AECOM

Shannon Technology and Energy Park (STEP) Power Plant

Appendix A7A.2: IWDG Monitoring Reports

Shannon LNG Limited

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Bottlenose Dolphin Monitoring at the site of the proposed Shannon Technology and Energy Park (STEP)

Bottlenose dolphin in the Shannon Estuary © Simon Berrow/IWDG

IWDG Consulting

Final Report to New Fortress Energy

(Ref: SHLL-IE-20180000045)

Bottlenose Dolphin Monitoring at the site of the proposed Shannon Technology and Energy Park (STEP)

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Executive Summary

The Irish Whale and Dolphin Group (IWDG) were contracted by New Fortress Energy to monitor the use of the site of the proposed Shannon Technology and Energy Park (STEP) at Ardmore Point, Co Kerry on the south side of the Shannon Estuary by bottlenose dolphins. The proposed marine facilities at STEP operate wholly within the Lower River Shannon Special Area of Conservation with bottlenose dolphins as one of the qualifying interests. Thus a high level assessment of the potential impacts of this proposed development on the dolphins and their habitats is essential.

A combination of land-based Vantage Point (VP) watches, static acoustic monitoring (SAM) and dedicated boat-based surveys using photo-identification was used to describe the use of the site by bottlenose dolphins and any other marine mammals (seals) present, including their distribution and relative abundance. Dedicated watches were carried out each week between April 2020 and April 2021 from Ardmore Point. Watches were carried out in good sea-states, defined as ≤3 and over a six hour tidal cycle. One CPOD was deployed at two sites for a period of 2 years at the proposed development area to collect SAM data and 10 dedicated boat-based surveys were carried out between May and September 2021.

A total of 50 VP watches were carried out from Ardmore Point. Dolphins were observed from Ardmore Point during 30 (60%) of watches, with a total of 42 sightings, ranging from 1-3 different groups recorded per watch. Mean group size (±SD) of all groups recorded was 5.5±4.0 dolphins. Most sightings of bottlenose dolphins from Ardmore Point were of groups off Moneypoint (41%) and mid-channel (26%) with two observations off Tarbert, west towards Scattery Island and mid-channel. Twelve sightings were within 500m of Ardmore Point, one of these one was within 100m and two within 50m of the shore. Seven of these sightings within 500m of Ardmore Point were of dolphins travelling and they did not stop at the site. Probable foraging activity was observed on four occasions. Dolphins rarely exhibited social behaviour while travelling past Ardmore Point. On 13 occasions individual grey seals were recorded, with most within 500m of the watch site and on three occasions they were observed within 300m of the shore and once within 50m. On one occasion in October 2020, a single harbour porpoise was observed during VP watches. During January 2021 a group of small dolphins were observed off the north side of the estuary, heading east up river. They were most likely common dolphins but species identification could not be confirmed. VP watches were modelled using GLMs to explore in finer detail the use of the site by bottlenose dolphins. A total of 596 scans were analysed with a total of 88 sightings of bottlenose dolphins was made resulting in 14.8% scans with sightings. This showed a significant difference between the presence/absence of dolphins on flooding tides, but no significant difference during low and high tides, while ebbing tides showed a significant difference when compared to flooding tides. Autumn was shown to have a higher proportion of positive scans compared to the other seasons, with the lowest proportion in spring.

During dedicated RIB surveys during 2021, a total of 26 individual dolphins were identified through photo-identification. Of the 22 individuals photographed opportunistically during 2020, 17 (77%) were also reported in 2021. Five dolphins recorded during 2020 were not recorded during 2021. Of the 26 individuals photographed during 2021, nine individuals were recorded on >50% of surveys with dolphins encountered and seven on >70% of surveys with dolphins. This shows great site fidelity and consistency. Of these 26 individuals, 92% (24 individuals) were matched to the Shannon Dolphin Project photo-identification catalogue. Of these 96% were from the subgroup of ~35 animals in the population who are most frequently sighted in

the inner estuary which accounts for 69% of the individuals reported in this subgroup. Only one animal was observed during these surveys from the subgroup which are most frequently seen in the outer estuary.

A total of six SAM deployments took place over the duration of the two year monitoring period. Two locations were monitored, and referred to as LNG1 and LNG2. A total of 694 days of monitoring data collected from LNG1 and 492 days from LNG2. The proportion of days with dolphin detections were very consistent throughout the monitoring period ranging from 37-69% of days at LNG1 and 47-62% of days at LNG1. Mean DPM per day which is a more robust measure of occurrence was also consistent ranging from 3.0-6.3 at LNG1 and 2.1-4.6 at LNG2. Between August 2019 and May 2020 dolphins were recorded on 62% of days at both locations with the number of cumulative dolphin positive minutes similar across the two sites. Durations per day ranging from 0-44 minutes with a peak during October 2019. During year 2, dolphins were recorded on 42 and 55% of days at each location. Durations per day ranged from 0-74 minutes with a peak during August 2020. There was a significant effect of season at LNG1 and LNG2 with less detections during winter and more during autumn compared to other seasons and more detections in the morning, night and evening. Tidal cycle was significant only at LNG1 with a higher detection rate and on high and flood tides. There is no evidence that 2020 or 2021 was an atypical year.

SAM data were consistent with a similar study carried out between 2006 and 2007. Over the 694 day deployment period analysed in this report dolphins were recorded on between 42% and 62% each year. This compares to 65% of days at LNG1 and 35% of days at LNG2 during the study between 2006 and 2007 (238 and 103 days sampled at each site). Mean DPM per day at LNG1 and LNG2 in the present study was 4.4 and 3.6 (Year 1) and 3.1 and 3.7 (Year 2) compared to 4.7 and 4.1 in 2006-2007. Despite the differences in sensitivities and detection ranges between T-PODs used in 2006-2007 and the CPODs currently used in the Shannon estuary, the results are quite consistent. Indeed these data were similar to that obtained at the same site during 2006 to 2007 and we are confident that these data represent the use of the site by dolphins.

Visual observations showed that dolphins did regularly pass through the site but rarely stopped for any prolonged period. SAM data supported this with most detections of short duration. They were only occasionally observed foraging and socialising off Ardmore Point. It is clear from the data presented that dolphins regularly use the proposed site of the LNG terminal. The site is likely used as a transition corridor where dolphins regularly move between the inner and outer estuary. There is no evidence that the proposed development site is a critical habitat for bottlenose dolphins but is an important part of the range of the "inner" estuary sub-group. This information needs to be taken into account when making risk assessments and to ensure there are no significant impacts on the dolphins or their habitats.

1.0 Introduction

The Irish Whale and Dolphin Group (IWDG) were contracted by New Fortress Energy to monitor the use of the site of the proposed LNG terminal at Ardmore Point, Co Kerry on the south side of the Shannon Estuary by bottlenose dolphins. The proposed Shannon LNG terminal and marine facility operates wholly within the Lower River Shannon Special Area of Conservation (Site Code 002165) with bottlenose dolphins as one of the qualifying interests. Thus a high level assessment of the potential impacts of this proposed development on the dolphins and their habitats is essential. This marine mammal report will be used by Aquafact International Services to inform the EIA and AA of the proposed development.

The study of bottlenose dolphins involved:

i. Weekly visual land-based monitoring in favourable weather conditions
ii. Static Acoustic Monitoring to assess the current use of the site by bottlenose dolphins
iii. Dedicated boat-based surveys to identify which individual dolphins would be exposed to risk

1.1 Bottlenose dolphins in the Shannon Estuary

The Shannon Estuary is one of the most important habitats for bottlenose dolphins in Ireland. Research on this population has been carried out since 1993 (Berrow et al. 1996) and has shown that the dolphins are resident, i.e. they are present in the estuary throughout the year, genetically discrete compared to bottlenose dolphins found elsewhere in Irish waters (Mirimin et al. 2011) and the estuary is an important calving area (Ingram 2000; Baker et al. 2018). Bottlenose dolphins are the only cetacean species to be regularly recorded within the estuary, upriver from Kilbaha, Co. Clare, with the highest concentrations found off Kilcredaun Head in the outer Estuary, and off Moneypoint and Tarbert power stations in the middle of the estuary (Ingram and Rogan 2002). Berrow (2009) suggested that dolphins also occur frequently upriver, during both summer and winter. Occasional sightings of minke whale and harbour porpoise occur in the outer estuary and on one occasion (June 2018) a group of two harbour porpoise were photographed east of Scattery Island, but this is exceptional.

The Shannon Estuary is a busy waterway with bulk carriers, fishing vessels and recreational craft utilising its sheltered waters. Due to its depth the estuary provides ideal shipping access to the largest vessels entering Irish waters (180,000-200,000 deadweight tonnage) while servicing six main terminals and handling up to 1,000 ships per annum carrying 10-12 million tons of cargo especially towards the ports at Foynes and Limerick (Anon, 2019). The Shannon Estuary is also a major centre of industry with an alumina smelting plant at Aughinish and two power stations located at Money Point and Tarbert in the mid-estuary. The River Shannon catchment includes large areas of farmland and several tributary rivers providing potential sources of eutrophication and contamination (Berrow et al. 2002).

Bottlenose dolphins (*Tursiops truncatus*) are resident in the Shannon Estuary, with the same individuals recorded throughout the year. The population is genetically discrete (Mirimin et al. 2011) and restricted to the Shannon Estuary and adjacent Tralee and Brandon Bays (Levesque et al. 2016). The abundance of dolphins in the estuary is known from a number of estimates carried out since 2007 using mark-recapture modelling of photo-id data. Estimates ranged from 140±12 in 2006 to 107± 12, CV = 0.12 in 2010 but are consistent (Ingram 2000; Ingram and Rogan 2003; Englund et al. 2007; 2008; Berrow et al. 2012; Rogan et al. 2015: 2018). A discovery curve using data collected by IWDG between 2011 and 2015 suggested all animals in the population were captured during this period, providing an abundance of 145 extant individuals (Blásquez et al. 2020).

1.2 Use of Site of the Proposed LNG terminal by Bottlenose Dolphins: 2006-2007

Static Acoustic Monitoring (SAM) of bottlenose dolphins using T-PODs was carried out at the proposed LNG site between June 2006 and June 2007 as part of an earlier environmental assessment of the proposed Shannon LNG terminal (Berrow 2007). A total of 341 days of SAM data were gathered in total from the two sites (LNG1 = 239 days and LNG2 = 102 days), which resulted in 120 acoustic encounters with dolphins and a total of 530 Detection Positive Minutes recorded. These encounters were short, with a modal duration of 1 minute and a mean of around 4 minutes at each site. Encounter rate declined from 2.8 encounters per day in June to around 0.20 encounters per day in December-March. There was evidence of an increase in detection rate in June 2007. Both the frequency and duration of detections decreased from September through the autumn and winter.

Most encounters (84%) were detected at LNG1 with only 19 encounters (16%) at LNG2. Of the 120 encounters, 64 (53%) were logged during darkness, which was consistent at both sites. Of the 19 encounters from LNG2, on 12 (63%) occasions dolphins were detected at LNG1 on the same day but on only two occasions (11%) within 10 minutes of dolphins being logged at LNG1. On four occasions there were dolphins detected at LNG2 but not on LNG1 on the same day.

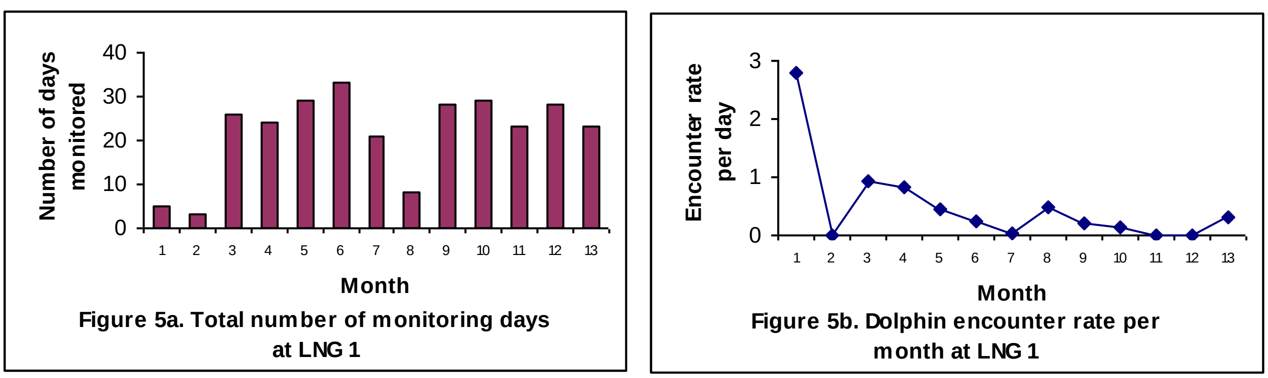


Figure 1. Monthly encounters of bottlenose detections from SAM data collected at LNG1 from June 2006-June 2007 (from Berrow 2007)

Monitoring data at LNG2 (n=102 days) was only collected from September to November 2006 and February to June 2007 (Fig 6a) with no data during the winter months of December and January. The peak in September 2006 was due to six encounters being recorded during three consecutive days. Despite good monitoring data from February and March 2007 (Fig 6b) there were no acoustic detections during this period.

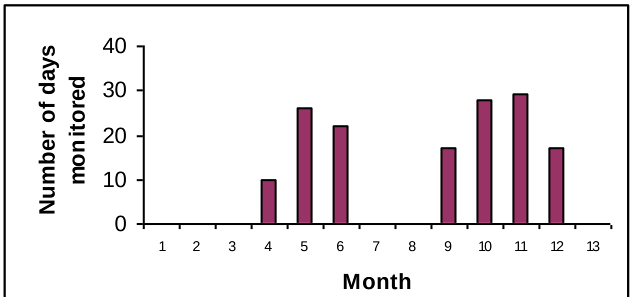


Figure 7a. Total number of monitoring days at LNG 2

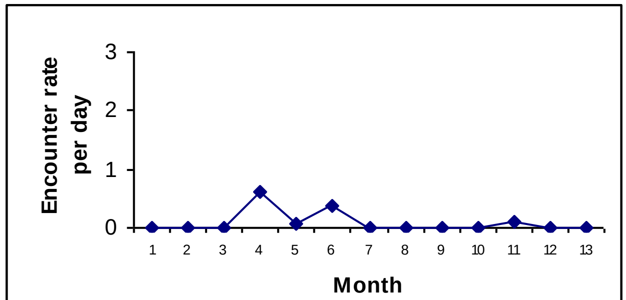


Figure 7b. Dolphin encounter rate per month at LNG 2

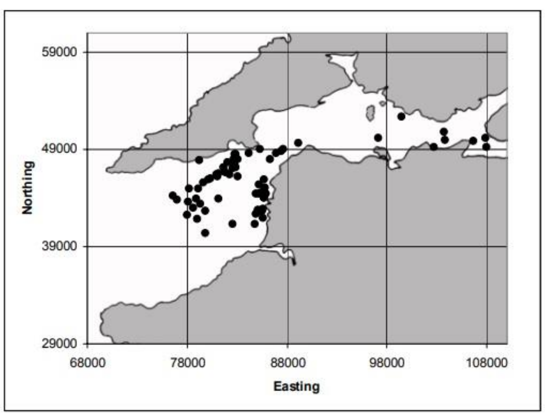
Figure 2. Monthly encounters of bottlenose detections from SAM data collected at LNG2 from June 2006-June 2007 (from Berrow 2007)

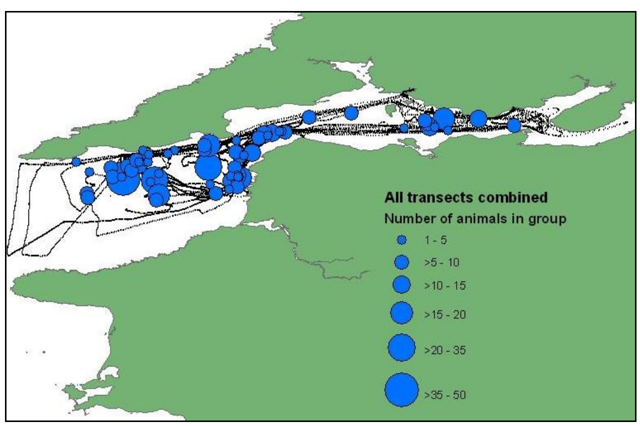
Mean (±SD) Detection Positive Minutes/day of monitoring was calculated at 1.6±2.4 at LNG1 (n= 239 days) and 0.5±0.8 at LNG2 (n= 102 days). The mooring at LNG2 is in shallow water (maximum 8m at mean high water) in the mouth of a shallow bay. Thus the detection range of the hydrophone at this location may be restricted and there may also be tidal restrictions on when dolphins can fully enter the bay lead to a decrease in the number of detections.

1.2.1 Use of site from boat-based visual data

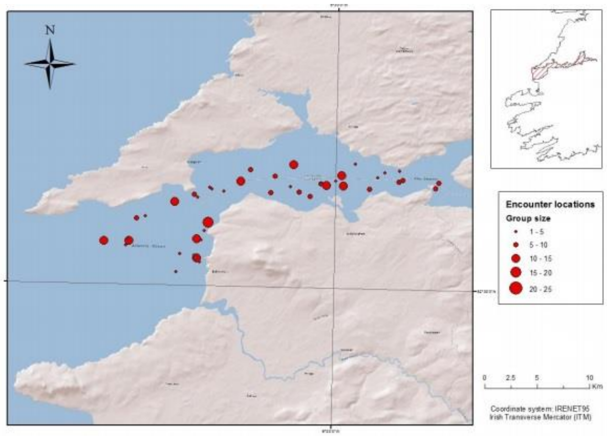
Dedicated surveys

Surveys of bottlenose dolphins have been carried during a number of studies. NPWS funded surveys to derive abundance estimates were carried out between July and September 2003 (Ingram and Rogan 2003) with three sightings adjacent to the proposed LNG terminal site (Fig. 3a). Berrow et al. (2010) carried out 12 transects between July and October 2010 and recorded only one sighting off the proposed LNG terminal site (Fig. 3b). Surveys carried out between June and October 2015 and 2018 reported three sightings adjacent to the proposed LNG terminal site. Most sightings in the middle-estuary were off Tarbert, upriver of the site (Figs. 3c and 3d).

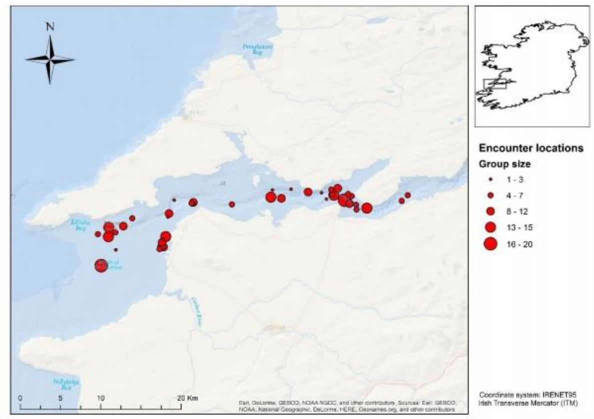




a. Ingram and Rogan (2003) b. Berrow et al. (2010)



c. Rogan et al. (2015)



d. Rogan et al. (2018)

Figure 3a-d. Sightings of bottlenose dolphins during dedicated boat-based surveys from 2003-2018.

The only study to present sightings data across both summer and winter was carried out by Englund et al. (2007). A total of nine surveys were carried out from June to September 2006 with 304 sightings, while there were only 64 sightings during 20 surveys carried out between October 2006 and April 2007.They showed that dolphin distribution was similar though with fewer sightings during winter, with sightings in the estuary adjacent to the proposed LNG terminal (Fig. 4). Berrow (2009) reported a group of 1-15 individuals socialising off Ardmore point in December 2003 during winter surveys (Fig. 4b).

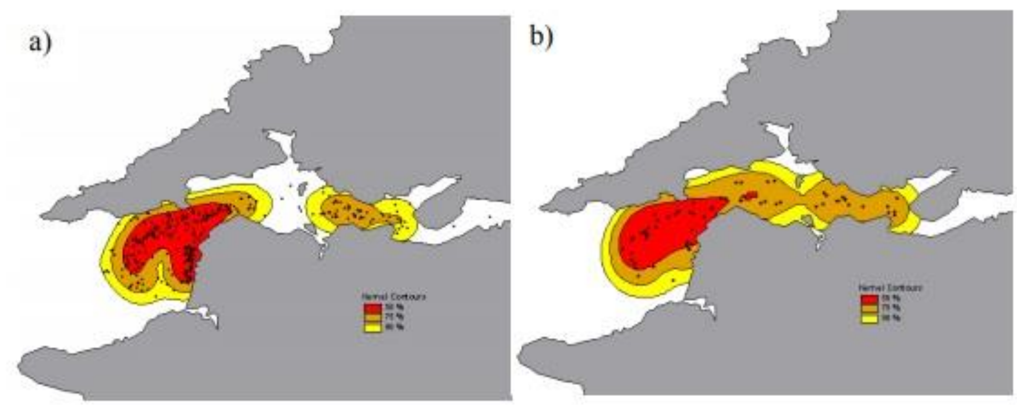


Figure 4a-b. Dolphin distribution (a) summer months (May to September) and b) winter months (October to April) from Englund et al. (2007)

1.2.2 Bottlenose dolphin sightings from dolphin tour-boats

Commercial dolphin-watching has been carried out in the middle and outer estuary since 1995 (Berrow and Holmes 1999). These dolphin-watching vessels are required to complete trip records as part of their permission to operate within the SAC. There is some bias associated with this dataset as tour-boat operators tend to look in known areas for the dolphins and often get sightings reported before leaving port. However, these records provide an oversight on where dolphins are located and also provide a platform for photo-identification by IWDG researchers. Data from 2000-2010 (excluding 2003 and 2004) were mapped into 2x2km grid cells to identify hot-spots of dolphin activity (Christophe and O'Connor, unpubl. data). These are areas with more sightings than expected from sightings effort. They also identify "cold-spots" with fewer sightings than might have been expected given tour-boat effort. This shows that the water adjacent to the proposed land-site of the LNG terminal and site of the proposed jetty is used by bottlenose dolphins but is not considered a "hot-spot" (Fig. 5). The terminal site is however only 2.8km across the estuary from a well-known hotspot off Moneypoint Power Station.

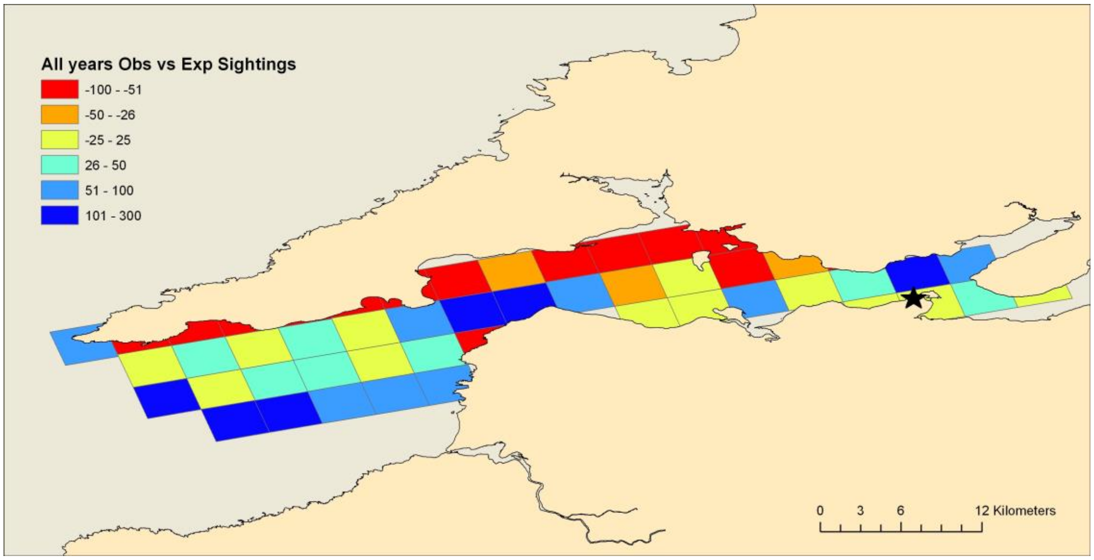


Figure 5. Observed v Expected distribution of bottlenose dolphins from tour boat data collected between 2000-2010 (excluding 2003 and 2004). Black star indicates site of the proposed LNG terminal.

2.0 Methodology

A combination of land-based Vantage Point (VP) watches and static acoustic monitoring (SAM) was used to describe the marine mammal community, its distribution and relative abundance at the site. The survey site is shown in Figure 6.

Figure 6. Vantage Point watch sites

Figure 7. View from vantage point watch site at Ardmore Point

2.1. Land-based Vantage Point Watches

Dedicated watches were carried out each week between April 2020 and September 2021 from Ardmore Point on the Kerry side of the estuary (Fig. 6), which is around 20m above sea-level. Watches were carried out in good sea-states which, for bottlenose dolphins, is defined as ≤2 and where possible over a 6 hour tidal cycle. Optics used included 8x40 and 10x50 binoculars and a Kowa TSH telescope with x20W eyepiece. This provided the ability to detect dolphins from up to about 4km from the VP in good sea-state. If no suitable weather windows occur within a week then the watch was slipped to the following week.

Full scans across the estuary, west to Scattery and Carrig Islands and east to Kilkerrin Point, were carried out each 30 minutes with both binoculars and telescope (each scan was from left to right and the next right to left) while between scans the water was watched with naked eye and any disturbances of the water checked through binoculars or telescope. Their behaviour was described according to Baker et al. (2017a).

To investigate whether dolphin presence and group size was influenced by tidal cycle and season, Generalised Linear Models (GLM) were used with a binomial distribution and logit link, due to the data being a non-normal distribution. The libraries *tidyverse*, *ggfortify* and *arm* were used to carry out the model and the construction of the plots. In these analysis, the model uses a treatment of contrasts due to the tidal cycle and season variables being categorical variables, therefore each estimate is compared to the value labelled 'Intercept', and the value labelled Intercept is an estimate for one of the levels of the treatment factor (i.e. the explanatory variable: tidal cycle, season). All four model possibilities were created (four tidal cycles and four seasons) and the final GLM used for the analysis of the presence/absence of bottlenose dolphins or group size.). The influence of these two variables was assessed for the presence of bottlenose dolphins and group size, using RStudio, version 4.1.1 (2021-08-10).

All scans were recorded with associated date, latitude, longitude, scan duration, presence/absence, group size as well as other environmental variables such as wind direction and strength, and sea state.

2.1.1 Statistical Modelling

Tidal cycle was classified into slack low (L), flooding (F), slack high (H) and ebbing (E) tides. This was achieved by allocating the hour before and after slack high as H. The hour before and after slack low were categorised as L. All hours between L and H were classified as F. All hours between H and L were classified as E. The variable "season" was also created and classified as Spring (from 20 March 2020 and 2021), Summer (from 20 June 2020), Autumn (from 22 September 2020) and Winter (from 21 December 2020).

To investigate whether dolphin presence was influenced by season. the model uses a treatment of contrasts due to the season variable being a categorical variable, therefore each estimate is compared to the value labelled 'Intercept', and the value labelled Intercept is an estimate for one of the levels of the treatment factor (i.e. the explanatory variable: season). All four model possibilities were created (four seasons).

In this analysis, the model used a treatment of contrasts due to the tidal cycle variable being a categorical variable, therefore each estimate is compared to the value labelled 'Intercept', and the value labelled Intercept is an estimate for one of the levels of the treatment factor (i.e. the explanatory variable: tidal cycle). All four model possibilities were created (four tidal cycles).

Lastly we explored whether dolphin group size was influenced by tidal cycle or season. The 'dispersion index' (calculated by dividing the residual deviance by the residual degrees of freedom) found this model overdispersed (2.91). By the common rule of thumb, a dispersion index greater than 2 may indicate a problem with overdispersion. Due to this, a *quasipoisson* distribution was fitted, however the dispersion index remained very high (2.90). A Negative Binomial Generalised Linear Model (GLM.NB), from the *MASS* library, was found to fit the data, due to its ability to work with overdispersed count data variables. In addition, the *simulateResiduals()*, *testDispersion()* function from the *DHARMa* library were used to calculate the overdispersion of the model (Fig. 9).

2.2. Dedicated RIB transects

Dedicated transects for photo-id were carried out from May to September 2021 (over 5 months). Two transects were carried out per month. Start time was randomised so that the survey area was sampled at various stages of the tide. Surveys were only carried out in good weather with sea-state ≤2 and in good visibility. A 6m XC RIB was used throughout with two persons onboard, including coxon. The track of the survey vessel was tracked with a hand-held GPs and all sightings way pointed at the start and end of each encounter.

2.3 Photo-identification

Where possible images of bottlenose dolphins suitable for photo-identification were collected in order to determine which individual dolphins were present in the survey area. Images were sorted and matched according to standardised methodology (Baker 2015). Images were matched by Mags Daly to those in the Irish Whale and Dolphin Group Shannon Dolphin Photo-ID Catalogue.

2.4 Static Acoustic Monitoring

One C-POD was deployed at two sites for a period of 24 months to the east and west of the propose development area (Figure 8). The deployment sites were consistent with monitoring carried out for the original EIA/NIS (Berrow 2007) where two sites were monitored using T-PODS (an earlier version of the C-POD). Multiple C-PODs were used to enable us to swap units on recovery for immediate re-deployment.

2.4.1 C-PODs

The C-POD (Fig. 9) is a fully automated, SAM system which can detect porpoises, dolphins and other toothed whales by recognising echolocation click trains these animals make in order to detect their prey, orientate themselves and interact with one another. These units are designed and manufactured by Chelonia Ltd and they are the only commercially available instruments with click train recognition software, which produces fully automated, accurate data on the behaviour and identification of odontocetes (see http://chelonia.co.uk). A single C-POD can monitor both porpoise and dolphins simultaneously through identifying characteristic click parameters which can be assigned to either harbour porpoise or dolphin species. Once deployed at sea, C-PODs operate in a passive mode and are 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.

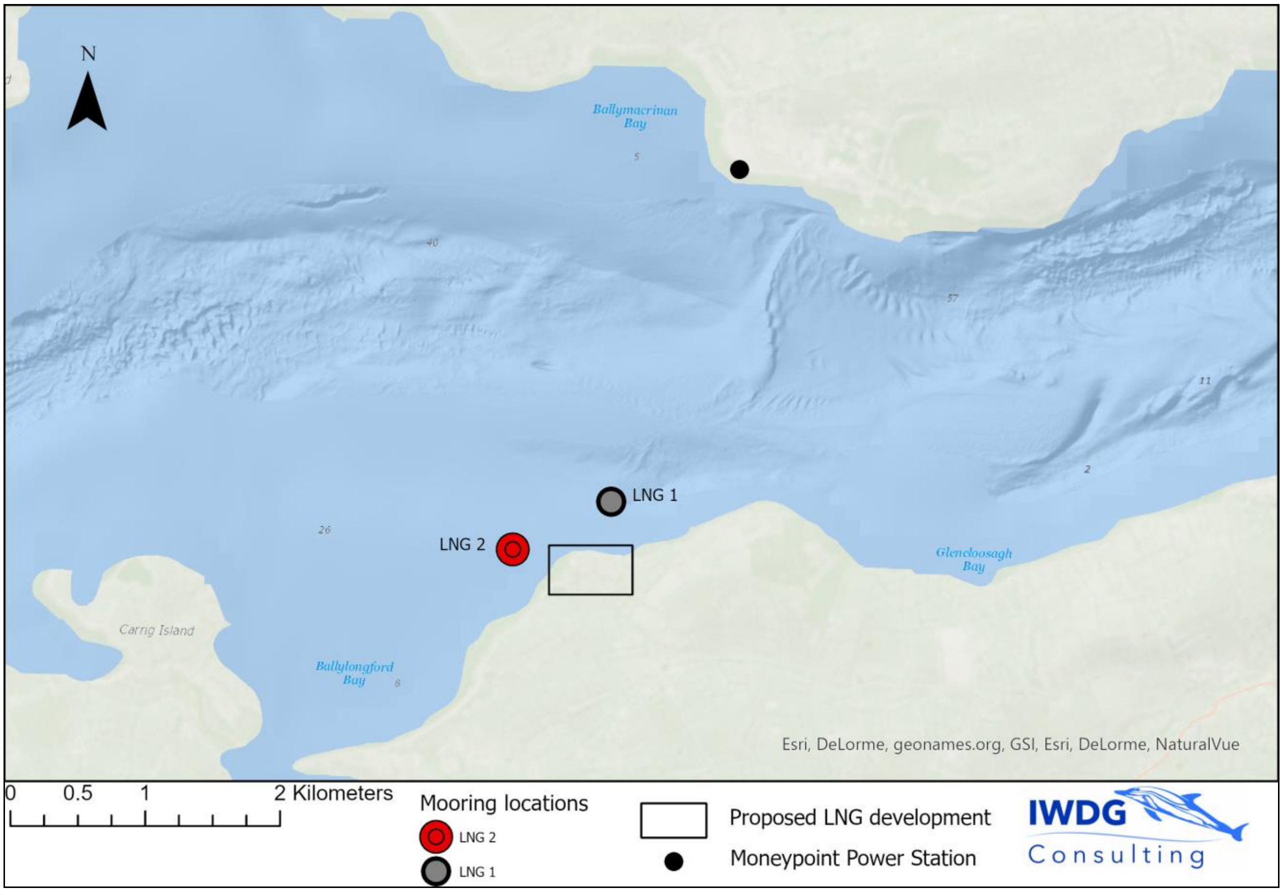


Figure 8. Map of the proposed LNG development site, mooring locations and the control site off Moneypoint

Internally, the C-POD is equipped with a Secure Digital (SD) flash card, and all data are stored on this card. Dedicated software, C-POD.exe, provided by the manufacturer, and 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. Additionally, the C-POD also records temperature over its deployment duration. It should be noted that 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 (Fig. 5 www.chelonian.co.uk). The detection distance for bottlenose dolphins in the Shannon Estuary was estimated at 798±61m (with 75% of groups recorded <400m) by O’Brien et al. (2013).

Figure 9: C-POD unit by Chelonia Ltd

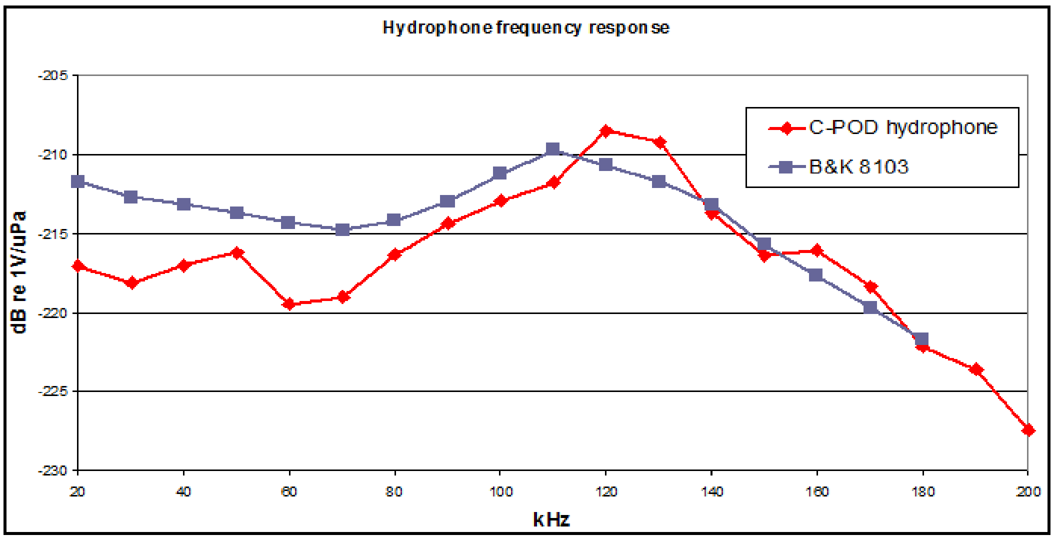


Figure 10: Threshold for detection across various frequency bands between 20 and 200 kHz for the C-POD (note 1Pa p-p is the SI unit for pressure and correctly represents the threshold) © Chelonia Ltd

Through the C-POD.exe software (example Figure 10), data can be viewed, analysed and exported. Additionally, the software can be used to change settings of individual SD cards. The software includes automatic click train detection, which is continually evolving as Chelonia Ltd receives more feedback from their clients. C-POD.exe can be run on any version of Windows and requires an external USB card reader, which reads the SD card into the directory. Version 2.044 (October, 2014) was used for all analyses. C-POD.exe software allows the user to extract click trains under five classification parameters but only the porpoise like category was used for this analysis of the long-term dataset.

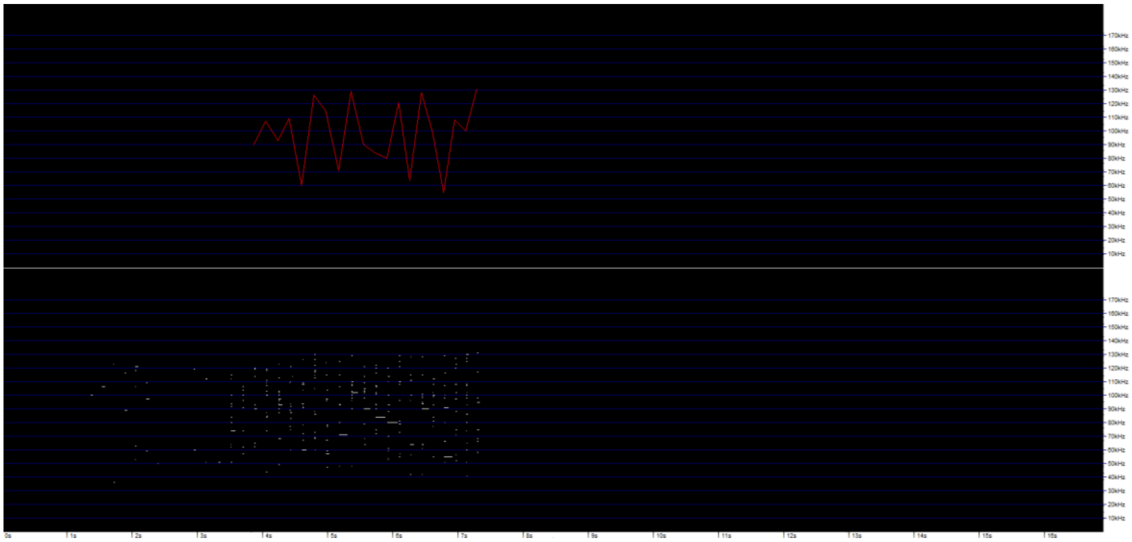


Figure 11: Screen grab of C-POD.exe, showing a bottlenose dolphin click train

SAM is independent of weather conditions once deployed and thus ensures high quality data is collected but only at a small spatial scale. C-PODs can be deployed on a mooring for 3-4 months before recovery and downloading of data. These data can be analysed as detection positive minutes (DPM) to generate an acoustic index of activity. This technique provides large datasets to enable changes in activity to be identified at high resolutions. DPM's provide high quality data on seasonal, diel and tidal occurrence. Data can be compared across sites, before during and after impacts following the BACI (before, after, control, impact) type design similar to Carstensen et al. (2006).

2.4.2 C-POD calibration

Calibration of SAM equipment is important in order to compare results across units. Chelonia LTD, the manufacturers of C-PODs, calibrate all units to a standard prior to dispatch. These calibrations are carried out in the lab under controlled conditions and thus Chelonia highly recommend that further calibrations are carried out in the field prior to their employment in monitoring programmes instead of further tank tests (Nick Tregenza *pers comms*). All C-PODs deployed during this present study were calibrated during field trials in the Shannon Estuary as part of regular monitoring of equipment performance by the IWDG.

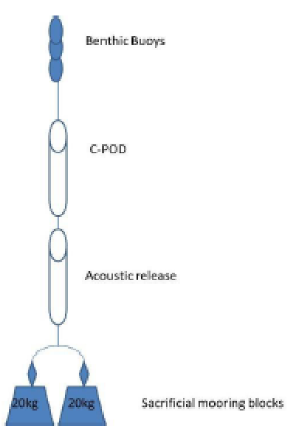


Figure 12. Mooring design and Sonardyne© acoustic release equipment used during the study (O'Brien *et al.* 2013)

Field calibrations are important where projects employ several units aimed at comparing detections across a number of sites. If units of differing sensitivities are used, then these data do not truly reflect the activity at a site. For example, a low detection rate may be attributed to a less sensitive C-POD, with a lower detection threshold, which in turn leads to a lower detection range, while the opposite holds for a very sensitive unit. It is fundamental that differences between units are determined prior to their deployment as part of any project, to allow for the generation of correction factors which can be applied to the resulting data. Field trials should be carried out in high density areas in order to determine the detection function (O'Brien et al. 2013). The field calibration of new and existing units are always carried out off Moneypoint (across the estuary from the proposed LNG site) and are carried out annually by the IWDG.

2.4.3 Environmental variables

Upon recovery of the CPODs, data were extracted under two categories;

1) Narrow Band High Frequency (NBHF) (porpoise band) and
2) Other (dolphin band) using the C-POD.exe software (Version 2.044, October, 2014).

These data were in the form of Excel.csv files using C-POD.exe software and analysed as Detection Positive Minutes (DPM) across hourly segments. Each hour of SAM monitoring was categorised according to season, diel, tidal cycle, tidal phase. Diel was categorised across 4 classes (Morning, Day, Evening and Night), according to the times of sunrise and sunset (www.timeanddate.com/sun/).

Hourly data segments were further categorised into each of the four tidal states (High, Low, Flood and Ebb) using Tarbert Island times, where three hours were assigned to each state (one hour either side of the hour, Low and High tide, flood and ebb in between).

Files were further split to correspond with tidal phase (spring and neap cycles) using admiralty data (WXTide 32) where two days either side of the highest tidal height was deemed spring, and two days either side of the least difference in tidal height between high and low tide was deemed neap, all other days were classified as transitional.

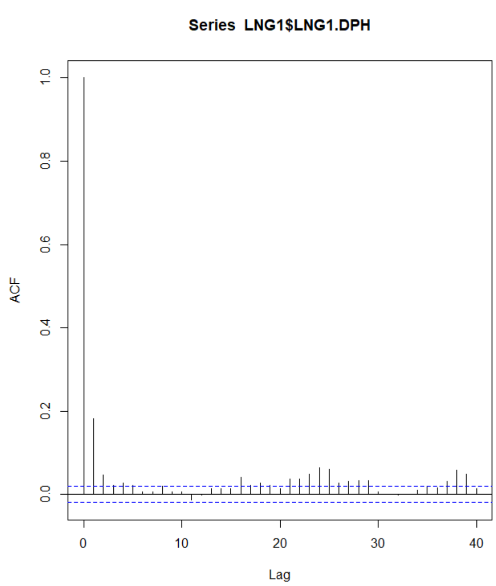


Figure 13. Autocorrelation function (ACF) plot of model residuals for LNG1 where some of the lags cross the 95% confidence bounds, but the correlation is below 0.2 indicating that the data is not temporally auto-correlated. It should be noted that ACF is always 1 at lag 0.

2.4.4 Statistical Modelling

Dolphin detections from both locations were transformed into a binary dataset where 1 was assigned to an hour with detections and 0 to where there are no detections (DOL.DPM). This binary dataset was then used for the Presence/Absence analysis. A binomial GLM with a logit link function was used to model the probability of dolphin presence at both locations based on recommendations by Zuur et al. (2009). Predictors were tested for collinearity by examining the variance inflation factor (VIF) values using the *corvif* function in R where collinearity was detected using a VIF cut-off value of 3 (Zuur et al. 2009; 2013). Best model among all combination of variables (full model, 3,2 or 1 variable) was selected based on the lowest AIC.

To determine whether autocorrelation was present in any of the models, patterns in the residuals were examined using an autocorrelation function (ACF) plot. If various lags cross the 95% confidence bounds and have significant correlation, then independence is violated (Nuuttila et al. 2017; Zuur et al. 2009). Nuutila et al. (2017) also used a correlation threshold of 0.2 in the ACF plot to determine whether there was temporal autocorrelation in in the models (Figure 13, example of and ACF plot from LNG1). In this study, the number of lags crossing the 95% confidence bounds and the magnitude of the correlation were both used to assess whether model residuals were temporally auto-correlated. Examples of how ACF plots were used to assess autocorrelation in this study are shown in Figures 9. For models where no autocorrelation was found, the nested GLM where all explanatory variables were significant were retained as the final model.

3.0 Results

3.1 Land-based Visual Monitoring

Between April 2020 and April 2021, a total of 50 watches were carried out from Ardmore Point over a 25 month period. No watches were carried out during weeks 9, 12, 14, 19, 33 and 35 due to poor sea conditions prevailing (Table 1). Total watch effort was 9,660 minutes (161 hrs) with watch duration less than the 360 minutes planned on fifteen (30%) occasions due to poor weather, low visibility or sea conditions deteriorating through watch to a state (sea-state >3), that was not considered suitable for detecting dolphins. Watch duration was >360 minutes on four occasions. A range of tidal states were sampled from ebbing and flooding tides and slack high and low waters (Table 1).

Dolphins were observed from Ardmore Point during 30 (60%) of watches, with a total of 42 sightings, ranging from 1-3 different groups per watch. Mean group size (±SD) of all groups recorded during watches was 5.5 ± 4.0 dolphins.

Table 1. Date and duration of watches carried out from Ardmore Point VP from April 2020 to April 2021

Date	Time started	Tidal state (HW)	Duration (minutes)	Dolphin Sightings
3 April 2020	14:00	-1 to +3 hrs	240	0
8 April 2020	12:00	-2 to +4 hrs	360	2
15 April 2020	12:00	+1 to -5 hrs	360	0
23 April 2020	12:00	-1 to +5 hrs	360	4
28 April 2020	12:30	-3 to +3 hrs	360	0
9 May 2020	13:00	-1 to +5 hrs	360	3
14 May 2020	12:00	+3 to -3 hrs	360	0
21 May 2020	12:30	-4 hrs	120	0
27 May 2020	12:00	+3 to -3 hrs	360	0
1 June 2020	11:00	-4 to + 2 hrs	360	1
Week 9	No Watch	-	-	-
17 June 2020	09:30	-6 hrs	360	2
25 June 2020	12:00	+3 to -3 hrs	360	0
Week 12	No Watch	-	-	-
1 July 2020	10:00	+4 hrs	270	0
10 July 2020	12:00	+4 to -2 hrs	360	0
Week 14	No Watch	-	-	-
23 July 2020	14:45	-3 to +3 hrs	300	0
31 July 2020	13:00	-3 to +3 hrs	360	2
6 August 2020	13:00	+1 to -5 hrs	360	0
18 August 2020	13:30	-3 to +3 hrs	360	2
30 August 2020	13:00	-4 to + 2 hrs	360	1
Week 19	No Watch	-	-	-
10 September 2020	10:00	+4 to -4 hrs	360	1
18 September 2020	12:00	-5 to +4.5 hrs	360	1
23 September 2020	07:45	-1 to +1 hrs	360	1
29 September 2020	13:30	-1.5 to +3 hrs	300	1
7 October 2020	09:45	-0.5 to 0.5 hrs	390	1
15 October 2021	07:50	-3.5 to 2.5 hrs	390	1
22 October 2021	07:50	-2.5 to 3.5 hrs	360	2
30 October 2021	09:00	-2.0 to 4.0 hrs	300	0
5 November 2020	07:30	5.5 to -5.5 hrs	360	1
9 November 2021	10:50	5.0 to -3.5 hrs	270	1
19 November 2021	09:40	-1.5 to 1.0 hrs	330	2

26 November 2021	09:30	0.5 to HW	360	1
6 December 2020	09:40	0.5 to LW	330	1
Week 33	No Watch			
17 December 2020	09:45	-2.5 to 0.5 hrs	270	0
Week 35	No Watch			
30 December 2020	11:20	-5.5 to 4.0 hrs	330	0
3 January 2021	10:40	-2.5 to 2.0 hrs	360	1
9 January 2021	11:00	3.0 to – 2.0 hrs	300	2
14 January 2021	09:45	-3.5 to 3.5 hrs	360	1
22 January 2021	09:30	3.5 to -3.5 hrs	360	0
1 February 2021	12:30	4.5 to -3.0 hrs	300	1
10 February 2021	10:50	LW to HW	360	0
17 February 2021	10:30	-1.5 to 1.0 hrs	330	0
26 February 2021	08:45	-2.5 to 2.5 hrs	360	1
3 March 2021	09:45	-1.5 to 1.5 hrs	360	0
16 March 2021	10:00	-3.0 to 2.0 hrs	360	1
20 March 2021	10:15	HW to LW	360	2
31 March 2021	10:00	-2.5 to 2.5 hrs	360	0
7 April 2021	09:00	-0.5 to 5.5 hrs	390	0
12 April 2021	09:00	3.0 to -3.0 hrs	390	1
20 April 2021	10:00	-5.5 to 4.5	360	1
29 April 2021	10:00	2.0 to -1.0 hrs	300	1

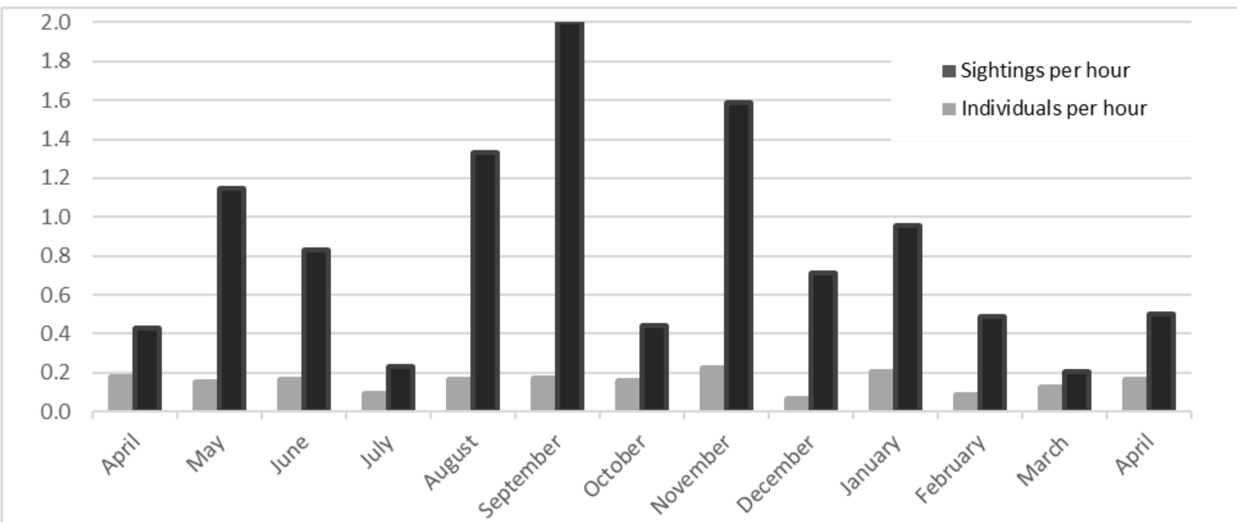


Figure 14. Bottlenose dolphin sighting rates per sighting and per individual during VP effort watches from Ardmore Point (April 2020 to April 2021)

Sighting rate was very consistent with sightings per hour varying from 0.1 to 0.2 sightings (Fig. 14). The sighting rate of dolphin numbers per hour was more variable with a peak of 2.0 in September but what is apparent is a peak in sighting rate from August to November. Sighting effort was consistent with between 1080 and 1680 minutes watched per month but effort was ≥1200 minutes for 77% of months surveyed.

3.1.1 VP Model outputs

A total of 596 scans were carried out between the 3 April 2020 and the 29 April 2021, with a total search effort of 161 hours. The number of scans per month was highest in April of 2020 with a total of 57 scans, and the lowest in December 2020 with 32 scans (Fig. 15a). A total of

88 sightings of bottlenose dolphins was made resulting in 14.8% scans had sightings. Mean group size (±SD) was 0.85 ± 2.58 (Table 2).

Table 2. Summary of scans carried out during VP watches

Date	Number of scans	Number of sightings	% of scans with sightings	Mean group size
April 2020	56	5	9	0.48±1.69
May 2020	47	4	9	0.77±2.81
June 2020	37	3	8	0.38±1.75
July 2020	42	2	5	0.12±0.63
August 2020	36	11	31	2.72±4.36
September 2020	47	6	13	1.55±4.59
October 2020	52	9	17	0.65±1.56
November 2020	47	11	23	1.43±3.14
December 2020	32	3	9	1.03±3.26
January 2021	49	11	22	0.84±2.18
February 2021	48	6	13	0.71±1.90
March 2021	52	7	13	0.21±0.64
April 2021	51	10	20	0.69±1.66

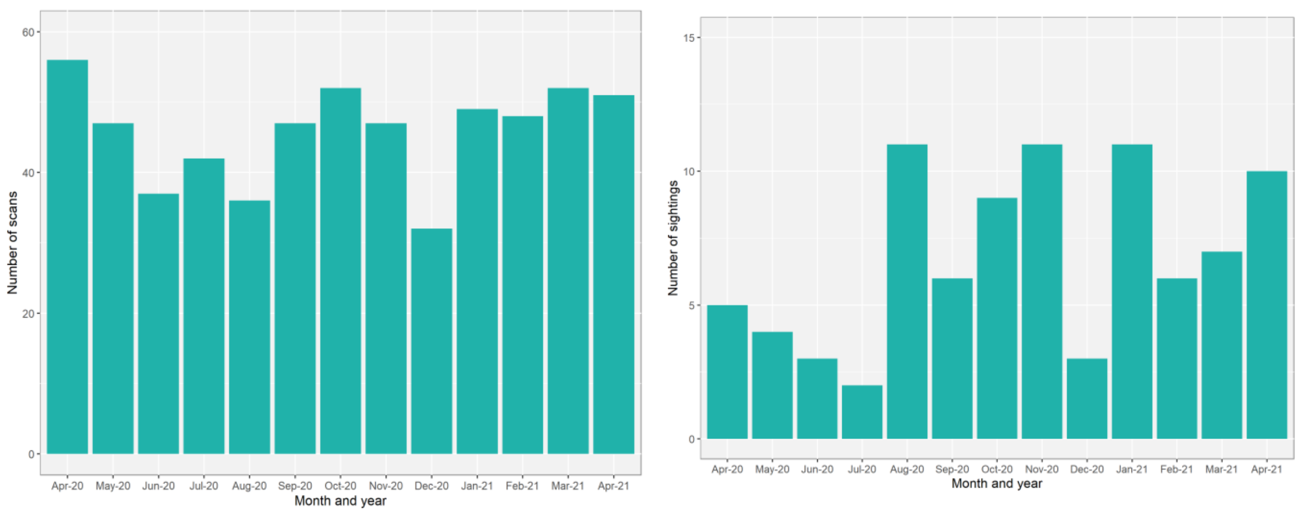


Figure 15: Distribution of a) the number of scans and b) the number of bottlenose dolphins sightings each month between April 2020 and April 2021

The number of sightings of bottlenose dolphins varied substantially with season, with a decline between April 2020 and June 2020, and marked by the lowest number of sightings in July 2020 (only 2 sightings) followed by a peak during August 2020 (11 sightings) (Fig. 15b). The last four months of the year 2020 showed an increase in the number of sightings until December 2020, which declined dramatically, before increasing considerably again in January 2021. The percentage of sightings was the highest in August 2020 with bottlenose dolphins present during 31% of the scans with the highest mean (±SD) group size value at 2.72 ± 4.36. This percentage was the lowest for the month of July 2020 with only 5%, along with the lowest mean group size 0.12±0.63.

In order to have a better visualisation of the number of sightings with the number of scans, the proportion of bottlenose dolphins sightings scans (i.e. scans with bottlenose dolphin sightings) was calculated as the number of sightings per number of scans per month. Each scan was classified for presence/absence of bottlenose dolphins with 0 for absence and 1 for presence of a sighting (Fig. 16).

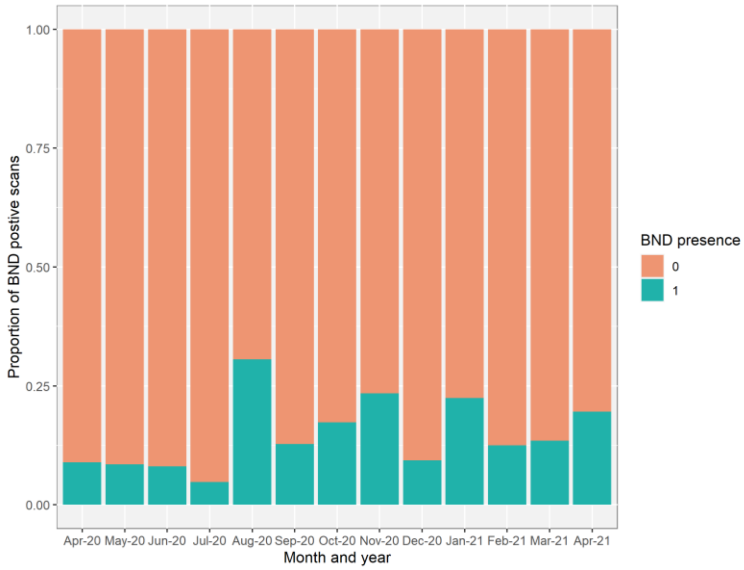


Figure 16. Proportion of bottlenose dolphin positive scans each month between April 2020 and April 2021.

Response variable - Presence of bottlenose dolphins: Tidal cycle

Initially, a bar plot was created with the raw data file to investigate the relation between the proportion of positive scans by tidal cycle (Fig. 17). Ebbing tides had a higher proportion of positive scans (0.18) compared to the other tides, with a lower proportion during flooding tides (0.09). High and low tides were approximately the same (Table 3).

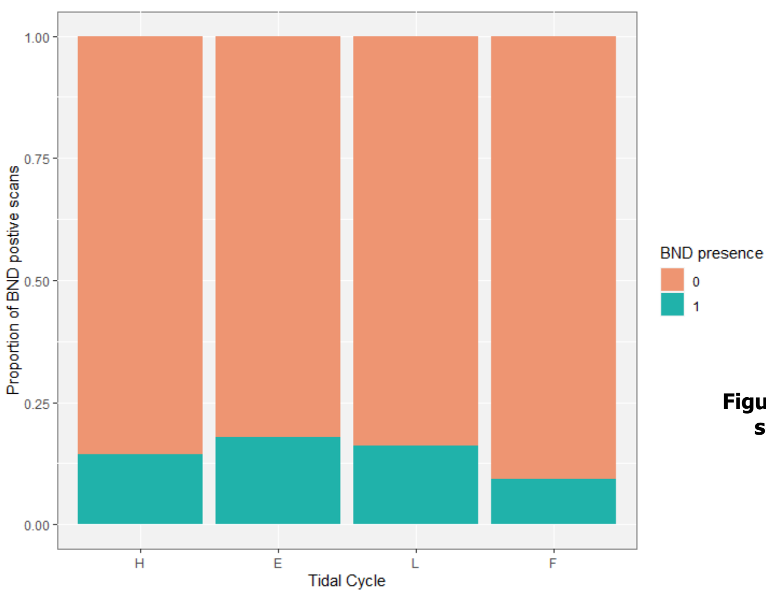


Figure 17. Proportion of bottlenose dolphin positive scans for each tidal cycle (High, Ebb, Low and Flood) between April 2020 and April 2021.

Table 3: Summary of the number of scans and number of bottlenose dolphin's sightings with associated proportion of positive scans for each tidal cycle, between April 2020 and April 2021

Tidal cycle	Number of scans	Number of sightings	Proportion of positive scans
E	195	35	0.18
F	150	14	0.09
H	84	12	0.14
L	167	27	0.16

Table 4: Final GLM obtained for presence/absence of bottlenose dolphins with estimates, standard error (SE), z-value and *p*-value for each tidal cycle. The statistical results include the residual deviance and Akaike Information Criterion (AIC)

Coefficients	Estimate	SE	z value	*p*-value
E (Intercept)*	-1.520	0.187	-8.145	3.80E-16
L	-0.126	0.281	-0.448	0.654
F*	-0.754	0.337	-2.237	0.025
H	-0.272	0.363	-0.748	0.454
Residual deviance	493.27 on 592 degrees of freedom			
AIC	501.27			

In order to assess the presence of under or over dispersion, the *binnedplot()* function was used to assess the binned residuals in the model, as the general calculation method of the dispersion index (ratio of residual deviance to residual DF) is not useful for binary data. In addition, the *simulateResiduals()*, *testDispersion()* function from the *DHARMa* library were used to calculate the overdispersion of the model (Fig. 18).

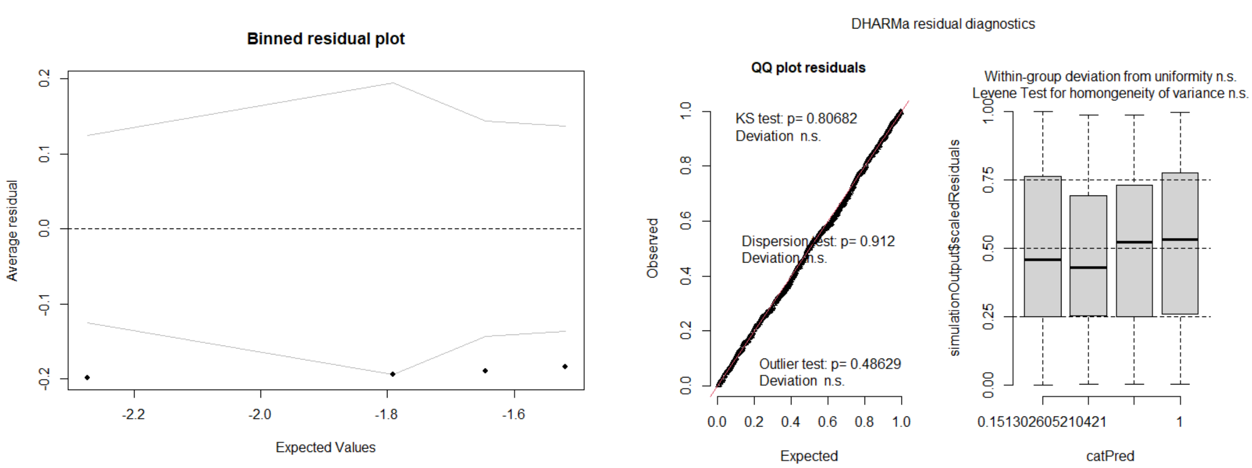


Figure 18: Binned residuals plot and DHARMa residual diagnostics plot of the GLM obtained for presence/absence of bottlenose dolphins for the explanatory variable tidal cycle.

The results from the binned residuals plot showed negative residuals outside the grey lines which can imply overprediction of the response variable by the model, however the *testDispersion()* function calculated a dispersion value of 1 and the *DHARMa* residuals plot also showed no major deviation issues, which indicates no substantial overdispersion in this model (Fig. 18). In the final GLM for the presence/absence of bottlenose dolphins for each tidal cycle, the estimate for the intercept was the mean value of the response variable (presence/absence of bottlenose dolphins) for ebbing tides (reference level).

The associated *p*-values showed **a significant difference between the presence/absence of dolphins for flooding tides** (*p*-value = 0.025), whereas no significant difference was seen for the low and high tides. The other three models showed no significant difference when low and high tides were treated as a reference level, **while ebbing tides showed a significant difference** when flooding tides was treated as a reference level, as expected from the final GLM (Table 4).

Season

Initially, a bar plot was created with the raw data file to investigate the relation between the proportion of positive scans by season (Fig. 19). **Autumn season showed to have a higher proportion of positive scans (0.18) compared to the other seasons, with the lower proportion values in the spring (0.13).** Summer and winter demonstrated the same proportion of positive scans for bottlenose dolphins (0.14) (Table 5).

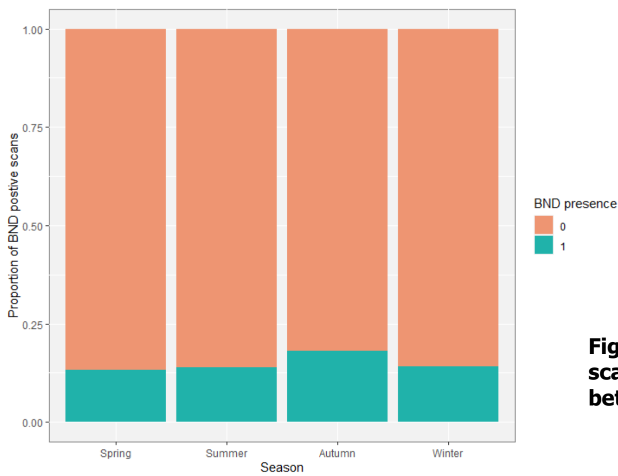


Figure 19. Proportion of bottlenose dolphin (BND) positive scans for each season (Spring, Summer, Autumn, Winter) between April 2020 and April 2021

Table 5: Summary of the number of scans and number of bottlenose dolphin's sightings with associated proportion of positive scans for each season, during April 2020 to April 2021

Season	Number of scans	Number of sightings	Proportion of positive scans
Autumn	143	26	0.18
Spring	204	27	0.13
Summer	115	16	0.14
Winter	134	19	0.14

3.1.2 Location and behaviour off Bottlenose dolphin sightings during VP watches

Most sightings of bottlenose dolphins from Ardmore Point were of groups off Moneypoint (41%) and mid-channel (26%) with two observations off Tarbert, west towards Scattery Island and mid-channel. There were twelve sightings (28%) within 500m of Ardmore Point and of these 1 was within 100 and two within 50m of the shore (Table 4). Seven of these sightings within 500m of Ardmore Point were of dolphins travelling and did not stop at the site. Probable foraging activity was observed on four occasions. Dolphins rarely exhibited social behaviour while travelling past Ardmore Point (Table 4).

Table 4. Details of dolphin sightings recorded during VP watches carried out from April 2020 to April 2021

Date	Group size	Location	Behaviour
8 April 2020	5	Moneypoint	Slow swim, possibly social behaviour
8 April 2020	2	mid-channel to Killimer and Tarbert	Travelling
23 April 2020	5	Moneypoint	Slow swim, possibly social behaviour.
23 April 2020	2	**<500 from watch site**	Social (caress), slow travel, did not stop
23 April 2020	6	West of Ardmore Point	feeding, breach
23 April 2020	9	Moneypoint	feeding, breach, head-slap)
9 May 2020	6	West of Moneypoint	Travelling, individuals were widespread
9 May 2020	13	**<500 from watch site**	Travelling at moderate speed, not stop
9 May 2020	4	**<500 from watch site**	Travelling at moderate speed, feeding, (surface rush, kerplunk, tail slap)
1 June 2020	3	Moneypoint	Feeding (Surface rush, tail slap)
17 June 2020	4	West of Moneypoint	Bow riding tanker
17 June 2020	10	**<500 from watch site**	Travelling at moderate speed
31 July 2020	4	**off Ardmore Point <50m**	Slow swim, did not stop
31 July 2020	1	East of Moneypoint	Bow riding tanker
18 August 2020	6	Moneypoint	Bow riding Dolphin Discovery
18 August 2020	7	**<500 from watch site**	Travelling at moderate speed
30 August 2020	11	Moneypoint	Social and foraging behaviour
10 September 2020	6	Moneypoint and mid-channel	slow swim, surface rush, sharking, breach and side slap
18 September 2020	8	Moneypoint	Slow travel
23 September 2020	7	Off Scattery Island	Slow travel breaching, milling
29 September 2020	11	Mid-channel	Slow travel upriver, spread <1000m
7 October 2020	2	off Moneypoint	Slow travel upriver, <500m of shore
15 October 2020	2-3	**<500m of Ardmore**	Foraging along tidal rip
22 October 2020	4	Moneypoint	slow travel west
22 October 2020	2	**<500m of Ardmore Point**	slow travel east along tide line
5 November 2020	2-3	Carrig buoy to Moneypoint	breaching, foraging
9 November 2020	10	Moneypoint	slow swim west with ebb tide
19 November 2021	5-6	tarbert	in tidal race heading east
19 November 2021	2-3	Moyne Bay west to Scattery	slow swim, milling, breach
26 November 2021	10-12	Moyne Bay, to Moneypoint	active, breach, forage
6 December 2021	10-12	**<300m of Ardmore**	foraging
3 January 2021	1	Moneypoint – mid-channel	logging
9 January 2021	5-6	**<300m of Ardmore Point**	slow swim
9 January 2021	9	Moneypoint	breaching/foraging
14 January 2021	3-4	mid-channel	slow travel
1 February 2021	5-6	500-1000m off Ardmore Point	slow travel
26 February 2021	5-6	mid-channel	foraging
16 March 2021	1	mid-channel	slow travel
20 March 2021	3	**<500m of Ardmore Point**	slow travel
12 April 2021	1	**<100m of Ardmore Point**	slow travel
20 April 2021	3-4	mid-channel	foraging
29 April 2021	5-6	mid-channel	slow travel

On three occasions (9 May and 17 June 2020, 15 October 2021) images suitable for photo-id were captured from land. On an additional two occasions, the IWDG RIB was also on the water during dedicated watches (9 May and 30 August 2020) and obtained images suitable for photo-id of the same dolphins seen off Ardmore Point during the dedicated watch. This provided information on the individual dolphins that use the waters off Ardmore Point (Table 5).

A total of 22 individual dolphins were recorded at the proposed development site during 2020 off Ardmore Point (Table 3). Most were only recorded once but that only means we obtained images of these individuals dolphins which may have been present in other groups but were not photographed. At least 10 (45%) were recorded on at least two of the four photo-ids sessions. Two of these dolphins were recorded during the first year of the Shannon Dolphin Project in 1993, making them at least 27 years old and an important part of the dolphin community. Ten individuals known since birth were recorded, including four calves born during 2018 and 2019. These dolphins were all part of the "inner" estuary sub-group (Baker et al. 2017b).

Table 5. Identify of individual dolphins recorded off Ardmore Point during dedicated VP watches and during RIB surveys carried out during 2020 on the same day as VP watches

Dolphin ID	23 April (RIB)	9 May (L)	17 Jun (L)	30 Aug (RIB)	15 Oct (L)	Notes
#006	√			√		old animal first recorded in 1993
#008	√	√				old animal first recorded in 1993 (male)
#044		√				adult
#084	√					(adult male)
#118	√					(female)
#173				√		adult
#216		√		√		adult
#236			√	√		adult
#242	√		√			female re-floated in 2011 (O'Brien et al. 2014)
#244			√	√		adult
#312			√	√		(adult male)
#313		√				(adult male)
#801				√		calf of 006 born 2012
#817	√				√	calf of 242, born 2012
#820		√		√		calf born 2014
#824		√				calf of 044, born in 2014
#862	√		√			older calf born 2015
#880	√			√		calf of 006 born 2018
#881				√		calf born 2018
#886				√		calf born 2019
#887		√				calf born 2019
#890				√		calf born pre 2011

3.1.3 Other marine mammal species

While the primary focus was bottlenose dolphins, all marine mammals sighted were recorded. On 13 occasions individual grey seals (*Halichoerus grypus*) were recorded. Most (62%) were within 500m of the watch site and on one occasion within 50m (Table 4). Seven of the sightings were of seals foraging (regular dives in same location) and on four occasions bottling or logging, which is indicative of sleep/rest. On three occasions they were observed within 300m of the shore and once within 50m (Table 6).

Table 6. Details of grey seal sightings recorded during VP watches carried out from April 2020 to April 2021

Date	No.	Location	Behaviour
23 April 2020	1	<500 m from VP	Slow swim, bottling
27 May 2020	1	<500 m from VP	Bottling, foraging
01 June 2020	1	800 m from VP	Bottling, slow swim heading east
30 August 2020	1	<500 m from VP	
23 September 2020	1	**<50m of Ardmore Point**	foraging
29 September 2020	1	<500m drifting west against tide	foraging
22 October 2020	1	**<100m off Ardmore Point**	foraging
30 October 2020	1	drifting upriver with incoming tide	bottling
30 December 2020	1	middle of estuary	logging
9 January 2021	1	**<300 of Ardmore Point**	logging
19 February 2021	1	500-1000m from Ardmore NW of site	foraging
20 April 2021	1	mid-channel	foraging
29 April 2021	1	<500m from Ardmore N of site	foraging

On one occasion a single harbour porpoise (*Phocoena phocoena*) was observed during VP watches. On 22 October 2020 it was observed off the wind turbines on the Clare side of the estuary, foraging on a tide line. Harbour porpoise sightings within the estuary, and especially east of Scattery Island are very rare (O'Callaghan et al. 2021).

Harbour porpoise near Moneypoint seen on 22 October 2020 during VP watches from Ardmore Point

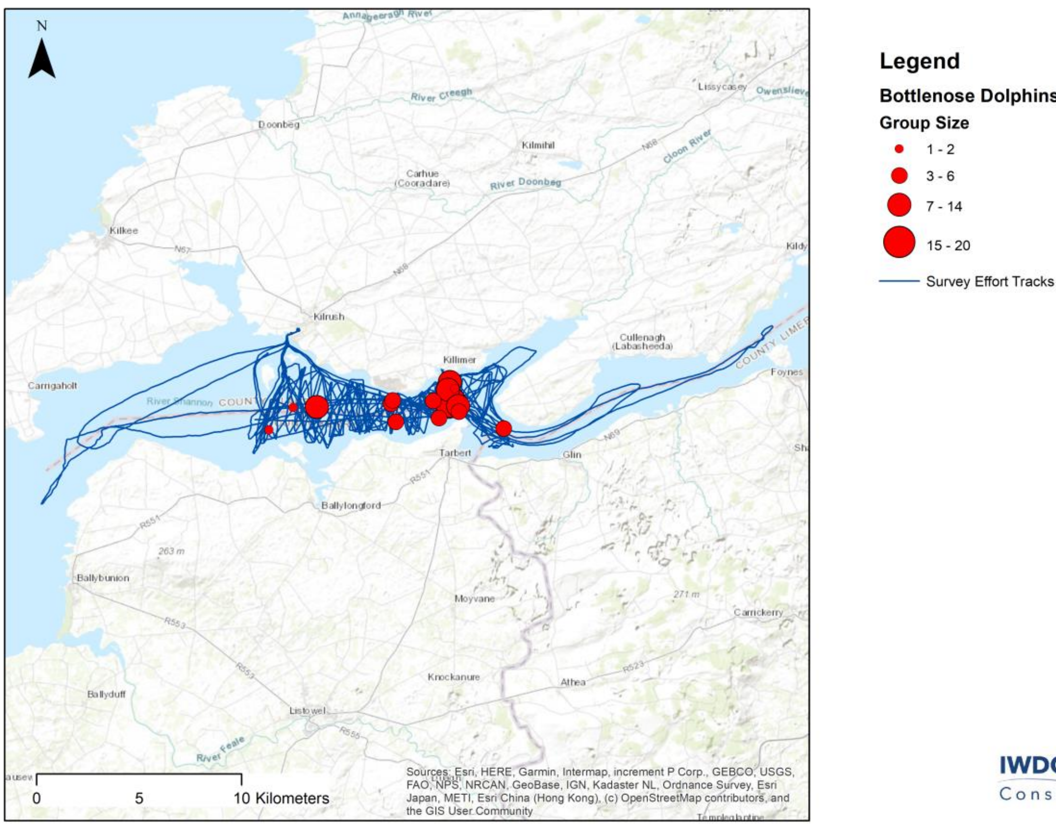
On the 14 January 2021 a group of 6-10 dolphins were observed off the north side of the estuary, heading east up river. They were active and appeared small and dark and not consistent with bottlenose dolphin appearance or behaviour but were more consistent with common dolphins (*Delphinus delphis*). Species identification could not be confirmed but it seems likely they were common dolphins as common dolphins were also reported off the ferry over the next few days but no images were taken to conform identification. Common dolphins were reported live stranded in Tarbert in January 2017 (O'Connell and Berrow 2019) so this sighting although rare is not unprecedented.

3.2 RIB transects

A total of 10 transects were carried out, all in favourable sea conditions (Table 7). Bottlenose dolphins were encountered on seven (70%) with a total of 17 different groups recorded. Most groups were recorded between Killimer to Tarbert or on the north side of the estuary, with three groups recorded between Ardmore Point and to Moneypoint (Figure 18)

Table 7. Summary of dedicated boat-based surveys (n=10)

RIB transect	Date	Time started	Distance covered	Dolphin sightings
T1	2 May 2021	11:00	40	2
T2	14 May 2021	10:30	56	0
T3	30 May 2021	11:30	50	3
T4	12 June 2021	11:00	No GPS	2
T5	30 June 2021	07:30	27	0
T6	16 July 2021	11:00	33	3
T7	1 August 2021	14:25	34	3
T8	23 August 2021	11:00	32	3
T9	8 September 2021	14:50	38	1
T10	20 September 2021	14:45	27	0



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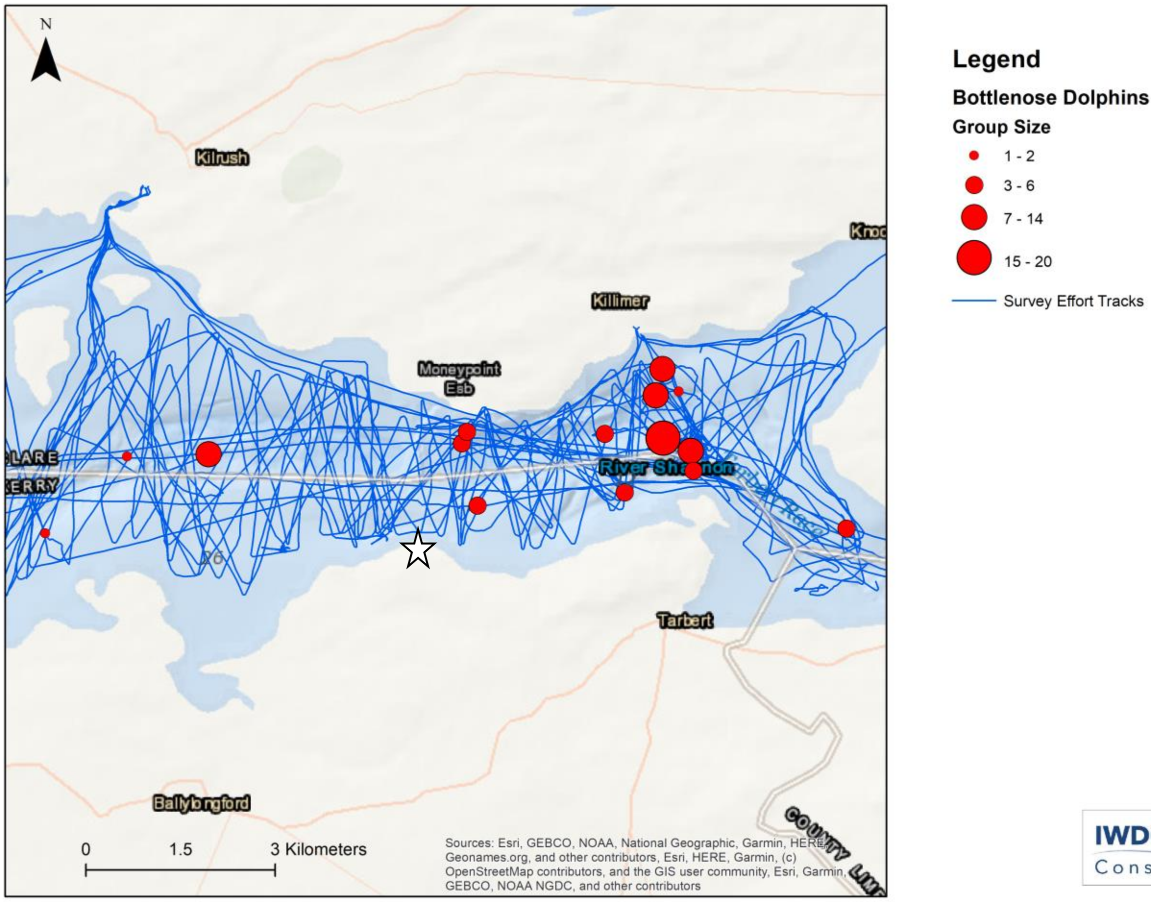


Figure 18. Distribution of bottlenose dolphin sightings during dedicated RIB transects. Note transects sometimes went beyond survey area. Ardmore Point is denoted by ☆

3.3 Photo-identification

During dedicated RIB transects a total of 26 individual dolphins were identified through photo-identification (Table 5). Of the 22 individuals (Table 5) photographed opportunistically during 2020, 17 (77%) were also reported in 2021 during dedicated surveys. Five dolphins recorded during 2020 were not recorded during 2021. Three of these are males, one of which (008) was recorded off the east coast of Ireland and southwest Scotland in April 2021 and has not been recorded within the Shannon Estuary since. ID number 173, is the calf of 118, which was seen during 2021. She was seen off Slea Head, Co Kerry this summer in the group going further south with her calf (890). Id No. 881 is the calf of 216; the unmatched animal B is most likely 881.

Of the 26 individuals photographed during 2021, nine individuals were recorded on >50% of transects with dolphins encountered and seven on >70% of transects with dolphins. This shows great site fidelity and consistency.

Table 8. Summary of photo-id data from all transects. Dolphin ID is the unique catalogue number each dolphin has been given by the IWDG during the Shannon Dolphin Project.

Dolphin ID	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	Total	% of transects with sightings
6	1	0	0	0	0	0	0	0	0	0	1	14%
44	0	0	1	1	0	1	1	1	1	0	6	86%
84	1	0	1	0	0	0	0	0	0	0	2	29%
93	0	0	0	0	0	1	1	0	0	0	2	29%
104	0	0	1	0	0	0	1	0	0	0	2	29%
118	0	0	1	0	0	1	1	0	0	0	3	43%
200	0	0	1	0	0	0	1	0	0	0	2	29%
216	0	0	0	0	0	0	1	0	0	0	1	14%
223	0	0	0	0	0	1	0	0	0	0	1	14%
236	0	0	1	0	0	1	1	1	0	0	4	57%
242	0	0	1	0	0	1	0	0	0	0	2	29%
244	0	0	1	1	0	0	0	0	0	0	2	29%
312	0	0	1	1	0	1	0	0	0	0	3	43%
801	1	0	1	1	0	0	1	1	0	0	5	71%
806	0	0	0	0	0	1	0	0	0	0	1	14%
817	0	0	1	1	0	1	1	1	0	0	5	71%
820	0	0	0	0	0	0	1	0	0		1	14%
824	0	0	1	1	0	1	1	1	1	0	6	86%
862	1	0	1	0	0	1	1	0	0	0	4	57%
864	0	0	1	0	0	1	1	1	1	0	5	71%
880	1	0	0	0	0	0	0	0	0	0	1	14%
886	1	0	1	1	0	0	1	1	0	0	5	71%
887	0	0	1	1	0	1	1	1	1	0	6	86%
906	0	0	0	0	0	0	1	0	0	0	1	14%
Unmatched	0	0	0	1	0	0	0	1	1	0	2	29%
Total = 26	**6**	**0**	**16**	**9**	**0**	**13**	**16**	**9**	**5**	**0**		

Of these 26 individuals, 92% (24 individuals) were matched to the Shannon Dolphin Project catalogue. Of the 24 matched animals, 23 (96%) are from a subgroup of ~35 animals in the Shannon dolphin population who are most frequently sighted in the survey area of the inner estuary and this accounts for 69% of the individuals in this subgroup.

Other animals in the population that are most frequently seen in the outer estuary have been sighted previously in the inner estuary, however only one animal (4%) was observed during these surveys. A further 2 animals photographed during the surveys could not be matched to the catalogue. See Appendix II for dorsal fins.

Table 9. Summary of known life-history of each individual dolphin recorded during dedicated boat transects and photo-id off the proposed LNG site

Dolphin ID	Age (years)	Fin	Sex	Description
6	20-25	Adult	F	A first generation, adult female, also known as Sarafina. Most likely born sometime between 1998 and 2003. She has 3 known calves, 801, 860, and 880, 2 of which have survived. She has a strong association with other dolphins seen mainly in the inner estuary, including her first calf 801 and the other female Sandy, 242 who is approximately the same age. She is most frequently seen in the inner estuary from Tarbert to Carrig Island and west to the outer estuary at Beal and Ballybunnion.
44	>30	Adult	F	A first generation, adult female, also known as Luna. Her year of birth is unknown, however she has been in the catalogue since the 90's, and so is at least 30 years old. She has 3 known calves, 824, 864 and 887, all of whom have survived, making her a very important female in the population. She has a strong association with other dolphins seen mainly in the inner estuary. She is most frequently seen in the inner and mid estuary from Tarbert to Beal.
84	>30	Adult	M	A first generation, adult male, also known as Sabre. His age is unknown, however he was first recorded in the late 90's as an adult, therefore he is at least 30 years old. He has a strong association with other dolphins that are primarily seen in the inner estuary such as Bob 104, Talon 180, Nala 801 and Fiádh 806. He is most frequently seen in the inner, from Tarbert, Carrig and Beal and on the Ballybunnion bank in late summer.
93	>30	Adult	F	A first generation, adult female, also known as Norma Jean. Her year of birth is unknown, like Sabre she was an adult when added to the catalogue in the late 90's, therefore she is at least 30 years old, although its likely she is much older. She has no known calves. She is most frequently seen in the inner estuary, from Tarbert to Carrig / Beal and on the Ballybunnion bank in late summer.
104	>30	Adult	M	A first generation, adult male, also known as Bob. He is one of our most frequently seen dolphins. Like the majority of dolphins sighted during these surveys he is most frequently seen in the inner estuary but will also been seen in the outer estuary. He is most frequently seen with 084, 180 and 242.
118	>30	Adult	F	A first generation, adult female, also known as Danú. Her year of birth is unknown but is estimated to be at least 25 -30 years old. She has 2 known calves, 173 who had her first calf in 2018, and 838, who suffered from moderate to severe scoliosis and was last seen in 2018. Her closest association would be with other animals primarily seen in the inner estuary.
200	>25	Adult	F	A first generation of unknown gender, also known as Solás. Year of birth is unknown but this dolphin is estimated to be at least 20-25 years of age. 200 is most frequently seen in the inner to mid estuary. This dolphin's fin is unmarked and its challenging to match if only photographed from a distance. The most distinctive features are the mild hypopigmentation on the dorsal fin, a result of freshwater exposure and tattoo skin lesions, and the notches on the dorsal surface of the tail stock.
216	>25	Adult	F	A first generation, adult female, also known as Fae. Her year of birth is unknown but she is estimated to be at least 20 years old. She has 4 known calves, 806, 847, 881 and 906. All her calves are known to have survived, making her another very important female in the population. Like the others she is most frequently seen in the inner estuary. She was not seen as frequently during the 2021 as other field seasons, she was seen during the surveys in late summer with her new born calf, 906.
223	>15	Adult	F	A first generation, adult female. Her year of birth is unknown but she is estimated to be at least 15 years of age. She is most frequently seen in the mid to outer estuary, Beal to Ballybunnion and Loop Head, and is rarely seen in the inner estuary. She has 3 known calves, it's is unknown if any of these calves have survived.
236	>20	Adult	Unk	A first generation of unknown gender, also known as Storm. Year of birth is unknown but this dolphin is estimated to be at least 20 years of age. Storm is most frequently seen in the inner estuary and at Beal and Ballybunnion. Closest associations would be with the male 008 and other members of the population that are primarily seen in the inner estuary and Beal.

242	~20	Adult	F	A second generation, adult female, also known as Sandy Salmon. Her exact year of birth is unknown but she was most likely born between 2000-2003. She is the only Shannon Dolphin known to have live stranded. She was refloated by IWDG and NPWS at Hannon Strand in North Kerry in 2012. She was 9 months pregnant at the time of stranding with her first calf, 817. She has 3 known calves, 817, 862 and 898. 898 was born during between January and February of this year and did not survive past April. Her closest associations are with the male Bob 104, Sarafina 006 and her other calves in the inner estuary.
244	~20	Adult	Unk	A first generation of unknown gender, also known as Astral. The exact year of birth is unknown, their age is estimated to be ~ 20 years. Astral is also most frequently seen in the inner estuary. Their closest association is with the male Prometheus 312. Astral currently a severe case of pox/herpes skin lesions, however this infection has improved over the last year and is not believed to impair their condition and prognosis for survival.
312	~20	Adult	M	A second generation, adult male, also known as Prometheus. Like 242 he was born around 2002-2003. He is the only known calf of 009. His closest association with the other male Pip 313, however this has changed this year since Pip has left the inner estuary / died and he is most frequently seen with Astral 244. He is most frequently seen in the inner estuary, in particular at Tarbert.
801	9	Adult	F	A second generation , adult female, also known as Nala. Born in 2011, she is the first known calf of 006 and the first calf to be added to the Shannon Dolphin catalogue. She continues to have a strong association with her mother 006, Sarafina, along with other females in the inner estuary with calves. She has one known calf, 886, born in 2018. She is most frequently seen in the inner estuary from Tarbert to Carrig Island, but has been seen as far west as Loop Head.
806	8	Sub-adult	F	A second generation, adult female, also known as Fiádh. Born in 2012, she is the first known calf of Fae 216. Her closest associations would be with the males normally seen in the inner estuary. She is often seen in the inner estuary with her mother's group, but ranges regularly to the mid to outer estuary as far west as Kilclogher.
817	8	Sub-adult	F	The oldest third generation animal in the catalogue, also known as Muddy Mackerel. Born in 2012, she is the first known calf of Sandy Salmon, 242. Her mother was 9 months pregnant with Muddy when she live stranded. She continues to have a strong association with her mother and other members of the population that are primarily seen in the inner estuary, in particular Stellar, 824 and younger sibling Comet 862. She also is regularly seen in the mid estuary at Beal and Ballybunnion.
824	7	Sub-adult	M	A second generation, sub adult male, also known as Stellar. He is the first known calf of 044. Born in 2014 Stellar is now 7 years old. Primarily seen in the inner estuary, he will also often range to Beal and Ballybunnion. His closest association would be with Muddy, 817 and other younger animals seen in the inner estuary and his mother Luna and younger sibling, Moon 864.
820	7	Sub-adult	F	A second generation , sub adult female, also known as Rue. She is the second known calf of 071, and younger sister of Sandy Salmon, 242. She was born in 2014 and is 7 years old. She ranges from the inner to the mid and outer estuary. She has a close association with inner estuary animals. Since 2019/2020, when her mother 071 was last seen, she has also been frequently seen with 106 and 226, when seen in the mid to outer estuary.
862	5	Juvenile	Unk	A third generation, juvenile of unknown gender, also known as Comet. Commet is the second calf of 242, Sandy Salmon. Born in 2016 Comet is now a juvenile at 5 years old and has gained nutritional independent from Sandy, however they continue to have a close association. Comet is also frequently seen with Moon, 864, who was born the same year and older sister Muddy 817.
864	5	Juvenile	Unk	A second generation, juvenile of unknown gender, also known as Moon. Moon is the second calf of 242, Sandy Salmon. Born in 2016 Comet is now a juvenile and has gained nutritional independent from Sandy but they continue to have a close association. Comet is also frequently seen with Moon, 864, who was born the same year and older sister Muddy, 817.
880	3	Calf	F	A second generation, juvenile female. 880 is the 3rd known calf of 006, Sarafina. Born in 2018 she is now 3 years old and continues to be most frequently seen with her mother and older sister Nala 801, along other

				juvenile Shannon Dolphins in the inner estuary.
886	2	Calf	Unk	A third generation, juvenile of unknown gender. Born in 2019, 886 the first known calf of Nala 801 and the first known grandchild of 006. At only 2 years old 886 has not gained full nutritional independence from their mother and therefore they are mainly seen together.
887	2	Calf	Unk	A third generation, juvenile of unknown gender. Born in 2019, 887 is the 3rd known calf of 044, Luna. Like 886, 887 is 2 years old and has not gained full nutritional independence and so they are mainly seen with mother Luna.
906	~ 1 mo	Neonate	Unk	A second generation, neonate of unknown gender. Born in late summer of 2021. 906 is the 4th known calf of Fae 216.

3.4 Static Acoustic Monitoring

A total of seven deployment/recoveries took place over the two year monitoring period between 28 August 2019 and 10 August 2021. Two locations were monitored, and referred to as LNG1 and LNG2 (Figure 8). A total of 694 days of monitoring data collected from LNG1 and 492 days from LNG2. No data were obtained from deployment 4 and 5 at LNG2 (November 2020 to May 2021) as C-PODs could not be recovered due to the acoustic releases failing to respond to the release code.

Most clicks detected were associated with dolphins (94.6%) with 6.4% associated with harbour porpoise characteristics. These "porpoise" clicks could also originated from dolphins but the recent sightings of harbour porpoises in the study area (O'Callaghan et al. 2021) shows harbour porpoises do occur. Interesting on deployment 4 (November 2020 to February 2021) there were no dolphin detections at LNG1 but a few porpoise detections (Table 10).

Table 10. Summary of results from SAM at each of the locations

Location	No. days	Dates	Porpoise	Dolphin	Total	% days detected	Mean DPM/day
LNG1	266	28 Aug 2019-18 May 2020	66	1,173	1,239	62	4.4
LNG2	250	28 Aug 2019-17 May 2020	127	904	1,273	62	3.6
LNG1	103	2 June-6 Sept 2020	4	315	319	37	3.0
LNG2	105	2 June-6 Sept 2020	12	474	486	53	4.6
LNG1	61	6 Sept – 5 Nov 2020	21	366	387	69	6.3
LNG2	61	6 Sept – 5 Nov 2020	23	255	278	59	4.6
LNG1	98	5 Nov 2020 – 5 Feb 2021	3	0	3	3	0.03
LNG2	-	5 Nov 2020 – 5 Feb 2021	-	-	-	-	-
LNG1	102	8 Feb -14 May 2021	12	362	374	57	3.7
LNG2	-	8 Feb -14 May 2021	-	-	-	-	-
LNG1	92	14 May-11 Aug 2021	7	273	280	49	3.0
LNG2	92	14 May-11 Aug 2021	19	178	197	47	2.1
LNG1	428	2 Jun 2020 - 10 Aug 2021	47	1,308	1,355	42	3.1
LNG2	242	2 Jun 2020 - 10 Aug 2021	54	904	958	55	3.7

The proportion of days with dolphin detections were very consistent throughout the monitoring period ranging from 37-69% of days at LNG1 (omitting 3% in Nov-Feb) and 47-62% of days at LNG1. Mean DPM per day which is a more robust measure of occurrence was also consistent ranging from 3.0-6.3 of days at LNG1 (omitting in Nov-Feb) and 2.1-4.6 of days at LNG1 (Table 10).

3.4.1 Year 1: Aug 2019-November 2020

Dolphins were recorded on 62% of days at both locations and the number of cumulative dolphin positive minutes were similar across the two sites (Table 5).

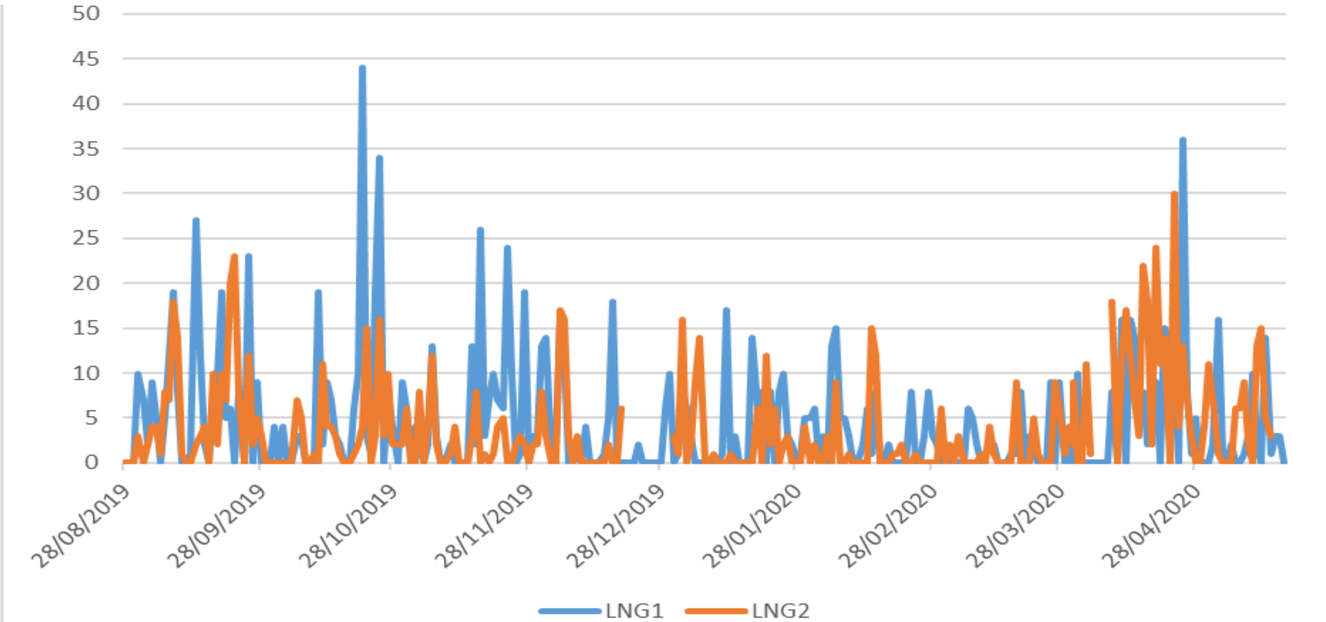


Figure 19. Number of dolphin detections per day recorded across all locations from August 2019 to May 2020 (250-266 days)

Durations per day ranging from 0-44 minutes with a peak during October 2019 (Figure 14). Detection Positive Minutes across dolphin and porpoise channels were extracted even though only a few records exist in the estuary for porpoises. As total of 66 "porpoise" detections occurred at LNG1 while 127 were recorded off LNG2 (Table 5). These detections were not used in the overall statistical model as they are too few to analysis effectively.

Dolphins were detected on 62% of days monitored at LNG1 across 266 days. Peaks in detections occurred in October and April (Figure 14). Results from the binomial GLM showed season to have a significant effect with more detections during the spring, summer and autumn. Diel effects were also present with significantly more detections during the evening and at night. Lastly, tidal cycle was also found to have significant effect with more detections during a flood tide (Table 6, Figure 15).

Table 11. GLM output results showing the estimate, standard error, Wald test statistic and P-values for each predictor. Significant variables are denoted with *

Variables	Estimate	SE	Wald	P(>|W|)	Significance
Intercept	-5.86575	0.4825	-12.2	**2e-16**	
Season					
SeasonSpring*	2.711258	0.461759	5.872	4.32e-09	**<0.001**
SeasonSumme*r	2.994966	0.498115	6.013	1.83e-09	**<0.001**
SeasonWinter*	1.696768	0.476196	3.563	0.000366	**<0.001**
Diel					
DielE*	0.525259	0.255115	2.059	0.039503	**<0.05**
DielM	0.130589	0.286156	0.456	0.648134	
DielN*	0.537214	0.195097	2.754	0.005895	**<0.006**
Tidal cycle					
Tidal.cycleL	-0.56185	0.316787	-1.774	0.076131	
Tidal.cycleH	0.003248	0.190119	0.017	0.986370	
Tidal.cycleF*	-0.42947	0.217879	-1.971	0.048704	**<0.05**

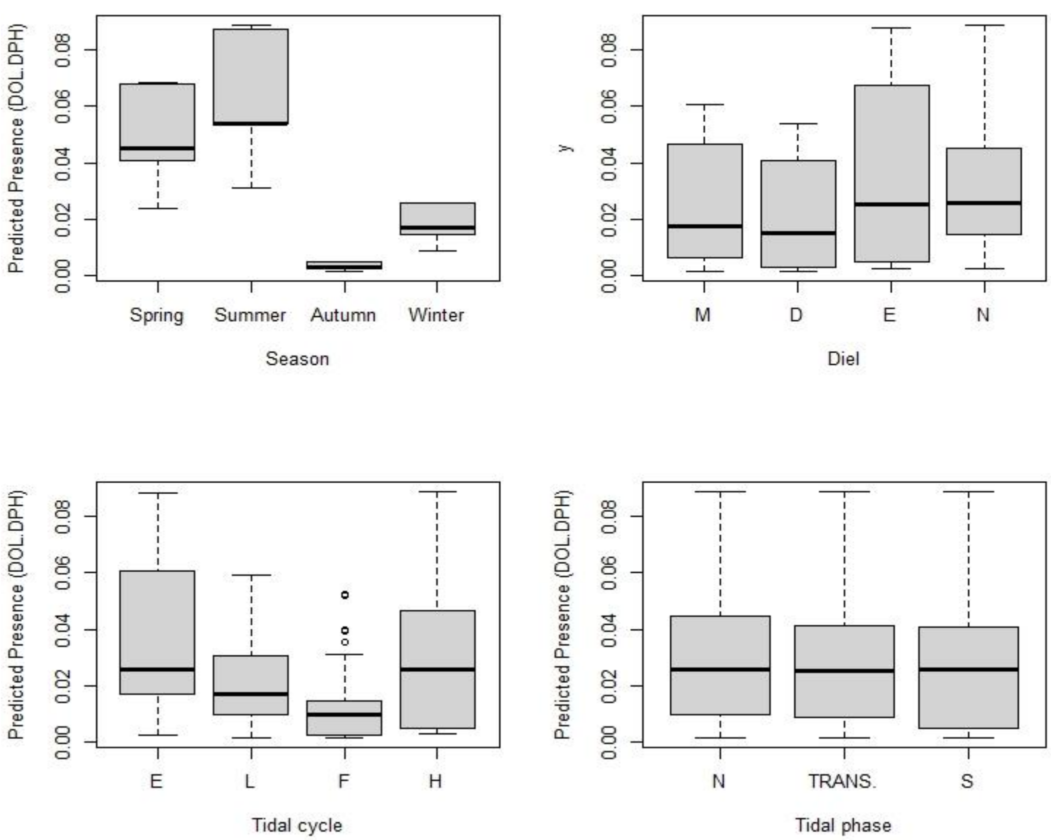


Figure 20. The predicted probability of bottlenose dolphin presence at LNG1 according to 1. Season, 2. Diel, 3. Tidal cycle and 4. Tidal phase

LNG2 Monitoring Site

Similarly to LNG1 bottlenose dolphins were detected on 62% of days at LNG2, monitored across 250 days, with peaks similar to LNG1. Results from the binomial GLM showed neither season, tidal phase or tidal cycle had any significant effect but there were significantly more detections during the evening (Table 7, Figure 16).

Table 12. GLM output results showing the estimate, standard error, Wald test statistic and P-values for each predictor. Significant variables are denoted with *

Variables	Estimate	SE	Wald	P(>|W|)	Significance
Intercept	-2.884936	0.211372	-13.649	**2e-16**	
Season					
SeasonSpring	-0.147524	0.161094	-0.916	0.3598	
SeasonSummer	0.364262	0.228382	1.595	0.1107	
SeasonWinter	-0.319158	0.164482	-1.940	0.0523	
Diel					
DielE*	0.425449	0.182379	2.333	0.0197	**<0.05**
DielM	-0.159934	0.218827	-0.731	0.4649	
DielN	-0.006086	0.148664	-0.041	0.9673	
Tidal cycle					
Tidal.cycleL	-0.075542	0.171586	-0.440	0.6598	
Tidal.cycleH	0.158787	0.157491	1.008	0.986370	
Tidal.cycleF	0.121639	0.189171	0.643	0.3133	

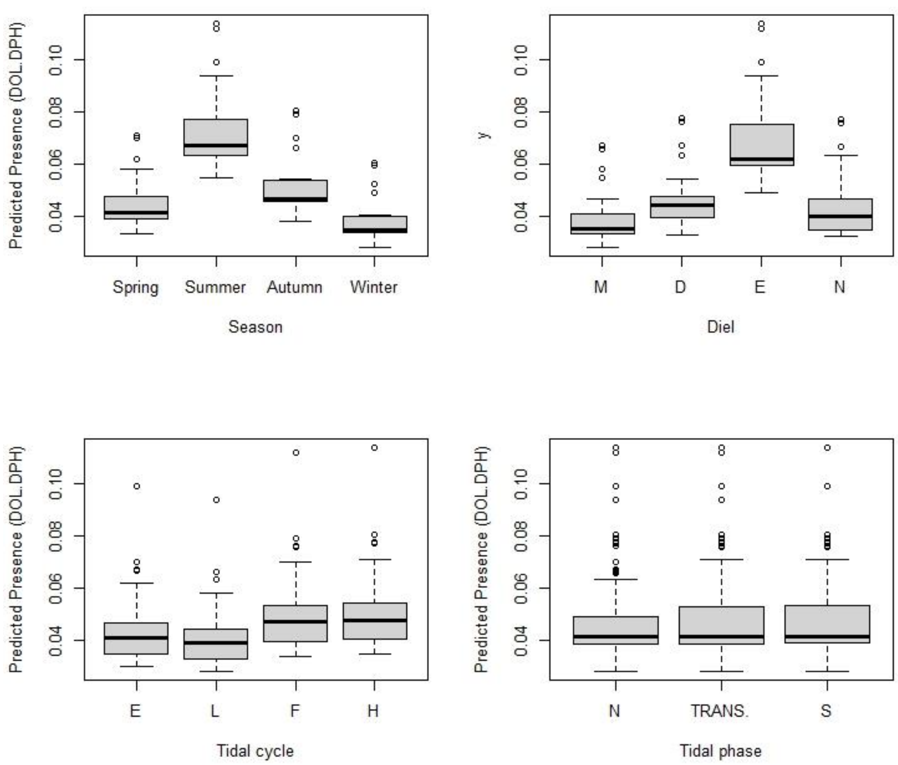


Figure 21. The predicted probability of bottlenose dolphin presence at LNG2 according to 1. Season, 2. Diel, 3. Tidal cycle and 4. Tidal phase

Comparison with SAM off Moneypoint

SAM data also collected from Moneypoint (2.8 km on the north shore of the Shannon Estuary) concurrent to monitoring of LNG. A random 46 day sample period was used to compare simultaneous monitoring days across all three sites (Between March and May 2020). This showed that detections were similar across all three sites during March and April but an absence of dolphins off Moneypoint was noted in the latter half of April, while detections continued off both LNG sites. However, a non-parametric Kruskal Wallis test (due to a non-normal dataset) (Table 8) showed no significant difference between the three locations showing all three area are regularly used by bottlenose dolphins.

Table 13. Kruskal Wallis output results showing the median, average rank and Z-value across three monitoring locations, LNG1, LNG2 and Moneypoint

Location	N	DPM/day	Mean	Ave rank	Z
LNG1	46	220	4.78	67.2	-0.47
LNG2	46	279	6.07	75.1	1.16
Moneypoint	46	156	3.40	66.2	-0.69
Overall	138			69.5	

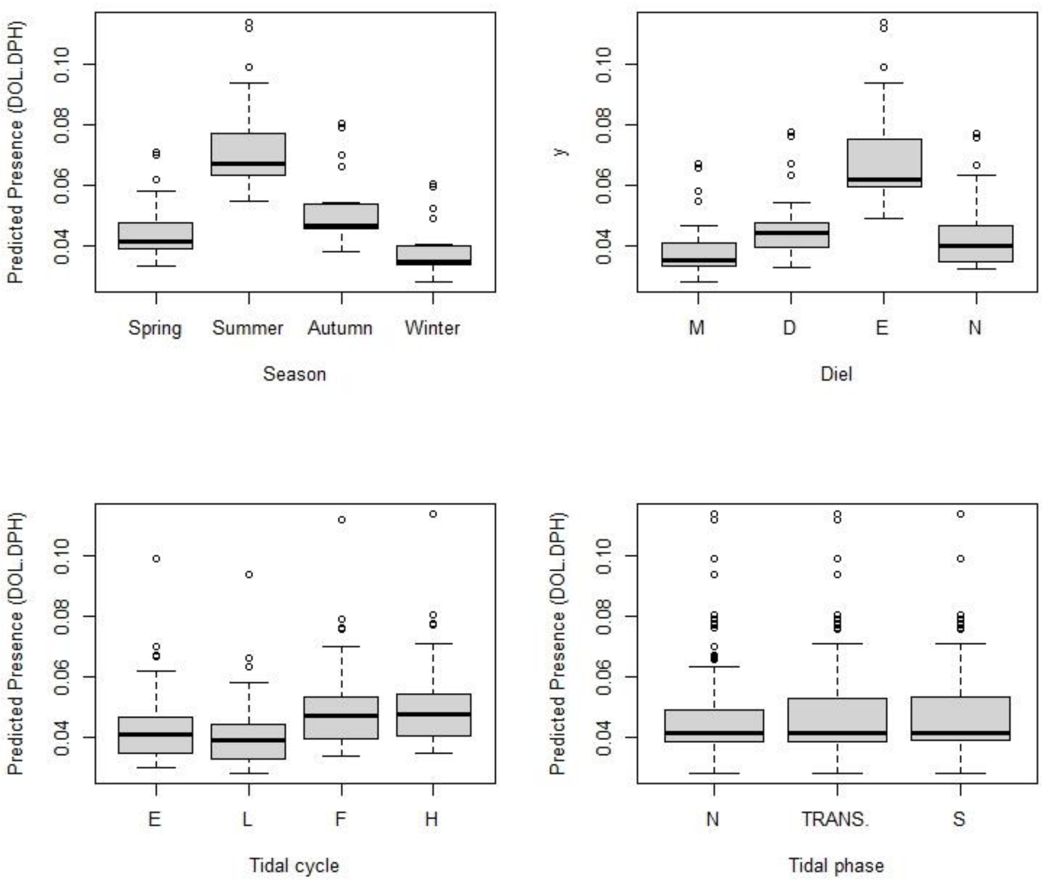


Figure 22. The predicted probability of bottlenose dolphin presence at LNG1 according to 1. Season, 2. Diel, 3. Tidal cycle and 4. Tidal phase

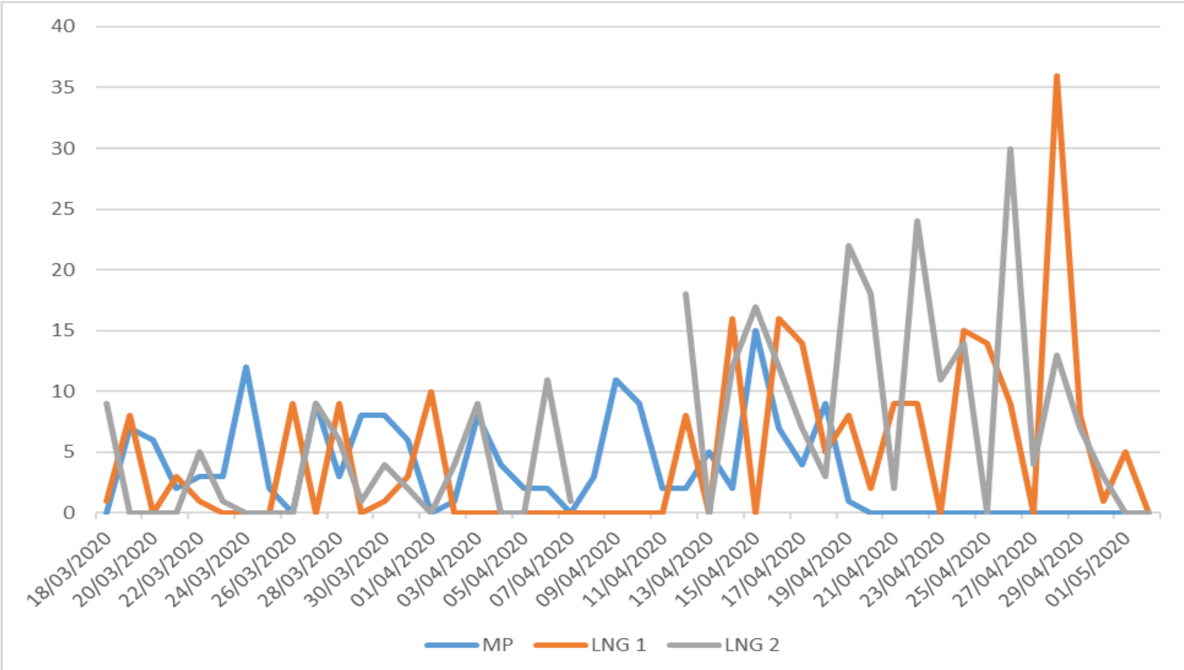


Figure 23. Bottlenose dolphin Detection Positive Minutes (DPM) per day from LNG1, LNG2 and Moneypoint

3.4.2 Year 2: November 2020 – August 2021

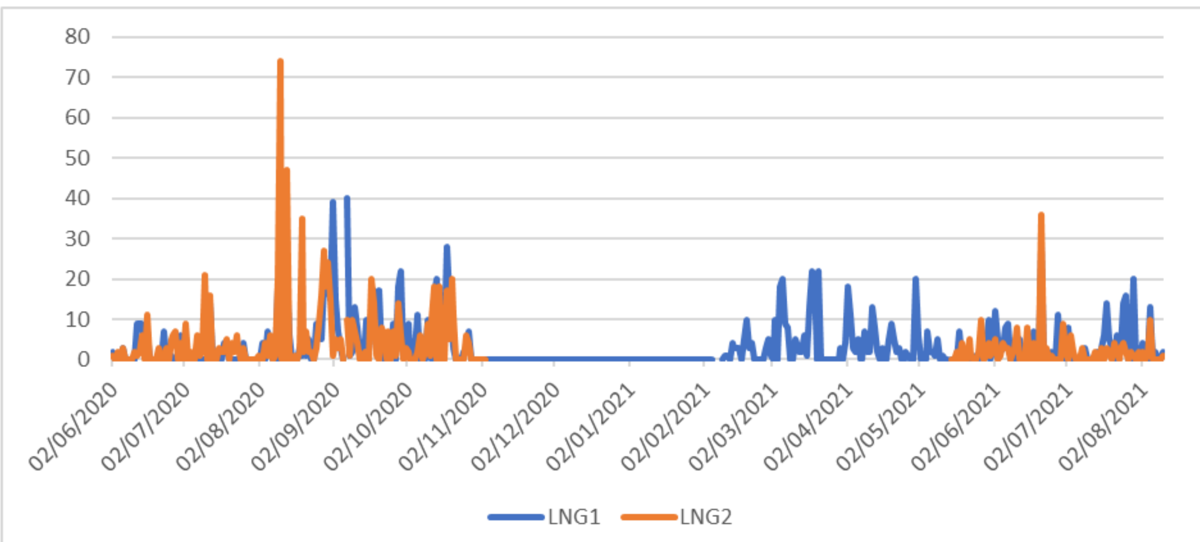


Figure 24. Number of dolphin detections per day recorded across all locations from June 2020 to August 2021 (434 and 245 days)

Dolphins were recorded on respectively 42 and 55% of days at LNG1 and LNG2 sites, and the number of cumulative dolphin positive minutes were similar across the two sites (Table 10). Durations per day ranging from 0-74 minutes with a peak during August 2020 (Figure 24). Detection Positive Minutes across dolphin and porpoise channels were extracted even though only a few records exist in the estuary for porpoises. A total of 47 "porpoise" positive hours occurred at LNG1 while 54 were recorded off LNG2 (Table 10). These detections were not used in the overall statistical model as they are too few to analysis effectively.

LNG1 Monitoring Site

Dolphins were detected on 42% of days monitored at LNG1 across 428 days. Results from the binomial GLM showed season to have a significant effect with more detections during the autumn and spring, and least during winter. Diel effects were also present with significantly more detections during the morning, night compared to day. Lastly, tidal cycle was also found to have significant effect with more detections during a high tide in comparison to flood tide, and less during ebb tide (Table 14, Figure 25).

Table 14. GLM output results showing the estimate, standard error, Wald test statistic and P-values for each predictor. Significant variables are denoted with *

Variables	Estimate	SE	Wald	P(>|W|)	Significance level
Intercept	-3.76767	0.15510	-24.292	**<2e-16**	
Season (relative to Summer)					
SeasonAutumn*	0.60228	0.13117	4.591	4.40e-06	**<0.001**
SeasonWinter*	-16.23978	228.20995	-0.071	0.94327	
SeasonSpring*	0.28428	0.14638	1.942	0.05212	**<0.1**
Diel (Relative to Day)					
Diel E	0.22970	0.14638	1.234	0.21735	
Diel N*	0.43123	0.18620	3.158	0.00159	**<0.01**
Diel M*	0.79068	0.13656	5.062	4.14e-07	**<0.001**
Tidal cycle (relative to Flood)					
Tidal.cycle H*	0.28143	0.14340	1.963	0.04969	**<0.05**
Tidal.cycle E*	-0.44626	0.17142	-2.603	0.00923	**<0.01**
Tidal.cycle L	-0.04708	0.15540	-0.303	0.76191	
Tidal phase (relative to Transitional)					
Tidal.phase Spring	0.15952	0.13940	1.144	0.25248	
Tidal.phase Neap*	0.28330	0.13714	2.066	0.03885	**<0.05**

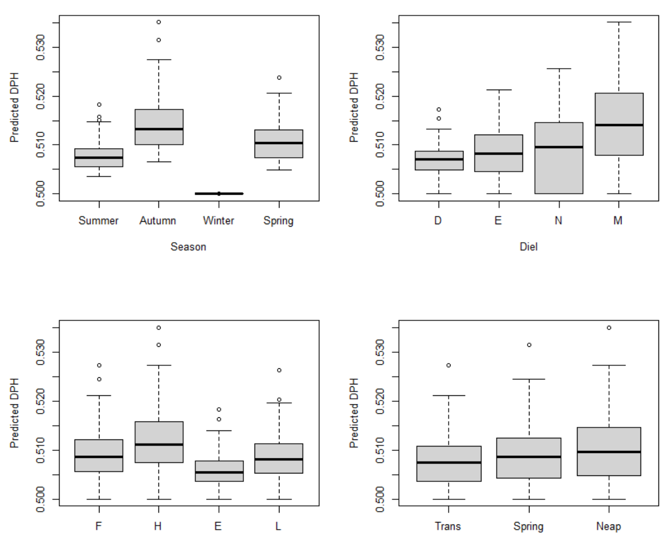


Figure 25. The predicted probability of bottlenose dolphin presence at LNG1 according to 1. Season, 2. Diel, 3. Tidal cycle and 4. Tidal phase

LNG2 Monitoring Site

Bottlenose dolphins were detected on 55% of days at LNG2, monitored across 242 days, with peaks similar to LNG1. Results from the binomial GLM showed neither tidal phase or tidal cycle had any significant effect as the best model only retained season and diel cycle as contributing factors to explain variance in detections. (Table 15, Figure 26). No data was gathered during Spring due to equipment loss, but as in LNG1, detections were higher in Autumn than in Winter. On a daily basis, probability of detection was highest during the morning, followed by night and evening compared to day, similar to the other site.

Table 15. GLM output results showing the estimate, standard error, Wald test statistic and P-values for each predictor. Significant variables are denoted with *

Variables	Estimate	SE	Wald	P(>|W|)	Significance level
Intercept	-3.84747	0.1361	-28.463	**2e-16**	**<0.001**
Season					
Season Autumn*	0.5115	0.1368	3.740	0.000184	**<0.001**
Season Winter	-14.3004	417.9964	-0.034	0.972708	
Diel					
Diel E*	0.4943	0.2223	2.223	0.026214	**<0.05**
Diel N*	0.8328	0.1648	5.053	4.34e-07	**<0.001**
Diel M *	0.9480	0.1946	4.871	1.11e-06	**<0.001**

Table 16. Kruskal Wallis output results showing the median, average rank and Z-value across three monitoring locations, LNG1, LNG2 and Moneypoint

Location	N	DPM/day	Mean	Kruskall-Wallis test
LNG1	142	518	3.64	Chi² = 5.9278
LNG2	142	539	3.80	p-value = 0.05162
Moneypoint	142	573	4.05	

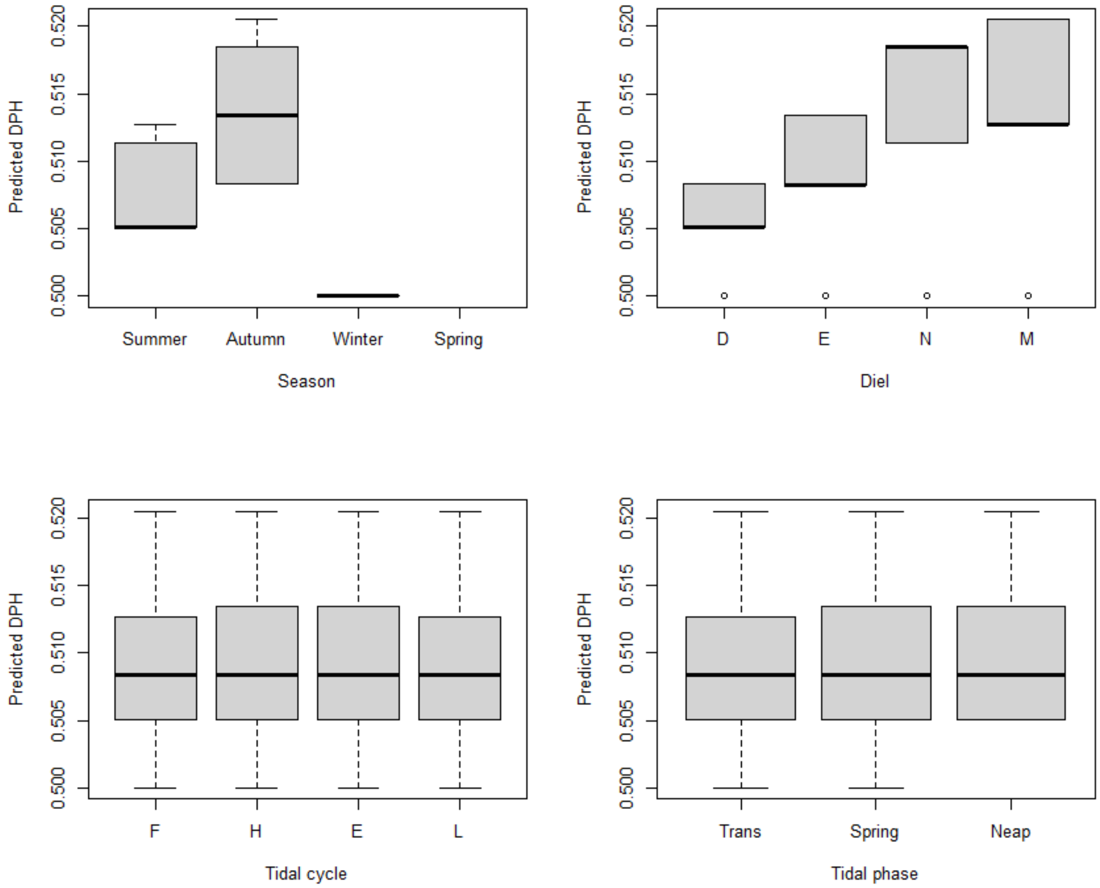


Figure 26. The predicted probability of bottlenose dolphin presence at LNG2 according to 1. Season, 2. Diel, 3. Tidal cycle and 4. Tidal phase

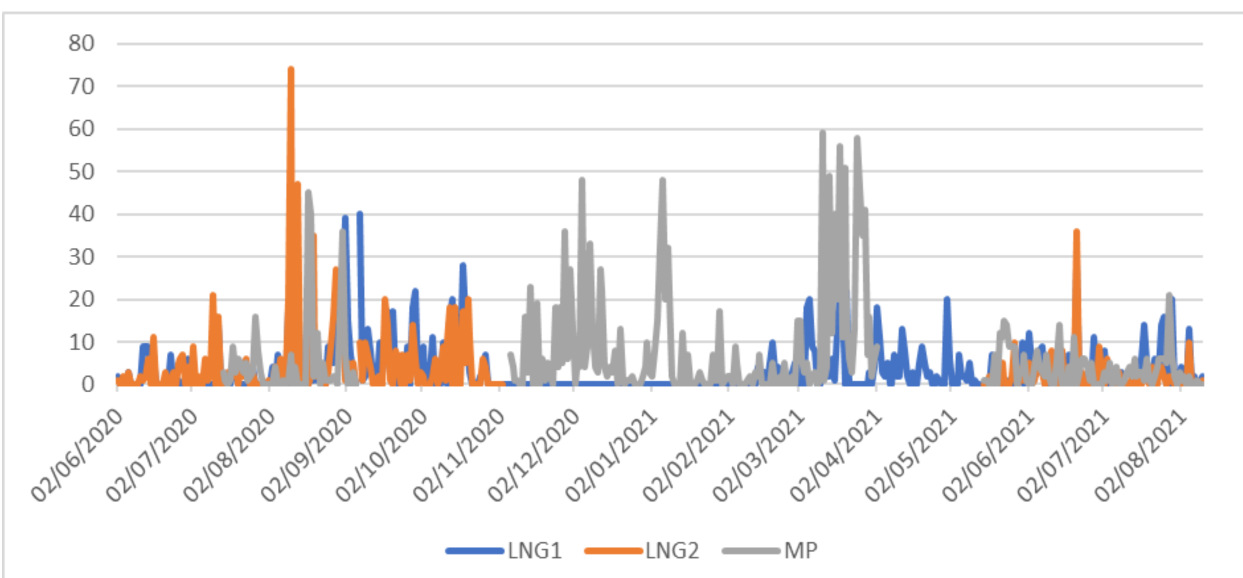


Figure 27. Bottlenose dolphin Detection Positive Minutes (DPM) per day from LNG1, LNG2 and Moneypoint

Comparison with SAM off Moneypoint

SAM data collected from Moneypoint (2.8 km on the north shore of the Shannon Estuary) during the 2020-2021 deployments was used to compare simultaneous monitoring days across all three sites (Between June 2020 and August 2021). This was to determine if detections off Moneypoint were typical for the year when compared to a long term SAM data set collected at this site. Despite slight variations in the daily DPM observed at each site (Figure 27), total and average daily DPM at the three sites were similar when including only dates monitored at the three sites simultaneously (Any day with missing data for at least one of the three sites was excluded), which resulted in a sample size of 142 days (Table 16). A non-parametric Kruskal Wallis test (due to a non-normal dataset) showed no significant difference between the three locations (Table 16).

4.0 Discussion

The IWDG were contracted by New Fortress Energy to assess the use of the proposed site of an LNG terminal off Ardmore Point, Co Kerry by bottlenose dolphins. The dolphins are resident in the estuary with a relatively small population of around 145 individuals. Although the dolphins have been reported throughout the estuary, from Limerick City to the east and off Loop and Kerry Head at the western boundary of the SAC they have also been regularly recorded in Tralee and Brandon Bays outside the SAC. However within this area there are some areas which are more important to dolphins than others. The present study sought to assess the importance of the site of the proposed LNG terminal and jetty to inform environmental impact assessments and planning. It used a combination of visual and acoustic techniques and updated earlier work at the site carried out between 2006 and 2007. As the site is within the Lower River Shannon SAC which list bottlenose dolphins as one of the qualifying interests it is essential that any development does not compromise the sites conservation objectives.

Defining important or "critical" habitats for marine mammals is not straight forward. Critical habitat has been defined as '*habitats that are critical to the survival of the species or community concerned'* (Gibson and Wellbelove 2010). These were described as "*areas or spatial environments that are vital for the day to day survival of individuals of the species and help to maintain a healthy population growth rate*". However, critical habitat should not simply be defined as areas of high animal density. Less densely occupied areas may be more critical to survival, depending on behaviour and population structure, and whether threats in these areas have an impact on the population (Gibson and Wellbelove 2010). Harwood (2001) defined critical habitats as "*in terms of the functioning ecological units required for successful breeding and foraging*".

Ingram and Rogan (2002) delimited critical areas in the Shannon Estuary by using the 50% contour derived from harmonic mean transformation of sighting locations. During this two-year study they showed that dolphins exhibited preferential use of areas of the estuary with the greatest benthic slope and depth (Fig. 18), highlighting the influence of environmental heterogeneity on habitat use by this species. The area off Ardmore Point, although providing benthic slope habitats was not identified as a critical area, however this study is now nearly 20 years old.

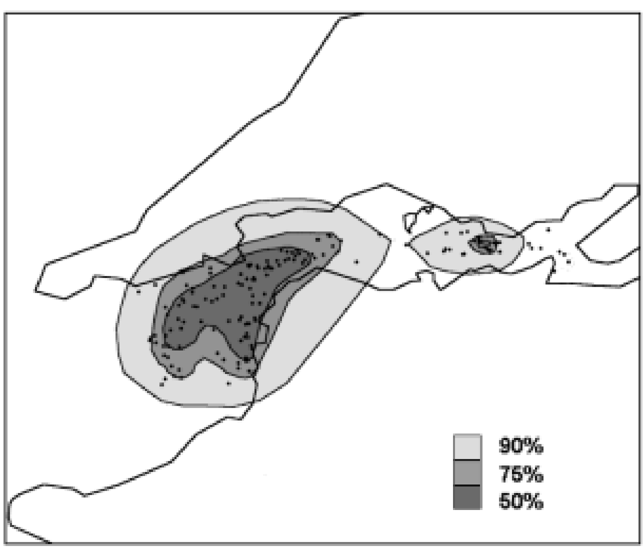


Figure 28. Distribution of bottlenose dolphin sightings within the outer Shannon Estuary. Each encounter location (n = 150) is denoted by a point. Contours are plotted to show the location of 50, 75 and 90% harmonic mean isopleths (from Ingram and Rogan 2002)

Visual monitoring

A combination of visual monitoring and Static Acoustic Monitoring (SAM) were used to assess dolphin use of the site. A total of 50 land-based watches were carried out between April 2020 and April 2021. Watches were carried out every week if sea conditions were suitable and for up to 6 hours each day. Dolphins were observed from Ardmore Point during 30 (60%) of watches, with a total of 42 sightings, ranging from 1-3 different groups per watch. There was a significant increase in the presence of dolphins on flooding tides, especially ebb tides and during Autumn showed to have a higher proportion of positive scans compared to the other seasons, with the lower proportion in spring. A change in dolphin distribution in July and August after the spring run of salmon, was reported by Barker and Berrow (2015), which has been associated with prey switching to pelagic species. Mean group size (±SD) of all groups recorded during watches was 5.5±4.0 dolphins which is quite consistent with that reported by Barker and Berrow (2015) for the inner estuary sub-group. Most sightings of bottlenose dolphins from Ardmore Point were of groups off Moneypoint and mid-channel. There were twelve sightings within 500m of Ardmore Point and of these one was within 100m and two within 50m of the shore. Seven of these sightings within 500m of Ardmore Point were of dolphins travelling and did not stop at the site. Probable foraging activity was observed on four occasions. Dolphins rarely exhibited social behaviour while travelling past Ardmore Point.

A total of 31 individual dolphins were recorded at the proposed development site off Ardmore Point, with 26 during dedicated transects. Some of these dolphins are the oldest individuals known while 10 calves of known age were also recorded, including five neonates born during 2018, 2019 and 2020. Although the bottlenose dolphins in the Shannon Estuary are found throughout the estuary some element of habitat partioning is evident. Baker et al. (2017b) carried out movement analysis and showed only 25% of the population of 145 individuals made regular use of the inner estuary. The dolphins frequently recorded in the "inner" estuary which is defined as east of Scattery Island, were also regularly recorded in the outer estuary, but a large proportion of the dolphins recorded in the "outer" estuary (west of Scattery Island) were never recorded in the inner estuary (Baker et al. 2017b). The "inner estuary" group numbers around 30-40 individuals of which nearly 70% have been recorded within and adjacent to, the proposed development site during this study.

Static Acoustic Monitoring

SAM was used to provide high resolution data of the use of the site by bottlenose dolphins. Two sites within the foreshore lease area were monitored. These sites were consistent with a similar study carried out between 2006 and 2007. The proportion of days with dolphin detections were very consistent throughout the monitoring period ranging from 37-69% of days at LNG1 and 47-62% of days at LNG1. Mean DPM per day which is a more robust measure of occurrence was also consistent ranging from 3.0-6.3 of days at LNG1 and 2.1-4.6 of days at LNG1. This compares to on 65% of days at LNG1 and 35% of days at LNG2 between 2006 and 2007 (Berrow 2007). Mean DPM per day at LNG1 and LNG2 in the present study was 4.4 and 3.6 (Year 1) and 3.1 and 3.7 (Year 2), compared to 1.6 and 0.5 in 2006-2007.

Monitoring at the site in 2006 and 2007 used T-PODs (Timed Porpoise Detector) which were the only available device for this type of work at the time. The C-POD, a digital version of the T-POD, was released in 2009 and O'Brien et al. (2013) conducted trials to compare the efficiency of both devices. They showed that C-PODs recorded seven times more detections than T-PODs during the same deployment period due, for example, to a greater sensitivity and detection range of the C-POD. Thus direct comparison of current detection rates from C-PODs with past acoustic monitoring at the site using T-PODs is not recommended. However it is reasonable to compare the broad overall trends in use of the site by dolphins at the site during these two studies.

During the current study there was a significant effect of season at LNG1 with fewer detections during autumn and winter compared to other seasons. More detection occurred during the evening and night. Lowest detection rate was associated to a flood tide. The only significant variable at LNG2 was increased detections in the evening, despite a similar overall number of detections at both sites. Between 2020 and 2021, fewest detection occurred in winter compared to other seasons. As in year 1, diel cycle was a significant factor affecting detection, highest during the morning, night and evening in compared to day. Tidal cycle was only significant at LNG1 site, with more detection occurring during high tide and flood.

Excluding the peak in autumn detections in 2020-2021, these trends were similar to that obtained at the same site during 2006 to 2007 although more detections were recorded during summer compared to the autumn in the present study and there were slightly more detections around night time at both sites. This suggests that these data do accurately represent the use of the site by bottlenose dolphins.

If we compare the results from the present study to studies carried out elsewhere in the estuary then we can put the use of the site into a wider context. The percent of days with detections is a crude estimate of dolphin presence. The highest occurrence was recorded off Moneypoint Power Station across the estuary from the proposed Shannon LNG site with around 70-80% of days with detections (Table 9). Detections from the current study (62% of days monitored the first year, 42-55% the second year) were similar to Tarbert (63%), Foynes (41%, 47%) or Moneypoint in 2016-2017 (54%) and greater than sites further up river, at which the percent of days with detections declined as you move furthest east.

A more detailed index is the mean number of Detection Positive Minutes (DPM) per day. Long-term SAM from Moneypoint Jetty returns a mean of around 6-7 DPM/day (Table 9). Detection rates during a shorter study at Tarbert jetty, just upriver of the proposed development site, was greater at 12.5 DPM/day. Further upriver, detections decreased as shown at Foynes, Aughinish and Shannon Airport monitoring sites (Table 9). These data compare to 4.4 and 3.6 (year 1) and 3.1 and 3.7 (year 2) DPM/day at LNG1 and 2 during the present study. Carmen et al. (2021), analysed click trains recorded at Moneypoint, during a total of 1,720 monitoring days between January 2009 and October 2015. Click trains were recorded across 71% of days monitored, 8.4% trains classified as foraging and showing seasonal variation in foraging suggests that Moneypoint is an important feeding area mainly during winter and spring. The differences in foraging across the tidal phases were relatively small, suggesting little effect on foraging, while tidal cycle, on the other hand, showed increased foraging detections during slack high tides and ebbing tides.

Clearly dolphins regularly occur at the proposed development site but their presence and detections are lower than at known foraging sites such as Moneypoint (2.8km across the estuary from Ardmore Point) (Carmen et al. 2021).

Results over a total of 641 days showed that tidal cycle had the greatest effect on detections, with the highest proportion of detections occurring during an ebbing tide and at slack low water. Seasonal differences in bottlenose dolphin presence were found to be significant with winter and summer having a higher detection rate than autumn and spring. Significant variance across diel cycle was attributed to a higher level of detections during the night and morning and significantly more detections during spring compared to neap tides (O'Brien et al. 2013).

Table 17. Comparison of results from SAM studies in the Shannon Estuary

Location	Duration (days)	% of days with detections	Detection Positive Minutes	Mean DPM/day (dolphin)	Reference
Moneypoint					
Jan 2009 - Feb 2011	671	73	4245	6.2	O'Brien et al. (2013)
Nov 2011 - Nov 2012	351	80	2737	7.0	O'Brien and Berrow (2012)
July 2016 - Mar 2017	142	54	895	6.3	O'Brien and Berrow (2017)
2009 - 2015	1,720	71			Carmen et al. (2021)
Tarbert					
July 2016 - March 2017	221	63	2762	12.5	O'Brien and Berrow (2017)
Foynes					
Feb 2009 – Oct 2010	591	41	1,227	-	O'Brien et al. (2013)
Nov 2011 - Nov 2012	288	47	1266	4.4	O'Brien and Berrow (2012)
Apr-Aug 2018	140	34	114	0.8	O'Brien and Berrow (2017)
2009-2014	1,428	39			Carmen et al. (2021)
Aughinish					
Nov 2011 - Nov 2012	225	31	252	1.0	O'Brien and Berrow (2012)
2011-2014	812	20			Carmen et al. (2021)
Shannon Airport					
Nov 2011 - Nov 2012	368	21	588	1.5	O'Brien and Berrow (2012)
2011-2013	738	16			Carmen et al. (2021)
Canon Island					
Apr-Aug 2018	140	4	9	0.06	O'Brien and Berrow (2018)
Ardmore Point					
LNG1 (Jun 2006-Jun 2007)*	239	65	262	1.6	Berrow (2007)
LNG2 (June 2006-Jun 2007)*	102	35	35	0.5	Berrow (2007)
LNG1 (Aug 2019-May 2020)	266	62	1239	4.4	This study
LNG2 (Aug 2019-May 2020)	250	62	1273	3.6	This study
LNG1 (Jun 2020-Aug 2021)	428	42	1,308	3.1	This study
LNG2 (Jun 2020-Aug 2021)	242	55	904	3.8	This study

*These data were from T-PODs and not C-PODS

Visual observations suggested that dolphins did regularly pass through the site but rarely stopped for any prolonged period. SAM data supported this with most detections of short duration though occasionally they occurred for longer periods. It is clear from the SAM data that dolphins regularly use the proposed site of the LNG terminal. The site is likely used as a transition corridor where dolphins regularly move between the inner and outer estuary.

In conclusion, we have shown that bottlenose dolphins regularly use the waters off Ardmore Point, which is the site of the proposed Shannon LNG terminal. The results from monitoring during 2019-2020 are broadly consistent with results obtained during monitoring at the same site during 2006-2007. Although dolphins were regularly recorded at the site there use seems largely transitory, passing through the site. There was no evidence dolphins are present for long periods or that it is used for foraging. However the site is an important part of the range of the bottlenose dolphins in the Shannon estuary.

The Shannon dolphins are a relatively small, and genetically discrete population and any degradation in this area will impact on the overall quality of the estuary for bottlenose dolphins and it is important that any development should ensure that there is no significant impacts on the dolphin population or its habitats.

5 References

Anon. (2019). Strategic integrated framework plan for the Shannon Estuary (2013–2020). RPS Consultants. Retrieved 26 May 2019 from http://www.limerick.ie/council/strategic-integrated-framework-plan

Baker, I. (2015) Researcher's guide to protocols for fieldwork and data entry (third edition). Shannon Dolphin and Wildlife Foundation, p 32.

Baker, I., O'Brien, J., McHugh, K. and Berrow, S. (2017a) An Ethogram for Bottlenose Dolphins (*Tursiops truncatus*) in the Shannon Estuary, Ireland. Aquatic Mammals 2017, 43(6), DOI 10.1578/AM.43.6.2017.

Baker, I., O'Brien, J., McHugh, K, Ingram, S. and Berrow, S. (2017) Social structure of a bottlenose dolphin (*Tursiops truncatus*) population is distinguished by age, area and female-male associations. Marine Mammal Science 34(2), 458-487. https://doi.org: 10.1111/mms/12562

Baker, I., O'Brien, J., McHugh, K, and Berrow, S. (2018) Female reproductive parameters and population demographics of bottlenose dolphins (*Tursiops truncatus*) in the Shannon Estuary, Ireland. Marine Biology 165:15 https://doi.org/10.1007/s00227-017-3265-z.

Barker, J. and Berrow, S. (2015) Temporal and spatial variation in group size of bottlenose dolphins (*Tursiops truncatus*) in the Shannon Estuary, Ireland. Biology and Environment: Proceedings of the Royal Irish Academy.

Beck, S., O'Brien, J., Berrow, S.D. and O'Connor, I. (2013) Assessment and monitoring of ocean noise in Irish waters. STRIVE report 2011-W-MS-6 prepared by the Galway–Mayo Institute of Technology for the Environmental Protection Agency, Wexford, Ireland.

Berrow, S.D., Holmes, B. and Kiely, O. (1996) Distribution and abundance of Bottle-nosed dolphins *Tursiops truncatus* (Montagu) in the Shannon estuary, Ireland. Biology and Environment. Proceedings of the Royal Irish Academy 96B (1), 1-9.

Berrow, S. D., McHugh, B., Glynn, D., McGovern, E., Parsons, K. M., Baird, R. W., and Hooker, S. K. (2002). Organochlorine concentrations in resident bottlenose dolphins (*Tursiops truncatus*) in the Shannon Estuary, Ireland. *Marine Pollution Bulletin*, *44*(11), 1296-1303.

Berrow, S.D. (2007) Dolphin monitoring as part of Shannon LNG Environmental Impact Assessment Draft Final Report to ARUP Engineering. Shannon Dolphin and Wildlife Foundation 23pp.

Berrow, S.D. (2009) Winter distribution of Bottle-nosed Dolphins *Tursiops truncatus* (Montagu) in the inner Shannon Estuary. Irish Naturalists' Journal. 30(1), 35-39.

Berrow, S., O'Brien, J., Groth, L., Foley, A. and Voigt, K. (2012) Abundance estimate of bottlenose dolphins (*Tursiops truncatus*) in the Lower River Shannon candidate Special Area of Conservation, Ireland. Aquatic Mammals 38(2), 136-144.

Blázquez, M., Baker, I., O'Brien, J.M. and Berrow, S.D. (2020) Population Viability Analysis and Comparison of Two Monitoring Strategies for Bottlenose Dolphins (*Tursiops truncatus*) in the Shannon Estuary (Ireland) to Inform Management. Aquatic Mammals 46(3), 307-325, DOI 10.1578/AM.46.3.2020.307.

Carstensen, J. Henriksen, O.D. and Tielmann, J. (2006) Impacts of offshore wind farm construction on harbour porpoises: acoustic monitoring of echo-location activity using porpoise detectors (TPODs). *Marine Ecology Progress Series*, 321, 295-308.

Carmen, M., **Berrow, S.D**., O'Brien, J.M. (2021) Foraging Behavior of Bottlenose Dolphins in the Shannon Estuary, Ireland as Determined through Static Acoustic Monitoring. J. Mar. Sci. Eng. 2021, 9, 275. https:// doi.org/10.3390/jmse9030275

Englund, A., Ingram, S. and Rogan, E. (2007). *Population status report for bottlenose dolphins using the Lower River Shannon SAC, 2006-2007*. Dublin, Ireland: Final Report to the National Parks and Wildlife Service.

Englund, A., Ingram, S. and Rogan, E. (2008). *An updated population status report for bottlenose dolphins using the Lower River Shannon SAC in 2008*. Dublin, Ireland: Report to the National Parks and Wildlife Service.

Erbe C, Marley SA, Schoeman RP, Smith JN, Trigg LE and Embling CB (2019) The Effects of Ship Noise on Marine Mammals—A Review. Front. Mar. Sci. 6:606.doi: 10.3389/fmars.2019.00606.

Fouda, L., Wingfield, J. E., Fandel, A. D., Garrod, A., Hodge, K. B., Rice, A. N. and Bailey, H. (2018). Dolphins simplify their vocal calls in response to increased ambient noise. Biology Letters. 14, 20180484. doi:10.1098/rsbl.2018.0484.

Gibson, L.E and Wellbelove, A.P. (2010) Protecting Critical Marine Habitats: The key to conserving our threatened marine species WWF-Australia | Humane Society International.

Harwood, J.A. (2001) Marine mammals and their environment in the Twenty-first century. Journal of mammology 82(3) 630-631.

Hastie, G.D., Wilson, B. and Thompson, P.M. (2003) Fine-scale habitat selection by coastal bottlenose dolphins: application of a new video montage technique. Can J Zool 81:469–478.

Hildebrand, J.A. (2005) Impacts of anthropogenic sound. The Johns Hopkins University Press, Baltimore, MD.

Holt, M. M., Noren, D. P., Dunkin, R. C., and Williams, T. M. (2015). Vocal performance affects metabolic rate in dolphins: implications for animals communicating in noisy environments. J. Exp. Biol. 218, 1647–1654. doi: 10.1242/%u200Bjeb.122424.

Ingram, S. D. (2000). *The ecology and conservation of bottlenose dolphins in the Shannon Estuary, Ireland* (Unpub. doctoral dissertation). University College Cork, Corcaigh, Ireland.

Ingram, S. N., and Rogan, E. (2002). Identifying critical areas and habitat preferences of bottlenose dolphins *Tursiops truncatus*. *Marine Ecology Progress Series*, *244*, 247-255.

Ingram, S., and Rogan, E. (2003). *Bottlenose dolphins (Tursiops truncatus) in the Shannon Estuary and selected areas of the west-coast of Ireland*. Dublin, Ireland: Report to the National Parks and Wildlife Service.

Levesque, S., Reusch, K., Baker, I., O'Brien, J. and Berrow, S. (2016) Photo-Identification of Bottlenose Dolphins (*Tursiops truncatus*) in Tralee Bay and Brandon Bay, Co. Kerry: A Case for SAC Boundary Extension. Biology and Environment: Proceedings of the Royal Irish Academy 2016. DOI: http://dx.doi.org/ 10.3318/BIOE.2016. 11

Lusseau D, Slooten E, Currey RJC (2006) Unsustainable dolphin-watching tourism in Fiordland, New Zealand. Tourism Mar Environ 3:173–178.

Mahon, M., Berrow, S.D. and O'Brien (In prep). Assessing the effects of onshore drilling on bottlenose dolphins (*Tursiops Truncatus)* in the Shannon Estuary Special Area of Conservation (SAC) Ireland, and a comparison of acoustic monitoring techniques.

McKenna, M.F., Katz, S.L., Wiggins, S.M., Ross, D., Hildebrand, J.A. (2012) A quieting ocean: unintended consequence of a fluctuating economy. Journal of the Acoustical Society of America 132:EL169–EL175.

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 using Irish coastal waters. Animal Conservation. 14(4), 342-353.

Noren, D. P., Holt, M. M., Dunkin, R. C., and Williams, T. M. (2013). The metabolic cost of communicative sound production in bottlenose dolphins (*Tursiops truncatus*). J. Exp. Biol. 216, 1624–1629. doi: 10.1242/jeb.083212.

NPWS (2012) Lower River Shannon SAC (site code: 2165) Conservation objectives supporting document: marine habitats and species. Version 1. National Parks and Wildlife Service. March 2012.

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.

Nuuttila, H. K., Courtene-Jones, W., Baulch, S., Simon, M., and Evans, P. G. H. (2017). Don't forget the porpoise: acoustic monitoring reveals fine-scale temporal variation between bottlenose dolphin and harbour porpoise in Cardigan Bay SAC. *Marine Biology*, *164*(3), 50. https://dx.doi.org/10.1007/s00227-017-3081-5.

O'Brien, J. and Berrow, S. (2012) The use of deep-water shipping berths by bottlenose dolphins in the Shannon Estuary. Final Report from static acoustic monitoring at Moneypoint, Foynes, Aughinish and Shannon Airport in the Shannon Estuary cSAC between November 2011 and November 2012. Shannon Integrated Framework Plan. pp18.

O'Brien, J., Beck, S., Wall, D. and Pierini, A. (2013) Developing Acoustic Monitoring Techniques In *Marine Mammals and Megafauna in Irish Waters – Behaviour, Distribution and Habitat Use*. (Eds. Berrow, S.D., O'Brien, J., O'Connor, I., McGrath, D. and Wall, D.) Marine Institute SeaChange Marine Research Sub-Programme 2007-2013 (PBA/ME/07/005(02)).

O'Brien, J., Baker, I., Barker, J., O'Donoghue, B., Berrow, S., O'Connell, M. and Ryan, C. (2014) The first confirmed successful re-float of a stranded bottlenose dolphin (*Tursiops truncatus*) in Ireland, and subsequent re-sighting with a neonate. Aquatic Mammals 40(20, 191-194.

O'Brien, J.M., Beck, S., Berrow, S.D., André, M., van der Schaar, M., O'Connor, I., and McKeown, E.P. (2016) The Use of Deep Water Berths and the Effect of Noise on Bottlenose Dolphins in the Shannon Estuary cSAC. The Effects of Noise on Aquatic Life II. Volume 875 of the series Advances in Experimental Medicine and Biology pp 775-783.

O'Brien, J. and Berrow, S.D. (2017) The Use of Areas of Opportunity for Renewable Energy as Potential Tidal Energy sites in the Shannon Estuary by Bottlenose dolphins. *EPA Small Project Grant.* December 2017. pp16.

O'Brien, J. and Berrow, S.D. (2018) Use of a proposed Tidal Energy Site by Bottlenose dolphins in the Shannon Estuary. Final Report to DesignPro December 2018. pp10.

O'Callaghan, S., Daly, M., Counihan, R., O'Connell, M., Berrow, S. and O'Brien, J. (2021) Harbour Porpoise (*Phocoena phocoena*) sightings, strandings and acoustic detections from within the inner Shannon Estuary. Irish Naturalists' Journal (in press).

O'Connell, M. and Berrow, S. (2019) Records from the Irish Whale and Dolphin Group for 2017. Irish Naturalists' Journal 36(2): 175-183.

OSPAR (2012) Measurements of ship noise. Information document. EIHA 12/4/Info.4-E

Rogan, E., Nykänen, M., Gkaragkouni, M., and Ingram, S. (2015). *Bottlenose dolphin surveys in the Lower River Shannon SAC, 2015*. Dublin, Ireland: Final Report to National Parks and Wildlife Service, the Department of Arts, Heritage and the Gaeltacht.

Rogan, E., Garagouni, M., Nykänen, M., Whitaker, A., and Ingram, S. N. (2018). *Bottlenose dolphin surveys in the Lower River Shannon SAC, 2018*. Dublin, Ireland: Final Report to National Parks and Wildlife Service, the Department of Arts, Heritage and the Gaeltacht.

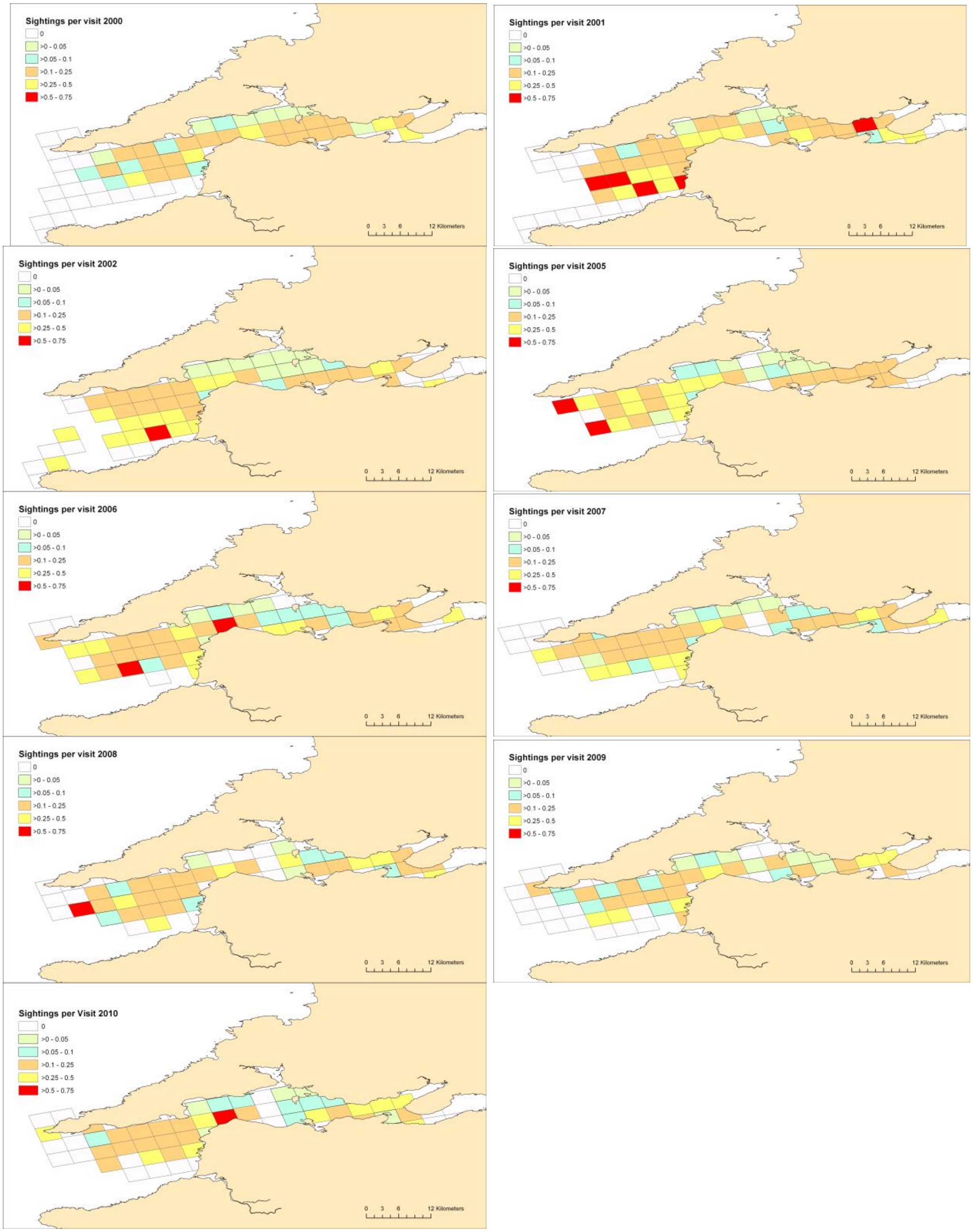
Wilson, O.B.J., Wolf, S.N. and Ingenito, F. (1985). Measurements of acoustic ambient noise in shallow water due to breaking surf. *Journal of the Acoustical Society of America 78*(1): 190-195.

Williams, R., Wright, A. J., Ashe, E., Blight, L. K., Bruintjes, R., Canessa, R., Clarke, K.W., Cullis-Suzuki, S., Dakin, D.T., Erbe, C., Hammond, P.S., Merchant, N.D., O'Hara, P.D., Purser, J., Ranford, A.N., Simpson, S.D., Thomas, L., and Wale, M. A. (2015). Impacts of anthropogenic noise on marine life: publication patterns, new discoveries, and future directions in research and management. *Ocean and Coastal Management*, *115*, 17-24.

Zuur, A. F., Ieno, E. N., Walker, N. J., Saveliev, A. A., and Smith, G. M. (2009). *Mixed effects models and extensions in Ecology with R*. New York, NY: Springer. https://dx.doi.org/10.1007/978-0-387-87458-6.

Zuur, A. F., Hilbe, J. M., and Ieno, E. N. (2013). *A beginner's guide to GLM and GLMM with R*. *A frequentist and Bayesian perspective for ecologists*. Newburgh, UK: Highland Statistics Ltd.

Appendix I: Observed v Expected distribution of bottlenose dolphins from tour boat data 2000-2010 (excluding 2003 and 2004). Source: IWDG Unpubl. data.



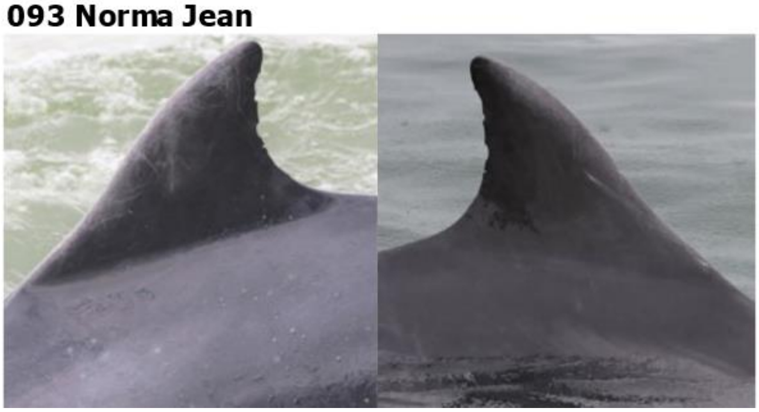
Appendix II: Indivudual Bottlenose Dolphins recorded during dedicated boat transects during 2021

006 Sarafina

044 Luna

084 Sabre

093 Norma Jean



104 Bob

118 Danú

200 Solas

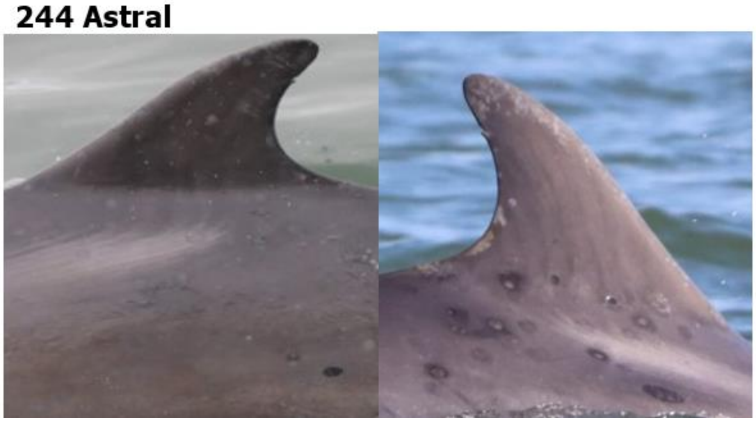
216 – Fae

223 Unnamed

236 Storm

242 Sandy Salmon

244 Astral



312 Prometheus

801 Nala

806 Fiadh

817 Muddy Mackerel

820 Rue

824 Stellar

862 Comet

864 Moon

880 Unnamed

886 Unnamed

887 Unnamed

906 Unnamed