ORBITAL
MARINE POWER

Orbital Marine Power

Orbital O2 Tidal Turbine

EMEC Berth 5, Fall of Warness, Eday, Orkney

Project Environmental Monitoring Plan

November 2025 Update

Document prepared for:

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1	James Murray	290520	Issue to Marine Scotland
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1 Overview

The O2 tidal turbine was installed at Berth 5 at the European Marine Energy Centre, Fall of Warness Tidal Test site in July 2022. The turbine has been operated there since then, with the exception of a 12 month period from February 2023 to March 2024, when the O2 was offsite for refurbishment work.

This report summarises how the proposed mitigation and monitoring measures associated with the project as detailed in the project environmental monitoring plan have been adhered to with a focus on activities since reinstallation.

Notable activities have included trials of a sonar/camera system to monitor for marine animal interactions around the rotor blades and turbine acoustic characterisation studies. Other notable wildlife interactions in this period include the high number of black guillemots recorded as roosting on the platform over summer months (See Section 2.3).

The report also provides a response to previous comments provided by NatureScot and Marine Directorate on the last PEMP update (Annex 1).

2 Environmental Mitigation and Monitoring Update

2.1 Acoustic Disturbance

Acoustic disturbance was identified as a potential environmental impact in the PEMP. An update is provided below of how mitigation has been applied through the installation and operation phases. An update is also provided on acoustic characterisation studies that took place in July and August 2025. The associated report is currently being produced.

Impact pathway	Receptor	Proposed mitigation/monitoring measure	Update November 2025
Disturbance – Noise from vessel activity (including transiting to and from site)	Cetaceans, Basking shark, Seals	**Mitigation**: The Scottish Marine Wildlife Watching Code (SMWWC)[1] will be adhered.	All vessels and personnel operating at the site and transiting to and from (associated with this project) have adhered to the SMWWC.

[1] Scottish Marine Wildlife Watching Code is downloadable from the Scottish Natural Heritage website: http://www.snh.gov.uk/enjoying-the-outdoors/what-can-i-see/wildlife-watching/watching-wildlife-responsibly/

Impact pathway	Receptor	Proposed mitigation/monitoring measure	Update November 2025
Disturbance – Noise from mooring installation methods	Cetaceans, Basking sharks, Seals	**Mitigation**: The SMWWC will be adhered to throughout all operations, where possible.	SMWWC was adhered to throughout the redeployment of the O2 on its moorings in early 2024.
Disturbance – Noise from operating turbine	Cetaceans, Harbour and grey seals	**Monitoring**: Acoustic monitoring of operational noise output to establish an acoustic signature of the Orbital O2 will be completed.	**Following consideration of feedback from NatureScot and discussion with relevant acoustic characterisation experts on the study methodology including the authors of the relevant acoustic characterisation standards IEC TS 62600-40:2019, a new acoustic characterisation study of the O2 was carried out in July and August 2025, building on the study reported in September 2021.** **This study is current being written up and will be presented in the next PEMP update. It will address all comments received to date on the acoustic methodology.**

2.2 Entanglement Risk

Impact pathway	Receptor	Proposed mitigation/monitoring measure	Update November 2025
Injury or death due to entanglement with mooring system/cable	Cetacean, Basking shark, Diving birds	**Monitoring**: The likelihood of impact through entanglement is anticipated to be very low. Regular drop camera footage of the mooring lines will be reviewed to look for evidence of entanglement events and entanglement of fishing gear etc. A	Six ROV inspections of the anchors, moorings and connectors have been carried out to date. MSS commented on 08/06/22 that they would welcome further information on how fishing gear would be removed. Orbital considers that the most likely entanglement area would be at the rotors. Should this occur, the design allows for the powertrains to be

		reporting protocol will be produced for the operator to follow in the event of an entanglement event.	brought to the surface following shutdown, allowing for removal and recovery of any fouled equipment by a surface boat. If fishing gear was trapped on the mooring lines, the gear would be subject to an assessment of the safest approach to removal. For a depth of <25m, it is likely that this would be carried out by a diver. Below 25m, ROV equipment would be used with a hydraulic cutting arm. This would be a more challenging scenario to successfully recover any fouled gear.

2.3 Disturbance/Displacement

Birds Update

Almost all observations of roosting birds on the O2 to date have been black guillemot. They have been observed through the desk cameras and occasional site maintenance visits. Their pattern typically shows higher number of individuals arriving at the platform with the onset of dusk, remaining on the device throughout the night and moving off again around dawn. It has also been observed that some individuals have remained or used the platform throughout the entire day, but this is less than the number residing on the platform at night.

There does not appear to be any one part of the platform that they prefer to reside. Although the birds appear year-round; they are lower in abundance in winter and greater in abundance in late spring through summer and decrease in numbers during the autumn.

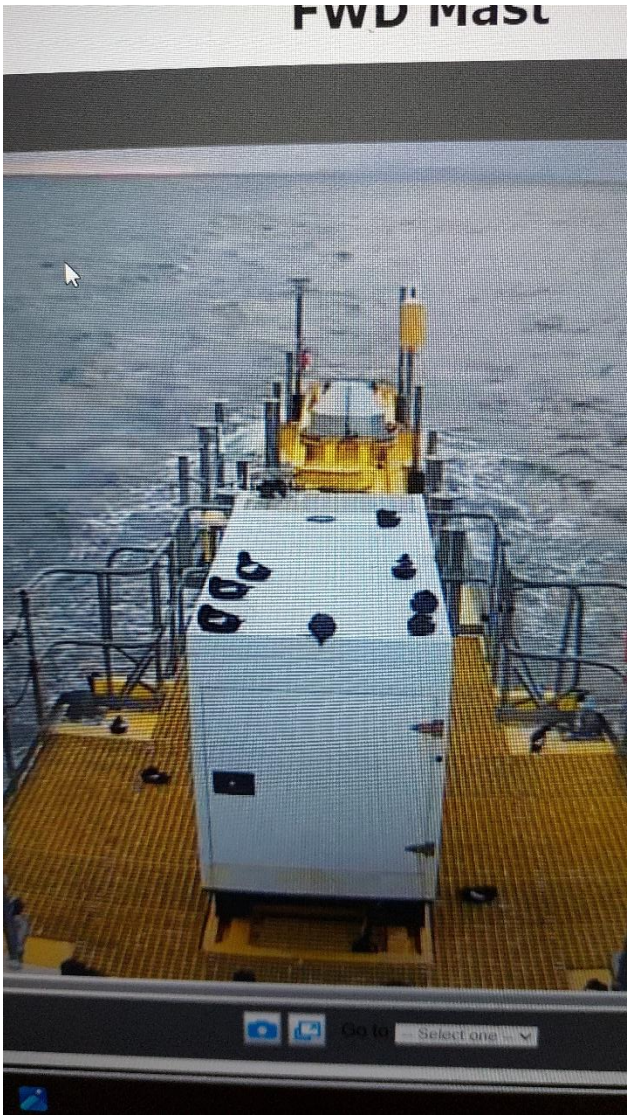


Figure 1 4th June 24 showing numerous black guillemot resting on turbine during daylight hours

A single cormorant was observed on 15th October 2024 on the O2 and ringed racing pigeon have also been observed on 13th June 2024.

Orbital would welcome the opportunity, if there is research benefit, to formalise data capture from the above-surface cameras. For instance, Orbital could take screenshots and record the number of birds residing within the field of view of the camera at given times throughout the year. This could, for instance, be a day-time and night-time instant on the order of one time per week to provide a long term data-set of how birds are using the platform. Orbital has been carrying this recording approach out since the beginning of 2025. Orbital is also hoping to shortly restore an infra-red light on the mast camera with better visibility which will improve the ability to take night-time counts.

Sample Day	Midday count	Midnight count	Highest number of black guillemot seen in one day that week	Highest number of black guillemot seen in one night that week
30/12/2024	0	0	0	
06/01/2025	0	0	0	
13/01/2025	0	2	0	2
20/01/2025	0	0	0	na
27/01/2025	0	0	0	na
03/02/2025	0	2	0	1
10/02/2025	0	3	0	5
17/02/2025	0	0	0	na
24/02/2025	0	0	0	na
03/03/2025	0	0	0	na
10/03/2025	0	5	0	6
17/03/2025	0	6	0	9
24/03/2025	0	7		10
31/03/2025				
07/04/2025		5	0	23
14/04/2025	0	7	0	11
21/04/2025	0	7	0	14
28/04/2025	0	7	0	30
05/05/2025	0	7	0	31
12/05/2025	1	7	1	29
19/05/2025	0	7	0	34
26/05/2025	1	7	1	38
02/06/2025	0	7	0	36
09/06/2025	0	7	0	44
16/06/2025	0	7	0	49
23/06/2025	0	7	0	51
30/06/2025	1	7	3	50
07/07/2025	0	7	0	48
14/07/2025	0	7	0	46
21/07/2025	0	7	0	50

28/07/2025	0	7	0	52
04/08/2025	2	6	3	48
11/08/2025	0	7	0	<10
18/08/2025	0	0	0	0
25/08/2025	0	0	0	0
01/09/2025	0	0	0	0
08/09/2025	0	0	0	0
15/09/2025	0	0	0	0
22/09/2025	0	0	0	0
29/09/2025	0	2	0	3
06/10/2025	0	6	0	6
13/10/2025	0	7	0	6

Table 1 Black Guillemot Counts 2025

It should however be noted that the presence of the black guillemots on the O2 in undesirable from a HSE perspective, particularly in the summer months when their numbers are higher. The volume of waste that the birds produce can prove a hazard and it becomes slippery to offshore operations staff. This is shown in the image below. Orbital would prefer from a HSE perspective that the birds do not reside upon the device. As such, Orbital would like to discuss the installation of a visual bird deterrent on the platform of the O2 during summer months, as shown in the images below.

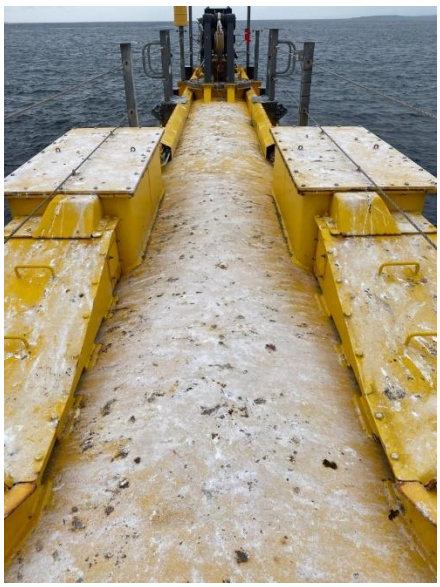


Figure 2 Black Guillemots presenting an HSE issue (May 2024)

Figure 3 Proposed Bird Scarer

The cameras themselves do not provide sufficient coverage to record to the behaviour of the guillemots around the device in the water. They have been typically observed to land in the water close to the platform and then exit the water onto the platform.

During installation and initial testing of a new pole mounted sonar and camera on 15th May 2025, a black guillemot was recorded at close range to the camera. Please see Annex 2 for the position of the camera.

As further trials of the pole mounted sonar and camera take place on the O2, it is possible that further evidence will emerge of the behaviour of the black guillemot around the platform.

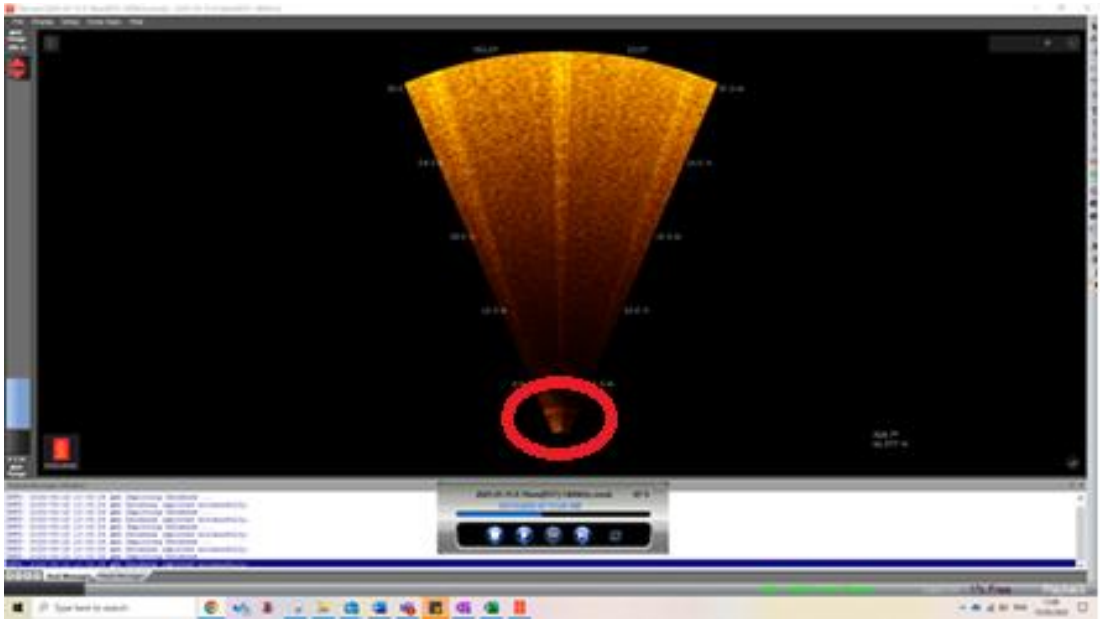


Figure 4 Camera and sonar screenshot of black guillemot (15th May 2025)

Marine Mammals Update

Two orcas were also observed transiting between the device and Eday on the 9th December 2024 and mitigations measures applied as per the table below to ensure no disturbance as they made this transit.

Figure 5 9th Dec 24 – two Orca spotted close inshore at Eday

Impact pathway	Receptor	Proposed mitigation/ monitoring measure	Update November 2025
Disturbance – Presence or noise from vessel activity (including transiting to and from site)	Cetaceans, Basking shark	**Mitigation**: The Scottish Marine Wildlife Watching Code (SMWWC) will be adhered, including the following measures: – Vessel speeds will be reduced to 6 knots when a cetacean is sighted in close proximity to the immediate vessel transit route. – A steady speed and vessel course will be maintained if a cetacean approaches a vessel involved in marine operations. – Utmost care will be taken in ensuring groups and mothers and young are not split up by vessels. – Sudden changes in speed and direction will be avoided to reduce the likelihood of any further disturbance to cetaceans in the vicinity. The completion of this mitigation measure will be dependent on ensuring safe navigation throughout activities, crew safety and completion of marine operations which are constrained by tidal or weather windows.	All vessels and personnel operating at the site and transiting to and from (associated with this project) have adhered to the SMWWC.
Harassment/Disturbance – Presence of vessel activity (including transiting to and from site)	Harbour and grey seals	**Mitigation**: SMWWC will be adhered to including the measures outlined above. In addition, during all vessel activity a minimum	All vessels and personnel operating at the site and transiting to and from (associated with this project) have

Impact pathway	Receptor	Proposed mitigation/ monitoring measure	Update November 2025
		approach distance will be complied with when passing designated seal haul-outs.	adhered to the SMWWC.
Disturbance – Presence of vessel activity (including transiting to and from site)	Seabirds	**Mitigation**: SMWWC will be adhered to including following particular measures: – Rafts of birds will not be intentionally flushed. – During seabird breeding season (April to August inclusive), vessel transit corridors will be at least 50m from shore in the vicinity of cliff-nesting seabirds to avoid disturbance.	All vessels and personnel operating at the site and transiting to and from (associated with this project) have adhered to the SMWWC. MSS provided feedback on 08/06/2022 requesting specific detail on aspects of the proposed mitigation, e.g. how will flushing of rafts of birds be avoided, e.g. by adjusting vessel speed and heading when rafts of birds are observed. Orbital offshore operations team complete daily report forms on which any records of marine life are noted. In the last 3 years of marine operations, the presence of rafting seabirds on route to the site has not been recorded. So, in practice, it hasn't been an issue. Vessel operators are aware of their responsibilities with regard this mitigation measure. In practice, Orbital typically access

Impact pathway	Receptor	Proposed mitigation/ monitoring measure	Update November 2025
			the O2 using a RHIB style vessel. Should rafting birds be observed, the RHIB would be reduced to a speed of around 6 knots to reduce vessel noise and allow for an alternative vessel heading to be made to provide a buffer of c. 100m from any rafting birds.
Disturbance – Presence or noise from mooring installation works and vessel presence onsite	Cetaceans, Seals, Basking shark	**Mitigation**: All operations will be conducted in line with SMWWC.	All vessels and personnel operating at the site and transiting to and from (associated with this project) have adhered to the SMWWC. See above record of two Orcas transiting between the O2 and Eday in December 2024.
Displacement – Barrier effect from the presence of device	Birds and potentially marine mammals, basking shark and fish	**Mitigation**: Mitigation only required if other research findings or monitoring indicates unacceptable impact. **Monitoring**: Record video footage from above-surface infrared cameras monitoring bird and marine mammal observations in the vicinity of the device[2].	There is significant roosting behaviour of black guillemot on the tidal turbine. See above and proposal to install bird scarer to deter roosting to address HSE issue.

[2] Two fish-eye cameras will be mounted on the communication masts will be able to capture the turbine deck and sea surface in the vicinity of the device. The cameras will operate in infrared at night and low-visibility conditions.

Impact pathway	Receptor	Proposed mitigation/ monitoring measure	Update November 2025
		In addition, roosting behaviour will be monitored. During device generation, an operator will be able to view video screens which show footage from both cameras[3]. Opportunistic recording of species behaviour will be recorded by the operator in line with an agreed protocol and reporting form.	See above proposal around black guillemot recording.

2.4 Seabed clearance

Impact pathway	Receptor	Proposed mitigation/monitoring measure	Update November 2025
Seabed loss due to the direct footprint	Benthic communities	**Monitoring:** Pre-installation and post-installation seabed survey will be conducted to understand the extent of the effect on the benthic ecology and seabed character caused during installation activities.	Pre-installation ROV video footage has been collected at each of the points where the project interfaces with the seabed. Orbital have 4 x ROV footage records of flapper skate around the O2 seabed infrastructure from pre-installation ROV footage and subsequent periodic footage. These images and associated coordinate information have been shared with the SharkScape project following an information request in July 2025.
Colonisation and loss of new habitat	Benthic communities	**Monitoring:** Pre-decommissioning seabed survey will be conducted 2 months	Not applicable at this stage.

[3] Following the commissioning stage, there is unlikely to be a permanent ongoing operator of the machine, with an automated operation process instead.

Impact pathway	Receptor	Proposed mitigation/monitoring measure	Update November 2025
		prior to decommissioning the anchors. The survey results will be used alongside the results from the surveys conducted when the mooring blocks were initially installed to investigate any effects on the benthic ecology and seabed character during the device deployment period.	
Recolonisation	Benthic communities	**Monitoring:** Post-decommissioning (within 3 months) seabed surveys will be conducted to investigate the effects on the benthic ecology and seabed character caused during decommissioning activities. There is also an opportunity to investigate the likelihood of recolonisation when analysing these results.	Not applicable at this stage.

2.5 Biofouling and non-native species

Impact pathway	Receptor	Proposed mitigation/monitoring measure	Update November 2025
Biofouling and the introduction of non-native species	Benthic communities	**Mitigation**: Compliance with good practice measures detailed in the 'Alien invasive species and the oil and gas industry – Guidance for prevention and management' produced by the IPIECA in 2010, 'Guidance for minimizing the transfer of invasive aquatic species as biofouling (hull fouling) for	These mitigation measures were applied when carrying out gearbox refurbishment work in 2024.

Impact pathway	Receptor	Proposed mitigation/monitoring measure	Update November 2025
		recreational craft' produced by the IMO in 2012 and the 'Code of Practice on Non-Native Species' made by Scottish Ministers under section 14C of the Wildlife and Countryside Act 1981.	
		Mitigation: Local vessels will be used throughout all installation, maintenance and decommissioning operations therefore there is not likely to be any potential for the introduction of NNS than those NNS already present in Orkney waters.	All installation and operations have been carried out with Orkney based vessels therefore reducing the potential for NNS transfer.
		Mitigation: Antifouling paints will be used which comply with the IMO International Convention on the Control of Harmful Anti-fouling Systems on Ships and national legislation.	The O2 main hull is not covered in anti-fouling paint and only discrete and sensitive areas are covered with anti-fouling coatings – specifically the turbine blades. Orbital operations regularly undertake inspections of these areas of coatings to ensure they remain intact – any loss of the coatings in the marine environment would be observed by areas of the undercoat becoming visible. Orbital uses a reputable supplier of antifouling and a brand that is fit for purpose in the tidal environment. This product does not contain organotin compounds acting as biocides and complies with the International Convention on the Control of Harmful Antifouling Systems on Ships as adopted by IMO October 2001 (IMO document AFS/CONF/26).
Biofouling, introduction of	Sessile communities	**Mitigation**: Opportunistic inspections of biofouling will be	In 2021/2022, Orbital provided Plymouth Marine

Impact pathway	Receptor	Proposed mitigation/monitoring measure	Update November 2025
non-native species and habitat creation for biofouling species		implemented which will have a dedicated procedure for removing biofouling species from the device. The organisms removed will be analyzed by experts to ensure a comprehensive species list is compiled.	Laboratory (PML) with biofouling samples from the O2 to develop a species list. Samples are time and date stamped and stored in 70% ethanol water solution for preservation, before transport.
Habitat removal for biofouling species	Sessile communities	A full device biofouling inspection may be conducted as the device is decommissioned. This inspection will be conducted by an expert in the biofouling field to ensure that a comprehensive species list is compiled.	Not applicable at this stage.

2.6 Collision Risk with Blades

Since the summer of 2025, the O2 is being utilised to install a combined pole-mounted multibeam sonar and underwater camera and inform the detailed design of a nearfield monitoring system that could be installed on future Orbital tidal turbines as and when required to support environmental monitoring objectives.

The main objectives of the trials on the O2 include:

- Gain learning around the power, communications and control interface;
- Testing performance of multibeam sonar (s) across different sensor configurations, tidal states and metocean conditions;
- Gain practical feedback on potential sources of interference including entrained air, mooring lines and umbilical cable;
- Eventual aim to collect sensor data using resulting optimised configuration to support developing algorithms for automated target detection.

A presentation that will be made to EIMR 2026 is included in Annex 2 and this provides a good overview of progress to date and next steps.

Impact pathway	Receptor	Proposed mitigation/monitoring measure	Update November 2025
Behavioural change, injury or death due to the interaction with turbine rotor with the potential for collision.	Diadromous fish; Gadoids, Cetacean, Basking shark or harbour and grey seal; All diving bird species (seaduck, red-throated diver, great cormorant, common guillemot, razorbill, Atlantic	Continual review of monitoring work carried at other sites with installed tidal turbines to ensure any required mitigation and monitoring measures are effectively employed. **Monitoring**: If possible, four underwater cameras will be mounted on the Orbital O2 system such that the full sweep of each blade can be observed. The cameras will only be effective during daylight hours[4].	Collision risk modelling has been completed for the O2 device at berth 5. To inform an accurate baseline for collision risk results, collision risk modelling using up to date data is being carried out under the EMEC S36 50 MW consent. In 2025 and into 2026, the O2 will be used as a test platform for validating the concept design of a nearfield integrated environmental monitoring system (IEMS). Progress to date is summarised is in Annex 2.

[4] This monitoring measure is dependent on the ability to design a mounting arrangement for the cameras on the device and sourcing suitable underwater cameras.

Impact pathway	Receptor	Proposed mitigation/monitoring measure	Update November 2025
	puffin, black guillemot, northern gannet).	The video footage can then be sampled at varying tidal states to understand fish, marine mammal, bird behaviour in close proximity to the device. A suitable measure for ensuring the camera lens remains free of biofouling and biofilms will also need to be determined.	

3 Conclusions and Next Steps

The O2 tidal turbine is being operated in line with the environmental monitoring plan mitigation and monitoring objectives.

It is apparent that the device hull is being significantly used by black guillemot , particularly during night-time hours and summer months.

Notable activities in this period include the sonar/camera near-field monitoring system trials which will inform the detailed design of such a system that can be installed on future units as required. This will continue into 2026.

Acoustic characterisation was carried out in line with IEC standards and a report will be submitted once the data has been analysed.

Annex 2. Previous PEMP Feedback Comments

	Marine Scotland Science Feedback 08/06/2022	Comments / Actions
1.1	Section 2.1 For acoustic disturbance, ornithology is not included as a receptor. MSS note that there is potential for disturbance to bird species (during diving and on surface) but that mitigation and monitoring outlined should be sufficient given the relatively low risk to bird species from the types and levels of noise expected from the operational activities.	No action required
1.2	Section 2.2 Ornithology (diving seabirds) are not included as a receptor, however, there is potential risk of secondary entanglement from	The PEMP has been updated to include this potential risk of secondary entanglement to diving seabirds.

	debris/fishing gear. Therefore, MSS suggest that this risk should also be noted.	
1.3	Section 2.3 For disturbance/displacement, birds are included for two potential impact pathways (*Disturbance – Presence of vessel activity (including transiting to and from site)* and *Displacement – Barrier effect from the presence of device*). MSS welcome that the Scottish Marine Wildlife Watching Code (SMWWC) will be followed, though note that this provides only high level guidance and is aimed at 'commercial and leisure activities involving the watching of marine wildlife' rather than more broadly considering marine activities which could impact on marine wildlife via disturbance. It would be helpful to include	Orbital offshore operations team complete daily report forms on which any records of marine life are noted. In the last 3 years of marine operations, the presence of rafting seabirds on route to the site has not been recorded. So, in practice, it hasn't been an issue. Vessel operators are aware of their responsibilities with regard this mitigation measure. In practice, Orbital typically access the O2 using a RHIB style vessel. Should rafting birds be observed, the RHIB would be reduced to a speed of around 8 knots to reduce vessel noise and allow for an alternative vessel heading to be made to provide a buffer of c. 100m from any rafting birds. Section 2.3 have been updated in this regard.

	more specific detail on aspects of the proposed mitigation, e.g. how will flushing of rafts of birds be avoided, e.g. by adjusting vessel speed and heading when rafts of birds are observed?	
1.4	Section 2.3 MSS welcome inclusion of above-surface monitoring via cameras (daylight and infrared 'night vision') of the device and near surroundings. It is noted that: *"Opportunistic recording of species behaviour will be recorded by the operator in line with an agreed protocol and reporting form."* MSS has not had sight of this protocol. MSS suggest that the protocol is included as an appendix for future iterations of the reporting or of PEMP. MSS further suggest that there is summary reporting of these observations given strategic interest such that this evidence can inform	Section 2.3 have been updated with notes on species recorded to date, which are almost entirely black guillemot, and a proposed methodology for ongoing data collection. We would welcome comments on this. Section 2.3 also highlights HSE issues resulting from the large number of black guillemots roosting on the platform during the summer months and a proposed solution.

	future development. Interestingly it is noted that no birds have been observed roosting on the platform thus far. This is in contrast to earlier evidence on a wave energy device (Jackson 2014) which was used by roosting birds, but the nature of that platform and how the two different devices function (i.e. tidal stream turbine versus wave energy convertor) are likely very different.	
1.5	Section 2.6 MSS note that underwater cameras have been installed to facilitate monitoring of underwater interactions of marine animals (including diving birds) with the turbine blade swept zone. MSS note that NatureScot (response issued 15 April 2022) advise that the next stage in better understanding collision risk will be to use monitoring data to verify	See Annex 2 for progress to date and planned next steps. We will provide regular updates as trials continue. Specifically in relation to image processing and analysis, preliminary image and video processing methodologies will be developed in collaboration with UHI. Currently, we are focussing on optimising the amount of usable data through testing various sonar configurations and gaining a better understanding of interference from turbine cables and mooring lines.

	the accuracy of existing modelling. MSS advise that an image processing and analysis methodology should be developed for the underwater video monitoring (assuming this has not already been done) given the difficulties in producing useable data from video data (requiring either semi/fully automated image processing via artificial intelligence or time-consuming human processing of video) to ensure best use is made of the monitoring data being collected.	
1.6	MSS understand that Orbital Marine Power are a partner on the Forward-2030 project[5] which includes environmental effects as a project component. This is	See above. FORWARD-2030 is part-funding the sonar/camera monitoring trials with funding also coming from the Supergen Flex Fund.

[5] Forward 2030 project website: https://www.forward2030.tech/

	mentioned in section 2.7 in relation to monitoring marine mammal behaviour, but it is not clear if there is wider scope, e.g. whether the camera data currently being collected will feed into this project. MSS suggest this is clarified in future reporting. NatureScot note that they have held discussions on the Forward-2030 project via a meeting (held 14 March 2022, mentioned in NatureScot response issued 15 April 2022).	
1.7	*Section 2.2* MSS welcome the monitoring and proposed reporting of entanglement risk through ROV inspection, however we would like better understand the methods of removing fishing gear should any be detected on the mooring lines.	Orbital considers that the most likely entanglement area would be at the rotors. Should this occur, the design allows for the powertrains to be brought to the surface following shutdown, allowing for removal and recovery of any fouled equipment by a surface boat. If fishing gear was trapped on the mooring lines, the gear would be subject to an assessment of the safest approach to removal. For a depth of <25m, it is likely that this would be carried out by a diver. Below 25m, ROV equipment would be used with a hydraulic cutting arm. This would be a more challenging scenario to successfully recover any fouled gear.

1.8	*Section 2.3* MSS welcome adherence to minimum distances of approach to designated seal haul-out sites however no distance is stated. We request that Orbital provides details on the minimum distance that has been determined so we can provide further comment. In lieu of this, MSS suggest adopting an approach which monitors behavioural state of seals on haul-outs and adjusting vessel speed and heading accordingly. If seals appear alert upon passage past or relatively close to the haul-out (heads raised and exaggerated movement towards the water line) slow vessel speed and divert course away from the haul-out until seals appear to ignore the vessel.	Orbital have approved passage plans and are aware of the grey seal breeding colony on the Green Holm areas. Orbital pass 0.5 nm clear to the north and 0.3 nm clear to the south of the haul out site. Vessel masters are aware of their obligations to alter course and heading when seals are sighted on the route itself and if required slow down. At these distances, the vessel masters have not observed any behavioural states that would suggest that the seals are sensitive to the transmits.

1.9	*Annex 1, Table 2:* MSS agree with the NS comments that more data would be appropriate to ensure the full tidal cycle is monitored, given differences in noise levels during flood and ebb tides at other sites. All drifts currently take place during the ebb tide. Flooding tide data is needed to ensure these are comparable across a cycle.	The 2025 acoustic characterisation report will address this.
1.10	While it has been noted that animals can avoid the elevated sounds of turbines during operations, distances of audibility would be useful. MSS suggest these data could be used in sound propagation models, taking bathymetry and tidal cycles into account, to determine the distance to which, and therefore locations where turbines will be audible. With these estimates, we can gain a better understanding of	Orbital will aim for any pertinent results from the acoustic characterisation study to be processed in time to inform the noise impact assessment for the Westray Tidal Array project EIA which can best consider matters such as barrier effects within the Westray Firth associated with multidevice deployment.

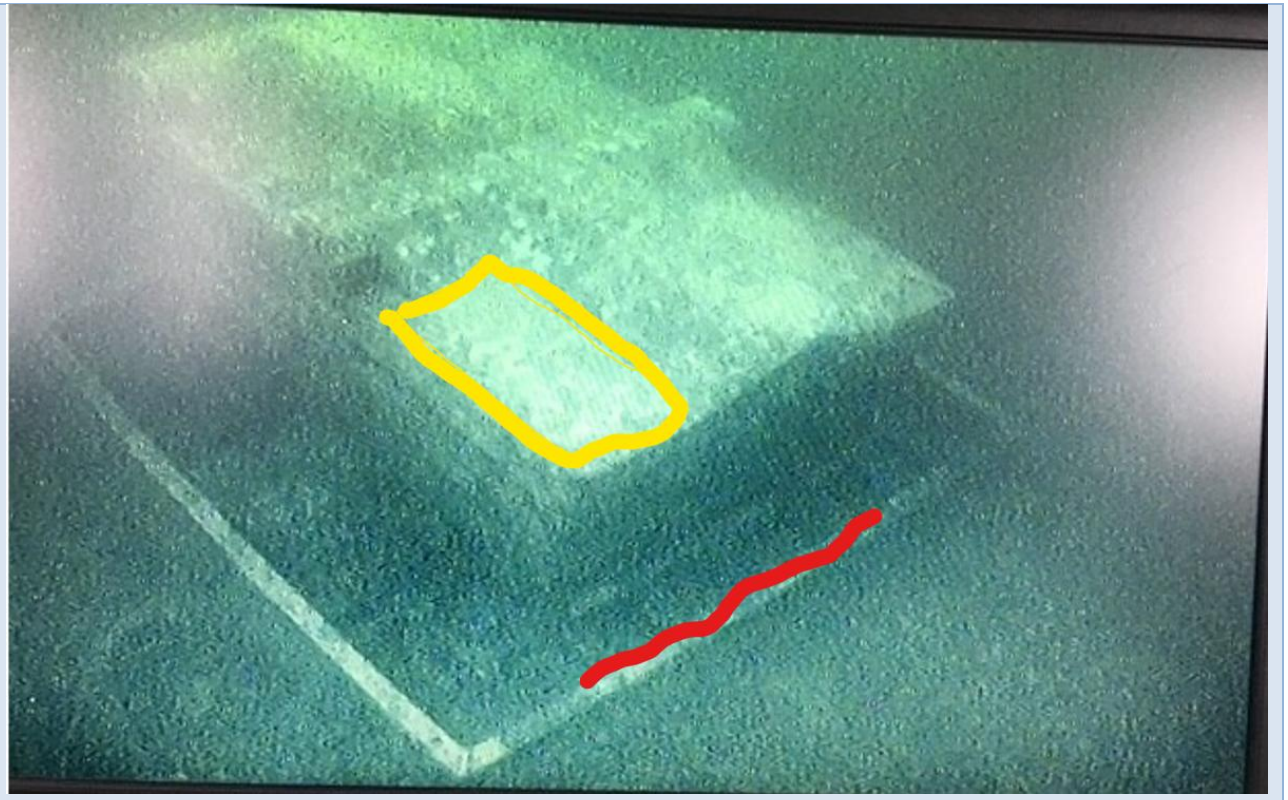
	the barrier effects or removal from ecologically important areas when compared with contemporaneous mammal distribution predictions.	
1.11	*Annex 2, Section 3.2* MSS note that, usefully, data derived animal densities have been used, however these values are now quite old and would benefit from updated counts. Furthermore, these counts should be undertaken during operational phases to ascertain whether animal density scales with operational status and therefore provide some rough estimates of medium scale avoidance.	Orbital and EMEC have collected 24 months of wildlife observations across the EMEC and Westray site to inform animal densities and there are also updated sources available. These animal densities are used in the CRM for the EMEC Fall of Warness 50 MW consent. The 50 MW application considers a CRM scenario 'Single Large Device Floating', which generally align well with the O2 device, though the O2 has a smaller rotor diameter than that assumed.
1.12	The summation that harbour and grey seal underwater activity is more likely to be represented by the	Orbital assume that the EMEC Fall of Warness 50 MW expansion CRM model for marine mammals will be produced to best practice in regard to this comment and will look at whether it would be beneficial to extract a standalone CRM model for the O2 from this assessment if of benefit. Again, the 'Single Large Device Floating' CRM scenario from the EIA generally aligns well with the O2 device.

	location of surface sightings is too simplistic and depends greatly on animal behaviour. Individuals in transit, travelling at minimum cost of transport speed (~1-2 ms^{-1}) could cross multiple grid cells during a dive. MSS suggest using the same method as the harbour porpoises, in lieu of behavioural data and individual identification.	
1.13	*Figure 2* Seabed depth is not the only defining feature of dive type. Sediment characteristics, tidal current flow rate (as mentioned earlier in the report) and time of day can all influence this. Data have been presented in various reports on this variation that could be incorporated here. We suggest consideration of the evidence presented in Evers *et al.* (2018) to help to refine these models.	Please see comment above.

1.14	MSS recommend that the units of the sound pressure level (SPL) are clarified in the PEMP. MSS assume that the levels are stated as "root mean square" (RMS) but this should be stated.	Yes, it refers to "root mean square" SPL
1.15	MSS agree with NS suggestion of multiple simultaneous DART system deployments.	The 2025 surveys employ single and two simultaneous DART system deployments (once confidence was gained that the simultaneous deployments could be safely carried out).
1.16	In Annex 2, Section 3, it is not clear to MSS from the report whether the broadband SPLs presented and the power spectral density (PSD) plots are from a point in the transect or whether they are for the whole transect duration. The data could be analysed at different points on the transect and then back-propagated using noise modelling methods to obtain a source level and spectrum. It may also be	The 2025 acoustic assessment will be presented in the next iteration of the PEMP and addresses this point.

	useful to plot the broadband SPLs spatially across the transects.	
	Marine fish ecology	
1.17	MSS are content with marine fish being considered under the impact pathway of displacement and a potential barrier effect from the presence of the device. MSS are also content with marine fish, in particular gadoids, being considered under the collision risk impact pathway, and welcome monitoring using underwater cameras.	No action required
1.18	However, MSS recommends including marine fish under the impact pathway of acoustic disturbance; in	Agreed. The acoustic characterisation methodology for the 2025 surveys ensures that data is collected to allow this impact pathway to be assessed.

	particular, noise from the operating turbine. This has the potential to cause a long-term and continuous pressure on marine fish, if the noise is within their hearing threshold.	
	Diadromous Fish This is an update on the monitoring being carried out under the agreed PEMP. MSS were not invited to comment on the PEMP with respect to diadromous fish, possibly because of uncertainty and lack of information on the extent of use of the Fall of Warness by diadromous fish, and we have no comments on this update with respect to diadromous fish.	No action required.
	Benthic Ecology MSS welcome the monitoring proposed for	Orbital would propose that a certain area of one of the anchors is selected for ongoing monitoring. For instance, this could be the sections outlined in yellow and red in the attached images. Orbital could then focus on these areas for marine biological assessment – ensuring appropriate light conditions, slow footage and close coverage.

	benthic communities in relation to seabed loss, colonisation of new habitat and recolonisation impact pathways. ROV footage may be appropriate for identifying features of conservation interest. We recommend ensuring that this imagery is quantifiable so that it can be used to assess change over time. For example, the use of lasers and systematic transects can help quantify the field of view and area of seabed covered. Without this quantification it may be difficult to compare species abundance at different time points. Seasonality should also be considered in the monitoring design to ensure that the data are comparable.	
	NatureScot Feedback 15/04/2022	

2.1	Overview – should be July 2021 instead of July 2022.	
2.2	Research integrated monitoring system – we had a useful discussion with EMEC on the 14th March 2022 regarding the development of the integrated monitoring system through the FORWARD-2030 project. We are happy to provide further input as the project develops.	Please find in Annex 2 an update on the integrated monitoring system trials.
2.3	The collision risk modelling (CRM) presented in the PEMP was very helpful for understanding the potential impacts of the device. Densities used in the CRM are from the EMEC Fall of Warness wildlife observation programme between 2005 and 2014. Although data from this programme is	Orbital will look at whether it would be beneficial to extract a standalone CRM model for the O2 from this Fall of Warness 50 MW expansion assessment if NatureScot would consider this of benefit as this assessment contains the most up to date animal density references. The 50 MW application considers a CRM scenario 'Single Large Device Floating', which generally align well with the O2 device, though the O2 has a smaller rotor diameter than that assumed.

	considered old, and there have been recent changes in species populations and distributions, they provide a useful benchmark for use in the CRM.	
2.4	The scenarios modelled include the single O2 device, a current scenario (where the encounter rate was calculated for all devices currently deployed at the Fall of Warness) and a future scenario (assuming 2 x Orbital devices). Results showed that the predicted collisions were less than those of the maximum scenario presented in the Environmental Appraisal (EMEC Fall of Warness 2014). However, for the future scenario it is likely that more devices may be present than only 2 Orbital devices.	Orbital will look at whether it would be beneficial to extract a standalone CRM model for the O2 from this Fall of Warness 50 MW expansion assessment if NatureScot would consider this of benefit as this assessment contains the most up to date animal density references. The 50 MW application considers a CRM scenario 'Single Large Device Floating', which generally align well with the O2 device, though the O2 has a smaller rotor diameter than that assumed.

	The sensitivity analysis showed that changes in the blade width had the greatest effect on encounter rates. We agree that the next stage will be to use monitoring data to verify the accuracy of the modelling.	
	NatureScot Acoustic Feedback	
3.1	A key conclusion is that the O2 turbine is detectable between 10 Hz and 1 kHz. This is in keeping with typical anthropogenic noise, but due to the novelty, we feel it would be beneficial to put these findings into context of existing knowledge about tidal turbine noise. It would also be useful to	Agreed. Orbital and EMEC will include this in the planning updated acoustic characterisation report.

	have a description of the noise. The noise attributed to the turbine is within human hearing, so a description of what the signal sounds like (whines, hum, clicking, squeak for example) would aid attribution of the noise to the turbine.	
3.2	This survey used a single DART system. We would recommend that multiple drifters are deployed simultaneously so that spatial and temporal variability can be better quantified. Noise levels are highly variable both in time and space, and whereas drifters are appropriate to measure levels in a tidal flow, the space time component needs to be fully explored. Here each drift is at a different time within the survey window, whereas having more than	The 2025 surveys are a mix of single drifted and two simultaneous drifts, once it was confirmed that the offshore operations were proceeding effectively and safely. The full details will be provided in the report.

	one at the same time will aid disentangling the temporal component.	
3.3	All data analysed is from one sample area box approximately 100m from the turbine. Therefore, this does not provide information at distance from the turbine. Analysing the data at greater ranges may be useful in order to consider how the noise propagates through the environment.	The 2025 surveys predominantly focused on a 300m area from the turbine in line with the IEC guidance. Some additional data from greater distances was also obtained, but it needs to be reviewed first to confirm if it was impacted by any vessels in the area. The details will be provided in the report.
3.4	The increase in noise levels (40dB SPL) when the turbine is operating (at 25%) is significant highlighting that we perhaps need to know how quickly this reduces with distance from the device.	Agreed. See above. Orbital is also seeking to support a Supergen Flexfund proposal to develop better models for tidal turbine sound propagation.
3.5	Figure 5 details that the berth of interest is in close proximity to other berths	There were no other turbines operating during the 2025 acoustic surveys.

	in the area. It is possible that some of the noise detected, could be generated from other berths also, and so the noise recorded here could be an accumulation from a number of sources. It would be useful to know that this was/has been accounted for.	
3.6	Also stated, is that the noise recordings were checked for vessel noise. It is assumed, rather than confirmed these segments were removed from analysis. It would be useful to know how much of the data available for analysis was therefore discounted. Also stated is a reference to an AIS log, but there is no indication as to the degree of vessel activity whilst the survey was underway. AIS does not pick up all vessel activity, therefore visual observations of any boat	The 2025 acoustic surveys methodology involved turning any vessels engines and sonar/echosounder systems off.

	traffic is also useful whilst the survey is underway.	
3.7	The methodology follows the IEC technical specification (IEC TS 62600-40-2019). We do not have sight of this Standard, but believe Brian Polague at the University of Washington was involved in its development. It is likely that this Standard is suitable, however we cannot advise further until we have been able to review this Standard. We are happy to review this if a copy could be sent to us.	We agree that it would be beneficial for NatureScot to have a copy of this standard. EMEC hold a copy and the associated license agreement for the specification and the license agreement does not permit EMEC to share the standard. An additional license agreement costs approximately £250. Orbital would be happy to purchase a license on behalf of NatureScot.
3.8	The noise levels are analysed within a specified sampling box, but there is no detail as to how the drift track is subsampled within the box. Drifting hydrophones record noise continuously, the information provided	It will be ensured that time stamps on hydrophones and GPS are matched, in processing we could cross-reference time stamps and GPS to audio if needed.

	suggests the window length was 1s, but there is no detail as to how many 1s samples there were within this box and whether there was a gap between these sample sections (*i.e.* the subsamples should not be overlapping). Table 2 indicates that the drifts within the box took about one minute between entering the box and exiting the box, so it should be possible to subsample without overlap.	
3.9	Acoustic analysis was conducted using PAMGuide. For information, we highlight that a bug in the code was found recently, and although now rectified, may have resulted in levels reported being out by several dBs at low frequencies (i.e below 1	Noted. We will consider in 2025 report.

	kHz)[6]. This is the frequency range of interest for this device. Therefore, this will be worth considering when surveys are repeated and compared with the work completed so far.	
3.10	Table 2, highlights that although the wind strength was reported as calm for all three surveys, the baseline sea state was SS1, the second survey when the device was not operating was SS2, and when the device was operating at 25% the sea state was SS3. This, plus light rain would elevate the noise levels for the device operating analysis. Tidal flow is broadly similar across the three surveys, but a faster flow (even by	The 2025 survey will provide additional data to inform the effect of rain and seastates on noise levels.

[6] Merchant *et al* (2014 – Corrigendum 2022) Measuring acoustic habitats. Methods in Ecology and Evolution https://besjournals.onlinelibrary.wiley.com/doi/10.1111/2041-210X.12330

	1m/s) will also increase the noise levels. There is mention of this issue (page 11), but it would be useful to put these findings into context by referring to established environmental levels (e.g. Wenz curves).	
3.11	Tidal areas are likely to be noisier than the Wenz curves; however, the frequency ranges of various contributions are applicable. In section 3 a noise characteristic called '*clouds'* is mentioned. This needs a reference. We also believe the reasons for the scale on Figure 4 axis being different should be explained. Figure 4 and Figure 5 highlight a strong signal at about 50 kHz, but there is no indication of what this signal could be.	When reporting we will aim to reference noise elements and predict where these are expected to come from with literature and observations.

3.12	Although the baseline at Westray is not far from the Fall of Warness site, and of similar conditions, it is highlighted in the report that this may in itself introduces differences. We agree, and are of the view that provided the differences can be discussed/ accounted for, a proxy area is of use. This may highlight that the device itself, whilst not operating, is a noise source purely due to its presence in the tidal flow, which is also useful information.	
3.13	Equipment calibration The calibration of the equipment as stated is not sufficient to be able to provide absolute levels of noise recorded. A standard factory calibration using a pistonphone can only	The relevant IEC standard authors were consulted for advice on calibration requirements. The calibration status of the hydrophones will be reported in the 2025 acoustic characterisation report.

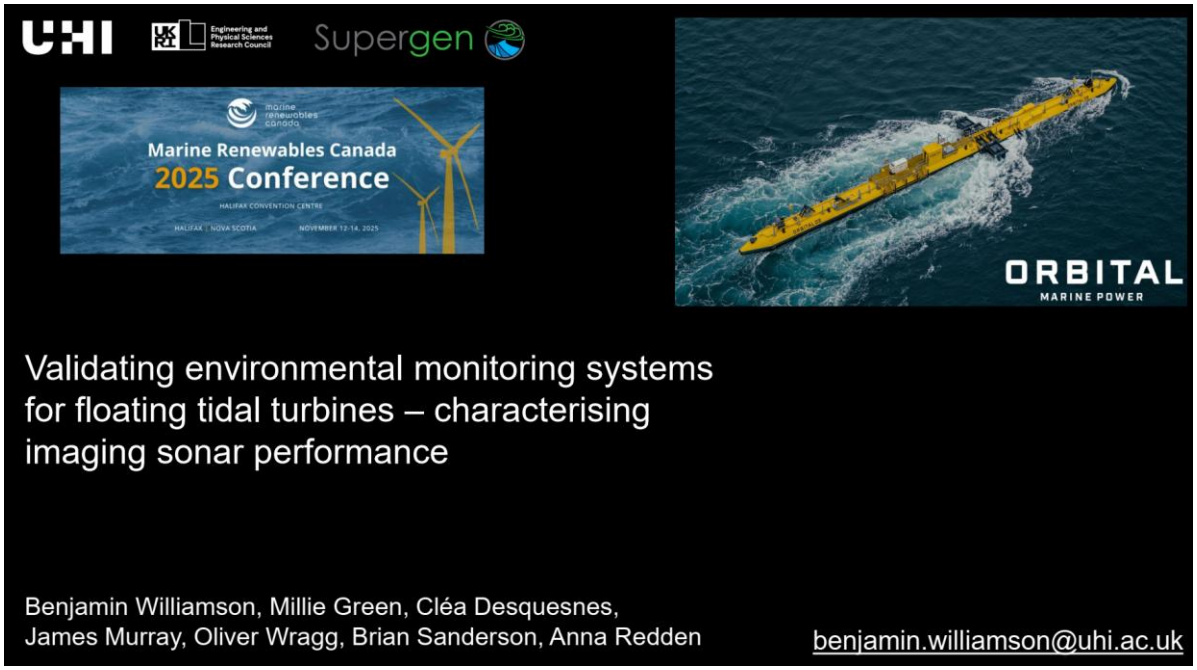
	check the performance of the hydrophone at 250Hz, there is therefore no information on the frequency response across the full range of frequencies recorded. The calibration was valid two years ago; there does not appear to be any information since then and so the performance of the hydrophone may not be as expected. NatureScot recommends the NPL guidance[7], which states - "*The recorder should be supplied with a full system calibration including all information required to determine the absolute levels of the measured data (including hydrophone calibration, amplifier gains, ADC scale factors, etc). If not supplied*	

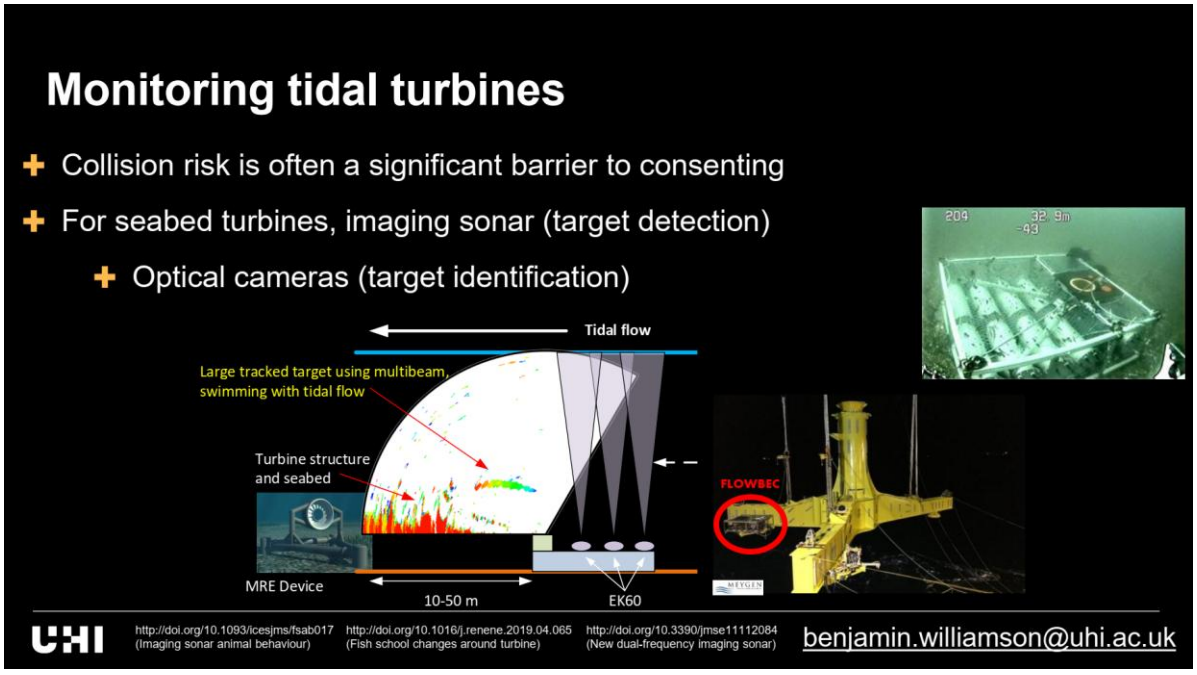
[7] Good Practice Guide for Underwater Noise Measurement, National Measurement Office, Marine Scotland, The Crown Estate, Robinson, S.P., Lepper, P. A. and Hazelwood, R.A., NPL Good Practice Guide No. 133, ISSN: 1368-6550, 2014. https://www.npl.co.uk/special-pages/guides/gpg133underwater

	by the manufacturer, a traceable calibration should be obtained from an accredited independent source, rather than relying on nominal figures from manufacturer's specification. An in-situ calibration check with a hydrophone calibrator (pistonphone) is strongly recommended before and after deployment. This will cause a signal of sound pressure level to be recorded within the stored data file, and will provide valuable information on the system performance (at least at one frequency)." Ideally, a full calibration should be done once a year. The pistonphone (although only at one frequency) is then a pre survey check of calibration to ensure the anticipated performance remains valid.	

	The evidence provided does not support an appropriate calibration, and so there is uncertainty if the levels presented are absolute levels. Nonetheless, it is still useful to see relative differences as this will highlight the contribution to the soundscape from the device, if not the absolute levels of noise. Clarity in the calibration is needed for the next update.	

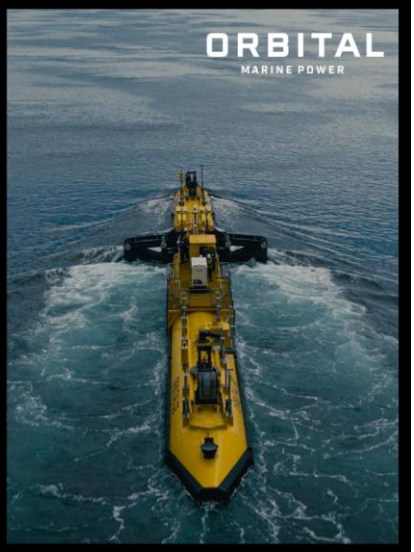
Annex 2: Presentation to IEMS 2026 – Validating Environmental Monitoring Systems for floating tidal turbines – characterising image sonar performance.





Floating tidal turbines

- Deeper water, installation / O&M / efficiency
- Monitoring challenges:
  - Flow speed, entrained air, dynamic platform
  - Limited existing data / transferability
- Monitoring opportunities:
  - Sensor access, accelerating progress
  - Power and communications connectivity



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Aim and objectives

- Validate robust monitoring
- Support scale-up and build-out
- Characterise imaging sonar performance
- Optimise for detecting animal interactions in rotor-swept area

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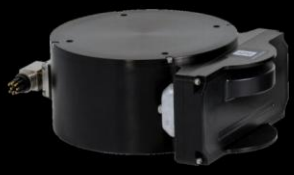
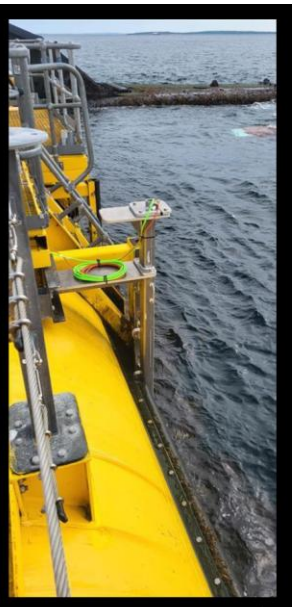
Methods

- Pole-mount imaging sonar and camera
  - Kongsberg Flexview sonar
  - Macartney LUXUS PUR camera

KONGSBERG



MacArtney
UNDERWATER TECHNOLOGY



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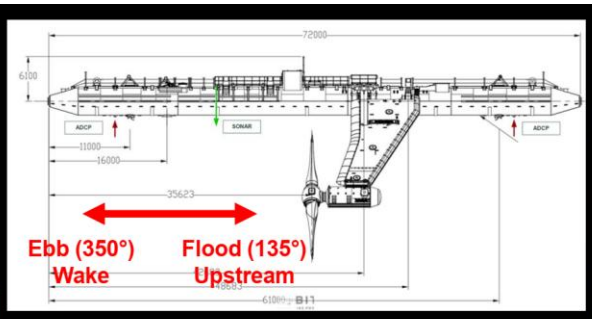
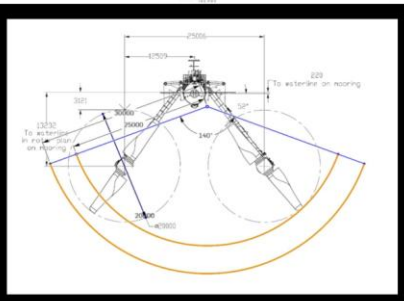
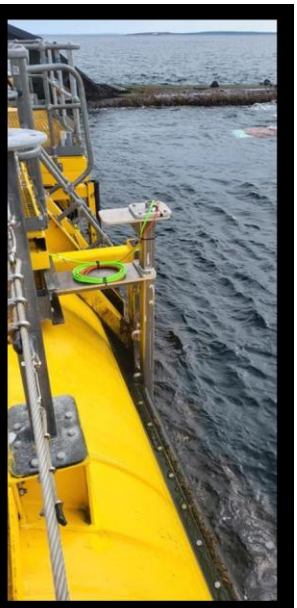
Methods







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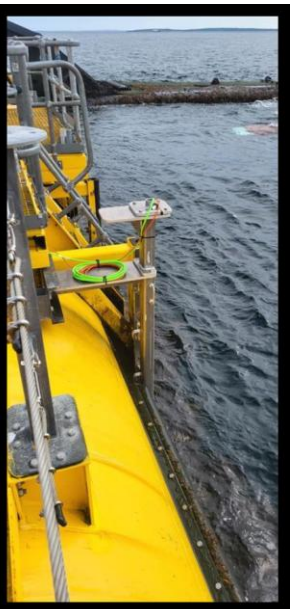
Methods

- Deployed from 6 May – 16 September 2025
- SNR and detectability of targets
- Characterise across tidal state, metocean conditions and turbine operation
- Inform transferability to other sites and turbines



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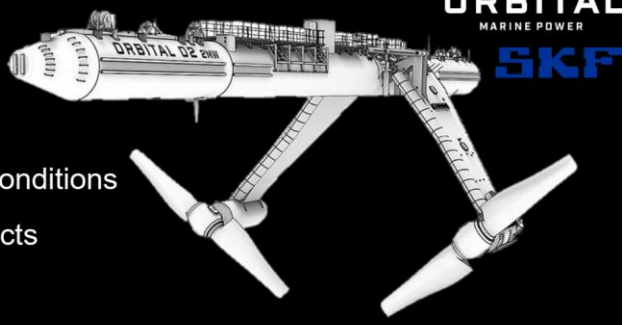
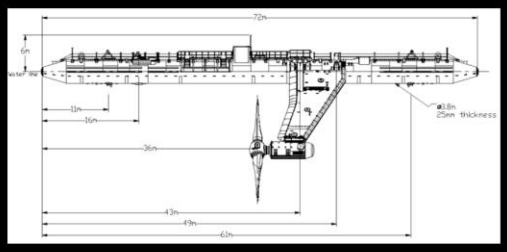
Data collection

- Entrained air – tidal & metocean conditions
- Turbine legs and rotors, wake effects





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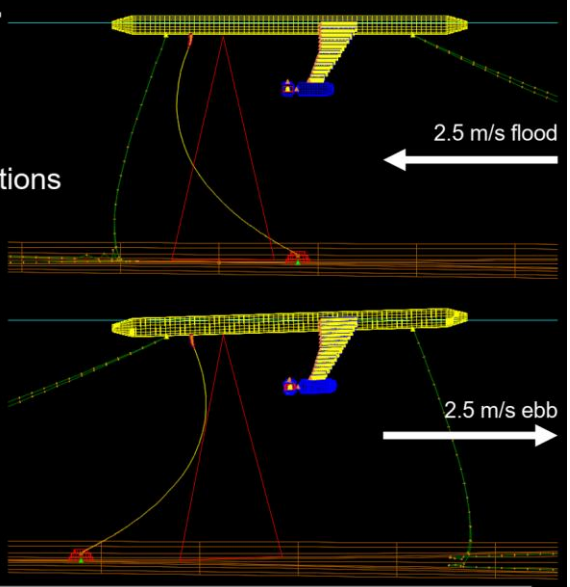
ORBITAL
MARINE POWER

Data collection

- Entrained air – tidal & metocean conditions
- Turbine legs and rotors, wake effects
- Turbine cable / mooring
- Target detection



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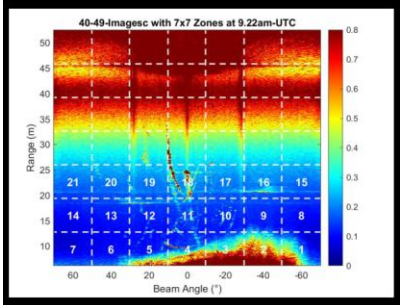
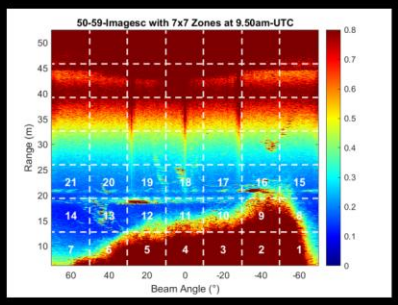
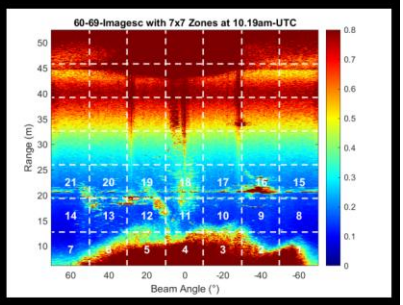
Data collection

- Near-surface entrained air (tidal state, metocean conditions)







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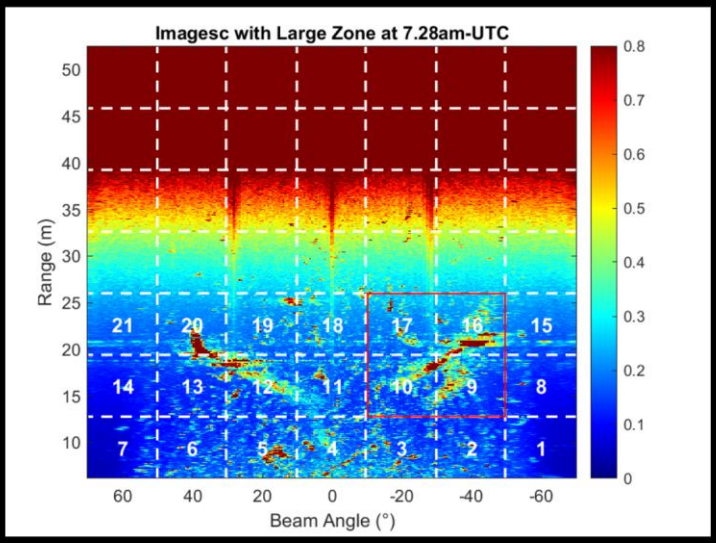
Data collection

- Rotor/wake effects



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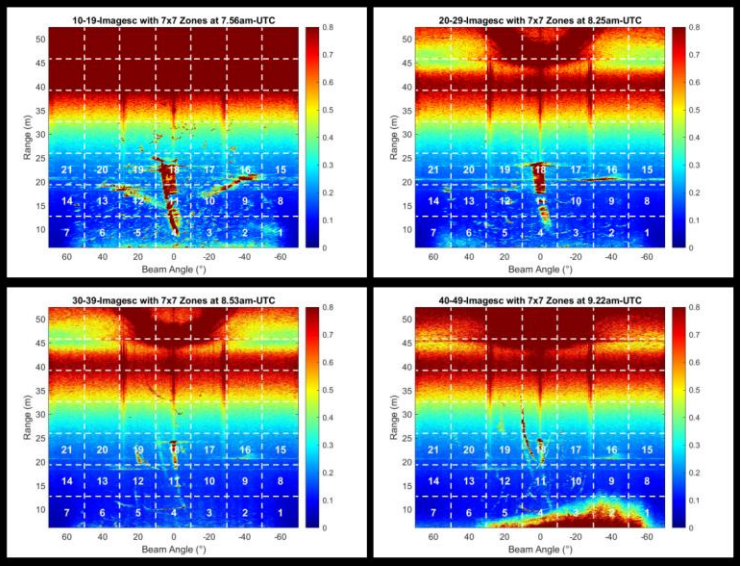
Data collection

- Cable / mooring effects



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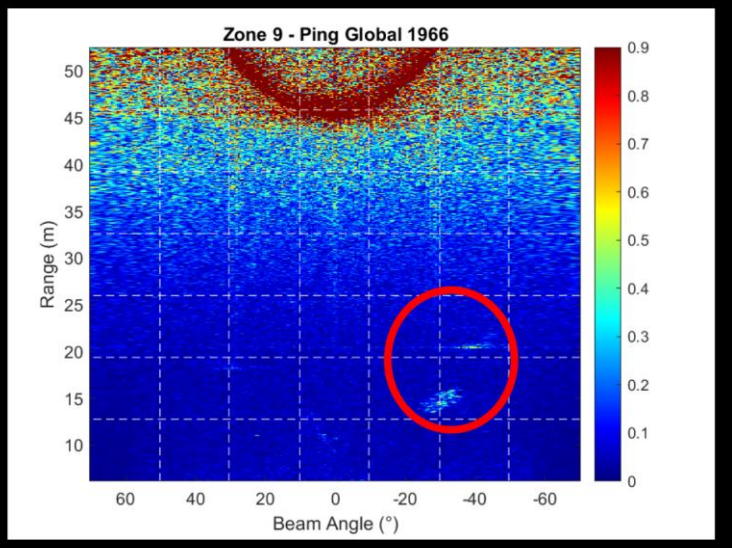
Data collection

- Target detection

  Fish schools



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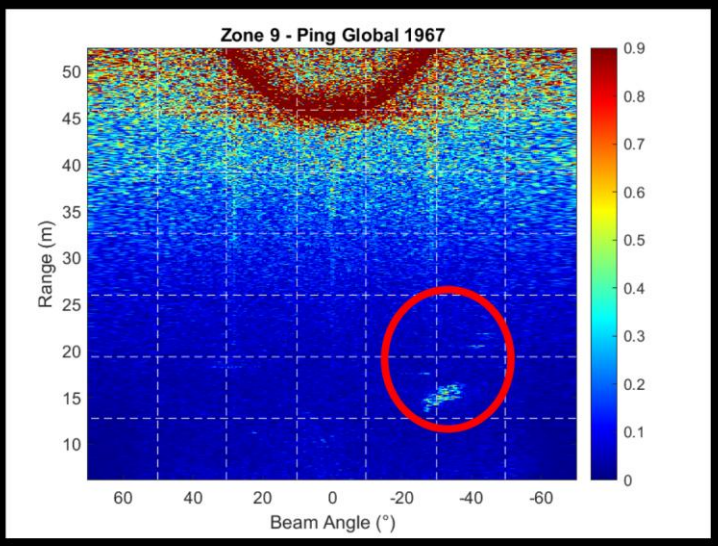
Data collection

- Target detection

  Fish schools



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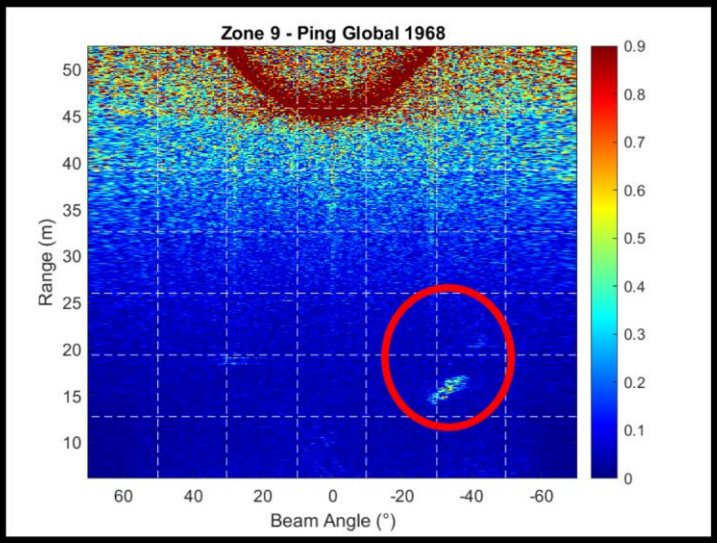
Data collection

- Target detection

  Fish schools



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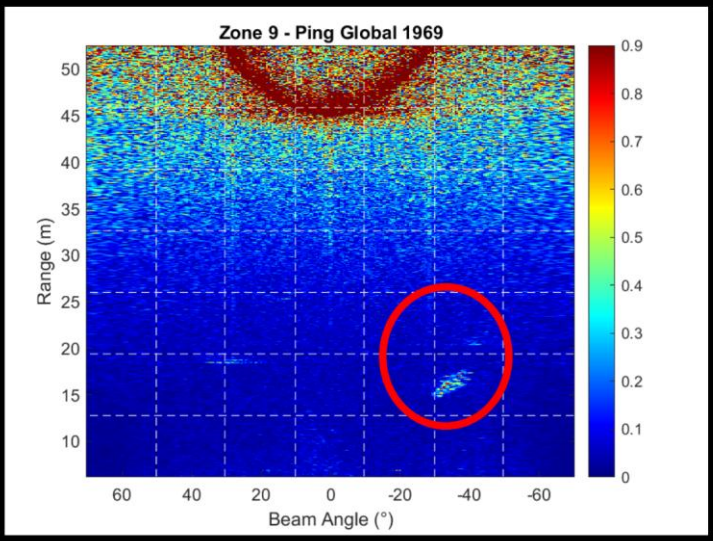
Data collection

- Target detection

  Fish schools



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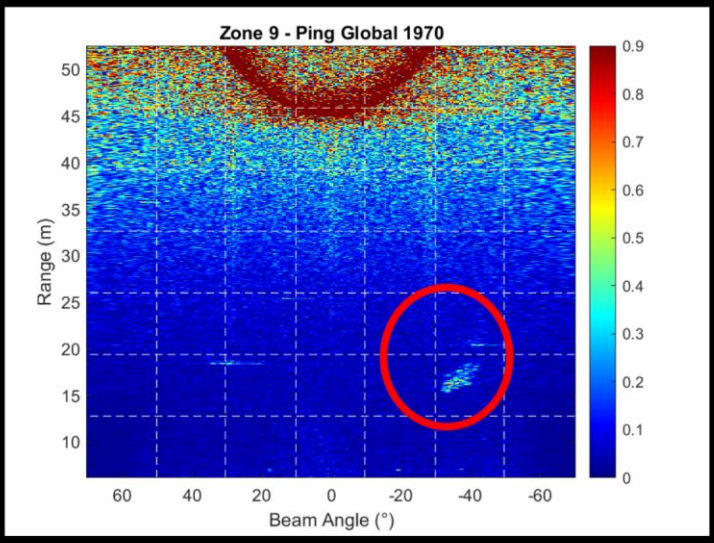
Data collection

- Target detection

  Fish schools



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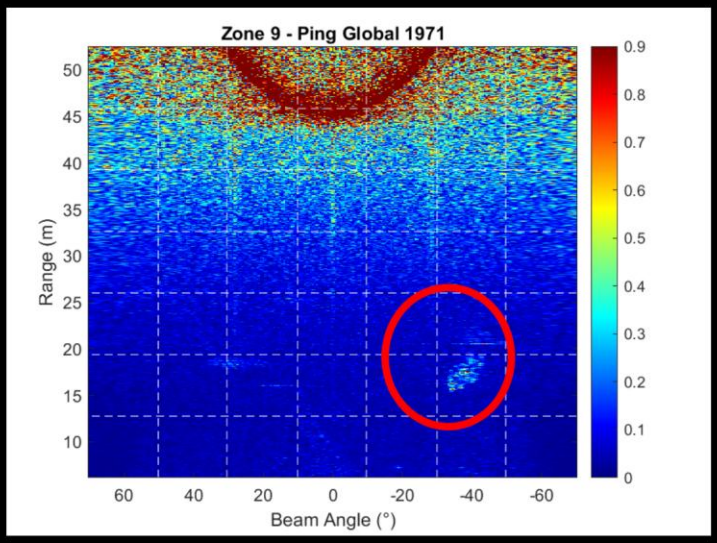
Data collection

- Target detection

  Fish schools



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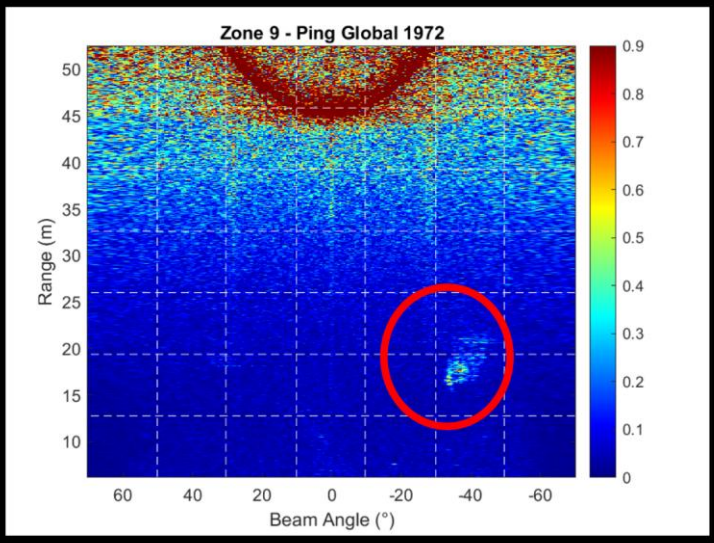
Data collection

- Target detection

  Fish schools



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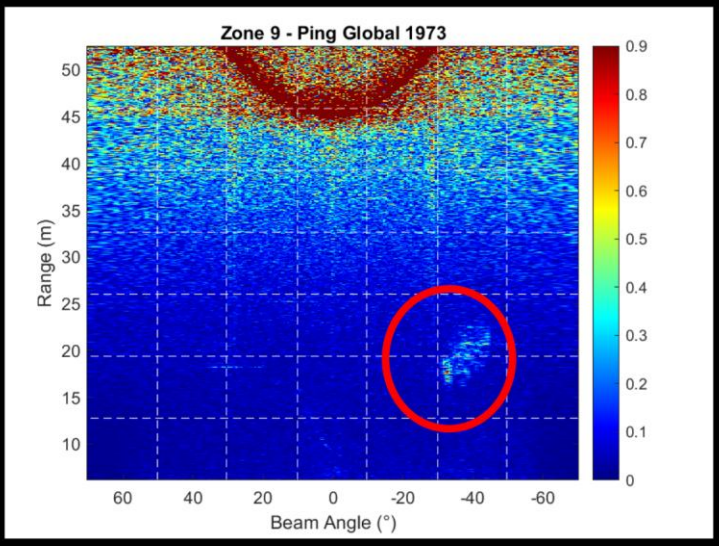
Data collection

- Target detection

  Fish schools



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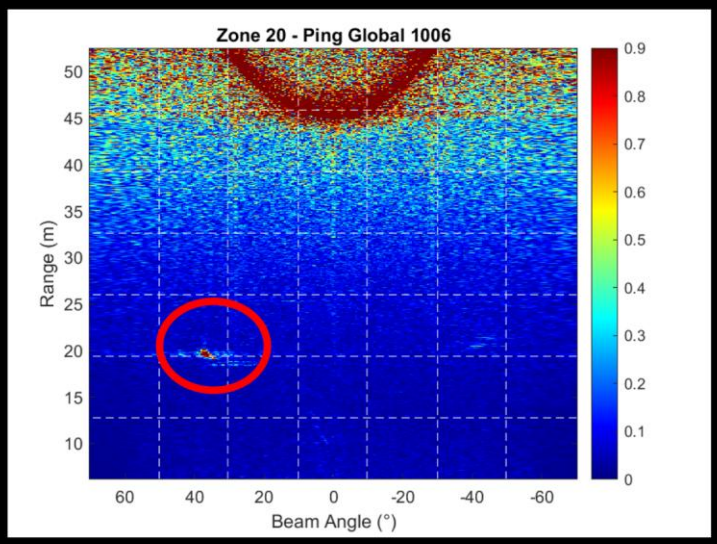
Data collection

- Target detection
  - Single targets



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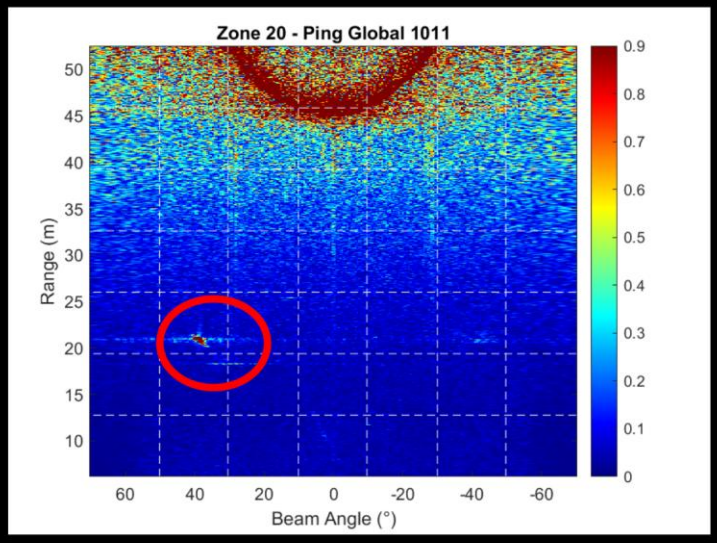
Data collection

- Target detection
  - Single targets



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