Static Acoustic Monitoring (SAM) of small cetaceans in inner Galway Bay

Final Report

Dr. Joanne O'Brien and Dr. Simon Berrow

04/12/2013

This final report presents SAM results from C-POD deployments in Galway Bay (Mutton Island) between 28 June 2011 and 4 October 2013.

Introduction

Cetaceans live in an acoustic world and increasingly attempts have been made to develop acoustic monitoring techniques rather than relying on visual methods, whose efficiency is hugely dependent on light, weather conditions and sea-state, especially for species such as the elusive harbour porpoise (*Phocoena phocoena* Linneaus). Acoustic monitoring can be carried out in a passive (e.g. towed hydrophone) or static (e.g. T-PODs and C-PODs) mode. Static Acoustic Monitoring (SAM) involves the recording or detection of cetacean vocalisations or echolocation clicks and is a very valuable tool for the exploration of fine scale habitat use by various odontocete species. This monitoring technique can be carried out with a number of devices including, static hydrophones (Berrow *et al.,* 2006), C-PODs and T-PODs (Carlström, 2005; Verfuß *et al.,* 2007; O'Brien *et al.* 2013). By comparison with SAM, visual observations carry with it many constraints and are influenced by variables such as sea state (Evans & Hammond, 2004; Teilmann, 2003; Palka, 1996; Clarke, 1982), observer variability (Young & Peace, 1999; O'Brien *et al.*, 2006), optics and height above sea level. Evans and Hammond (2004) state that visual surveys should generally not be carried out in sea states above Beaufort scale 2, as the probability of detecting animals is strikingly reduced above this. SAM is especially useful for monitoring small vocal odontocetes since it can be carried out without the interference of the variables mentioned above, and does not negatively impact upon the animals.

All cetaceans and their habitats are protected under Irish and international law. The Wildlife Act (1976) and Amendment (2000) entitles all cetaceans and their habitats within territorial waters (up to 12nmls from the coast) to full protection including from disturbance and wilful interference. All cetacean species occur on Annex IV of the EU Habitats Directive and are thus entitled to strict protection. Two species (harbour porpoise and bottlenose dolphin) are on Annex II which requires the designation of Special Areas of Conservation (cSAC) to protect a representative range of their habitats. In order to evaluate the importance of an area, it is fundamental that the presence of small cetaceans at a site is fully understood and this requires monitoring over time scales of at least years. Visual monitoring of cetaceans can provide density and abundance estimates but can be biased due to factors such as observer effect and unfavourable sea conditions. Therefore, a complete overview of site usage by cetaceans cannot be achieved by this method alone, necessitating the requirement of SAM to fully evaluate the importance of a site. Through SAM, intrinsic datasets, robust enough to detect distinctive trends in presence across a range of factors can be achieved much more rapidly than visual means.

The Irish Whale and Dolphin Group (IWDG) were contracted by McCarthy Keville O'Sullivan LTD on behalf of Galway Harbour Authority to carry out a baseline Static Acoustic Monitoring (SAM) survey of small cetaceans adjacent to the proposed extension area of Galway Docks, between June 2011 and October 2013. This final report includes a detailed exploration of cetacean activity in the vicinity as determined through Static Acoustic Monitoring using C-PODs.

Methods

<u>Static Acoustic Monitoring</u>

Static Acoustic Monitoring (SAM) was carried out at a single site approximately 500m south of Mutton Island lighthouse using self-contained monitoring units called C-PODs (Figure 1).

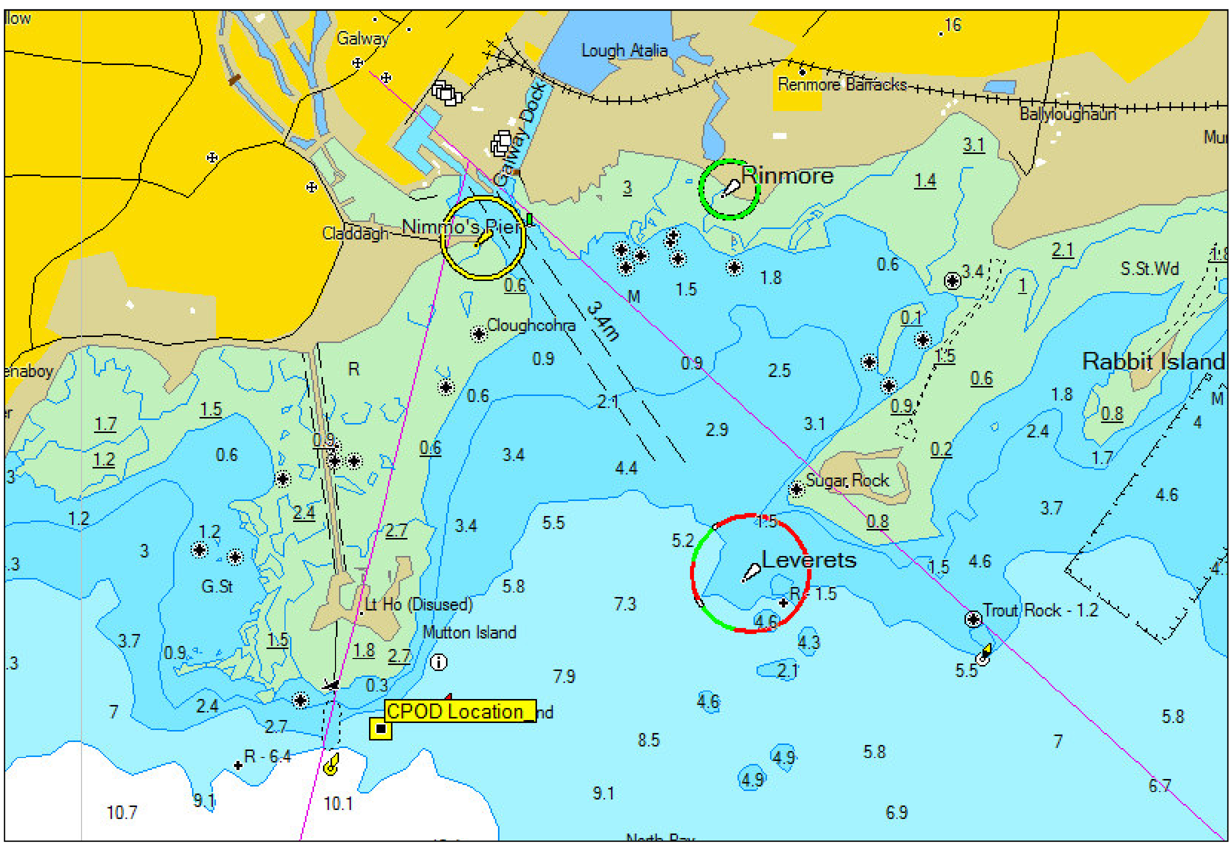

Figure 1. Position of the C-POD during the survey

C-PODs (Figure 2) are self-contained click detectors which log the echolocation clicks of porpoises and dolphins. A single C-POD can monitor both porpoise and dolphins simultaneously through identifying characteristic click parameters which can be assigned to either species. Once deployed at sea, the C-POD operates in a passive mode and are constantly listening for tonal clicks within a frequency range of 20kHz to 160kHz. When a tonal click is detected, the C-POD records the time of occurrence, centre frequency, intensity, duration, bandwidth and frequency of the click. Internally, the C-POD is equipped with a Secure Digital (SD) flash card, and all data are stored on this card. Dedicated software, CPOD.exe, provided by the manufacturer, is used to process the data from the SD card when connected to a PC via a card-reader. This allows for the extraction of data files under pre-determined parameters as set by the user. Additionally, the C-POD also records temperature over its deployment duration. It must be noted that the C-POD does not record actual sound files, only information about the tonal clicks it detects. Using the dedicated C-POD.exe software, a train detection algorithm is run through the raw data to produce a CP.3 file. Through this process of train detection, C-PODs record a wide range of click types but the train detection searches for coherent trains within them. Recent detection distance trials carried out in Galway Bay show a maximum detection distance of 534m for harbour porpoises, while results from trials in the Shannon Estuary were 797m for bottlenose dolphins (O'Brien *et al.,* 2013).

Figure 2. C-POD unit by Chelonia LTD

Deployments

A single C-POD was deployed close to Mutton Island (53° 15.022N, 9°03.145W) from 28 June 2011 to 4 October 2013 (27 months, 804 days). During the third deployment on 8 January, 2012, a C-POD unit became detached from the main mooring and drifted ashore. The unit was found by a local fisherman washed up on a beach at Oranmore in early February, and a new unit was re-deployed on 20 February, therefore approximately 30 days monitoring were lost at the site at this time. However, this was the only gap in the data acquisition at the site over the 27 months.

Moorings

Light weight mooring designs were employed during monitoring of the site. These consisted 40kg bottom weights acting as anchors, with a roped line running from the surface mooring buoys to the bottom weights. At approximately mid-water a loop was etched in the line and the C-POD units were shackled secure. The units are positively buoyant, but salmon float are attached to them to ensure they stay upright even in heavy seas and strong currents (Figure 3).

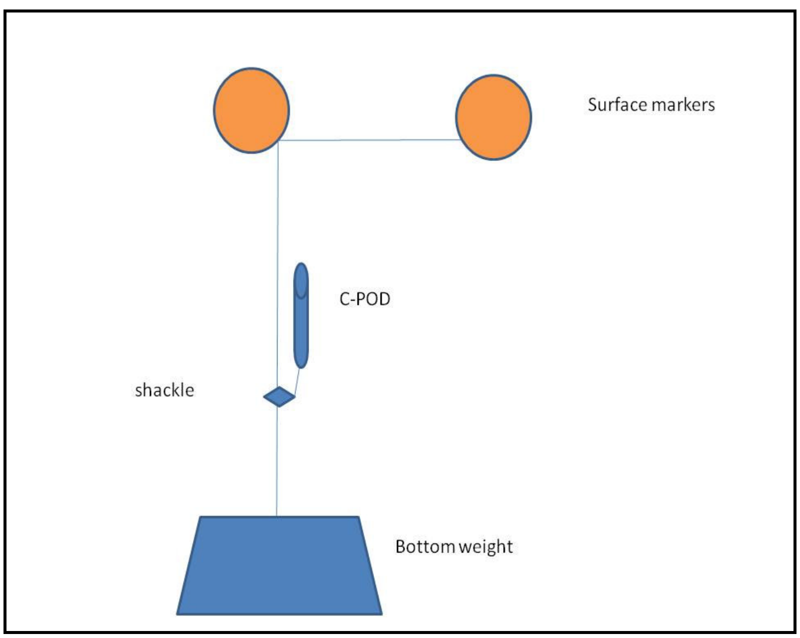

Figure 3. Diagram of moorings used to deploy C-PODs during SAM survey off Mutton Island

C-POD calibration

Calibration of 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. Field calibrations aim to assess differences in sensitivity between units, and also facilitate comparisons between datasets from different locations using multiple loggers (O'Brien *et al*., 2013). This is especially 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 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 are carried out in high density areas in order to determine the detection function (O'Brien *et al.* 2013). The field calibration of new units should be carried out in conjunction with a reference C-POD, where a single unit is used solely for calibrations and is deemed a reference. This allows for the incidence where new units are acquired over the course of a project to be calibrated with the reference. Calibration trials were carried out in the Shannon Estuary prior to commencement of monitoring during the present survey.

Seven separate units were used to carry out SAM during the present project. Prior to the commencement of this project, all C-PODs were deployed in the Shannon Estuary with a total of 16 units (Figure 4). This was carried out in conjunction with another project and provided further confirmation that C-PODs were conforming within an acceptable standard. C-PODs 173, 547, 548, 796, 947, 951 and 1525, were deployed with a reference unit 169 and deployed synchronously strapped together in the Shannon Estuary for 23 days (Figure 5). This allowed enough time to establish if sensitivity would be a confounding factor between units before been deployed as part of the present study.

Upon recovery of the units, data were extracted under two categories, 1) NBHF (porpoise band) and 2) Other (dolphin band) using the C-POD.exe software (Version 2.013, June 2011). These data were in the form of Excel.xlsx files using C.POD.exe software and analysed as Detection Positive Minutes (DPM) across hourly segments. Statistical analyses were carried out using the program R (R Development Core Team, 2011). All combinations of C-POD pairs were modelled using an orthogonal regression of DPM across hourly segments. This was compared to a null model, assuming no variation in C-POD detections, a = 0 and b = 1, and used to assess C-POD performance. An error margin of ±20% DPM per hour was plotted along the null model to distinguish between an acceptable level of variation in C-POD performance and problematic variation due to faulty or highly sensitive units (Tregenza pers comm.). From these graphs it is possible to determine successful or unsuccessful C-POD combinations. The mean intercept and gradient values of the orthogonal model for each C-POD pair were extracted and used to create centipede plots where, deviation from 0 on the horizontal axis, of mean intercept values and deviation from 1 on the horizontal axis, of mean gradient values indicated deviations from the null model. This was also used to identify if only one or two POD combinations were unsuccessful and also the extent of variability within the intercept and gradient values. Results were then used to highlight poor performing units or very sensitive units, if they existed and a correction factor can be generated and applied to the data.

Long-term analyses

The long-term dataset was categorised into the following factors year, season, diel, tidal phase and tidal cycle in order to explore potential factors influencing the presence of dolphins and porpoises at the site. Season was categorised as spring (February, March, April), summer (May, June, July), autumn (August, September, October) and winter (November, December, January). Diel cycle was split into four phases (morning, day, evening and night) following methods described by Carlström (2005). Morning began at the onset of civil twilight, and the length was calculated as twice the duration between the beginning of civil twilight and sunrise. Evening ended at the end of civil twilight and lasted twice the duration of the time between sunset and end of civil twilight. Information on sunset and sunrise was obtained from the U.S. Naval Observatory (http://aa.usno.navy.mil/data/docs/RS_OneDay.php). As data were extracted from the C-POD units by hour, times between 12:30 and 13:29 were classified as 13:00, times between 13:30 and 14:29 were classified as 14:00 etc. Tidal phase was categorised according to the phases of the moon using admiralty data (WXTide 32). Spring tide was calculated as 24 hours either side of the highest high water and neap tide lowest low water (O'Brien, 2009). Data were further classified by tidal cycle. One hour before and after high water was termed slack high, while one hour before and after low water was termed slack low. Hours that fell between slack high and slack low were deemed an ebbing tide. Similarly hours that fell between slack low and slack high were deemed as flood.

In order to facilitate this analyses the dataset was then converted to the binomial Detection Positive Hours (DPH), where 1=detection(s) recorded and 0=no recorded detections in order to reduce the amount of zeros in the dataset. C-POD ID number was included as a random factor and a binomial generalized linear mixed-effect model (GLMM) was fitted using R statistical software (R Development Core Team, 2011). Akaike's information criterion (AIC), log likelihood and a histogram of fitted residuals were used as diagnostic tools for model selection. Wald chi-squared tests were computed for each variable and predicted proportions of DPH were extracted across all levels.

Results

Calibration trials

All units used over the duration of the present study were calibrated as part of a bigger project where 16 units were deployed together in the Shannon Estuary. Results from this extensive trial are presented in Figure 4 and some discrepancies between units are evident. However, as part of the present project calibration analyses was only carried out on the 7 units deployed (173, 547, 548, 796, 947, 951 and 1525) in relation to the reference unit (169). Results are presented in Figure 5. Further exploration into individual unit performance showed that C-POD performance was within the acceptable error margin of ±20% DPM per hour (Figures 6 and 7) and therefore no correction factor was required to be applied to the data to make them comparable.

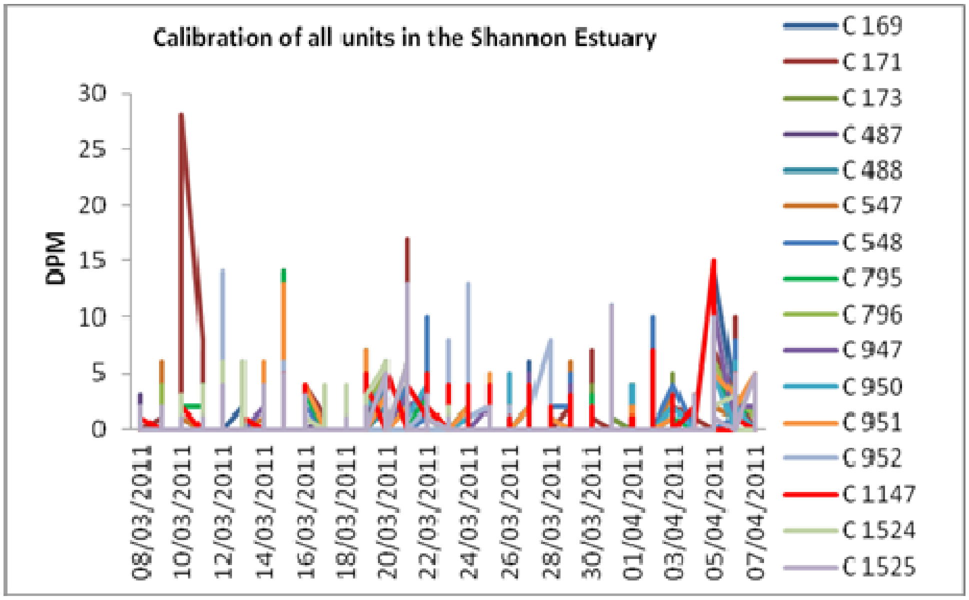

Figure 4. Detection Positive Minutes from all C-PODs deployed during a large scale calibration exercise. C-169 is the reference unit, prior to the application of a correction factor (*cf*).

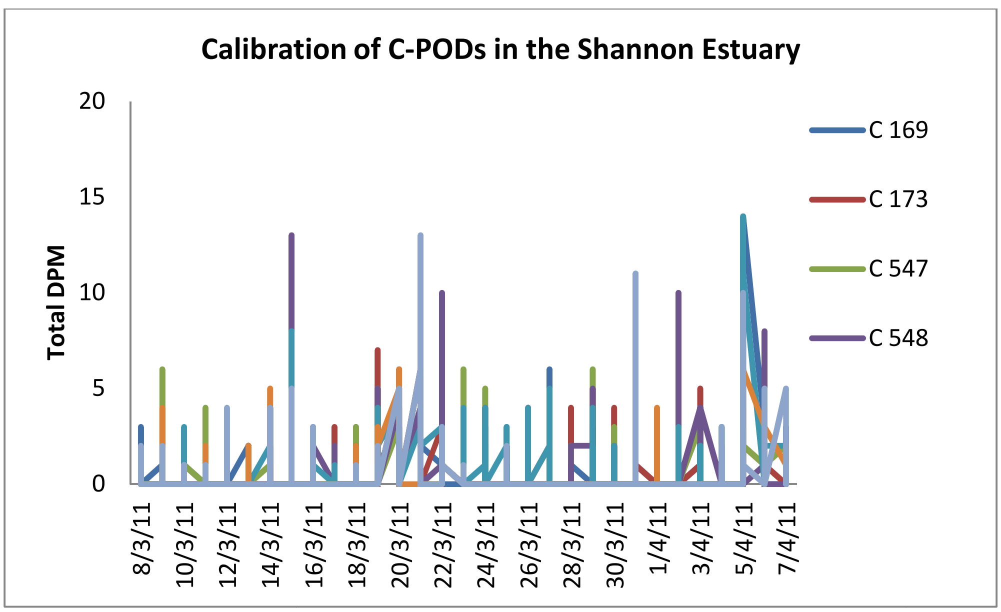

Figure 5. Detection Positive Minutes from units used during the present study, C-PODs 169, 173, 547, 548, 796, 947, 1525. C-169 is the reference unit. No correction factor (*cf*) required.

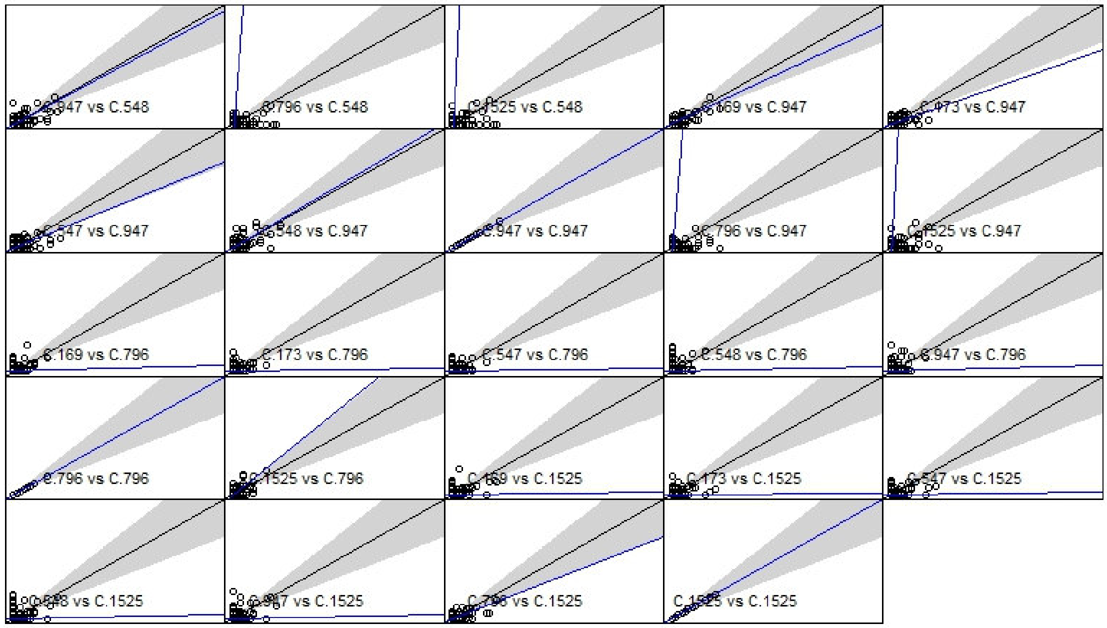

Figure 6. Orthogonal regression plot of C-POD comparisons in calibration trial, in blue, with a null model where each unit performs exactly the same, in black and an acceptable error margin of ±20%, in grey.

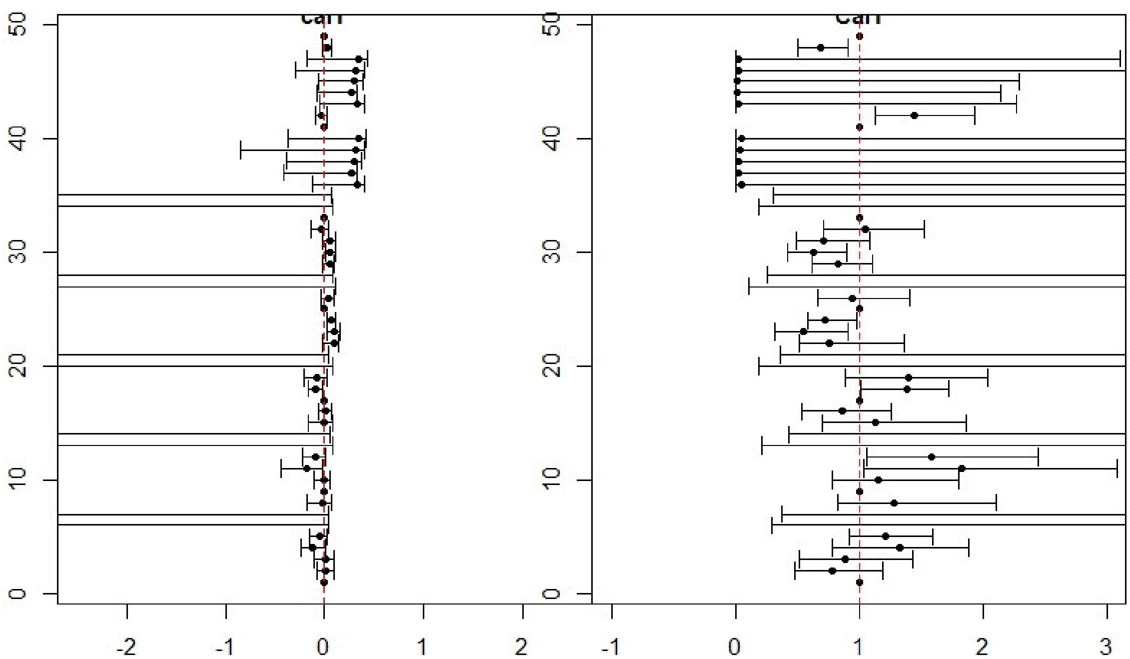

Figure 7. Centipede plot of the intercept and slope values (±std), of the orthogonal regression plots, for each pod performance comparison in calibration trails at Money Point 2011. Deviation from the red dotted lines, 0 on the intercept plot and 1 on the gradient plot, indicates deviation from the null model assuming no variation. Plot indicates that a greater extent of variation is found within the gradient values.

Static Acoustic Monitoring

Static Acoustic Monitoring using C-PODs was carried out at a single site for 804 days. Detections were recorded on 85% of days (Table 1; Table 2). The number of Detection Positive Minutes per day ranged from 0 to 212 per day with a mean of 18.3 porpoise detection positive minutes per day and a mean of 2.2 dolphin detection positive minutes per day (Figure 8). We can distinguish between harbour porpoise and dolphins through the high frequency clicks generated by harbour porpoise. Thus most detections (97%) were of harbour porpoise. A monitoring index of 0.3%DPM for porpoises was generated and 0.04% for dolphins. This unit of measurement can be compared across locations, or with results from previous studies taken place.

Table 1. Summary of results from acoustic monitoring using C-PODS.

Date	C-POD Number	Duration (days)	% of days with detections	Detection Positive Minutes	Porpoise Positive Minutes	Dolphin Positive Minutes	Mean DPM/day (porpoise)	Mean DPM/day (dolphin)
28.06-28.07.2011	173	31	100	969	740	229	23.8	7.3
28.07-07.12.2011	947	133	99	2499	2437	62	18.32	0.47
07.12.11-18.01.12	547	42	90	1852	1783	69	37.1	1.4
20.02-08.05.12	547	79	59	121	77	44	1	0.6
08.05-06.07.12	548	61	89	121	370	48	6.1	0.8
16.07-13.12.12	951	161	85	721	621	100	3.9	0.6
13.12-16.05.2013	1525	155	67	1535	1400	135	9	0.9
16.05-04.10.13	796	142	91	1149	998	151	7	1.1
Totals		**804**	**85**	**8967**	**8426**	**838**	**13.3**	**1.6**

Table 2. Results of C-POD deployments Mutton Island, including the calculation of a monitoring index %DPM

				NBHF	NBHF	NBHF	NBHF	Dol	Dol	Dol	Dol
Location	Total Days	Total Hours	Total Min	DPD	Total DPM	% DPD	% DPM	DPD	Total DPM	% DPD	% DPM
Mutton Island	804	19296	1157760	290	5407	84	0.3	111	452	32	0.04

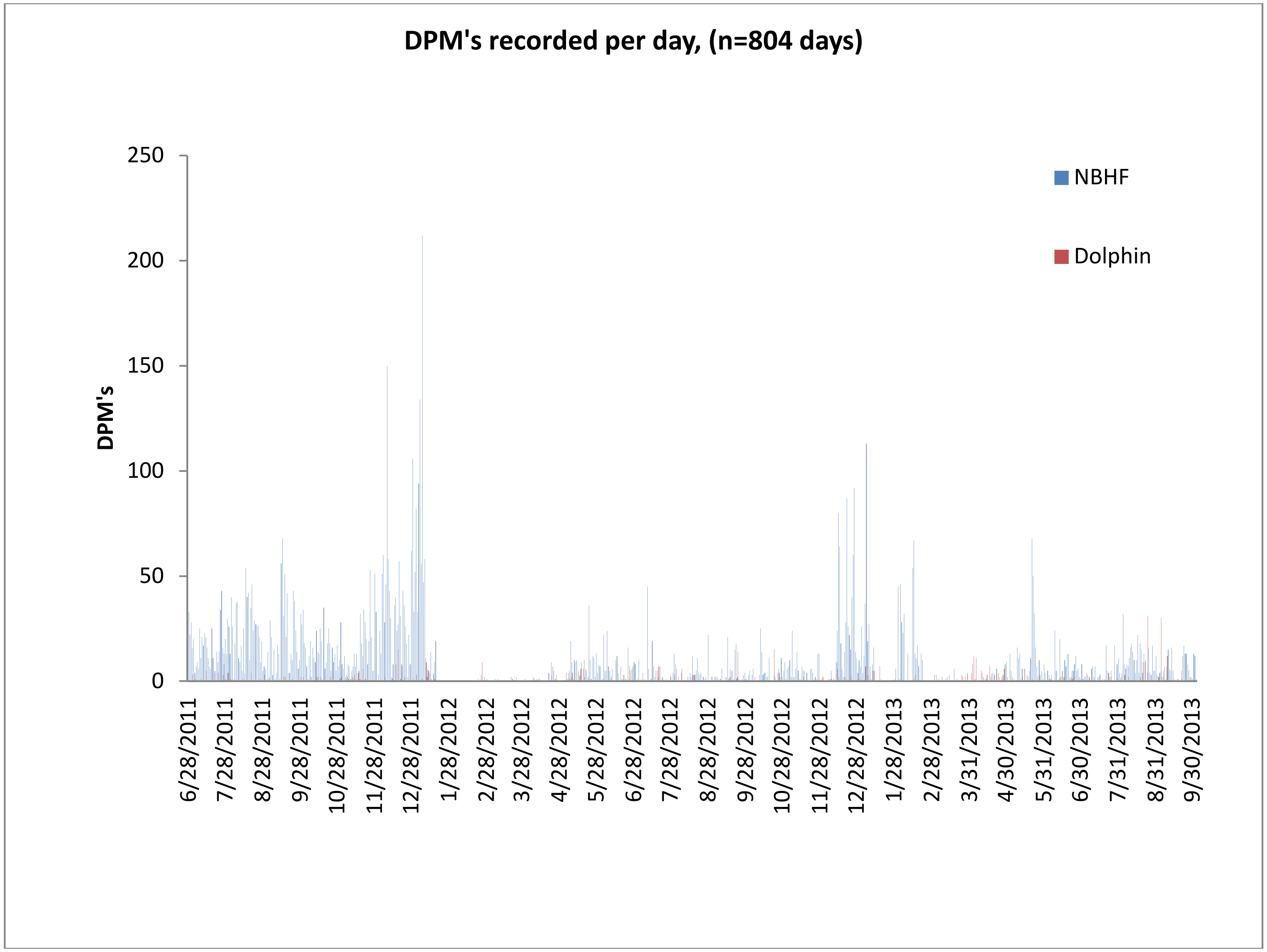

Figure 8. Porpoise (NBHF) and Dolphin Positive Minutes (DPM) recorded over the deployment peroiod

Generalized linear mixed-effect model (GLMM) analyses

1. *Pooled data*

The data were analysed separately by year and also pooled to assess if trends were unique temporally or spatially. Results from the generalized linear mixed-effect model (GLMM) analyses (Figure 9) on the pooled data showed that season had a significant effect on the presence of porpoises at the site. A significant peak in porpoise detections was recorded during the winter and autumn (χ^2= 196.4, p<0.0001). Most porpoise detections were recorded during the diel phase night (χ^2= 132.4, p<0.0001) showing they are more active at the site during night-time hours. Tidal cycle and tidal phase were not found to be significant factors influencing harbour porpoise presence. Dolphin detections at Mutton Island were low in comparison with porpoise detections and therefore analyses were restricted and clear trends were not as easily highlighted through statistical models. Season was found to have a significant influence on dolphin detections with more detections registered during the summer and winter months. All other factors were found to be insignificant due to the low number of detections for the species.

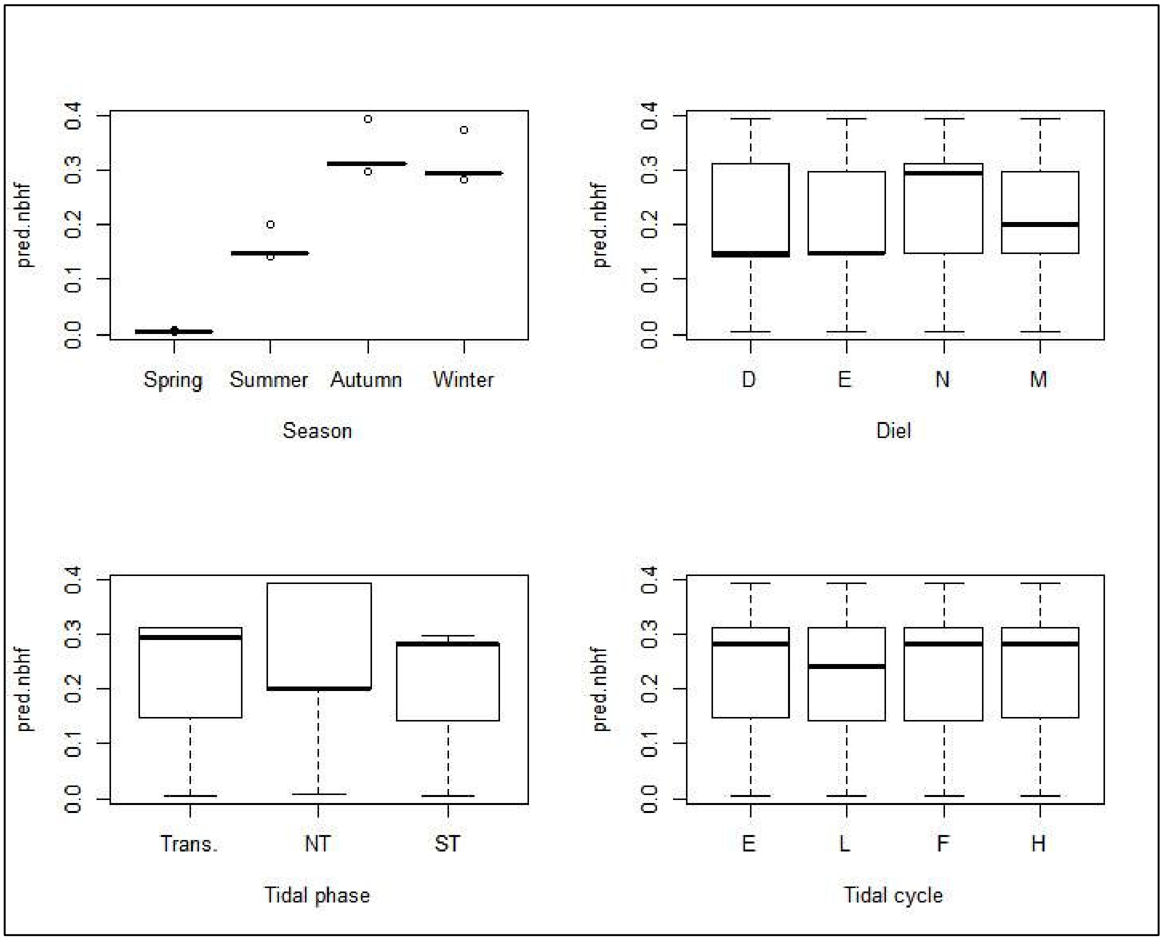

Figure 9. Predicted proportion of porpoise detection positive hours, in the narrow band high frequency channel from Mutton Island across season, diel (where D = day, E = evening, M = morning and N = night), tidal phase (where Trans. = transitional phase, NT = neap tide and ST = spring tide) and tidal cycle (where E = ebb, L = slack low, F = flood and H = slack high) as determine through statistical analyses in R.

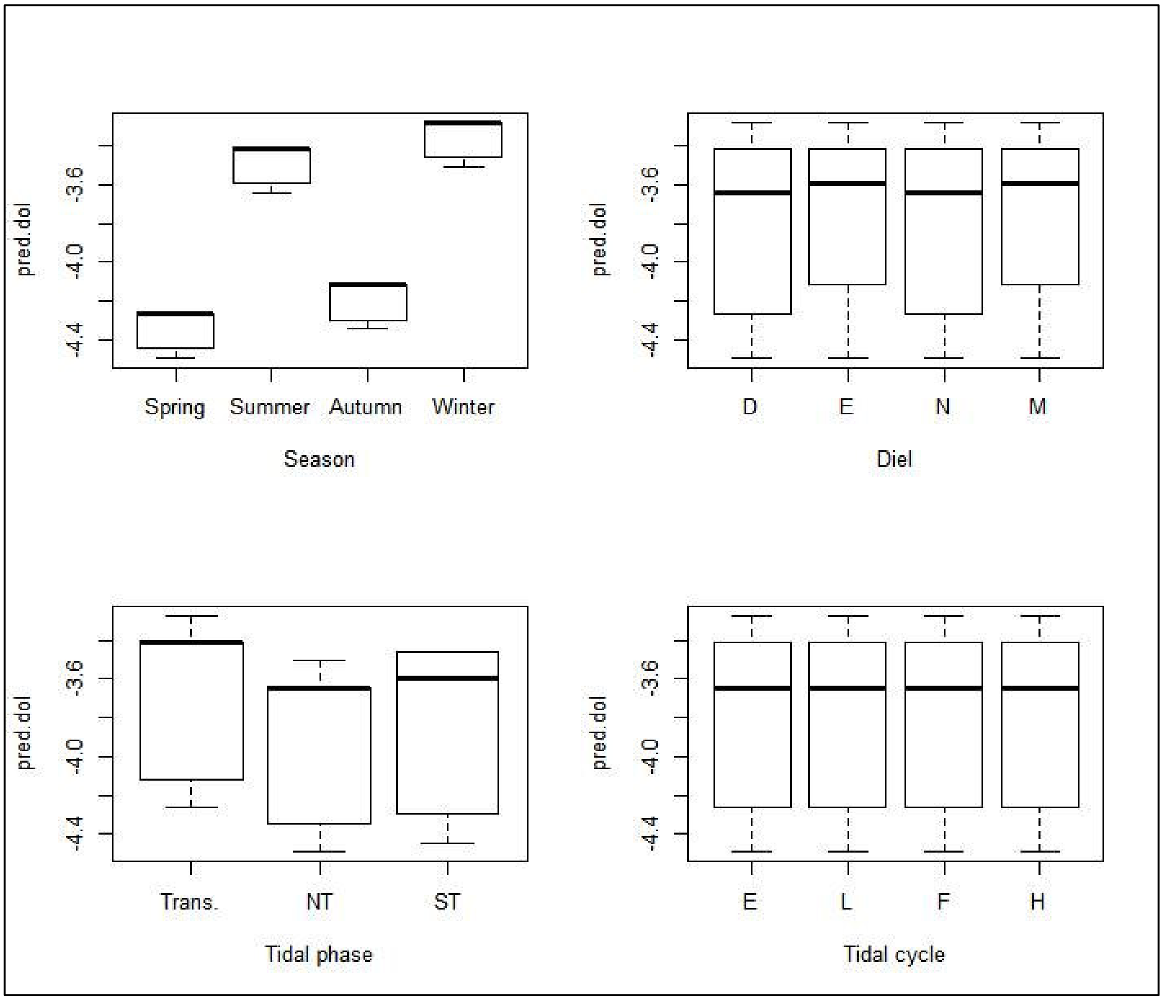

Figure 10. Predicted proportion of dolphin detection positive hours, in the dolphin channel from Mutton Island across season, diel (where D = day, E = evening, M = morning and N = night), tidal phase (where Trans. = transitional phase, NT = neap tide and ST = spring tide) and tidal cycle (where E = ebb, L = slack low, F = flood and H = slack high) as determine through statistical analyses in R.

2. *Year 1*

As dolphin detections were so low, analyses per year was only carried out on the harbour porpoise data. Data from year 1 comprised of data from July 2011 to June 2012 (Figure 11). Results were similar to the pooled data whereby season was significantly different with more detections during the autumn and winter (χ^2= 196.3, p<0.001). Diel factor night had the greatest detections (χ^2= 196.4, p<0.0001).

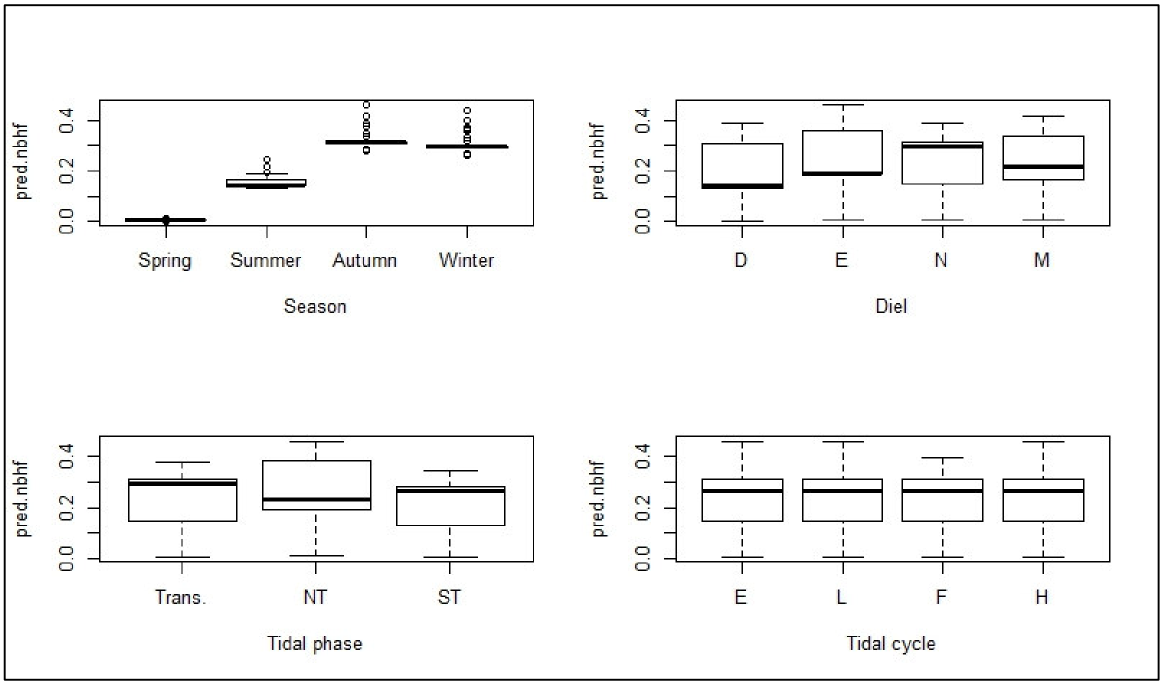

Figure 11. Predicted proportion of porpoise detection positive hours, in the narrow band high frequency channel from Mutton Island in Year 1 across season, diel (where D = day, E = evening, M = morning and N = night), tidal phase (where Trans. = transitional phase, NT = neap tide and ST = spring tide) and tidal cycle (where E = ebb, L = slack low, F = flood and H = slack high) as determine through statistical analyses in R.

3. <u>Year 2</u>

Similarly, the year 2 dataset comprised of July 2012 to October 2013 (Figure 12) showed significantly more detections during the winter months ((χ^2= 247.5, p<0.0001). Night-time had again significantly more detections (χ^2= 138.6, p<0.0001). It is clear from the data analyses that the most important factors driving harbour porpoise presence are season and diel factors and that clear temporal trends are evident with more detections recorded over the autumn and winter months and during night-time hours.

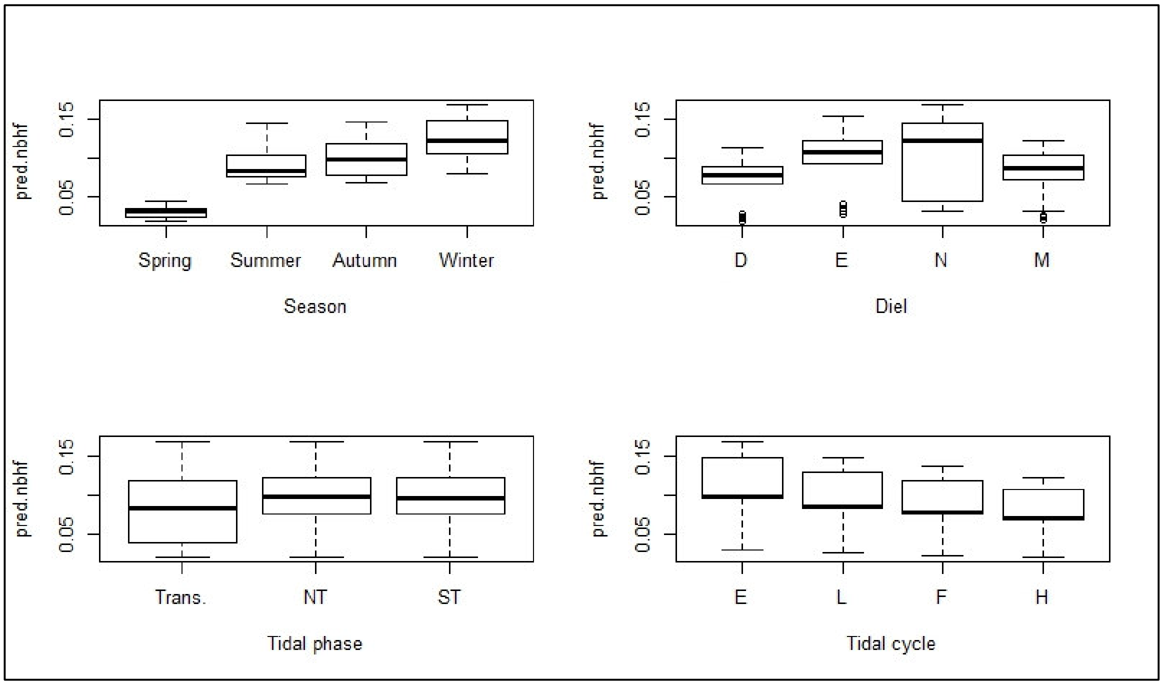

Figure 12. Predicted proportion of porpoise detection positive hours, in the narrow band high frequency channel from Mutton Island in year 2 across season, diel (where D = day, E = evening, M = morning and N = night), tidal phase (where Trans. = transitional phase, NT = neap tide and ST = spring tide) and tidal cycle (where E = ebb, L = slack low, F = flood and H = slack high) as determine through statistical analyses in R.

Discussion

Cetaceans live in an acoustic world and increasingly attempts have been made to develop acoustic monitoring techniques rather than relying on visual methods, whose efficiency is hugely dependent on light, weather conditions and sea-state, especially for species such as the elusive harbour porpoise (*Phocoena phocoena* Linneaus). Static Acoustic Monitoring (SAM) involves the recording or detection of cetacean vocalisations or echolocation clicks and is a very valuable tool for the exploration of fine scale habitat use by various odontocete species. The main advantage of SAM is that is can provide information on species that can go undetected visually for up to 87.1% of the time (bottlenose dolphin *Tursiops truncatus* Montagu; Mate *et al.,* 1995) and 95% (harbour porpoise; Read & Westgate, 1995). Patterns of cetacean presence have been described over seasonal scales (Canning *et al*., 2008, Bolt *et al*., 2009; Simon *et al*., 2010; Gilles *et al*., 2011) diel cycle (Cox & Read 2004; Carlström, 2005; Todd *et al*., 2009; Phillpot *et al*., 2007) and tidal patterns (Philpott *et al*., 2007; Marubini *et al*., 2009). In order to evaluate the importance of an area, it is fundamental that the presence of small cetaceans at a site is fully understood and this requires monitoring over time scales of at least years. Visual monitoring of cetaceans can provide numbers for density and abundance estimation but will be biased due to factors such as observer effect and unfavourable sea conditions. Therefore, a complete dataset cannot be gathered, necessitating the requirement of Static Acoustic Monitoring (SAM) to fully evaluate the importance of a site. Through SAM, revealing datasets, robust enough to detect distinctive trends in presence across a range of factors can be achieved much more rapidly than visual means.

The aim of the present study was to explore the presence of small cetaceans through static acoustic monitoring in the vicinity of the proposed development site at Galway docks. Results showed that porpoises were recorded at the site on 84% of days monitored and dolphins on 32% of days monitored. This is consistent with previous work carried out at a site west at Spiddal between 2006 and 2008 with porpoises detected on 88% of days (O'Brien, 2009). More recently, under the PReCAST projectmonitoitng took place at Spiddal between 2008 and 2010 and porpoises were detected on 94% of days (N=569 days); (O'Brien *et al.* 2013). A monitoring index comprising %DPM was generated and facilitated comparison with previous work carried out at Spiddal (O'Brien *et al.,*2013; O'Brien, 2009). Results from the present study presented a lower monitoring index for porpoise but slightly higher for dolphins. This difference is most likely due to a longer monitoring period from Spiddal. The percentage of detection positive days was similar to previous studies in the Bay (O'Brien *et* al. 2013; O'Brien,2009) (94% and 88% of days). The dataset was explored for significant factors effecting presence such as season, diel, tidal phase and tidal cycle. Season was found to be a significant factor in porpoise presence with more detections recorded during the Autumn and Winter. This result is similar to that found by O'Brien *et al*. (2013) from Spiddal. Porpoise detections were found to be greater at Mutton Island during night-time hours, a result that could not be determined if monitoring relied solely on visual means. Dolphin detections also showed a seasonal effect with more detections recorded during the summer and winter months.

Clearly the area is important for small cetaceans with the almost daily presence of some species at the survey area. As harbour porpoise (Annex II species of the Habitats Directive) are present throughout the year and entitled to strict habitat protection, care must be taken to ensure this development does not degrade this habitat or cause undue disturbance. SAM results will serve to inform protocols of best practice for the area if work is to go ahead and thus ensure the presence of small cetaceans in the area is not negatively impacted upon.

Potential impacts

There are a number of potential impacts on cetaceans including during construction and operation. The presence of MMO's would mitigate against this as well as limiting works to daylight hours. Where blasting or other noise related operations, using a soft start/warning approach will allow for animals to be alerted and leave an area. Ongoing monitoring through SAM during and after construction is also recommended in order to carry out the BACI approach.

References

Bolt, H.E., Harvey, P.V., Mandleberg, L., and Foote, A.D. (2009) Occurrence of killer whales in Scottish inshore waters: temporal and spatial patterns relative to the distribution of declining harbour seal populations. *Aquatic Conservation* 19, 671–675.

Canning, S.J., Santos, M.B., Reid, R.J., Evans, P.G.H., Sabin, R.C., Bailey, N. and Pierce, G.J. (2008): Seasonal distribution of white-beaked dolphins (*Lagenorhynchus albirostris*) in UK waters with new information on diet and habitat use. *Journal of the Marine Biological Association of the United Kingdom* 88, 6, 1159-1166.

Carlström, J. (2005) Diel variation in echolocation behaviour of wild harbour porpoises. *Marine Mammal Science* 21, 1, 1-12.

Cox, T.M. and Read, A.J. (2004) Echolocation behavior of harbor porpoises (*Phocoena phocoena*) around chemically enhanced gill nets. *Marine Ecology Progress Series* 279, 275–282.

Gilles, A., Adler, S., Kaschner, K., Scheidat, M., Siebert, U. (2011) Modelling harbour porpoise seasonal density as a function of the German Bight environment: implications for management. *Endangered Species Research* 14, 157-169.

Marubini, F., Gimona, A., Evans, P.G.H., Wright, P.J. and Pierce, G.J. (2009) Habitat preferences and interannual variability in occurrence of the harbour porpoise (*Phocoena phocoena*) off northwest Scotland. *Marine Ecology Progress Series* 381, 5, 297–310.

Mate, B.R., Rossbach, K.A., Nieukirk, S.L., Wells, R.S, Irvine, B.A., Scott, M.D., and Read, A.J. (1995) Satellite monitored movements and dive behaviour of a bottlenose dolphin in Tampa Bay, Florida. *Marine Mammal Science* 11, 4, 452-463.

O'Brien, J. (2009) The inshore distribution and abundance of small cetaceans on the west coast of Ireland: Site assessment for SAC designation and an evaluation of monitoring techniques. Galway-Mayo Institute of Technology, Unpublished Ph.D Thesis, pp 1-226.

O'Brien, J., Beck, S., Wall, D. and Pierini, A., 2013. Marine Mammals and Megafauna in Irish Waters – Behaviour Distribution, and Habitat Use. Report to the Marine Institute, Galway, Ireland. PBA/ME/07/005(02). 198 pp.

Philpott, E., Englund, A., Ingram, S. and Rogan, E. (2007) Using T-PODs to investigate the echolocation of coastal bottlenose dolphins. *Journal of Marine Biological Association* 87, 11-17.

R Development Core Team (2011). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.

Read A.J. and Westgate A.J. (1995) Monitoring the movements of harbour porpoises (*Phocoena phocoena*) with satellite telemetry. *Marine Biology* 130, 315–322.

Simon, M., Nuuttila, H., Reyes-Zamudio, M.M., Ugarte, F., Verfuß, U.K. and Evans, P.H. (2010) Passive acoustic monitoring of bottlenose dolphin and harbour porpoise with implications for habitat use and partitioning. *Journal of the Marine Biological Association of the United Kingdom* 90, 8, 1-7.

Todd, V.L.G., Pearse, W.D., Tregenza, N., Lepper, P.A. and Todd, I.B. (2009) Diel echolocation activity of harbour porpoises (*Phocoena phocoena*) around the North Sea offshore gas installations. *ICES Journal of Marine Science* 66, 4, 734-745.

Acknowledgements

The IWDG would like to thank the staff at the Harbour office for assisting with deploying, diving and retrieval of equipment. Thanks to Corina Colleran of McCarthy Keville O'Sullivan LTD for her assistance throughout the study.