Marine mammal monitoring in Broadhaven Bay 2009

Progress report to RSK Environment Ltd.

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COASTAL AND MARINE RESOURCES CENTRE

ENVIRONMENTAL RESEARCH INSTITUTE

UNIVERSITY COLLEGE CORK

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1.0 Summary

This report summarises the results of the ongoing marine mammal monitoring programme in Broadhaven Bay candidate Special Area of Conservation (*c*SAC) for the 2009 field season. The programme was initiated due to the proposed installation of a gas pipeline from the Corrib Offshore Gas Field through the bay. The monitoring in 2009 followed the successful implementation of a baseline monitoring project in 2001/2002 (Ó Cadhla *et al.,* 2003) and continued monitoring in 2005 (Englund *et al.,* 2006) and 2008 (Coleman *et al.,* 2009) by the Coastal and Marine Resources Centre (CMRC), University College Cork (UCC). Following suspension of the pipeline construction in 2008, the pipeline was constructed during 2009, while monitoring effort continued throughout 2008 and 2009.

The main aim of this report is to provide insight in cetacean and seal habitat use within the Broadhaven Bay cSAC, in order to determine the importance of the area for these species. This report presents an overview of all data gathered on marine mammal diversity, presence, abundance, sub-adult presence, spatio-temporal patterns and behaviour during the field seasons 2001/2002, 2005, 2008 and 2009, with the main focus on the data collected during the 2009 field season. This report thereby precedes insights into the potential effects of the construction activities on cetacean and seal habitat use of Broadhaven Bay, which have taken place in the area between 2002 and 2009, that will be further investigated during ongoing monitoring throughout any further construction and post-construction phases in 2010 and 2011.

The primary findings of the 2009 study are as follows:

- Land based, vessel based and acoustic effort was conducted from January 1st to December 31st. Visual effort from the primary look-out sites covered 19% of days (68 days), vessel based effort was conducted over 14 days and acoustic effort was obtained for all days of deployment (223 days).

- A species of baleen whale previously unrecorded in the *c*SAC was observed during 2009: sei whale (*Balaenoptera borealis*). Marine mammal diversity in, and in the vicinity of, Broadhaven Bay now totals 11 species: 2 species of baleen whales, 7 species of toothed whales, and 2 species of seals. For many of these species, the cSAC functions as a foraging area. Species proposed habitat use is summarised in Table 3 of the results.

- Overall, sighting rates of cetaceans and seals showed a significant decrease for the 2005, 2008 and 2009 field seasons compared to the first field season (baseline) in 2001/2002. However, different patterns were observed for different species. For example, abundance of Risso's and common dolphins have remained stable between years. By contrast, bottlenose dolphin group size were higher in 2009 than any other year recorded in the bay, while the number of seal sightings was considerably lower than in 2001/2002.

2.0 Introduction

2.1 Background

The marine mammal monitoring programme in Broadhaven Bay, County Mayo, conducted by CMRC was continued in 2009. Monitoring was initiated in 2001/2002, as part of a monitoring programme put in place following plans for the construction of a gas pipeline through the bay for the Corrib Offshore Gas Project and was continued during 2005 and 2008 (Ó Cadhla *et al.,* 2003, Englund *et al.,* 2006, Coleman *et al.,* 2009). While the construction of the pipeline was initiated, but suspended, in previous years, it was finally laid in the summer of 2009 during continuous marine mammal monitoring effort.

The marine construction work which has been taking place in Broadhaven Bay concerns an underwater gas pipeline which was brought ashore from its source, 65 km offshore, via a 3x3 m dredged trench through the nearshore sections of Broadhaven Bay, making landfall near Glengad, in Rossport Bay (Figure 1). Construction activities included seabed acoustic surveys, dredging, transportation of excavated sediment and rock-trenching. This resulted in increased vessel traffic and increased levels of anthropogenic noise being introduced to the ecosystem. The details of marine construction works were described in a monitoring plan drafted by CMRC and RSK Environment Ltd (RSK). (RSK, 2008).

Marine construction work has the potential to cause various types of environmental impacts on marine mammals (Appendix 1). The implementation of a marine mammal monitoring scheme during construction work can be used to evaluate these impacts, establish mitigation measures and aims to aid protection of animals by gaining a more comprehensive understanding of potential environmental impacts. By undertaking detailed site selection, construction design and operational planning, some impacts can be minimised. As a result of the monitoring effort in 2001/2002 and in 2005, a '*Code of Conduct for vessels and personnel operating within Broadhaven Bay SAC'* was instigated, providing guidelines for construction works in relation to marine mammal presences in the area (NPWS 2007; Appendix 2). In addition, proposed blasting activities as part of the construction, within the cSAC were found not to be required and were not carried out.

The significance of marine resource management is apparent from the wealth of current national, European and global conservation measures, and research and funding programmes for marine mammals and their habitats. Cetaceans are afforded protection

within the 200-mile Exclusive Fishery Zone (EFZ) limit of the Irish State under the 1976 Wildlife Act and a 1982 amendment to the Whale Fisheries Act. The EFZ was declared a whale and dolphin sanctuary in 1991 (Rogan and Berrow 1995).

Since 1992, designated species and habitats are protected under the EC Council Directive on the Conservation of Natural Habitats and Flora and Fauna (Habitats Directive; 92/43/EEC). All cetaceans are listed under Annex IV of the Habitats Directive, designating them as "species of community interest in need of strict protection". A further five species of marine mammals occurring in Irish waters are listed under Annex II, designating them as "species of community interest, whose conservation requires the designation of special areas of conservation". Under the Habitats Directive, as well as the implementation of conservation measures, all activities likely to have a significant effect on the conservation objectives of designated species should be assessed.

2.2 Marine mammals in Broadhaven Bay

To date, 24 species of cetacean have been recorded in Ireland and the country's waters are recognised as providing some of Europe's most important habitats for cetaceans (Berrow *et al.,* 2002). Irish waters are thought to represent breeding grounds for up to 11 of these species (Berrow, 2001). In addition to cetaceans, two seal species (Order *Pinnipedia*) are native to Ireland. Dedicated research into the distribution and abundance of marine mammals in coastal and offshore Irish waters (Gordon *et al.,* 1999, Cronin *et al.,* 2007, Ó Cadhla *et al.,* 2004, Pollock *et al.,* 2000), as well as historical data (Fairley, 1981) and voluntary records from the Irish Whale and Dolphin Group (IWDG) (Berrow *et al.,* 2002) have highlighted the potential importance of the waters of northwest Mayo for cetaceans and seals.

In 2000, Broadhaven Bay was designated by the National Parks and Wildlife Services, Department of the Environment, Heritage and Local Government (NPWS) as a candidate Special Area of Conservation (cSAC). This designation concerns (i) the presence of four key marine/coastal habitat types that are listed in Annex I of the Habitats Directive, including Atlantic salt marsh, tidal mud and sand flats, reefs and large shallow bays; (ii) the presence of a number of unusual marine communities and species, and; (iii) the seasonal presence of wintering wildfowl and breeding terns (*Sterna spp.*). Furthermore, the inner part of Broadhaven Bay, known as Rossport Bay, is designated as a Special Protection Area (SPA) and is together with the nearby Glenamoy Bog complex SAC important for wintering wildfowl species, in particular for the Brent Goose (*Branta bemicla*).

However, prior to the present monitoring study, very little was known about cetacean and seal distribution in Broadhaven Bay. Following the baseline study in 2001/2002 (the first period of marine mammal monitoring), the waters of Broadhaven Bay and northwest Mayo area were identified as representing "a significant habitat for marine mammals and other biota" (Ó Cadhla *et al.,* 2003). Results from the monitoring project in subsequent field seasons further corroborated these findings: Broadhaven Bay was used by 10 species of marine mammals: 8 species of cetaceans and 2 species of seals throughout the year, with up to nine species recorded in the cSAC per month. Species diversity peaks in summer. All four marine mammal species granted specific protection under Annex II of the EC Habitats Directive; bottlenose dolphin (*Tursiops truncatus*), harbour porpoise (*Phocoena phocoena*), grey seal (*Halichoerus grypus*) and harbour (common) seal (*Phoca vitulina*) were recorded in the bay almost year-round, including the winter months (Ò Cadhla *et al.,* 2003, Englund *et al.,* 2006, Coleman *et al.,* 2009).

2.3 Marine mammal monitoring programme – 2001/2002 - 2011

The monitoring programme, commissioned by RSK aims to examine and mitigate the potential impact of construction activities from the installation of the gas pipeline on marine mammals in Broadhaven Bay *c*SAC. The objectives and approach to the current study were worked out in consultation between the CMRC and RSK. (RSK, 2008).

Programme Objectives:

1. To provide an assessment of cetacean occurrence and habitat use in the waters of Broadhaven Bay cSAC, based on results from visual and acoustic survey methods and photo identification;

2. To determine whether changes in marine mammal habitat use of Broadhaven Bay cSAC exist between pre-construction, construction and post-construction phases of the Corrib Offshore Gas Project;

3. To collaborate with NPWS and RSK in the development of a monitoring plan and of mitigation methods to minimise the impacts of construction activities on marine mammals during the period of marine construction work; and,

4. To further contribute to the international knowledge base regarding marine mammals on the west coast of Ireland.

The 2001/2002 monitoring effort represented a baseline study of marine mammal occurrence and habitat use in the area prior to construction of the pipeline, with particular consideration given to the evaluation of how potential construction impacts on animals might be minimised. In accordance with the recommendations from this study, monitoring recommenced in 2005 and in 2008 when pipeline construction was initiated, but postponed prior to completion. The continuation of the monitoring during 2009, in addition to planned post-construction monitoring effort of a minimum of one year, now ensures a pre – during, and post construction monitoring approach. This enables comparison between phases with and without construction activities, and allows insights into the recovery of the system where impacts were observed.

2.4 Marine Mammal Monitoring 2009

In this report, we describe cetacean and seal habitat use in Broadhaven Bay cSAC in order to determine the importance of the area for these species. Data is collated on marine mammal diversity, presence, abundance, sub-adult presence, spatio-temporal patterns and behaviour during the field seasons 2001/2002, 2005, 2008 and 2009, with a main focus on the data collected during the 2009 field season. This report thereby focuses on the first programme objective, preceding insights into the potential effects of the construction activities on cetacean and seal habitat use of Broadhaven Bay, which have taken place in the area between 2002 and 2009 (Programme Objective 2). The latter will be further investigated during ongoing monitoring effort during construction and post-construction phases in 2010 and 2011.

3.0 Methodology

Field methods included the use of elevated land based sites for visual observations in combination with underwater deployment of acoustic listening stations, vessel based line transect surveys and photo identification of bottlenose dolphins. All field methods were conducted by CRMC personnel experienced in marine mammal monitoring techniques and in the identification of species and their behaviours. In order to ensure compatibility of data, the methodology used in 2009 was comparable to the methodology used during all previous field seasons. For further details of these methods reference should be made to the methods sections of the final and progress reports, which were published following the field seasons in 2001/2002, 2005 and 2008, (Ó Cadhla *et al.,* 2003, Englund *et al.,* 2006 and Coleman *et al.,* 2009).

3.1 Study area

Broadhaven Bay is situated on the north west coast of County Mayo. The bay has a northerly and north-westerly aspect, and is approximately 8.6km in width at its seaward extent, between Erris Head to the westand Kid Island to the east (Figure1). As in the previous years, the present study incorporates the waters of Broadhaven Bay cSAC, with visual observations extending to a distance of approximately 10 km offshore, outside the cSAC area.

3.2 Land based effort

Visual observation from elevated coastal sites is commonly used for the monitoring of marine mammals in nearshore areas. Two primary sites and one secondary site were selected for land based observations during the baseline study of 2001/2002 and were used again in 2005 and 2008 (Ó Cadhla *et al.,* 2003, Englund *et al.,* 2006, Coleman *et al.,* 2009) and during the present study. One secondary site was added in 2009 (Figure1). All sites were selected based on their suitability for cliff-based observations, with a particular emphasis on height above sea level and the field of view offered over the survey area.

Primary sites were used on all occasions when conditions were suitable to conduct land based observations. The cumulative field of view presented by the two primary sites covered the entirety of the bay. The primary site at Doonanierin Point was situated close to Rossport Bay and thus provided an excellent view over the central to eastern areas, including the landfall site for the pipeline (the main area of marine construction work). The other primary observation site used, Gubastuckaun, was located on the opposite side of the bay, in the vicinity of Erris Head, providing an excellent vantage point for monitoring marine mammals entering or leaving the central to western bay areas (Figure1).

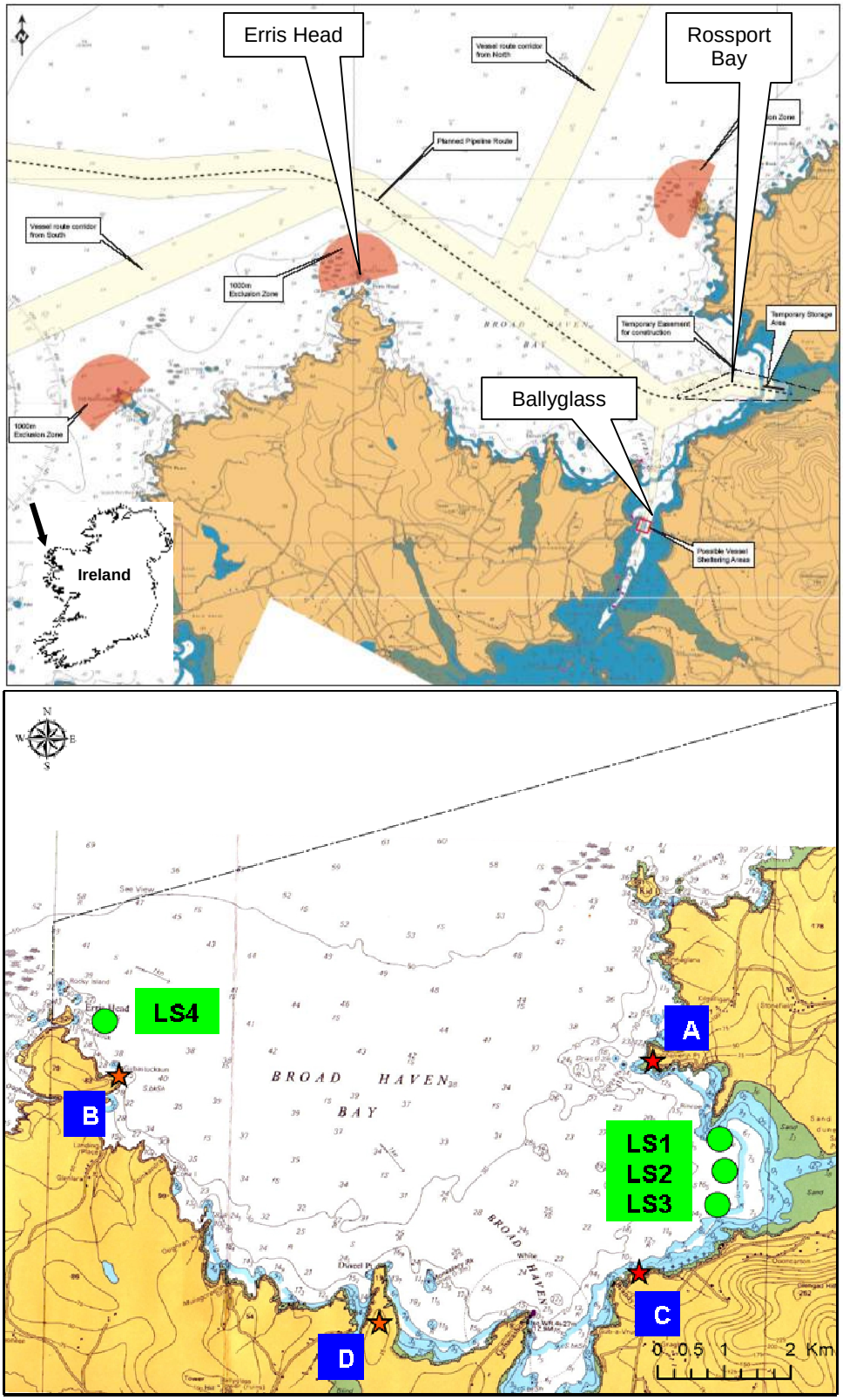


Figure 1. Top map: Broadhaven Bay and surrounding area showing the proposed pipeline route (dotted line) and vessel routes (yellow corridors). Bottom map: The study area, comprising much of Broadhaven Bay cSAC with the sites used for land based (;) and acoustic monitoring (●). Primary land based look-outs are located at A) Doonanierin and B) Gubastuckaun. Secondary look-outs are located at C) Brandy Point and D) Pollacoppul (added in 2009). Acoustic listening stations are located in Rossport Bay (LS1-3) and near Erris Head (LS4).

The secondary land based site east of Brandy Point, adjacent to the relatively sheltered inner section of Broadhaven Bay, provided a potential alternative observation site for inshore observations when conditions at Doonanierin were unfavourable for effective monitoring. Although at a considerably lower vantage point, Brandy Point provided a good view of Rossport Bay, close to which aspects of construction work were concentrated. The secondary site at Pollacoppul, which was added in 2009, was used to monitor construction related activities and environmental conditions when conditions were unfavourable for land based monitoring from the primary sites. The location was chosen for its height and accessibility (road), enabling daily overviews of the study area in all weather conditions (Figure1).

Data collection

Land based visual effort from the primary observation sites was conducted throughout the entire research period, whenever conditions allowed (Beaufort sea state <4, good visibility, no precipitation). Whenever possible, two observers were present at each observation site. Visual observations were made using telescopes (Kowa) equipped with a 32x wide-angle eyepiece and handheld binoculars (7x50; Telamax). Environmental conditions (sea state, wind and weather variables) were recorded at the start of each observation.

Watches comprised all visual effort from the same look-out on an observation day. During watches, two types of visual observations were conducted: scans and focal follow observations. Scans were conducted from the primary observation sites. During scans, the entire study area was systematically scanned using the telescope (observer 1) and the binoculars (observer 2). Scans had an optimal duration of 1 hour, while allowing for 15 minutes less or more observation time, depending on sighting conditions and the number of sightings which needed to be recorded. For each sighting of marine mammals, sunfish, turtles or basking sharks, the following was recorded: species, group size, sub-adult presence, location, direction of travel and behaviour (point-sampling; Mann, 1999). Additionally, for all vessels present in the study area, vessel category (construction, fishing, recreation, etc.), size (small, medium, large), activity and location was recorded. Scans were conducted at regular intervals throughout an observation day and were spaced minimally 1 hour apart to obtain independent scan samples. All observation effort not classified as scans was labelled as opportunistic effort. All sightings of the target species made during monitoring effort not classified as scan effort (opportunistic effort) were recorded as opportunistic sightings.

Daily (spring, summer, autumn) or 3-weekly (winter) scans were also conducted from the secondary observation site at Pollacoppul, whenever observations from the primary observation sites were limited due to weather conditions. These scans were conducted to retain an overview of the vessel presences, construction activities and prevailing weather and sea state conditions in the study area during periods where visual observation opportunities were limited.

Focal follow observations were conducted by tracking individual sightings for a prolonged period of time (Mann, 1999). Group size, sub-adult presence, location, direction of travel and behaviour were recorded at 10-15 minute intervals. Focal follow observations, or tracks, typically started at the first sighting of a target species and were continued as long as possible. Tracks were ended when individuals moved out of the sighting range, observation conditions deteriorated or when observations were ended due to darkness. Whenever observations were made simultaneously from both primary sites, the tracking was shared between the two observer-teams as to ensure optimal sighting conditions for the team tracking the individuals. Compared to the other field seasons, in 2009 more emphasis was put on the conduct of focal follow observations in order to gain further understanding of the areas used by the different species of marine mammals, their behaviour and temporal aspects of their presence in the cSAC. The geographical location of sightings during scans and focal follows were determined using digital surveyor's theodolites (Sokkia), or, when the use of the theodolite was restricted, by estimating distance (km) and bearing (degrees) from the observation site.

3.3 Vessel based effort

Two types of vessel based effort were conducted: line transects and opportunistic surveys. All line transect surveys were conducted aboard a 40-foot sea angling boat, *An Gearóidín*; the same vessel as used for line transects in 2008. This vessel provided an observation platform at c.3 m above sea-level. Line transect surveys were conducted using standardised methodology in accordance with the method employed during previous field seasons (Buckland *et al*., 1993, Ó Cadhla *et al.,* 2003). Line transects were conducted in sea states ≤ Beaufort 3 and were spaced minimally 2 weeks apart. All surveys were carried out when observers were working simultaneously from cliff-based monitoring sites on east and west sides of the bay. Communication between boat and cliff-based observers thus allowed the research team to co-ordinate survey effort. All sightings of target species along the transect route were recorded, as well as sightings which were seen off-effort (recorded as opportunistic sightings) (point sampling; Mann, 1999). Additionally, photo identification

(photo-ID) effort was conducted whenever bottlenose dolphins were recorded in the study area.

Opportunistic surveys were conducted for the purpose of photo-ID of bottlenose dolphins whenever the species was recorded in the bay and weather conditions were suitable for vessel based observations and photo-ID. Opportunistic surveys were conducted from the same vessel, which was used for the line transects or from the *Óisin Óg*, a 40-foot fishing vessel operating as a utility vessel in Broadhaven Bay for the Corrib Offshore Gas Project during 2009.

Photo identification was carried out with a Nikon D70 digital SLR camera, equipped with a 70-200 mm zoom lens, using standardised methods developed to capture the left and right sides of the dorsal fins of as many individuals in the group as possible. The methods used were identical to those used in previous field seasons and to those used in other field studies along the west coast of Ireland (Englund *et al.,* 2008, Coleman *et al.,* 2009). Efforts were made to minimise disturbances to cetacean groups during photo-ID effort.

3.4 Acoustic surveys

Passive acoustic monitoring is frequently used in the study of cetaceans in order to better our understanding of their presence and utilisation of the marine environment. This is especially valuable during times when effective visual monitoring is limited (e.g. in poor weather conditions or at night). Also, it allows for continuous monitoring for prolonged periods of time.

Three fixed listening stations (LS1-3), using T-PODs for passive acoustic monitoring, were installed in Rossport Bay in 2002, creating an acoustic detection “gateway” whereby all echo-locating small cetaceans entering or leaving the area should be logged by the T-PODs (Figure1). In this area, effects relating to construction-related noise and other environmental impacts were expected to be most critical (. Ó Cadla *et al.,* 2003).

T-PODs are fully automated cetacean detection systems that employ passive acoustics to distinguish odontocete vocalisations. They can be deployed at sea for extended periods of time. T-PODs are designed to detect porpoise and dolphin vocalisations (Ingram *et al*., 2004). T-PODs log the times and duration, to 10 microseconds resolution, of clicks resembling the echolocation clicks produced by the target species. In each minute a T-POD runs six successive scans of 9.3 seconds each so that clicks at different frequencies can be collected. For each of these scans the user can define the target and reference frequencies and the effective maximum bandwidth of click that will be logged. This allows the user to distinguish between harbour porpoise and dolphin presence as these species generally

utilise different frequencies to communicate. For all three T-PODs, four scans were set to log harbour porpoise echolocation and the remaining two scans were set to log dolphin echolocation.

For the first time in 2009 the successor to the T-POD, the C-POD (version 1) was deployed in Broadhaven Bay. The three listening stations in Rossport Bay were equipped with a C-POD and a T-POD strapped together encased in a net and deployed 5 m from the seabed. Average depth at the listening stations in Rossport Bay was 17 m. Prior to 2009 all PODs were deployed on a mooring 5 m from the sea surface. However due to increased vessel traffic in Rossport Bay since 2002, it was decided to deploy the PODs at a greater depth, in order to minimise the risk of collision and equipment loss.

Also in 2009, a fourth listening station was added: a C-POD was deployed between Erris Head and Gubastuckaun (Figure1). This C-POD was kindly provided on loan by Dr. N. Treganza of Chelonia Ltd. (www.chelonia.co.uk); the developer of the PODs. The vision for this listening station was to log dolphin and harbour porpoise echolocation at the outer range of Broadhaven Bay, presenting a different habitat and a different level of exposure to construction activities as opposed to the listening stations in Rossport Bay. Additionally, it was aimed to collect data on Risso's dolphin echolocation in conjunction with visual land observations in order to contribute to the species detection function of the C-POD software. Depth at the location of this listening station is 37 m; the C-POD was deployed at approximately 7 m from the seabed. As this listening station is more frequently exposed to high swell and strong currents compared to LS1, LS2 and LS3 the C-POD was deployed farther up the mooring line from the seabed to lessen the chance of damage due to potential impact on the seabed.

The new generation T-POD, the C-POD offers a range of advantages over the previous model. Opposed to the T-PODs, which have to be taken to shore, the C-PODs are more user-friendly and can be serviced at sea and immediately re-deployed, allowing for continuous monitoring effort. Also, C-PODs have a greater memory capacity and use less energy, ensuring doubled deployment times (up to four months) compared to the T-PODs. Additionally, the C-PODs use improved data recognition algorithms, which, in time, will enable automated recognition of different odontocetes (*see also* www.chelonia.co.uk).

Due to potential risks regarding winter sea state conditions (i.e. strong swell) and the presence of mid water trawlers in the area, it was chosen not to deploy the C-PODs at listening stations 1-3 during the period November 2009 – March 2010. The T-PODs at LS1-3 and the C-POD at LS4 remained deployed. The acoustic data and effort provided in this

report covers the start of the deployment of all PODs up to November 11th, 2009, the date of the last servicing (and data retrieval) during 2009.

3.5 Data Analysis – Visual effort & photo-ID

In order to investigate marine mammal habitat use of Broadhaven Bay, a set of species characteristics was determined in data analysis, using the data derived from the different techniques applied in the land based and vessel based monitoring. These characteristics included species diversity, group size, sub-adult presence, relative abundance, temporal patterns of presence, spatial patterns of presence and behaviour. In order to facilitate comparisons of marine mammal habitat use between field seasons, three project data-bases were compiled comprising all data for 2001/2002, 2005, 2008 and 2009: 1) Visual effort, sightings and tracks; 2) Acoustic effort and detections and 3) Photo identification.

Species diversity and sightings

Species diversity and species presence in Broadhaven Bay cSAC was determined from all visual land based and vessel based effort. The number of sightings of each species was determined by the number of distinct sightings during the study period. Distinct sightings were defined as: “the first sighting of a group or individual made during visual land or vessel based effort”. As such, all confirmed re-sightings of the group from the same look-out post, or from a second look-out post were not included. In order to allow for comparison between years, the number of distinct sightings was compared for the period June - September (the common time period sampled in all field seasons).

Sighting rates and temporal patterns

Species relative abundance was determined from sighting rates during scans. The sighting rate was calculated by dividing the total number of sightings by the total number of scans. Only high quality scans, which were conducted from the primary look-out sites at suitable environmental conditions (Bft <3, good visibility) were included in analysis. As well, only scans with a duration of 60 ±15 minutes, which were spaced minimally 1 hour apart, were included, in order to obtain comparable and independent samples of the study area. To enable comparison of sighting rates between years, all scanning effort from 2001/2002, 2005 and 2008 was re-analysed systematically. Statistical analysis to determine whether significant differences existed between years was conducted using Kruskall-Wallis tests in SPSS 12.0.1. The analysis was conducted for the complete period of observation effort of each field season, as well as for the period June-September for each field season, the common time period sampled in all field seasons.

Spatial patterns

Spatial distribution of species presence was determined from distinct sightings (one record per sighting). Additionally, habitat usage of the cSAC was investigated using tracks obtained from focal follows. While the individual points recorded during tracks do not represent independent records of species spatial distribution, the collated data of different tracks provides valuable insights in the areas used, routes, behaviour and other potential patterns of habitat use in the bay. All distinct sightings were plotted on a georeferenced map of the study area, using GIS software *ArcGIS Version 9.2 © ESRI Inc*. All sightings recorded during focal follows (tracks) were mapped likewise. Each location, either recorded by the theodolite or by the estimate of distance and bearing, was translated to Irish National Grid coordinates (ING; Easting and Northing). In the mapping analysis, estimates of distance and bearing were used only when theodolite readings of the location were not available (*see also* Coleman *et al.,* 2009). Sightings, which were located far outside the boundary limits of the cSAC area were not included in mapping analysis.

Temporal patterns

Temporal patterns of species presence in Broadhaven Bay cSAC were analysed by comparison of sighting rates per week. A 'week' was defined in a different way than is usually done for calendar weeks (Sunday to Monday), by dividing each month into four static weeks (1= day 1-8; 2= day 9-16; 3= day 17-24; 4= day 25-31). This results in 12 x 4 weeks = 48 weeks for each year. By defining weeks in such a way, each week will cover the exact same time period in each year and thereby forms a static unit of time, which is comparable between years. Temporal patterns of relative abundance were calculated for each field season and for all field seasons combined. Only weeks with a minimum number of 5 high quality scans were included in analysis in order to avoid skewed distributions when few observations were made. Additionally, presences were listed for all weeks during which species presence was recorded during opportunistic effort.

Vessel presences and spatio-temporal patterns

The number of vessels present in the study area was determined from scans from the primary observation sites and from the secondary observation site at Pollacoppul. For each observation day, the number of vessels recorded during the first scan of that day was included in analysis, resulting in one record of the number of vessels and their location in the study area per day. Analyses were conducted separately for the different vessel types. All vessels which were involved in construction activities in the bay (*i.e.* dredging, pipe-laying) were labelled as 'construction vessels'. All vessels, which were clearly involved in the Corrib Offshore Gas Project, but not directly performing construction activities (*i.e.* safety vessels,

crew-changes, support and transport vessels) were labelled as 'Utility vessels' of which all Rigid Inflatable Boats (RIBs) where labelled 'Utility RIBs'. All vessels, which were fishing in the study area or were observed travelling to fishing areas outside of the cSAC were labelled as 'fishing vessels'. Spatial patterns of vessel distribution in the bay were determined similarly as was done for all marine mammal sightings (see above). Temporal patterns of vessel abundances were determined by calculating the average number of vessels present per scan per week.

Photo identification

All photographs obtained during photo identification effort were processed as described in Coleman *et al.,* (2009; Section 4.2.2), following standardised methodology to allow for comparison of individuals between sightings, between years and between study areas.

3.6 Data analysis - Acoustics

Following downloading of the raw data from the T-PODs and the C-PODS, cetacean click trains logged by the PODs were identified and exported using specifically designed software packages (www.Chelonia.co.uk). Since 2002, when PODs were first used in the study area, more advanced versions of POD-software packages have become available. To allow for comparative analysis between field seasons, T-POD data collected in 2005 was re-analysed along with the analysis of 2008 acoustic data with the newest version of TPOD software (v.8.24). All 2009 data was also analysed with v8.24. Different version in POD units meant 2002 data could not be re-analysed (see Coleman *et al.,* 2009 for more details). The raw C-POD data was analysed using the software CPOD.exe version 1.020 for listening stations within Rossport Bay (LS1-3). Following the advice from the developer of the C-PODs, different settings were used for the C-POD at LS4 in order to make the device more receptive to Risso's dolphin echolocation. Due to the difference in settings these data were analysed with CPOD.exe version 1.029.

The click trains extracted using the T-POD and C-POD software were then translated to Detection Positive Minutes (DPM) by classifying each minute during which a click train was recorded as '1'. The DPM is then divided by the number of hours of effort, creating DPM / hour of effort. This is the most commonly used statistic when analysing acoustic data derived from PODs (Philpott *et al.,* 2007). Analyses were conducted separately for dolphins and harbour porpoises. The unit DPM per hour of effort was interpreted as the acoustical activity recorded in a given area or in a given time period and was thereby indicative of species spatial and temporal patterns of habitat use. Comparisons were performed between acoustic

detections in different time periods (field seasons, months), between listening stations and between species.

3.7 Habitat-use of Broadhaven Bay cSAC

To determine habitat use of Broadhaven Bay cSAC, for each species, data on relative abundance, group size, sub-adult presence, spatio-temporal patterns and behaviour was combined. Together, these characteristics provide an indication of the functionality of the bay area and may indicate a level of importance.

To obtain a measure for the number of groups and individuals using the cSAC, species were grouped in three categories of relative abundance: high, medium and low. Categories were given based on the year of maximum relative abundance whereby 'high' = sighting rate >0.1; 'medium' = sighting rate >0.01 and 'low' = sighting rate <0.01. Values were catagorised relative to the abundance of the other species using the bay and hence categorise species abundance on the level of the bay area, not related to the population sizes or densities of these species in Irish waters.

The range, mean and standard deviation (SD) of group size was determined from all distinct sightings in all years. Sub-adult presences – juveniles, calves and new born calves were indicated for all species for which these were recorded. The absence of records of sub-adults does not indicate these age-classes were not present in the cSAC; the precautionary approach of the visual observations entails that sub-adult presence was only recorded when observers were absolutely sure of the ageclass of the individuals. For several species, especially seals, this can be difficult to determine from a remote platform.

Spatial distribution was given by the area(s) in which the species were mainly recorded, based on the distribution of all distinct sightings and, to a lesser extent, on the tracks obtained in focal follows. While this provides a good overview of species spatial distribution, further analysis should take into account the distribution of effort from the two primary sites, which was not done in the present analysis. The preferred areas were chosen from the categories: 'bay margin', 'central bay' (open water), 'outer bay' (northern half of bay), 'inner bay' (southern half of bay) and '(north of) Erris Head'. As all species were recorded mainly inside off the cSAC boundary, no specific category was dedicated to inside/outside the cSAC. Sightings outside of the boundary were indicated as 'outer bay'.

Four measures of temporal patterns were extracted from the data. 1) For each species the period of presence was categorised as 'year-round' (sighted during all months with

observations), 'year-round except for winter months' (Nov. – Feb.) and 'seasonal' (yearly distinct period of presence). 2) For each species, peak abundance was given by the period during which overall highest relative abundance was recorded during all field seasons. 3) For each species, the regularity of presence within their period of presence was determined. This was done by dividing the mean number of weeks the species was recorded during each field season by the number of weeks recorded for the total period of presence. Only field seasons covering the complete period of presence were included in analysis. For example: bottlenose dolphin was recorded from week 10 to week 43 (24 weeks) and was sighted during 14, 5 and 10 weeks in 2001/2002, 2008 and 2009 respectively, resulting in a mean presence of 28% of weeks in each year. Regularity of presence was catagorised as 'constant' (presence in >50% of weeks), 'regular' (presence in >25-50% of weeks), 'occasional' (presence in 10-25% of weeks) or 'rare' (presence in <10% of weeks). 4) The temporal scale on which re-sightings of the same individual or group was recorded was categorised as 'hours' (longer-term focal follow has recorded presence of minimally 2 hours in the bay), 'days', 'month' or 'years' (re-sightings of individuals between days, months or years have been recorded by photo identification).

For each species, each behavioural type, which was observed during minimally two different observations and for a minimum duration of 30 minutes, was given. Behavioural types included foraging, resting, travelling and socialising.

4.0 Results

All comparisons to results from monitoring effort in previous years in this section refer to Ó Cadhla *et al.,* (2003) for the 2001/2002 field season, to Englund *et al.,* (2006) for the 2005 field season and to (Coleman *et al.,* (2009) for the 2008 field season.

4.1 Effort

4.1.1 Visual Effort

From January 1st to December 31st, 2009, land based survey effort from the primary observation sites was conducted during 68 days (541 hours), comprising 114 watches, 238 scan-surveys (222 hours) and 319 hours of opportunistic effort. During a total of 139 days, starting May 2009, 173 scans comprising 69 hours of effort, were made from the secondary observation site at Pollacoppul. Combined visual land based observation effort covered 183 out of 365 days (50%) of the research period. Vessel based effort was conducted during 14 days (55 hours), including 6 transects (27 hours) and 8 opportunistic surveys (28 hours). The majority of photo identification effort, 7 out of 8 events, was carried out during opportunistic effort, 1 event took place during transect effort (Figure2).

Due to the variation in weather conditions, the distribution of land based and vessel based effort was variable over the year. The main distribution of scanning effort was centred in the spring and summer months: the majority of effort was conducted between May and September, peaking in June/July. Weather conditions outside this period were largely limiting for visual observations. For example, while 12 days (40%) were suitable for conducting land based watches in July, only between 1-3 days per month (3-10%) were suitable from November to April. However, observations were made at each possibility during these winter/early spring months, providing for near year-round monitoring effort in Broadhaven Bay cSAC and hence valuable insights into year-round marine mammal presence in the area (Figure2).

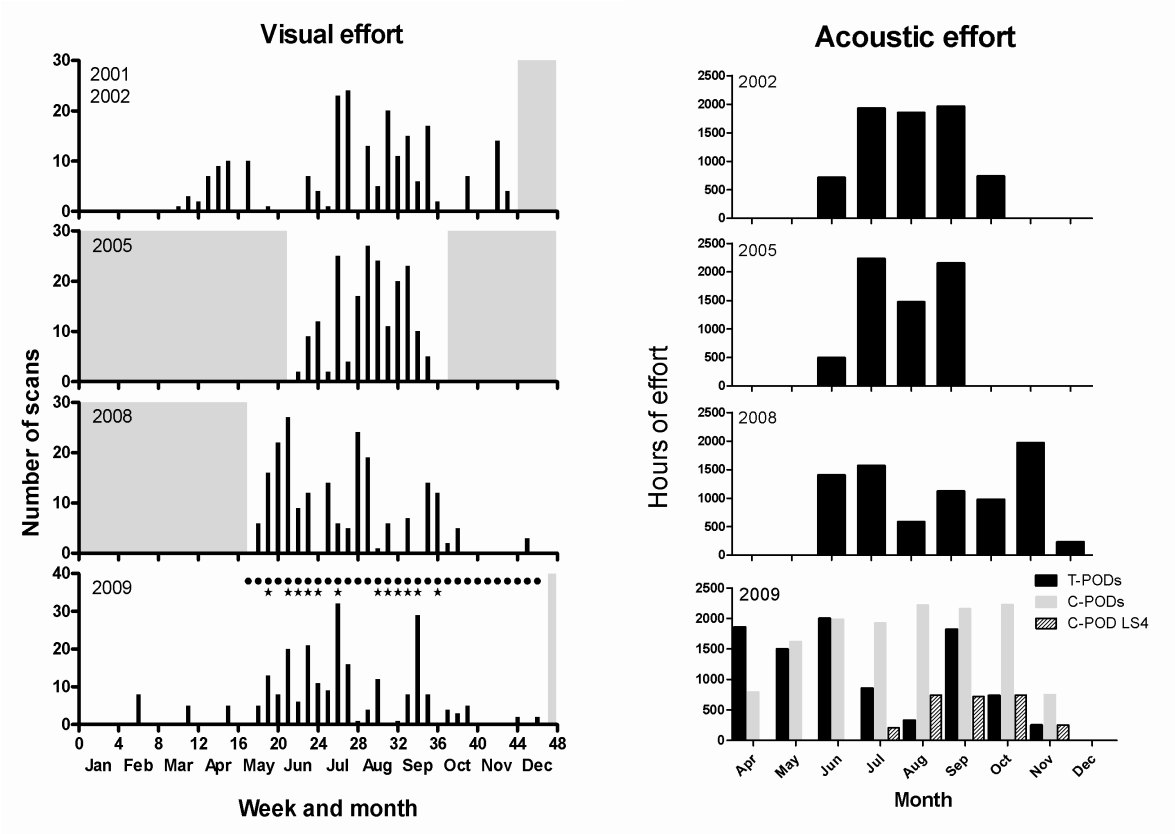
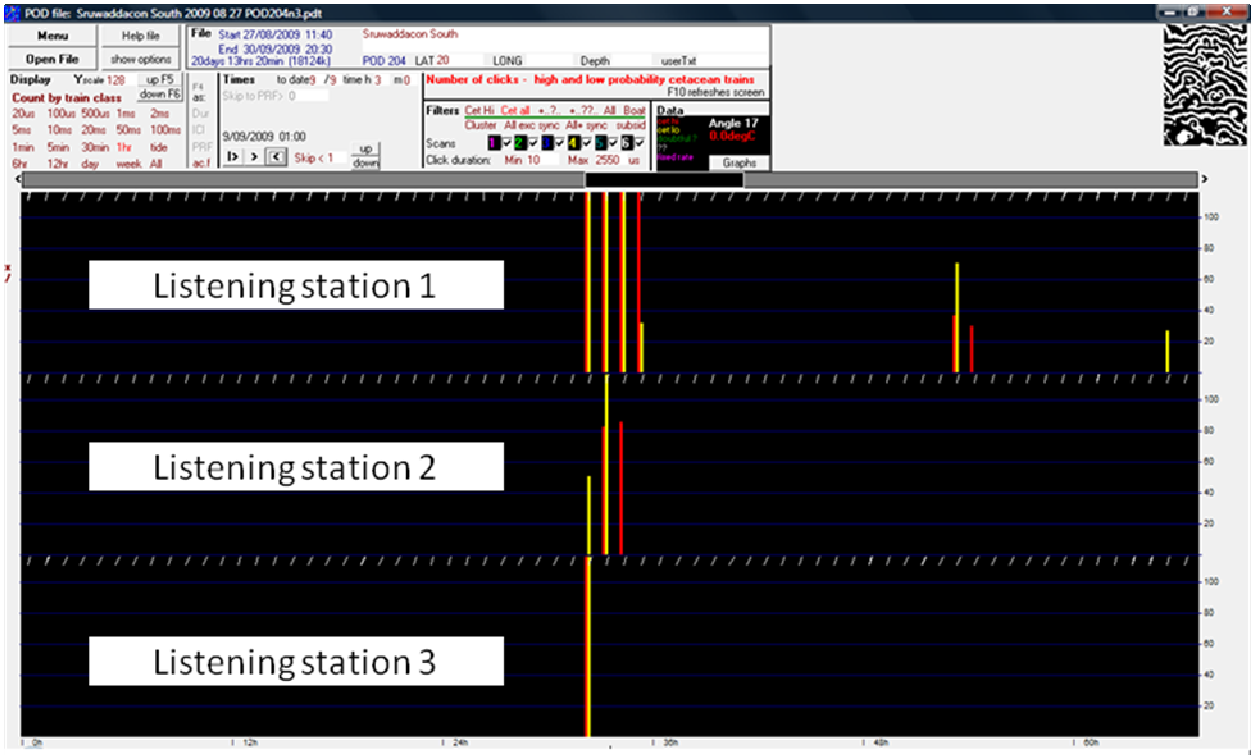


Figure 2. ***Left panel:*** *Distribution of visual survey effort per week (number of scans per week); for 2009 weekly vessel based effort (stars) and effort from the secondary site at Pollacoppul (filled circles) are also given. Grey areas indicate periods with no monitoring effort.* ***Right panel:*** *Distribution of acoustic survey effort per month for the field seasons 2001/2002, 2005, 2008 and 2009. Black bars: total hours of effort of T-PODs at listening stations 1-3; Grey bars: total hours of effort of C-PODs at listening stations 1-3 (2009 only); Arched bars: total hours of effort of C-POD at listening station 4 (2009 only). 2009 December effort not included.*



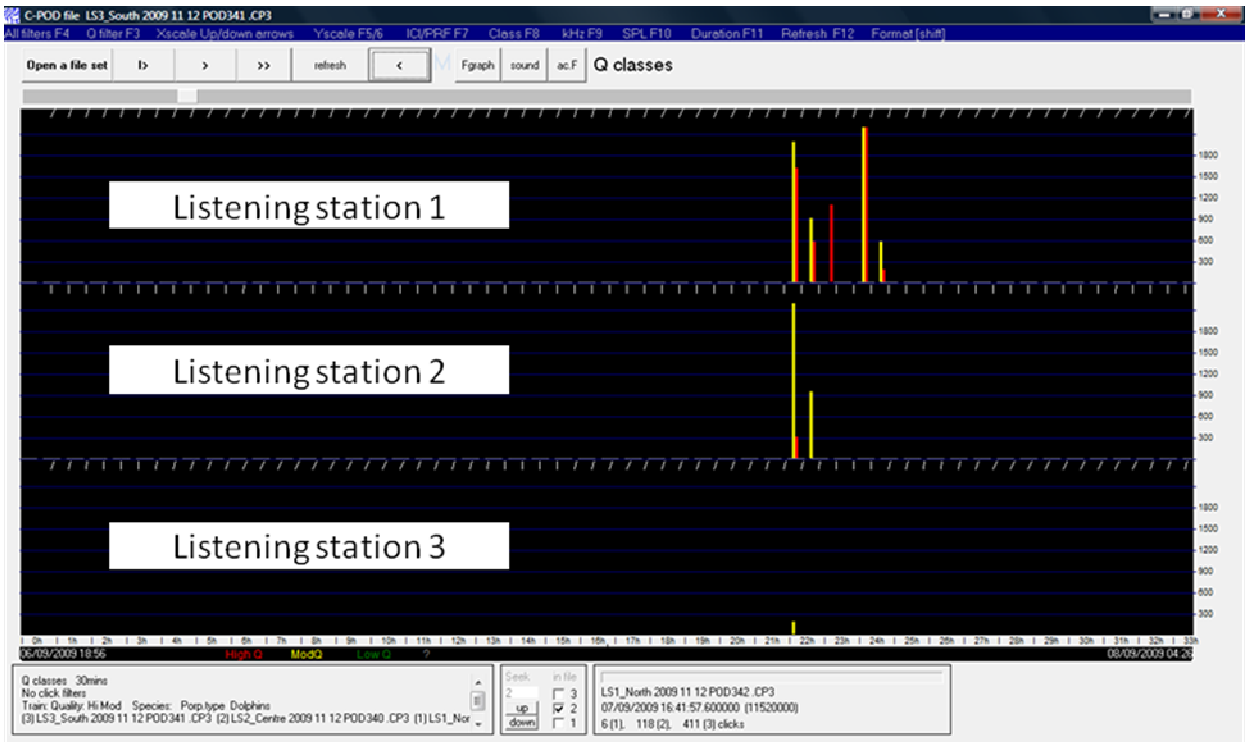


Figure 3. ***Top panel:*** *Screen grab from TPOD.exe v8.24 of simultaneous detections on the three T-PODs in Rossport Bay (LS1-3).* ***Bottom panel:*** *Screen grab from CPOD.exe v.1.020 of simultaneous detections on the three C-PODs in Rossport Bay (LS1-3). In both figures, cetacean detections are indicated by red (high probability) or yellow (medium probability) lines. The x-axis indicates the number of detections on a 12 hour scale.*

4.1.2 Acoustic effort

The C-PODs and T-PODs located at listening stations 1, 2 and 3 in Rossport Bay (Figure1) were deployed from April 3rd – November 11th 2009 (Figure2). During this period all PODs were serviced four times for data retrieval and equipment maintenance. The C-POD at the new listening station between Erris Head and Gubastuckaun was deployed from July 27th to date. This C-POD was serviced on three occasions.

During the period of deployment, the 3 C-PODs at listening stations 1, 2 and 3 together recorded during all 223 days for a total of 13,687 hours. The T-PODs at the same 3 locations together also recorded for the full 223 days during a total of 9,341 hours. All PODs successfully recorded dolphin and harbour porpoise click trains (Figures 2 & 3). Hence the C-PODs successfully logged during 86% of total deployment time and the T-PODs during 58% of total deployment time in Rossport Bay. Stations 1 and 2 were both covered by logging effort of a C-POD or a T-POD during the complete period of deployment, listening station 3 was not covered during 15 days of deployment. The C-POD at the new, 4th listening station near Erris Head functioned perfectly throughout the period of deployment, logging the full 2,663 hours during its 112 days of deployment. Next to the servicing of the PODs, incomplete coverage during the period of deployment was caused by exceeding of the memory capacity of the T-PODs due to a high intensity of vessel noise (sonar) and power-loss. Compared to acoustic effort for the previous years (during the period June-September), the T-PODs worked similarly well during 2009: 5,002 hours of logging were recorded, versus 5,003, 6,350 and 4,678 in 2002, 2005 and 2008 respectively.

4.2 Marine mammals in Broadhaven Bay

4.2.1 Species diversity and sightings

Marine mammals were sighted during 44 days, out of 68 days with monitoring effort from the primary look-out sites in Broadhaven Bay (65%). In total 139 distinct sightings were made of 7 species of cetaceans (n=62) and 2 species of seals (n= 77). 50 sightings, mainly of seals, could not be identified to species level (Table 1). All species which were sighted in the bay during previous years, besides white-beaked dolphin (*Lagenhorynchus albirostris*), were observed in Broadhaven Bay cSAC during 2009. While killer whales (*Orcinus orca*) were not observed under monitoring effort, the species was reported present in the bay during May and July 2009 (www.iwdg.ie). In 2009, most sightings were made of bottlenose dolphins and minke whales (Table 1). With the exception of bottlenose dolphin, group sizes in 2009 were similar as compared to the other field seasons for all species (Table 2).

Table 1. The number of distinct marine mammal sightings and individuals for the complete monitoring period in 2009 and comparisons between the number of distinct sightings and individuals recorded in the months June to September for 2002, 2005, 2008 and 2009 (i.e. the common period of monitoring across the four years). U. = unidentified.

	Number of distinct:		Number of distinct sightings (June – Sept.)				Number of distinct individuals (June – Sept.)			
Species	**Sightings 2009**	**Individuals 2009**	**2002**	**2005**	**2008**	**2009**	**2002**	**2005**	**2008**	**2009**
Cetaceans										
Minke whale	**15**	**17**	**4**	**1**	**6**	**9**	**4**	**1**	**6**	**9**
Sei whale	**3**	**4**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**4**
Killer whale	**0***	**0***	**0**	**2**	**1**	**0***	**0**	**6**	**3**	**0***
Risso's dolphin	**3**	**13**	**6**	**4**	**7**	**2**	**19**	**11**	**38**	**8**
Bottlenose dolphin	**19**	**471**	**14**	**8**	**3**	**15**	**152**	**81**	**27**	**413**
Common dolphin	**6**	**370**	**3***	**5**	**4**	**4**	**49**	**307**	**192**	**75**
Whitesided dolphin	**1**	**30**	**3***	**0**	**0**	**0**	**91**	**0**	**0**	**0**
Whitebeaked dolphin	**0**	**0**	**2***	**0**	**0**	**0**	**8**	**0**	**0**	**0**
Harbour porpoise	**5**	**10**	**16**	**3**	**4**	**2**	**34**	**3**	**7**	**5**
U. Whale	**1**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**3**	**0**
U. Dolphin	**9**	**208**	**4**	**7**	**14**	**4**	**9**	**75**	**74**	**33**
Cetaceans total	***62***	***1124***	***52***	***30***	***40***	***39***	***366***	***484***	***350***	***547***
Seals										
Grey seal	**31**	**34**	**58**	**22**	**8**	**27**	**63**	**24**	**13**	**29**
Harbour seal	**6**	**6**	**31**	**10**	**0**	**6**	**83**	**10**	**0**	**6**
U. Seal	**40**	**42**	**2**	**2**	**11**	**33**	**8**	**2**	**12**	**34**
Seals total	***77***	***82***	***91***	***34***	***19***	***66***	***154***	***36***	***25***	***69***
TOTAL	***139***	***1205***	***143***	***64***	***59***	***105***	***520***	***520***	***375***	***616***

** Killer whales were reported present in the area on two occasions during 2009 (2 distinct sightings of a total of 8 individuals; www.iwdg.ie).*

An interesting addition was made to the species previously observed in the bay: sei whales (*Balaenoptera borealis*) were observed present in the bay for the first time during three different days in September 2009. While an unidentified whale, potentially sei or fin whale (*Balaenoptera physalus*), was also sighted during monitoring effort of 2008, this individual could not be identified to species level (Coleman *et al.,* 2009). Behaviour (skim-feeding), prolonged duration of presence and proximity to the look-outs and the research vessel of the sei whale(s) enabled positive identification of the species on all occasions. This sighting in September 2009 comprised the first confirmed sighting of a sei whale in Irish coastal waters since the early 1900's (Oudejans and Visser, *in press*).

Hereby, cetacean diversity in Broadhaven Bay cSAC now totals 9 species: 2 species of baleen whales, 1 *phocoenid* species and 6 species of toothed whales (*delphinids*). In addition, 2 species of seals are observed yearly (Table 1; Figures 4&5). Broadhaven Bay cSAC is also used by the otter (*Lutra lutra*), the basking shark (*Cetorinus maximus*), loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) turtles and sunfish (*Mola mola*).

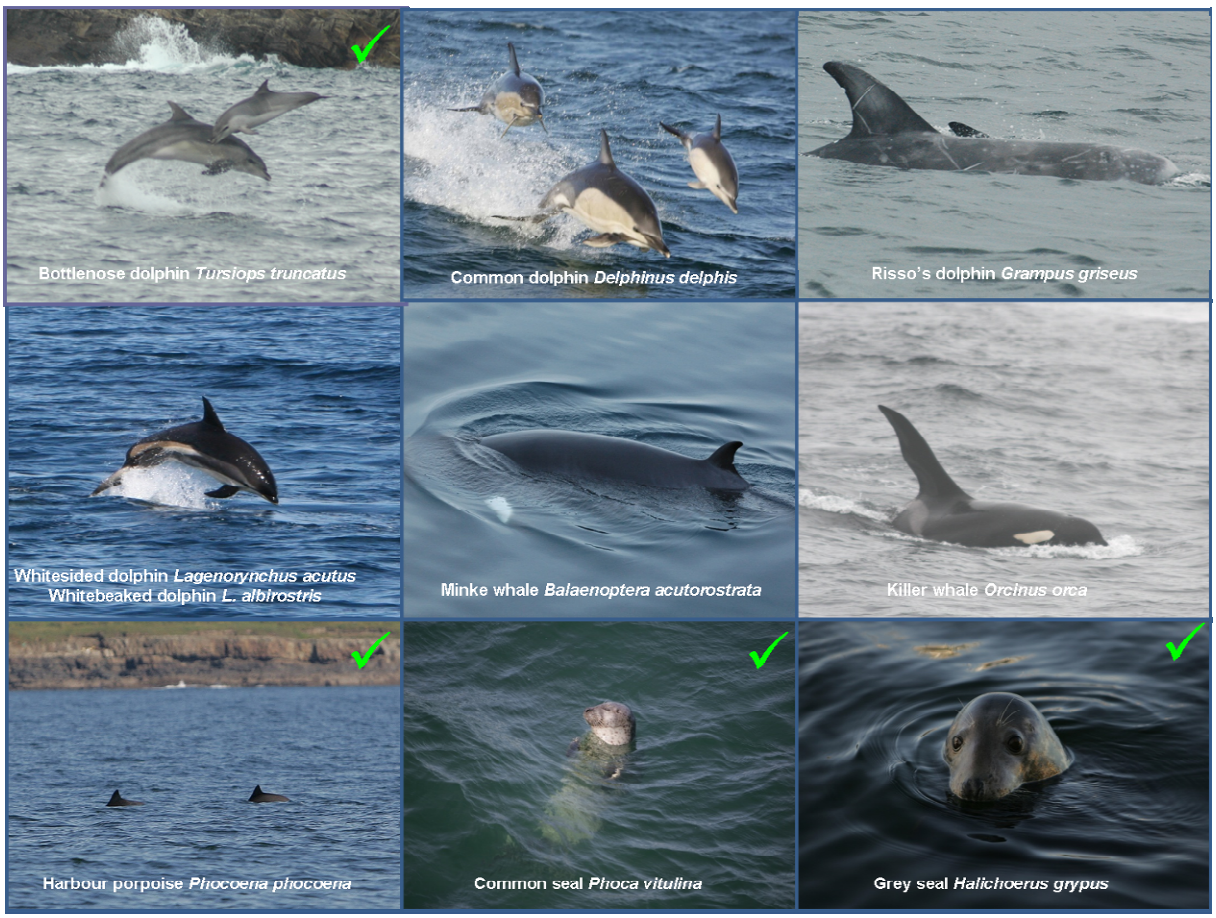


Figure 4. Cetacean and seal species recorded in Broadhaven Bay cSAC during the marine mammal monitoring program. Not shown: Sei whale (see FigureFigure 5) and white-beaked dolphin. ✓= Annex 2 species.

Figure 5. Sei whale Balaenoptera borealis *recorded for the first time in Broadhaven Bay cSAC, and in coastal Irish waters, in 2009 by CMRC observers. Pictures show skim-feeding individual present within cSAC boundary.*

4.2.2 Sighting rates

In 2009, overall sighting rates for cetaceans showed comparative values to 2008. Sighting rates for cetaceans showed significant differences between years: highest values were observed in 2002, lowest values during 2005 (X^2 = 18.2; df=3; p<0.001). The same pattern was observed for seals (X^2 = 62.9; df=3; p<0.001), with a stronger increase in sighting rates as compared to 2008 (Figure6).

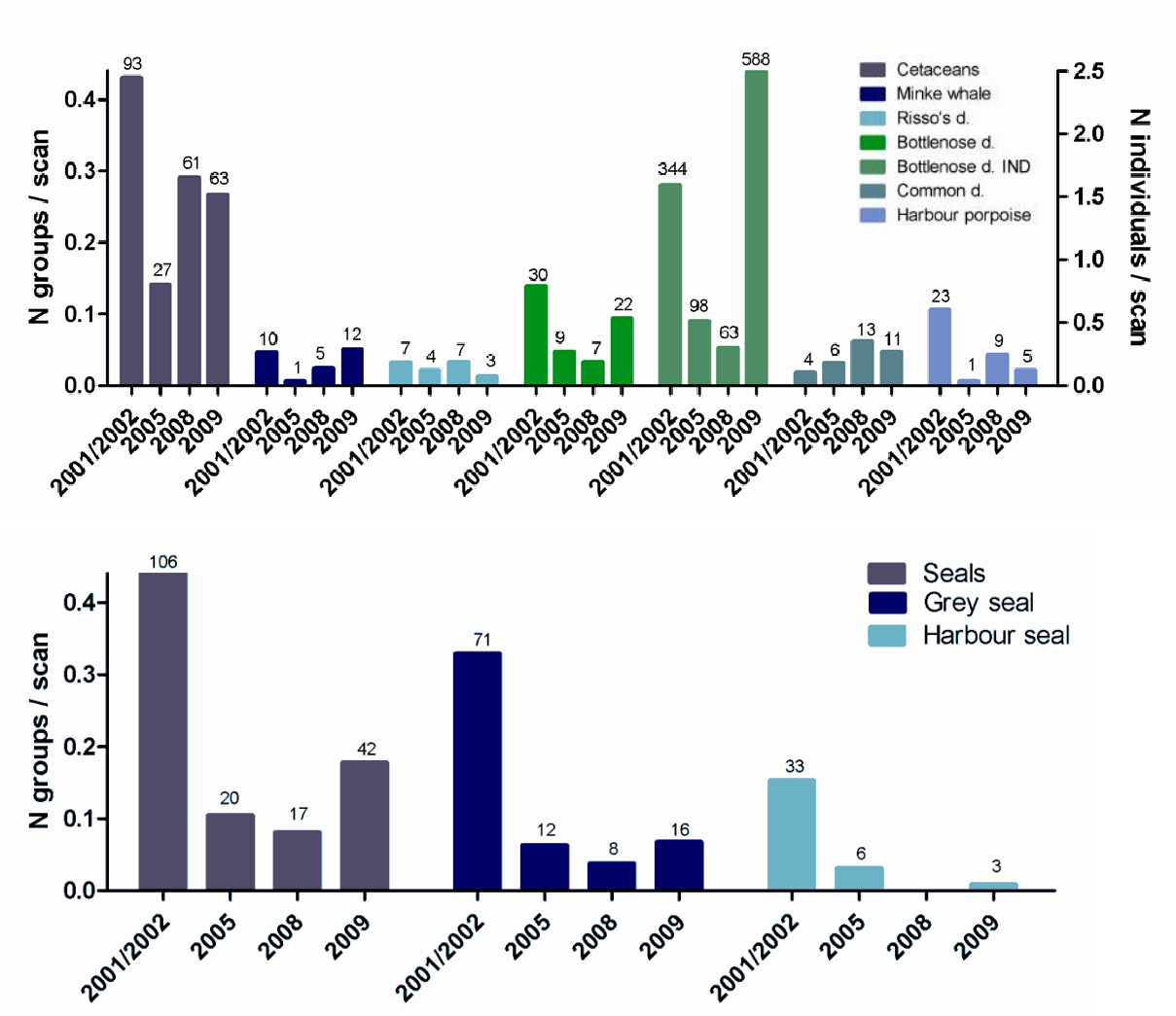


*Figure 6.Sighting rates for cetaceans (**top graph**) and seals (**bottom graph**) in Broadhaven Bay cSAC for all field seasons. Sighting rate was calculated as the mean number of groups observed per scan of the study area. For bottlenose dolphin, sighting rates per number of individuals (IND) are also given. Numbers above bars indicate the number of sightings during scans for each field season.*

Table 2. The range of marine mammal group sizes recorded in Broadhaven Bay between June and September for all field seasons. Also given: sub-adult (calf or juvenile) presences recorded during 2009

Species	Group size range 2002	Group size range 2005	Group size range 2008	Group size range 2009	Sub-adult presence 2009
Cetaceans					
Minke whale	1	1	1	1	
Sei whale	-	-	-	1-2	▲
Killer whale	-	2-4	3	-	
Risso's dolphin	1-3	1-5	1-10	3-5	
Bottlenose d.	1-18	4-20	1-17	1-90	▲
Common d.	1-49	5-250	1-125	1-25*	▲
Whitesided d.	4-25	-	-	-	
Whitebeaked d.	3-4	-	-	-	
Harbour porpoise	1-4	1	1-4	1- 4	
Seals					
Grey seal	1-7	1-2	1-4	1-3	▲
Harbour seal	1-11	1	0	1	

** Max. group size recorded for October was 300 individuals.*

4.2.3 Spatial distribution of sightings

The majority of cetacean sightings and all sightings of seals were made within the boundaries of Broadhaven Bay cSAC (Figure7A). Over the complete period (2001/2002 – 2009), cetaceans were shown to make use of the complete bay area, especially towards the eastern and western margins and from the outer half of the bay out into deeper water beyond the cSAC boundary (Figure7B). In 2009, cetaceans showed a general preference for the western bay area, a pattern that was not observed in previous years (Figure7B). As well, on several occasions, cetaceans were observed to the far south inside of the bay, passing Ballyglass lighthouse towards Ballyglass pier, a movement that had not been recorded previously (Figure7A). The distribution of seal sightings in 2009 was comparable to other years, showing preferences for margins of the bay near and northwards of Erris head (northwest) and Doonanierin (east) (Figure7C). The concentration of sightings close to the primary look-out sites at Doonanierin and Gubastuckaun is likely due to the fact that the seals, which generally show only a small part of their body (head) above water and display inconspicuous surface behaviour, are more easily observed when present at a small range from the look-outs. However, a similar pattern emerges when looking at vessel based records of seal presences alone, showing preferences for the margins of the bay and the area north of Erris Head, indicating that the higher number of sightings in these areas are not solely related to the proximity to the two primary look-out sites (Figure7D). Since 2001/2002 no sightings of seals were made in the inward, sandy area of Rossport Bay, a known haul-out site for harbour seals (Figure7C).

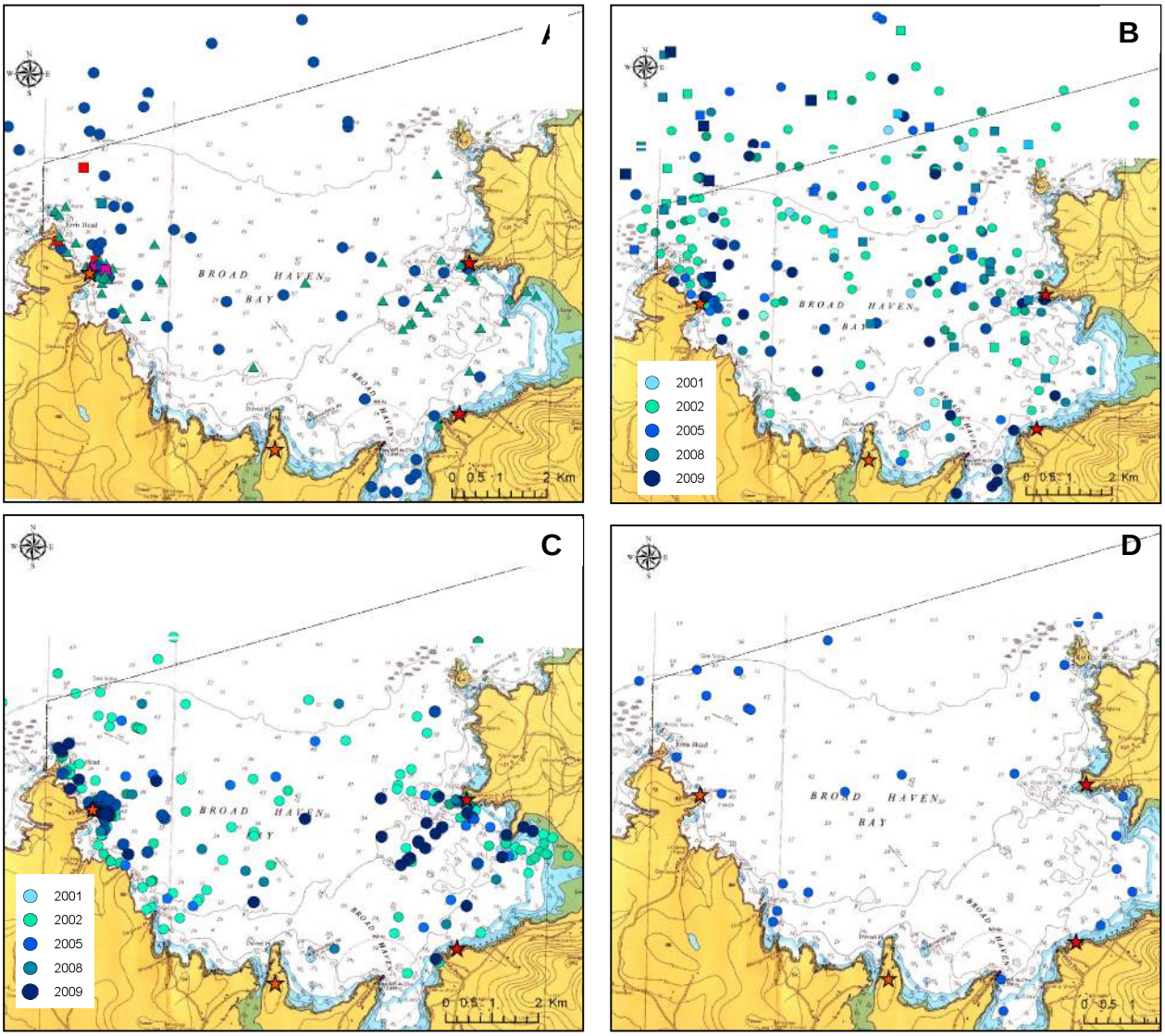


Figure 7 A-D. Spatial distribution of marine mammals in and around Broadhaven Bay cSAC. A. Spatial distribution of all distinct cetacean (●), seal (▲), basking shark (■), sunfish (■) and turtle (■) sightings during 2009. B. Spatial distribution of all distinct cetacean sightings for all field seasons (2001/2002 – 2009). C. Spatial distribution of all distinct seal sightings all field seasons. D. Spatial distribution of all distinct seal sightings for all field seasons from vessel based platforms only.

4.2.4 Temporal distribution of sightings

Cetacean species were observed during all months of the year, except January (Figure 8). No effort was conducted in January, however, due to weather conditions. Highest relative abundances were recorded in August/September (2001/2002, 2008), July (2005), March and October (2009) respectively. The overall pattern shows a year-round presence with increasing cetacean abundance towards the end of summer/beginning of autumn. Seals were also recorded year-round, mainly from March/April to September with a preference for spring (April) and summer months (Jul-Sept.) (FigureFigure 8).

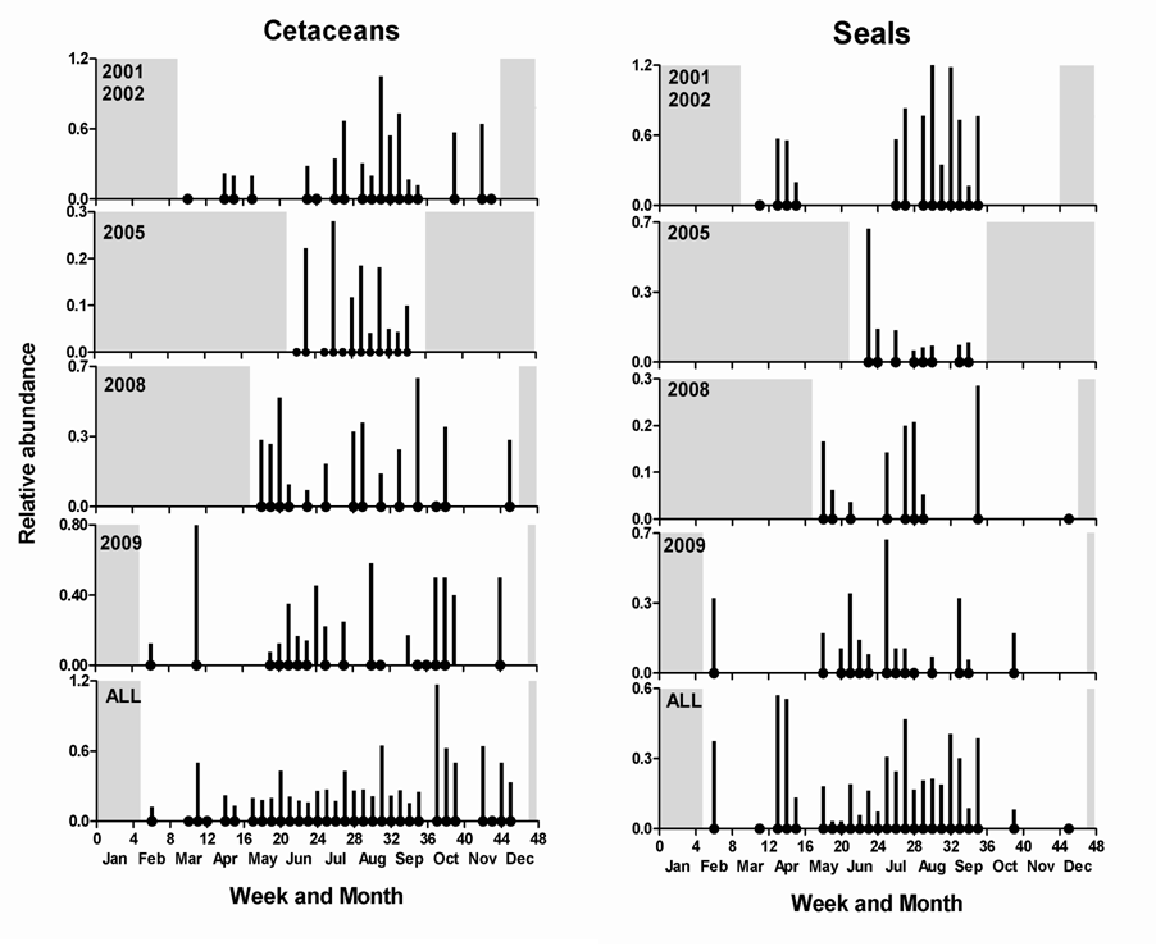


Figure 8. Temporal distribution of cetacean (left panel) and seal (right panel) relative abundance (number of sightings per scan per week) over the year for the field seasons 2001/2002, 2005, 2008, 2009 and for all field seasons combined. Filled circles indicate all presences recorded during opportunistic or scanning effort. Grey boxes indicate periods with no scanning effort due to un-suitable environmental conditions.

4.3 Acoustic detections

As for the previous years, both porpoises and dolphins were successfully detected by the T-PODs. All 4 C-PODs also successfully detected both porpoise and dolphin vocalisations (Figures 3 & 9). In total, the T-PODs at listening stations 1, 2 and 3 in Rossport Bay recorded 503 porpoise detection positive minutes (DPM) and 288 dolphin DPM; the C-PODs recorded 265 porpoise DPM and 125 dolphin DPM at these locations. The C-POD at listening station 4 recorded 533 porpoise DPM and 191 dolphin DPM. Dolphins were recorded during 43 days (T-PODs) and during 47 days (C-PODs) respectively at the listening stations in Rossport Bay. Combined, the C- and T-PODs recorded dolphins during 72 different days, showing dolphin presence during a minimum of 32% of deployment time (1 out of 3 three days). Porpoises were recorded during 53 days (T-PODs) and 41 days (C-PODs) respectively in Rossport Bay. Combined, the C-PODs and T-PODs recorded porpoises during 76 days, showing porpoise presence during 34% of the period of deployment (1 out of 3 days). Dolphins and porpoises were both recorded during 48 days of deployment at listening station 4, showing dolphin and porpoise presence near Erris Head during a minimum of 43% of the deployment time (1 out of 2-3 days).

In general, detection rates for both dolphins and porpoises are higher for the T-PODs compared to the C-PODs (FigureFigure 9). The difference between the detections of porpoises between the C-PODs and the T-PODs at listening stations 1, 2 and 3 can be largely explained by a loss of power of the C-PODs at listening station 2 and 3 during the single period of exceptionally high detection rates for this species. This occurred during April (Figure9). The difference in detection of dolphins, however, does not show a clear relation to loss of effort and may be due to the detection function of the C-PODs for dolphins, which is currently being developed.

4.3.1 Acoustic detections – temporal patterns.

Figure 9, depicting the detections per day for dolphins and porpoises at Rossport Bay and Erris Head, shows some interesting patterns of temporal presences for both types of cetaceans. Porpoises show presences throughout spring, summer and autumn. The spring months (April and May) show a near continuous daily presence in Rossport Bay, with a pronounced peak in detections in early April. Daily detection rates then become less regular during the summer and autumn months (June – November) showing days with detections alternated by one or several days without detections (Figure9B). The temporal pattern of detections of porpoises shows a different pattern for the Erris Head area, recording near continuous daily presence for the period of deployment (July – November) with two peaks of detections in late summer and autumn (Figure9D).

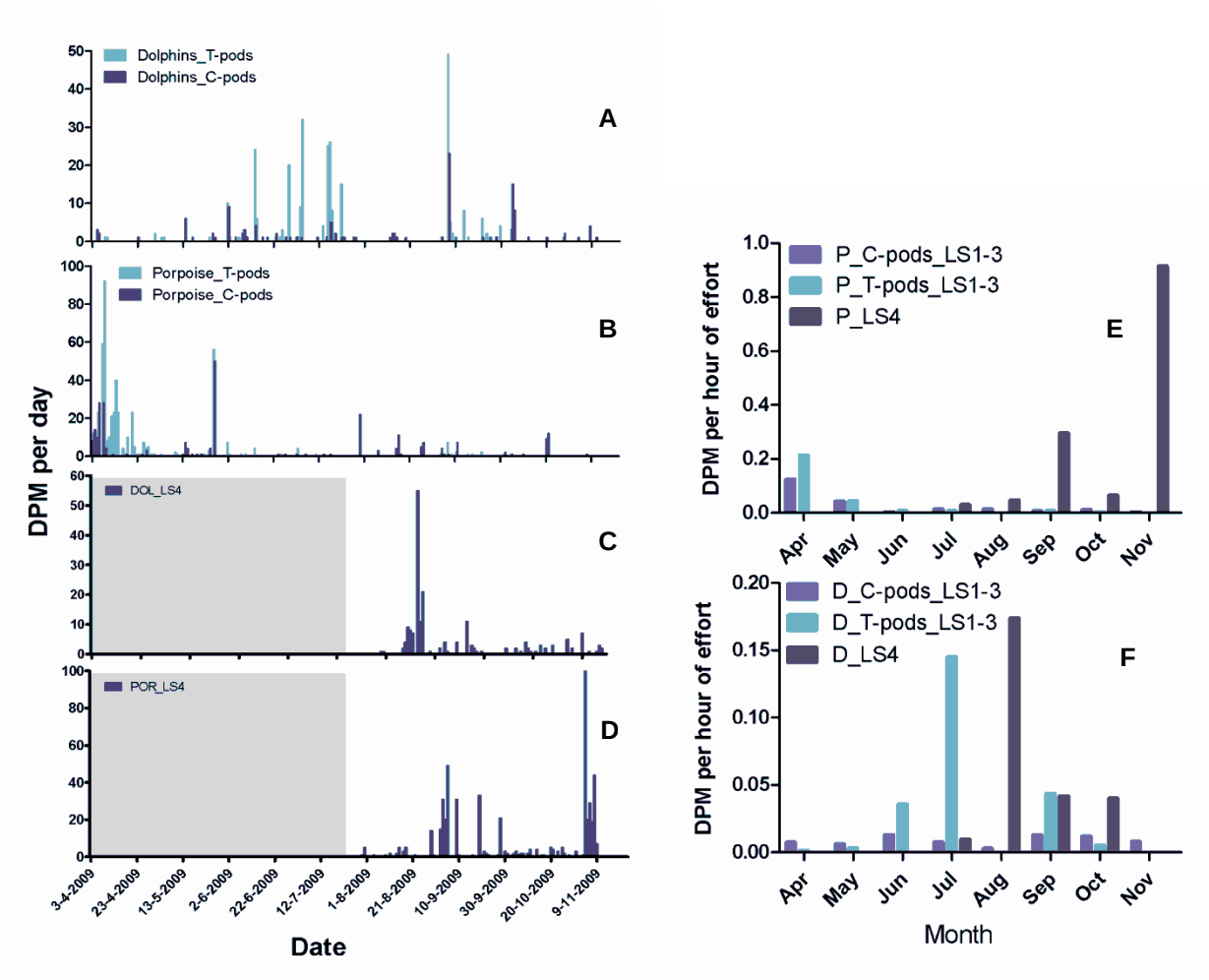


Figure 9. ***Left panel:*** *Detection positive minutes (DPM) per day for dolphins (**A**) and porpoises (**B**) in Rossport Bay (LS1, LS2 and LS3) for the T-PODs and C-PODs and DPM per day for dolphins (**C**) and porpoises (**D**) near Erris Head (LS4) for the period of deployment (April 3rd – November 11th 2009). Grey areas indicate period with no acoustic effort. Right panel: Detection positive minutes (DPM) per hour of effort for each month of T-POD and C-POD deployment for harbour porpoise (**E**) and dolphins (**F**). Both detections for the inner bay area (LS1-3) and the Erris Head area (LS4) are given.*

As the C-POD at Erris Head was first deployed in July, it can only be speculated whether the observed difference in temporal presence highlight a shift in the spatial use of the area between seasons (from inner to outer bay area), or whether the outer bay also shows a high rate of detections during spring months.

Dolphins show a near continuous daily presence, starting in June up to September (Figure9A, C). Presence appears to alternate between the inner and outer bay area, shifting towards the outer part (near Erris Head) in August, back towards the inner bay in September and remains continuous (at lower detection rates) in the outer bay area up to November. While porpoise detections peak in spring and autumn, main detections of dolphins were made during summer. The same pattern is shown by the mean monthly acoustic detection rates for both types of cetaceans (Figure9E, F).

4.3.2 Acoustic detections - spatial patterns

Like the pattern found for all previous years of acoustic monitoring in the inner bay area, porpoises showed a clear preference for the area near the southern listening station (LS3) (Figure10) (*i.e.* Coleman *et al.,* 2009). Interestingly, detection rates are similar for the southern part of the inner bay area (LS3) and the Erris Head area (LS4), potentially indicating that these areas have a similar functionality throughout the year (although at different times; Figure9B, D). For the dolphins, there is no clear pattern for differences in habitat use between sections of the inner bay area. However, this would be more difficult to detect, as dolphin vocalisations would be picked up over longer (>500m) ranges than harbour porpoise vocalisations (200 m; Philpott *et al.,* 2005), while the three listening stations are spaced 500 m apart. However, there does appear to be a preference for the outer bay area, showing more than double DPM as compared to the inner bay. Figure 9A and C suggest potential seasonality of this pattern.

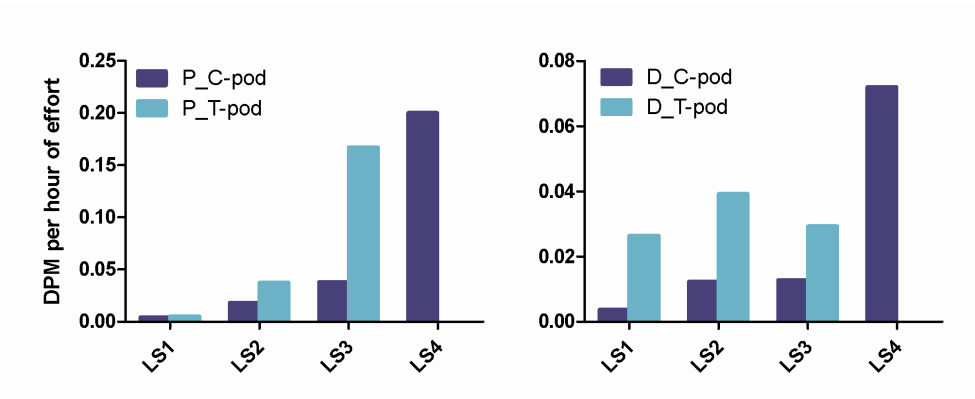


Figure 10. Detection positive minutes (DPM) per hour of effort for the four listening stations for harbour porpoise (P; ***left panel****) and dolphins (D;* ***right panel****).*

4.4 Species characteristics

4.4.1 Baleen whales *Mysticeti*

Two species of baleen whales were recorded during 2009: minke whale and sei whale (Figures 4&5). Minke whale was recorded during all previous years of the study (Table 1), while the sei whale was recorded for the first time in Broadhaven Bay cSAC -and in Irish coastal waters- since the early 1900's (Oudejans and Visser *in press*).

Minke whale *Balaenoptera acutorostrata*

Fifteen distinct sightings of minke whales were recorded in 2009, representing mostly solitary individuals (Table 2). On two occasions, a group size of two individuals was recorded. Minke whales have been recorded mostly solitary from the start of the monitoring project in 2001/2002. No calves or sub-adults were positively identified during any of the years of monitoring (Table 2). Following a strong decrease in sighting rates during 2005 and 2008, in 2009 the overall sighting rate was restored to the level observed in 2001/2002 (Figure6). Significant differences between sighting rates were found between years when including the complete period of observation effort for each field season (X^2 = 8.0; df=3; p=0.047). However, when analysing sighting rates for the period June-September only, no significant differences were found (X^2 = 4.2; df=3; p=0.24). This indicates that minke whale relative abundance during the period July – September has remained relatively constant between the field seasons, but also that this period may not be representative for minke whale presence in the study area. Main distribution of minke whale abundance was recorded in April/May, July and October (Figure12).

The largest part of minke whale sightings were made within the cSAC, occurring mainly in the central and outer parts of the bay, especially at the western margin from Erris Head northwards. Minke whales were not observed in the southern part of the bay (Figure11A). Minke whale behaviour can be difficult to asses from visual observations, especially in the absence of clear foraging events such as lunge feeding or skim feeding. Minke whales are generally observed during short surfacings, which are spaced several minutes apart and often behave inconspicuously when present at the surface. In 2009, CMRC observers succeeded in recording 5 tracks of individual minke whales, of which 2 had a duration of >2 hours (Figure11B). These two long-term focal follows clearly showed minke whale foraging behaviour: on both occasions, the whale remained in a confined area for 2 hours or more, showing repeated (deep) dives and short surfacings. Interestingly, the foraging whale(s) used exactly the same area on both days (observations spaced one day apart: May 31st and June 1st). Next to foraging, travelling behaviour was observed.

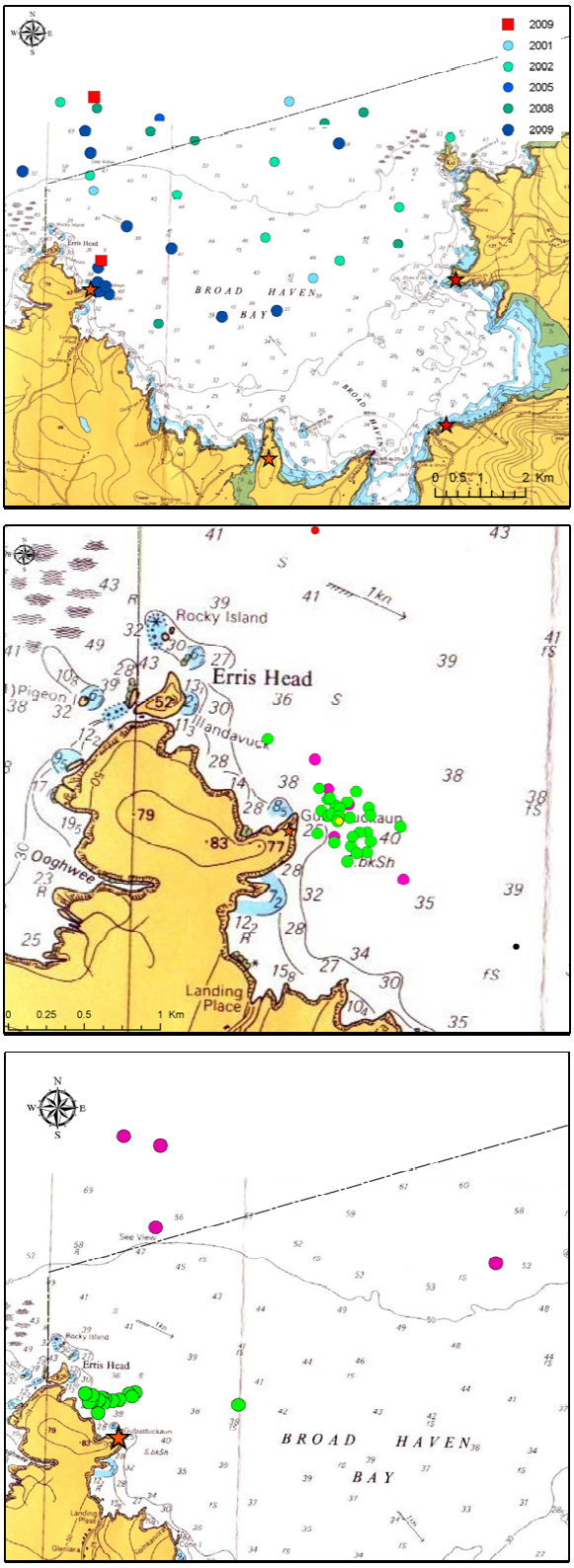


Figure 11A-C. ***A****: Spatial distribution of distinct sightings of minke whales (circles) and sei whales (squares) in and around Broadhaven Bay cSAC during all field seasons.* ***B****: Map of Broadhaven Bay cSAC zoomed in at the north-western margin at Erris Head showing three tracks of minke whales (green, pink and yellow dots respectively) recorded on two different days in 2009. C. Two tracks of sei whales (green and pink dots respectively) recorded on two different days in 2009, showing foraging behaviour very close to the cliff edge near Erris Head (green) and in more open water just outside the cSAC boundary moving inward towards the central bay area (pink).*

Minke whales were observed from April to October, generally with a time-span of several weeks between sightings. Overall higher relative abundance was recorded in spring (Apr.-May) and autumn (Oct.) (Figure12).

Sei whale *Balaenoptera borealis*

Three distinct sightings of sei whales were made during September 2009 in close proximity of the western margin at Erris Head and just outside of Broadhaven Bay cSAC (Figure11A). On at least one occasion, two individuals were recorded, of which one was a juvenile. On all three occasions the sei whale(s) were observed foraging for 2-4 hours in close proximity to the coast, continuously skimfeeding in a confined area (Figures 5 & 11C). One individual was photo-identified and re-sighted the next day. The sei whales were apparently feeding on sprat, which were observed in large patches at the surface in the immediate vicinity of the foraging whale(s).

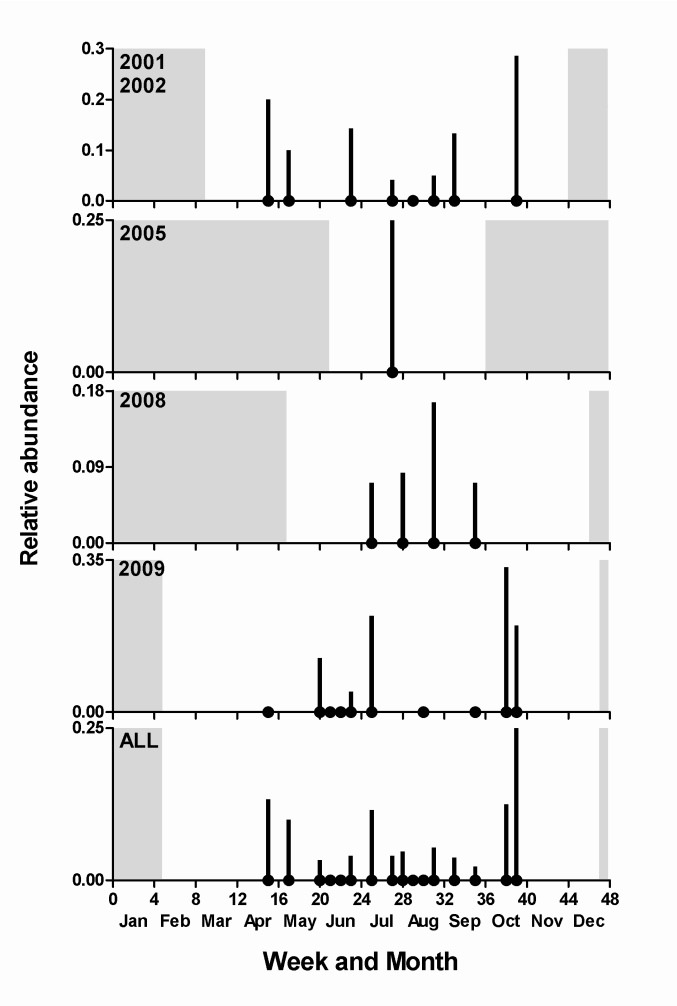


Figure 12. Temporal distribution of minke whale relative abundance (number of sightings per scan per week) over the year for the field seasons 2001/2002, 2005, 2008, 2009 and for all field seasons combined. Filled circles indicate all presences recorded during opportunistic or scanning effort. Grey boxes indicate periods with no scanning effort due to un-suitable environmental conditions.

4.4.2 Toothed whales *Odontoceti*

Five species of toothed whales were observed in Broadhaven Bay cSAC during 2009. Two species of odontocetes, white beaked dolphin (*Lagenorynchus albirostris*) and killer whale (*Orcinus orca*) were not recorded on effort in 2009, but were present in Broadhaven Bay during previous monitoring effort in 2001/2002 and in 2005 and 2008 respectively (Table 1; Figure.4). Killer whales, however, were recorded present and photographed in Broadhaven Bay cSAC by marine mammal observers operating from a Corrib Project construction vessel and by personnel of a naval vessel present in the bay in June and July 2009 respectively (www.iwdg.ie).

Risso's dolphin *Grampus griseus*

Three distinct sightings were made of Risso's dolphin in 2009, comprising 13 individuals (Table 1). Group sizes were comparable to sightings recorded during previous years, ranging from 3 to 5 individuals. In contrast to 2008, when larger groups of Risso's dolphin including 2 or more calves were observed, sub-adults were not recorded present during monitoring effort in 2009 (Table 2). No significant differences in sighting rates were found between field seasons for Risso's dolphin.

Risso's dolphin displays a spatial distribution in Broadhaven Bay, which is largely confined to the area surrounding Erris Head, in close proximity to the coast and extending northwards outside of the cSAC. No usage of the southern, inner bay area was recorded (Figure13A). The area off Erris Head is characterised by the presence of a tidal rip, which may explain the presence of Risso's dolphin at this location (potential feeding opportunities). The same pattern is observed from tracks of Risso's dolphin groups: main usage of the bay is recorded in the north-western part of Broadhaven Bay (Figure13B). Risso's dolphins do extend their use to both sides of the bay, as indicated by two tracks recorded in 2009 whereby Risso's dolphin groups crossed the bay from west to east (Figure13B; green and dark blue tracks). Foraging behaviour was observed on several occasions during 2009, alternated with short resting bouts (loggings). Travelling behaviour was observed most frequently.

Temporal presence of Risso's dolphin in Broadhaven Bay was mostly confined to the summer months: the species was observed during a short period of 1 to 4 weeks each year. All but some sightings of the species occurred during July and August, apart from 2005 when presence and highest relative abundance were recorded in June (Figure14).

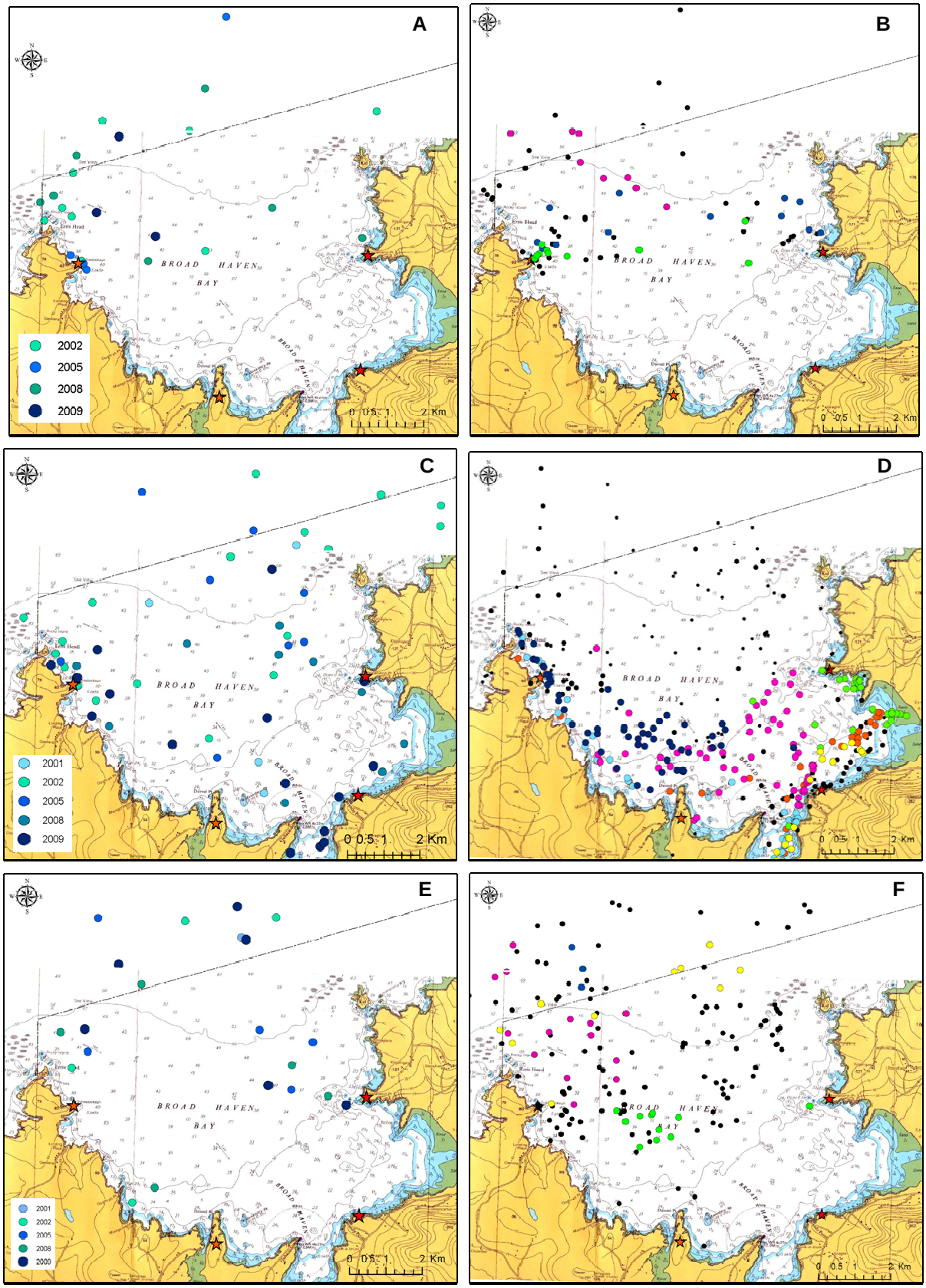


*Figure 13A-F **A**, **C** and **E**: Spatial distribution of distinct sightings of (**A**) Risso's dolphin, (**C**) bottlenose dolphin and (**E**) common dolphin in and around Broadhaven Bay cSAC during all field seasons. **B, D** and **F**: All tracks of (**B**) Risso's dolphin, (**D**) bottlenose dolphin and (**F**) common dolphin recorded during all field seasons. For 2009, each distinct track is indicated by coloured dots (one colour for each track). Tracks recorded in the 2001/2002, 2005 and 2008 field seasons are indicted by black dots.*

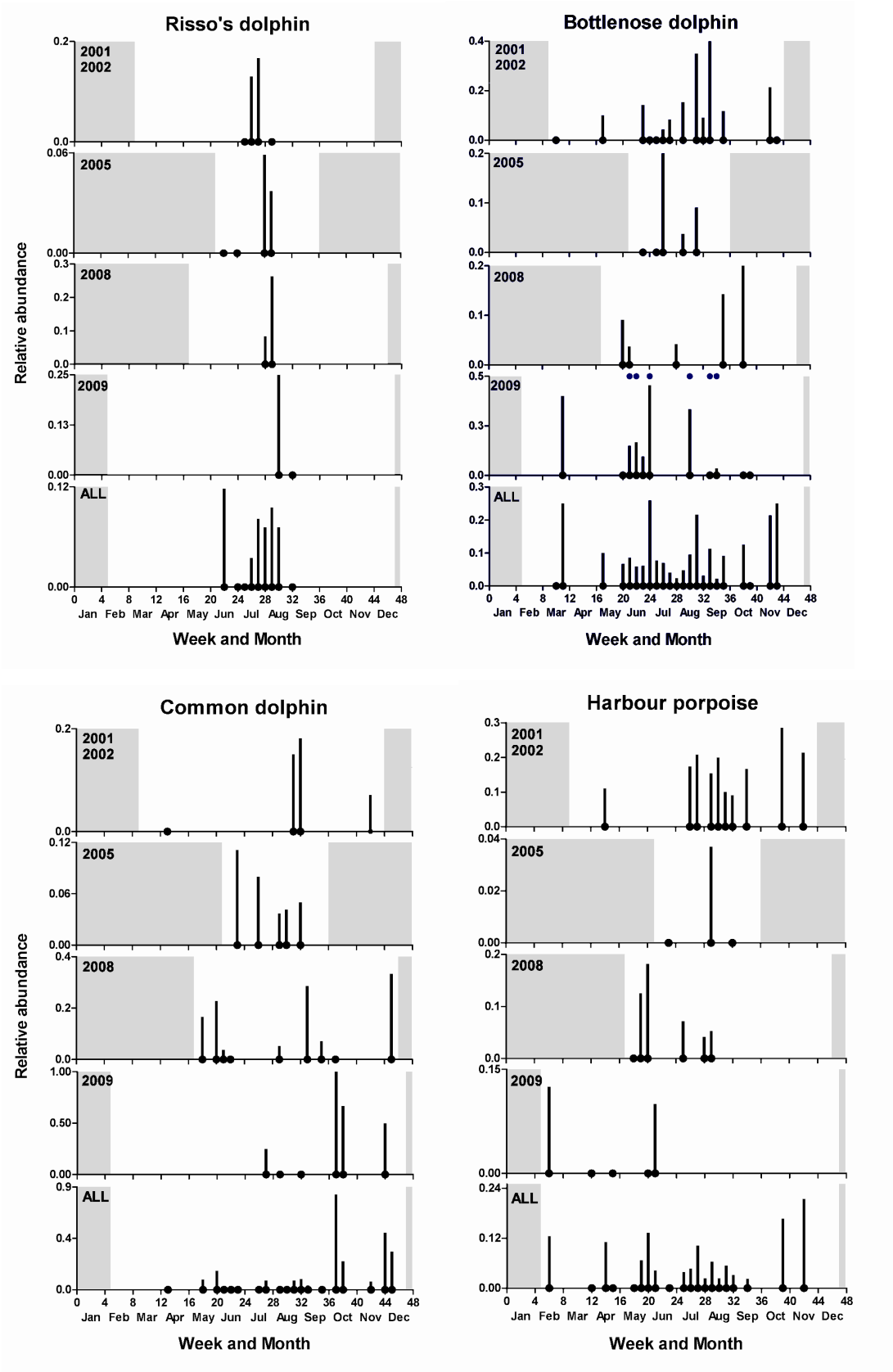


Figure 14. Temporal distribution of Risso's dolphin, bottlenose dolphin, common dolphin and harbour porpoise relative abundance (number of sightings per scan per week) for the field seasons 2001/2002, 2005, 2008, 2009 and for all field seasons combined. Filled circles indicate all presences recorded during opportunistic or scanning effort. Grey boxes indicate periods with no scanning effort due to un-suitable environmental conditions.

Bottlenose dolphin *Tursiops truncatus*

Patterns of bottlenose dolphin presences in Broadhaven Bay in 2009 differed from patterns observed in previous years of monitoring, especially concerning group size and the number of individuals observed. Nineteen distinct sightings were made of bottlenose dolphin in 2009 between March and October, comprising 471 individuals (Table 1). Group size ranged up to 90 individuals, 4.5 to 5 times higher than was reported for all previous years (Table 2). Mean group size was 28 individuals, 2.5 to 4 times higher than was previously recorded (2001/2002: mean = 11; 2005: mean = 10; 2008: mean = 7). The presence of sub-adults, including juveniles, calves and new born calves, was recorded in 68% of bottlenose dolphin groups (13 out of 19 groups).

In 2009, sighting rates of bottlenose dolphins, which had dropped significantly in 2005 and 2008 as compared to the first year of monitoring (2001/2002), showed an increase to the level observed in 2001/2002 for both the number of distinct groups (X^2 = 20.5; df=3; p<0.001) and the number of individuals (X^2 = 20.7; df=3; p<0.001) (Figure6).

Bottlenose dolphins were recorded throughout Broadhaven Bay cSAC, with a preference for the western and eastern margins of the bay, especially the area off Erris Head, and for the mouth of the bay (Figure13C). Most sightings were made very close to the coast. As well, for the first time in 2009, bottlenose dolphins were recorded several times in the innermost part of Broadhaven Bay, passing Ballyglass lighthouse and Ballyglass pier and travelling up to 3 km southward into the shallow, narrow channel leading to the enclosed inner bay area (Figure13C). In 2009, six presences of bottlenose dolphin groups in the cSAC of 5.5 hours or longer were recorded during focal follow observations. The maximum duration of presence recorded for one group of bottlenose dolphins was 8 hours and 55 minutes (10:53 h – 19:48 h). These prolonged presences indicate that, rather than just travelling through the bay, bottlenose dolphin groups specifically use the cSAC area for foraging, resting and/or socialising purposes.

The tracks recorded during the focal follow observations show that bottlenose dolphins preferably enter and leave the bay via the western margin, at Erris Head. In the north-western part of the bay, routes taken lie very close to the cliff edge and follow the outline of the bay, moving more towards the central bay area, or cross over to the eastern part of the bay once the dolphins have reached the southern, inner part of the bay. Likewise, in the eastern part of the bay, bottlenose dolphin groups are found mainly very close to the coast, far into the eastern margin of the bay at Rossport Bay. With only one exception, all groups travelling into the channel towards Ballyglass pier entered and left the channel via the

eastern side. Especially in 2009, usage of the northern, central bay area was highly restricted (Figure13D).

Apparently, for bottlenose dolphins, in 2009 main usage of the bay was concentrated in the southern bay area. As well, there was a strong overlap in the routes taken by groups of bottlenose dolphins on different days and between different years. This indicates some preference may exist for the specific routes taken and for the areas used for travelling, resting/socialising and foraging, within Broadhaven Bay cSAC. As well, it could indicate that the same individuals displaying similar behaviour whenever they enter the bay re-use the bay area during several occasions over the year. Interestingly, this preference is largely mirrored to the spatial patterns displayed by Risso's dolphin and common dolphin, which both concentrate their presence in the northern, upper part of Broadhaven Bay cSAC (Figures 13B&F).

Behaviour displayed by bottlenose dolphins during their presence includes travelling, foraging, resting and socialising. Generally, especially for larger groups with a presence of several hours, all four behavioural types were recorded during their presence in the bay. Longer bouts of social and resting behaviour were recorded at the eastern margin, in the shallow waters of Rossport Bay. Foraging was observed mainly in the more central bay area and in the channel leading up to Ballyglass pier. Travelling was observed throughout the area used by bottlenose dolphin, especially at the western margin.

Bottlenose dolphins were recorded present throughout the year, with the exception of December - February and April (Figure14) However, visual observation effort in these months was generally low (April) or (nearly) absent (Dec. – Feb.) (Figure2). Thus, bottlenose dolphins were recorded throughout the year whenever regular monitoring effort was conducted. Additionally, dolphin clicks, potentially bottlenose dolphin clicks, were recorded at listening stations 1-3, stationed in Rossport Bay (eastern inner bay area), during April 2009 (Figure9).

Bottlenose dolphin presence appears to be non-continuous, whereby one to several weeks with species presence recorded is alternated by a period of absence (during day-time periods when visual monitoring is possible). The main period of presence was recorded from the end of May through to the end of September, October and November, with yearly variation in peak abundance (early summer - late summer/autumn).

In addition, the acoustics data shows regular recordings of dolphins from the second week of May to the end of July and from September to November in Rossport Bay. As well, daily records of dolphin vocalisations were recorded at listening station 4 off Erris Head throughout its time of deployment (Aug. – Nov.), peaking in August (Figure9). While the vocalisations recorded for 'dolphins' can not all be ascribed to bottlenose dolphin, visual observations show that, throughout the day, the inner bay area of Rossport Bay is used on a regular basis by bottlenose dolphin, but not by any other species of dolphin (Figure13). The main other dolphin species contributing to the vocalisations recorded by the PODs is common dolphin (Table 1, 2). Common dolphins however, mainly make use of the northern part of the bay (Figure13E, F). Therefore, a large part of the recordings during day-time from the listening stations in Rossport Bay can likely be attributed to bottlenose dolphin, comprising detections during 32% of days in the period April – November. This is not the case for vocalisations recorded at listening station 4, off Erris Head, which is stationed in an area used by bottlenose dolphin, Risso's dolphin and common dolphin on a regular basis throughout their period of presence (Figure13A-F).

Photo identification

In addition to visual and acoustic data, photo identification data was collected for bottlenose dolphin in 2009. Seven groups of bottlenose dolphins were photographed on 7 different days between June 2nd and September 14th 2009 (Figure2). The number of individuals identified during each encounter ranged from 4 to >70. A minimum of 120 different individuals were identified. A large part of individuals was re-sighted at least once during the 3.5 months between the first and the last photo identification trip. Regular re-sightings were made of mother-calf pairs.

Common dolphin *Delphinus delphis*

In 2009, 6 distinct sightings were made of common dolphins, comprising a total of 370 individuals (Table 1). Very large group sizes were recorded, ranging up to 300 individuals (Table 2). Mean group size, 73 individuals, was c. 3 times higher than was previously recorded for the species (mean group size: 19 – 30 individuals). Similarly large groups, ranging up to 250 animals, were recorded in 2005, but not during the other years of monitoring effort (Table 2). Sub-adult presence, including calves, was recorded in 83% of groups. No significant differences were found between sighting rates of the different field seasons (Figure6).

Common dolphins were recorded inside as well as just outside Broadhaven Bay cSAC, with a preference for the eastern and western margins and the northern, outer bay area (Figure13E). Tracks recorded during 2009 show patterns of travelling groups (*i.e.* yellow

track in Figure13F) and of foraging groups (*i.e.* green and pink tracks in Figure13F). Presences of common dolphin groups in the bay of several hours, ranging up to 8.5 hours, were recorded on several dates in July and October. Main behavioural patterns recorded during 2009 were alternating bouts of foraging and travelling, and few, generally short occurrences of socialising or resting behaviour (loggings, milling). As for bottlenose dolphin, the prolonged presences recorded in the bay suggest a specific functionality of the bay area for the common dolphin, rather than an area, which is used in transit alone. This is further corroborated by the observations of common dolphin foraging behaviour in the cSAC.

Common dolphins were recorded in the bay from April to December, with a main preference for the autumn and winter months (October – Nov. / early Dec.). The species shows a relatively irregular presence in the study area whereby weekly presences are alternated by a period of absence (Figure14). As was described for bottlenose dolphin (see above), common dolphin presence can be partly inferred from acoustic detections of dolphin vocalisations by the PODs. Based on the spatial distribution of the species (Figure13E,F), it is likely that part of the vocalisations recorded from August to November at listening station 4 near Erris Head can be attributed to common dolphins, comprising regular, near-daily detections of dolphins between April and October (Figure9A,C).

Harbour porpoise *Phocoena phocoena*

Five distinct sightings were made of harbour porpoise in 2009, comprising a total of 10 individuals (Table 1). Maximum group size recorded was 4 individuals, comparable to the other years of monitoring effort (Table 2). No sub-adults were observed. In 2009, sighting rates were significantly lower than recorded for 2001/2002 and 2008 (X^2 = 16.1; df=3; p=0.001; Figure6). However, harbour porpoise, known for its generally inconspicuous surface behaviour, is difficult to observe, even at sea states 3 or less. Results obtained from visual observations, especially from remote platforms should be interpreted with caution.

Harbour porpoise was recorded present in Broadhaven Bay cSAC almost year-round from visual observations (not in December/January) (Figure14). The species was recorded throughout the cSAC, including the areas covered by the 4 listening stations in Rossport Bay and at Erris Head (Figure15). While the opportunities for visual observations may be relatively limited, harbour porpoise can be detected and identified very well acoustically using the T- and C-PODs. Harbour porpoise vocalisations were recorded throughout the complete period of deployment of the listening stations in Rossport Bay (April – November) and Erris Head (August – November). Peak detections occurred in April (Rossport Bay) and November (Erris Head area), potentially indicating a shift in habitat use from the inner to the outer bay

between spring and autumn (Figures 9B, D, E &10). Please see also sections *Acoustic Detections – temporal patterns* and – *spatial patterns* above for further results on harbour porpoise spatial and temporal patterns of presence.

White-sided dolphin *Lagenorynchus acutus*

One distinct sighting was made of white-sided dolphin in 2009, comprising 30 individuals (Table 1; Figure15). Sightings of white-sided dolphins in Broadhaven Bay cSAC are rare and generally entail mixed groups. In 2009, the species was recorded in a mixed group with bottlenose dolphins in May. In 2002, the species was sighted in mixed groups with common dolphin and white-beaked dolphins in August.

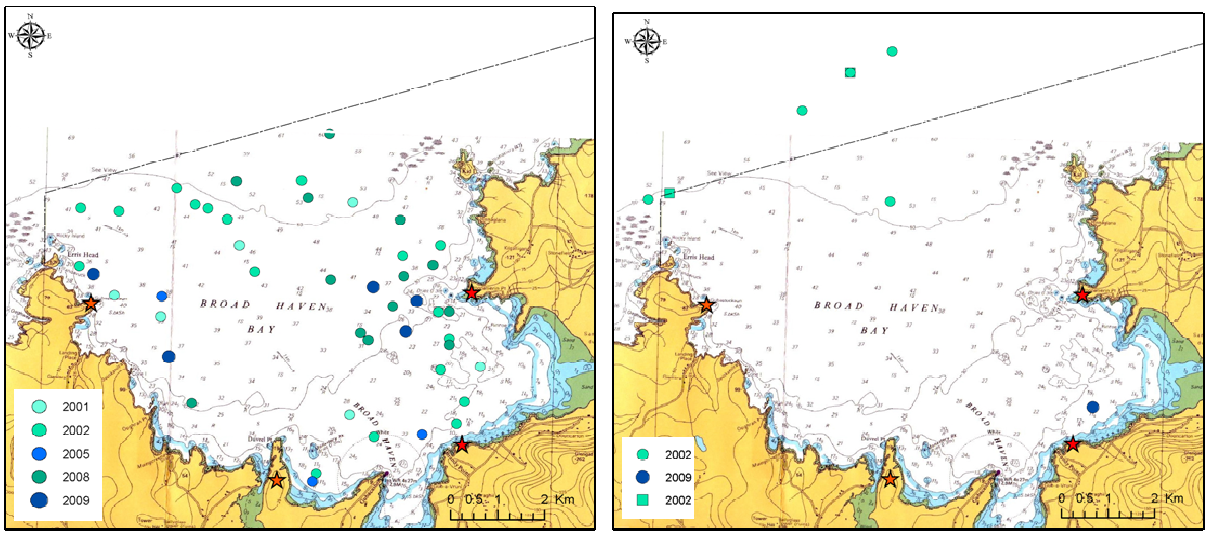


Figure 15. ***Left panel:*** *Spatial distribution of harbour porpoise in and around Broadhaven Bay cSAC for all field seasons.* ***Right panel:*** *Spatial distribution of white-sided (circles) and white-beaked (squares) dolphin for all field seasons.*

4.4.3 Seals *Pinnipedia*

Grey seal *Halichoerus grypus*

Thirty one distinct sightings were made of grey seals in Broadhaven Bay cSAC in 2009, comprising thirty four individuals (Table 1). The largest part of observations was of single individuals (mean group size = 1.1; Table 2). One observation was made of a sub-adult grey-seal, hauled out on the rocks near Erris Head. Sub-adults were also recorded during previous years of monitoring, mainly in 2001/2002. Sighting rates in 2009 were similar to those observed in 2005 and 2008, but significantly lower than was observed for 2001/2002 (X^2 = 57.3; df=3; p<0.001; Figure6).

Most presences of grey seals in Broadhaven Bay cSAC were recorded at the eastern and western margin of the bay, close to the rocky shoreline, with some records extending out of the cSAC area off Erris head and into the central and inner bay area (Figure16). The highest numbers of recordings were made in close vicinity of the land based look-outs at Gubastuckaun and Doonanierin. This is likely to be a result of limitations of field of view as opposed to representing the preferred at-sea distribution of grey seals in these areas (*see also* Figure7C,D). Seals in close vicinity of the look-out are more easily observed than those further offshore and visual cues that increase the likelihood of observing cetaceans (*e.g.* breaches and blows) do not pertain to seals.

It is difficult to make inferences on seal behaviour at sea, based solely on observations, telemetry technologies are usually used for this purpose, but it is likely that the seals are using the bay for foraging and navigating between haul-out sites and foraging areas. Grey seals were observed mainly from the end of March to September, with a limited number of observations extending into February and October (Figure17). In spite of regular monitoring effort outside of this period (Figure2), grey seals were not observed. The period March – September is largely outside of the known periods for the female (Nov. –Feb.) and male (Jan. - Apr.) annual moult and also largely outside of the yearly pupping and mating season (Sept. – Nov.). The grey seals present in Broadhaven Bay likely form part of the population inhabiting the nearby Inishkea islands, where they breed and moult. Telemetry research in southwest Ireland and the UK suggests grey seals spend increased periods of time at sea post-moult in the spring and summer months prior to the breeding period, presumably foraging (McConnell *et al* 1999; M. Cronin, CMRC *pers. comm.*). The presence during spring and summer months therefore suggests the functionality of the area as a foraging area for grey seals.

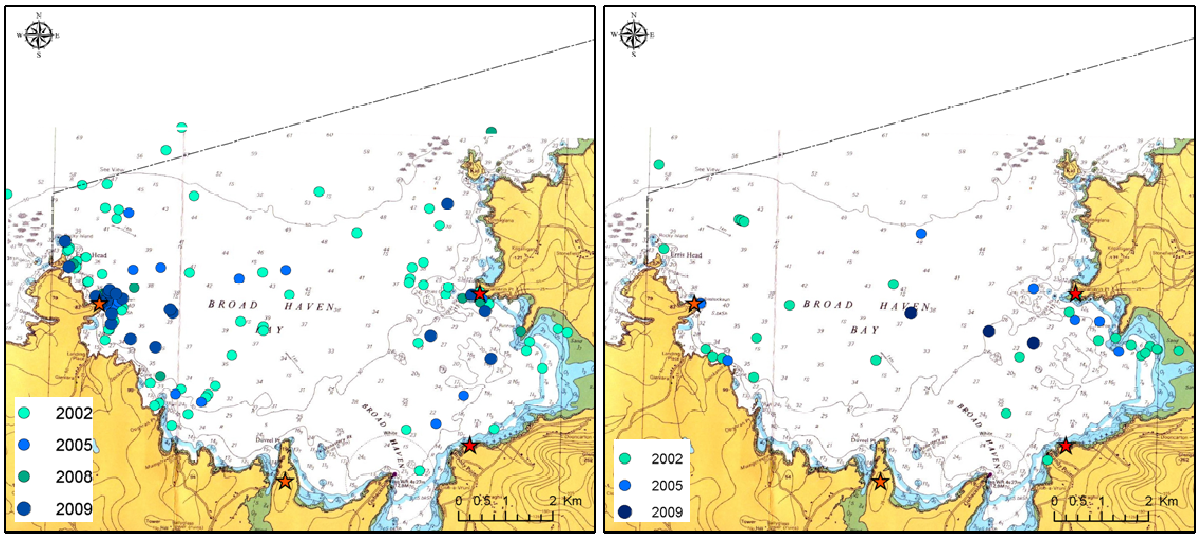


*Figure 16. Spatial distribution of grey seal (**left panel**) and harbour seal (**right panel**) sightings for all field seasons in and around Broadhaven Bay cSAC.*

Harbour seal *Phoca vitulina*

Six distinct sightings were made of harbour seals, comprising six individuals (Table 1). As with grey seals, it is generally difficult to determine harbour seal age-class. No juveniles or calves were recorded with certainty. As was reported for the grey seal, sightings for this species dropped significantly since 2001/2002 (X^2 = 56.8; df=3; p<0.001; Figure 6). It is likely that at least part of this variation is due to observer bias, however, we cannot rule out changes in harbour seal habitat use over the monitoring period.

Spatial distribution of harbour seals is similar to the distribution of the grey seal, although more harbour seals were observed at the eastern, inner part at Rossport Bay (Figure 16). Harbour seals were observed in Broadhaven Bay between June and September and in April (Figure17). This period coincides with the annual period for mating, pupping and moulting. Two haul-out locations are known for harbour seal in Broadhaven Bay: the beach at Rinroe (eastern margin) and the small island of Inishderry. The latter is not visible from the look-outs in Broadhaven Bay and individuals seen swimming in the bay could have originated from there. The beach at Rinroe did function as a haul-out during previous years of monitoring (2001/2002), but no sightings were made of individuals hauled out on the beach in 2009.

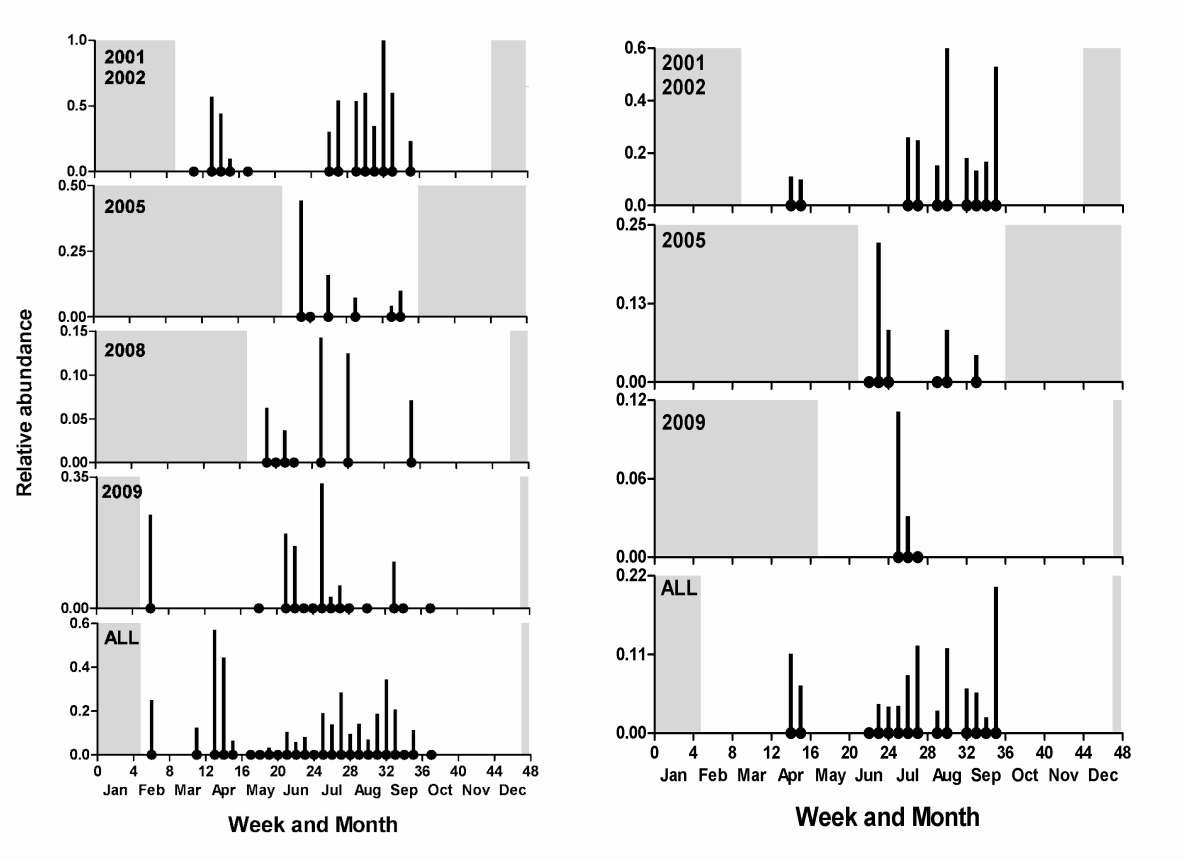


*Figure 17. Temporal distribution of grey seal (**left panel**) and harbour seal (**right panel**) relative abundance (number of sightings per scan per week) over the years for the field seasons 2001/2002, 2005, 2008, 2009 and for all field seasons combined. Filled circles indicate all presences recorded during opportunistic or scanning effort. Grey boxes indicate periods with no scanning effort due to un- suitable environmental conditions.*

4.4.4 Other species of interest

Basking shark *Cetorhinus maximus*

Three distinct sightings were made of basking sharks, comprising three individuals. Basking sharks were recorded along the margins and the mouth of the bay, as well as in the central parts and all the way into the southern bay area (Figure18). The species was observed from May to September and showed a temporal shift in its main period of presence between 2001/2002 and 2009: peak abundances were recorded earlier each year, showing an overall bimodal pattern of highest abundances in May and August (Figure19).

Sunfish *Mola mola*

Four distinct sightings were made of sunfish during 2009 in the months July, August and September. Summer presences of sunfish were also recorded during the previous years of monitoring. Sunfish were recorded mostly in open water in the central and outer parts of Broadhaven Bay cSAC (Figure18).

Turtles

Two distinct sightings were made of large turtles in September and October. The turtles could either be loggerheads (*Caretta caretta*) or leatherbacks (*Dermochelys coriacea*), but could not be identified to species level from the land based platform. One other sighting was made of a turtle in Broadhaven Bay, during August 2002 (Figure18).

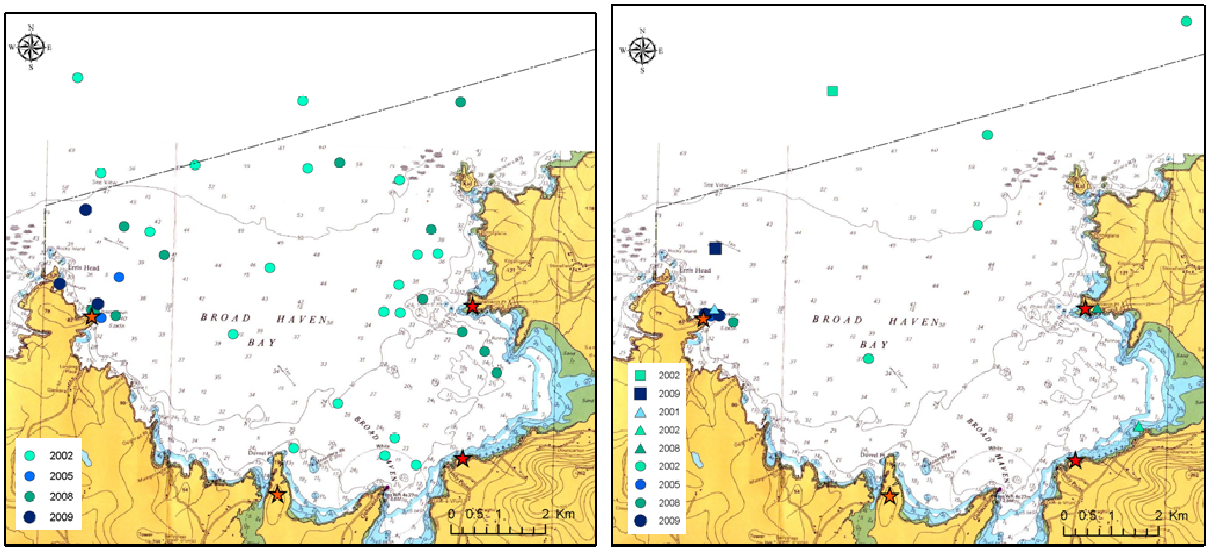


*Figure 18. Spatial distribution of distinct sightings of basking shark (**left panel**) and distinct sightings of sunfish (circles), turtles (squares) and otters (triangles) (**right panel**) for all field seasons in and around Broadhaven Bay cSAC.*

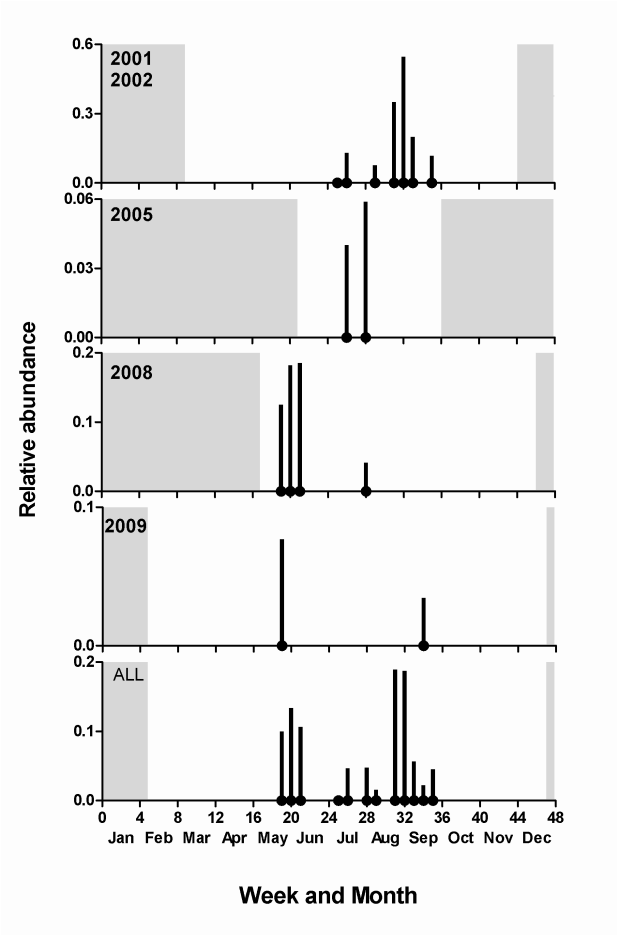


Figure 19. Temporal distribution of basking shark relative abundance (number of sightings per scan per week) over the year for the field seasons 2001/2002, 2005, 2008, 2009 and for all field seasons combined. Filled circles indicate all presences recorded during opportunistic or scanning effort. Grey boxes indicate periods with no scanning effort due to un-suitable environmental conditions.

4.5 Marine mammal habitat-use in Broadhaven Bay cSAC

Marine mammal habitat use of Broadhaven Bay is summarised in Table 3, stating the summary of characteristics of relative abundance, group size, sub-adult presence, spatio-temporal patterns of distribution for each species.

Abbreviations used in Table 3; Abundance between years: VAR = significant differences between field seasons; STABLE = no significant differences; Sub-adult presence: NB = newborn calf; C = calf; JUV = juvenile; Period of presence: YEAR = year-round presence; YEAR - W = year-round presence outside of winter months; SEASON = seasonal presence; Behaviour: FOR = foraging; TRAV = travelling; SOC = socialising; REST = resting.

Table 3. Habitat use of marine mammals in Broadhaven Bay cSAC, 2001/2002, 2005, 2008 and 2009

	ABUNDANCE		GROUP SIZE		SPATIAL	TEMPORAL				BEHAVIOUR
Species	Sighting rates	Between years	Range & mean ± SD	Sub-adult presence	Distribution in cSAC	Period of presence	Peak presence	Regularity	Re-sightings of presence	Types observed
Baleen whales (balaenopteridae)										
Minke whale	Medium	Var	1-2 1.1 ± 0,2		Central, outer bay; North of Erris Head	YEAR-W (Apr - Oct)	Apr/May & Oct	Regular	Hours	FOR; TRAV
Sei whale	Low		1-2 1.7 ± 0,6	Juv	Western margin at Erris Head, central, outer bay	SEASON Sept			Days	FOR
Toothed whales (odontoceti)										
Killer whale	Low		3-4 (6) 3.3 ± 0,6	Juv	Outer bay	SEASON (May, July)	July	Rare		TRAV
Risso's dolphin	Medium	Stable	1-10 2.7 ± 1.7	Calf; Juv	Outer bay; margins, north of Erris Head	SEASON (Jun - Aug)	July-Aug	Regular	Hours	FOR; TRAV
Bottlenose dolphin	High	Var	1-90 15.5 ± 15.7	NB; Calf; Juv	Margins, full inner bay (margin and central), outer bay	YEAR Mar - Nov	Early summer - late summer/autumn	Regular	Hours; Days; Months; Years	FOR; TRAV; SOC; REST
Common dolphin	Medium	Stable	1-300 31.9 ± 42	Calf; Juv	Outer, central bay	YEAR Apr - Dec	Autumn / Winter	Occasional	Hours	FOR; TRAV
White-sided d.	Low		7-25 17.3 ± 9.3	Calf; Juv	Outer and inner bay	SEASON (Mar, Aug)		Rare		
White-beaked d.	Low		3-4		Outer bay	SEASON (July, Aug)		Rare		
Harbour porpoise	High	Var	1-4 1.9 ± 1	Juv	Inner and outer bay	YEAR (Feb - Nov)	April & October	Constant		
Seals (pinnipedia)										
Grey seal	High	VAR	1-7 1.1 ± 0.6	JUV	Margins and central bay	YEAR (Feb - Oct)	April, summer	Regular		REST; TRAV
Harbour seal	High	VAR	1-11 1.9 ± 2.2		Margins and central bay	SEASON (Apr - Sept)	Summer	Occasional		REST; TRAV; FOR

4.6 Vessel presences in Broadhaven Bay cSAC

Vessel presences were recorded during 160 out of 188 days with scanning effort (85%) in the period May to December 2009. In total, construction vessels were recorded during 149 days (79%), of which 100 days (53%) showed the presence of construction vessels involved in dredging, pipe-laying or otherwise. Utility vessels were observed present during 133 days (71%). Fishing vessels were recorded present during 87 days (46%) (Figure20).

In total, 1048 construction and utility vessel presences were recorded during the 188 of scanning effort, of which 322 presences of construction vessels, 360 presences of utility vessels and 366 presences of utility ribs. 141 presences of fishing vessels were recorded during the same period. Additionally, 4 records were obtained of the research vessel and 35 of recreational vessels.

Construction vessels were present throughout the period of observations, with high numbers of vessels recorded from May to August (mean 5-20 vessels per day), peaking in June and July during the laying of the pipeline (Figure20). A maximum number of 30 construction and utility vessels was recorded present in June. Main presence of construction vessels was recorded in Rossport Bay, the channel leading to Ballyglass pier and in the central bay area along the pipeline route (Figure 1 & 21).

Fishing vessels were recorded present in low numbers throughout spring and summer (mean <1.3 vessels), showing a slight increase during autumn and winter (Figure20). Winter presences of fishing vessels are mainly composed of the presence of (pair)-trawlers during this period. The distribution of fishing vessels is spaced relatively evenly over the bay, with a slight preference for the western bay area (Figure21).

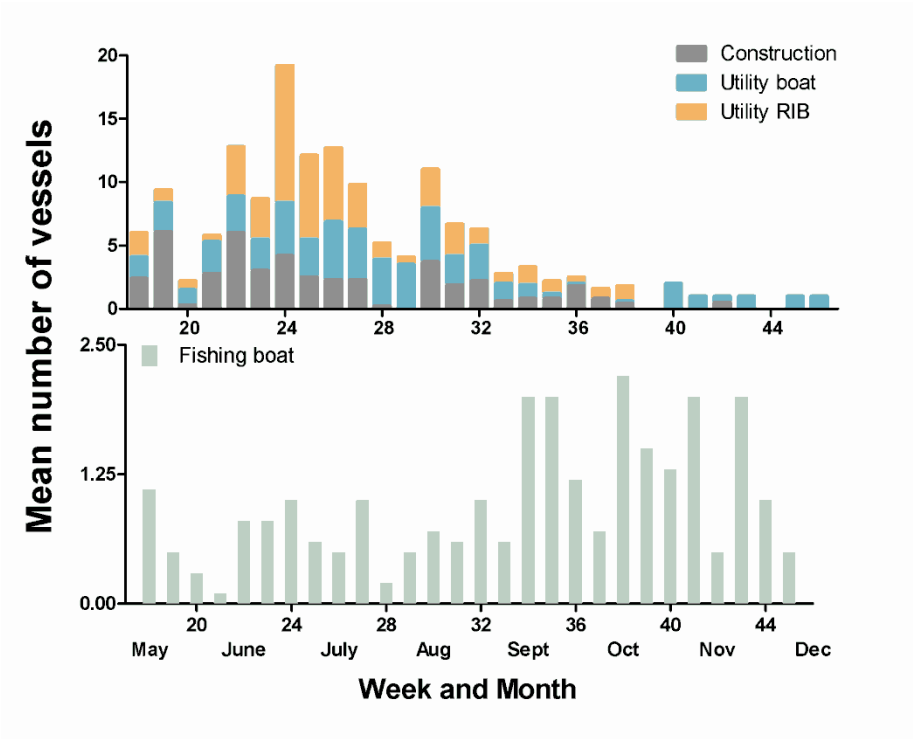


Figure 20. Temporal distribution of vessel abundance (mean number of vessels per scan per week) for construction vessels (top graph) and for fishing vessels (bottom graph) in Broadhaven Bay cSAC, May – Dec. 2009. Note the scale differences of the different graphs.

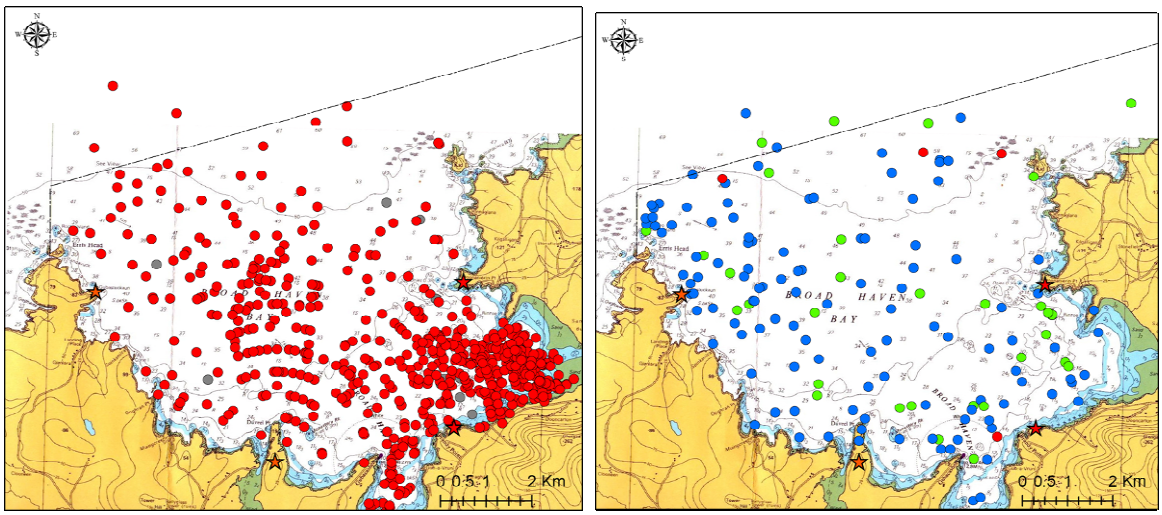


Figure 21. ***Left panel****: Spatial distribution of construction vessels in Broadhaven Bay cSAC, March – Oct 2009;* ***Right panel****: Spatial distribution of fishing vessels (blue), recreational vessels (green) and research vessels (red) in Broadhaven Bay cSAC, March – Oct 2009.*

5.0 Discussion

Monitoring effort

During the marine mammal monitoring programme in 2009, year-round monitoring was conducted in Broadhaven Bay cSAC, adding to the visual land based, vessel based and acoustic monitoring effort conducted in the area in 2001/2002, 2005 and 2008. During the four field seasons combined, near year-round coverage of visual observation effort from the primary look-out sites was obtained. Main distribution of land based and vessel based effort was centred in the spring and summer months, due to limiting weather conditions outside this period. However, despite these limiting conditions, valuable observations were made during autumn and winter months, showing marine mammal presences in each period in which observations were conducted.

While environmental conditions proved limiting for visual observation methods in some occasions, additional, continuous monitoring data was obtained by acoustic monitoring of dolphins and harbour porpoise vocalisations. Acoustic monitoring was conducted during the months April – December. Next to the three listening stations in Rossport Bay, which have been installed since 2002, acoustic detections were monitored from a second location, near Erris Head, in 2009. As was found for Rossport Bay, this location proved to be an excellent position to record dolphin and harbour porpoise vocalisations and acoustic monitoring in this location will be continued in 2010.

A new generation of T-PODs; C-PODs were installed in addition to the three T-PODs at the three listening stations in Rossport Bay and a single C-POD was installed at listening station 4 near Erris Head. The great added value of the C-PODs, equipped with higher memory and battery capacities, becomes apparent from the differences in successful logging effort, which was approximately 50% higher for the C-PODs during a similar period of deployment as compared to the T-PODs (86% vs. 58%). Detection rates of both harbour porpoise and dolphins, however, were higher on the T-PODs (1.4 and 2.2 times higher overall detection rates on the T-PODs respectively). For harbour porpoise, the discrepancy in the detection rates can be largely explained by loss of C-POD logging effort during the peak of harbour porpoise vocalisations in Rossport Bay, during April. No such pattern is apparent for dolphin detections however, where the lower detection rates of the C-PODs are potentially caused by the C-POD detection-logarithm for dolphin echolocation, which is currently being optimised.

Marine Mammal Diversity and habitat use

In 2009, a new marine mammal species was observed in Broadhaven Bay cSAC, the sei whale (*Balaenoptera borealis*). This observation was the first sighting of this species in Irish coastal waters since the ending of the whaling era in the early 1900's (Oudejans and Visser *in press*). Now, in total, 11 species of marine mammals have been observed in the cSAC, of which 2 are species of baleen whales, 7 species of toothed whales and 2 species of seals. This is the highest marine mammal diversity found to date in a concentrated area in Irish inshore waters (*e.g.* Berrow *et al.,* 1996, Ingram 2000, Rogan *et al.,* 2000, Ingram and Rogan 2002, Ingram *et al.,* 2003, 2005*a*, 2005*b*). This high species richness and regular, year-round occurrence of marine mammals found in north-western Irish waters could partly be explained by the relative closeness to the shelf edge, known for its high productivity and marine mammal diversity (*e.g.* Ó Cadhla *et al.,* 2004).

Marine mammals were observed year-round, with species diversity peaking in the summer months (nine species; July). Cetaceans as well as seals were observed from February to December (no observation effort in January). Cetacean relative abundance peaked in the summer and autumn months, seal abundance peaked in early spring (April) and during summer. Marine mammals used the complete bay-area, including the bay margins, shallow sandy areas, coastal and central bay waters and the inner bay area. Longer-term use of the area was recorded for both species of baleen and toothed whales, either by recurrences in the bay over several days or months (sei whale, bottlenose dolphin) or presences of several hours during day-time (common and bottlenose dolphin, sei and minke whale). Main behaviours recorded in the bay area were foraging and travelling. Together, this suggests a general functionality of Broadhaven Bay cSAC as a foraging area for cetaceans, which is visited specifically for this purpose whenever conditions are suitable. This is further corroborated by the species specific patterns of habitat use identified.

Species specific patterns of habitat use

Habitat use and importance or functionality of Broadhaven Bay was investigated by combining data on species presence, abundance, behaviour, sub-adult presence and spatio-temporal patterns of distribution. Results are summarised in Table 3. When analysing species specific characteristics of habitat use, several interesting patterns emerge, suggesting species specific habitat functionality of Broadhaven Bay of varying degrees of importance for the different species, spatio-temporal variations in habitat use and potential habitat-partitioning between species.

For minke whale, regular, near year-round presence was recorded, as well as longer-term presences (several hours) in the bay with clear observations of foraging behaviour. The

species was generally observed alone. Together, this suggests that Broadhaven Bay functions as a foraging area for minke whales on a regular basis throughout the year (except the winter months).

Similarly, the bay functions as a foraging area for common dolphins, especially in autumn and winter when peak abundance of the species was recorded, in combination with highest group-sizes. Presences in the bay with a duration of several hours, during which groups were observed foraging and travelling were recorded. Group sizes vary greatly, between and within years; potentially reflecting temporal patterns in species grouping structures and/or foraging opportunities in the cSAC.

For bottlenose dolphin, again, a functionality of the bay as a foraging area can be concluded: the species is observed regularly foraging and travelling in the cSAC and was recorded present year-round with peak abundance in summer. In addition, observations of social and resting behaviour may indicate a functionality of the bay as a sheltered area in which socializing and resting can take place. This may be of extra importance considering the regular occurrence of (newborn) calves and juveniles in the bottlenose dolphin groups. Group sizes vary between years, with biggest groups recorded in 2009. The occurrence of large(r) groups of bottlenose dolphins in coastal waters in 2009, was reported throughout Ireland (*e.g.* Connemara, Killary Harbour *(*A. Englund, *pers. comm.)),* Blacksod Bay, Co. Mayo *(*M. Oudejans*, pers. comm.)* and Donegal (www.iwdg.ie) and does not appear to be a pattern inherent to Broadhaven Bay alone*.* In contrast to the other species of odontocetes (except harbour porpoise) and baleen whales, bottlenose dolphin use the inner as well as the outer bay area for foraging and other behavioural types. Photo identification has revealed some very interesting patterns of species presence, showing individuals returning to the bay area between months and between years (2008-2009), indicating a degree of site-fidelity and regular, recurrent use of the area for foraging and other behaviours on the long term. Along with harbour porpoise and the grey seal, bottlenose dolphin makes most intensive use of the area.

For harbour porpoise, recorded constantly and year-round in the cSAC by acoustic and visual monitoring combined, functionality can only be assessed indirectly due to the difficulty in assigning a behavioural type to an observation. However, continuous records of vocalisations in both Rossport Bay and near Erris Head indicate that the species uses the bay for foraging and/or socialising. The species displays interesting patterns of spatial and temporal variation, showing preferences for the southern part of Rossport Bay (as opposed to the north) and peak detection rates in the inner bay in spring and in the outer bay in

autumn. While these patterns need further investigation, they do indicate that harbour porpoise shows specific spatial and temporal patterns of habitat use in the cSAC.

A same pattern becomes apparent again for Risso's dolphin. This species does not show a year-round presence, but a distinct, short, seasonal pattern of presence. Main spatial preference is recorded for the area off Erris Head. Risso's dolphin has been recorded present in the bay area for several hours, foraging and travelling. Being a teuthophagous cetacean, Risso's dolphin is the only species which is recorded in the cSAC which has a diet mainly composed of squid (Pauly *et al.,* 1998). Perhaps, the clearly defined and restricted time-window of presence in the Erris Head area marks a yearly period, which is optimal for foraging on squid or octopus.

For the other species of cetaceans, white-sided and white-beaked dolphin, killer whale and sei whale, which are recorded at low abundance, habitat use is difficult to determine. The rare presences of these species indicates that the cSAC is of low importance for these particular species. For sei whales, which were observed for the first time in Broadhaven Bay on three different occasions, research into the species habitat use in the bay will not be possible until more sightings are recorded of species presence in the bay. However, the individuals which were recorded present in 2009 all clearly used the waters of Broadhaven Bay for foraging. On all three occasions, the whales were observed skim-feeding for several hours on end within the cSAC boundary. Besides establishing habitat use in the bay, continuous recording of species presence in the area will be highly valuable in regard to the potential re-establishment of the species presence in Irish coastal waters, following an absence since the early 1900's (Oudejans and Visser *in press*).

For both species of seals, the cSAC most likely functions as a foraging area. Grey seals have known haul-out sites at the nearby Iniskea Islands which are used for moulting, resting and breeding (Ó Cadla *et al.,* 2005). Harbour seals, however, are known to use haul-out sites within the cSAC: the beach of Rossport Bay and the island of Inishderry. Hence, for harbour seals, functionality may also include pupping and moulting (although not recorded in this study). Resting at the haul-out site at the beach in Rossport Bay was recorded in 2001/2002, but not in subsequent years.

In summary, we can conclude that it is likely that the cSAC area functions as a foraging area for the species of marine mammals, which are recorded at medium or high abundance. These species include minimally 1 species of baleen whale, 4 species of toothed whales and 2 species of seals. Apparently, the cSAC provides year-round or seasonal feeding

opportunities for marine mammals with a range of different diets, occupying different niches and trophic levels (Pauly *et al*., 1998). The observed spatial and temporal differences in habitat use may result from these differences in diet and could indicate habitat partitioning between species in order to further reduce inter-species competition.

Unfortunately, the importance of the area, relative to the populations of the species inhabiting surrounding waters is difficult to assess. Especially as we have no means of identifying which part of these populations uses the waters of the cSAC. Sighting rates are relatively low, encompassing 35 sightings or less of each species each year (60 sightings for grey seal). Still, 9 species of cetaceans are observed in the area, indicating a specific functionality of the waters. It does not seem likely that, other than potentially for harbour seal and harbour porpoise, Broadhaven Bay constitutes the home-range for the marine mammal species observed, it is more likely that the area forms part of a larger home-range and is visited on a more or less regular basis, depending on the species.

Marine mammals and construction activities

Two patterns were identified which may indicate potential effects of the construction activities in the bay: 1) an overall decrease in sighting rates in the 2005, 2008 and 2009 field seasons as compared to the first field season 2001/2002 and; 2) the absence of observations of use of the haul-out site at Rossport Bay by harbour seals since 2001/2002 and a general preference shown by marine mammals for the western bay area in the 2009 field season, a pattern which was not observed previously.

Decrease in sighting rates

An overall decrease in sighting rates of cetaceans and seals was recorded between the start of the monitoring programme in 2001/2002 and the subsequent field seasons (2005, 2008 and 2009. Between these field seasons, construction activities in the bay increased. For cetaceans, this pattern varies between species, for example, while common dolphin and Risso's dolphin did not show significant changes in sighting rates between years, bottlenose dolphin relative abundance was significantly higher in 2002 and 2009, compared to 2005 and 2008. However, as the number of sightings for each cetacean species is relatively low (range 1-34) and abundance, as well as observation effort, is variable over the year, these results should be interpreted with caution.

Grey seal and harbour seal both show the pattern of decreased sighting rates from the start of the monitoring programme in 2001/2002 to 2005, 2008 and 2009 although an increase in seal sighting rates was observed in 2009 as compared to 2005 and 2008. This indicates that there has been a possible change in the use of Broadhaven Bay by seals over the monitoring

period, whereby seals may potentially be spending less time in the bay since 2001/2002. This could be a result of construction related activities in the bay: seals, like cetaceans, are affected by noise and disturbance from shipping and construction work. The beach in Rinroe, which was identified as an active haul-out site in 2001/2002 was not used during 2005, 2008 and 2009. Considering the proximity of the pipeline landfall to this site it is likely that the seals no longer use this haul-out site due to disturbance resulting from construction and/or ongoing activity near the site.

Alternatively, it could be related to changes in resource availability. However, a pinniped biologist was on the monitoring team in 2001/2002 which may have contributed to increased sightings rates of seals during that field season compared to the other years and hence have resulted in observer bias. Unfortunately, without detailed data on habitat use of Broadhaven Bay by pinnipeds, as could be obtained by using telemetry technologies, it is impossible to draw any conclusions on potential effects of construction related activities on pinnipeds over the monitoring period.

To further investigate potential construction related alterations in marine mammal habitat use, the data presented in this report will be analysed using a habitat-model. With this model, the effects of environmental variables, time-variables, construction activity and observers on sighting rates and species presences will be analysed for the before, during and post-construction phases. In this way, natural variation in marine mammal habitat use of Broadhaven Bay cSAC can be distinguished from construction and observer-related effects.

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Photographic credits: Photographic images used in this report are credited as follows: Cover photo's and Figure 4: bottlenose dolphin and risso's dolphin © Machiel Oudejans; harbour porpoise and harbour seal © Anneli Englund; White-sided dolphin, minke whale and killer whale © Fleur Visser; grey seal © Ó Cadhla. Aerial pictures cover: Shell Exploration and Production Ireland Ltd.. Cover photo observer + scope © Margaret Haberlin; Figure 5 © Fleur Visser.

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Appendix 1. Mitigation of impacts on marine mammals

As marine mammals whose predominant sense is that associated with hearing, cetaceans are particularly vulnerable to underwater noise and water-borne pressure waves from a wide range of sources (Richardson *et al.,* 1995). While the effects of exposure to noise are the subject of ongoing research, there is sufficient evidence to indicate that marine mammals can suffer direct physical trauma from pressure waves such as those caused by underwater explosions (Ketten 1995, Richardson 1995). In some cases this can lead to disorientation, increased stranding rates and mortalities. The effects of noise from anthropogenic sound sources may vary depending on the source type. In the case of construction work, where the main sound sources of concern are from vessels, seismic surveys and dredging, the direct impacts include masking (of animals' own acoustical communication), habitat displacement, behavioural change and behaviourally-mediated effects (Boyd, 2008).

Construction work in Broadhaven Bay has the potential to have a direct negative impact on the bay's marine mammal population in the event of direct collision with a vessel or construction equipment. The likelihood and potential gravity of such an incident however must be considered in the context of the marine environment of the area in general, where animals encounter boat traffic (albeit at lower frequencies) due to the utilisation of the area by fishing and recreational vessels.

Avoidance of possible collision events and noise is likely to represent the most probable impact of construction on animals. Additionally, animals may be affected by construction activity due to indirect means: e.g. through changes in habitat quality or in prey availability and distribution, perhaps the most important factors governing their natural distribution (*e.g.* Evans 1990). Such an impact is probable on a temporary basis due to the effect of construction on water quality (e.g. sedimentation), which may affect prey species and their availability, thereby altering foraging opportunities for marine mammals. More permanent habitat degradation potentially induced by pipeline installation and the cumulative effects of construction impacts overall remain difficult to pre-empt.

Vessel and/or area avoidance would signify a behavioural response to the presence of construction vessels and their associated noise. Changes in behaviour of marine mammals in response to the presence of boats has been the subject of much investigation (e.g. bottlenose dolphins in New Zealand, (Lusseau 2003); bottlenose dolphins in Scotland (Lütkebohle 1995); killer whales in Canada (Erbe 2001); bottlenose dolphins in Florida (Nowacek *et al.,* 2001)). The concern associated with a behavioural response as such would relate to the resultant changes in behavioural budget and the consequent effect on an animal's energetic budget (Lusseau 2003) in response to increased vessel presence in the bay. The threat in the long-term might be displacement of animals to avoid the energetic costs of boat impact (Lusseau 2003). The complexity of quantifying such an impact is considerable and therefore prevention of impacts would represent the best option particularly given the 24-hour nature of construction work, which offers no respite from disturbance.

While a certain degree of temporary displacement and an impact on behaviour is inevitable, the potential for permanent displacement remains a threat. Long term monitoring of marine mammals to evaluate the magnitude of such impacts would be invaluable as marine mammals (in their role as top predators) represent potential indicators of overall ecosystem integrity (e.g. Mössner and Ballschmiter 1997).

Mitigation aiming to ensure marine mammal protection is provided for via a *"Code of Conduct for vessels and personnel operating within Broadhaven Bay SAC"* and the NPWS requirement that "coastal works" be carried out according to guidelines based on a variation of the "*Code of Practice for the Protection of Marine Mammals during Acoustic Seafloor Surveys in Irish Waters"* (NPWS, 2007) (where "coastal works" are defined as "*any operations outside of acoustic seafloor surveys where mitigation for potential impacts of marine noise are required for marine mammals e.g. dredging, pile-driving etc*" (npws.ie)). Alleviation of such an indirect impact may be achieved to some extent through application of best practice methods for construction to minimise environmental impacts and through adequate habitat reinstatement post-construction.

Appendix 2. Code of Conduct

FOR VESSELS AND PERSONNEL OPERATING WITHIN BROADHAVEN BAY SAC

The following protocol is based on a Code of Practice to protect small cetaceans in the Shannon Estuary and on Guidelines set up by the Department of Communications, Energy and Natural Resources (Marine Notice No 15). This Code of Conduct is designed to reduce the potential for construction vessel- and person-related impacts on local marine mammal populations, their natural behaviour and habitats in Broadhaven Bay SAC, Co. Mayo. This code of conduct refers only to all vessel traffic movements, dredging and geophysical (i.e. multibeam) surveys. If any other work, is required, then appropriate measures and suitable safety distances will need to be considered.

Under current National Legislation - S.I No. 94 of 1997, Natural Habitat Regulations, Cetaceans are listed, and regulations prohibit the deliberate disturbance of these species. Included are several measures proposed for the offshore and near shore construction vessels, which will be operating within the SAC. Craft that do encounter any species are encouraged to log all sightings and to advise officers of the National Parks and Wildlife Service, which is a division of the Department of Environment Heritage, and Local Government.

Marine mammal species likely to be encountered during works are: European otter (*Lutra lutra*), Grey seal (*Halichoerus grypus*), Harbour seal (*Phoca vitulina*), and various cetacean (i.e. whale and dolphin) species including Bottlenose dolphin (*Tursiops truncatus*), Harbour porpoise (*Phocoena phocoena*), Common dolphin (*Delphinus delphis*) and Minke whale (*Balaenoptera acutorostrata*) (See: O'Cadhla *et al.,* 2003; Englund *et al.,* 2006).

Listed below are additional guidelines to be followed to minimise the effects of the construction vessels on marine mammals:

1. Any vessel and/or person(s) shall attempt to maintain a minimum distance of 100m from any individual marine mammal or group thereof. Vessels that are themselves approached by marine mammals may remain but should gear their engines into *Neutral* providing this does not cause a safety hazard.
2. No vessel and/or person(s) shall approach or remain within 100m of any marine mammal(s) at any time for more than 30 minutes. Boats do not need to move off if they have been approached by the mammal. However in the case where a boat is working or otherwise the behaviour of marine mammals should be recorded and provided to CMRC personnel, especially in the event of a change in the conduct of work on or immediately surrounding the vessel.
3. No vessel shall, when less than 100m from the marine mammal(s), exceed a speed of 5 knots. Providing this does not cause a safety hazard.
4. No vessel shall alter speed or course suddenly when less than 100m from any marine mammal(s).
5. No person or vessel shall deliberately approach to less than 100m from any marine mammal(s) situated on land except under licence from the Minister or unless approved to do so by the relevant authority.
6. Persons ashore that are approached by marine mammals shall carefully make the animal(s) aware of their presence and shall allow the animal(s) free access and ample opportunity to move into the water. Under no circumstances shall a person behave in an obtrusive or noisy manner around the animal(s).
7. No vessel shall use underwater acoustic transmitters, except navigational systems, when less than 1000m from any marine mammal.
8. No unauthorised divers should be allowed to enter the water within 100m of any marine mammal. This will be in the interest of health and safety of the divers as well as any marine mammal. Commercial divers should be aware that they might be approached by mammals during the course of their work.
9. Nothing in these guidelines shall operate to prohibit anything done for the preservation of life at sea or in the interests of public safety.
10. Nothing in these guidelines shall operate to restrict the obligations on persons and vessels to obey rules for the prevention of collision at sea and the regulations enacted by statutory Harbour Authorities.

References

Marine Notice No. 15 of 2005. Guidelines for correct procedures when encountering whales and dolphins in Irish coastal waters.. DEPARTMENT OF COMMUNICATIONS, MARINE AND NATURAL RESOURCES

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