MARINE MAMMAL RISK ASSESSMENT OF PROPOSED DREDGING AT BALLYCOTTON, CO CORK AND DISPOSAL AT SEA

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1 | INTRODUCTION

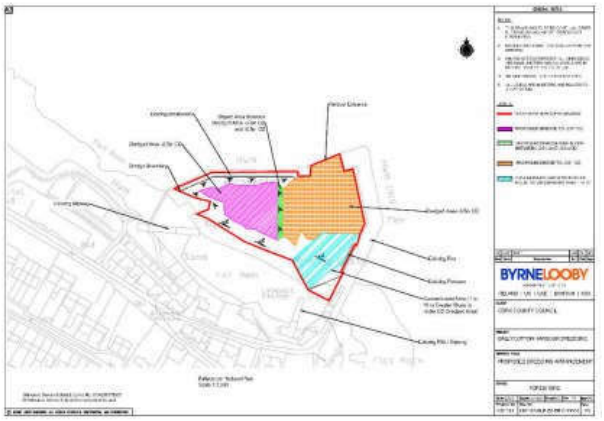
The Irish Whale and Dolphin Group (IWDG) were contracted by the engineering and environmental consultants MERC Consultants to carry out a Marine Mammal Risk Assessment of the proposed dredging operations at Ballycotton, Co Cork and subsequent disposal of dredge material at a proposed dump site located around 16km to the southwest. The proposed works in Ballycotton Harbour will involve the removal of approximately 19,500 m^3 of material.

The proposed dump site is outside of any Special Areas of Conservation (SACs) but is halfway between the Saltee Islands SAC, which includes grey seal as a qualifying interest and Roaringwater Bay and Islands SAC, which includes harbour porpoise as a qualifying interest. The proposed works will take place over 8 weeks at a time informed by this MMRA.

Figure 1. Ballycotton Harbour, Co Cork and adjacent Ballycotton Island

Proposed works

The dredge site is within Ballycotton, Co. Cork and with a dump site at Powers Head, off the Cork coast. The dredge material is comprised of silts, sands and gravels. It is estimated that a total volume of 19,500 m^3 (35,743 tonnes) will be excavated. It is not anticipated that there will be any requirement to dredge rock from the harbour.



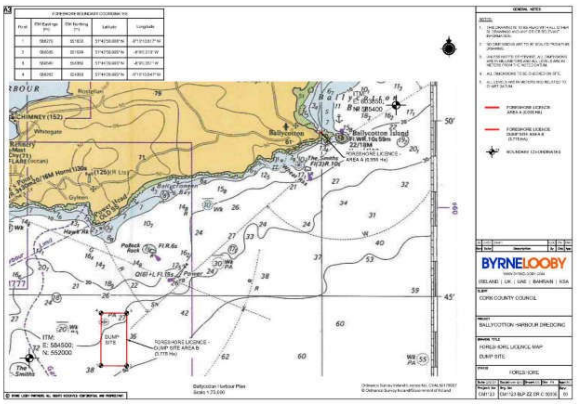


Figure 2a. Areas to be dredged in Ballycotton Harbour **2b. Disposal at Sea disposal site**

2 | METHODS

The risk assessment was based on a review of the available literature and data sources. Maps of the distribution of cetacean sightings adjacent to Ballycotton Harbour were prepared using data from the Irish Whale and Dolphin Group's sightings database (IWDG, accessed April 2021).

3 | LEGAL STATUS

Irish cetaceans and pinnipeds are protected under national legislation and under a number of international directives and agreements which Ireland is signatory to. All cetaceans as well as grey and harbour seals are protected under the Wildlife Act (1976) and amendments (2000, 2005, 2010 and 2012). 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). The act applies out to the 12 nml limit of Irish territorial waters.

All cetaceans and pinnipeds are protected under the EC Habitats Directive. 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 (*Halichoerus grypus*) and harbour seal (*Phoca vitulina*) are designated Annex II species which are of community interest and whose conservation requires the designation of special areas of conservation.

Ireland is also signatory to conservation agreements such as the Bonn Convention on Migratory Species (1983), the OSPAR Convention for the Protection of the Marine Environment of the northeast Atlantic (1992) and the Berne Convention on Conservation of European Wildlife and Natural Habitats (1979).

In 2007, the National Parks and Wildlife Service (NPWS) of the Department of Arts, Heritage and the Gaeltacht 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) which include mitigation measures specific to dredging. 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.

4 | BASELINE ENVIRONMENT

4.1 | Ambient Noise Levels

The ambient noise levels at the site are not known with the closest site with data available is Cork Harbour (Sutton et al. 2014). However, as Cork is a busy shipping port, these measurements are not considered relevant to Ballycotton Harbour. Ambient noise off Ballycotton Harbour is expected to be dominated by environmental noise (e.g. tidal movement of water and sediment, and wind and wave noise) and shipping noise, especially with peaks in noise due to small vessels using Ballycotton Harbour and large vessels transiting to Cork and Waterford Harbours.

4.2 | Cetaceans

A review of cetacean (whale, dolphin and porpoise records) submitted to the IWDG during the period 1 January 2000 to 31 December 2020 was accessed on 5 April 2021 and mapped. During this period, 281 validated cetacean records were available. In addition 38 sighting records of basking sharks were also exported and mapped.

Most records were of bottlenose dolphins (106 or 37.7% of all records) followed by common dolphin with 45 records (16%), which were the most abundant species. Another six species including harbour porpoise, fin, humpback, minke and killer whale and Risso's dolphin were also recorded reflected the high species diversity and productivity of this area (Table 1).

Cetacean sightings were made throughout the area of interest with concentrations off Ballycotton (Figure 3).

Table 1. Cetacean sightings (including IWDG downgrades) recorded off Ballycotton Harbour, Co Cork from 2000-2020.

Species	Number of sightings	Number of individuals	% of total sightings
Bottlenose dolphin	106	738	37.7
Common dolphin	45	2943	16.0

Fin whale	33	91	11.7
Minke whale	16	45	5.7
Harbour Porpoise	15	79	5.3
Killer whale	7	14	2.5
Humpback whale	5	111	1.8
Risso's dolphin	2	20	0.8
Dolphin species	18	210	6.4
Large whale	11	23	3.9
Dolphin possibly harbour porpoise	8	91	2.8
Whale species	7	14	2.5
Sei/Fin/Blue	3	7	1.1
Cetacean species	3	34	1.1
Patterned dolphin species	1	3	0.4
Medium whale	1	1	0.4
Total	**281**	**4324**	**100**

Bottlenose dolphin (Tursiops truncatus)

Bottlenose dolphins are frequently recorded off Ballycotton Harbour, Co Cork and adjacent to the disposal site (Figure 3). Bottlenose dolphins are widespread and relatively abundant off the Irish coast with most sightings along the western seaboard (Berrow *et al.* 2010).

Recent genetic evidence (Mirimin *et al.* 2011) suggests the existence of three discrete populations of bottlenose dolphins in Ireland: the Shannon Estuary, an inshore population and an offshore population that ranges from the Bay of Biscay and the Azores (Louis *et al.* 2014). The inshore population is highly mobile and photo-identification has shown individuals recorded off Co Cork to be part of this population (O'Brien et al. 2009). Although the semi-resident dolphins in Cork Harbour (Ryan *et al.* 2010) were attributed to the "Shannon" genetic population (Mirimin *et al.* 2011), it is likely that the dolphins off Ballycotton are part of the inshore population. Bottlenose dolphins have mainly been recorded during spring and summer months. Bottlenose dolphins are listed on Annex II of the EU Habitats Directive but the nearest SAC for this species is the Shannon estuary.

Common dolphin (Delphinus delphis)

Common dolphins are distributed around the entire Irish coast but highest concentrations are off the southwest and west coasts (Berrow *et al.* 2010). However, in the winter large numbers of common dolphins enter the Celtic sea to feed on schools of pelagic fish such as herring and sprat. Common dolphin were sighted throughout the area of interest (Figure 5) but almost exclusively during the winter period. They have been reported adjacent to the disposal site (Figure 6).

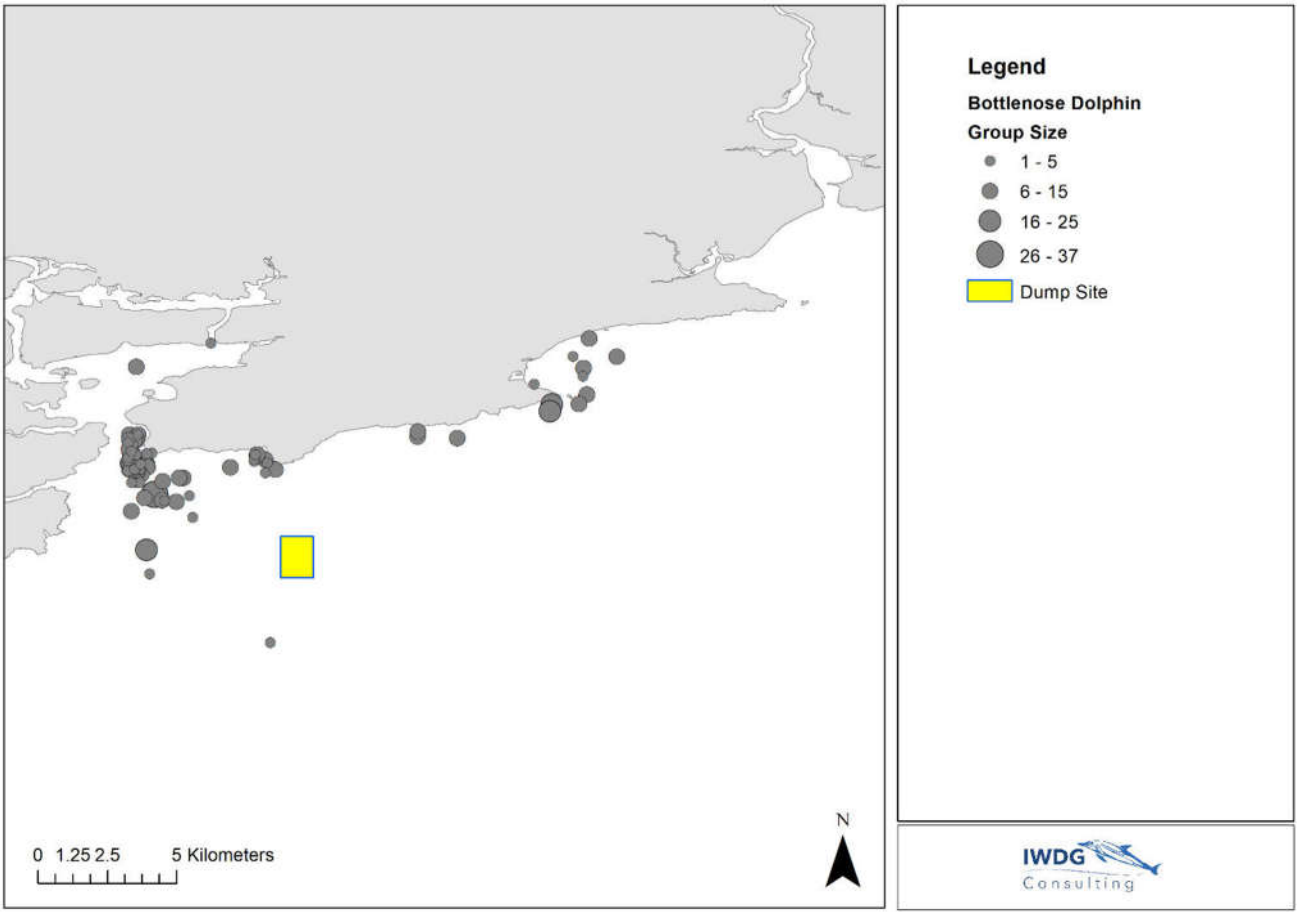


Figure 3. Sighting records of bottlenose dolphins off Ballycotton Harbour, Co Cork (from IWDG accessed April 2021)

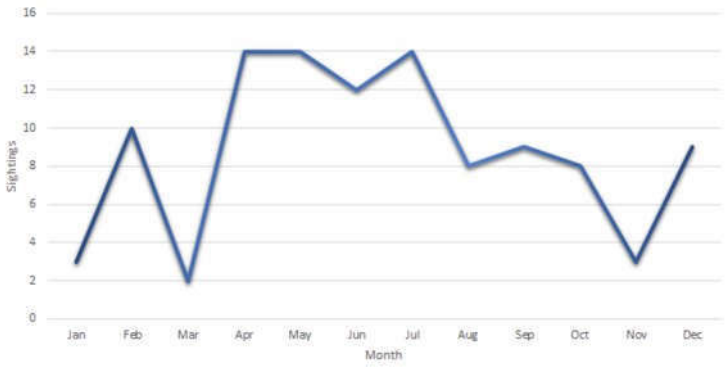


Figure 4. Monthly distribution of bottlenose dolphin sightings off Ballycotton Harbour, Co Cork (from IWDG accessed April 2021)

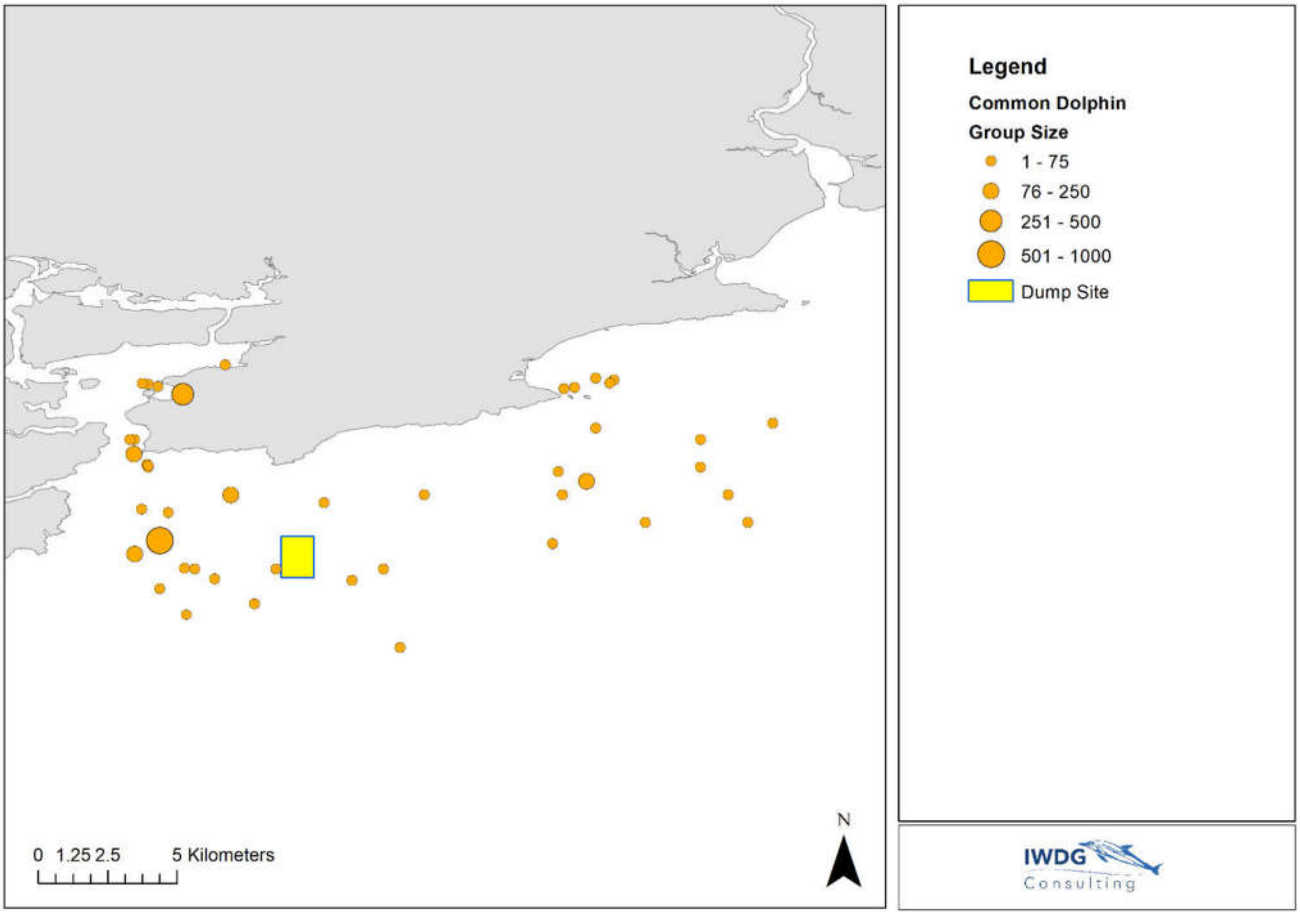


Figure 5. Sighting records of common dolphins off Ballycotton Harbour, Co Cork (from IWDG accessed April 2021

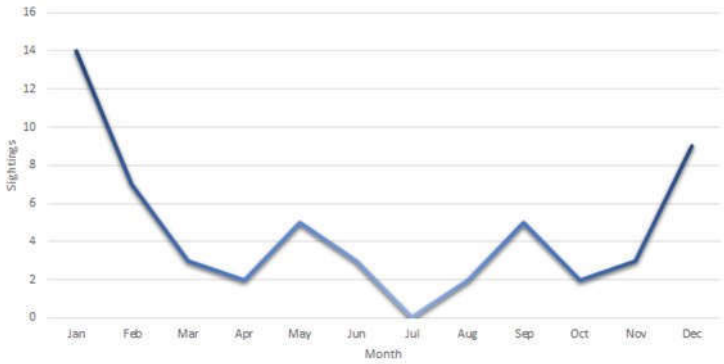


Figure 6. Monthly distribution of common dolphin sightings off Ballycotton Harbour, Co Cork (from IWDG accessed April 2021)

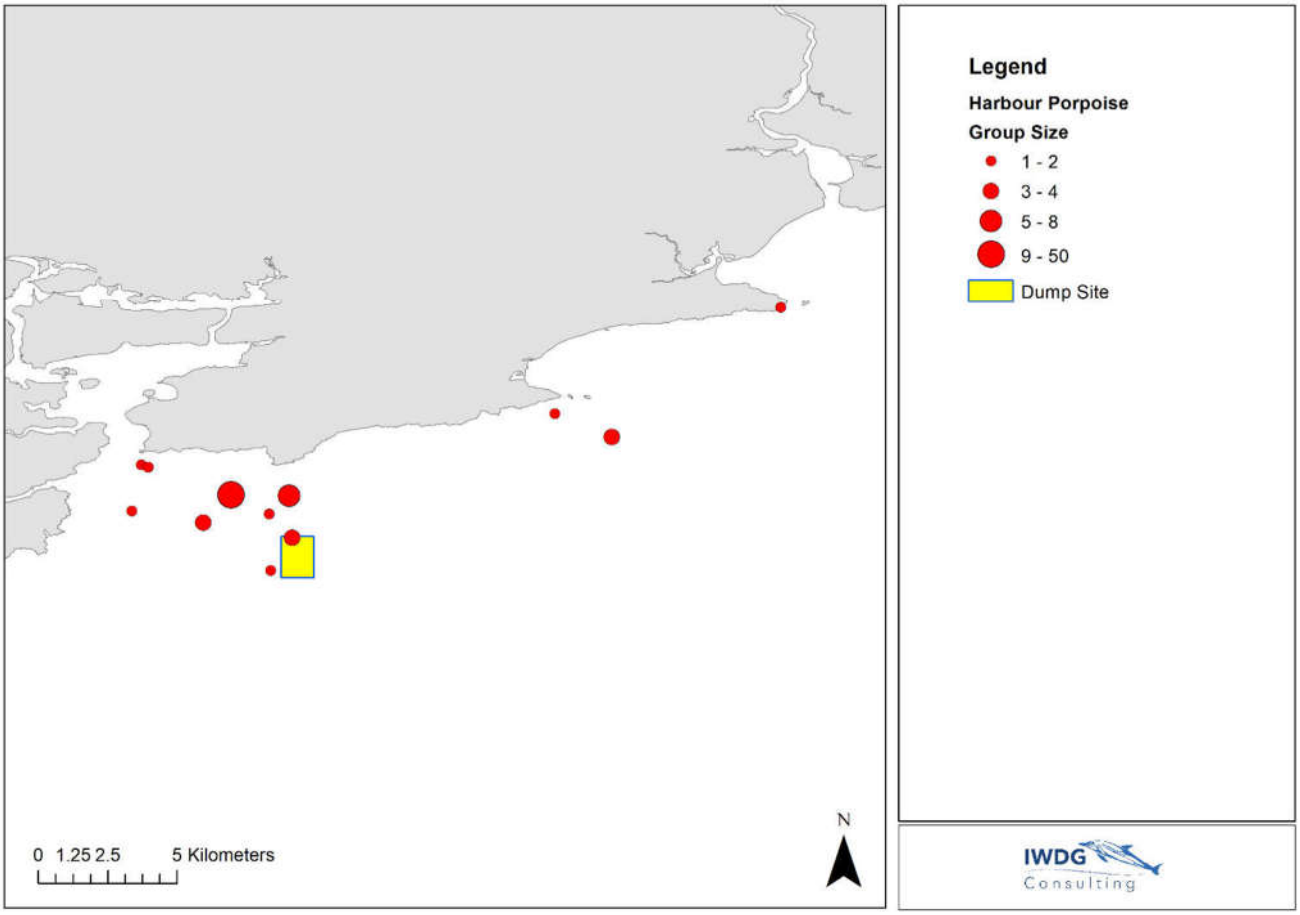


Figure 7. Sighting records of harbour porpoise off Ballycotton Harbour, Co Cork (from IWDG accessed April 2021)

Harbour porpoise (Phocoena phocoena)

Harbour porpoise are the most widespread and abundant cetacean in inshore Irish waters, with highest abundances in the Irish Sea (Berrow *et al.* 2010). Harbour porpoise were sighted in small numbers throughout the area of interest but with most sightings off Cork Harbour to the west of the disposal site (Figure 7). There were few sightings near Ballycotton Harbour. Sightings occurred at the proposed dredge site and adjacent to the disposal site and throughout the year (Figure 8) though there were more sightings in winter.

Figure 8. Monthly distribution of harbor porpoise sightings off Ballycotton Harbour, Co Cork (from IWDG accessed April 2021)

Harbour porpoise are known to particularly associate with areas of strong tidal currents and can be regularly seen foraging off Hook Head. Sightings of harbor porpoise have occurred in all months with a peak in numbers during the winter.

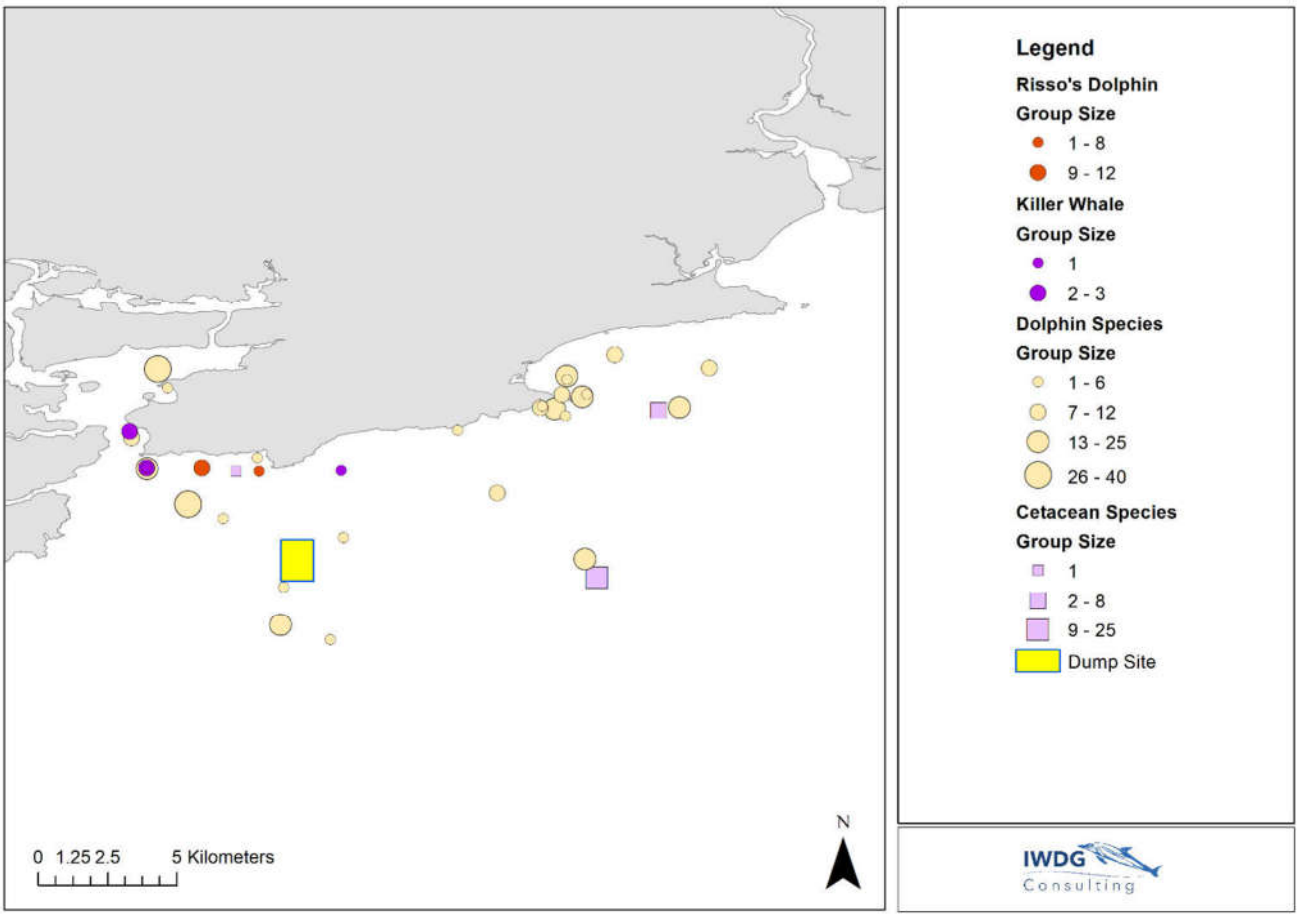


Figure 9. Sighting records of killer whales and dolphins off Ballycotton, Co Cork (from IWDG accessed April 2021)

Killer whale (Orcinus orca)

Killer whales or Orca are widespread in Ireland and recorded off all coasts (Berrow *et al.* 2010) but are unpredictable. There have been 7 sightings of a total of 14 individuals over the past 20 years in the area of interest (Figure 9) but with the proximity to Cork Harbour these are likely to include the three that took up residency in 2001 (Ryan and Wilson 2003).

Risso's dolphin (Grampus griseus)

Risso's dolphins are also patchily distributed around the Irish coast but seem to favour islands, especially off west Kerry, Galway and the Saltee Islands (Berrow *et al.* 2010). There were two sightings of a total of 20 individuals, both west of the disposal site in the mouth of Cork Harbour (Figure 9).

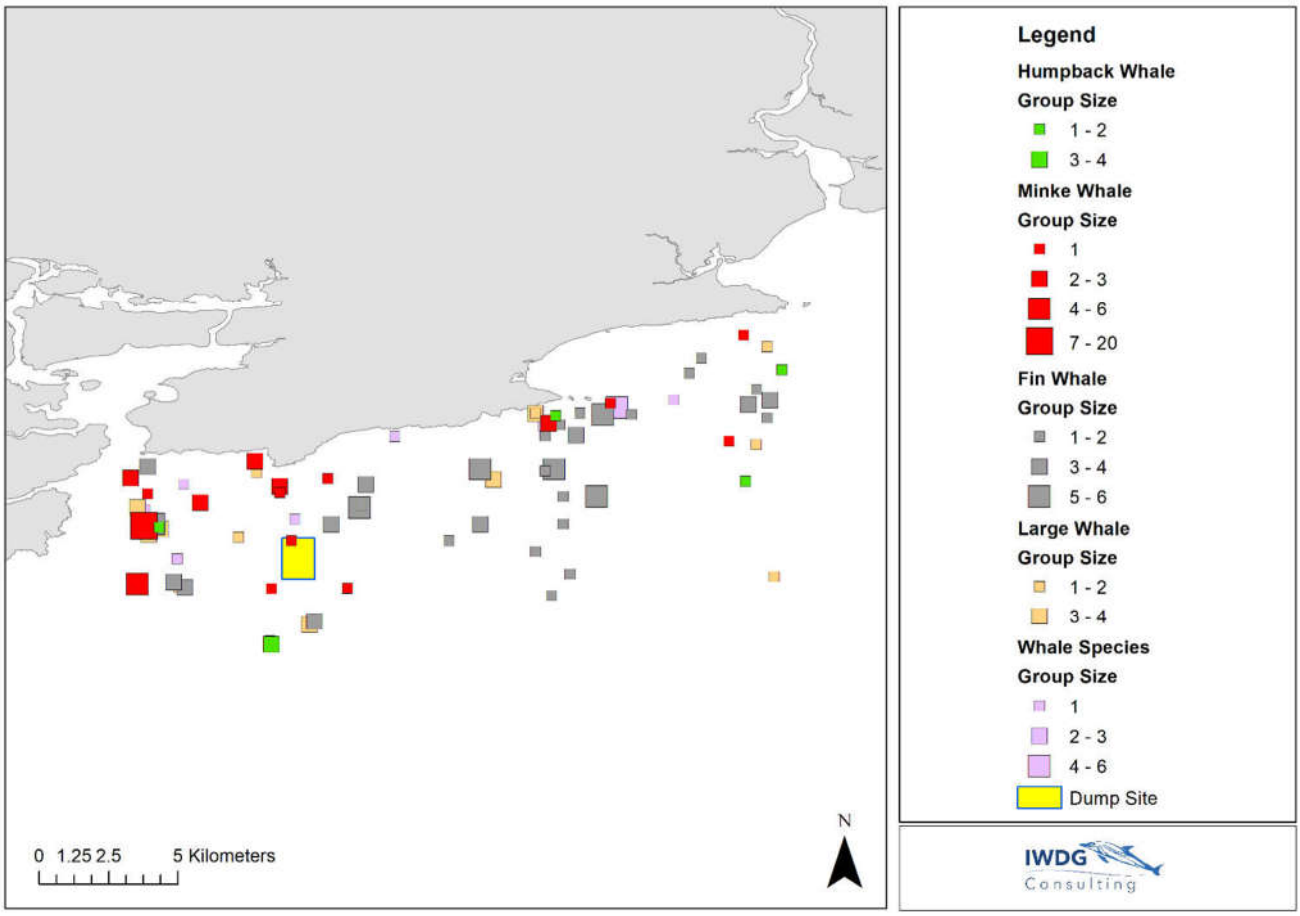


Figure 10. Sighting records of whales off Ballycotton, Co Cork (from IWDG accessed April 2021)

Fin whale (Balaenoptera physalus)

Fin whales were the most frequently record baleen whale, accounting for 11.7% of all sightings (Table 1). They were recorded offshore along the entire area of interest and adjacent to the disposal site (Figure 10) and almost exclusively during the winter (Figure 11) from October to February.

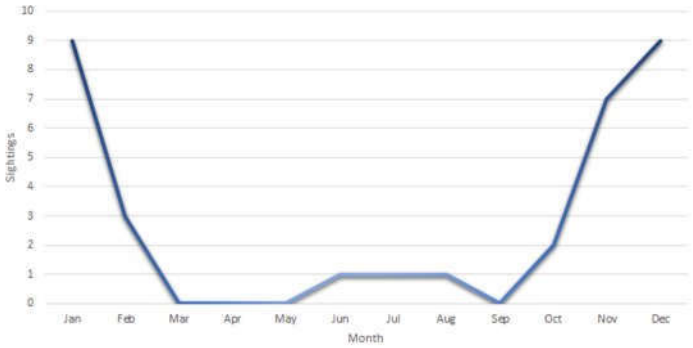


Figure 11. Monthly distribution of fin whale sightings off Ballycotton Harbour, Co Cork (from IWDG accessed April 2021)

Fin whales are regularly recorded off the south coast of Ireland especially during winter (Berrow *et al.* 2010). Whooley *et al*. (2011) showed using photo-identification that it was frequently the same individual fin whales returning each year to the south coast and they stayed in coastal waters for many months feeding on pelagic schooling fish such as herring and sprat. Timing of their easterly movement through the winter seemed to coincide with herring moving inshore to spawn.

Minke whale (Balaenoptera acutorostrata)

Minke whales are widespread and abundant in inshore Irish waters from May to October (Berrow *et al.* 2000). The summer distribution tends to be concentrated around southwest Ireland. They were recorded within the entire area of interest including adjacent Ballycotton Harbour and within the disposal site (Figure 10). They were reported

mainly between April and August (Figure 12).

Figure 12. Monthly distribution of minke whale sightings off Ballycotton Harbour, Co Cork (from IWDG accessed April 2021)

Humpback whale (Megatera novaengliae)

Humpback whales are regularly recorded off the south coast of Ireland especially during winter (Ryan *et al.* 2015). The same individual humpback whales are recorded each year and spend many months feeding on pelagic schooling fish such as herring and sprat. Sightings of humpback whales were made throughout the area of interest and adjacent to the disposal site (Figure 10) and were nearly all of single individuals sighted during January and February.

Basking shark (Cetorhinus maximus)

Although not currently protected under Irish wildlife law, basking sharks are listed under threatened and/or declining species by OSPAR and are frequently recorded throughout the area of interest (Figure 13) largely between April and June (Figure 14)

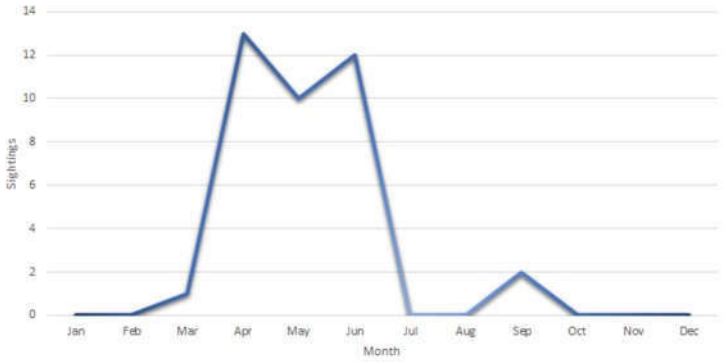


Figure 14. Monthly distribution of basking shark sightings off Ballycotton Harbour, Co Cork (from IWDG accessed April 2021)

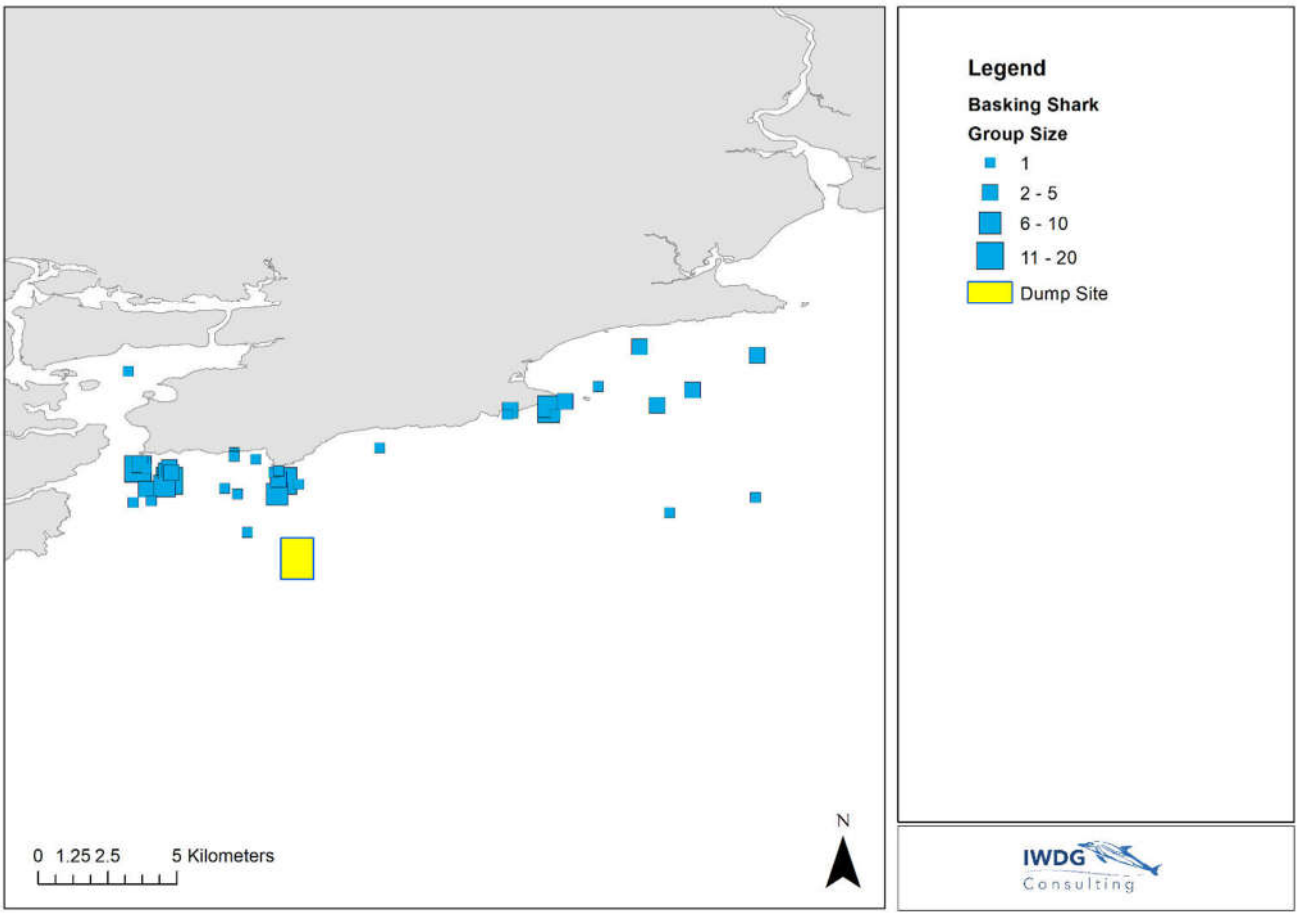


Figure 13. Sighting records of basking sharks off Ballycotton, Co Cork (from IWDG accessed April 2021)

4.3 | Pinnipeds

Grey and harbour seals are distributed around the entire Irish coast with grey seals being more abundant along the western seaboard (Cronin *et al.* 2004; O'Cadhla and Strong 2007; Morris and Duck, 2019).

Harbour Seal (Phoca vitulina)

There were no major harbour seal haul-out or breeding sites recorded near Ballycotton during the National Parks and Wildlife Service (NPWS) surveys during 2002 or 2003. A small number of harbour seals (six) were recorded hauled out at Dungarvan to the east and in Kinsale Harbour to the west in 2003 (Cronin *et al.*, 2004). Duck and Morris (2013) counted no seals during August/September 2012 using thermal imagery. A repeat survey carried out in 2017/18 also recorded along the south coast (Morris and Duck, 2019) (Figure 15). Harbour seals generally forage close to their haul out sites and are unlikely to occur at the dredging or dumping sites.

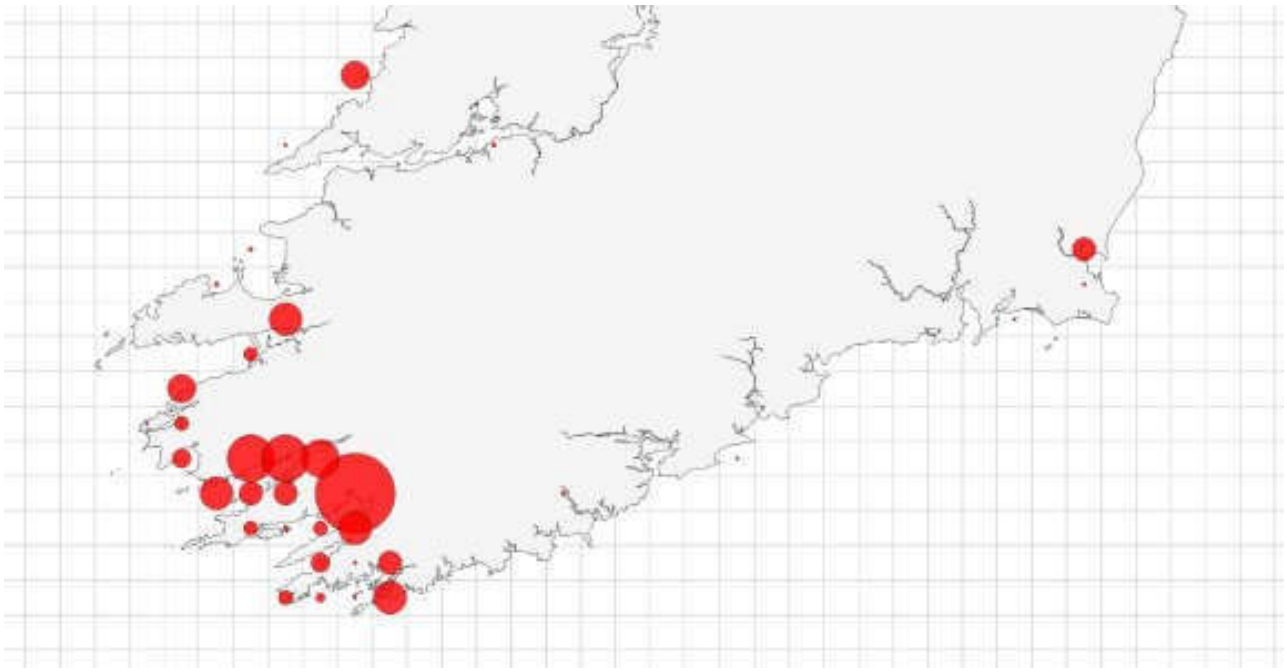


Figure 15. Map of the locations of groups of harbour seals recorded on the south coast of Ireland, August and September 2017/18 (from Morris and Duck 2019)

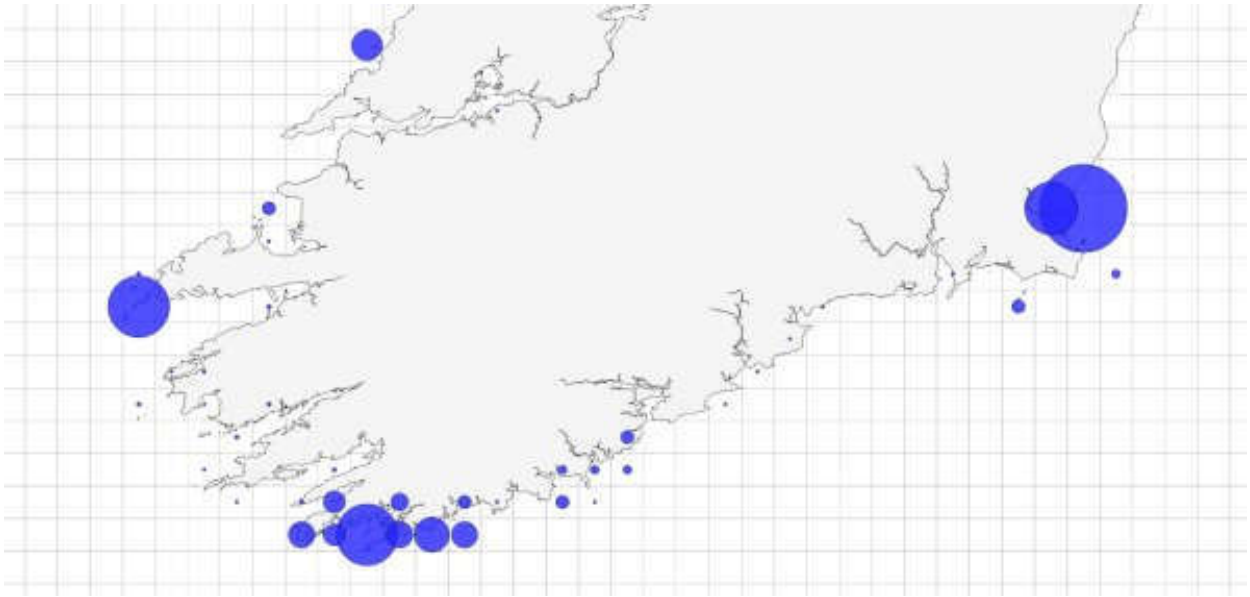


Figure 16. Map of the locations of groups of grey seals recorded on the south coast of Ireland, August and September 2017/18 (from Morris and Duck 2019)

Grey Seal (Halichoerus grypus)

There were no major grey seal haul-out or breeding sites recorded near Ballycotton reported during the National Parks and Wildlife Service (NPWS) surveys since 2003. Cronin et al. (2004) reported 6 grey seals hauled out in Kinsale Harbour in August 2003 during an aerial survey for harbour seals. O'Cadhla and Strong (2007) reported no grey seals east of Saltee Islands and west of Kedge Island to the west during an aerial survey during the moulting period. Duck and Morris (2013) reported no seals between Power Head and Youghal in August/September 2012 using thermal imagery. A repeat survey carried out in 2017/18 recorded single grey seals hauled out in Ballycotton Bay (Morris and Duck, 2019) (Figure 16).

Grey seals forage locally and may also range long distances and are likely to be encountered at the disposal site and during dredging. Grey seals are typically encountered as individuals when foraging.

5.1 | Description of Activities

As part of the proposed site works the activities likely to impact on marine mammals include:

5.1 Dredging

The dredge site is within Ballycotton Harbour and consists of gravel silt and sand. This will be dredged by long reach back-hoe excavator from a floating barge. An estimated total quantity of 25,000m^3 of material is being dredged. It is likely that dredging activities will take place 24hrs per day, 7 days per week to achieve the maximum production rates within tidal envelopes, and continue for around 8 weeks.

5.2 Dumping

The disposal site is approximately 16km southwest of Ballycotton and 4.81 kms (2.59 nmls) offshore and has been used previously to dispose of dredge material.

The dredged material will be loaded onto a hopper barge with 1,000m^3 capacity and towed to the disposal site with a tug. Therefore it is anticipated around 25-30 loads will be transported to the dump site at a rate of 3-4 loads per week.

Typical Dredge Barge, Backhoe Excavator, And Hopper Barge

5.3 Vessel noise

The barge once filled with dredged material will transit to the disposal site. At a speed of 8 nmls and a distance of 12nmls, it will take around 3 hours minutes for a round trip back to Ballycotton harbour and a total of 25-30 trips to dispose of 25,000m^3. This increase in vessel noise is very low and is unlikely to cause any significant disturbance as fishing and other vessels regularly use this area.

The timing of the dredging and disposal at sea is dependent on the recommendations of this Marine Mammal Risk Assessment.

5.2 | Literature Review of Impacts and Mitigation

The NPWS '*Guidance to manage the risk to marine mammals from man-made sound sources in Irish waters – January 2014*' recommends that listed coastal and marine activities, undergo 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. It is required that such an assessment must competently identify the risks according to the available evidence and consider (i) direct, (ii) indirect and (iii) cumulative effects of anthropogenic sound (NPWS, 2014).

A risk assessment, following NPWS Guidelines, was conducted based on the published literature, data from the IWDG sightings databases and knowledge of the study area.

Dredging Impacts

Todd *et al.* (2015) provide a very useful review of the state of current knowledge and potential impacts of dredging on marine mammals. Dredging produces continuous, broadband, low frequency sound, below 1 kHz, with sound pressure levels between 168dB and 186dB re 1µPa at 1m (Todd *et al.* 2015). In most cases the noise is continuous in nature.

There have been few studies on the effects of marine dredging (Thomsen *et al*. 2006; Nowacek *et al.* 2007). Richardson *et al*. (1995) identified only two studies on the effects of dredging on marine mammals and both were on large baleen whales (bowhead and northern right whales). Both Odontocetes (toothed whales) and Mysticetes (baleen whales) have been recorded regularly at the proposed dredging and dump site so here we considered the effects on both groups as well as seals.

Baleen whales

Of the baleen whales in the vicinity of the proposed operations, minke whales would potentially be exposed to dredge disposal activity during summer months and fin and humpback whales during winter. Richardson *et al.* (1995) reported on a controlled exposure experiment on Bowhead whales which received broadband levels of <113 – 131 dB re 1 µPa (<11 – 30 dB above ambient) from a suction dredger which lead to weak and inconspicuous avoidance, however he considered the low frequency components were under-represented. Off the southeast coast of the US, Northern Right whales exposed to intensive dredging by noisy hopper dredges apparently show some tolerance of this noise (cited in Richardson *et al.* 1995). The best documented case of long-term change by baleen whales is from Baja California where Gray whales breeding in lagoons subjected to industrial activities, including dredging were virtually absent during years with shipping which led to the suggestion that the constant dredging may have been the main source of disturbance (cited in Richardson *et al.* 1995).

Odontocetes

The effects of dredging on dolphins and porpoise have been poorly studied. Belugas showed less reaction to stationary dredges than moving barges in the Mackenzie estuary, Canada and it was concluded that passage of belugas along a shoreline was temporarily blocked by a dredging operation involving frequent barge traffic but not by a dredging operation with little barge traffic (cited in Richardson *et al.* 1995).

Recently Pirotta *et al.* (2013) carried out the most comprehensive study of the potential effects of dredging on bottlenose dolphins using static acoustic monitoring before, during and after maintenance and capital dredging of Aberdeen Harbour off NE Scotland, where 400,000m^3 of spoil was removed. The Moray Firth is home to a resident group of bottlenose dolphins and they demonstrated a clear avoidance response to dredging at a foraging area despite it being a highly urbanised site. Dolphins spent less time in the harbour as the intensity of dredging increased. Visual monitoring also showed a lower probability of observing dolphins occurred when dredging boats were present. Group size was not affected suggesting that all individuals in a group were affected equally and were likely to leave the area (Pirotta *et al.* 2013). The mechanism leading to displacement was not clear. The response may have been due to the discontinuous and rarely occurring stimulus, not regularly experienced by dolphins, or due to masking and impacting on communication or foraging. The effect may have been indirect by effecting the dolphins prey within this prey patch.

Diederichs *et al.* (2010), through the use of acoustic monitoring with click detectors, showed that porpoises temporarily avoided an area where sand extraction took place off the Island of Sylt in Germany. The authors found that when the dredging vessel was closer than 600m to the monitoring location, it took three times longer before a porpoise was again detected compared with times without sand extraction. However, all of these studies only considered dredging and not the dumping of dredged material. Tougaard *et al.* (2015) recently reviewed proposed noise exposure limits for harbour porpoises. TTS was previously induced at 164 dB at 4kHz with a single pulse or 164-175 if exposed for longer periods and a range of frequencies. Tougaard *et al.* (2015) suggested TTS could be elicited at SEL of 100-110 dB but this work was really aimed at pulse sounds from pile driving and not continuous sound produced by dredging and shipping. It is clear that of all the odontocetes, harbour porpoise are likely to be most affected by anthropogenic noise due to their high foraging rates as they tend to prey on small fish (Wisniewska *et al.* 2016).

Odontocetes are often quite tolerant of shipping noise, being repeatedly exposed to many vessels, small and large. Thus dredging seems to have less effect on marine mammals than moving sound sources although avoidance behaviour of whales exposed to high levels of activity have been documented. Reactions, when measured have only occurred when received sound levels are well above ambient levels.

Seals

Although there are fewer studies on pinnipeds or odontocetes these animals do tolerate considerable noise from such sources (Richardson *et al.* 1995). Elevated noise from dredging could also affect seals which are sensitive to a lower frequency range (Todd *et al.* 2015). Todd *et al.* (2015) reported on observations of dredging operations in Geraldton, Western Australia between 2002 and 2003, reported that New Zealand fur seals and Australian sea lions showed no sign of disturbance reactions, despite the relative closeness of dredging to popular haul-out sights. Similarly, Hawaiian monk seals showed no adverse reactions to bucket dredgers around Tern Island. Anderwald *et al.* (2013) found that grey seals showed some level of avoidance to high construction vessel traffic in Ireland, although it should be noted that observations were undertaken from a cliff, so animals possibly taking advantage of increased food close to operating dredgers may have been missed by observers.

Pinnipeds may exhibit great tolerance to coastal activities and often haul out on man-made structures where there is considerable human activity. This exposure may lead to some chronic exposure to man- made noise, with which they tolerate. Ecological or physiological requirements may leave some marine mammals with no choice but to remain in these areas and continue to become chronically exposed to the effects of noise. In areas with repeated exposure, mammals may become habituated with a decline in avoidance responses and thus become less sensitive to noise and disturbance (Richardson *et al*. 1995).

Despite these references to the potential effects of dredging on marine mammals there is little consideration of the impact of the actual dumping of dredge material as opposed to removal of material from the site to be dredged. This is either an oversight, or more likely reflects the extremely low impact of the dumping of dredged material on marine mammals, compared to the effects of dredging, which are considered low down the spectrum of impacts of coastal activities on marine mammals. OSPAR (2008) suggested that the dumping of dredge materials are largely irrelevant with

respect to environmental impact and the issue are confined to disturbance due to underwater noise emission during the dumping process and during the transport (ship noise).

5.2.2 Turbidity

A review carried out by Truitt (1988) showed that significantly elevated turbidity levels are generally confined to the lower 15-20% of the water column depth, declining by orders of magnitude toward the surface. Turbidity levels at all depths decline rapidly, approaching background levels within a matter of minutes to tens of minutes, with the bottom levels declining slowest.

Sedimentation and any increases in turbidity are unlikely to affect marine mammals, which use echolocation. Marine mammals often inhabit turbid environments, and many utilise sophisticated sonar systems to sense the environment around them (Au *et al.* 2000). Pinnipeds do not produce sonar for prey detection purposes, however Newby *et al.* (1970) reported apparent blindness in three harbour seals on Gertrude Island, Puget Sound, Washington and found them to appear healthy suggesting their ability to forage was unaffected by blindness. McConnell *et al.* (1999) tracked grey seals in the North Sea and included one blind seal in their study. No significant difference in foraging behaviour was found indicating vision is not essential to pinnipeds' survival or ability to forage.

5.3| Risk Assessment

The total amount to be dredged is estimated at 25,000 m^3 and with a full load of a maximum of 1000 m^3 per operation it is calculated that around 25-30 dumping operations will be carried out. This is a relatively small

compared to larger dredging operations in ports along the south coast, including adjacent Waterford and Cork Harbours. The disposal site has been routinely used for the dumping of dredged material, with approximately eight million tonnes of material dumped at this site between 1997 and 2012 at an average rate of around 550,000 m^3 per annum. The site is is 4.81 kilometers (2.59 nautical miles) offshore of Power Head. There is a large diversity and abundance of marine mammals in the area. The risk of a negative interaction is restricted to the potential impact of the dumping of dredged material in the dump zone and the potential for disturbance associated with the dump vessel.

5.3.1 Acoustic disturbance

Noise associated with dredging

The potential for disturbance to marine mammals is greatest when elevated levels of underwater noise are considered. Marine mammals, especially cetaceans, have well developed acoustic capabilities and are sensitive to sound at much higher frequencies compared to humans (Richardson *et al.* 1995). They are less sensitive to lower frequencies but there is still great uncertainty over the effects of sound pressure levels on marine mammals and thus the assessment of its impact. Sources of noise include that generated during dredging and the vessel transiting to and from the disposal site.

Received levels of dredging noise by marine mammals can exceed ambient levels to considerable distances depending on the type of dredger used (Richardson *et al.* 1995). Noise levels emanating from a backhoe dredger operating around the Shetland Islands, UK, were recorded by Nedwell et al. (2008). Using a scaling of 10 log (R/1 m), the back-calculated source level was 163 dB re 1 mPa at 1 metre (bandwidth ¼ 20 Hz–100 kHz). In contrast, Reine et al. (2012) calculated source levels of 179 dB re 1 mPa at 1 metre (bandwidth ¼ 3 Hz – 20 kHz), but the used scaling was different [15 log (R/1 m)], so results are difficult to compare. McKeown (2016) carried out underwater noise measurements during the 2016 maintenance dredging campaign in Dublin Port. The PSD plots of the dredging operation show some lower frequency tonal components between 200 Hz and 2 kHz were attributed to the pump. The dredging operation has a higher frequency signal in comparison to the dumping operation. Sound levels for the dredging operations at ranges of 213 and 268 m were below the disturbance threshold for harbour porpoise of 140 dB re 1 µPa SPLRMS and 140 dB re 1µPa^2 s SEL. Noise levels were below the NOAA general behavioural threshold for marine mammals of 160 dB re 1 µPa SPLRMS (McKeown 2016).

Audiograms for bottlenose dolphins show peak sensitivity between 50-60 kHz and no sensitivity below 2 kHz and above around 130 Khz (Richardson *et al.* 1995). Because of rapid attenuation of low frequencies in shallow water dredge noise normally is undetectable underwater at ranges beyond 20- 25km (Richardson *et al.* 1995). The effects of low frequency (4-8 kHz) noise level and duration in causing threshold shifts in bottlenose dolphins were predicted by Mooney *et al.* (2009). They found that if the sound exposure levels were kept constant, significant shifts were induced by longer duration exposures but not for shorter exposures.

NPWS (2014) identify increased sound pressure levels above ambient do occur due to TSHD dredging which could be detected up to 10km from shore. These levels are thought to potentially cause masking or behavioural effects but are not thought to cause injury to a marine mammal. There is no guidance on the effects of noise generated by disposal of dredge material on marine mammals.

5.3.2 Noise associated with shipping

Shipping produces low broadband and “tonal” narrowband sounds. The primary sources are propeller cavitation and singing and propulsion of other machinery (Richardson *et al.* 1995). For large and medium vessels, tones dominate up to around 50Hz and broadband components may extend to 100Hz.

Many odontocetes show considerable tolerance to vessel traffic. Sini *et al.* (2005) showed bottlenose dolphins resident in the Moray Firth generally exhibited a positive reaction to medium (16-30m) and large vessels (>30m) and showed some evidence of habituation. Buckstaff (2004) suggested an exposure level of 110-120 dB from vessel noise solicited no observable effect on bottlenose dolphins. A similar exposure level solicited minor changes in orientation behaviour and locomotion changes in minke whales (Palka and Hammond 2001). Harbour porpoise are frequently observed near vessels but tend to change behaviour and move away and this avoidance may occur up to

1-1.5km from a ship but is stronger with 400m (cited from Richardson *et al.* 1995). Seals show considerable tolerance to vessel activity but this does not exclude the possibility that it has an effect.

5.3.3 Disturbance during transit

The presence of a dredger and associated craft in the harbour will lead to a very slight increase in vessel traffic and associated noise. Back-hoe dredgers produce largely low frequency sounds, however, given the use of Ballycotton Harbour by vessels, creating ambient noise already experienced at this site, the presence of an additional vessel and associated noise, is extremely unlikely to be significant. The increased noise above ambient levels generated by the activity will be of relatively short duration (8 weeks).

5.3.4 Disturbance during disposal of dredged material

The disposal site has been used previously for the dumping of dredged material. Increased noise from dredging soft sediment is restricted to <100m from dredging operations during disposal (McKeown 2016), thus increased sound pressure associated with spoil disposal will be above ambient noise levels within a very small area (radius <100m). It might be expected to be slightly higher for sand dredging and disposal.

Marine mammals are tolerant of shipping noise, being repeatedly exposed to many vessels, small and large. Pinnipeds also exhibit much tolerance and often haul out on man-made structures where there is considerable human activity. This exposure may lead to some chronic exposure to man-made noise, with which they tolerate. Ecological or physiological requirements may leave some marine mammals with no choice but to remain in these areas and continue to become chronically exposed to the effects of noise. In areas with repeated exposure, mammals may become habituated with a decline in avoidance responses and thus become less sensitive to noise and disturbance (Richardson *et al.* 1995). Thus, dredging seems to have less effect on marine mammals than moving sound sources although avoidance behaviour of whales exposed to high levels of activity have been documented. Reactions, when measured have only occurred when received sound levels are well above ambient levels.

5.3.5 Physical Disturbance

The risk of injury or mortality is considered extremely low as marine mammals are exposed to considerable vessel traffic on a daily basis and would be aware of their presence. The towing vessel is slow moving and not able to turn quickly thus any animals in the area would have sufficient time to avoid any collisions and thus injury or mortality. The chance of actually releasing dredged material on top of a marine mammal is extremely unlikely. The duration of the release of dredged material is very short (<1 minute) and the vessel slows down during spoil release.

5.3.6 Collision Risk

Collisions are extremely unlikely due to the slow speed of the tug and barge. Dredging is unlikely to cause damage to marine mammal auditory systems, but masking and behavioural changes are possible (Todd *et al.* 2015). Sediment disturbance and any increases in turbidity are unlikely to affect marine mammals that use echolocation, or pinnipeds since research indicates that vision is not essential to pinnipeds' survival or ability to forage (McConnell *et al.* 1999). It is unlikely that vessels will encounter many marine mammals during operations and those in the vicinity will have time to avoid the towing vessel and barge.

5.3.7 Indirect impacts on preferred prey

No adverse effects on fish species are expected from dredging and disposal operations.

5.3.8 Potential disturbance to life-cycle

The dumping of dredged material will not cause any adverse effects on cetaceans or seals in the area providing mitigation measures are in place but may affect prey availability. Small shoaling fish that occur regularly in the diet of seals and small cetaceans and are likely to be affected during operations. Any displacement resulting from indirect impacts on available prey will be short-term and local, with fish returning to the area at the completion of

dumping activity.

Increased turbidity will result from dumping spoil within the disposal site. Increased turbidity is unlikely to have a direct effect of marine mammals but may have an indirect effect through impacts on prey (Todd *et al.* 2015). There is limited evidence for an effect of increased turbidity on marine mammals. Harbour porpoise use echolocation to navigate and locate prey and thus would not be affected by
increased turbidity. Even when increased turbidity has been shown to substantially reduce visual acuity in seals, which are not known to use sonar for prey detection, there is no evidence of reduced foraging efficiency (Todd *et al.* 2015).

5.3.9. Cumulative Effects

The use of the disposal site by Port of Cork could lead to cumulative effects oif dredging at Ballycotton and in Cork Harbour occurred at the same time. The Port of Cork have recently applied for a Disposal at Sea licence to cover the period 2021 to 2029 for maintenance dredging. The proposed maintenance dredging campaigns may occur throughout the year excluding November and February. This is a change to previous dredging campaigns, which was restricted to the autumn period (September – October). Thus it is important that dreging at Ballycotton does not coincide with dredging campaign in Cork Harbour with both using the same disposal site simultaneously.

6 | Identification of Relevant Natura 2000 sites with marine mammals as a qualifying interest

Marine mammals are highly mobile and range far outside those sites designated to protect them. Grey seals are known to travel up to 75 and 100 km day^{-1} (McConnell et al. 1999). There are two SAC with marine mammals as qualifying interests along the south coast, within approximately 100km of the activity.

Table 2. Special Areas of Conservation, which list marine mammals as a Qualifying Interest, with reasonable foraging range of Ballycotton Harbour and the proposed disposal site

Site	Qualifying Interest			Distance to Dredging Sites	
	Grey seal	Harbour seal	Harbour porpoise	nmls	km
Saltee Islands SAC (Site Code 000707)	X	-	-	54	100
Roaringwater Bay and Islands SAC (Site Code 000101)	X	-	X	58	106

The two closest SACs with grey seals as qualifying interests are presented in Table 2. The Saltees Islands SAC off Co Wexford is an important breeding site for grey seals and occurs 100km to the east of the site, while the Roaringwater Bay and Islands SAC is 106km from the site, in the other direction (west). Despite this distance, individual grey seals from these sites could potentially forage at the dredging and dumping sites (Cronin *et al.* 2016). Roaringwater Bay and Islands SAC is also designated for harbour porpoise and individuals using this SAC are part of a wider population that also occur off east Cork.

The Conservation Objectives of these two SACs (NPWS 2011a; 2011b) are to maintain their favourable conservation condition, which is defined by a number of attributes and targets:

Access to suitable habitat

i) Species range within the site should not be restricted by artificial barriers to site use.

Breeding behaviour

ii) The breeding sites should be maintained in a natural condition.

Moulting behaviour

iii) The moult haul-out sites should be maintained in a natural condition.

Resting behaviour

iv) The resting haul-out sites should be maintained in a natural condition.

Population composition

v) The grey seal population occurring within this site should contain adult, juvenile and pup cohorts annually

Disturbance Level of impact

vi) Human activities should occur at levels that do not adversely affect the grey seal population

The only attribute which could potentially be impacted is attribute vi) disturbance. It is extremely unlikely that any disturbance associated with dredging or disposal of spoil would lead to any likely significant effects and thus this conservation objective will not be compromised.

No artificial barriers will be created and disturbance, if it occurs at all will be temporary and very local and have no significant effect on seals or harbour porpoise or the conservation objectives of either SAC.

6. Mitigation Measures

Potential mitigation measures during the dumping operation are limited. Similar activities both nationally and internationally have been monitored through the provision of a Marine Mammal Observer (MMO) who ensures that there are no marine mammals within a pre-agreed distance prior to dredging and disposal during daylight hours. The MMO can also record any reaction to the dumping operation. However, this mitigation measure will only be effective during daylight hours and in favourable weather conditions.

The National Parks and Wildlife Service recommend a distance of 500m radial distance of the dredging sound source in water depths of <200m (NPWS 2014) on commencement. If a significant negative change in behaviour is recorded such as rapid movement away from vessel or distress then the MMO should have the authority to cease operations. If marine mammals enter the buffer zone during dredging. Marine mammals should not be within 50m of the dredger when it is dumping.

6.1 Disturbance

The most effective way of mitigating the potential effects of disturbance is through the provision of an MMO ensuring no marine mammals are present within an agreed buffer zone.

6.2 Collision, injury and mortality

The most effective way of mitigating the potential effects of collision, injury and mortality is through the provision of an MMO ensuring no marine mammals are present within an agreed buffer zone.

6.3 Disruption of normal behaviour

Dredging activity is of short duration and displacement will be short term. Pre, during and post dredge monitoring would allow for an assessment of any disruption and if it is evident then the level can be quantified. Post-dredge monitoring would also provide a means to establish if disruption occurred and how long it takes for animals to return to an area and resume site usage.

While sound exposure levels from such operations are thought to be below that expected to cause injury to a

marine mammal, disturbance, from the noise generated by dredging, from the physical presence of the dredger, and associated vessels, and possibly from the increased water turbidity in the area of operations have the potential to cause, for example, low level disturbance, masking or behavioural impacts (NPWS, 2014). The activities of a long reach excavator will lead to a very localised increase in noise levels and the use of seagoing vessels such as barges to a very slight increase in vessel traffic and associated noise. Small work vessels produce low frequency sounds (Table 2). The presence of an additional small vessel and the associated noise produced, is very unlikely to have a significant impact on marine mammals, though it may discourage seals from using the immediate area of the operations.

Table 2. Estimated noise emissions from small workboat / tug (Wyatt, 2008)

Vessel Type	Displacement Tonne	Length m	Propulsion	Activity	Measurement	Measurement band kHz	Extrapolation dB re 1 µPa m peak to peak	Reference
Tug with Barge[55]	Tug Gross tonnage 104	19.5 (64 ft)	Main engine 1095 hp diesel	Unloaded Speed 7.4 knots	173 dB re 1 µPa @ 1 m Source level	0.01 to 20	182 Broadband 10 to 2500 Hz with broad peak between60 and 600Hz	(Zykov and Hannay 2006)

7 | NPWS Assessment Criteria

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

There are a variety of marine mammal species recorded in the area, especially bottlenose and common dolphin, harbour porpoise and minke, fin and humpback whales. All are part of a larger population and very mobile.

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

The project will not cause injury or death but could lead to local disturbance, from noise associated with the project.

Noise Impact

The activities proposed during this project consist of dredging and disposal operations. It is extremely unlikely any noise generated will be capable of causing permanent or temporary hearing injury to a marine mammal. Localised disturbance to marine mammals in the works area may occur during operations, but is limited by:

- The location of the dredging site, within and adjacent to Ballycotton harbour. Any marine mammals in the harbour will be accommodated to human activities. Noise transmission to the wider bay is very unlikely.
- The very shallow nature of the dredging site.
- The regular transit of fishing and recreational vessels.
- The relatively short duration of the planned activity of 8 weeks
- If dredging takes place during summer months the species most likely exposed to disturbance include bottlenose dolphin, harbour porpoise and minke whale while dredging and disposal during winter will expose common dolphin and fin and humpback whales. Then breeding and pupping seasons for grey seals lies between August to November.

Physical Impact

The risk of injury or mortality is considered low as marine mammals in the in the immediate vicinity of the site are exposed to human activity on a daily basis and would be accommodated. The dump vessel is slow moving and thus 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?

No abundance estimates for cetaceans are available but it's likely that the numbers in the area for each species are <50. Great Saltee Island may have up to 300 seals hauled out during the grey seal pupping season and moult

period and up to 150 grey seals in the Roaringwater Bay and Islands SAC.

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

The proposed works are recommended to be carried out between March and August. This avoids the grey seal pupping and breeding season and the peak period for common dolphin and fin and humpback whales.

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

There are no data to suggest that any particular seal or cetacean gender or age group predominates in the around Ballycotton Harbour and adjacent disposal site. Both adult and juvenile grey seals have been recorded on the Saltee Islands and in Roaringwater Bay as it is a pupping and breeding site. All ages of harbour porpoise have been recorded in the Roaringwater Bay and Islands SAC (O'Brien and Berrow 2020).

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

While bottlenose and common dolphins, harbour porpoise and grey seals frequently and regularly occur in the area in small numbers, there may be temporary disturbance to these but they are accommodated to human activities and are likely to not be affected. Large baleen whales occur during winter and roam over a much wider area during this period.

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

While there may be temporary disturbance all marine mammals in the area are accommodated to human activities and are likely to recover from any temporary disturbance within hours or days.

8 | Mitigation

Timing of Dredging and Disposal at Sea

Both grey seals and bottlenose dolphins, and to a lesser extent harbour porpoise, can potentially be affected by the proposed operations and are listed on Annex II of the EU Habitats Directive. Harbour porpoise are considered as being particularly sensitive species to noise from demolition and dumping operations. Baleen whales are more sensitive to the low frequency noise generated by an additional vessel and dredging in the area.

If dredging takes place during summer months, the species most likely exposed to any temporary disturbance include bottlenose dolphin, harbour porpoise and minke whale while dredging and disposal during winter will potentially expose common dolphin and fin and humpback whales. The breeding and pupping seasons for grey seals lies between August to November. Given the proximity of the SAC for grey seals and the presence of fin and humpback whales, both species considered Endangered under the IUCN Conservation status criteria, dredging and dumping outside of the seal breeding season and winter period for baleen whales and takes place between March and August would result in less exposure of marine mammals to potential dredging and dumping impacts. To accommodate dredging at all times of year we recommend adoption of the NPWS Guidelines for minimising impacts of man –made sounds in Irish waters.

Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters

The mitigation measures recommended by the NPWS are for the presence of a trained and experienced Marine Observer (MMO) and the use of "ramp up" procedures for noise and vibration emitting operations. The proposed mitigation measures (Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters) recommended by the Department of Arts, Heritage and the Gaeltacht in 2014 are designed to mitigate any possible effects.

The following mitigation measures are proposed to minimise the potential impacts on marine mammals and to allow animals move away from the area of dredging operations:

7. All personnel will be appropriately trained about environmental issues prior to the start of the operation.
8. All equipment will be in good condition to avoid spillage or discharge of oil, smoke and excessive noise.
9. Refuelling will be carried out by competent and trained people away from any environmentally sensitive areas; and dredger to be moored up securely.
10. An appropriate waste container will be placed to collect waste before the final disposal by authorised company and hazardous material storage areas will be identified, labelled, and properly marked and fitted with spill containment systems;
11. Excavators and barges will be checked for any fuel / oil leaks on a regular basis by the crew.
12. Any spills we be reported immediately to the site agent/authorities
13. In the event of a major spill due to damage to the dredger. Locate and isolate, inform harbour authorities, Project manager and environmental agency.
14. A dedicated Marine Mammal Observer will conduct a 30 minute watch for marine mammals within 500m of the excavator prior to start up. If a seal or cetacean (or otter) is sighted within 100m of the excavator, start-up must be delayed until the animals is observed to move outside the mitigation zone or the 15 minutes has passed without the animal being sighted within the mitigation zone.
15. A dedicated Marine Mammal Observer will conduct a watch for marine mammals prior to disposal at sea. If a seal or cetacean (or otter) is sighted within 50m of the vessel once it has reached the dump site, disposal must be delayed until the animal(s) are observed to move outside this mitigation zone or the 15 minutes has passed without the animal(s) being sighted within the mitigation zone.
16. The excavator will be started at lowest revs of the pump, with pump revs increased over a 15 minute period to allow wildlife an opportunity to move further away from the vessel prior to the pumps reaching full power.

9 | Residual Impacts

With implementation of the above mitigation measures, it is very unlikely that there will be negative residual impacts from the proposed dredging works on marine mammals in the area. It is also very unlikely that any animals will be injured or killed as a result of the proposed works. Seals using the area are likely to be tolerant of vessel noise and any animals which might be displaced from the vicinity of the excavator or barge can be expected to quickly re-establish use of the area following cessation of the works.

10 | SUMMARY

The waters around Ballycotton Harbour are important for marine mammals including the regular occurrence of bottlenose and common dolphins, harbour porpoise and minke, fin and humpback whales as well as being within foraging range of SACs for breeding grey seals. Dredging between March and August would result in less exposure to more sensitive species.

We recommend the NPWS Guidelines to minimise the acoustic impacts of dredging be implemented to enable a dredging campaign to be carried out at any time of year, which will result in no significant impacts to marine mammals.

Au, W.W.L., Popper, A.N., and Fay, R.R. (2000) Hearing by whales and dolphins. Springer Handbook of Auditory Research. Springer-Verlag, New York

Anderwald, P., Brandecker, A., Coleman, M., Collins, C., Denniston, H., Haberlin, M. D., Donovan, M., Pinfield, R., Visser, F. and Walshe, L. (2013) Displacement responses of a mysticete, an odontocete, and a phocid seal to construction related vessel traffic. Endangered Species Research, 21: 231–240.

Berrow, S.D., Whooley, P., O'Connell, M. and Wall, D. (2010) Irish Cetacean Review (2000-2009). Irish Whale and Dolphin Group, Kilrush, Co. Clare. 60pp.

Buckstaff, K. C. (2004). Effects of watercraft noise on the acoustic behaviour of bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida. *Marine Mammal Science*, *20*, 709-725.

Cronin, M., Duck, C., Ó Cadhla, O., Nairn, R., Strong, D. and O' Keeffe, C. (2004) Harbour seal population assessment in the Republic of Ireland: August 2003. Irish Wildlife Manuals, No. 11. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland.

Cronin, M, Gerritsen H., Reid D., Jessopp, M. (2016) Spatial Overlap of Grey Seals and Fisheries in Irish Waters, Some New Insights Using Telemetry Technology and VMS. PLoS ONE 11(9): e0160564. doi:10.1371/journal.pone.0160564

Duck, C. and Morris, C. (2013) An aerial survey of harbour seals in Ireland: Part 2: Galway Bay to Carlingford Lough. August-September 2012. Unpublished report to the National Parks & Wildlife Service, Department of Arts, Heritage & the Gaeltacht, Dublin.

Diederichs, A., Brandt, M. Nehls, G. (2010) Does sand extraction near Sylt affect harbour porpoises? Wadden Sea Ecosystem, 199-203. EC. 2010. Commission Decision of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters. Brussels: European Commission.

Louis, M., Viricel, A., Lucas, T., Peltier, H., Alfonsi, E., Berrow, S., Brownlow, A., Covelo, P., Dabin, W., Deaville, R., de Stephanis, R., Gally, F., Gauffier, P., Penrose, R., Silva, M.A., Guinet, C. and Benoit S-B. (2014) Habitat-driven population structure of bottlenose dolphins, *Tursiops truncatus*, in the North-East Atlantic. Molecular Ecology 23, 857-874.

McConnell, B.J., Fedak, M.A., Lovell, P. and Hammond, P.S. (1999) Movements and foraging areas of grey seals in the North Sea. *Journal of Applied Ecology* 36, 573-590

McKeown, M. (2016) *Underwater Acoustic Emissions, Dublin Port Report on July 2016 Dredging and Dumping Operations*. Alexandra Basin Dublin Port. Technical Report for RPS, September 2016. 18 pp.

Mirimin, L., Miller, R., Dillane, E., Berrow, S. D., Ingram, S., Cross, T. F., and Rogan, E. (2011) Fine-scale population genetic structuring of bottlenose dolphins in Irish coastal waters. Animal Conservation, 14(4), 342-353.

Mooney, T.A., Nachtigall, P.E., Breese, M., Vlachos, S. and Au, W.W.L. (2009) Predicting temporary threshold shifts in a bottlenose dolphin (*Tursiops truncatus*): The effects of noise level and duration. *Acoustical Society of America* 125 (3), 1816-1826.

Morris, C.D. and Duck, C.D. (2019) A*erial thermal-imaging survey of seals in Ireland, 2017 to 2018.* Irish Wildlife Manuals, No. 111 National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht, Ireland

Nedwell, J. R., Parvin, S. J., Brooker, A. G., and Lambert, D. R. 2008. Modelling and measurement of underwater noise associated with the proposed Port of Southampton capital dredge and redevelopment of berths 201/202 and assessment of the disturbance to salmon. Subacoustech Report, 805R0444

Newby T. C., Hart F. M., Arnold R. A. (1970) Weight and blindness of harbor seals*. Journal of Mammalogy, 1970, vol. 51 pg. 152.*

Nowacek, D.P., Thorne, L.H., Johnston, D.W. and Tyack, P.L. (2007) Responses of cetaceans to anthropogenic noise.

Mammal Review 37(2), 81-115.

NPWS (2007) Code of Practice for the Protection of Marine Mammals during Acoustic Seafloor Surveys in Irish Waters. National Parks and Wildlife Service, 7 Ely Place, Dublin 2.

NPWS (2011a) Conservation Objectives Series: Saltee Islands SAC: SAC 000707. National Parks and Wildlife Service, 7 Ely Place, Dublin 2.

NPWS (2011b) Conservation Objectives: Roaringwater Bay and Islands SAC 000101. National Parks and Wildlife Service, 7 Ely Place, Dublin 2.

NPWS (2014) Guidance to manage the risk to marine mammals from man-made sound sources in Irish waters – January 2014. National parks and Wildlife Service, 7 Ely Place, Dublin 2.

O'Brien, J.M., Berrow, S.D., Ryan, C, McGrath, D., O'Connor, I., Pesante, P., Burrows, G., Massett, N., Klötzer, V. and Whooley, P. (2009) A note on long-distance matches of bottlenose dolphins (*Tursiops truncatus*) around the Irish coast using photo-identification. Journal of Cetacean Research and Management 11(1), 71-76.

O'Brien, J. and Berrow, S.D. (2020). Harbour porpoise surveys in Roaringwater Bay and Islands SAC, 2020. *Irish Wildlife Manuals*, No. XXX. National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht, Ireland.

Ó Cadhla, O., Strong, D., O'Keeffe, C., Coleman, M., Cronin, M., Duck, C., Murray, T., Dower, P., Nairn, R., Murphy, P., Smiddy, P., Saich, C., Lyons, D. and Hiby, A.R. (2007). An assessment of the breeding population of grey seals in the Republic of Ireland, 2005. Irish Wildlife Manuals No. 34. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Dublin, Ireland.

O'Cadhla, O. and Strong, D. (2007) Grey seal moult population survey in the Republic of Ireland, 2007. CMRC.

O'Dwyer, P. (2017) Marine Mammal Observers Report for Dredging and Dumping Activity, September to October 2017. Port of Cork. Dumping at Sea Permit: S0013-02. IWDG Consulting. 82pp.

OSPAR (2008) *Draft Assessment of the Environmental Impact of Underwater No*ise. Biodiversity Series. OSPAR.

Palka, D., and Hammond, P. S. (2001). Accounting for responsive movement in line transect estimates of abundance. *Canadian Journal of Fisheries and Aquatic Sciences*, *58*, 777-787.

Pirotta, E., Laesser, B.E., Hardaker, A., Riddoch, N., Marcoux, M. and Lusseau, D. (2013) Dredging displaces bottlenose dolphins from an urbanised foraging patch. Marine Pollution Bulletin 74, 396-402.

Reine, K., Clarke, D., and Dickerson, C. 2012a. Characterisation of Underwater Sounds Produced by a Backhoe Dredge Excavating Rock and Gravel. ERDC-TN-DOER-XXX. Department of Energy Resources, Washington DC, 29 pp.

Richardson, W.J., Greene, C.R., Malme, C.I. and Thomson, D.H. (1995) *Marine Mammals and Noise*. Academic Press.

Ritter, F. (2012) Collisions of sailing vessels with cetaceans worldwide: First insights into a seemingly growing problem. *Journal of Cetacean Research and Management* 12(1), 119-127.

Ryan, C. and Wilson, P. (2003) Observations on the behaviour of a pod of killer whales *Orcinus orca* L. that visited Cork Harbour in 2001. Irish Naturalists' Journal 27(5), 187-191.

Ryan, C., Whooley, P., Berrow, S.D., Barnes, C., Massett, N., Strietman, W. J., Broms, F., Stevick, P.T., Fernald Jr, T.W. and Schmidt, C. (2015) A longitudinal study of humpback whales in Irish waters. Journal of the Marine Biological Society (UK), doi:10.1017/S0025315414002033.

Ryan, C., Rogan, E., and Cross, T. (2010). The use of Cork Harbour by bottlenose dolphins (*Tursiops truncatus* (Montagu, 1821)). Irish Naturalists' Journal, 31(1), 1-9.

Sini, M.I., Canning, S.J., Stockin, K.A. and Pierce, G.J. (2005) Bottlenose dolphins around Aberdeen harbour, north- east Scotland: a short study of habitat utilization and the potential effects of boat traffic. *Journal of the Marine Biological Association (UK),* 85, 1547-1554.

Sutton, G., Jessopp, M., Folegot, T. and Clorenec, D. (2014) *Mapping the spatio-temporal distribution of underwater noise in Irish waters*. EPA STRIVE Programme 2007-2013 Report No. 121.

Todd, V.L.G., Todd, I.B., Gardiner, J.C., Morrin, E.C.N., MacPherson, N.A., DiMarzio, N.A., and Thomsen, F. (2015) A review of impacts of marine dredging activities on marine mammals. ICES Journal of Marine Science 72(2), 328- 340.

Thomsen, F., Lüdemann, K., Kafemann, R., Piper, W. (2006) Effects of offshore windfarm noise on marine mammals and fish, biota, Hamburg, Germany on behalf of COWRIE Ltd., Newbury, UK.

Tougaard, J., Wright, A.J. and Madsen, P.T. (2015) Cetacean noise criteria revisited in the light of proposed exposure limits for harbor porpoises. Marine Pollution Bulletin 90, 196-208.

Whooley, P., Berrow, S., and Barnes, C. (2011) Photo-identification of fin whales (*Balaenoptera physalus* L.) off the south coast of Ireland. *Marine Biodiversity Records*, 4, e8.

Wisniewska, D.M., Johnson, M., Teilmann, J., Rojana-Donata, L., Shearer, J., Sveegaard, S., Miller, L.A., Siebert, U. and Madsen, P.T. (2016) Ultra-High foraging rates of harbor porpoises make them vulnerable to anthropogenic disturbance. Current Biology Reports. 26, 1441-1446.

Wyatt, R., (2008) Review of existing data on underwater sounds produced by the OandG industry. Issue 1. Report to the Joint Industry Programme on Sound and Marine Life.

Appendix II Breeding bird Survey