Appendix 9: Marine Mammal Risk Assessment (MMRA)

Marine Mammal Risk Assessment on Proposed Maintenance Dredging and Disposal at Sea at Aughinish Jetty, Co. Limerick

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1. Introduction

The Irish Whale and Dolphin Group (IWDG) were contracted by Malachy Walsh and Partners to carry out a review of marine mammal activity in the vicinity of Aughinish Alumina Ltd.'s (AAL) Jetty, Co. Limerick, within the Lower River Shannon Special Area of Conservation (SAC, site code 002165) and produce a Marine Mammal Risk Assessment (MMRA) for the proposed maintenance dredging campaigns (in relation to the effects of noise) at the site. In 2016, a Dumping at Sea (DaS) permit (Nr. S0026-01) and Foreshore Licence (Nr. FS006578) was granted to provide for ongoing maintenance dredging activity, covering an 8-year period which expires in August 2024. Currently, a new DAS permit for a further period of 8 years for ongoing maintenance dredging is required. A new Marine Usage Licence (MUL) (formerly known as a foreshore licence) from the Maritime Area Regulatory Authority (MARA) will also be required.

The previous DaS permit allowed for dredging by means of plough dredging at three defined locations, across two dredge periods per year, with each period having a duration of 4 - 5 days and was restricted to days when the berth at the main jetty was shut down for maintenance. Plough dredge technology was the only method licenced. The new application is aimed to employ a range of dredging technologies (including; plough, Trailing Suction Hopper Dredging (TSHD) and Long Reach Track Machine on a barge), and increasing the duration of dredging campaigns (from 4-5 days, twice a year to maximum 21 days (24 hour operation), twice a year), over larger areas.

The proposed works involve maintenance dredging at the 4 sites highlighted below (Figure 1), including the inner and outer berths of the jetty which are approximately 900m offshore and accessed by a causeway road (Areas A and C). A third site, area B, is located close to the mainland, to the right of where the causeway begins and area D is located adjacent to the east of the causeway. The proposed methods to be employed across the locations are presented in Table 1. The location of AAL Jetty and the proposed works are within the Lower River Shannon SAC, with species of interest including otter (*Lutra lutra)* and bottlenose dolphins (*Tursiops truncatus*). The Shannon Estuary is home to Ireland's only resident group of bottlenose dolphin. Both harbour and Grey seals are known to occur up river as far as Limerick docks.

Table 1. Location of the 4 proposed dredge and dump sites and the methods to be used.

Location	Dredge/Dump Methods
Area A main berth	TSHD, Plough and a Long Reach Track Machine on a barge.
Area B the cells -	Plough and Long Reach Track Machine on a barge.
Area C inner berth	TSHD, Plough and a Long Reach Track Machine on a barge.
Area D jetty approach arm	Plough and Long Reach Track Machine on a barge

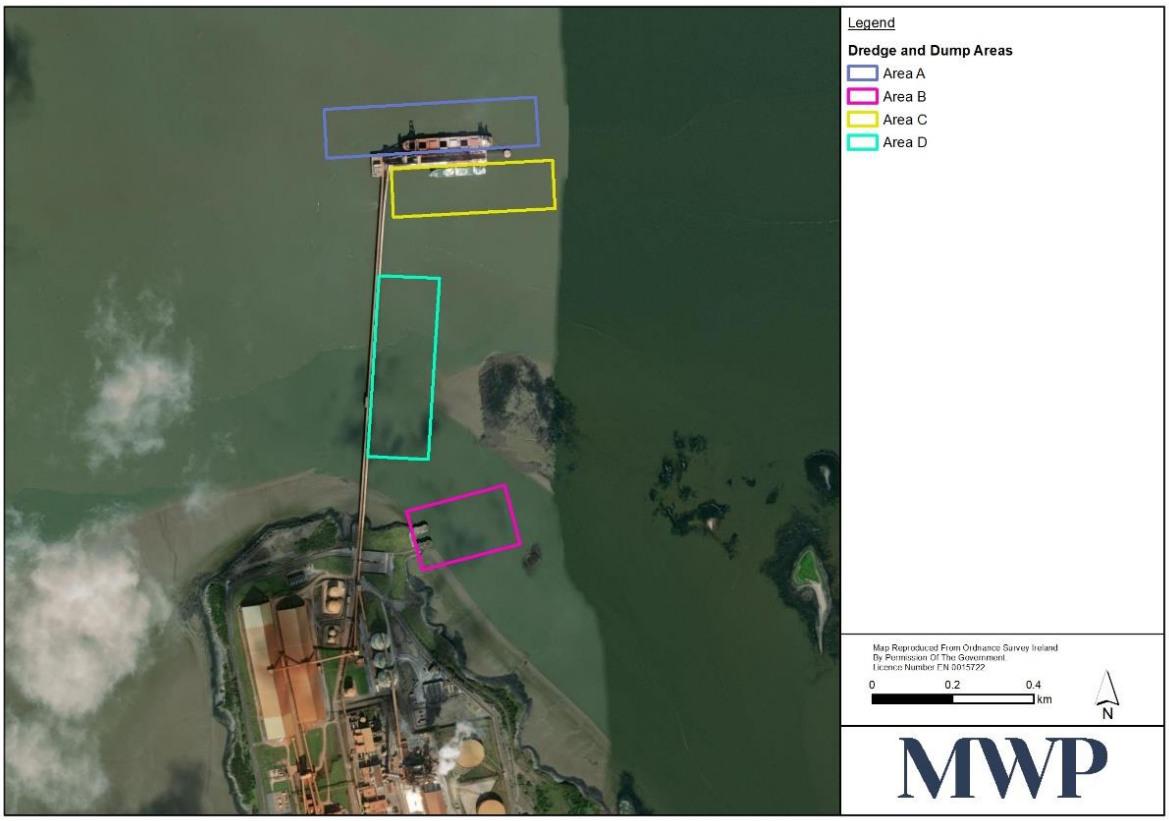

Figure 1. Location of the 4 proposed dredge/dump sites at Aughinish Alumina LTD's Jetty and surrounding areas, Co. Limerick © MWP.

As TSHD will be used, there is also need to identify a suitable dumpsite and obtain a licence to make use of it. A potential dump site location (Figure 2), is located within an area currently licenced to SFPC as a dumpsite off Foynes Island (EPA Nr. S0009-03; Figure 2), so an additional licence is sought for AAL. The proposed dumpsite has an area of 8.43ha and will only receive material from the TSHD activity. A maximum volume of 53,846 tonnes per annum would be deposited with the volume varying from year to year depending on the dredging cycle, deposition rates and requirements within the main berth.

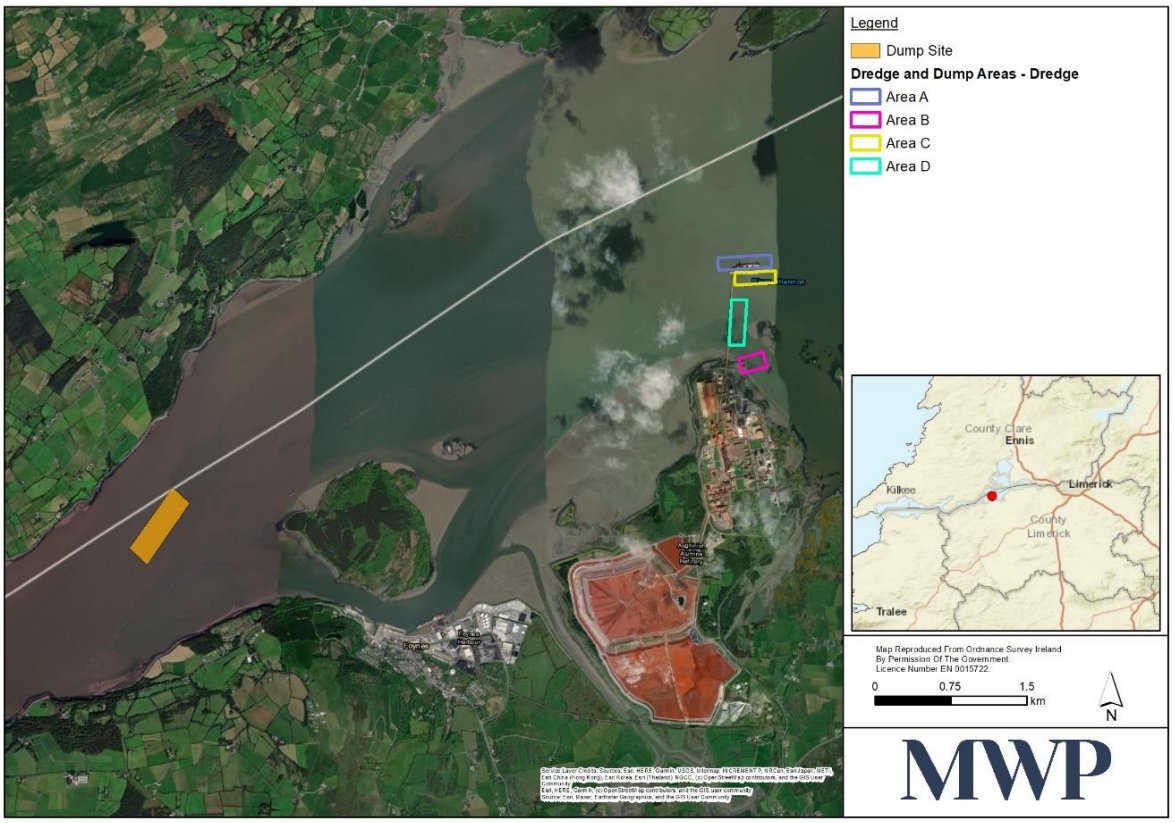

Figure 2. Location of the proposed dumpsite NW of Foynes Island (shaded in orange) © MWP.

A MMRA is a requirement of the application for a dumping at sea permit and a marine usage licence within this SAC. This MMRA will consider the following based on the NPWS guidance document to minimise risks for marine mammals in response to **noise sources** (NPWS, 2014). This MMRA will take the following into account;

1. **Source**; by assessing the characteristics of the noise source, from the vessel itself but also the dredging and dumping process.
2. **Species**; by gathering all available datasets on marine mammals in the vicinity of the proposed works.
3. **Environment**; where dredging activities will take place, marine mammal occurrence within these areas will be assessed.

2. Legal Status of Marine Mammals in Ireland

In Ireland, cetaceans (whale, dolphins and porpoises), pinnipeds (Grey grey (*Halichoerus grypus*) and Harbour seals(*Phoca vitulina*)) and the Eurasian otter (*Lutra* lutra) are protected under a suite of national and international legislation. All cetaceans, as well as Grey and harbour seals and our only species of otter are protected under the Wildlife Act (1976) and amendments (2000, 2005, 2010, 2012, 2018 and 2021). Under the act and its amendments, it is an offence to hunt, injure or wilfully interfere with, disturb or destroy the resting or breeding place of a protected species (except under license or permit from the Department). The act applies out to the 12 nm limit of Irish territorial waters. Additionally, all cetaceans, pinnipeds and otter are protected under the EU Habitats Directive, where all cetaceans are included in Annex IV of the Directive as species 'in need of strict protection'. Under this Directive, the harbour porpoise (*Phocoena phocoena*), bottlenose dolphin (*Tursiops*

truncatus),Grey seal, Harbour seal and Eurasian Otter are listed under Annex II, which identifies these species of community interest and whose conservation requires the designation of Special Areas of Conservation (SACs).

In 2007, the National Parks and Wildlife Service (NPWS) of the Department of Housing, Local Government and Heritage produced a '*Code of Practice for the Protection of Marine Mammals during Acoustic Seafloor Surveys in Irish Waters* (NPWS, 2007). These were subsequently reviewed and amended to produce '*Guidance to manage the risk to marine mammals from man-made sound sources in Irish waters*' (NPWS, 2014). This guidance document sets out the potential risks to marine mammals from man-made sounds. It states that "*An assessment of risk forms an important part of the decision-making framework for mitigating the effects of anthropogenic sound in the marine environment. It is recommended that … [certain] coastal and marine activities undergo a risk assessment for anthropogenic* ***sound-related impacts*** *on relevant protected marine mammal species, to inform the consenting process*."

The NPWS draft guidance states:

> *"A risk assessment for each marine mammal species of relevance to the proposed works area needs to consider the nature of the sound source, its likely and/or potential effects on individuals and/or populations and on their likely habitat…*
>
> *Where an assessment identifies the likelihood of a risk to protected marine mammal species, either by virtue of (a) the proposed operation or activity and/or (b) the sensitivity of a particular site in which the sound-producing operation or activity is proposed, it is recommended that appropriate risk management measures are pursued by the relevant Regulatory Authority."*

The guidance goes on to state:

> *"Following the initial identification and assessment of risk arising from an operation or activity … a menu of management options is available to Regulatory Authorities in their decision making process and it includes:*
>
> ***A1. Consent without mitigation*** *(e.g., where the risk of any adverse effects has been ruled out)*
>
> ***A2. No consent given for the activity***
>
> ***A3. Avoid critical habitats for marine mammals*** *(e.g., designated sites or other locations identified as sensitive via the risk assessment process)*
>
> ***A4. Avoid operations during key periods of the species' life cycle*** *(e.g., breeding/resting, migration)*
>
> ***A5. Avoid time periods when effective impact mitigation is not possible, and/or***
>
> ***A6. Risk minimisation measures, namely***
>
> ***A6.1.*** *Minimise the duration over which the sound-producing activity is intended to take place;*
>
> ***A6.2.*** *Minimise the individual and cumulative sound pressure and exposure levels delivered into the environment by the activity. If necessary the use of alternative, lower impact equipment and methods should be explored (e.g., vibratory hammer, gravity base piles).*

A6.3. *Incorporate the use of clear "ramp-up" or "soft-start" procedures, whereby sound energy input to the marine environment is gradually or incrementally increased from levels unlikely to cause significant behavioural impact on marine mammals to the full output necessary for completion of the activity.*

A6.4. *Incorporate the use of fully enclosing or confined bubble curtains, encircling absorptive barriers (e.g., isolation casings, cofferdams) or other demonstrably effective noise reduction methods at the immediate works site, in order to reduce underwater sound propagation from on-site operations. Studies have shown that such methods can provide a significant reduction in sound input to the wider aquatic environment in the order of 10-30 dB.*

A6.5. *The use of trained marine mammal observers (MMO's) provides effective means of detecting marine mammals in the vicinity of coastal and marine operations. Associated operational considerations should also be taken into account."*

The NPWS guidance document includes measures specific to dredging activities. The guidelines recommend that listed coastal and marine activities (including dredging) be subject to a risk assessment for anthropogenic sound-related impacts on relevant protected marine mammal species to address any area-specific sensitivities, both in timing and spatial extent, and to inform the consenting process. Once the listed activity has been subject to a risk assessment, the regulator may decide to refuse consent, to grant consent with no requirement for mitigation, or to grant consent subject to specified mitigation measures (Figure 3).

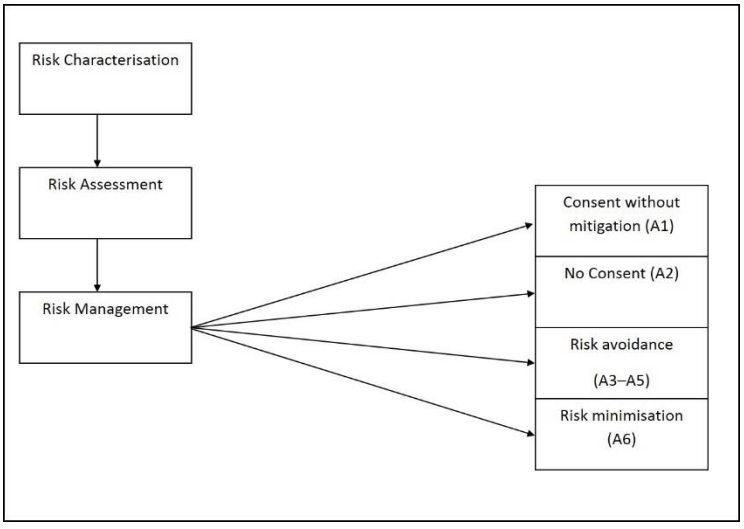

Figure 3. Flow diagram illustrating the staged process towards managing risk (NPWS, 2014).

1. Information on the Proposed Activity

The AAL jetty is used for the import of bauxite, and other raw materials, and the export of alumina.). In order to maintain the required depths at each of the 4 proposed locations, a combination of dredge techniques will be employed. Two dredge campaigns per annum for a total of 21 days each, 24 hours a day are proposed. The proposed dredging technologies include TSHD, a plough and long reach excavator/barge which will allow material to be moved locally on the seabed. The use of a long reach machine on a barge is necessary to move material that is not accessible to the plough dredged or

TSHC, for example material under the jetty structure or close to jetty structures. The TSHD is only expected to be used every few years within the overall 8-year cycle. This technology may also be required in the inner berth, but based on historical deposition rates it is unlikely.

A hydrodynamic model has been prepared which models the dredging and dumping events and outputs from the model show localised increases in turbidity from dredging as there will be disturbance of silt/sand/mud on the bed as it is removed, spread out or pulled to a lower lying area. This re-suspension of sediment is more localised during plough dredging, staying close to the sea bed. This is a temporary impact, and once each stage of dredging is completed, the material will re-settle on the sea bed and some will remain in suspension within the water column. The proposed dumpsite is the same as what SFPC use when maintenance dredging of Foynes Port.

2. Marine Mammal Activity within the Area of Proposed Activity

To date 26 species of cetaceans have been recorded in Irish waters and two regularly occurring seal species*, the Grey Seal and Harbour Seal*. Of the 26 cetacean species recorded in Irish waters, two species are known only from strandings (Gervais beaked whale (*Mesoplodon europaeus*) and Dwarf sperm whale (Kogia sima), 3 species are known only from sightings ((Beluga (*Delphinapterus* leucas) Northern right whale (*Eubalaena glacialis*) and Bowhead whale **(**Balaena mysticetus)**,** while 21 species have been recorded both stranded and sighted (Berrow 2001; O'Brien *et al.,* 2009). This high number (around a quarter of the world's total number of species) reflects the diversity of habitats from the relatively shallow (<200m) continental shelf, to the deep water (>2000m) to the west (including the shelf edge). Seal species have been found to breed around all coastlines of Ireland and use the coastal and offshore waters in their daily lives for foraging, transit between terrestrial resting places (known as haul-out sites), and other behaviours linked to their annual life cycles (e.g., social behaviour, territoriality).

The following marine mammal data sources were accessed to determine their occurrence within and around the area of the proposed dredge and dumping operations at AAL jetty. These sources included;

1. The National Biodiversity Data Centre (NBDC) online database of species (accessed at www.biodiversityireland.ie on 16th September, 2023)
2. A review of published literature on the distribution and abundance of bottlenose dolphins in the Shannon Estuary SAC.
3. A review of Static Acoustic Monitoring (SAM) data from Aughinish (Carmen *et al.* 2021).

This risk assessment was based on a review of the available data and literature sources listed above. SAM provides a very robust method of monitoring as it can provide an insight in site usage 24 hours a day and during adverse weather conditions. SAM can allow for an effective estimate of possible impacts on dolphins from the proposed works as data is available 24 hours a day. The data is collected through the use of C-PODs. Once deployed at sea, the C-POD operates in a passive mode and is constantly listening for tonal clicks within a frequency range of 20 to 160 kHz. When a tonal click is detected, the C-POD records the time of occurrence, centre frequency, intensity, duration, bandwidth and frequency of the click (Chelonia Ltd). Internally, the C-POD is equipped with a Secure Digital (SD) flash card, and all data are stored on this card. Dedicated software, CPOD.exe, provided by the manufacturer, is used to process the data from the SD card when connected to a PC via a card-reader. This allows for the extraction of data files under pre-determined parameters, as set by the user. The C-POD does not record actual sound files, only information about the tonal clicks it detects. The C-POD detector is a sound pressure level detector with a threshold of 1Pa peak to peak at 130 kHz, with the frequency response shown below. A detection distance of 797.6m ±61m (75% of groups recorded

<400m) for C-PODs and bottlenose dolphins was generated in the Shannon Estuary (O'Brien *et al*. 2013).

2.1 The National Biodiversity Data Centre's online mapping system of species records

The National Biodiversity Data Centres' (NBDC) online database was accessed for Grey and Harbour seal records, as well as European otter records in the vicinity of the proposed works at AAL. The maintenance dredge operations at AAL will take place entirely within National Grid Square (NGS), R25X. This NGS as well as the surrounding NGSs (at 10km resolution) were also checked for records of all three species (Harbour seal, Grey seal, and Otter).

(i) Harbour seals

Some of the most important haul-out sites for harbour seals are along the west coast of Ireland, including; Bantry Bay, Kenmare River, Galway Bay, Sligo Bay and the Donegal Coast and Carlingford Lough (Lyons, 2004). Harbour seals are less widespread and abundant in Ireland than Grey seals. Previous abundance estimates for Harbour seals in the Republic of Ireland, include 2,905 from a 2003 survey (Cronin *et al*. 2004), but more recent estimates by Duck and Morris (2013) in 2011 and 2012, showed an increase of 18.1% increase from 2003, with a total of 3,489. Only two records of harbour seals exist for the Inner Shannon Estuary within the NBDC database, none of which occur within the area of the propose works, but across the estuary in the Fergus Estuary. The last seal survey undertaken in the Shannon Estuary was in 2012, when a single harbour seal was sighted (Duck and Morris, 2013; Figure 3).

(ii) Grey seals

Grey seals are widespread and abundant in Ireland, with the greatest numbers found in the south-western, western and northern coasts, but smaller populations are also found on the east and south coasts. Previous work has shown the largest populations exist on the Blasket Islands, Inishkea Island group and the Saltees (Lyons, 2004). A minimum estimate of 5,343 grey seals was recorded among haul-out sites in the Republic of Ireland between 1-9 March, 2007, with over 45% of all grey seals recorded on two islands, Inishkea North, Co. Mayo and the Great Blasket Island, Co. Kerry (O'Cadhla *et al*. 2007). Grey seals are highly mobile and may remain at sea for extended periods, especially outside the breeding season, travelling distances of several hundred kilometres from breeding colonies (Cronin *et al.* 2013). During the 2012 aerial survey, no grey seals were recorded in the Shannon Estuary (Duck and Morris, 2013; Figure 5). Some records exist for the species from telemetry data on the NBDC database showing the presence in June and July 2009 (Table 2).

Table 2. Records of Harbour and Grey seals within and surrounding NGS R25.

Grid square	Species	Date	Location	Precision	Source
R25	Harbour seal	16/08/2003	Fergus Estuary	100m	NBDC/NPWS
R25	Harbour seal	16/08/2003	Fergus Estuary	100m	NBDC/NPWS
R25	Harbour seal	16/08/2003	Fergus Estuary	100m	NBDC/NPWS
R28	Grey seal	16/08/2003	Fergus Estuary	100m	NBDC/NPWS
R25	Harbour Seal	01/09/2012	Fergus Estuary	100m	Callan and Duck, 2013

R27	Grey seal	19/06/2009	Fergus Estuary	1000m	NBDC /MC
R27	Grey seal	18/06/2009	Fergus Estuary	100m	NBDC /MC
R25	Grey seal	03/07/2009	Fergus Estuary	100m	NBDC /MC
R25	Grey seal	18/06/2009	Fergus Estuary	100m	NBDC /MC
R25	Grey seal	19/06/2009	Fergus Estuary	1000m	NBDC /MC
R27	Grey seal	19/06/2009	Fergus Estuary	1000m	NBDC /MC
R23	Grey seal	18/06/2009	Fergus Estuary	100m	NBDC /MC
R20	Grey seal	18/06/2009	Fergus Estuary	100m	NBDC /MC
R20	Grey seal	19/06/2009	Fergus Estuary	100m	NBDC /MC

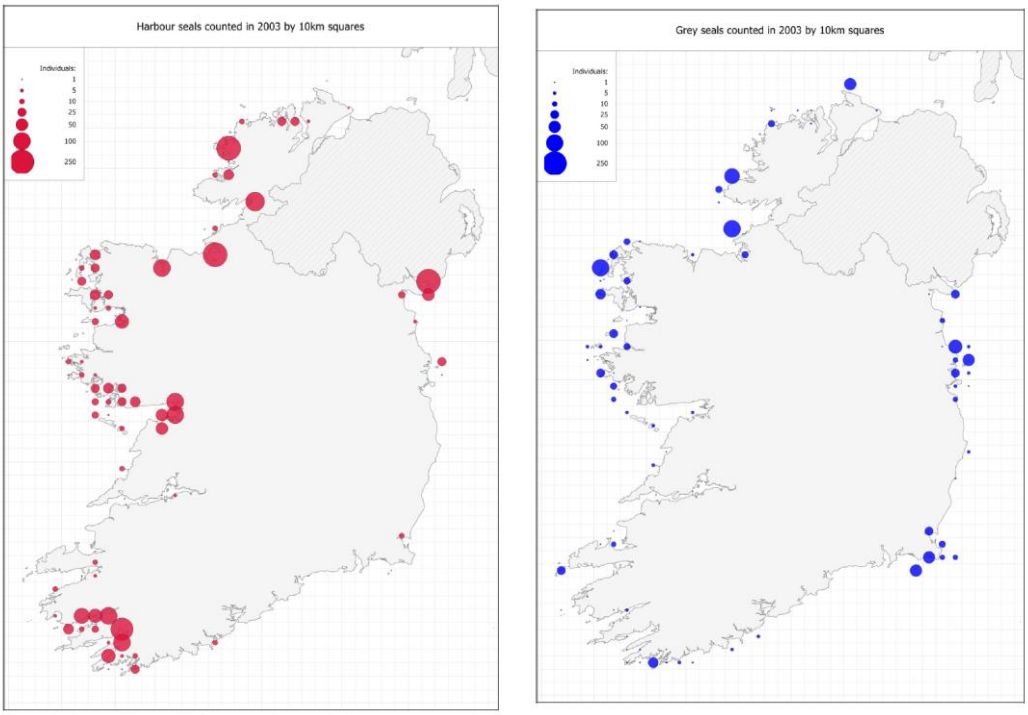

Figure 4 and 5. The number and distribution of harbour (orange) and grey seals (blue) counted in west, south-west, south and east Ireland from the 2003 Irish Seal Survey (From Duck and Morris, 2013).

(iii) Otter

Otters are found across a variety of aquatic habitats, including; rivers, lakes, estuaries, canals, marsh and along the coast. Coastal dwelling otters require access to fresh water to regularly rinse their fur to avoid problems with insulation. No records of otters were found to exist on the NBDC database in the vicinity of the proposed works, and only 2 records at adjacent areas, but all well outside the area of the proposed works (Table 3).

Table 3. Records of Otter within and surrounding NGS Q72

Grid square	Species	Date	Location	Precision	Source
R25	Otter	15/10/2010	Aughinish	100m	NBDC/SJ
R25	Otter	24/01/2005	Poulaweala Creek	100m	NBDC

2.2 A review of bottlenose dolphin sightings in the Shannon Estuary from published literature

Bottlenose dolphins are widespread and relatively abundant off the Irish coast with most sightings along the western seaboard (Berrow *et al.* 2010a). Genetic evidence (Mirimin *et al.* 2011) suggests the existence of three discrete populations of bottlenose dolphins in Ireland: the Shannon Estuary, a coastal inshore population and a putative offshore population (confirmed by Louis *et al.* (2014)), who showed offshore dolphins in Ireland are genetically discrete from the Inshore population and part of a large wide-ranging group that includes dolphins from the Bay of Biscay and the Azores.

Resident Bottlenose dolphins of the Shannon Estuary

The Shannon Estuary is the most important habitat for bottlenose dolphins in Ireland, where research carried out since 1993 has shown that the dolphins occurring here are resident, i.e. they are present here throughout the year, and the estuary has been highlighted as a very important calving area (Berrow *et al.* 1996; Ingram 2000). Until recently, bottlenose dolphins were the only cetaceans to be recorded within the estuary alive (recent sightings have included harbour porpoise, and common dolphins), upriver from Kilbaha, Co. Clare, with the highest concentrations found in the outer Estuary, off Kilcredaun Head and in the middle of the estuary off Moneypoint and Tarbert (Ingram and Rogan 2002). Berrow (2009), suggested that dolphins are found to frequently range upriver, during both summer and winter. The abundance of dolphins in the estuary is known from a number of estimates carried out to date, with estimates ranging from 140±12 in 2006 to 107± 7, CV = 0.07 in 2021 (Ingram 2000; Ingram and Rogan 2003; Englund *et al.* 2007; 2008; Berrow *et al.* 2013; Berrow et al. 2022).

Noise levels from the Shannon Estuary have been previously described and an effect of vessel activity on bottlenose dolphin presence was assessed acoustically (O'Brien *et al.* 2015). Results showed a significant increase in the inter-click-interval (ICI) of dolphin echolocation clicks in the presence of vessels, but it was uncertain if this behavioural shift was a negative response, or a possible coping mechanism for managing an increase in ambient noise levels. A significant change in the acoustic repertoire is cause for concern and proves the need for assessments of potential sources of disturbance, especially given results on other species have proven foraging disruption caused by boat presence found in other species such as killer whales and common dolphins (Williams *et al.* 2006; Stockin *et al*. 2008).

Information on bottlenose dolphin site usage at Aughinish cannot be established as very few sightings exist upriver. Dedicated research is carried out within the middle of the estuary, Tarbert out west to Ballybunion Bank. Berrow (2009) looked at the winter distribution of bottlenose dolphins and areas upriver previously not covered during dedicated surveys, but no sightings were recorded upriver of Foynes Island. Therefore, based on current sightings data, very little information could be concluded on the occurrence of dolphins at Aughinish.

3.3 Static Acoustic Monitoring (SAM) data from AAL Jetty

SAM was carried out around the estuary as part of the Shannon Integrated Framework Plan (SIFP; https://shannonestuarysifp.wordpress.com/) for the Shannon Estuary, where a number of deep-water ports were the focus of long-term monitoring (Figure 6).

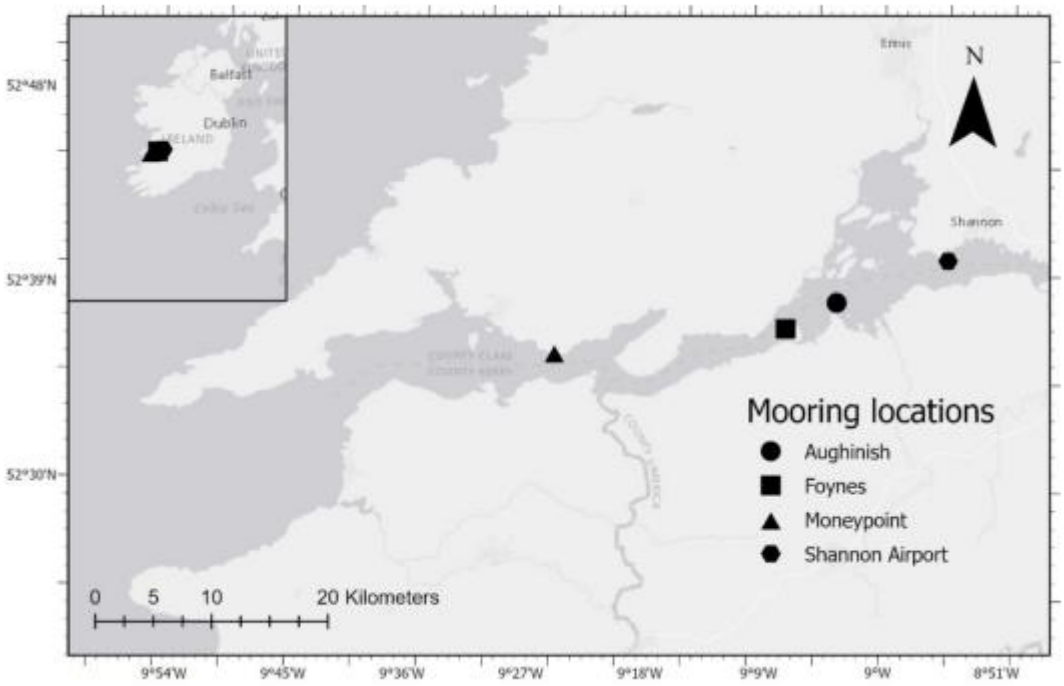

Figure 6. Long-term SAM deployments using C-PODs © Carmen *et al*. (2021).

SAM was carried out from AAL Jetty from November 2011 to November 2014, with a total of 812 days monitored (Carmen *et al.* 2021; Figure 6). Dolphins were detected across 20.3% of days monitored. In order to assess how dolphins were using the site, Carmen *et al*. (2021) extracted a total of 3,471 click trains were across 165 different days (Figure 7), with 437 click trains (12.6% of total) classified as foraging trains at this site (Figure 7). This dataset was analysed to assess trends across seasons, stages of the tidal cycle and tidal phase and across day and night-time hours. The results yielded some very important results where foraging was found to take place significantly more during the autumn months (Figure 7). Across the tidal cycle, foraging was mostly detected during ebbing tides and during neap tides of the tidal phase and during the hours of darkness with 85% of all trains recorded during night-time hours (Carmen *et al.* 2021).

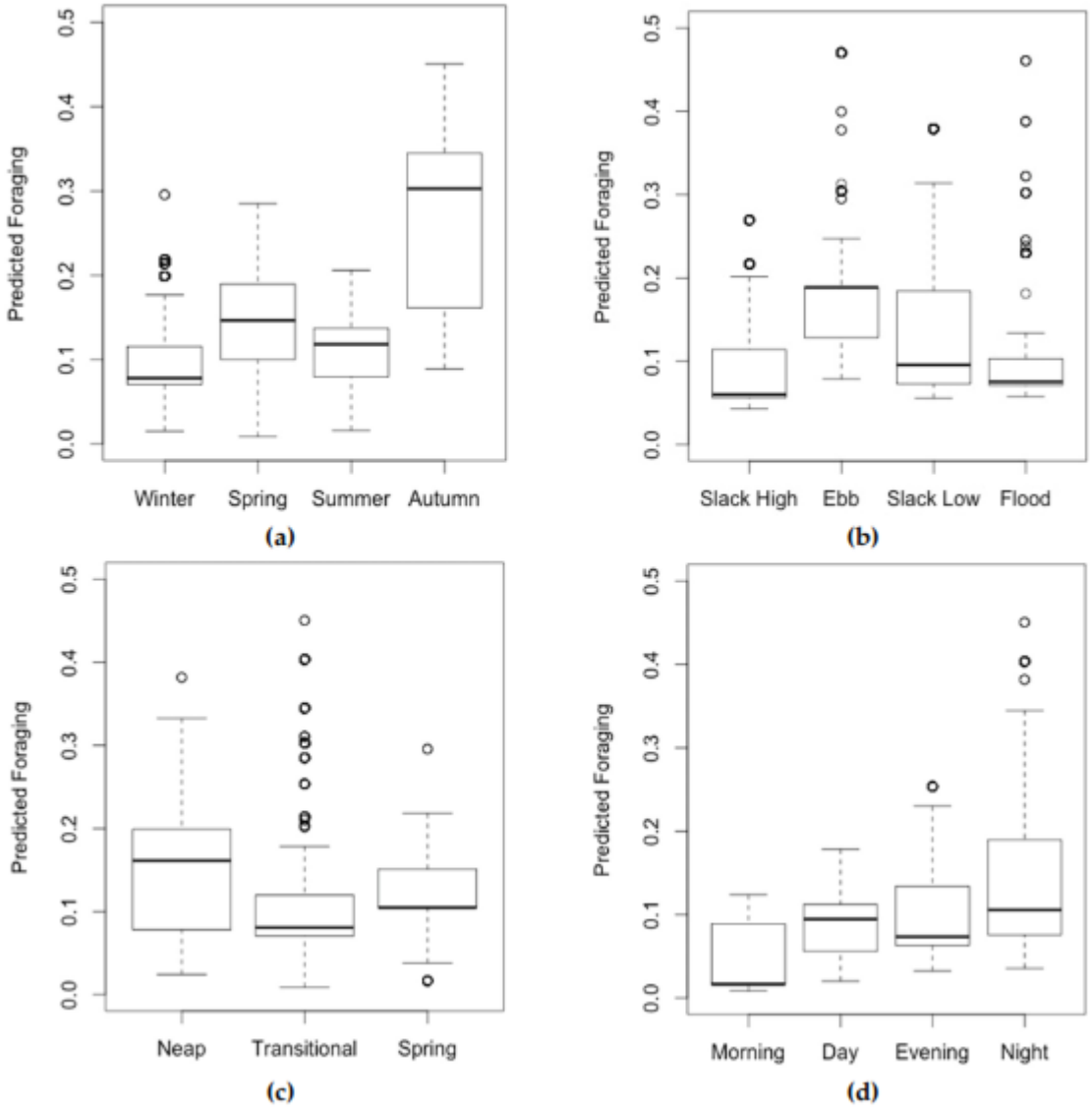

Figure 7. Results from models by Carmen et al (2021) assessing the foraging rates of Bottlenose dolphins at Aughinish across a range of variables, including; Season, Tidal cycle, Tidal phase and Diel patterns.

4.5 Summary of Desktop Data Records of Marine Mammals

In summary, from the data sources accessed, Harbour seals and Otters have not been recorded close to the proposed works. There are a few records of Grey seals in the area from telemetry data but these records were only over 2 days in June and 1 in July 2009. From the SAM data, a good picture of bottlenose dolphin activity at the site is available. Bottlenose dolphins were found to be present on 21% of days monitored at Aughinish. Based on the results by Carmen *et al.* (2021), its likely to encounter dolphins at the site across all seasons. Additionally, detections have been recorded across all tidal states but significantly more during a neap tide, and during ebbing tides, and significantly more detections recorded during night-time hours, which could explain the low number of visual records upriver.

4. Impact Assessment

4.3 Description of Dredging Activity and Impacts

For the majority of dredge operations worldwide, one of four kinds of dredgers are used. These include; cutter suction dredgers (CSD), trailing suction hopper dredgers (TSHD), grab dredgers (GD) and backhoe dredgers (BHD). Additionally, a plough or seabed leveller is used to flatten/level areas without lifting material from the seabed and dumping it elsewhere, including three main types of plough, i) agitators and ii) levellers and iii) material movers.

A trailing suction hopper dredger (TSHD), plough and Long Reach Track Machine on a barge are the proposed methods for works at AAL (Figure 8). Results from noise measurements conducted internationally during the extraction of sand using a TSHD showed that the dredger had an estimated source level of between 184-188 dB re 1µPa^{2}m^2, with the main energy occurring between 100 and 500Hz (Itap, 2007; WODA, 2013). These source levels (SL) at frequencies below 500 Hz are similar with those expected from a cargo ship travelling at a speed of between 8 and 16 knots (Arveson and Vendittis, 2000). Work by Robinson *et al.* (2011) has shown that source levels at frequencies above 1 kHz show elevated levels of broadband noise generated by the aggregate extraction process; which is dependent on the aggregate type being extracted, e.g. coarse gravel generating higher noise levels than sand.

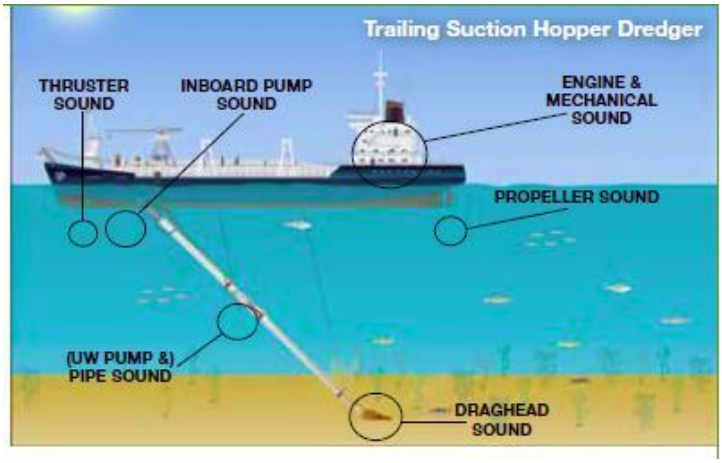

Figure 8. Trailing Suction Hopper Dredger (TSHD)©WODA

Results from SAM show that bottlenose dolphins regularly use deepwater berths that are the main shipping routes used in the estuary and so are exposed daily to shipping. Noise-monitoring results show that the estuary is a noisy place (100 ± 7.5 dB) but is marginally quieter in comparison with the results generated by Beck *et al.* (2013) for Dublin Bay (113 ± 8.2 dB).

A review of the literature on the effects of dredging on marine mammals found that previous work in Aberdeen Harbour showed a clear avoidance response by bottlenose dolphins to dredging activity in a highly urbanised foraging patch (Pirotta *et al*. 2013). Given the level of vessel activity in the harbour, these dolphins were expected to show a high level of tolerance towards disturbance at the site, but results showed dolphins spending proportionally less time in the harbour as the intensity of dredging activity increased and in one year with dolphins leaving the harbour completely for approximately five weeks during the dredge works (Pirotta *et al*. 2013).

Todd *et al*. (2014), carried out a review of impacts of marine dredging activities on marine mammals, highlighting collision as a possibility but only a single incident is available in the literature

of a single right whale. The authors conclude, collisions are possible, but improbable given that operating dredgers are either stationary or moving at slow speeds. Studies on New Zealand fur seals were reviewed where results showed no evidence of disturbance, despite the relative closeness of a dredger to popular haul-out sites (Bossley *et al*. 2022).

Todd *et al.* (2014) explained that a marine mammals response is likely to depend on the types of dredger used, state of operation, local sound propagation conditions, and the receiver characteristics with regard to the sensitivity and bandwidth of hearing. Additionally, noise from dredging is well below suspected injury thresholds or PTS (exposure criteria from Southall *et al*., 2007 update 2019); however, TTS cannot be ruled out if marine mammals are exposed to noise for prolonged periods [as highlighted in a study on effects of long-term exposure in harbour porpoises; Kastelein *et al.* (2012). Limited data exists on the effects of dredging, but is unlikely to cause physiological damage to marine mammal auditory systems, but more likely leading to masking and behavioural disturbances, with baleen whales the most at risk taxa. Indirect impacts are listed as changes to their physical environment, to their prey and toxins and pollutants from dredge spoil but the aim of this review is to deal specifically with noise. Effects of turbidity are often localised with minimal direct impact on marine mammals (Todd *et al.* 2014). Plough dredging is routinely used in the Shannon Estuary as part of maintenance operations. Dredge operations emit continuous low frequency sound into the marine environment, and because of this sound signature, these type of works are generally considered of lesser concern for impacts on marine mammals. The M.V. Shannon 1 (Figure 9) is the vessel frequently used for plough operations, and this technique of dredging gives rise to a lesser amount of re-suspension of sediment into the water column as the work is localised to the seabed. The Shannon Estuary is a very murky environment, and monitoring data from previous dredge campaigns since 2016 have showed plough dredging activities at Aughinish have had no impact on turbidity. Sound production from this operation will be largely influenced by sediment properties, and based on how hard or consolidated these mounds are, will determine how much force the dredger must apply to move the material (Robinson *et al*. 2011). These operations are most likely to occur within the frequency band 70-1000 Hz, peaking at 100-110 dB, with sounds inaudible at approximately 500 m from the source (Clarke, 2002). The dredger itself is a source of continuous noise, reaching 100 to 115dB in the immediate vicinity of the dredger, but it is likely this noise diminishes to acceptable levels (50-70dB) a few hundred metres from the dredging site (Bray, 2008). These source levels (SL) at frequencies below 500 Hz are similar with those expected from a cargo ship travelling at a speed of between 8 and 16 knots (Arveson and Vendittis, 2000).

Figure 9. Plough dredger used in the Shannon Estuary M.V. Shannon 1©Irish Waterway History

Sound exposure levels from these operations are thought to be well below thresholds expected to cause injury to a marine mammal. However, noise generated by dredging, from the physical presence of the dredger, and possibly from the increased water turbidity in the area of operations have the potential to cause low level disturbance such as masking or behavioural impacts such as displacement. The presence of an operational dredger at the site will lead to a small local increase in noise, but given the Shannon Estuary is Ireland's premier deep-water port, and caters for ships up to 200,000 deadweight tonnage, disturbance from these operations are likely to be minimal.

5.2 NPWS Assessment Criteria

1. Do individuals or populations of marine mammal species occur within the propose area?

- From the data sources accessed, the most likely species to be encountered at the site are bottlenose dolphins or Grey seals. Bottlenose dolphins were found to be more active at the site during the autumn and night-time hours, while some telemetry data showed grey seals visited the area but only for a brief period.

2. Is the plan or project likely to result in death, injury or disturbance of individuals?

- There is some potential for direct or indirect impact from the dredge operations on marine mammals in the area, mainly through increased noise, leading to masking or displacement.
- With regards to these potential impacts, the proposed works are expected to be intermittent and over short durations, keeping potential disturbance to a minimum. Additionally, the Shannon Estuary is a busy shipping port so the presence an additional vessel for these short intermittent durations should not have a significant impact.
- The risk of injury or mortality of a marine mammal over the course of the works is considered extremely low as the sighting and detection rates for the area are low. If marine mammals occur with the area, they are already exposed to large vessels on a daily basis and would be aware of their presence. The dredge vessel will be relatively slow moving and thus ensuring any animals in the area would have sufficient time to avoid any collisions and thus injury or mortality.

3. **Is it possible to estimate the number of individuals of each species that are likely to be affected?**

- Based on abundance estimates for the Shannon Estuary carried out to date (2006 to 2021), it is likely the population of bottlenose dolphins lies between 140±12 (2006) and 107± 12 (2021). The number of dolphins likely to occur as far up river as Aughinish are low, given that all abundance estimates to date are based on survey coverage from Tarbert west towards Ballybunion Bank in the outer estuary.

4. **Will individuals be disturbed at a sensitive location or sensitive time during their life cycle?**

- Given that dolphins were only detected on 21% of days monitored out of a total of 812 days in comparison with Moneypoint, where they are detected on average 71-73% of days (O'Brien *et al.* 2013; Carmen et al. 2021) suggests that this is not a core habitat for their daily habits and therefore not a sensitive habitat for their lifecycle.

5. **Are the impacts likely to focus on a particular section of the species' population, e.g., adults vs. juveniles, males vs. females?**

- It is impossible to assess this impact/risk as the data available does not permit. Sightings of dolphins upriver are sporadic and little photo-identification studies have been carried out in this section to provide a robust assessment.

6. **Will the plan or project cause displacement from key functional areas, e.g., for breeding, foraging, resting or migration?**

- Based on the datasets available, it is extremely unlikely that the proposed works will cause displacement from key functional areas.

7. **How quickly is the affected population likely to recover once the plan or project has ceased?**

- It is expected that animals displaced from the vicinity of the dredging site would return after the works have stopped. Displacement if evident should be short lived based on the duration of the proposed works, and given this area of the estuary is susceptible to regular daily shipping activity.

5.2 Mitigation

To minimise the risk of permanent or temporary injury and disturbance to marine mammals, especially bottlenose dolphins in the vicinity of dredging operations, the NPWS 'Guidance to manage the risk to marine mammals from man-made sound sources in Irish waters – January 2014' (NPWS, 2014) recommended that stated mitigation procedures for dredging are followed and monitored by a suitable qualified Marine Mammal Observer (MMO).

1. A qualified and experienced marine mammal observer (MMO) shall be appointed to monitor for marine mammals and to log all relevant events using standardised data forms (as presented in Appendix 7; NPWS, 2014).

2. A dedicated Marine Mammal Observer will conduct a 30-minute watch for marine mammals (specifically bottlenose dolphins at this site) within 500m of the *dredging* vessel prior to start up. If a seal, otter or bottlenose dolphin is sighted within 500m of the vessel, start-up must be delayed until the animals are observed to move outside the mitigation zone or the 30 minutes has passed without the animal being sighted within the mitigation zone.

Pre-start monitoring

3. Dredging 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.

Dredging operations

7. Once normal dredging operations commence, there is no requirement to halt or discontinue the activity at night-time, nor if weather or visibility conditions deteriorate nor if marine mammals occur within a 500m radial distance of the sound source, i.e., within the Monitored Zone.

Breaks in sound output

8. If there is a break in dredging sound output for a period greater than 30 minutes (e.g., due to equipment failure, shut-down or location change) then all Pre-Start Monitoring must be undertaken in accordance with the above conditions prior to the recommencement of dredging activity.

Reporting

9. Full reporting on MMO operations and mitigation undertaken must be provided to the Regulatory Authority as outlined in Appendix 7 (NPWS, 2014).

Additionally, when bathymetry surveys are required to assess the levels of the seabed, the following NPWS mitigation is required in the vicinity of multibeam, single beam, side-scan sonar and sub-bottom profiler surveys.

1. A qualified and experienced marine mammal observer (MMO) shall be appointed to monitor for marine mammals and to log all relevant events using standardised data forms (Appendix 6).

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 500m radial distance of the sound source intended for use, i.e., within the Monitored Zone.

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. This prescribed Pre-Start Monitoring shall subsequently be followed by a Ramp-Up Procedure which should include continued monitoring by the MMO.

Ramp-Up Procedure

7. In commencing an acoustic survey operation using the above 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: 1µPa @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: 1µPa @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.

8. 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.

9. 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 500m radial distance of the sound source, i.e., within the Monitored Zone.

Breaks in sound output

10. 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.

11. For higher output survey operations which have the potential to produce injurious levels of underwater sound (see sections 2.4, 3.2) 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.

Reporting

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

5.3 Summary

Based on the location of the AAL Jetty within the Lower River Shannon SAC, and given that there is evidence for the year round detection of dolphins at the site, it is recommended that the NPWS guidelines are adopted and followed for the duration of all works. Observations should be carried out from land, or from the dredge vessel, and the relevant mitigation outlined above implemented. All observations and a detailed report of mitigation should be used to inform future works. The proposed works with the mitigation outlined above are considered unlikely to present a risk to bottlenose dolphins or other marine mammals that could be encountered at the site. However, as this permit is for an 8-year period, AAL should review operations after each maintenance campaign or on an annual basis to ensure the mitigation is working or to identify potential issues that may arise to ensure effective mitigation over this licence period. Guidance and clarification on how to effectively implement the MMO guidelines should be sought from the NPWS before the onset of works and to ensure the 2014 guidance is still current.

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