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Bottlenose Dolphin and Harbour Porpoise Monitoring in Cardigan Bay and Pen Llŷn a'r Sarnau Special Areas of Conservation



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Sea Watch Foundation



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EXECUTIVE SUMMARY

This report summarises the research conducted by the Sea Watch Foundation in 2011 on behalf of the Countryside Council for Wales, to monitor bottlenose dolphin and harbour porpoise populations in Cardigan Bay. The aims of this study were: to provide preliminary information on the condition of bottlenose dolphins and harbour porpoises in both the Cardigan Bay and Pen Llyn a'r Sarnau Special Areas of Conservation (SACs); to use photographic ID techniques to evaluate dolphin movements, distribution and abundance; to assess population structure; and to gather evidence of anthropogenic activities within the site. A series of boat-based surveys were conducted in Cardigan Bay using both line-transect and Photo ID techniques in order to collect data that would achieve these objectives.

Fifteen line-transect surveys were conducted in Cardigan Bay, amounting to 1993 km travelled in addition to 1706 km of effort during *ad libitum* surveys in Cardigan Bay SAC. Abundance analyses from line-transect surveys using the software Distance 6 found lower numbers ($n = 114$) of bottlenose dolphins in the Cardigan Bay SAC than in previous years. The abundance estimate for the whole of Cardigan Bay was 296. Due to the fact that funding was not granted until September 2011, and then bad weather, the numbers of surveys and thus the volume of effort collected were lower than our recommendations. Therefore, caution must be taken when interpreting these results, since the low numbers may be attributable to the lower effort resulting in fewer detections. The same is true when considering population estimates for harbour porpoise. Very few detections of the species within Cardigan Bay SAC meant that the value of 302 animals had wide confidence limits and so may not be reliable. By comparison, increased numbers of sightings of the species when including the whole of Cardigan Bay provided a more robust estimate of 990 individuals.

Population estimates of bottlenose dolphins calculated by the mark-recapture method based on Photo ID results also suggest lower numbers in both Cardigan Bay SAC and the whole of the Bay during 2011 than most previous years. Results from an open population model indicate that the probability of emigration from Cardigan Bay, and the probability that animals will stay out of the site, have increased. This suggests that fewer dolphins are currently using Cardigan Bay.

The home ranges of bottlenose dolphins from Cardigan Bay are known to extend to the northern Irish Sea at least as far as the Isle of Man. Increased activity off N Wales in summer includes individuals previously showing a strong site fidelity to Cardigan Bay, and supports the mark-recapture results showing that fewer dolphins may now be using Cardigan Bay.

Despite these apparent changes, Cardigan Bay remains an important site for a large proportion of Welsh dolphins. Cardigan Bay SAC in particular has seen increased levels of residency, and remains important for mothers and young calves, exhibiting a reasonably healthy birth rate (5.75% for a closed population model and 7.73% for an open population model).

An initial assessment of the condition of bottlenose dolphins is that a core sub-population of animals seems to remain faithful to Cardigan Bay, but there may be fewer non-residents utilising the area. Potential explanations for these changes include a change in prey availability at the site or increased anthropogenic disturbance. In order to assess whether this is the start of a trend, further monitoring encompassing the entire field season from at least April until October is needed.

1. INTRODUCTION

Cardigan Bay is known to host the largest population of semi-resident bottlenose dolphins in the UK (Evans and Pesante, 2008b). The species is protected under the EU Species and Habitats Directive and as such, two marine Special Areas of Conservation (SACs) were established in Cardigan Bay to conserve bottlenose dolphins. One other semi-resident population is known in the UK in the Moray Firth, north-east Scotland (Wilson *et al.* 1997, 1999; Thompson *et al.*, 2004), and a small resident population exists in the Shannon Estuary, south-east Ireland (Ingram and Rogan, 2002, 2003; Mirimin *et al.*, 2011). Bottlenose dolphins are also recorded off other coasts of the UK including Cornwall, Devon, and the Hebrides, as well as in offshore waters along the Northwest European shelf edge (Evans *et al.*, 2003; Reid *et al.*, 2003; Hammond, 2008).

In Cardigan Bay, sightings of bottlenose dolphin have long been recorded, going back at least to the 1920s (Evans and Scanlan, 1989). In recent years, a number of studies of the species have existed including two photo identification (also known as Photo ID) projects during the early 1990s (Arnold *et al.*, 1997; Lewis, 1999), and a land-based study on marine mammal disturbance from 1994 (Ceredigion County Council 1998; Pierpoint *et al.*, 2009). Since 2001 to the present day, the Sea Watch Foundation (SWF) has been regularly monitoring the population incorporating abundance estimates, and studies of ranging pattern, population structure and life-history characteristics from Photo ID (Baines *et al.*, 2002; Ugarte and Evans, 2006; Pesante *et al.*, 2008b; Feingold *et al.*, 2011).

There is some evidence for an overall increase in abundance since 2001, with summer population estimates ranging from 150-250 individuals (Baines *et al.*, 2002; Ugarte and Evans, 2006; Pesante *et al.*, 2008b; Feingold *et al.* 2011). Cardigan Bay, and particularly Cardigan Bay SAC, is thought to be important in the summer months. However, a proportion of the population is known to remain in the region year-round (Baines *et al.*, 2002; Pesante *et al.*, 2008b). It has become increasingly evident that a significant number of animals leave Cardigan Bay in winter months, moving northwards. High concentrations of individuals have been reported off the north coast of the Isle of Anglesey, in Liverpool Bay and around the

Isle of Man involving animals that have been previously and often regularly identified by Photo ID within Cardigan Bay (Pesante *et al.*, 2008a). At present, the waters around the Isle of Man appear to be the northernmost range limit of this population (although bottlenose dolphins are seen regularly in the Solway Firth, no photographs exist suitable for matching), and as of yet, Photo ID catalogues from Ireland, Hebrides, Moray Firth, Cornwall or the English Channel have yielded no matches with the SWF Photo ID catalogue, showing no evidence of exchange outside of the Irish Sea (Pesante *et al.*, 2008b).

In addition to winter sightings of the species in the northern Irish Sea, bottlenose dolphins have recently been recorded off the North Wales coast also in summer. Due to the intensive anthropogenic pressures resulting from industry and pollution in these regions, which are currently unprotected for bottlenose dolphins, there is some concern as to what impact these pressures may have on the population.

In addition to the pressures based in the northern Irish Sea, in Cardigan Bay scallop dredging has intensified in recent years (Woolmer, 2009; Evans and Hintner, 2010). The effects of this activity on bottlenose dolphins is currently unknown and further monitoring encompassing the whole of Cardigan Bay, including offshore areas is necessary to assess potential impacts.

With several areas of the Irish Sea currently being targeted for offshore renewable energy projects and scallop dredging ongoing, it is imperative that we accurately identify where and when particular localities are used by bottlenose dolphins so that CCW can advise on appropriate mitigation measures to minimize threats to their conservation status. Different types of measurements are required to characterise features (species presence, densities and habitat use); monitor impacts (numbers disturbed/displaced/ injured; reduction in densities); and determine significant changes in populations (time-series).

It is important for nature conservation management and measurement of the achievement of Favourable Conservation Status that reliable estimates of the number of dolphins, their trends and the effects of human activity on the population in the SACs are made. The UK's Common Standards Monitoring (CSM) programme led by the Joint Nature Conservation Committee (JNCC) requires monitoring of mandatory attributes in SACs across Britain. For bottlenose dolphins the mandatory attribute is 'numbers of bottlenose dolphins using the SAC'. Population dynamics, physiological health, natural range and distribution, supporting habitat and management of human activities are valuable indicators identified as attributes for monitoring bottlenose dolphins in Welsh SACs.

An attribute considered essential to assessing the condition of the feature is the 'number of individual dolphins using the SAC' and is assessed for all sites. Monitoring, using Photo ID techniques, of individual animals by vessel will build on previous research to determine bottlenose dolphin abundance, seasonal habitat use, range, distribution and reproductive success. (Also, it is important that opportunistic monitoring occurs for other cetacean species in the region, particularly the harbour porpoise, but also common dolphin, Risso's dolphin and minke whale).

Annual assessments of absolute abundance in southern Cardigan Bay have been made by Sea Watch Foundation from 2001 to 2007, mostly funded by CCW as part of a systematic monitoring programme. Since then, a scaled back programme of monitoring which concentrated Photo ID along the coastal strip of the Cardigan Bay SAC with limited coverage elsewhere has been continued by Sea Watch Foundation up to 2010. This provides an estimate of the numbers of animals using that area but is insufficient to determine overall trends or whether some areas of Cardigan Bay are being used less now than others. Thus, there has been a gap of three years in monitoring this primary feature of Cardigan Bay SAC and qualifying feature of Pen Llŷn a'r Sarnau SAC. A mixture of line-transect and photo-monitoring undertaken by SWF has given a systematic and scientifically robust means of assessing changes in status and distribution. The current project combines vessel-based surveys and Photo ID throughout Cardigan Bay on a regular basis (minimum once a month) and equally spaced out in time throughout 2011-2012, and subsequent years should the contract be extended.

1.1 *General Aims*

- To record, document, statistically analyse and report indicators of the condition of bottlenose dolphins and harbour porpoises in both the Cardigan Bay and Pen Llŷn a'r Sarnau SACs.
- To collect images and refer to those from established catalogues, at sites within and outside the key study areas, using photographic ID techniques, to evaluate dolphin movements, abundance estimates and distribution.
- To monitor the number of bottlenose dolphins using the sites and to assess the supporting habitat and estimate population structure (age and sex).
- To gather evidence of any anthropogenic activities within the sites, while monitoring bottlenose dolphins. This will contribute to the determination of the effect of scallop dredging on bottlenose dolphins in Cardigan Bay SAC through a measure of how the population is faring in terms of use of the area, population size and structure, and production, and will support the impact assessment.

1.2 *Objectives*

- a) Record, document and report numbers of bottlenose dolphins in Cardigan Bay SAC and Pen Llŷn a'r Sarnau SAC, and more widely in Cardigan Bay in order to determine the total population using the SACs and Cardigan Bay.
- b) Report on fine and broad-scale distribution patterns of bottlenose dolphins and the relative temporal use of different parts of this range.
- c) Document and report on the presence of calves and young juveniles in order to estimate the number of calves born annually by the population.

d) Measure both juvenile and calf survival rates for the population on an annual basis by monitoring the proportion of animals still alive and recording known deaths.

e) Record numbers of juveniles, female and male bottlenose dolphin adults, in order to report on population structure parameters (age and sex ratios) and site use, e.g. by family groups or bands.

f) Identify the home range sizes of individual identifiable animals, including determination of ranging movements and core areas.

g) In order to investigate the nature of the supporting habitats, e.g. estuary, headland or reef, record the number of bottlenose dolphins in each of the respective habitats and the location of each habitat within the site if necessary. Record all environmental and physical parameters at the time of recordings, e.g. tides, beach aspect, wind direction & speed, sea state, air temperature, and relevant biological information, e.g. aggregations of feeding birds or shoaling fish. The combination of information on habitat type and some of the above list will allow a preliminary assessment of habitat in the SACs. Results from this work will inform more targeted evaluation of both habitat and prey species.

h) Categorise bottlenose dolphin behavioural activities in the region (areas and proportion of time spent in resting, socialising, travel and feeding), and analyse yearly and seasonal behavioural patterns.

i) Whilst conducting the above quantitatively record, document and report all observed incidents of:

- anthropogenic activity at each site at time of survey;
- evidence of any recent change in anthropogenic use of sites. This should be evaluated in light of any historical records changes in use or otherwise;
- bottlenose dolphin disturbance by anthropogenic or other factors, its cause and outcome;
- bottlenose dolphin absence from historically used sites that can be attributed to an activity (human or otherwise) whether the activity is present or not at the time of observation;
- entanglement of cetaceans in anthropogenic debris, e.g. fishing gear;
- significant fresh injuries commensurate with propeller or boat collision;
- evidence of body condition/health e.g. lesions.

j) To interpret past and current data, in order to provide a reasoned opinion on the status of bottlenose dolphins in the SACs and Cardigan Bay and develop targets for monitoring. A recommendation of condition should be made but CCW reserves the right to accept or reject. All available data should be integrated at the appropriate level.

k) Critically review the methodologies used and report on best scientific and fieldwork practice for monitoring of bottlenose dolphins in Wales. To include a cost benefit

analysis concentrating on abundance and life history parameters but covering all attributes listed in Section 1. Alternative sampling strategies should be explored.

1) Along with CCW staff and relevant contractors, attend a meeting to discuss guidance for generic bottlenose dolphin monitoring in Wales.

2. METHODOLOGY

2.1 The Study Area

Cardigan Bay is the largest bay in the UK. Two Special Areas of Conservations (SACs) were proposed for the protection of the bottlenose dolphin, an Annex II species (designated as candidates in 2001, with full status in 2004) under the 1992 EU Habitats and Species Directive.

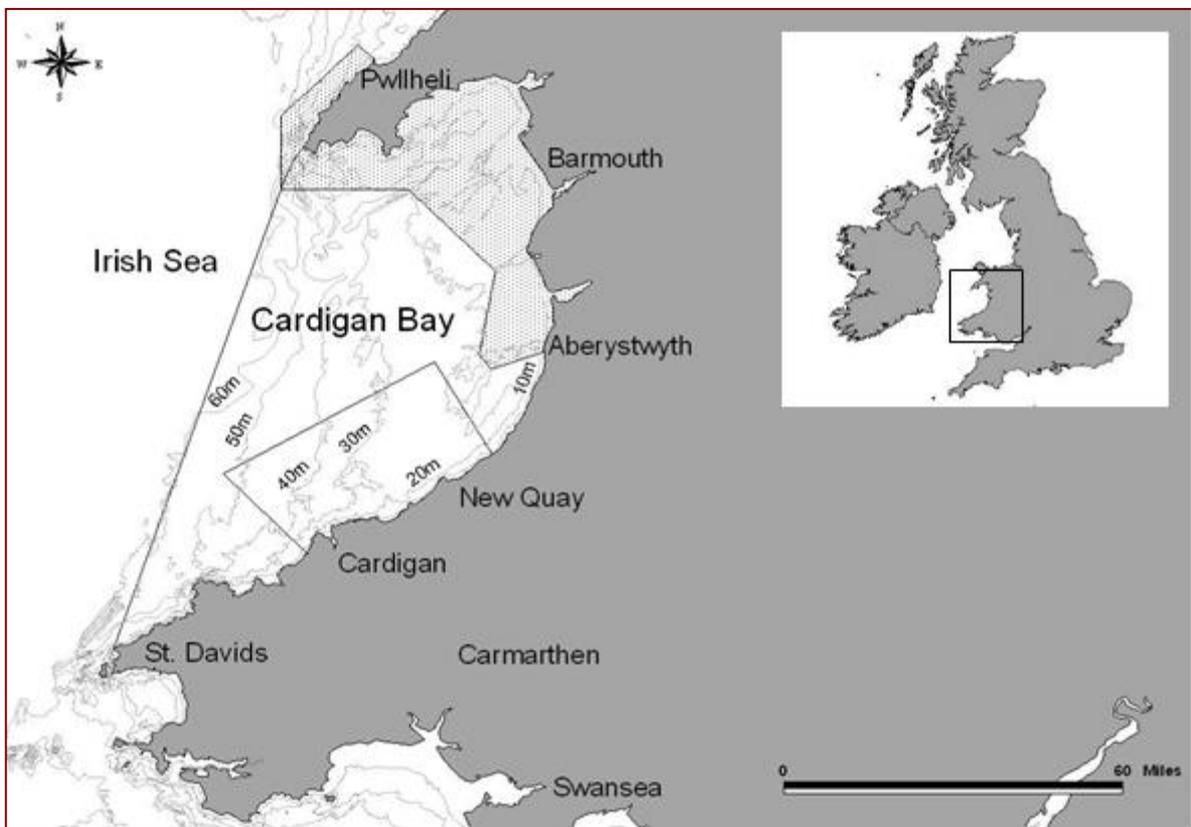


Figure 1: The study area: Cardigan Bay in West Wales. The rectangle in the south of the bay represents Cardigan Bay SAC. The hatched polygon situated in the northern half of Cardigan Bay illustrates Pen Llŷn a'r Sarnau SAC

Cardigan Bay SAC is a rectangular area in the south of the bay, off the Ceredigion coastline, encompassing 958.65km², with the boundaries 52.08°N to 4.76°W; 52.22°N to 5.00°W; 52.43°N to 4.40°W and 52.25°N to 4.23°W (Figure 1). The site, as well as being recognised as important for bottlenose dolphin, is also thought to be a key area for Atlantic grey seals (*Halichoerus grypus*) as well as important for some fish and invertebrate species. The SAC hosts a number of habitat types, including sand banks, reefs and caves, which have an

important conservation role in maintaining biodiversity. Research effort for marine mammals has in the past been largely concentrated at this site compared to the rest of Cardigan Bay (Ugarte and Evans, 2006; Evans and Pesante, 2008; Pesante *et al.*, 2008b).

Pen Llŷn a'r Sarnau SAC is situated in the north of Cardigan Bay and covers a larger area of 1460.35 km². The latitudinal range of the SAC is 52.43°N to 52.97°N. The distance from the coast varies throughout the site, the offshore longitudinal limit being 4.83°W (Figure 1). *Ad libitum* surveys have been conducted in this region in previous years, although not to the same intensity as in Cardigan Bay SAC (Evans and Pesante, 2008; Pesante *et al.*, 2008b; Feingold *et al.*, 2011). Line-transect surveys have never been conducted at this site and, therefore, no abundance estimates have been calculated for marine mammals in this area to date.

There is a significant area remaining in Cardigan Bay that is not covered by the SACs (Figure 1). Few boat-based surveys have been conducted here in the past. Winter aerial surveys conducted in 2007, detected bottlenose dolphins, harbour porpoise and grey seals in the outer area. Bottlenose dolphins showed a strong preference for this offshore area in winter (Pesante *et al.*, 2008b). Little is known about the activity of the species in this region of the bay during summer.

2.2 Line-transect surveys

In order to report on bottlenose dolphin numbers in Cardigan Bay, distance sampling in the form of line-transect surveys were conducted. Line-transect surveys in Cardigan Bay SAC have been performed successfully in previous years, providing abundance estimates for bottlenose dolphins but also harbour porpoise and Atlantic grey seals that are known to be abundant in the region (Baines *et al.*, 2002; Ugarte *et al.*, 2006; Pesante *et al.*, 2008b). The methodology used in 2011 was comparable to surveys performed in previous years in order to ensure consistency between years.

Commencing in July 2011, dedicated line-transect surveys were conducted by SWF staff and a team of trained volunteers when Beaufort sea state was 2 or less, visibility was more than 1.5 km, and there was no precipitation. These surveys were conducted in Cardigan Bay SAC, Pen Llŷn a'r Sarnau SAC and outer Cardigan Bay. Vessels used during these surveys are listed in Table 1.

Table 1: Vessels used for line-transect surveys in Cardigan Bay in 2011
(* Cardigan Bay SAC; ** Pen Llŷn a'r Sarnau SAC)

Vessel name	Length	Eye Height (m)	Speed (kn)	Engine Type	Area surveyed
<i>Dunbar Castle II</i>	9.7	3.5	7	120hp diesel	CB SAC*
<i>Ma Chipe Seabrin</i>	10	4.5	10	Twin 220hp diesel	PL SAC**
<i>Pedryn</i>	11	3.0	10	350hp diesel	PL SAC** & offshore

In Cardigan Bay SAC, transect lines previously used by Ugarte *et al.* (2006) and Pesante *et al.* (2008b) were also used in 2011 (Figure 2). As in previous years, transects were divided into inner and outer transects (split at 52.15°N, 4.89°W and 52.33°N, 4.31°W), since bottlenose dolphin density within Cardigan Bay SAC has been shown to be highest in inshore waters (Baines *et al.*, 2002). For the first time, line-transects were conducted in Pen Llyn a'r Sarnau SAC and outer Cardigan Bay. Systematically spaced lines were drawn to cover this area with the aim to maximise coverage (Figure 3).

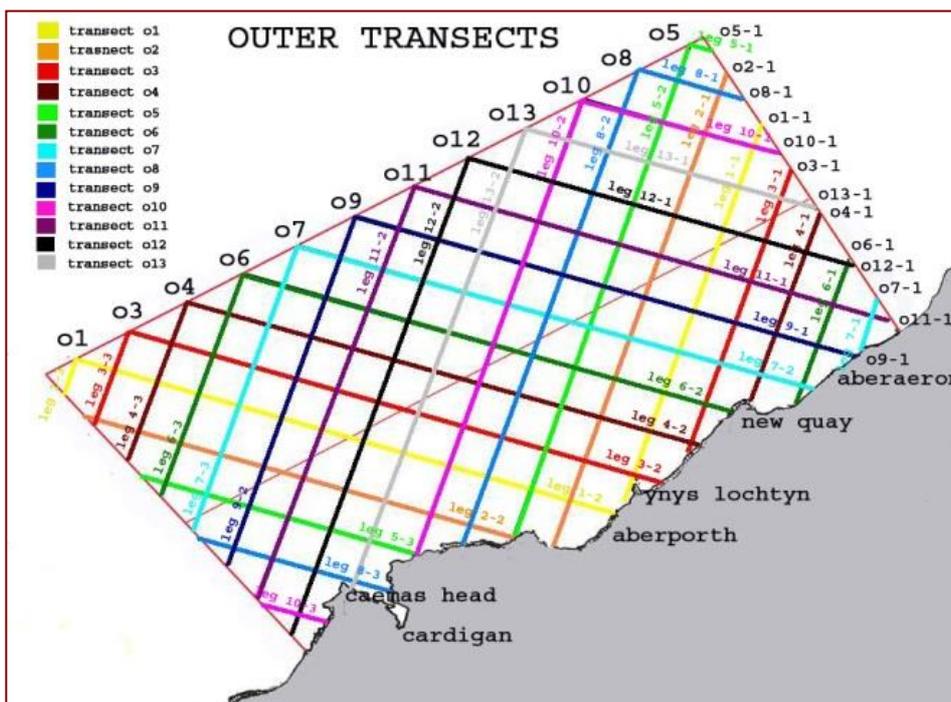
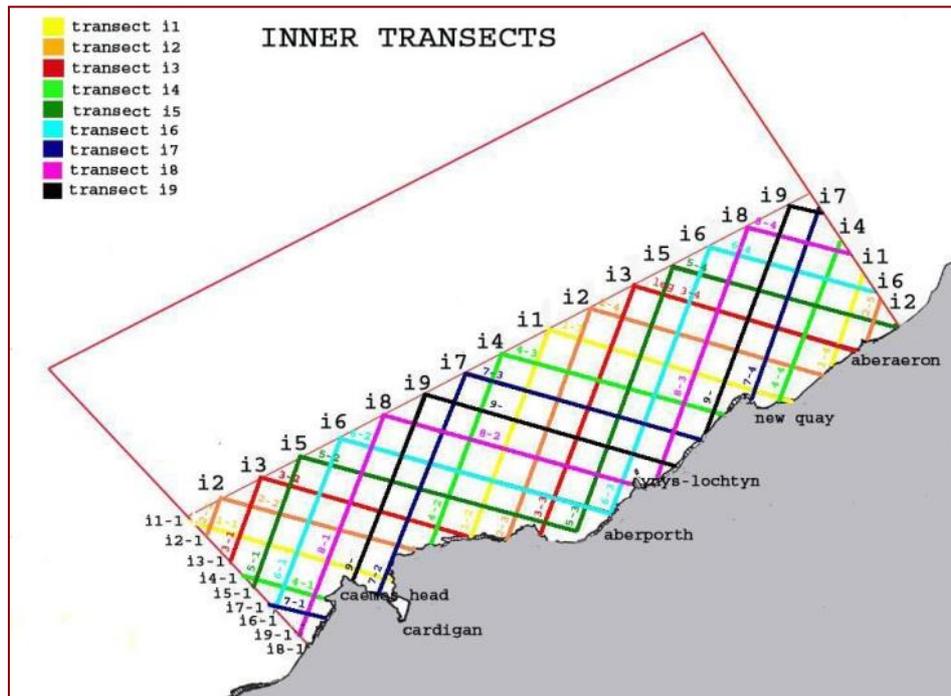


Figure 2: Transect lines (inner and outer) used for line-transect surveys in Cardigan Bay SAC

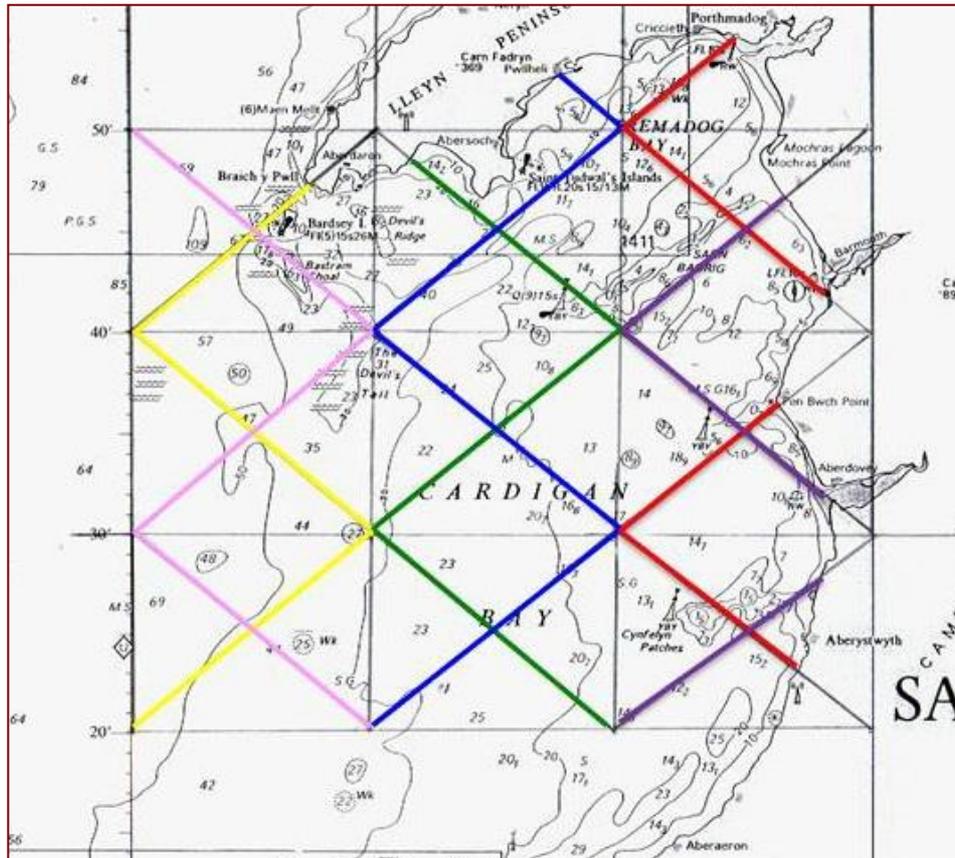


Figure 3: Transect lines designed for Pen Llyn a'r Sarnau SAC and outer Cardigan Bay (Transect numbers: PL1- red; PL2- purple; PL3- green; PL4- blue; PL5- pink; PL6- yellow)

In Cardigan Bay SAC, before each survey began, a transect number was chosen at random. This number dictated which pre-determined transect line that the vessel would follow for the duration of the survey. Surveys aboard *Ma Chipe Seabrin* were restricted to the inshore transects in Pen Llyn a'r Sarnau SAC (PL1 and PL2, Figure 3). The route of *Pedryn* surveys was chosen before departure in order to maximise coverage.

When on transect, the vessel travelled at a constant speed. This speed of necessity varied between vessels (Table 1). Any significant change in speed was noted on the effort form, as was any movement away from the transect line, such as to conduct Photo ID. When this occurred, the vessel returned as close as possible to the position where the track line was left, and the transect was resumed.

When there were enough people onboard, a double platform of observers was used, consisting of two pairs of observers. Observers were paired so that at least one was experienced with a minimum of 20 hours of survey time achieved.

Two primary observers (POs) were positioned on the roof of the vessel for one-hour shifts. These observers scanned from abeam (90°) on their side to 10° on the opposite side. POs

scanned with the naked eye and used binoculars only to investigate possible sightings. Observations of marine mammals were recorded on a standardised 'sighting form' (see Appendix 2).

Two independent observers (IOs) were positioned where they could have the best view of the track line without being seen by the POs. On *Dunbar Castle II*, IOs could only be positioned near the stern of the vessel, where the view of the track line was partially blocked by the wheelhouse. IOs aboard *Ma Chipe Seabrin* and *Pedryn* were positioned further forward and had a clear field of view. IOs concentrated their effort on the track line, scanning from 45° on their side to 10° on the other for one-hour shifts. Scanning was conducted entirely with binoculars in an attempt to detect sightings at a distance, in an attempt to spot the animals before any potential responsive movement. Sightings were reported on an 'independent observer' form (Appendix 3). It was important that the IO did not communicate their sightings to the POs. Once the sighting had passed the beam, the person dedicated to effort checked with the POs whether they had detected that particular sighting and recorded this on the IO form.

Both POs and IOs estimated the distance to the animals when first detected. The survey team were given regular distance training sessions by testing them with objects of known distances. For the majority of sightings, distances were confirmed by SWF staff. Staff also tested themselves against known distances and their estimations were calibrated. The angle between the vessel bow and sightings when first detected was recorded using an angle board. Rounding was avoided for both distance and angle readings. POs estimated an initial group count before Photo ID began and also a final count after the encounter, to assess whether dolphins were actively attracted to the vessel.

One person was dedicated to recording effort using the 'effort form' (Appendix 4), which logged the vessel journey and environmental variables throughout the survey. One line was filled on the form each time any of the variables collected (sea state, visibility, swell height, boat course, end of transect leg, etc) changed. Otherwise, if none of these variables had changed, a line of effort was recorded every 15 minutes by default. The track of the vessel was recorded continuously using GPS. The number and type of boats in view was recorded during every line of effort in order to have a record of boat traffic in the vicinity of the location. Four types of effort were considered during the survey: a) line-transect, where the vessel travelled along the pre-defined transect line with dedicated observers scanning for sightings; b) dedicated search, where POs were on duty but the boat was not following a transect line. This occurred when leaving the transect line to conduct Photo ID, or once the transects for the day had been completed and the vessel returned to port; c) casual watch, with no dedicated observers scanning for cetaceans (e.g. when weather conditions turned bad or the boat had to stop for any reason); d) photo identification, when the boat approached and persisted with a group of dolphins at close in order to obtain images used for Photo ID.

When dolphins were detected, where possible, the line-transect survey was paused and the vessel left the track line in order to approach the animals for photo identification. The method used for Photo ID is explained in section 2.3. Once the group had been comprehensively

photographed, the vessel travelled to the point that the vessel last left the transect line and resumed the line-transect survey (Figure 4).

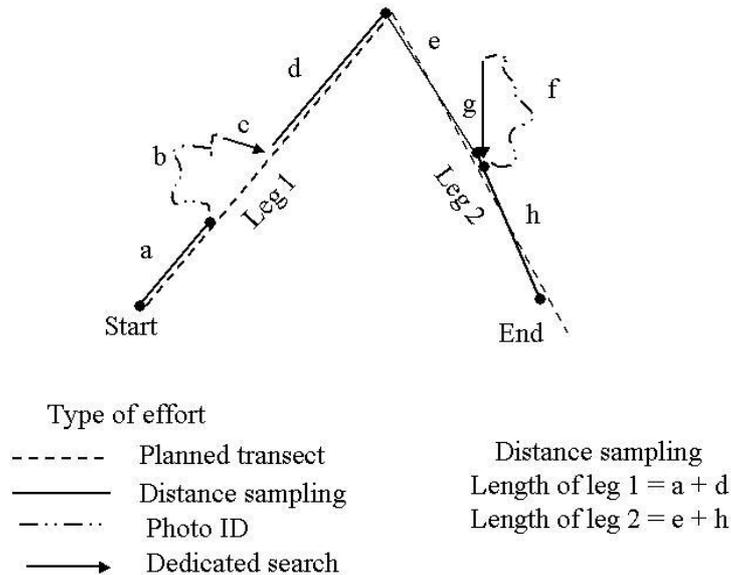


Figure 4: Schematic representation of two transect legs temporarily interrupted in order to take Photo ID pictures

2.3 Data Analysis- Line-transect surveys

Effort and sightings data were entered into Microsoft Excel. The distance of each sighting was adjusted according to the results of the distance test and calibration experiment taken by SWF staff. Effort and sightings maps were plotted using Arc View 3.2. The length of each effort leg, sea state, along with the radial distance, angle and group size of each sighting and the area of each stratum was imported into software Distance 6.0. Abundance estimates were calculated for bottlenose dolphin and harbour porpoise using a half-normal cosine model.

2.4 Ad libitum surveys

In addition to the line-transect surveys, *ad libitum* surveys were conducted within Cardigan Bay SAC using a number of vessels. Since the funding granted by CCW was not confirmed until September 2011, line-transect surveys could not be conducted by SWF for the first part of the season. Between May and July 2011, dedicated *ad libitum* surveys were performed on *Dunbar Castle II* with the aim to collect sightings information and Photo ID data. *Boat Gallois* was also used for this purpose. In addition, trained SWF volunteers joined dolphin-watching trips kindly provided by three commercial boat operators, ‘New Quay Boat Trips’, ‘SeaMor’ and ‘A Bay to Remember’. All vessels used (Table 2) were launched from New Quay Harbour with the exception of *Bay Explorer*, which departed from Gwbert near Cardigan. During these trips, SWF collected effort and sightings data, and when dolphins were sighted close to the vessel, took photographs for Photo ID purposes. A SWF member licensed by CCW to approach dolphins in order to collect images was onboard *Bay Explorer*

surveys and, therefore, dedicated Photo ID took place on these trips. From June, during surveys where Photo ID was conducted, an initial estimate of group size was recorded as well as a final group count.

Table 2: Vessels used during *ad libitum* surveys in Cardigan Bay SAC in 2011

Vessel name	Length	Eye Height (m)	Speed (kn)	Engine Type
<i>Dunbar Castle II</i>	9.7	3.5	7	120hp diesel
<i>Ermol V</i>	11.5	2.5	6	Twin 128hp diesel
<i>Ermol VI</i>	10.9	2.5	6	350hp diesel
<i>Islander</i>	7	2.5	6	Twin 60hp petrol
<i>Bay Explorer</i>	10	2.5	variable	Twin 200hp petrol
<i>Boat Gallois</i>	5	1.5	8	60hp petrol

2.5 Data Analysis- Ad Libitum surveys

Effort and sightings data were entered into Microsoft Excel. Maps of track lines and sightings were plotted using ArcView 3.2. Data from all surveys conducted in Cardigan Bay SAC was then examined to investigate temporal variation in sightings and group composition and to assess activity budgets. Statistical analyses were performed using SPSS 20. To test for significance between group size and month, a Kruskal-Wallis test was used. A Wilcoxon test was used to test for significance between initial and final group count of dolphins in order to assess whether individuals were positively attracted to the vessel.

2.6 Photo Identification

Photo ID is a mark-recapture method that makes use of naturally produced markings. Bottlenose dolphins are an ideal study species for this technique since many acquire nicks and scratches on the dorsal fin and body, from interactions with other individuals. These are unique to individual animals and, with good quality photographs, are recognisable. SWF began in the early 1990s its own catalogue of images collected in Cardigan Bay. Since 2001, this has grown and been maintained to the present day by regular dedicated Photo ID surveys. In 2007, the catalogue was extended to include data from surveys conducted in North Wales and around the Isle of Man, resulting in a catalogue of individuals reported for the wider Irish Sea. This non-invasive method has proved very successful and has been used to assess abundance and population trends, define habitat use and fidelity, and home ranges, as well as to investigate social structures and study life history (such as birth and death rates) (Ugarte *et al.*, 2006; Pesante and Evans, 2008; Pesante *et al.*, 2008b; Feingold *et al.*, 2011).

In 2011, images used for Photo ID were collected during dedicated surveys (line-transect and *ad libitum*), onboard passenger trips and during land-based watches from New Quay Harbour. In some cases, images were also provided from others including Janet Baxter (Friends of Cardigan Bay), Alan Gray (Shearwater Cruises) and Tom Felce (Manx Whale and Dolphin Watch). Members of the public were also encouraged to send in their photos,

taken during sightings from passenger trips or from New Quay Pier, so long as some basic sightings information was provided, including date, location and group size.

Photographs obtained by SWF were taken using Canon 40D and Canon 20D bodies with a 18-300 or 75-300mm telephoto zoom lens. During dedicated surveys, dolphins were approached to 20-50 metres. Photographs were obtained under CCW licence, following their protocols.

2.7 *Data analysis - Photo ID*

Photo ID matching was performed using ACDSee Pro. All matched encounters were confirmed by a second person. Software programs MARK 6 and CAPTURE were used to calculate population estimates using mark-recapture analysis. The Chao (Mth) model was used for closed populations and the Robust Design Method was conducted for the open population model.

3. RESULTS

3.1 *Line-transect surveys*

Due to the fact that funding for bottlenose dolphin monitoring was not granted until September 2011, line-transect surveys began relatively late in the season. For this reason, combined with restrictions due to bad weather conditions, fewer surveys were conducted than we would have recommended. Despite this, there was reasonable coverage of Cardigan Bay, including the area outside of the SACs (Figure 5). In total, 1992.58 km of survey effort were completed during these surveys. Of these, 1198.01km were conducted on line-transect mode (Table 3); Note that the final *Pedryn* survey conducted outside of the sample region (see outer *Pedryn* track in Figure 5), was excluded from these results.

From the 1992.58 km surveyed, a total of 67 bottlenose dolphin, 56 harbour porpoise and 74 grey seal sightings were made. Of these, 31 bottlenose dolphin sightings were detected from the transect line, as well as 43 harbour porpoise and 44 grey seals (Table 4).

No bottlenose dolphins were recorded outside of the SACs. One sighting was detected on the outer border of Pen Llyn a'r Sarnau SAC. However, this locality is relatively close to land. Surveys from all three vessels indicate a strong preference for inshore waters, as seen in previous years. Bottlenose dolphin sightings were highest within Cardigan Bay SAC, although this was only true for the inner transects. No dolphins were detected in the outer section of this SAC (Figure 6).

Harbour porpoise and grey seals were relatively widely distributed, with detections in both inshore and offshore waters (Figure 6). Harbour porpoise sightings were most regular during *Pedryn* surveys, with 20 sightings recorded in just three surveys. This is most likely due to the fact that two of the three surveys followed offshore transects. By contrast, harbour porpoise sightings were relatively low in Cardigan Bay SAC. Thirty porpoise sightings were

recorded throughout the field season compared with 55 bottlenose dolphin and 56 grey seal detections. Surveys within Pen Llŷn a'r Sarnau SAC yielded relatively similar numbers of porpoises and dolphins.

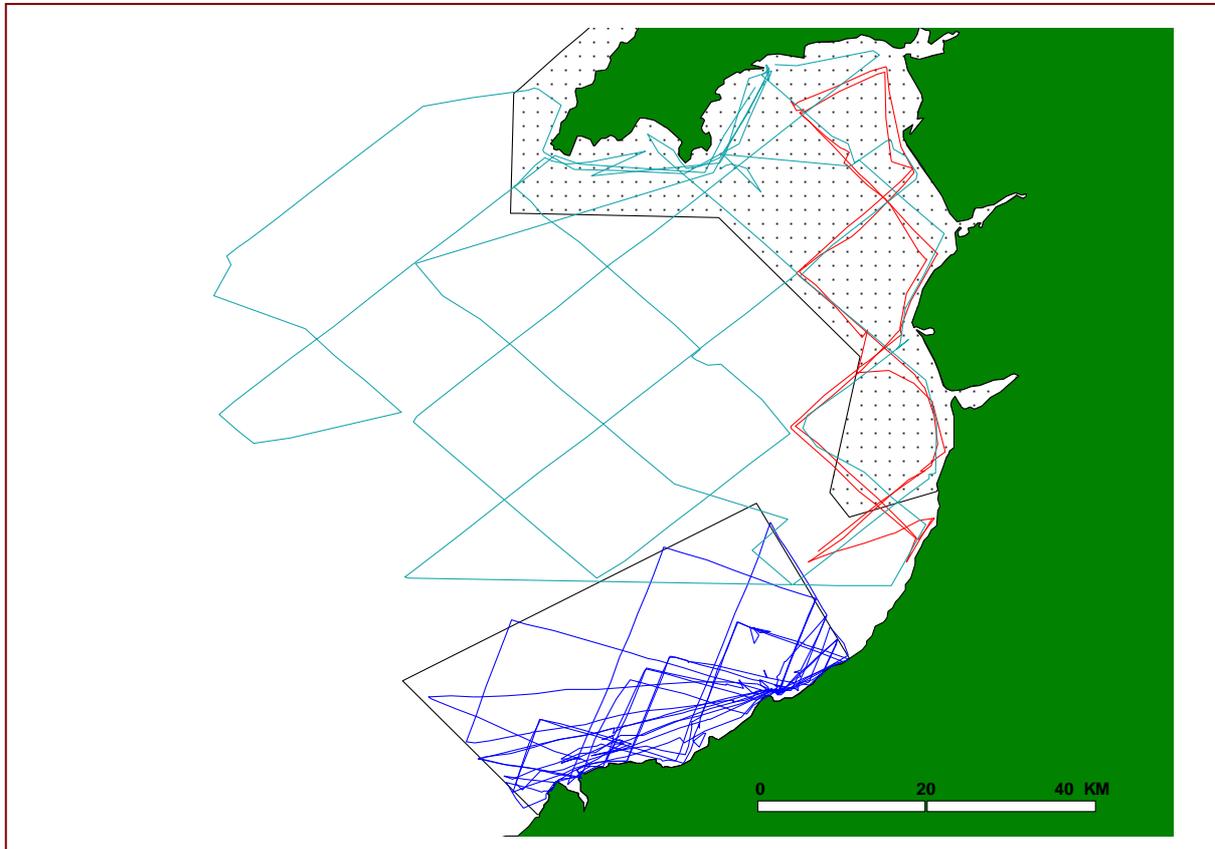


Figure 5: Tracks of line-transect surveys conducted in Cardigan Bay in 2011
(Vessels used: *Dunbar Castle II* - dark blue; *Ma Chipe Seabrin* - red; *Pedryn* - light blue)

Table 3: Line-transect (LT) survey effort conducted in Cardigan Bay in 2011

Vessel	No. surveys	No. legs	Km travelled	Km travelled in LT mode	Km in inner transects	Km in outer transects
<i>Dunbar Castle II</i>	10	35	897.42	497.71	336.78	160.93
<i>Ma Chipe Seabrin</i>	2	13	382.82	256.47	-	-
<i>Pedryn</i>	3	19	712.34	443.83	-	-
TOTAL	15	67	1992.58	1198.01		

Table 4: Marine mammals sightings yielded from line-transect (LT) surveys conducted in Cardigan Bay in 2011 (BND - bottlenose dolphin; HP - harbour porpoise; GS - Atlantic grey seal)

Vessel	No. BND sightings	No. BND in LT mode	No. HP sightings	No. HP in LT mode	No. GS sightings	No. GS in LT mode
<i>Dunbar Castle II</i>	55	24	30	21	56	31
<i>Ma Chipe Seabrin</i>	7	5	6	4	2	2
<i>Pedryn</i>	5	2	20	18	16	11
TOTAL	67	31	56	43	74	44

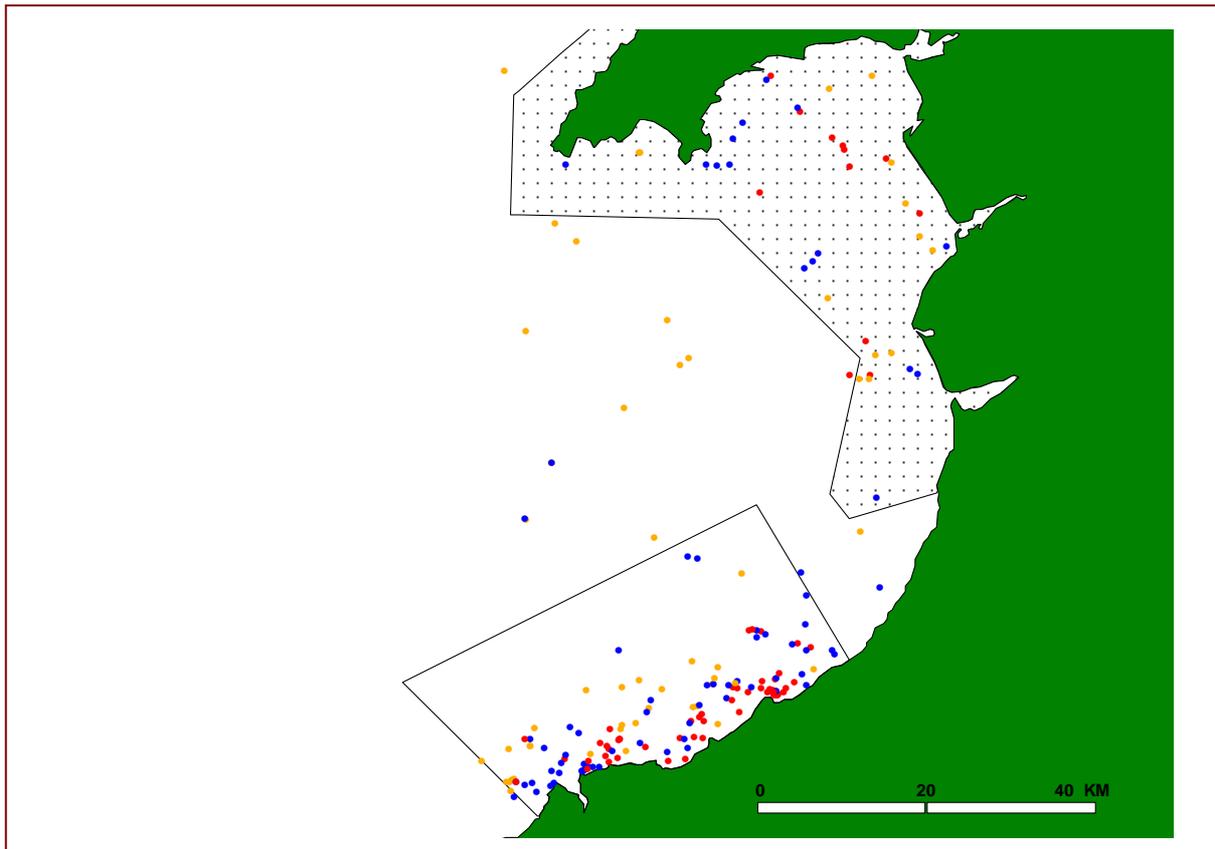


Figure 6: Sightings recorded during line-transect surveys in Cardigan Bay in 2011 (bottlenose dolphin - red; harbour porpoise - yellow; Atlantic grey seal - blue)

Abundance estimates, calculated using software Distance 6, for the whole of Cardigan Bay combining all surveys, are shown in Table 5. The estimated population for bottlenose dolphins is 296 animals. The CV of 28.82 is higher than we would like (ideally it should be 20 or less), and this is most likely due to the fact that not as many surveys were achieved or sightings detected due to the late start in the season and weather limitations. Further surveys would confirm whether this is an accurate abundance estimate for the species.

Table 5: Abundance estimates of bottlenose dolphin (BND) and harbour porpoise (HP), from line-transect surveys in Cardigan Bay

Definition	BND	HP
Abundance	296	990
95% CI	170-518	585-1673
CV	28.82	27.1
Observations	29	43

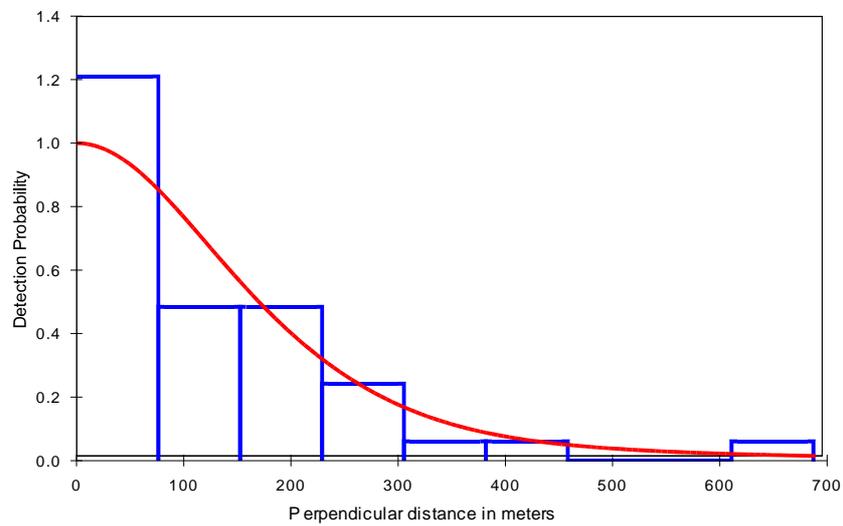
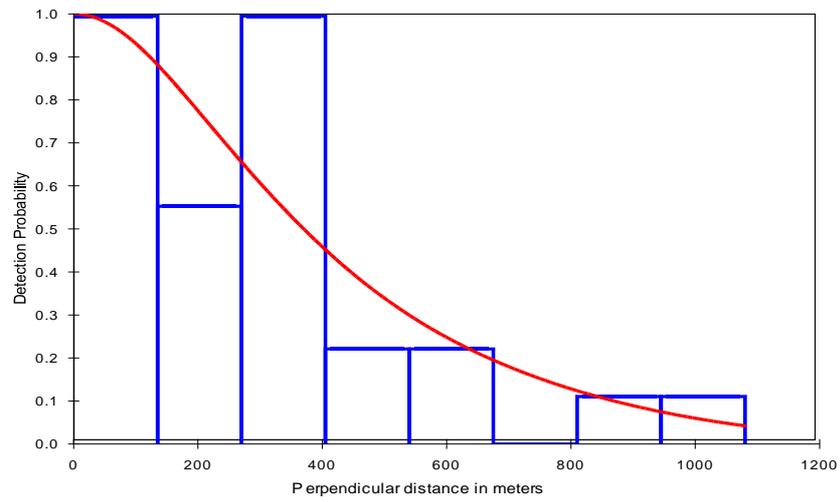


Figure 7: Detection probability of bottlenose dolphins (top) and harbour porpoise (bottom) in Cardigan Bay

The abundance estimate for harbour porpoise was significantly higher than for bottlenose dolphin, with 990 individuals (but also with a high CV). This is to be expected since it is thought that harbour porpoise is the more common and widely distributed species.

Abundance estimates were also calculated for Cardigan Bay SAC only (Table 6). An estimate of 114 bottlenose dolphins was calculated for the site. In previous years when regular line-transect surveys were undertaken (Ugarte *et al.*, 2006; Pesante *et al.*, 2008b), a general increase in population size was observed between 2003 (N=140) and 2006 (N=206), but in 2007, numbers dropped markedly (N=109) (Table 7).

Harbour porpoise detections were particularly low within Cardigan Bay SAC in 2011. This resulted in an estimate of 302 individuals, although this must be interpreted with caution since the CV of the estimate was high (44.61). A comparison of abundance estimates between years is given in Table 8. There were insufficient sightings in Pen Llŷn a'r Sarnau SAC to calculate accurate abundance estimates for this location alone.

Table 6: Abundance estimates of bottlenose dolphin (BND) and harbour porpoise (HP), from line-transect surveys in Cardigan Bay SAC

Definition	BND	HP
Abundance	114	302
95% CI	64-204	129-711
CV	29.81	44.61
Observations	24	21

Table 7: Comparison of abundance estimates between years of bottlenose dolphins in Cardigan Bay SAC

	Abundance	95% CI	CV	Observations
2003	140	69-284	36.58	19
2004	-	-	-	-
2005	154	90-264	27.81	45
2006	206	105-403	35.16	30
2007	109	49-239	41.70	24
2011	114	64-204	29.81	24

Table 8: Comparison of abundance estimates between years of harbour porpoise in Cardigan Bay SAC

	Abundance	95% CI	CV	Observations
2003	236	148-337	24.02	50
2004	215	136-339	23.08	46
2005	167	121-230	16.46	73
2006	170	113-225	20.96	53
2007	214	145-314	19.80	46
2011	302	129-711	44.61	21

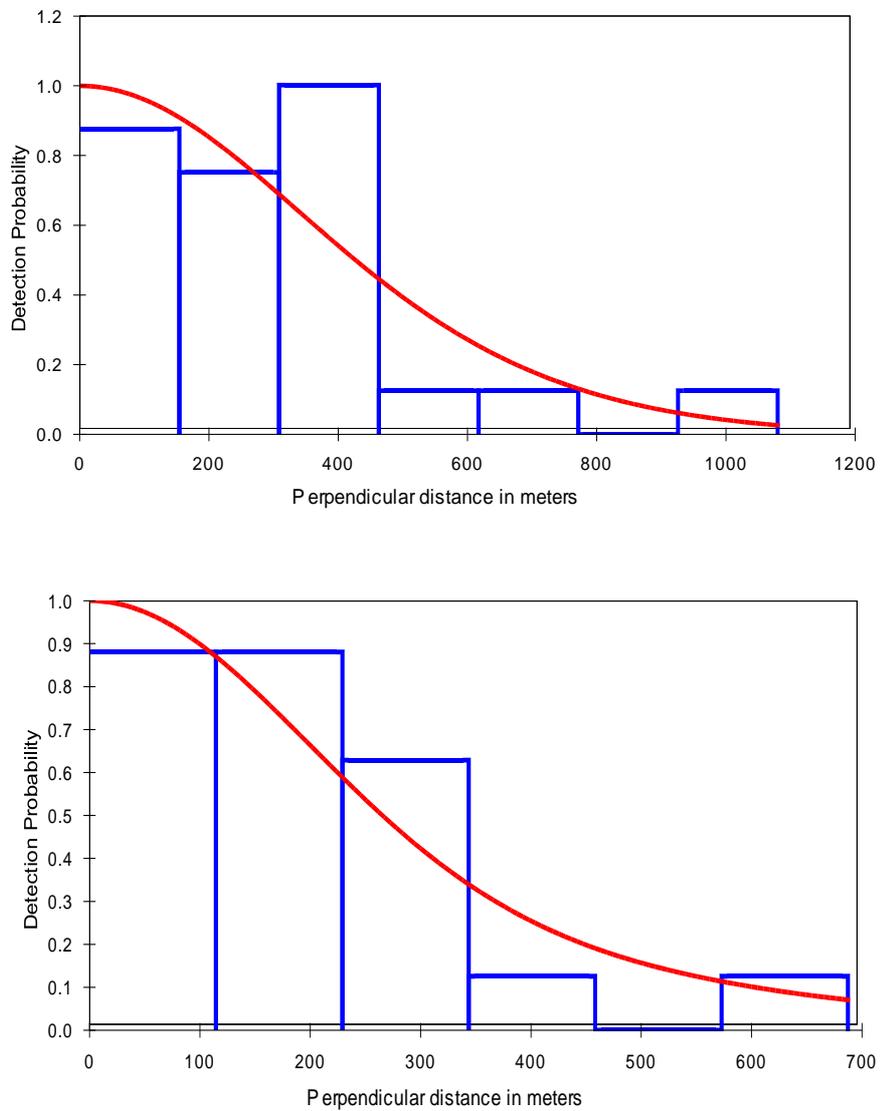


Figure 8: Detection functions of bottlenose dolphin (top) and harbour porpoise (bottom) in Cardigan Bay SAC

3.2 *Ad Libitum* surveys

Previous to funding being granted, dedicated *ad libitum* trips were conducted in Cardigan Bay SAC between May and July 2011 aboard *Dunbar Castle II* and *Boat Gallois*. In addition, a number of dolphin-watching boats in the region were used as platforms of opportunity to collect regular effort, sightings and Photo ID data (Table 9). All boats except *Bay Explorer* departed from New Quay and travelled south, remaining relatively inshore (Figure 9).

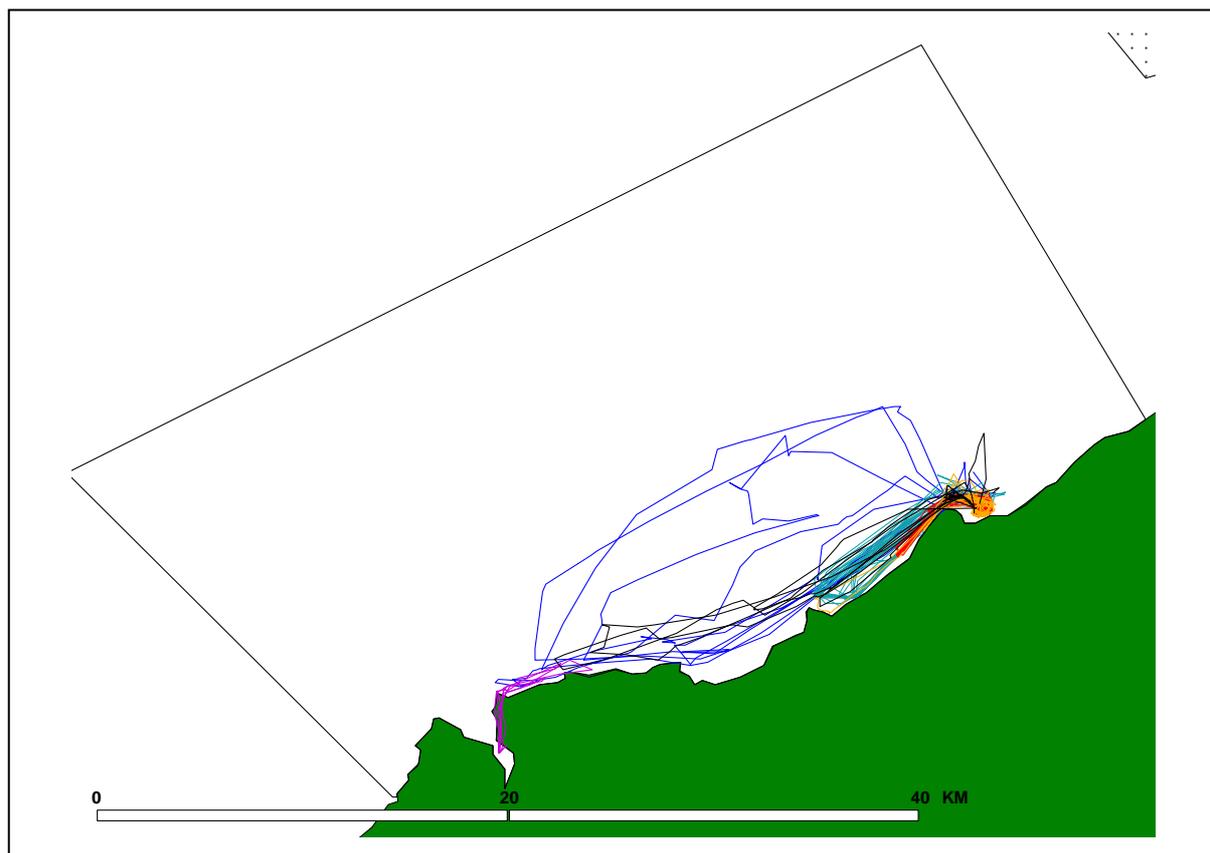


Figure 9: Effort tracks of *ad libitum* surveys conducted in Cardigan Bay SAC in 2011 (Vessels used: *Dunbar Castle II* - dark blue; *Islander* - yellow; *Bay Explorer* - purple; *Ermol V* - light blue; *Ermol VI* - red; *Boat Gallois* - black)

Table 9: Total effort and sightings recorded during *ad libitum* surveys in Cardigan Bay SAC in 2011

Vessel	No. surveys	Km of effort	BND sight.	BND sight./km	HP sight.	HP ight./km	GS sight.	GS sight./km
<i>Dunbar Castle II</i>	7	282.51	22	0.08	2	.007	6	0.02
<i>Ermol V</i>	30	745.33	41	0.06	0	0	59	0.08
<i>Ermol VI</i>	46	379.11	47	0.12	0	0	20	0.05
<i>Islander</i>	14	108.59	7	0.06	1	.009	6	0.06
<i>Bay Explorer</i>	3	41.63	4	0.10	0	0	4	0.10
<i>Boat Gallois</i>	6	148.69	14	0.09	3	.020	3	0.02
TOTAL	106	1705.86	135	0.08	6	.004	98	0.06

All marine mammal sightings recorded in Cardigan Bay SAC from boat based surveys (line-transect and *ad libitum*) are illustrated in Figure 10. Sightings of bottlenose dolphin were well distributed along the coastline with a hotspot forming off New Quay. However, effort was highest at New Quay since all boats except *Bay Explorer* departed from this site.

Harbour porpoise and grey seals were also widely distributed along the coastline. Grey seal sightings occurred particularly between New Quay and Ynys Lochtyn, but since this was also the most common route taken by commercial boat operators, effort was most intense in this part of the SAC, so that seals may be over-represented on this route compared to the rest of the SAC.

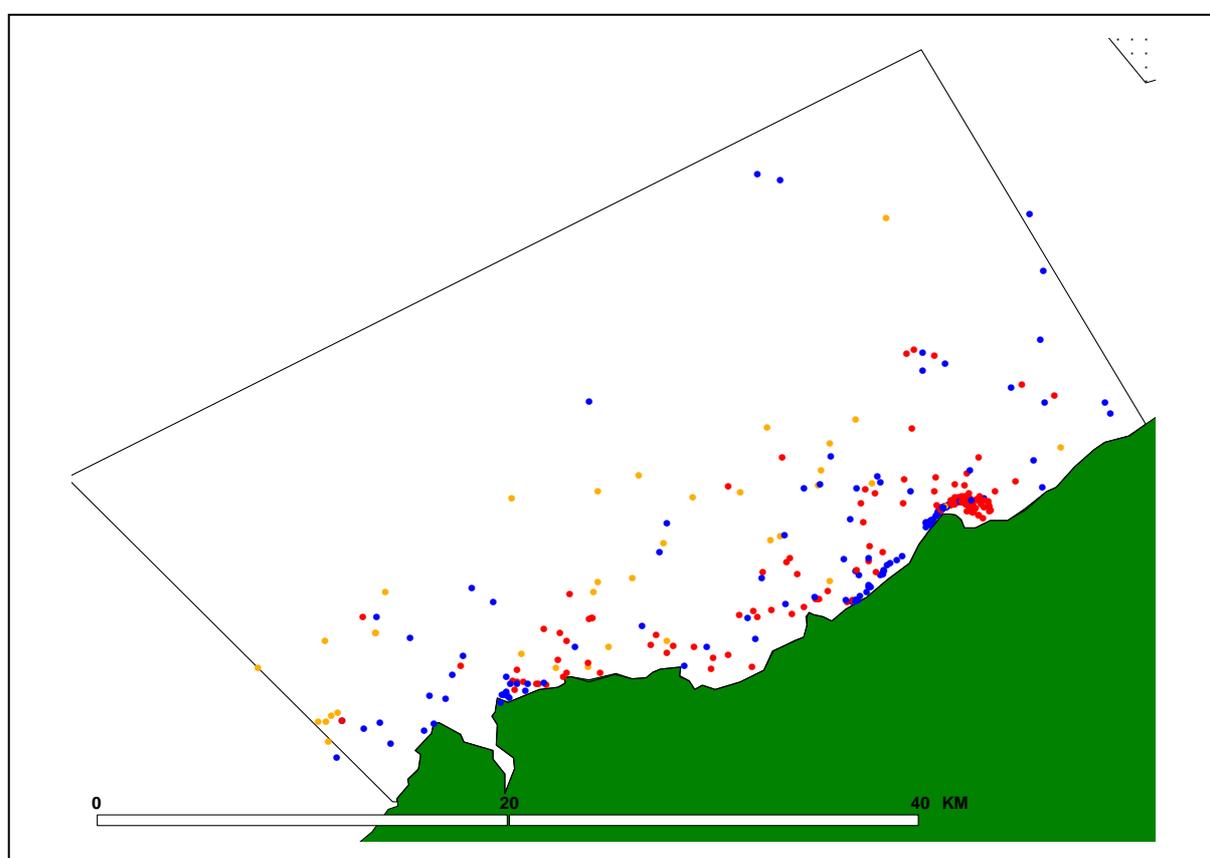


Figure 10: Sightings recorded during all surveys (line-transect and *ad libitum*) in Cardigan Bay SAC in 2011 (bottlenose dolphin - red; harbour porpoise - yellow; Atlantic grey seal - blue)

All boat data in Cardigan Bay SAC were collated to investigate seasonal patterns of occurrence. The number of sightings per kilometre was relatively similar between May and September except for a peak in June. Sightings rates were lower in April and October (Figure 11). The average group size generally increased as the season progressed (Figure 12), with regular encounters of ten or more animals in September and October, and a peak of 38

animals on the last survey in the SAC at the end of October. However, group size did not change significantly per month ($\chi^2 = 2.317$, $df = 2$, $p = 0.314$). Figure 12 shows that there is a significant difference between initial group size (count when animals are first encountered) and final group count (post Photo ID encounter), particularly in June, September, and October ($Z = -3.24$; $p = <0.001$), suggesting that dolphins are attracted to the boat during the time that Photo ID is taking place.

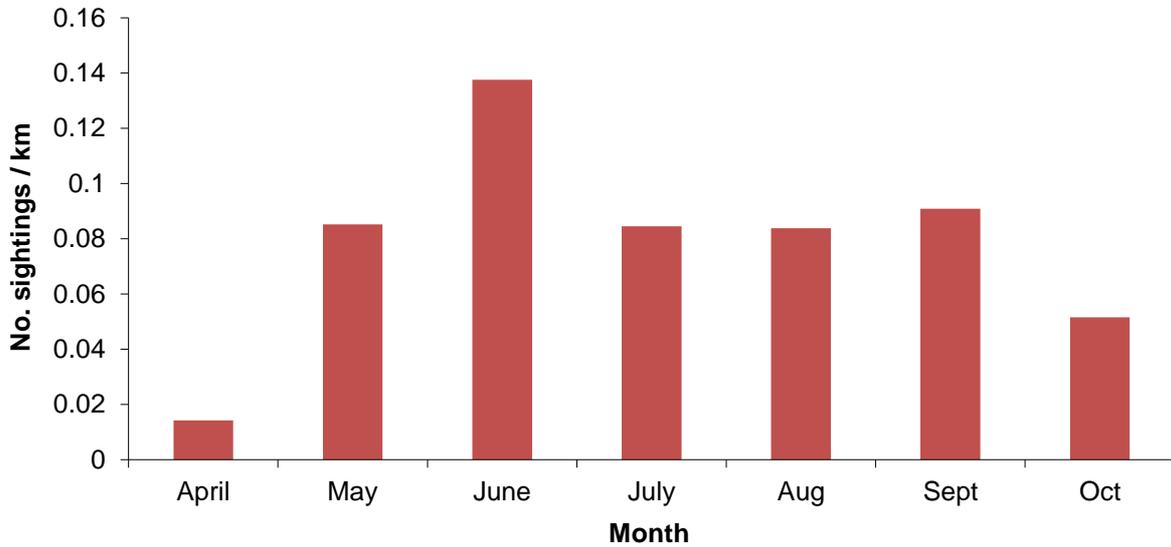


Figure 11: Number of bottlenose dolphin sightings per kilometre travelled recorded from boat-based surveys each month in Cardigan Bay SAC

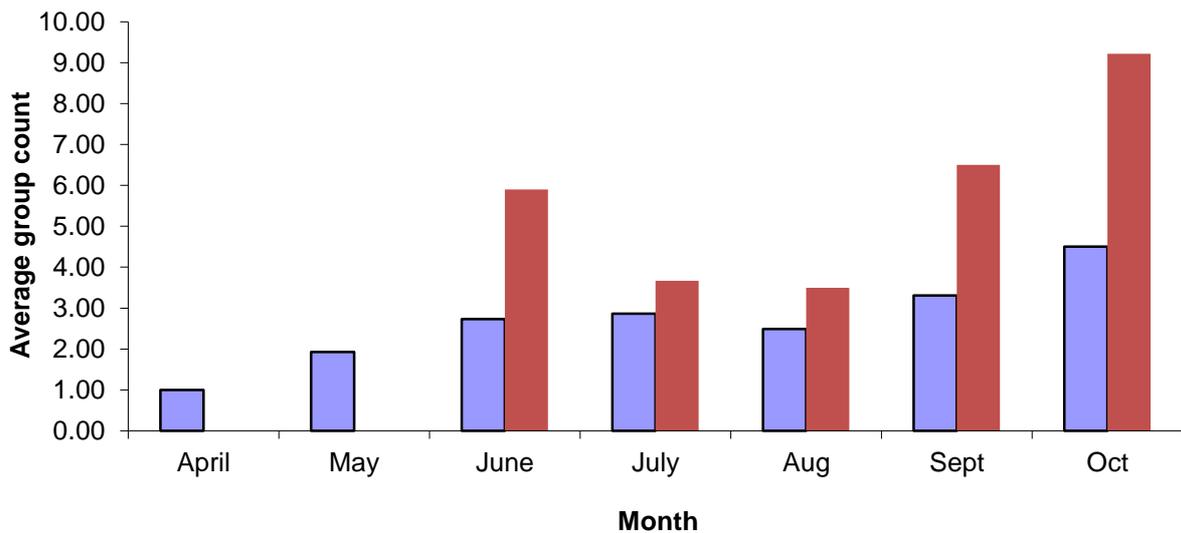


Figure 12: Average group size of bottlenose dolphins recorded from boat-based surveys each month in Cardigan Bay SAC (blue - initial group count; red - group count at the end of an encounter)

3.3 Activity Budgets

During summer 2011, bottlenose dolphins were encountered feeding 50% of the time (Figure 13). They were never recorded resting and seemed to spend only a small proportion of their time socialising (6%). However, if *ad libitum* surveys are discounted and the line-transect data alone investigated, the behavioural budget changes significantly, with just 22% of sightings recorded feeding, and social activity increasing to 16% (Figure 14). For the majority of the time, animals were recorded travelling (62%). The increased feeding activity when incorporating the largely coastal *ad libitum* survey data, suggests that dolphins use the near-shore to feed.

The activity budget of bottlenose dolphins recorded during line-transect surveys in Pen Llŷn a'r Sarnau SAC is similar to that seen during line-transects in Cardigan Bay SAC (Figure 15), suggesting that the two sites may be utilised in similar ways. Further analysis of coastal sites in Pen Llŷn a'r Sarnau SAC would determine whether this coastline is also predominantly used for feeding.

Comparison of activity budgets between years in Cardigan Bay SAC is shown in Figure 16. Travelling behaviour consistently has been the most frequently recorded activity during line-transect surveys, followed by feeding, the level of which has fluctuated between years. In 2005, feeding behaviour was recorded in 45% of sightings but in 2006, the proportion of time spent feeding seemed to drop significantly, as this activity was recorded in just 12% of sightings. By comparison, the intensity of feeding in 2011 appears to be relatively low, with the exception of 2006 (Figure 14).

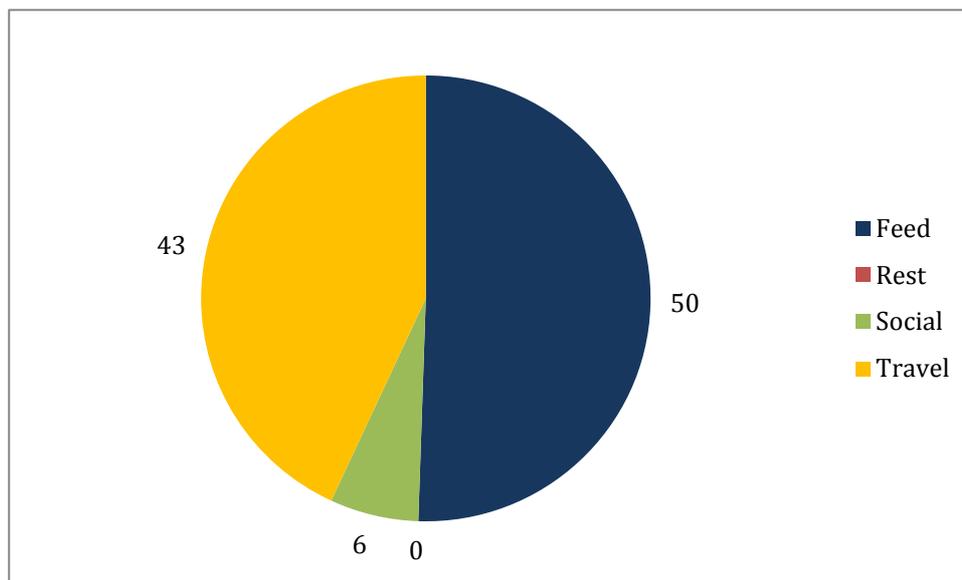


Figure 13: Behavioural budget of bottlenose dolphins recorded from all boat surveys in Cardigan Bay SAC

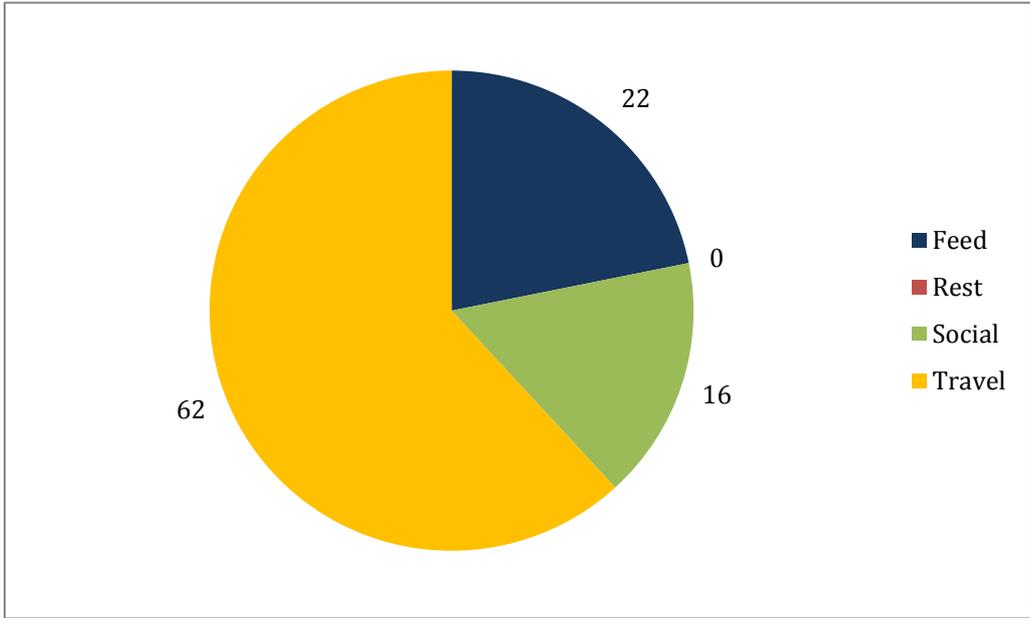


Figure 14: Behavioural budget of bottlenose dolphins recorded from line-transect surveys in Cardigan Bay SAC

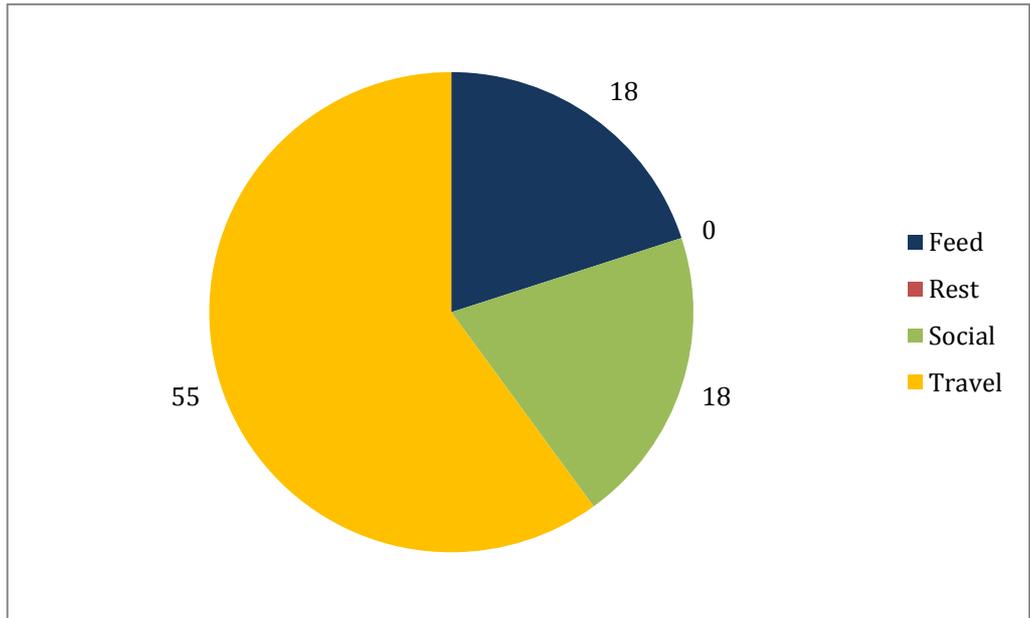


Figure 15: Behavioural budget of bottlenose dolphins recorded from line-transect surveys in Pen Llŷn a'r Sarnau SAC

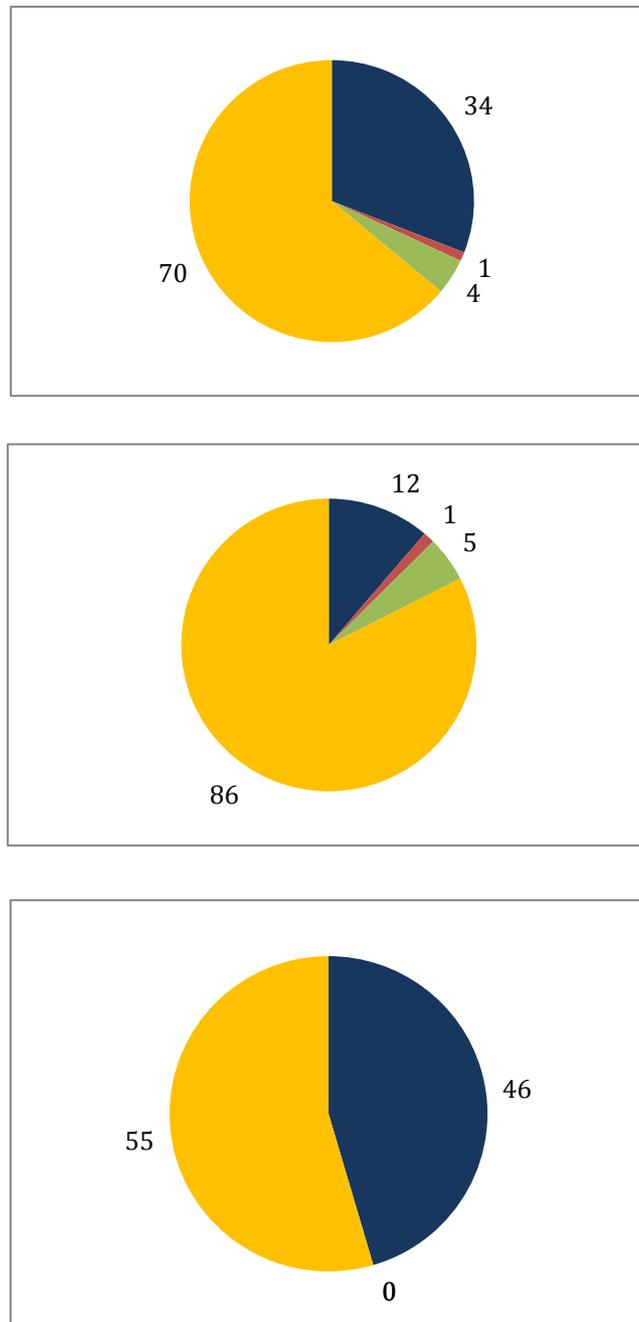


Figure 16: Behavioural budget of bottlenose dolphins recorded from line-transect surveys in Cardigan Bay SAC in 2005 (bottom), 2006 (middle) and 2007 (top)

3.4 Reproductive & Mortality Rates

Forty-three percent of groups encountered in Cardigan Bay SAC had one or more calves present, confirming that the site is an important nursery ground for the species. Ten newborn calves were recorded in 2011 in Cardigan Bay SAC. The numbers of newborn calves recorded has fluctuated between years in this SAC. Peak years include 2006 and 2010, with an average value of ten newborn calves per year (Table 10). Calculated birth rates in the Cardigan Bay SAC using mark-recapture population estimates with a closed population model show an increase between 2001 and 2004 reaching a peak of 8.39% in the latter year.

The birth rate then steadily declined, reaching its lowest value in 2009 at 1.95%. In 2010 and 2011, the birth rate has increased to 6.14% and 5.75% respectively. Birth rates calculated using an open population model, suggest a high birth rate in 2005 of 11.43%. This rate again declined until 2009 to 3.36%, followed by a marked increase in 2010 and 2011 (7.14% and 7.73% respectively). The mean birth rate for the site is 5.24% using a closed population model, and 7.73% with an open model (Table 10; Figure 17).

The inter-birth interval in Cardigan Bay between 2001 and 2009 was calculated using definite mothers that had been recorded each year between births (N=17). Most mothers were found to give birth to a new calf every three years (Figure 18; see also Pesante and Evans, 2010).

Calving season in Cardigan Bay between 2001 and 2010 was analysed and shows that calves are born in all months of the field season with the exception of October. Peaks in the number of births were observed in July and August (Figure 19).

Calf mortality rates were calculated from a sample of 49 mother-calf pairs born between 2001 and 2006, and it was found that in the first two years the rate of mortality was highest at 20.41% in year one, and 24.49% in year two. This rate dropped in the third year to 10.20% (Figure 20). A total of 44.90% of the calves survived into their fourth year (Pesante and Evans, 2010).

Table 10: Number of newborns recorded in the Cardigan Bay SAC and birth rates calculated for the sites using mark-recapture population estimates for closed and open population models

Year	No. newborns	Population estimate (closed)	Population estimate (open)	Birth rate (closed)%	Birth rate (open)%
2001	7	129	99	5.43	7.07
2002	8	166	77	4.82	10.39
2003	10	150	135	6.67	7.41
2004	12	143	126	8.39	9.52
2005	12	198	105	6.06	11.43
2006	13	229	145	5.68	8.97
2007	10	225	171	4.44	5.85
2008	6	260	127	2.31	4.72
2009	4	205	119	1.95	3.36
2010	14	228	152	6.14	9.21
2011	10	174	140	5.75	7.14
MEAN	9.64	-	-	5.24	7.73

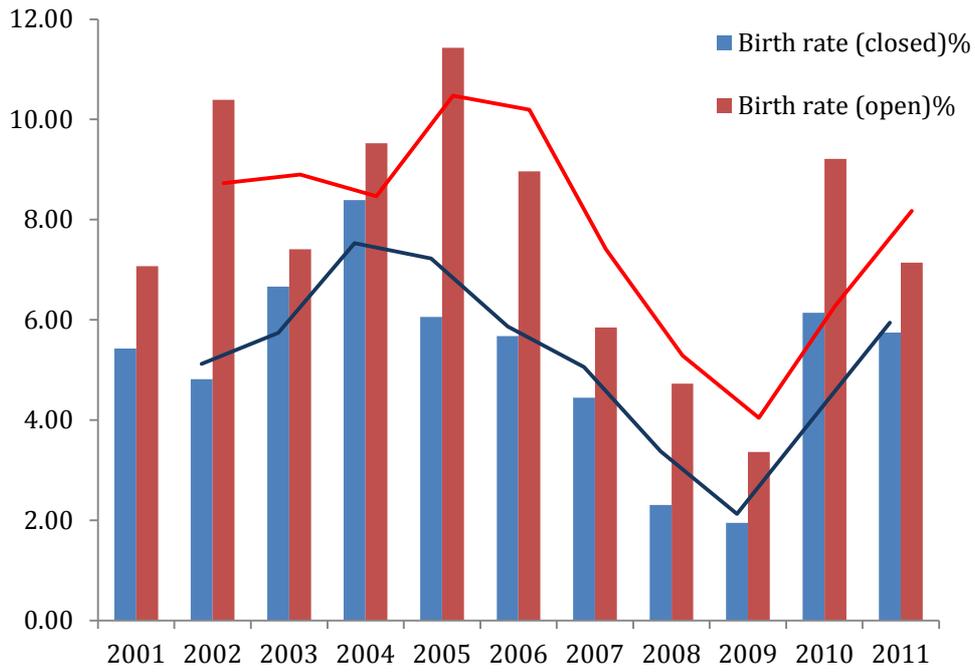


Figure 17: Birth rates of bottlenose dolphin calves in Cardigan Bay SAC

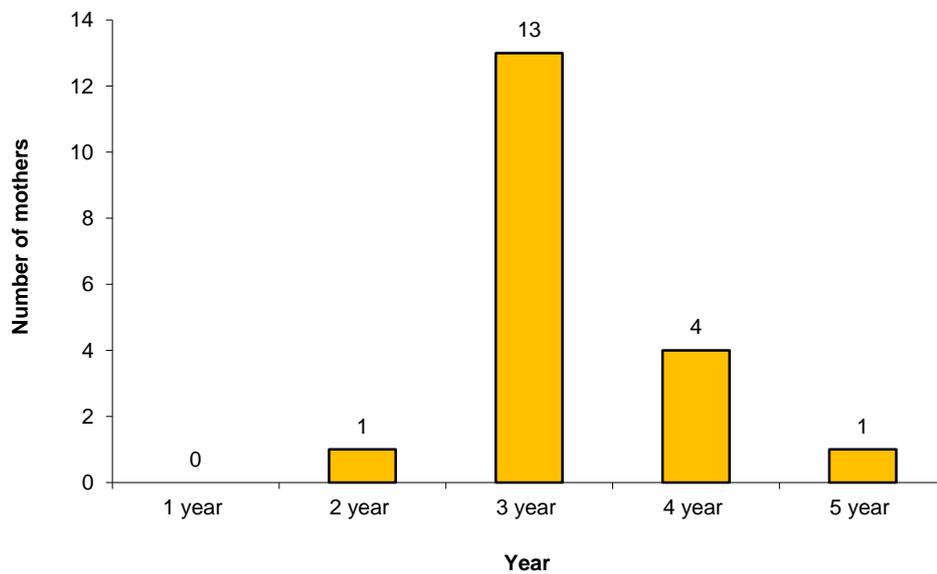


Figure 18: Inter-birth intervals of known mothers in Cardigan Bay between 2001 and 2009

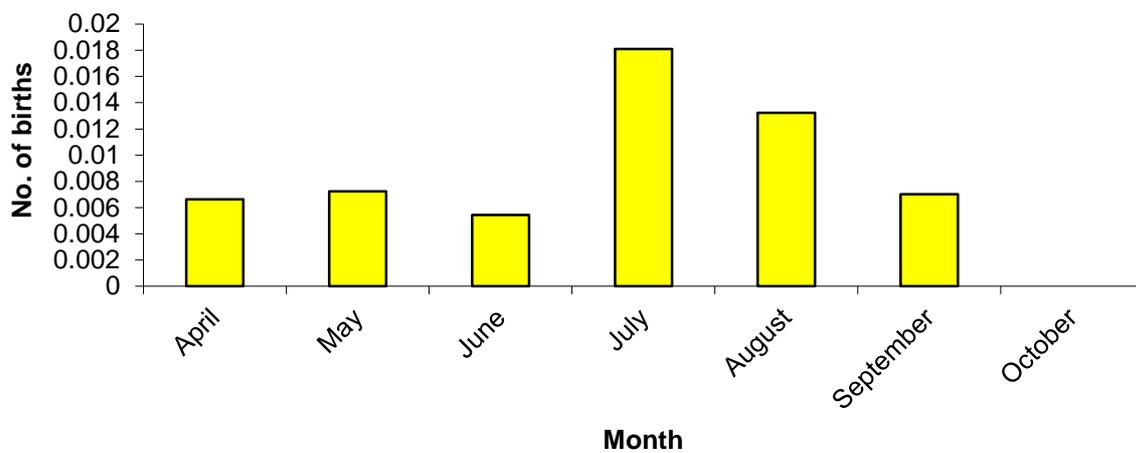


Figure 19: Number of births recorded in Cardigan Bay between 2001 and 2010

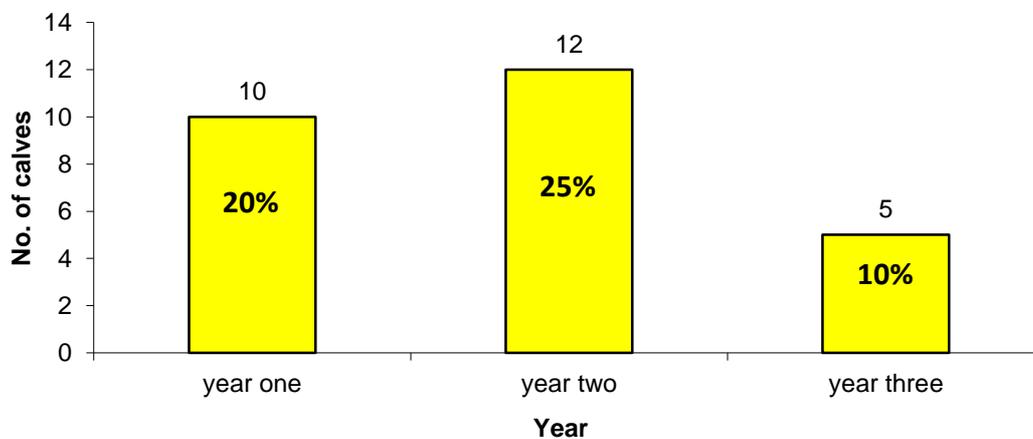


Figure 20: Number of calves that have died between age 1 and 3 years

3.5 *Photo ID*

A total of 148 bottlenose dolphin encounters were made in 2011 throughout Cardigan Bay and off North Wales. From these, 200 dolphins were identified (Table 11). Twenty-seven new animals were added to the catalogue, giving an updated total of 513 images, and a minimum of 382 dolphins (Table 12).

Table 11: Bottlenose dolphin encounters in 2011

Total no. encounters	148
Total no. dolphins identified	200
No. well marked dolphins identified	61
No. slightly marked dolphins identified	84
No. unmarked dolphins (left) identified	24
No. unmarked dolphins (right) identified	31

Table 12: SWF catalogue content in 2011

Well marked	106
Slightly marked	144
Left	131
Right	132
Total	513

A discovery curve plotting encounters from 2001 until 2011 confirms that new dolphins are currently still being identified, in all areas. This is particularly true when encounters from Pen Llŷn a'r Sarnau and North Wales are included whereas in Cardigan Bay SAC there has been levelling off over the last few years (Figure 21).

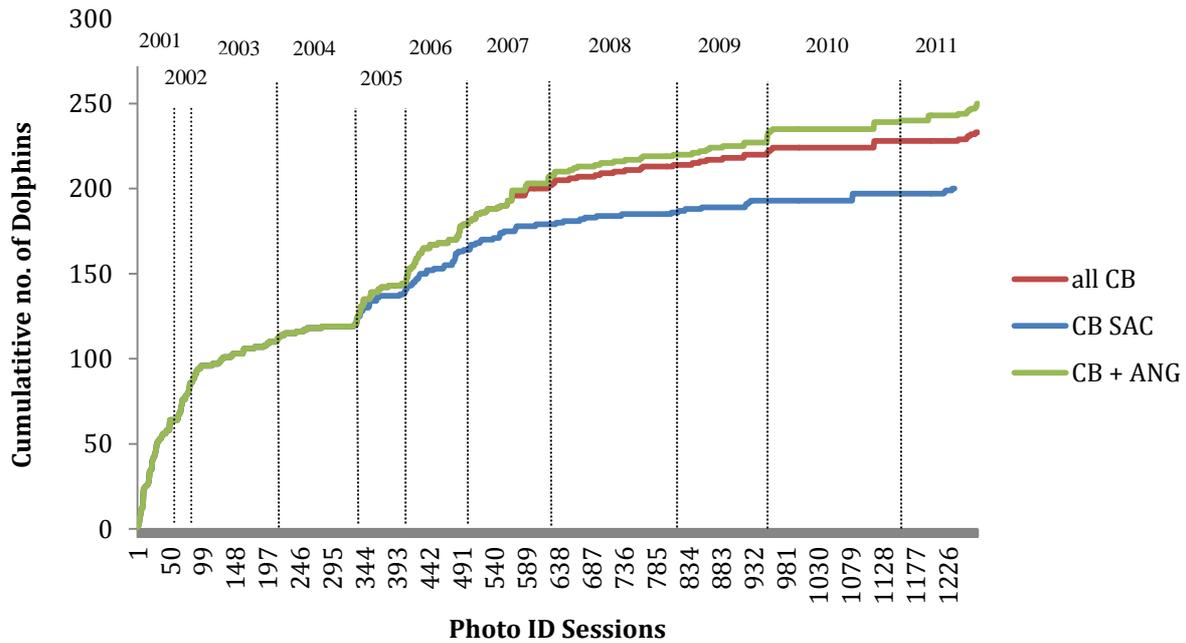


Figure 21: Discovery curve for marked bottlenose dolphins (all CB- Cardigan Bay; CB SAC- Cardigan Bay SAC, CB+ANG-Cardigan Bay and encounters from North Wales)

Considering the marked individuals of the Cardigan Bay SAC only, 42% of animals (99 individuals) are classified as residents (identified on more than 12 occasions); 30% of dolphins (70 individuals) are occasional to the area, having been identified between four and 11 times. 28% of individuals (66 dolphins) have been recorded on three occasions or less, classifying them as transients (for those individuals that were encountered more than once in a day, just one encounter was counted in this analysis) (Figure 22). The number of re-sightings within the SAC varied widely between individuals, with one dolphin having been recorded on 103 days in total. The average frequency of re-sightings was 5.47 (Figure 23).

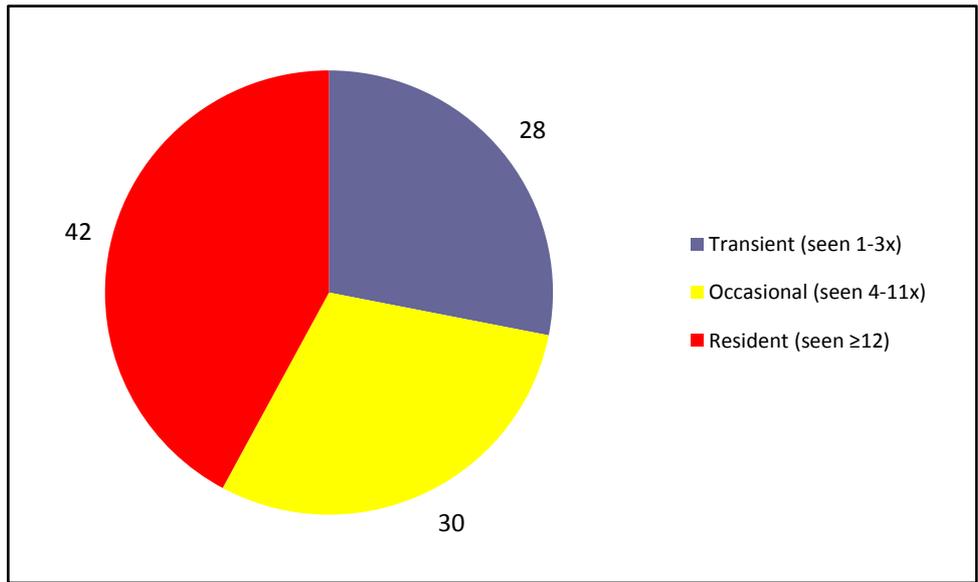


Figure 22: Percentage of re-sightings of marked individuals in Cardigan Bay SAC

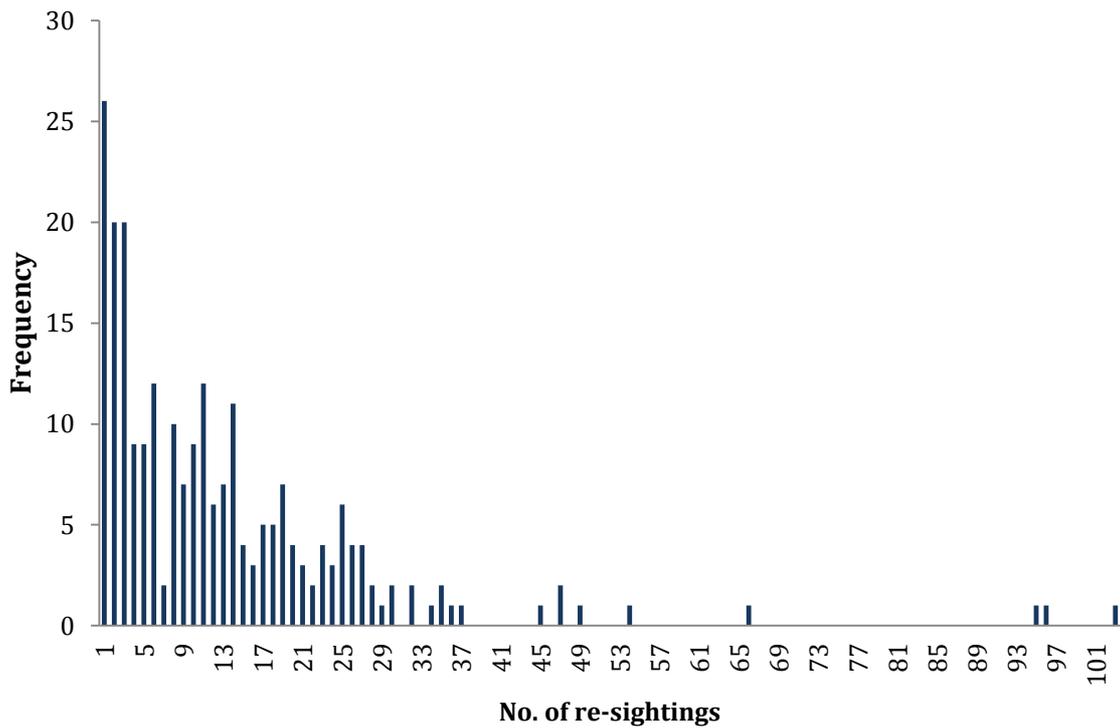


Figure 23: Frequency of re-sightings of individuals in Cardigan Bay SAC 2001-11

Population estimates of Cardigan Bay using the mark-recapture method and a closed population model show a general increase in numbers from 2005 until 2009, reaching a peak of 295 dolphins. Since then, the population estimate has declined to 209 animals in 2011 (Table 13). Testing the same data with an open population model, which considers emigration and immigration from Cardigan Bay and birth and deaths, shows small

fluctuations in numbers between years, reaching a peak in 2007, at 221 individuals. Since then, despite further fluctuations, there has been a noticeable decline with a population estimate of only 153 dolphins in 2011 (Table 14). The probability of emigration from Cardigan Bay between 2010 and 2011 has risen to 35%, and the probability of dolphins remaining out of the study area increased to 42% (Figure 24). This suggests that some proportion of the population may no longer be using Cardigan Bay.

Table 13: Population estimates of bottlenose dolphins occupying Cardigan Bay, calculated using the mark-recapture method, and a closed population model, taking account for the marked proportion of individuals

Year	Capture events	Animals captured	Population estimate	Lower 95% CI	Upper 95% CI	Standard error	Proportion well-marked
2005	141	83	182	153	242	14.55	0.661
2006	219	117	217	197	260	9.97	0.649
2007	286	129	252	237	288	7.49	0.583
2008	239	122	291	248	370	19.80	0.646
2009	187	107	295	234	405	28.04	0.661
2010	245	110	282	237	363	19.35	0.620
2011	162	85	209	182	273	12.30	0.549

Table 14: Population estimates for bottlenose dolphins in Cardigan Bay for the years 2005-2011, obtained using an open population model, and considering the marked proportion of individuals

Year	Population estimate	Standard Error	Proportion of marked
2005	127	2.07E-16	0.661
2006	180	5.35E-05	0.649
2007	221	0.00E+00	0.583
2008	189	1.75E-29	0.646
2009	162	2.23E-44	0.661
2010	182	5.41E-05	0.62
2011	157	1.39E-04	0.549

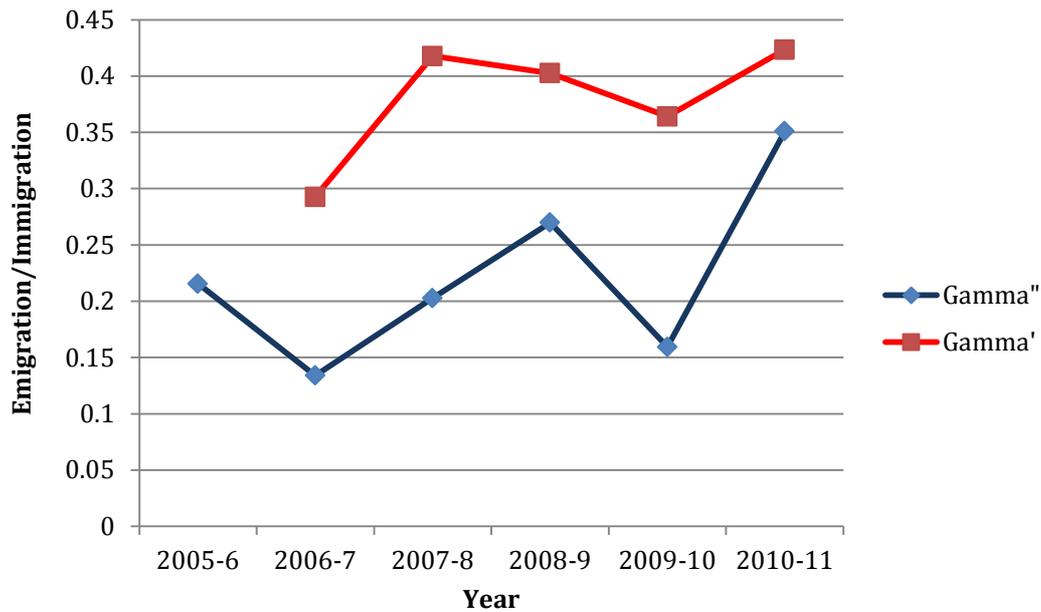


Figure 24: Bottlenose dolphin residency patterns in Cardigan Bay using an open population model (gamma''= probability of an animal emigrating out of the study area; gamma' = probability of an animal staying out of the study area)

Considering the Cardigan Bay SAC only, where there has been a more even coverage of effort over time, population estimates between 2001 and 2011 using a closed population model also show a recent decrease in numbers to 174 in 2011 (Table 15). This is the lowest estimate recorded since 2004. An open population model illustrates fluctuations in estimates between years but still a low value of 140 in 2011 (Table 16). The probability of individuals leaving the site between years is 30%, similar to that seen between 2007 and 2009, but major fluctuations between years disguise any clear pattern. However, the likelihood that animals stayed out of Cardigan Bay SAC shows an overall decline (Figure 25). This may show that a sub population is loyal to the site but that there is a reduction in visits by more transient animals.

Table 15: Population estimates of bottlenose dolphins occupying the Cardigan Bay SAC, calculated using the mark-recapture method, and a closed population model, taking account of the marked proportion of individuals

Year	Capture events	Animals captured	Population estimate	Lower 95% CI	Upper 95% CI	Standard error	Proportion well-marked
2001	117	64	129	112	177	10.10	0.644
2002	46	37	166	108	337	25.64	0.483
2003	237	87	150	142	175	5.16	0.646
2004	200	80	143	133	168	5.46	0.637
2005	95	66	198	148	310	24.75	0.630
2006	134	86	229	187	316	18.96	0.595
2007	162	91	225	195	289	12.05	0.533
2008	125	77	260	193	399	30.70	0.607
2009	142	76	205	163	293	20.50	0.639
2010	210	92	228	192	296	16.07	0.619
2011	149	75	174	155	222	8.81	0.535

Table 16: Population estimates for bottlenose dolphins in the Cardigan Bay SAC for the years 2001-2011, obtained using an open population model and considering the marked proportion of individuals

Year	Population estimate	Standard Error	Proportion of marked
2001	99	0	0.644
2002	77	0	0.483
2003	135	0	0.646
2004	126	0	0.637
2005	105	0	0.63
2006	145	0	0.595
2007	171	0	0.533
2008	127	0	0.607
2009	119	0	0.639
2010	152	0	0.619
2011	140	3.33E-05	0.535

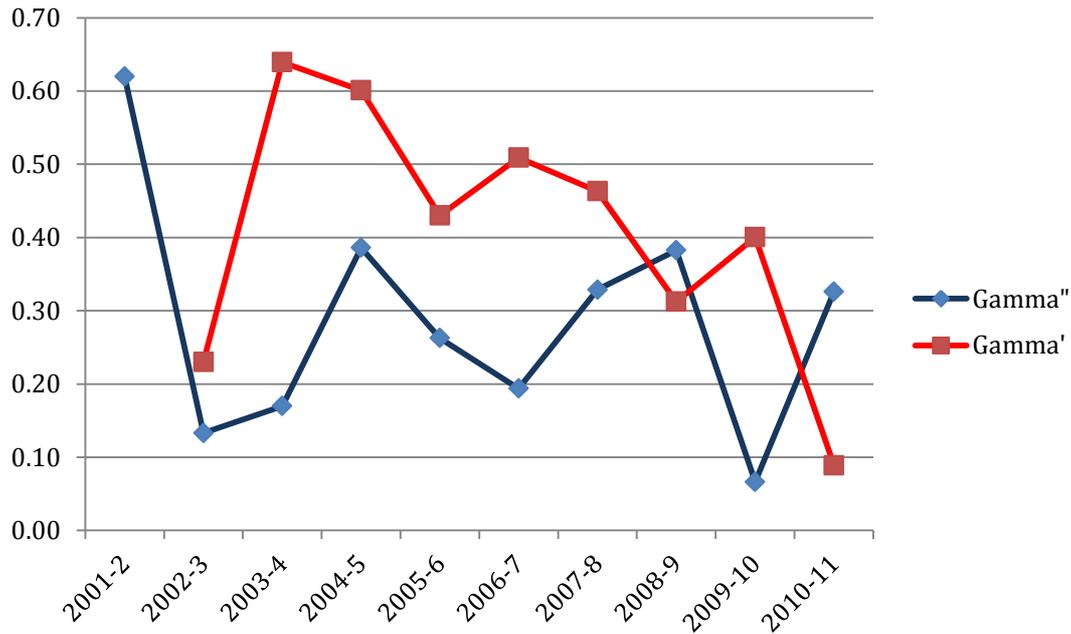


Figure 25: Bottlenose dolphin residency patterns in Cardigan Bay SAC using an open population model (gamma''-probability of an animal emigrating out of the study area; gamma' - probability of an animal staying out of the study area)

3.6 Home ranges

It is now well established that individually identifiable bottlenose dolphins from Cardigan Bay can be seen off North Wales and the Isle of Man (Pesante *et al.*, 2008a, b). Between 2007 and 2011, 57% of individuals within the SWF Photo ID catalogue have been identified in both Cardigan Bay SAC and north of the Llŷn Peninsula (32% of these were recorded within both SACs as well as off North Wales), showing that at least in some years, these individuals migrate outside of the SACs. Other individuals appear to have smaller, more localised home ranges with 17% of dolphins preferring a more northerly distribution recorded only from northern Cardigan Bay and north of the Llŷn Peninsula, and never within Cardigan Bay SAC. At the same time, 12% of individuals within the catalogue have been recorded only in Cardigan Bay SAC.

There is a strong seasonal migration northwards in winter months from Cardigan Bay to North Anglesey and beyond, where groups form that are much larger than those seen in Cardigan Bay. Analysis from Photo ID encounters off North Anglesey between the months of December to February shows that 94% of the dolphins identified had been recorded previously in Cardigan Bay (including 72% from Cardigan Bay SAC particularly). Just 5% of the animals matched were dolphins that had only been encountered off North Anglesey. However, encounters of animals in the summer months off North Anglesey have also been recorded there in winter suggesting that some may be more or less resident. Since 2008, four Photo ID encounters between the months of June and July have been recorded and analysed. The composition of those individuals was very different, with 39% of animals identified as previously recorded in Cardigan Bay (32% from Cardigan Bay SAC), leaving 61% of

individuals recorded only ever off North Anglesey. This suggests that there may be dolphins that never use Cardigan Bay. However, it is not clear why some individuals that have previously shown a strong fidelity to Cardigan Bay in summer, have also been identified in waters off North Wales at the same time of year.

3.7 Body condition

On the 13th October 2011, a group of 34 bottlenose dolphins was encountered during a survey in Tremadog Bay, within Pen Llŷn a'r Sarnau SAC. Of these, four animals were noticeably underweight with rib cages clearly showing (Figure 26). Two of these individuals are known mothers and currently have dependent calves of approximately one year of age. The sex of the other two individuals is unknown. One other underweight dolphin was noted in 2011 in Cardigan Bay SAC in the 27th October. However, the identity of this dolphin is unknown (Figure 27).



Figure 26: Underweight dolphins recorded during an encounter in Pen Llŷn a'r Sarnau SAC on the 13th October 2011



Figure 27: An underweight individual recorded off Cemaes Head in Cardigan Bay SAC on the 27th October 2011

4. DISCUSSION

4.1 *Line-transect surveys*

2011 was the first year that line-transect surveys for the whole of Cardigan Bay were conducted with the aim of calculating the first abundance estimates for the region for bottlenose dolphin and harbour porpoise. The overall Cardigan Bay abundance estimate for bottlenose dolphin was 296 with a CV of 28.82. This CV is slightly higher than hoped for, suggesting that the lower number of surveys and/or detections may have influenced the result. In order to confirm this figure, further surveys in following years should be performed. The abundance estimate for harbour porpoise was much higher than that for bottlenose dolphin, at 990 (CV 27.1). This supports previous evidence that harbour porpoises are more abundant and widespread over the area (Hammond, 2008; Pesante *et al.*, 2008b; Baines and Evans, 2009).

In Cardigan Bay SAC, the most recent abundance estimates calculated were for 2007 (Pesante *et al.*, 2008b). Since then, SWF has continued monitoring the bottlenose dolphin population but with fewer resources available, line-transect surveys were not possible. Generally, since 2003, estimates for bottlenose dolphin have shown a gradual increase until 2007, when the numbers were much lower (Ugarte *et al.*, 2006; Pesante *et al.*, 2008b). The reason for this low estimate was thought to be due to relatively low survey effort compared to previous years, and therefore fewer detections, with just 24 sightings. In 2011, there were also just 24 observations, and the abundance estimate calculated was similar to that of 2007 (N=114). However, we believe this to be a more reliable estimate, and the CV is significantly smaller than in 2007. Interestingly, despite reaching the same number of observations, the kilometres travelled in 2007 in Cardigan Bay SAC was more than double that which was achieved in 2011. This may suggest that numbers of the species within the SAC are indeed significantly higher now compared with 2007, which had been interpreted as a poor year. Despite this, overall, the bottlenose dolphin population appears to be lower than in previous

years. Whether this is a true representation or is due to lower effort in recent years remains unclear. The same is true for harbour porpoise, for which detections were particularly low within Cardigan Bay SAC in 2011. Again, it is not clear whether this is due to an actual decline of the species in the area or lower effort achieved. If the monitoring is to continue, it is strongly recommended that a decision is made early in the season (preferably by April), to allow line-transect surveys to be conducted throughout the entire field season, resulting in higher effort. This is particularly important given that weather conditions in recent years have been much better in early summer compared with late summer.

Unfortunately, there were insufficient observations of bottlenose dolphin or harbour porpoise within Pen Llŷn a'r Sarnau SAC to calculate local abundance estimates. Once again, if monitoring is to continue, surveys should be started early in the season to achieve the effort required to provide reliable estimates.

Despite the wider coverage achieved this year, no bottlenose dolphins were recorded outside of the SACs. Since line-transect surveys commenced later than recommended, it is not known whether the species is absent throughout the entire field season since surveys in outer Cardigan Bay only began in October. Aerial surveys conducted in 2007 confirmed that bottlenose dolphins are using the outer area of Cardigan Bay (Pesante *et al.*, 2008b), in the winter months at least.

Similarly, the first survey in Pen Llŷn a'r Sarnau SAC was not conducted until August so the distribution of bottlenose dolphins in northern and outer Cardigan Bay remains unclear for spring and early summer. It is thought that bottlenose dolphins are abundant in this area during the spring months, when many make their migration from the northern Irish Sea to southern Cardigan Bay (Pesante *et al.*, 2008a, b). More equal temporal coverage beginning in the spring months would provide a more accurate picture of the distribution of the species throughout the region.

The distribution of bottlenose dolphins was confined to inshore areas, which has tended to be the case in previous years, although there have been occasional sightings offshore (Ugarte *et al.*, 2006; Pesante *et al.*, 2008b). On the other hand, survey effort beyond the SACs has been minimal in the past.

By contrast, grey seal and harbour porpoise were evenly distributed in inshore and offshore waters. Harbour porpoise in particular was the dominant species recorded during surveys in outer Cardigan Bay.

4.2 *Ad libitum surveys*

Bottlenose dolphin distribution in Cardigan Bay SAC, combining all boat surveys, shows a relatively even distribution along the Ceredigion coastline, particularly between New Quay and Cardigan, although some sightings were recorded close to the boundaries of the SAC. All sightings of the species occurred in the inner half of the SAC. Grey seal and harbour porpoise

were also evenly distributed along the coastline, but with a few sightings recorded offshore, particularly of grey seal.

Previous studies have also shown that bottlenose dolphins exhibit a strong preference for inshore waters in Cardigan Bay SAC, whereas harbour porpoise and grey seals utilise more of the area (Baines *et al.*, 2002; Pesante *et al.*, 2008b).

There was a slight increase in group size towards the end of the season, which is most likely due to the arrival of herring shoals from September until October, which often attract aggregations of dolphins. In September, groups of ten or more with a number of calves including newborns, were seen regularly. There is evidence to suggest that mothers with young calves may sometimes join larger groups containing adults, possibly to gain advantages such as enhanced calf assistance and protection, and to promote calf learning (dos Santos and Lacerda, 1987; Bearzi, 1997), and this seems to have occurred regularly during the latter part of the 2011 season.

A comparison of group size before a Photo ID encounter and post encounter shows that the group count increases noticeably during the encounter. Although it is possible that the initial group counts, which need to be taken relatively quickly, could be under-estimations, the large difference between these counts strongly suggests that dolphins are attracted to the vessel during Photo ID.

4.3 *Activity budgets*

Behavioural budgets recorded in Cardigan Bay SAC since 2005 have confirmed that a high proportion of dolphins are feeding at the site, particularly in nearshore waters. Bottlenose dolphins in Cardigan Bay are thought to be feeding in this region mainly on bottom-dwelling fish and crustaceans (Evans *et al.*, 2000; Pesante *et al.*, 2008b), as well as taking some pelagic species. They are sighted most regularly in shallow waters of five to ten metres (Pesante *et al.*, 2008b). In the field, dolphins are regularly witnessed taking prolonged vertical dives where they are thought to be foraging close to or on the bottom. In addition, salmonids from the River Teifi, in the southern end of the SAC may be attracting dolphins early in the season (Baines *et al.*, 2000).

A comparison of activity budgets during line-transect surveys has shown major fluctuations between years in the proportion of encounters of dolphins engaged in feeding activities, with a relatively low proportion (22%) in 2011. This suggests that there may be 'good' and 'bad' food years in the SAC as prey availability fluctuates. There are core areas within the Bay where a high proportion of feeding occurs, at particular times during the summer (Beddia, 2007). Activity budgets during 2011 have been assessed from line-transect surveys. These have been evenly distributed both spatially and temporally (with the exception of early 2011), so there should be little bias in the proportion of time spent feeding.

During summer 2011, activity budgets in Cardigan Bay and Pen Llŷn a'r Sarnau SACs were similar, suggesting that the two sites are utilised by the dolphins in the same way.

Further monitoring of activity budgets in future years throughout Cardigan Bay should confirm whether fluctuations in the time spent feeding continue to occur, or if there is a true decline in prey availability at the site.

4.4 Reproductive & Mortality Rates

Cardigan Bay SAC is considered to be an important nursery area for bottlenose dolphins since mother-calf pairs including newborns have frequently been observed over the years. In 2011, 43% of groups encountered had one or more calves present, supporting the view that the site is used as a nursery ground. On average, ten newborn calves are recorded in the SAC each year. However, these numbers vary between years, ranging from four in 2009 to 14 in 2010. A higher number of births in particular years may be a result of a number of females becoming reproductively mature at the same time, creating a “baby boom”. This has been seen in other studies of bottlenose dolphin (Bearzi *et al.*, 1997; Haase and Schneider, 2001), and also in Atlantic spotted dolphins (*Stenella frontalis*) (Herzing, 2007).

Table 17: Crude birth rates from studies of bottlenose dolphins around the world

Location	Crude birth rate	Source
Eastern Australia	1.2	Lear & Bryden, 1980
North Adriatic, Croatia	4.9	Bearzi <i>et al.</i> , 1997
Cardigan Bay, Wales (closed)	5.2	This study
Sado Estuary, Portugal	5.4	Gaspar, 2003
Sarasota Bay, Florida	5.5	Wells & Scott, 1990
Moray Firth, Scotland	6.0	Wilson <i>et al.</i> , 1999
Doubtful Sound, New Zealand	6.6	Haase & Schneider, 2001
Southern California	7.2	Hansen, 1990
Northern Gulf of Mexico	7.7	Leatherwood, 1977
Cardigan Bay, Wales (open)	7.7	This study
Florida	8.2	Irvine <i>et al.</i> , 1981
Argentina, South Atlantic Coast	9.6	Würsig, 1978
Tampa Bay, Florida	9.7	Weigle, 1990

The mean birth rate is 5.24% considering a closed population model, and 7.73% using an open population model. The estimated mean birth rate of the other resident population of bottlenose dolphins in the UK, in the Moray Firth, is 6.0% (Table 17; Wilson *et al.*, 1999; Grellier, 2000; Thompson *et al.*, 2004), broadly similar to that in Cardigan Bay. According to

Wells and Scott (1990) the average birth rate for bottlenose dolphins in Sarasota, Florida is also approximately 5.5%, suggesting that reproduction in Cardigan Bay SAC is more or less average. The mean inter-birth interval in Cardigan Bay is currently estimated to be three years, also similar to other studies of the species (Table 18).

Calf mortality rates were 20% and 25% in the first and second year respectively, reducing to 10% by the third year. The first year mortality rate is comparable to that in Sarasota Bay (Wells and Scott, 1990) and Doubtful Sound, New Zealand (Haase and Schneider, 2001) (Table 19). The slight increase in mortality in the second year may reflect increased vulnerability with growing independence.

Table 18: Inter-birth intervals from studies of bottlenose dolphins around the world

Location	Mean (years)	Range (years)	Source
North Carolina, USA	2.9	2-7	Thayer, 2008
Doubtful Sound, New Zealand	3.0	2-5	Haase & Schneider, 2001
Natal, South Africa	3.0	2-6	Cockcroft & Ross, 1990
Cardigan Bay, Wales	3.0	2-5	This study
Moray Firth, Scotland	3.2	3-6	Mitcheson, 2008
Shark Bay, Australia	4.1	3-6	Connor <i>et al.</i> , 2000
Sarasota Bay, Florida	5.4	2-11	Wells & Scott, 1999

Table 19: Juvenile mortality rates from studies of bottlenose dolphins around the world

Location	First year	Second Year	Third Year	Source
North Carolina, USA	11%	-	-	Thayer, 2008
Indian & Banana rivers, Florida	11%	-	-	Hersh <i>et al.</i> , 1990
Sarasota Bay, Florida	19%	-	-	Wells & Scott, 1990
Cardigan Bay, Wales	20%	25%	10%	This study
Doubtful Sound, New Zealand	20%	-	-	Haase & Schneider, 2001
Natal, South Africa	22%	-	-	Cockcroft <i>et al.</i> , 1989
Shark Bay, Australia	29%	18%	3%	Mann <i>et al.</i> , 2000

4.5 Photo ID & Home Ranges

The Photo ID catalogue of bottlenose dolphins in the Irish Sea has grown extensively since it was first created, now reaching 513 images. It continues to grow with 27 new dolphins being added to the catalogue in 2011. Many of these new animals are juveniles that were previously unmarked. Due to the high numbers of calves in the region, it is expected that new animals will be added to the catalogue each year, as the juveniles acquire marks. In addition, there are new adult dolphins in the catalogue, suggesting that dolphins not encountered before are still being discovered. This is especially true for dolphins encountered off North Wales, particularly those spotted in summer months.

The population in Cardigan Bay SAC is a combination of residents, occasional visitors and transients. Residents make up 42% of the dolphins recorded in Cardigan Bay SAC, and many of these have been recorded regularly in the SAC for the duration of this long-term study. The proportion of the population thought to be resident to Cardigan Bay SAC has increased since 2007. From findings between 2001 and 2007, 31% of dolphins recorded in the Cardigan Bay SAC had been identified on more than nine occasions (Pesante *et al.*, 2008b).

Despite an increase in the number of residents in the Cardigan Bay SAC, overall population estimates suggest that 2011 was a poor year for bottlenose dolphins. Mark-recapture calculations using a closed model show a general decline in numbers since 2008. At 174 individuals, 2011 had the lowest estimate of individuals since 2004. Population estimates showed greater variation using an open population model. However, the 2011 estimate remains relatively low at 140 dolphins.

When considering the whole of Cardigan Bay, for which survey data exists only since 2005, estimates derived from a closed population model indicate a general increase until 2009, when a peak estimate of 295 animals was obtained. However, in 2009 and 2010, there was low survey effort in Pen Llŷn a'r Sarnau SAC due to lack of funds so the estimates should be viewed with caution. The population estimate declined from 291 individuals in 2008 to 209 in 2011. The open population model shows a decrease in numbers between 2007 and 2011. This is further supported by the gamma'' and gamma' rates, for which emigration and the probability that emigrated dolphins remain out of the area between years has increased to 35% and 42% respectively. This suggests that dolphins may be using Cardigan Bay less than in previous years. Further monitoring is needed to confirm whether or not there is a true decline in Cardigan Bay, or whether 2011 was specifically a poor year for sightings.

The combination of increased residency in Cardigan Bay SAC and overall lower population estimates may suggest that a core group of individuals continue to use Cardigan Bay SAC but that occasional visitors and transients are entering Cardigan Bay on fewer occasions, thus reducing overall numbers.

In 2007, SWF expanded survey coverage to include the waters off NE Anglesey, and since then have recorded significant numbers of bottlenose dolphins, particularly in winter. Many of the dolphins encountered in Cardigan Bay have now been identified off the Isle of Anglesey and also around the Isle of Man (Pesante *et al.*, 2008a, b). Encounters from around

Anglesey in winter months have revealed that 94% of the dolphins identified have been previously recorded in Cardigan Bay. However, sightings of the species off Anglesey have occurred increasingly also in summer, when in previous years it was a rare occurrence. Encounters have revealed that 39% of animals identified in summer had been recorded in Cardigan Bay. Many of these individuals have, in past years, shown a strong site fidelity to Cardigan Bay in the summer months. These findings further support the suggestion that fewer animals are using Cardigan Bay in recent years.

Reasons for this potential shift in site preference are not known. Prey abundance is likely to be a factor influencing movements of bottlenose dolphins. So if fewer dolphins are using Cardigan Bay, this could be a result of reduced prey availability in the Bay or alternatively, increased availability in the other parts of the Irish Sea, attracting the dolphins to other sites.

Anthropogenic disturbance may also have an influence on bottlenose dolphin movements. A localised study investigating the effects of boat traffic on bottlenose dolphins around New Quay Harbour was analysed for 2005 until 2010. This study showed that boat type and behaviour can have a significant effect on dolphin disturbance as well as the behaviour of the dolphins (Veneruso *et al.*, 2011). These findings should be considered when assessing anthropogenic disturbance by vessels throughout Cardigan Bay, and it is recommended that a Code of Conduct is in place and patrolled throughout the whole region (A Code of Conduct currently exists for the Ceredigion Heritage Coast and is patrolled by Ceredigion County Council).

A preliminary analysis of boat traffic throughout Cardigan Bay since 2006 has shown an increase in traffic, coinciding with a decrease in sightings at these same sites. Increased scallop dredging fishing activity may also have an effect on the dolphin's usage of Cardigan Bay but this cannot be determined one way or the other without further research, particularly in the offshore areas of Cardigan Bay.

4.6 Body condition

On the 13th October in the Pen Llŷn a'r Sarnau SAC, four underweight dolphins were recorded amongst a group of 34 animals with the rib cages clearly showing. It is unusual to see the rib cage of bottlenose dolphins from UK waters as they tend to have a much thicker blubber layer than dolphins from populations in warmer waters. It is particularly unusual to have this many underweight dolphins in one group. Two of these individuals are known mothers currently with suckling calves. Neither of them is a first time mother. The gender of the remaining two individuals is unknown, but both have been encountered on a number of occasions in recent years without calves. Although it is possible that a mother suckling her young may lose weight, this is not evident in other mothers recorded in Cardigan Bay in previous years. A further dolphin, recorded in Cardigan Bay SAC also in October, was found to be emancipated. These unusual observations may suggest that there is low prey availability in the region, or that disease or parasite burdens are affecting them. Neither of these possibilities can be confirmed at this stage, but if monitoring is to be continued in subsequent

years, it is recommended that all underweight dolphins encountered are noted, and to follow future sightings of the underweight individuals identified in 2011.

5. REVIEW OF OBJECTIVES AND CONCLUSIONS

In this section, the original list of objectives will be reviewed and conclusions reached from the current study, will be presented.

5.1 Record, document and report numbers of bottlenose dolphins in Cardigan Bay SAC and Pen Llŷn a'r Sarnau SAC, and more widely in Cardigan Bay in order to determine the total population using the SACs and Cardigan Bay.

Estimates of population size have been assessed using two different methods: line-transect surveys and Photo ID. Line-transect analysis estimates the average number of animals in the study area. Prior to 2011, numbers of animals in Cardigan Bay SAC were on the increase until 2007 when abundance estimates declined. It was not clear whether this was a true drop in numbers of dolphins, or a consequence of reduced effort. Unfortunately, funding ceased in 2008 and so line-transect surveys could not be continued, so the reason for this decrease in numbers could not be investigated further. In 2011, an estimated 114 dolphins were counted in Cardigan Bay SAC, a relatively low number once again. Since fewer surveys were conducted than recommended, due to the late confirmation of funding and bad weather, it is difficult to interpret this result with confidence. However, population estimates calculated using the mark-recapture method based on Photo ID results, also show low numbers for Cardigan Bay SAC in 2011, with estimates of 174 individuals (closed population model) and 140 individuals (open population model), despite increased levels of residency.

When considering the whole of Cardigan Bay, mark-recapture estimates also show a decline in 2011 to 209 (closed population model) and 157 individuals (open population model). The probability of dolphins leaving the site, and of remaining outside of the study area, has increased. A first abundance estimate, calculated from line-transect surveys, indicates 296 animals occupying the Bay.

A preliminary assessment of the bottlenose dolphin population suggests that although a core group of dolphins may remain faithful to Cardigan Bay SAC, fewer non-residents are currently using the site. It is recommended that monitoring is continued in order to assess whether this is a temporary situation or the start of a declining trend in Cardigan Bay.

5.2 Report on fine and broad-scale distribution patterns of bottlenose dolphins and the relative temporal use of different parts of this range.

The distribution of bottlenose dolphins seems to be largely confined to inshore areas throughout Cardigan Bay. Surveys conducted during 2011 in the offshore region of Cardigan Bay, outside of the SACs, found no bottlenose dolphins. There is evidence to suggest that increased feeding activity occurs in the nearshore zone, which is likely to be the reason that the great majority of sightings are recorded in these waters. However, since funding was not

granted until September, there were noticeable gaps in temporal coverage. Line-transect surveys commenced in July for Cardigan Bay SAC, in August for Pen Llŷn a'r Sarnau SAC and October for outer Cardigan Bay. At this stage we do not know whether the species is generally absent from outer Cardigan Bay throughout the entire field season. In addition, we are not clear about the distribution of animals within Pen Llŷn a'r Sarnau SAC in spring and early summer. If funding is granted in subsequent years, it is recommended that line-transect surveys should begin in spring at all sites with the aim to maintain even temporal coverage throughout the season. This would provide a clear picture of the distribution of the species over the whole region.

The overall distribution of the population may be changing, with increased summer activity in North Wales seen in recent years. In 2011, large groups of dolphins were recorded in that region several times during the summer months, and included individuals that have previously shown a strong site fidelity to Cardigan Bay at this time of year. It may be the case that prey availability has become greater off the waters off North Wales, and so dolphins do not make the journey into Cardigan Bay. Alternatively, there could be a prey shortage in Cardigan Bay, meaning that dolphins need to travel more widely, including outside of the study area, in order to find food. Interestingly, these observations mirror the mark-recapture results seen in 2011. Information on the abundance of key prey species in Cardigan Bay and other parts of the Irish Sea would be useful in order to investigate this possibility.

There is also an increasing number of dolphins that seem to only inhabit waters north of the Llŷn Peninsula. There is currently no targeted protection for bottlenose dolphins in the Northern Irish Sea, which is subject to a number of anthropogenic pressures that currently do not exist in Cardigan Bay. If this trend of increased bottlenose dolphin activity north of Cardigan Bay continues, it would be wise to consider implementing appropriate conservation management actions for the species in this area.

5.3 Document and report on the presence of calves and young juveniles in order to estimate the number of calves born annually by the population.

Reproductive rates have been investigated in Cardigan Bay SAC and confirm that the site is very important for calves and young juveniles. Relatively healthy birth rates (mean: 5.2% using a closed population model, and 7.7% using an open population model) have been recorded and are about average by comparison with other populations. Cardigan Bay SAC has seen fluctuations in birth rates between years. However, we do not think that this is cause for concern yet, as this has been noted in other populations of the species. Further monitoring of Pen Llŷn a'r Sarnau SAC and Outer Cardigan Bay is required to assess whether the Cardigan Bay SAC is specifically targeted by mothers with young calves, or if the whole region is an important area for reproduction.

5.4 Measure both juvenile and calf survival rates for the population on an annual basis by monitoring the proportion of animals still alive and recording known deaths.

Calf mortality rates calculated for Cardigan Bay SAC were 20% and 25% in the first and second year respectively, decreasing to 10% in the third year. The first year mortality rate

seems to be average compared to other populations of the species. There are fewer studies that show the mortality rate of calves in the second year, so our calculation cannot be easily compared. The second year sees a slight increase in mortality. It is not clear at this stage why this is the case. It is possible that increasing independence of calves in the second year may expose naïve individuals to more threats.

A total of 44.9% of calves survived into their fourth year. Bottlenose dolphin calves in Cardigan Bay tend to leave their mother by the fourth year. Unfortunately, once they leave the mother's side, they are no longer recognisable as individuals if they have not acquired any markings useful for Photo ID. For this reason, it is difficult to report on juvenile survival rates past the age of three to four years.

5.5 Record numbers of juveniles, female and male bottlenose dolphin adults, in order to report on population structure parameters (age and sex ratios) and site use, e.g. by family groups or bands.

At this stage, is it not possible to provide an accurate report on the sex and age ratios of this population. Animals can be positively sexed if the genital area of known individuals is seen or, in the case of females, if a dolphin is recorded with a calf on several occasions (we use a minimum of three as the criterion). Since there are many mother-calf pairs in the region, females can be identified more easily and for this reason there is likely to be under-representation of known males confirmed in the catalogue. Genetic sampling would allow us to sex individuals and also to identify family groups, as well as to establish whether genetic connectivity exists between individuals recorded at other sites within the region and with other populations. If this aspect is to be addressed, genetic sampling of this population (by skin biopsy) will be necessary, as has been conducted with the Irish & Scottish populations.

5.6 Identify the home range sizes of individual identifiable animals, including determination of ranging movements and core areas.

It is now clear that the home ranges of some dolphins that use Cardigan Bay extend to North Wales and the Isle of Man. Despite comparison with other Photo ID catalogues around the UK and Ireland, no individual matches have yet been found with those, suggesting that this population's range may be restricted to the Irish Sea.

Recent analysis shows that 57% of individuals in the SWF Photo ID catalogue have been recorded in both the Cardigan Bay SAC and in North Wales. However, 17% of dolphins in the catalogue have only been recorded in Pen Llŷn a'r Sarnau SAC or North Wales, suggesting that a proportion of individuals have smaller, more localised home ranges. This emphasises the need for further monitoring in northern areas of Cardigan Bay and North Wales as well as further south. Since coverage has been largely within the Cardigan Bay SAC, it is possible that there is a sub set of the population remaining in the north that is not being monitored effectively. Furthermore, an increasing number of summer encounters off North Wales, shows that 61% of individuals identified have only ever been recorded north of the Llŷn Peninsula.

5.7 *In order to investigate the nature of supporting habitats, e.g. estuary, headland or reef, record the number of bottlenose dolphin in each of the respective habitats and the location of each habitat within the site if necessary. Record all environmental and physical parameters at the time of recordings, e.g. tides, beach aspect, wind direction & speed, sea state, air temperature, and relevant biological information, e.g. aggregations of feeding birds or shoaling fish. The combination of information on habitat type and some of the above list will allow a preliminary assessment of habitat in the SACs. Results from this work will inform more targeted evaluation of both habitat and prey species.*

The geographical location of all bottlenose dolphin sightings was recorded by latitude and longitude. A number of environmental parameters were recorded during surveys including sea state, swell height and precipitation, and additional biological information was recorded if present. Supervision of two Masters students from the University of Bangor resulted in projects involving habitat modelling of bottlenose dolphin and harbour porpoise distributions in West Wales (see Appendix 1).

5.8 *Categorise bottlenose dolphin behavioural activities in the region (areas and proportion of time spent in resting, socialising, travel and feeding), and analyse yearly and seasonal behavioural patterns.*

Activity budgets of bottlenose dolphins were assessed from line-transect surveys from 2005 until 2011, confirming that a high proportion of dolphins are engaged in foraging at these sites, particularly those recorded close to the coast. However, a comparison of activity budgets between years in Cardigan Bay SAC shows major fluctuations in the proportion of animals feeding, suggesting that there are ‘good’ and ‘bad’ food years. 2011 recorded a relatively low proportion of animals feeding (22%). Further monitoring in future should show whether this decline is part of a normal fluctuation or represents a decline in prey availability. Other evidence (underweight dolphins, and an apparent decline in numbers using Cardigan Bay) suggests this may be the case.

Dolphins have very rarely been recorded resting, and the proportion of time spent socialising is relatively low, ranging from 4% to 16%. There appears to be a marked increase in social activity during encounters from line-transect surveys in 2011, compared to 2005, 2006 and 2007. Potential reasons for this are currently unknown, but may reflect the lower proportion of time spent feeding.

Activity budgets of Cardigan Bay SAC and Pen Llŷn a’r Sarnau SAC were similar, suggesting that the two sites may be used in the same way. However, coverage of the Pen Llŷn a’r Sarnau SAC is relatively low and it is recommended that further monitoring of this site is continued, to better assess habitat use by the species.

5.9 *Whilst conducting the above quantitatively record, document and report all observed incidents of:*

- *Anthropogenic activity at each site at time of survey;*
- *Evidence of any recent change in anthropogenic use of sites. This should be evaluated in light of any historical records, changes in use or otherwise;*
- *Bottlenose dolphin disturbance by anthropogenic or other factors, its cause and outcome;*
- *Bottlenose dolphin absence from historically used sites that can be attributed to an activity (human or otherwise) whether the activity is present or not at the time of observation.*

Boat traffic, including the number and type of surrounding boats was recorded at regular intervals during all surveys as part of the effort collection. A preliminary assessment of boat traffic in Cardigan Bay between 2006 and 2011 suggests an increase in traffic is occurring in locations where sightings have decreased most. We hope to investigate this further, and complete the analyses of this study in 2012. A localised study of New Quay Harbour suggests that when assessing the effects of boat traffic on bottlenose dolphins, boat type and behaviour and also dolphin behaviour should be considered.

2011 was the first year that survey coverage extended across much of Cardigan Bay, and even then, surveys were late to start. It is therefore not yet possible to assess whether anthropogenic disturbance in Cardigan Bay is having a significant impact on the population of bottlenose dolphins. No dolphins were recorded in Outer Cardigan Bay, an area that for the last few years has been subject to scallop dredging in winter months. Further surveying of this region is necessary to assess the potential effects of this fishing activity upon the species.

- *Entanglement of cetaceans in anthropogenic debris, e.g. fishing gear*

There were no observations by SWF of entanglement in anthropogenic debris in 2011. Commercial fishing is at a relatively low level in Cardigan Bay, with most of the industry focused upon potting. To our knowledge, there is relatively few net fisheries operating in the area.

- *Significant fresh injuries commensurate with propeller or boat collision*

There were no observations by SWF of fresh injuries suggestive of propeller or boat collision. However, one dolphin (035-03W), previously known since 2007 to have a significant injury thought to be due to a propeller cut, was observed in 2011. Despite the extent of the injury, the wound of which does not appear to have healed, this dolphin has been recorded consistently since 2007. In 2011, 035-03W was recorded in Cardigan Bay SAC in July, and off Anglesey in October, suggesting that this serious looking injury has not affected the mobility of this animal (Figure 28).



Figure 28: Bottlenose dolphin (035-03W) that received an injury, thought to be caused from a boat propeller.
Left photo – 2008; Right photo – 2011

- *Evidence of body condition/health, e.g. skin lesions*

Dolphins that appear underweight have been recorded throughout 2011, of which there were two encounters, both occurring in October. Four dolphins in a single group of 34 individuals in Pen Llŷn a'r Sarnau SAC were identified as underweight. It is highly unusual to see this many underweight dolphins in one encounter. Possible reasons for this could be a lack of available prey or disease/parasites. A record of underweight dolphins should be kept in future surveys, and the individuals identified as underweight in 2011 should be monitored.

Skin lesions were present on many individuals. In this first year of study, there has been no analysis of the presence and type of skin lesions.

5.10 To interpret past and current data, in order to provide a reasoned opinion on the status of bottlenose dolphins in the SACs and Cardigan Bay, and develop targets for monitoring. A recommendation of condition should be made but CCW reserves the right to accept or reject. All available data should be integrated at the appropriate level

In order to provide an opinion on the status of bottlenose dolphins in the SACs and Cardigan Bay, long-term monitoring with consistent effort and coverage is required. SWF has been running this study for 11 years in Cardigan Bay SAC. However, due to lack of resources, there are some years where there was little survey coverage and no overall abundance estimates could be calculated, thus providing some gaps in our knowledge. Despite this, abundance estimates of Cardigan Bay SAC suggest that the population was relatively stable or slightly increasing between 2001 and 2006. Estimates in 2007 and 2011 appear to show a decline in numbers (Figure 29). Since the volume of effort collected during these years was not consistent with those previous, these figures must be taken with caution. Due to the fact that there was no funding in 2008-10, and therefore line-transect studies could not be conducted, we cannot compare the 2011 estimates to recent years. In order to assess whether these estimates are a true reflection of the status of the population, consistent monitoring needs to be maintained. 2011 was the first year of line-transect surveys outside of Cardigan Bay SAC, and so it is not yet possible to assess the status of animals using the entire region.

Photo ID studies have been more consistent during the study period, and population estimates in fact show a similar trend compared with the line-transect abundance estimates (Figure 30). Overall, there appears to have been a slow but steady increase in population size until 2007/08. Recent years have suggested there are now fewer animals in both Cardigan Bay generally and within the Cardigan Bay SAC.

An assessment of Cardigan Bay SAC shows high levels of residency and a reasonably healthy birth rate. Despite this, overall, there seems to have been a recent decline in the size of the Cardigan Bay population. Due to the gaps in coverage in recent years, these results should be considered as preliminary, and only further monitoring will determine whether 2011 was simply a 'bad' year for dolphins, or whether this is a true reflection of the status of the population. Increasing evidence from surveys from North Wales suggests that animals may be showing an increasing preference for waters in the northern Irish Sea, and are using Cardigan Bay less.

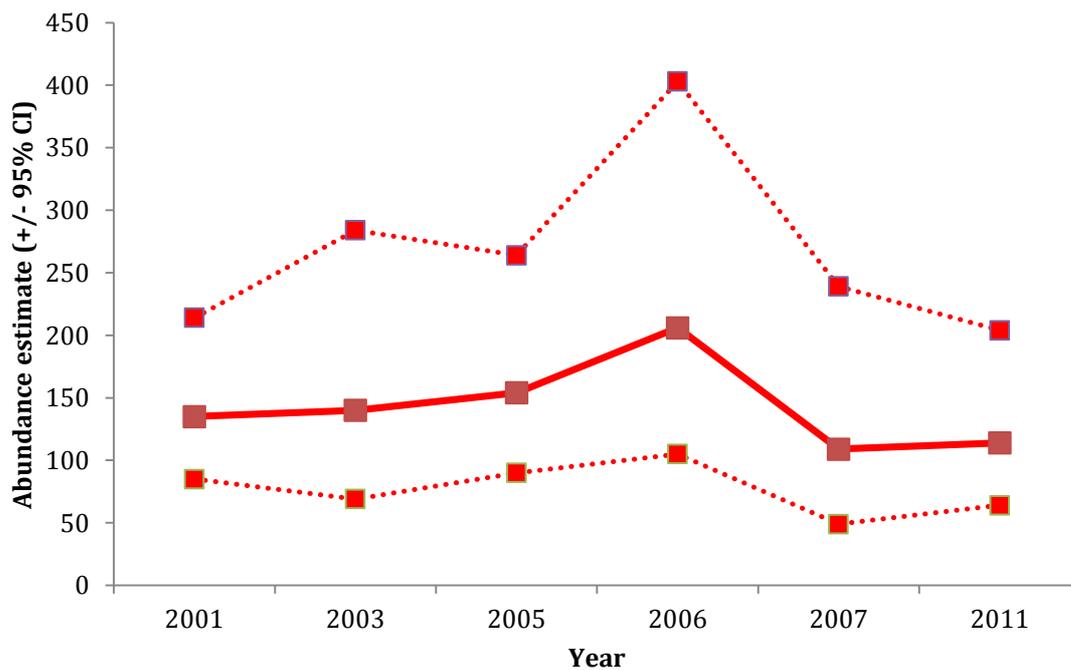


Figure 29: Trend in abundance estimates of bottlenose dolphins from line-transect surveys in Cardigan Bay SAC

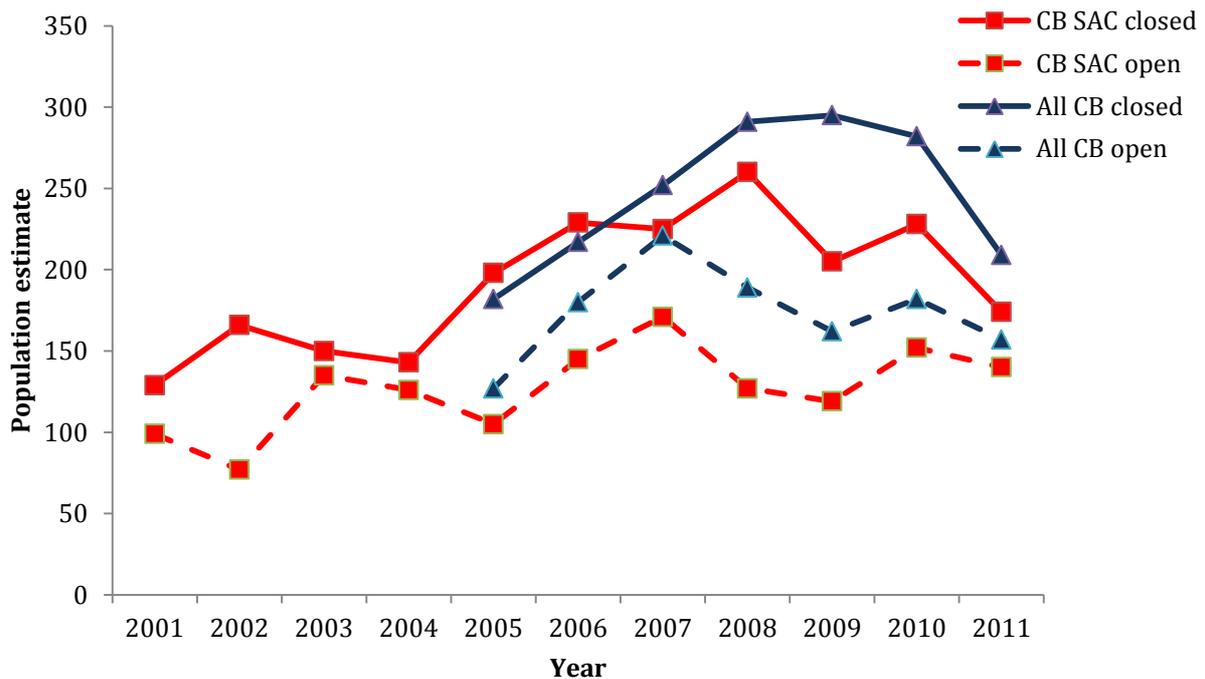


Figure 30: Trend in abundance estimates of bottlenose dolphins from line-transect surveys in Cardigan Bay SAC and all of Cardigan Bay

5.11 *Critically review the methodologies used and report on the best scientific and fieldwork practice for monitoring of bottlenose dolphins in Wales. To include a cost benefit analysis concentrating on abundance and life history parameters but covering all attributes listed in Section 1. Alternative sampling strategies should be explored*

A combination of methods has been used to monitor this population of bottlenose dolphins, and to maximise the information collected. These techniques have both advantages and disadvantages, but when combined are effective in assessing abundance and life history parameters.

Vessel-based line-transect surveys were conducted to calculate abundance estimates for bottlenose dolphin and harbour porpoise. These surveys allow systematic coverage of the site, allowing one to provide spatially unbiased population estimates for these species. One limitation of using the technique for bottlenose dolphins is that, in some cases, dolphins are thought to be positively attracted to the vessel. Therefore, there is a risk of over-estimation of abundance if animals are showing responsive movement by heading towards the track line in pursuit of the vessel. In order to overcome this bias, independent observers have focused upon detecting animals at a distance, and the methodology was changed slightly in 2011 to record an initial and final group count, of which only the initial count was used for line-transect analysis.

One further weakness is that in order to calculate abundance estimates with low CVs, a high volume of effort must be conducted. The Welsh weather conditions often leave fewer opportunities for surveys than recommended. Therefore, a full field season is necessary in

order to achieve the required volume of effort. For this reason, the recruitment of volunteers for the 2012 field season has been extended to include most of April and all of October, in the hope that funding for line-transects will allow SWF to begin line-transect surveys in spring. Line-transect surveys are the standard method for calculating abundance of harbour porpoise, and indeed are the only technique available to provide robust estimates for the species. The unusually low number of detections of porpoises in late summer 2011 generated relatively high CVs, but in previous years, when line-transect surveys have been conducted over the entire season, this technique has proved very successful.

Photo ID was another technique used in conjunction with line-transect surveys, in order to provide an independent assessment of abundance. Population estimates using Photo ID work well in small-ranging populations of this species. However, the migration of individuals to other areas can cause difficulties, and should be addressed if it becomes evident that more dolphins are staying out of Cardigan Bay. In addition to abundance estimates, life history parameters and home ranges can be assessed from the Photo ID data.

All dedicated surveys have also allowed regular recording of boat traffic, and the collection of behavioural and environmental data, making these trips very cost-effective by combining these methods within the same surveys.

For data collection related to sex ratios, genetic relatedness, connectivity between populations, and dietary preferences, skin and biopsy sampling will be necessary, as current methods are not suitable to collect this information.

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APPENDIX 1: STUDENT PROJECTS

MSc Thesis Abstracts

Coomber, F. (2011) *An investigation into the environmental determinants of harbour porpoise (*Phocoena phocoena*) distribution using an inter-annual predictive habitat model within West Welsh waters: with respect to SAC implementation*. MSc thesis, University of Bangor Wales. 54pp.

Marine mammals are highly mobile species with extensive geographical ranges, often cryptic and problematic to study. This presents inherent issues for their conservation and protection. Habitat niche models are being used progressively as a tool in the science of ecology and for conservation management, to infer a species' potential distribution and suitable habitat from the relationship between environmental variables and the species known distribution.

This project utilised an existing dataset of cetacean sightings in the Irish Sea, to identify areas of high sighting rates and suitable habitat for the harbour porpoise (HP: *Phocoena phocoena*) within West Welsh waters, taking into consideration any spatial and temporal variations that were identified. The findings may be used to suggest possible areas for HP protection in order to fulfil the Natura 2000 agreement. Quality control measures were applied to the raw data to generate a comparable homogeneous dataset of effort and associated sighting which, could be used as the response variables within a model. A range of environmental predictor variables were sourced with known implications on HP distribution. Both sets of data were entered into a habitat niche model to create predictions of suitable habitat, taking into account temporal variations.

It was found that throughout the entire survey area and temporal scale of the project that HP sighting rates were relatively uniform. However, the spatial distribution of HP within the survey area was not, with areas of high and low sighting rates. These areas coincided with the model predictions of suitable habitat probabilities. However, inter-annual variations in habitat predictions occurred, with some areas having continuous high probability between the years, whilst others varied dramatically. The important environmental variables found to be determining habitat suitability were Chlorophyll a, depth and tidal current. These determinants act as proxies for HP prey items and may work in unison to generate fine scale habitats that aggregate prey, improving HP foraging abilities. Areas found to be important, in respect to high sighting rates, continuous presence and habitat for the HP, were around the Llŷn Peninsula, Bardsey Island, Skoma Island, Cardigan and Newport. Much of this area is already protected by Special Areas of Conservation (SACs), except for the area around Newport estuary and it is therefore an ideal candidate for the implementation of a new SAC.

Meatcher, H. (2010) *Modelling inter-seasonal and inter-annual habitat use of bottlenose dolphin *Tursiops truncatus* (Montagu, 1821) in West Welsh waters*. MSc thesis, University of Bangor Wales. 75pp.

Marine mammals are highly mobile apex predators. Their life history is often cryptic and problematic to study. Costs of monitoring protected populations effectively are prohibitively high. The improvement in computer technology and the development of specialist tools for ecologists, has led to the proliferation in modelling species habitat from a limited amount of observations as a cost effective way to monitor conservation zones for their effectiveness.

Geographical Information Systems make the findings of the analyses accessible to stakeholders responsible for the conservation management. Modelling a species potential distribution is achieved by exploring the relationship between several environmental predictor variables and the species' known distribution in the form of field observations. Variables were chosen a priori for the model because of their known direct or indirect effect on dolphin ecology, based on literature reviews. A niche habitat was defined for each season and each year, to enable inter - and intra - annual comparisons of habitat use and preference, and to test the effectiveness of the two SACs in Cardigan Bay. A presence only model was selected for analysis of the sightings data.

It was found that dolphins used the same areas in the early summer months, which coincides with the period when most calves are born. A seasonal pattern was observed in the bearing of the slope aspect of the seabed they were sighted over indicating a persistent trend in their habitat use. Habitat maps showed that their niche habitat in Cardigan Bay is well protected by the existing management plan and conservation areas of the two SACs in Cardigan Bay. Analysis of the broader context of their range highlights a potential impact from boat noise and collision in the Irish Sea, excluding them from niche environments there. This could be addressed with modelling habitat within this context and validating the models with surveys.