Tursiops truncatus*) and Common Porpoise (*Phocoena phocoena*).

The Southern Canyons cSAC, which overlaps with our study area in Whittard Canyon, does not formally list cetaceans as Qualifying Interests, however, deep-diving whales and dolphins are known to use the canyon habitat. The NGO Irish Whale & Dolphin Group (IWDG) indicates that the Southern Canyons region (including the off-shelf canyons like the Whittard Canyon) is a suitable habitat for Long-finned pilot whales (*Globicephala melas*) and different species of beaked whales. The IWDG also note a presence of common dolphins and harbour porpoise in wider Irish deep waters. Though not explicitly confirmed for the specific cSAC, they are plausible given the offshore habitat.

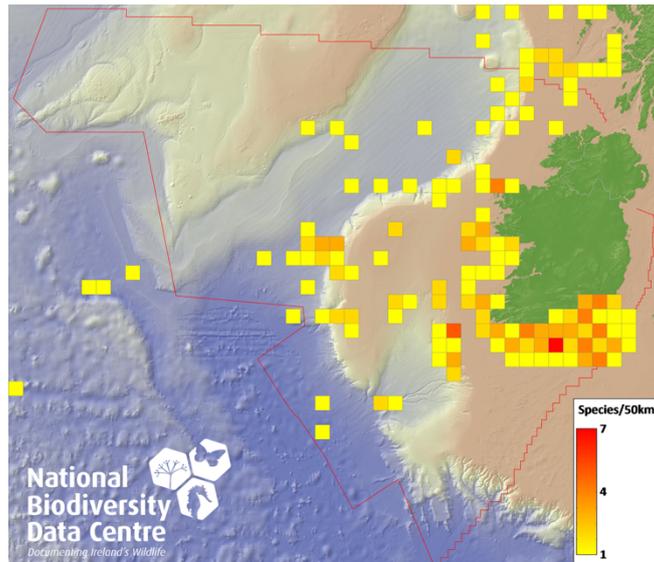


Figure 4: Example of data used in this assessment - Ship sightings of cetaceans from Irish Whale & Dolphin Group, IWDG Ship Surveys Sightings - IWDG Surveys 2003 - 2015, National Biodiversity Data Centre, Ireland, image, accessed 17 November 2025, <https://maps.biodiversityireland.ie/Dataset/MarineSpeciesDistributionMapPrintSize/233>

4.2. Otters

Coastal otters use nearshore marine habitats for foraging and feeding at certain times of the year. The proposed study areas lie at least 100 km offshore and are therefore well beyond the typical range of otter commuting or foraging activity. In addition, no otter records exist within the proposed survey locations.

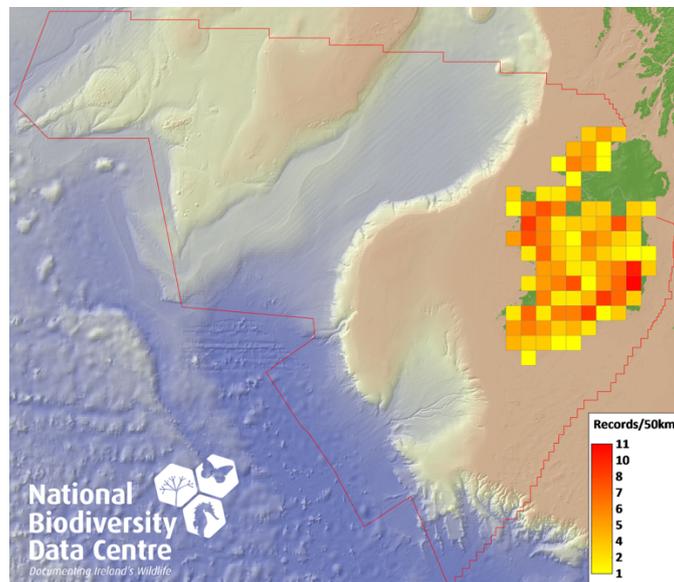


Figure 5: Otter survey of Ireland 2004-2005 from National Parks & Wildlife Service, Department of Housing, Local Government and Heritage, Otter survey of Ireland 2004 & 2005, National Biodiversity Data Centre, Ireland, image, accessed 17 November 2025, <https://maps.biodiversityireland.ie/Dataset/MarineRecordDistributionMapPrintSize/161>

4.3. Reptiles (marine turtles)

Leatherback Turtles (*Dermochelys coriacea*) are recorded sporadically around the Irish coastline. No occurrences were identified within or immediately surrounding the proposed

Whittard Canyon study area, and only three individual sightings have been documented within the Gollum Channel site.

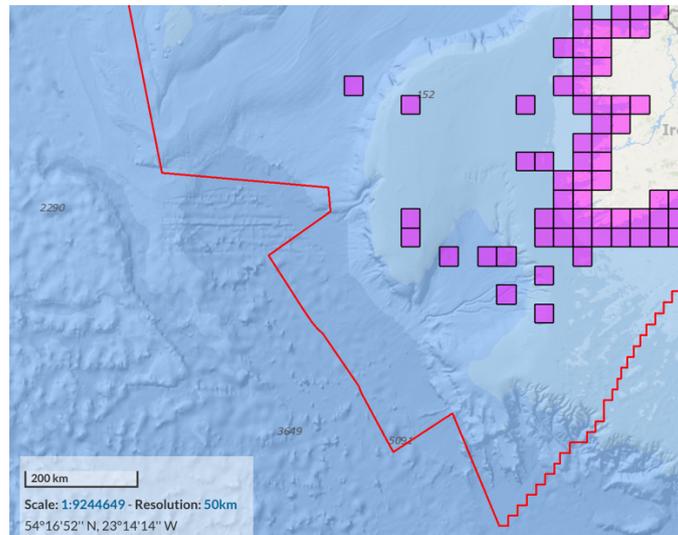


Figure 6: Marine turtle records in Irish waters from <https://maps.biodiversityireland.ie/Map/Marine/Dataset/114>

4.4. Bats

Vessel-based acoustic surveys pose no risk to bats, their habitats, or their roosting sites. The survey area is located well offshore, beyond the range at which coastal roosts or foraging activity could be affected. Accordingly, bats are not considered further in this assessment.

5. Risk Assessment for Annex IV species

For Annex IV species, the only plausible impact pathways for the proposed scientific survey activities are:

1. Underwater noise from survey operations (geophysical surveys and acoustic instruments)
2. Localised physical disturbance of seabed habitats and associated benthic fauna, including potential for very localised, short-term turbidity plumes
3. Vessel presence and collision risk at the surface

We now discuss these specific activities with relevance to risks posed to the different species identified earlier.

5.2. Cetaceans

Underwater Noise

Underwater noise has the potential to disturb, harm, or injure marine mammals, depending on the noise type, frequency, intensity, and the distance between the source and the receptor. Cetaceans are particularly sensitive to sound, relying on it for navigation, communication, and perceiving their environment. Their behavioural responses to noise vary with context and individual characteristics such as experience, motivation, conditioning, and current activity (Southall et al., 2007). It is therefore essential to assess the potential effects of any introduced sound source on a case-specific basis (NPWS, 2014).

As sound travels through the water, it dissipates with increasing distance from the source, and its propagation is shaped by local oceanographic conditions. Exposure to sufficiently high noise levels can cause auditory injury in marine mammals, ranging from a temporary reduction in hearing sensitivity—Temporary Threshold Shift (TTS)—to a more lasting impairment, known as Permanent Threshold Shift (PTS). The likelihood of such effects depends on how the noise frequency aligns with the species’ hearing range and on the duration of exposure. Ultimately, the Sound Exposure Level (SEL) received by an individual determines the magnitude of potential impact.

Table 8 summarises the hearing-related functional groups relevant to the majority of cetacean species occurring in Irish waters.

Table 8: Cetacean functional groups relative to hearing at different sound frequencies

Low frequency 7 Hz-22 kHz	Mid-frequency 150 Hz-160 kHz	High frequency 200 Hz–180 kHz
Baleen whales	Most toothed whales, dolphins	Certain toothed whales, porpoise
Species – Ireland Humpback whale Blue whale Fin whale Sei whale Minke whale	Species – Ireland Sperm whale Killer whale Long-finned pilot whale Beaked whale species Dolphin species	Species – Ireland Pygmy sperm whale Harbour porpoise

Based on NPWS (2014). Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters.

Table 9 presents the sound-pressure level thresholds for the relevant functional hearing groups, based on Southall et al. (2007) and the subsequent refinements introduced by Southall et al. (2019), which maintain broadly comparable injury criteria for the purposes of this assessment.

Table 9: Sound pressure levels associated with Temporary Threshold Shift (TTS) and Permanent Threshold Shift (PTS)

Functional group	Injury Criteria (based on a single pulse)	
	TTS	PTS
Low frequency cetaceans	224 dB re: 1 µPa (peak)	230 dB re: 1 µPa (peak)
Mid frequency cetaceans	224 dB re: 1 µPa (peak)	230 dB re: 1 µPa (peak)
High frequency cetaceans	224 dB re: 1 µPa (peak)	230 dB re: 1 µPa (peak)
Pinnipeds (in water)	212 dB re: 1 µPa (peak)	218 dB re: 1 µPa (peak)

The frequencies used by the shipboard multibeam echosounder, the ADCP (45 kHz), and the USBL (19–34 kHz) fall within the hearing ranges of Bottlenose Dolphin and Harbour Porpoise, and could therefore cause temporary behavioural responses if these species are present during survey operations. The USBL and sub-bottom profiler frequencies also overlap with the hearing ranges of low-frequency cetaceans such as Humpback and Minke Whales, which may occur within the wider study areas. Although noise from this equipment is unlikely to propagate beyond approximately 3 km from the relatively small survey sites, a precautionary 20 km Zone

of Influence has been adopted. Given the extensive availability of alternative foraging habitat in the region, significant impacts on these species are considered unlikely; however, temporary disturbance to Bottlenose Dolphin, Harbour Porpoise, Humpback Whale, and Minke Whale remains possible—particularly within the Gollum Channel study area, which lies closest to the Belgica Mounds Province SAC.

It should also be noted that multibeam echo-sounders will not be deployed within the Belgica Mounds Province SAC. Even if they were, the planned operating frequency of 30 kHz lies outside the functional hearing range of cetaceans. The USBL operates within the hearing ranges of Bottlenose Dolphin, Harbour Porpoise, Humpback Whale, and Minke Whale, however the noise generated is low intensity and short duration. As a result, noise from the multibeam echosounder and USBL will not affect Annex II/IV cetaceans within this protected area, which is more than 50 km away from the proposed study area in Gollum Channel and >210 km away from the Whittard Canyon study area. The ADCP, however, is hull-mounted and produces noise within the hearing range of Bottlenose Dolphin and Harbour Porpoise. Despite this, the availability of extensive alternative habitat and mobile nature of the species concerned means that survey-related noise is unlikely to have significant impacts on either species.

With regards to the local sediment sampling that is proposed, the act of lowering and retrieving a gravity or box corer does not in itself generate high-level impulse or tonal noise. The corer is lowered slowly through the water column on a wire. The device penetrates the seabed under its own weight (and optional additional weights), taking a discrete sediment sample. After penetration, the corer is recovered back to deck for processing.

Noise emissions are those of:

- Normal vessel propulsion / dynamic positioning system; and
- Occasional winch noise transmitted into the hull.

These sources are:

- Broadband, continuous and comparable to typical commercial shipping or research vessel operations;
- Orders of magnitude lower than seismic airgun arrays or pile-driving in terms of peak source level and sound exposure level;
- Localised around the vessel and temporally short-lived at each station.

As NPWS (2014) guidance on man-made sound emphasises, the highest risk to marine mammals arises from high-intensity impulsive sources (airguns, impact piling, explosives), with vessel noise and low-power scientific systems generally representing a low to moderate risk, managed through standard good practice.

- Coring operations are short in duration at each station;
- Sources are comparable to routine vessel operation, which cetaceans and turtles already experience widely; and
- Sampling occurs in deep offshore waters with no resident Annex II marine mammals designated as site features in the immediate area (other than near to the Belgica Mound Province SAC),

Therefore, the incremental noise contribution from sediment coring is considered negligible relative to the wider shipping / survey noise environment. It is highly unlikely to cause injury (PTS/TTS) or significant behavioural disturbance to Annex IV species at population or site level.

Physical disturbance of seabed

With regards to seafloor disturbance, the only activities to be employed that will interact with the seafloor are associated with sediment sampling (i.e. piston coring, box coring) which only remove a very small footprint of seabed:

- Piston corer: ~0.15 m diameter → disturbance footprint ~0.05 m² per core;
- Box corer: ~0.5 x 0.5 m, plus frame → ~1 m² per core.
- Mega corer: frame diameter ~1m
- Mooring anchor: max 1m diameter

Even with multiple replicate cores per station, the total area disturbed is very small relative to the scale of canyon / basin habitats (many km²). Effects include:

- Removal of a small volume of sediment and associated infauna/epifauna;
- Localised seabed compaction or minor penetration marks.

Annex IV cetaceans do not depend directly on the deep benthic community at these depths for foraging (their prey are primarily pelagic / epipelagic), so this disturbance pathway does not translate into a meaningful effect on their foraging habitat or prey base. Any effect is limited to deep benthic invertebrates and associated demersal fauna, not Annex IV species.

Turbidity / sediment plumes

Penetration and recovery of corers may generate a small plume of resuspended sediment:

- Spatially confined to a few tens of metres around the coring point and much smaller than natural sediment transport events known to occur in and around the canyon/channel systems;
- Temporally limited (minutes to at most hours) before particles resettle;
- Density contrast is minimal in the deep-water column and unlikely to propagate far.

Vessel presence and collision risk

During sediment coring and other scientific activities, the research vessel operates at very low speed or remains on station. Collision risk is therefore:

- Lower than during transit, because propeller and hull are moving slowly;
- Comparable to that of any stationary or slow-steaming vessel in offshore waters.

Standard marine mammal (e.g. maintaining a vigilant watch, adherence to safe vessel speed when animals are observed near the bow) is sufficient to keep collision risk for Annex IV species extremely low.

5.3. Otters

Underwater Noise

Otters are not acoustically adapted for underwater hearing, though experimental studies have shown that they may exhibit behavioural reactions to certain underwater sounds. In practice, otters forage very close to shore—typically within 100 m of the coastline. While occasional records exist of individuals occurring 200–300 m offshore around the UK, such instances are considered atypical. As the proposed survey sites are located more than 100 km from land,

they lie well beyond the commuting and foraging range of otters. Accordingly, impacts on this species from the proposed survey operations are not considered possible.

Furthermore, no spatial overlap is anticipated between the proposed activities and any otter foraging or commuting habitat; therefore, no additional assessment of potential impacts is required.

5.4. Reptiles (Marine Turtles)

Given the very limited number of marine turtle records within the proposed study areas and the overall scale and nature of the project, impacts on marine reptiles are not considered possible. Nonetheless, standard marine-mammal observation protocols—such as maintaining a vigilant lookout and reducing vessel speed when animals are sighted near the bow—are sufficient to ensure that collision risk for Annex IV species, including turtles, remains extremely low. In addition, turtles do not rely on deep-water benthic communities for foraging, as their prey is primarily pelagic or epipelagic. Consequently, any disturbance associated with the small-scale sediment sampling proposed would not have a meaningful effect on turtle foraging habitat or prey availability.

6. Conclusion

Based on the available evidence and accounting for a conservative, worst-case assessment of the proposed survey equipment, the project is not expected to cause behavioural disturbance or Temporary Threshold Shift (TTS) in cetaceans that may occur in the survey area. The identified risks are similarly not applicable to other species such as otters or bats. Under Article 12 of the EU Habitats Directive, Member States must ensure the strict protection of Annex IV species, including the prohibition of “deliberate disturbance,” particularly during sensitive periods such as breeding, rearing, hibernation, and migration.

Although no potential impacts have been identified, and in keeping with the precautionary principle, the mitigation measures outlined in Section 7 are recommended to prevent any risk of disturbance to the species mentioned above and will be applied should the project proceed.

7. Proposed Mitigation

NPWS (2014) provide guidance to manage the risk to marine mammals from human-made sound sources in Irish waters. This document provides guidance and mitigation measures to address key potential sources of anthropogenic sound that may impact negatively on marine mammals in Irish waters. The mitigation methods will follow the guidance prescribed by the National Parks and Wildlife Service. Specifically, in relation to geophysical acoustic surveys, which are included in this project, the guidance set out in NPWS (2014), as stated below, will be fully implemented.

1. A qualified and experienced marine mammal observer (MMO) shall be appointed to monitor for marine mammals (as well as for turtles and diving birds as appropriate) and to log all relevant events using standardised data forms (Appendix 6, NPWS, 2014).
2. Unless information specific to the location and/or plan/project is otherwise available to inform the mitigation process (e.g., specific sound propagation and/or attenuation data) and a distance modification has been agreed with the Regulatory Authority, acoustic surveying using the above equipment shall not commence if marine mammals are detected within a 500 m radial distance of the sound source intended for use, i.e., within the Monitored Zone.

7.1. Pre-Start Monitoring

3. Sound-producing activities shall only commence in daylight hours where effective visual monitoring, as performed and determined by the MMO, has been achieved. Where effective visual monitoring, as determined by the MMO, is not possible the sound-producing activities shall be postponed until effective visual monitoring is possible.
4. An agreed and clear on-site communication signal must be used between the MMO and the Works Superintendent as to whether the relevant activity may or may not proceed, or resume following a break (see below). It shall only proceed on positive confirmation with the MMO.
5. In waters up to 200m deep, the MMO shall conduct pre-start-up constant effort monitoring at least 30 minutes before the sound-producing activity is due to commence. Sound-producing activity shall not commence until at least 30 minutes have elapsed with no marine mammals detected within the Monitored Zone by the MMO.
6. Where operations occur in waters greater than 200m depth (i.e., >200m), pre-start-up monitoring shall be conducted at least 60 minutes before the activity is due to commence. Sound-producing activity shall not commence until at least 60 minutes have elapsed with no marine mammals detected within the Monitored Zone by the MMO.
7. This prescribed Pre-Start Monitoring shall subsequently be followed by a Ramp-Up Procedure which should include continued monitoring by the MMO.

7.2. Ramp-up Procedure

8. In commencing an acoustic survey operation using the proposed acoustic equipment, the following Ramp-up Procedure (i.e., "soft-start") must be used, including during any testing of acoustic sources, where the output peak sound pressure level from any source exceeds 170 dB re: 1 μ Pa @1m:
 - a. Where it is possible according to the operational parameters of the equipment concerned, the device's acoustic energy output shall commence from a lower energy start-up (i.e., a peak sound pressure level not exceeding 170 dB re: 1 μ Pa @1m) and thereafter be allowed to gradually build up to the necessary maximum output over a period of 20 minutes.
 - b. This controlled build-up of acoustic energy output shall occur in consistent stages to provide a steady and gradual increase over the ramp-up period.
 - c. Where the acoustic output measures outlined in steps (a) and (b) are not possible according to the operational parameters of any such equipment, the device shall be switched "on" and "off" in a consistent sequential manner over a period of 20 minutes prior to commencement of the full necessary output.
9. In all cases where a Ramp-Up Procedure is employed the delay between the end of ramp-up and the necessary full output must be minimised to prevent unnecessary high-level sound introduction into the environment.
10. Once the Ramp-Up Procedure commences, there is no requirement to halt or discontinue the procedure at night-time, nor if weather or visibility conditions deteriorate nor if marine mammals occur within a 500 m radial distance of the sound source, i.e., within the Monitored Zone.

7.3. Line Changes

11. Where the duration of a survey line or station change will be greater than 40 minutes, the activity shall, on completion of the line/station being surveyed, either:
 - (a) shut down and undertake full Pre-Start Monitoring, followed by a Ramp-Up Procedure for recommencement, or
 - (b) undergo a major reduction in seismic energy output to a lower energy state where the output peak sound pressure level from any operating source is 165-170 dB re: 1 μ Pa @1 m, and then undertake a full Ramp-Up Procedure for recommencement. It is important that this significant reduction in sound output is to a minimum point (i.e., minimum peak sound

pressure level) that in theory remains audible above most ambient sound and shipping noise and yet is also consistent with the Ramp-up Procedure.

12. Where the duration of a survey line or station change will be less than 40 minutes the activity may continue as normal (i.e., under full seismic output).

7.4. Breaks in sound output

13. If there is a break in sound output for a period greater than 30 minutes (e.g., due to equipment failure, shut-down, survey line or station change) then all Pre-Start Monitoring and a subsequent Ramp-up Procedure (where appropriate following Pre-Start Monitoring) must be undertaken.
14. For higher output survey operations which have the potential to produce injurious levels of underwater sound as informed by the associated risk assessment, there is likely to be a regulatory requirement to adopt a shorter 5–10-minute break limit after which period all Pre-Start Monitoring and a subsequent Ramp-up Procedure (where appropriate following Pre-Start Monitoring) shall recommence as for start-up.

7.5. Reporting

15. Full reporting on MMO operations and mitigation undertaken must be provided to the Regulatory Authority as outlined in Appendix 6 of NPWS (2014).

References

NPWS (National Parks and Wildlife Service), 2014. Guidance to manage the risk to marine mammals from man-made sound sources in Irish waters. Department of Arts, Heritage and the Gaeltacht, Dublin.

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Southall, B.L., Finneran, J.J., Reichmuth, C., Nachtigall, P.E., Ketten, D.R., Bowles, A.E., Ellison, W.T., Nowacek, D.P. and Tyack, P.L., 2019. Marine mammal noise exposure criteria: updated scientific recommendations for residual hearing effects. *Aquatic Mammals*, 45(2), pp.125-232.