Small Cetacean Site Survey Investigations 2008

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Small Cetacean Site
Survey Investigations 2008

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Cover image: Bottlenose dolphin in Donegal bay © Simon Berrow/NPWS

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Summary

A survey of small cetaceans was carried out at three sites (Carnsore Point, Blasket Islands cSAC and Donegal bay) to derive density and abundance estimates using distance sampling. Single platform line-transect surveys were carried out on three days at each between July and September 2008.

During nine days of surveys, a total of 121 track-lines were surveyed of a total distance of 622.80 km in sea-state ≤2. From the total of 63 sightings, 122 individual harbour porpoise (*Phocoena phocoena*) were recorded. There were also four sightings of single minke whales (*Balaenoptera acutoratrata*), two sightings of bottlenose dolphins (*Tursiops truncatus)* with a total of 26 individuals and one sighting of two common dolphins (*Delphinus delphis*).

Density estimates were calculated using the track-line as the sample and the sighting as the observation. Overall density estimates ranged from 0.58 porpoises per km^2 at Carnsore Point 0.88 porpoises per km^2 in Donegal bay but all estimates had a high CV. The density estimate in the Blasket Islands cSAC at 1.65 porpoises per km^2 was similar to that reported in 2007 (1.33). Mean group size varied from 1.76 to 2.40.

Harbour porpoise density estimates were compared to other similar surveys carried out in Irish waters during 2008 and 2007. The highest density estimates were from North County Dublin (2.03) and the Blasket Islands cSAC at 1.76 porpoises per km^2. The density estimate from Carnsore Point was the second lowest recorded during 2008 and also had a high CV due to the low overall number of sightings. This estimate should be treated with caution and this site is not recommended as a potential SAC. The density estimate in Donegal bay at 0.88 porpoises per km^2 was less than the reference value of 1.33 from the Blasket Islands and was influenced by the high relative group size.

Bottlenose dolphins were only recorded in Donegal bay and at no other site. Minke whales and common dolphins were only recorded in the Blasket Islands cSAC. No abundance estimates could be made for common dolphins or minke whales using distance sampling as there were too few sightings. No abundance estimates could be made using mark-recapture methodology as dolphins were only recorded on one visit, however there was evidence of long-distance movements by bottlenose dolphins between Donegal bay and other sites in Ireland. As this site had good densities of harbour porpoise and was the only site where both harbour porpoise and bottlenose dolphins were recorded we recommend it is designated as an SAC. Future surveys should seek to explore the use of the bay by bottlenose dolphins and determine whether is it is used regularly and attempt to collect enough photo-identification data to derive an abundance estimate.

For monitoring purposes monthly sampling should be carried out each year between April and October, in order to take advantage of good weather conditions and obtain a good dataset for creating density estimates with low CVs at each site. Twice monthly sampling may be necessary to obtain sufficient sightings to derive a robust density estimate using distance sampling. In order to determine seasonal variation in abundance we recommend single platform line-transect sighting surveys should be carried out in every month for at least one year at each site during the next reporting round of the EU Habitats Directive.

Introduction

EU member states are required to designate Special Areas of Conservation (SAC) for species listed under Annex II of the EU Habitats Directive. This includes harbour porpoise (*Phocoena phocoena*) and bottlenose dolphins (*Tursiops truncatus*). All species of cetacean in Irish waters are listed on Annex IV, which require strict protection, but not the designation of protected sites.

To date, the Blasket Islands and Roaringwater Bay have been designated as candidate Special Areas of Conservation (cSAC) for harbour porpoise and the Lower River Shannon cSAC for bottlenose dolphins. The NPWS seek information on a number of other sites to asses their potential to be designated as SACs. This survey compliments a similar survey of harbour porpoises being carried out at five sites around the coast during the same period (Berrow *et al.,* 2008) and a harbour porpoise survey of the Blasket Islands in 2007 (Berrow *et al*., 2007).

Small cetaceans are typically described as the small odonotocetes (dolphins and porpoises). Of the 24 species of cetacean recorded in Ireland, 11 species of small odontocetes have been recorded (Berrow, 2001). Of these long-finned pilot whale (*Gobiocephala melas*), Atlantic white-sided (*Lagenorhynchus acutus*), white-beaked (*L. albirostris*) and striped dolphin (*Stenella coeruleoalba*) tend to occur offshore and false killer whale (*Pseudorca crassidens*) and beluga (*Delphinapterus leucas*) are rare vagrants (Reid *et al.* 2003). Five species are frequently recorded inshore namely; harbour porpoise, bottlenose, common (*Delphinus delphis*), Risso's dolphin (*Grampus griseus*) and killer whale (*Orcinus orca*) (Reid *et al.* 2003). We have also included the minke whale (*Balaenoptera acutorostrata*) in our definition of a small cetacean, which although it is a mysticete, is relatively small and common in Irish coastal waters.

Objectives

The objectives of the present survey were to:

1. calculate the density of small cetaceans, primarily bottlenose dolphins and harbour porpoises, at three sites
2. assess the abundance of small cetaceans within these sites
3. make recommendations as to the suitability of each site as potential SACs

Methods

Survey sites

The survey sites are shown in Figure 1. Carnsore Point was the smallest site (151 km^2), while Donegal bay was the largest at 281 km^2. The boundaries of the Blasket Islands cSAC (Area 227 km^2) were the same as that surveyed in 2007 by Berrow *et al.* (2007).

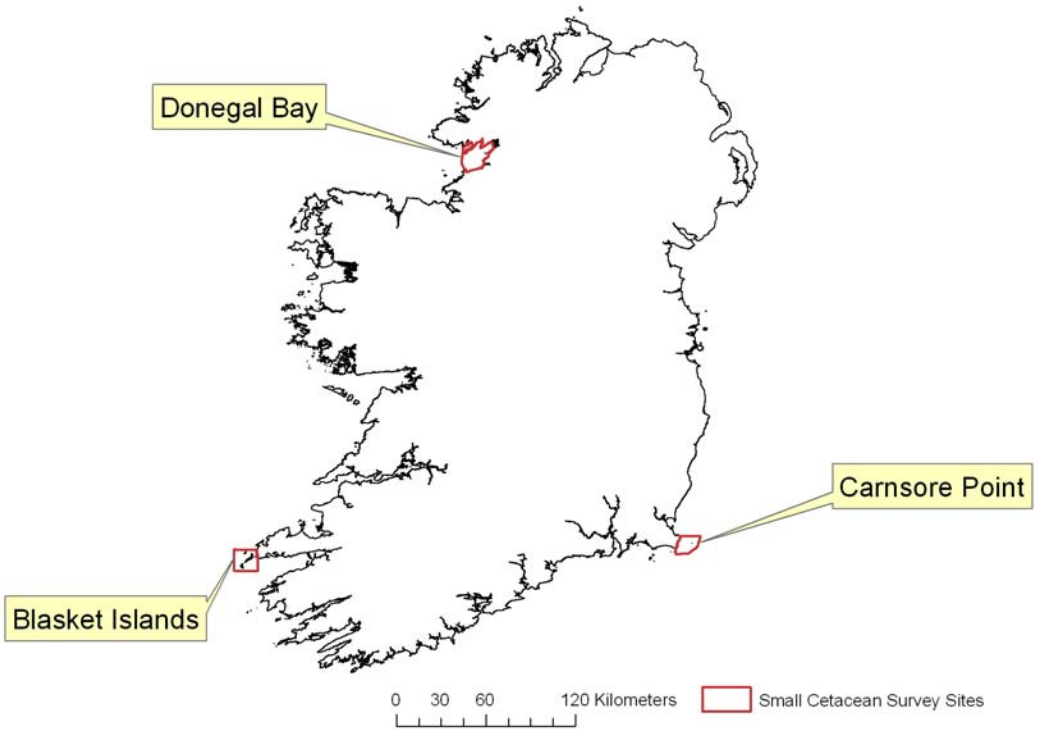

Figure 1. Map of Ireland showing location of sites surveyed for small cetaceans during 2008

Survey platforms

Four vessels were chartered during this survey (Table 1). MV Endevour was used for all surveys off Carnsore Point and MV Blasket Princess in the Blasket Islands cSAC. MV Smoothound had engine problems after the first visit to Donegal bay and MV Kiwi Girl was chartered out of Mullach mór, Co Sligo for the other two surveys at this site.

Table 1. List of vessels chartered during the Small Cetacean Site Investigations Survey 2008

Vessel	Port	Type	Length (m)	Platform height (m)
MV Blasket Princess	Ventry, Co Kerry	Passenger Ferry	13	3.5
MV Kiwi Girl	Mullach mór, Co Sligo	Kingfisher Fastcatch Sporthunter	10	2.8
MV Smoothhound	Donegal, Co Donegal	Vigalente	11	3.0
MV Endeavour	Kilmore Quay, Co Wexford	Safehaven Interceptor 38	12	3.0

Survey training

For this tender we proposed to establish a team of surveyors who could take advantage of suitable weather conditions at short notice. This strategy contributed to the successful completion of the survey (combined the Harbour Porpoise Survey 2008) as on two occasions, three teams surveyed three different sites simultaneously, while on two occasions two sites were surveyed on the same day. However, this use of multiple observers can increase the variability within a dataset through inter-observer error and variability in observer performance and was therefore a potential concern.

In order to address this issue a training weekend was organized from 6-8 June in Kilrush, Co Clare. All participants were introduced to the theory behind line-transect surveys and how the data will be handled and analysed. A survey of the Shannon estuary aboard two chartered vessels was carried out to gain experience of LOGGER software and how to estimate distance and angle to sightings. Trials on an observer's ability to detect small cetaceans were carried out on bottlenose dolphins from two land-sites sites (Kilcredaun point and Moneypoint) in the Shannon estuary. Two teams of six observers were sent to each site on two occasions. All observers were visually excluded from each other and asked to record the time of any sightings and an estimate of group size, therefore allowing for the assessment of variability between observers in time taken to record first sighting, estimation of distance to the observed animals, number of groups and group size.

To assist in estimating distance, two trials were carried out where observers were asked to estimate distances to a RIB on the estuary. The distance was then verified using a Leica Rangemaster 1200. This range finder reports an accuracy to within ±2m over 800m or ±0.5% over 600m. In trial 1 observers were given 10 distances to estimate between 50 and 1000m with no feedback between estimations as to the actual distance. The results show very accurate distance estimation up to 200m with a very small under-estimate of short distances (Figure 2a). At greater distances accuracy was less with a tendency to under-estimate the distance. In trial 2, ten more distances were estimated but observers were told the actual distance between each estimate, thus enabling them to improve on their subsequent estimation following this feedback (Figure 2b). We can see that observers improved their ability to estimate large distances when feedback was received, although there shorter distance estimates do seem to be a little less accurate. The model used for this survey was set to truncate beyond 200m, and therefore sightings beyond this were not used to generate density estimates. There would have been variability between observers, however overall errors were considered minimal. Thus, the team of observers used during the survey proved to be capable of accurately determining distances up to 200m. Thus observers during the Small Cetacean Site Investigations survey were able to determine distances up to around 200m with a very high degree of accuracy.

Figure 2a. Trial 1

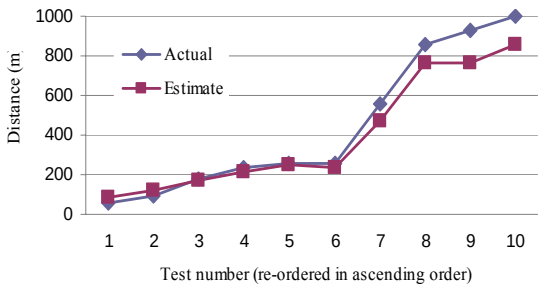

Figure 2b. Trial 2

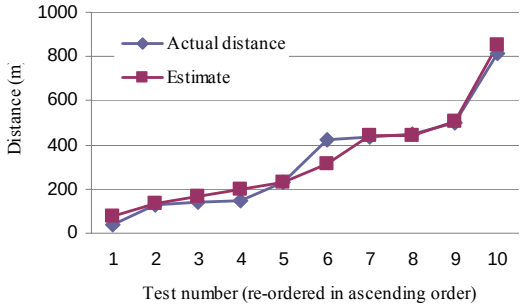

Figure 2. Mean distance estimates during blind trials with a. No feedback and b. With feedback

Another source of variability in these trials was group size. For these trials we used bottlenose dolphins as the target species and group sizes ranged from four to 19 individuals. Group sizes of harbour porpoises tend to be much smaller, typically 1-3 and very occasionally up to eight individuals. Thus observers should be able to determine harbour porpoise group size with a high degree of accuracy and we do not think this was a major source of variability for this species. Dolphin species typically encountered in Irish coastal waters include common and bottlenose dolphins. These species may occur in large numbers making accurate group size difficult to determine.

Survey methodology

Conventional single platform line-transect surveys were carried out within or in close proximity to the boundaries of survey sites along pre-determined routes. Transect lines were chosen to cross depth gradients and provide as close to equal coverage probability as possible following the recommendations of

Dawson *et al.* (2008) who suggested systematic line spacing resulted in better precision than randomized line spacing. The lines were changed for each survey to try and get full coverage of the cSAC over the study period to ensure no important concentrations were overlooked. Distance sampling was used to derive a density estimate and to calculate abundance estimates. During this survey we assumed g(0) was equal to one, i.e. that all the animals on the track-line were observed.

Each survey vessel traveled at a speed of 12-16 km hr^{-1} (7-9 knts), which was 2-3 times the typical average speed of the slowest of the target species as recommended by Dawson *et al.* (2008). Traveling too fast could result in fewer sightings as there will be less time for the animals to surface within viewing range. Two primary observers were positioned on the flying bridge, which provided an eye-height above sea-level of between 4-6m depending on the height of the platform (Table 1) and the observer. Primary observers watched with naked eye from dead ahead to 90º to port or starboard depending on which side of the vessel they were stationed. All sightings were recorded but sightings over 200m (300m if sea-state 0 predominated) from the track-line were not used in the distance model as these extreme values give little information and make it difficult to fit the detection function and estimate density. Calves/juveniles were defined as animals ≤ half the length of the accompanying animal (adult) and in very close proximity.

During each transect the position of the survey vessel was tracked continuously through a GPS receiver fed directly into a laptop while survey effort, including environmental conditions (sea-state, wind strength and direction, glare etc.) were recorded directly onto LOGGER software (©IFAW) every 15 minutes. When a sighting was made the position of the vessel was recorded immediately and the angle of the sighting from the track of the vessel and the angular distance of the sighting from the vessel recorded. These data were communicated to the recorder in the wheelhouse via a VHF radio. The angle was recorded to the nearest degree via an angle board attached to the vessel immediately in front of each observer. Accurate distance estimation is essential for distance sampling. During some surveys an orange buoy 225mm in diameter was towed 200m astern of the observers' position on the survey vessel. This provided a reference point against which to estimate distances.

Abundance estimate

The abundance of harbour porpoises and other species excluding bottlenose and possibly Risso's dolphins was to be determined through distance sampling. The abundance of species which carry marks that can be used to facilitate individual recognition can be determined through photo-identification and mark-recapture analysis (see Photo-identification).

The software programme DISTANCE (Version 5, University of St Andrews, Scotland) was used for calculating the density of animals on the track of the vessel (g(0)) and thus deriving abundance estimates. This software allows the user to select a number of models in order to identify the most appropriate for the data. It also allows truncation of outliers when estimating variance in group size and testing for evasive movement prior to detection.

Berrow *et al.* (2007) showed that using the track-line as the sample with sightings used as observations reduced the variance around the mean without changing the density estimate. This was due to the sample size being much greater than if the day was used as the sample. This method of analysis was used throughout.

Under the NPWS contract all sightings in sea-state 2 or less were to be used in the analysis. All sightings in sea-state 3 are listed in the site summary tables but were excluded from the DISTANCE analysis. Estimates of abundance are presented for each survey day providing there were sufficient sightings to generate an estimate. The overall abundance estimate was derived from all track-lines in sea-state 2 or less from all days combined. We have assumed that there were no major changes in distribution within each site between sample days or any immigration or emigration into or out of the site.

We fitted the data to a number of models. We found that a Half-Normal model with Hermite Polynomial series adjustments best fitted the data according to Akaike's Information Criterion. The recorded data were grouped into equal distance intervals of 0-20, 20-40 up to 180-200. Cluster size was analysed used size-

bias regression method with log(n) of cluster size against estimated g(x). The variance was estimated empirically.

Maps were created using Irish Grid (TM65_Irish Grid) with ArcView 3.2; the map of the SAC was obtained from National Parks ands Wildlife Service. Data used in the creation of the maps of transects, effort, abundance and density estimates were stored in a single MS Access database, which was queried from within the GIS to produce maps.

Photo-identification

The use of photo-identification for estimatimg the abundance of coastal populations of cetaceans is becoming more widespread (Evans and Hammond, 2004). This approach can provide accurate estimates with a measure of precision. Bottlenose dolphins lend themselves to this technique as they often have unique and permanate marks that can be easily photographed. Photo-identification of bottlenose dolphins has been used extensively in the Shannon estuary (Ingram, 2000; Englund *et al.,* 2007) and elsehere in Irish coastal waters (Ingram *et al.,* 2001; O'Brien *et al.,* submitted). Photo-identification is the preferred method of monitoring coastal populations of bottlenose dolphins in Ireland (NPWS *pers. comm.*).

Images of bottlenose dolphins are examined for photographic quality and the severity of marks and lesions on individual dolphins (see Ingram (2000) for detailed methodology). Only individuals with permenate marks (Grade 1) are used for mark-recapture abundance estimates to minimise the possibility of false negatives (i.e. not recapturing a marked animal).

During this survey high quality digital cameras with f2.8 70-200 mm lense (including x2 converters) were carried on all surveys. At least two such cameras were available on each survey. If bottlenose dolphins were encountered the track-line was broken and the dolphins were photographed until we obtained images of all individuals present in the group or dolphins were showing signs of disturbance by the presence of the vessel. We conformed to the Marine Notice 15 of 2005 whenever possible. Other species such as common dolphin and minke whale were photographed opportunistically but the track-line was not broken as these species do not lend themselves to obtaining abundance estimates through photo-identification and mark-recpature analysis.

Results

Results are presented under each site with a summary table presented in the Discussion. All sightings recorded on-effort during each survey are shown in the summary table but only those sightings made in sea-state 2 or less were used in the DISTANCE analysis. All density estimates have used the track-line as the sample and sighting as the observation.

Harbour porpoise

Carnsore Point

Three surveys were carried out in Carnsore Point (Table 2). Only harbour porpoises were observed within this site. On 21 July sea-state 2 or less was recorded during 77% of the survey, resulting in seven sightings. On 22 August although sea-state 2 or less was recorded on 95% of the survey nearly one-half was in sea-state 2 and only two sightings were recorded. On the last day (13 September) sea-state was mainly 2 but sea-state 3 accounted for 32% of the survey time. Only four sightings were made.

An important constraint at this site was the strong tides. Not only were we trying to identify days with low wind speed for surveying but also trying to limit surveys to periods of neap tides. This was not always possible and with an average survey duration on around 5-6 hours there will always be a period of strong tides during the survey causing high sea-states especially on the shallow sand banks to the northwest of the study site.

Table 2. Date, sea-state and number of sightings of harbour porpoises within Carnsore Point during 2008

Sample	Date	No. of track lines	Total distance (km)	Sea-state (% of total survey time)				Number of sightings	Total Animals
				0	1	2	3		
1	21 July	8	45.08	8.2	56.3	12.4	23.1	7	14
2	22 August	16	86.17	0	47.3	48.1	4.6	2	2
3	13 September	9	54.35	0	0	68.4	31.6	4	7
Total		**33**	**183.59**					**13**	**23**

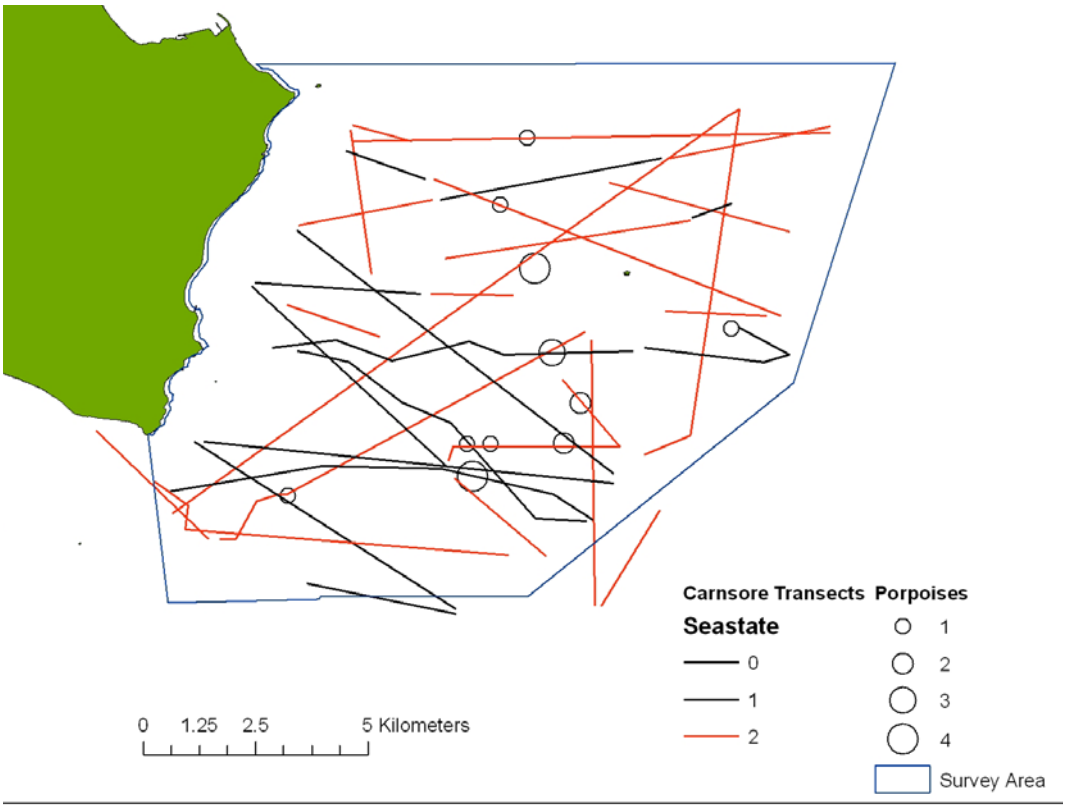

Figure 4. Map showing location of all track lines surveyed and harbour porpoise observed

The track-lines and sightings are shown in Figure 4. The distribution of effort in sea-state 0 and 1 (black lines) is concentrated to the southern half of the study site. Harbour porpoise were distributed throughout the study area concentrations to the south-east of the site.

The detection function is shown in Figure 5. The function is a poor fit (P=0.64) reflecting the very low number of sightings. The proportion of the variability accounted for by the encounter rate was 49.3%, with 28.3% attributed to detection probability and 22.4% due to group size. These figures again reflect the small number of sightings and this density estimate should be treated with caution.

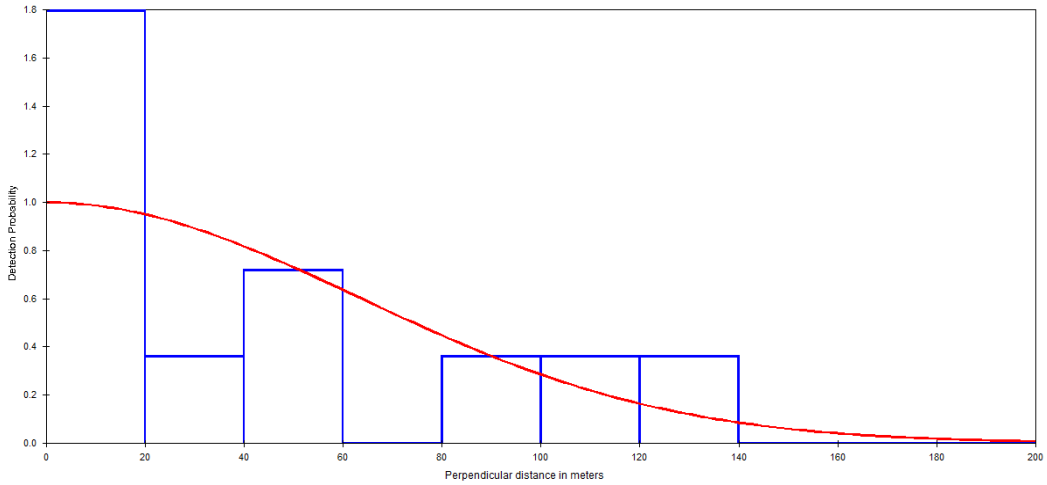

Figure 5. Detection Function for harbor porpoises in Carnsore Point (X^2 = 6.1, 8df, p=0.64)

Density estimates for Carnsore Point are shown in Table 3. No estimate was possible for the second or third survey days, due to low number (≤4) of sightings. The only density estimates from a single day was 1.77 harbour porpoise per km^2 on 21 July based on seven sightings of a total of 14 individuals and had a large CV and SE. The sightings on all track-lines ≤2 during all survey days were used in the overall estimate of 0.58 harbour porpoises per km^2. Mean group size was around 2 animals. This resulted in an abundance estimate of 87±36.3 (95% CI: 39-196).

Table 3: Mean density and abundance of harbour porpoise per track line per day in Carnsore point

Sample Day	N (95% CI)	SE	CV	Density (per km^2)	Group size Mean (95% CI)
1	267 (91-784)	146.1	0.55	1.77	2.00 (1.18-3.39)
2	-	-	-	-	-
3	-	-	-	-	-
Overall	**87 (39-196)**	**36.3**	**0.42**	**0.58**	**1.91 (1.25-2.92)**

Blasket Islands cSAC

Three surveys were carried out within the Blasket Islands cSAC with three species (harbour porpoise, common dolphin and minke whale) recorded. Track-lines were repeated during each survey day to explore the variability between days, unlike Berrow *et al.* (2007) who changed the track-lines during each visit to the Blasket Islands cSAC. Harbour porpoise are distributed throughout the site (Berrow *et al.*, 2007) and the track-lines used sample the site with equal probability. We hoped this modification would help inform a monitoring protocol.

All three surveys were carried out in sea-states mainly 2 or less with the final survey on 25 September conducted in sea-state ≤1 for 92% of the survey (Table 3). This resulted in 19 harbour porpoise sightings of a total of 37 individuals, which was higher than any day surveyed in 2007 by Berrow *et al*. (2007).

Table 4. Date, sea-state and number of sightings of Harbor porpoises within the Blasket Island cSAC during 2008

Sample	Date	No. of track lines	Total distance (km)	Sea-state (% of total survey time)				Number of sightings	Total Animals
				0	1	2	3		
1	24 July	13	53.63	0	9.8	74.8	15.4	7	7
2	22 August	24	70.59	1.3	30.5	60.2	8	5	13
3	25 September	17	84.03	56.5	35.2	8.3	0	19	37
Total		**54**	**208.26**					**31**	**57**

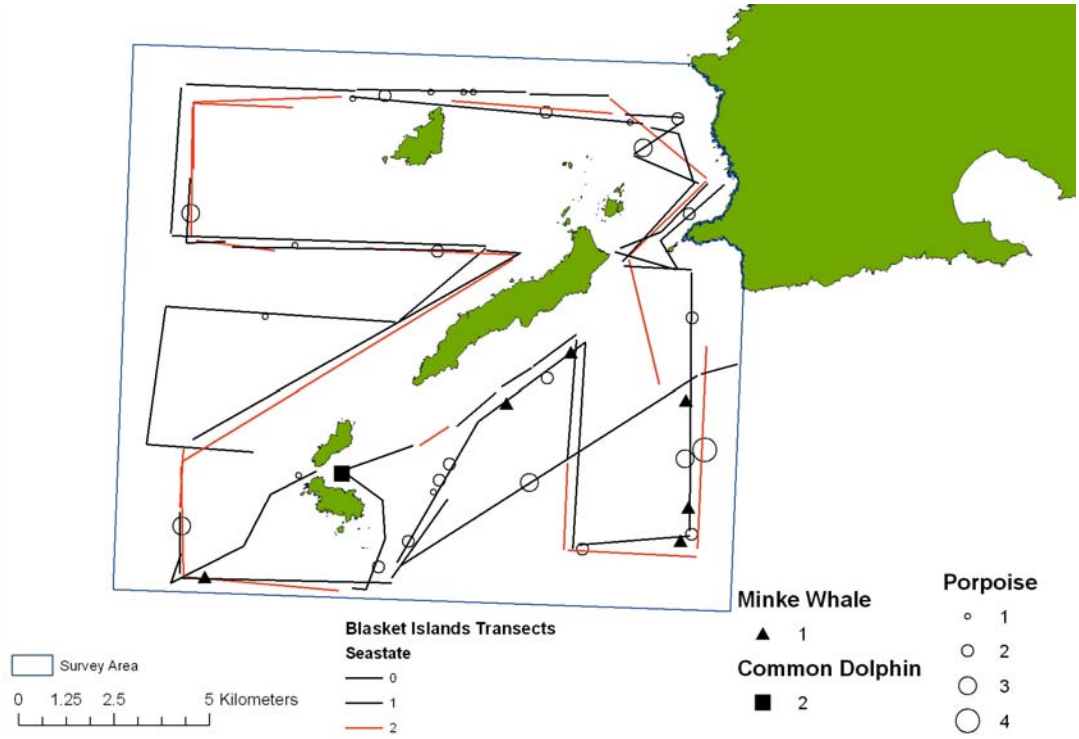

Figure 6. Map showing location of all track lines surveyed and small cetaceans observed

The track-lines and position of each sighting are shown in Figure 6. Effort in sea-state 0 and 1 was distributed throughout the site though generally there was more effort in sea-state 2 (red lines). There were concentrations of harbour porpoises on the south side of Great Blasket and to a lesser extent in Blasket Sound (Figure 6).

For the distance analysis data from the first two days (13 and 28 July) were omitted as the sea-state was high and the number of sightings low (3 on each day). Thus a total of 54 track-lines and 50 sightings were used in the analysis. The detection function is shown in Figure 7 which indicates evasive movement with a peak in sightings 40-60m and 80-100 from the track-line. The fit is not significant (P=0.50) and thus estimates should be treated with caution. The proportion of the variability encounter for by the encounter rate was 68%, with 23.7% attributed to detection probability and 8.4% due to group size.

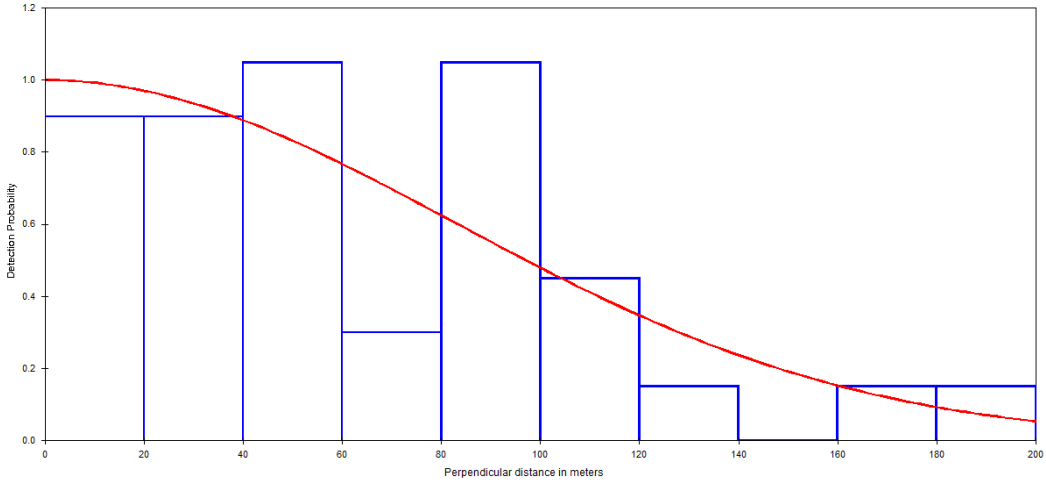

Figure 7. Detection Function for harbor porpoises in Blasket Islands cSAC (X^2 = 7.33, 8df, p=0.502)

The density estimates for each sample day are shown in Table 5. There was a large range in parameters and estimates reflecting the large differences in the number of sightings between survey days. Density estimates ranged from 0.38 to 2.67 per km^2 which gave abundance estimates of between 86 and 605 harbour porpoises. The mean group size also ranged greatly from 1.00 to 2.29. The overall density estimate was 1.65 per km^2 which gave an abundance of 372±105 (95% CI 216-647) with a surprisingly low CV (0.28).

Table 5. Mean density and abundance of harbour porpoise per track line per day in Blasket Islands cSAC

Sample Day	N (95% CI)	SE	CV	Density (per km^2)	Group size Mean (95% CI)
1	86 (22-329)	60.0	0.70	0.38	1.00 (1.00-1.00)
2	221 (75-654)	126.5	0.57	0.97	2.29 (1.56-3.35)
3	605 (216-1254)	222.5	0.36	2.67	1.77 (1.47-2.14)
Overall	**372 (216-647)**	**105.3**	**0.28**	**1.65**	**1.76 (1.50-2.07)**

Donegal bay

Three surveys were carried out in Donegal bay (Table 4). Harbour porpoises and bottlenose dolphins were recorded in this site. Two surveys were carried out in sea-state ≤1 for the majority of the survey but on 23 July only 4 sightings of harbour porpoises were made. This coincided with two sightings of bottlenose dolphins on the same day. On the third survey day the highest number of sightings of harbour porpoise and total number of individuals counted were recorded but no bottlenose dolphins.

It is widely recognized that bottlenose dolphins may attack and kill harbour porpoises (Ross and Wilson, 1996) and therefore a degree of exclusion of harbour porpoises from Donegal bay may have occurred when bottlenose dolphins were present. Recent photo-identification work shows bottlenose dolphins recorded in Donegal bay have also been recorded in Co Antrim, Co Galway and Co Cork which suggests they are transient and enter Donegal bay for short periods.

Table 6. Date, sea-state and number of sightings of Harbor porpoises within the Donegal bay during 2008

Sample	Date	No. of track lines	Total distance (km)	Sea-state (% of total survey time)				Number of sightings	Total Animals
				0	1	2	3		
1	23 July	13	104.39	87.3	12.7	0	0	4	6
2	30 August	13	63.29	7	32.8	51.9	8.3	6	10
3	23 September	8	63.27	60.1	35.1	4.8	0	9	26
Total		**34**	**230.95**					**19**	**42**

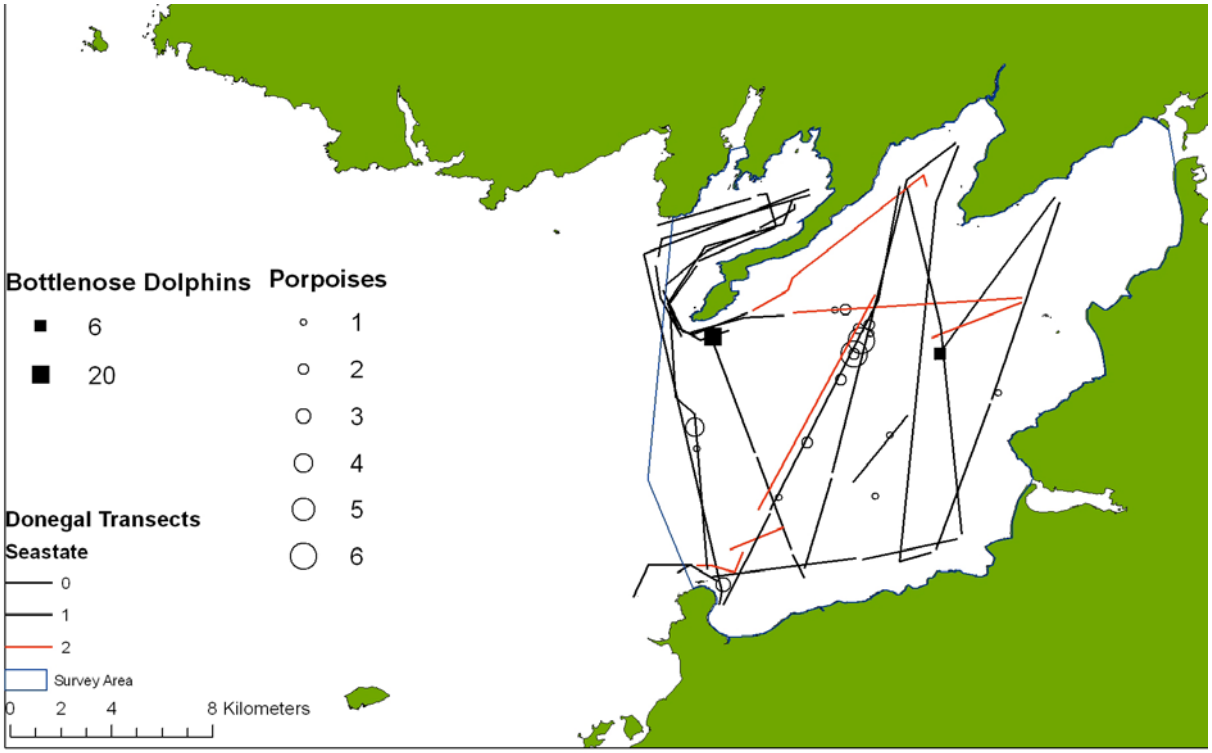

Figure 8. Map showing location of all track lines surveyed and all small cetaceans observed

The track-lines and sightings are shown in Figure 8. Sea-state ≤1 was distributed throughout the site but most harbour porpoise sightings were concentrated in the centre of the bay (Figure 8).

The detection function is shown in Figure 9 and is a poor fit (P=0.66). There was evidence of considerable evasive movement, with a peak of sightings at 60-80m from the track-line. The proportion of the variability accounted for by the encounter rate was 59.6%, with 23.8% attributed to detection probability and 16.7% due to group size. The variability attributed to the encounter rate was relatively low with a higher proportion attributed to group sizes, reflecting the large range in group sizes recorded. However the dataset for this site is small and a few sightings of large groups (up to eight individuals) may have had a big influence on the detection function if large group sizes were detected away from the track-line.

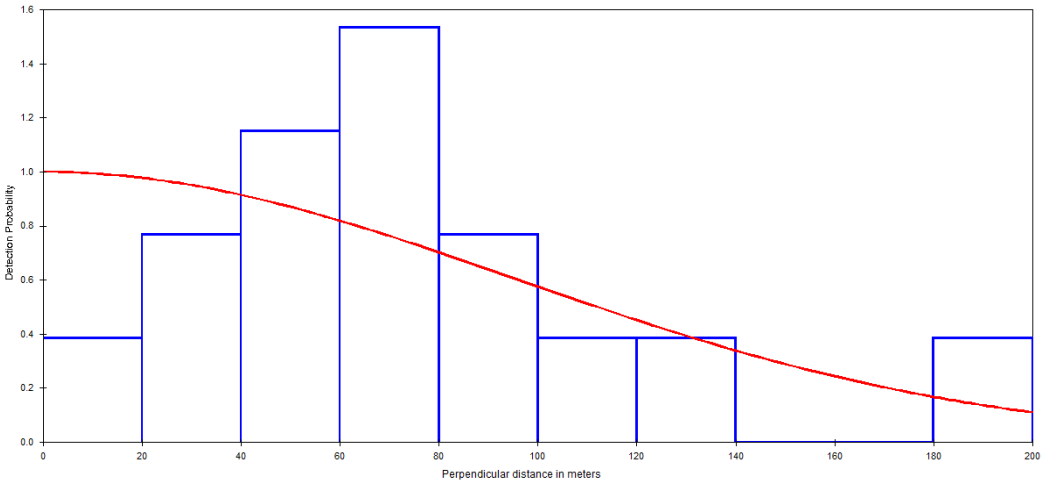

Figure 9. Detection function for harbour porpoise in Donegal bay (X^2 = 5.92, 8df, p=0.66)

The density estimates are shown in Table 7. There were too few sightings in sea-state 2 or less on day 2 to derive an abundance estimate and the CV for estimates on day 1 and day 3 were very high suggesting these estimates should be treated with caution. Mean group size was high on day 3 compared to day 1 which will have elevated the density estimate. The overall estimate was 0.88 giving an abundance of 249±111.5 with 95% Confidence Intervals of 106-586.

Table 7: Mean density and abundance of harbour porpoise per track line per day

Sample Day	N (95% CI)	SE	CV	Density (per km^2)	Group size Mean (95% CI)
1	34 (5-220)	32.5	0.95	0.12	1.67 (1.00-3.53)
2	-	-	-	-	-
3	772 (211-281)	514.9	0.67	2.75	2.89 (1.72-4.84)
Overall	**249 (106-586)**	**111.5**	**0.45**	**0.88**	**2.40 (1.63-3.53)**

Proportion of adults to young

An important criteria for consideration of a site as a potential SAC is a "*high ratio of young to adults during certain periods of the year*". There are no guidelines as to what is considered "high". The surveys were carried out during the estimated time of peak calving (excluding June). We have calculated the proportion of adult to young (combining records of those animals described as juveniles or calves) porpoises for each site (Table 8).

Young porpoises were recorded at all sites. The proportion of calves in Donegal bay was smaller (8%) than the other two sites which recorded 14% and 18% young. The total number of sightings in Carnsore Point was very low so this figure should be treated with caution. Similarly the very high figure from the Blasket Islands cSAC should also be treated with caution as this was strongly influenced by data from one day. Berrow *et al.* (2007) reported only 2% young during a similar survey at this site in 2007.

Table 8. Proportion of adult to young for all sites

Site and date of survey	No. of sightings	No. of animals	No. of adults	No. of juveniles	No. of calves	% young
Carnsore Point	12	22	19	3	0	14
Blasket Islands	30	55	45	0	10	18
Donegal bay	18	40	37	0	3	8

Bottlenose dolphin

Bottlenose dolphins were only recorded at one site (Donegal bay) and on one survey day (23 July 2008) (Table 9). Two groups were observed but the second group could not be approached for photo-identification.

Table 9. Sightings of bottlenose dolphin, recorded during the Small Cetacean Site Investigations Survey 2008

Site	Date	Species	Number of individuals	Location		Behaviour
				Latitude	Longitude	
Donegal Bay	23 July	BND	20	54.56124	-8.450987	Bow Riding
Donegal Bay	23 July	BND	6	54.55597	-8.310414	Leap/Splashing

Around 200 images were taken of the first group which included three calves. From these 10 individual dolphins could be recognized (see Appendix I for individual dolphins). Photographs were graded as per Englund *et al.* (2007). Images were only obtained from the left side of the dorsal fin but 70% of images were of good quality. No images were taken of the second group of 6 individuals as they were observed from a distance and were traveling fast.

Table 10. Quality of marks and lesions of bottlenose dolphins from Donegal bay on 23 July 2008

Photo Grade	L	R	Marks Grade	L	R	Total
1	7	0	1	7	0	7
2	3	0	2	3	0	3
3	0	0	3	0	0	0
Total	**10**	**0**		**10**	**0**	

Marks Grade 1: significant fin damage or deep scarring that were considered permanent
Marks Grade 2: deep tooth rakes and lesions
Marks Grade 3: superficial rakes and lesions

There were not enough data to derive an abundance estimate using mark-recapture analysis. Two dolphins identified on 23 July 2008 (DB04 and DB07) were matched to a group photographed in Galway bay on 26

March 2007, a distance of 300km and a gap of 483 days (see O'Brien *et al.* submitted). Five of the dolphins identified on 23 July were matched to a survey day funded by the IWDG in Donegal bay on 15 August 2008.

Common dolphin

Common dolphins (*Delphins delphis*) were observed on one occasion in the Blasket Islands cSAC on 22 August (Table 11). There were too few sightings to derive an abundance estimate.

Table 11. Sightings of common dolphin, recorded during the Small Cetacean Site Investigation Survey 2008

Site	Date	Species	Number of individuals	Location		Behaviour
				Latitude	Longitude	
Blasket Islands	22 August	CD	2	52.05091	-10.60614	Fast Swim

Minke whale

Single minke whales (*Balaenoptera acutorostrata*) were observed on four occasions, all in the Blasket Islands cSAC (Table 12). There were too few sightings to derive an abundance estimate.

Table 12. Sightings of minke whale recorded during the Small Cetacean Site Investigation Survey 2008

Site	Date	Species	Number of individuals	Location		Behaviour
				Latitude	Longitude	
Blasket Islands	22 August	MW	1	52.02532	-10.65698	Slow Swim
Blasket Islands	25 September	MW	1	52.07095	-10.47603	Slow Swim
Blasket Islands	25 September	MW	1	52.04575	-10.47384	Feeding
Blasket Islands	25 September	MW	1	52.08122	-10.52052	Slow Swim

Discussion

Statistical inference using distance sampling rests on the validity of several assumptions (Buckland *et al.,* 2001). These include that objects are spatially distributed according to some stochastic process. If transect lines are randomly placed within the study area we can safely assume that objects are uniformly distributed with respect to the perpendicular distance from the line in any given direction. Another assumption is that objects on the track-line are always detected (g(0)=1) and are detected at their initial location prior to any movement in response to the observer. Finally, if objects on or near to the track-line are missed the density estimate will be biased low. To minimise the effect of movement it is recommended that the speed of the observer is at least twice the speed of the object and if this is the case then movement of the object causes few problems in line transect sampling (Buckland *et al.,* 2001).

Typically for surveys of harbour porpoise g(0)= 0.4 or 0.5, i.e. only one-half of the animals on the track-line are detected. If this was the case with the present survey then we could double the density estimates. Without a double-platform methodology it is not possible to accurately determine the numbers missed on the track-line. The detection functions for most sites also suggest there was evasive movement from the

boat. These factors will reduce the density estimates. However these sources of variability were constant throughout the present survey and methods were consistent with the methods used by Berrow *et al.* (2007; 2008), which allows direct comparison of the data between surveys and within each survey.

The ability to detect small cetaceans visually at sea and thus the accuracy of density and abundance estimates is extremely dependent on sea-state. During the present study, transects were carried out, whenever possible, in sea-state 2 or less as the ability to detect small cetaceans decreases significantly in sea-state ≥3 (Teilman, 2003). Berrow *et al*. (2007) recommended that all harbour porpoise surveys should only be carried out in sea-state 0 or 1 to ensure all animals are detected and g(0)=1. This is rarely possible and given the poor weather throughout the summer in 2008 we were fortunate to be able to carry out as many surveys as we did in relatively good sea-state (sea-state ≤2). The data can be stratified by sea-state in the future if monitoring records any changes in density estimates. Acoustic monitoring is much less weather dependent.

During nine days of surveys, a total of 121 track-lines were surveyed for a total distance of 622.80 km in sea-state ≤2. From the total of 63 sightings a total of 122 individuals of harbour porpoise (*Phocoena phocoena*) were recorded. Three other species were recorded but only bottlenose dolphins at one site (Donegal bay) and common dolphin and minke whale at one site (Blasket Islands cSAC). Only harbour porpoise were recorded at Carnsore Point.

Comparison of harbour porpoise density estimates

The Habitats Directive states a site which "*corresponds to the ecological requirements of the species*" may be designated as an SAC. The Directive states that the selection of sites eligible for identification as of Community importance are those "*for aquatic species which range over wide areas, such sites shall be proposed only where there is a clearly identifiable area representing the physical and biological factors essential to their life and reproduction*". It has proved difficult for member states to identify sites based on these criteria due to insufficient data and other criteria have been proposed including the regular or continuous presence of the species, good population density (in relation to neighbouring areas) and high ratio of young to adults during certain periods of the year (Johnston *et al.,* 2002).

A comparison of density estimates and associated statistics at eight sites are shown in Table 13. The sites with only three survey days have high CV and SE and wide confidence intervals and these results should be treated with caution. The mean group sizes of harbour porpoise varied quite considerably between sites with larger groups recorded on the south and west coasts compared to the east coast.

Table 13. Density estimates of harbour porpoise during dedicated sighting surveys in 2007 and 2008

Location	Year	Area (km^2)	Mean group size	% young	Density (per km^2)	Abundance ± SE (95% Confidence Intervals)	CV	Reference
Carnsore Point	2008	151	1.91	14	0.58	87±36.3 (39-196)	0.42	This study
Blasket Islands	2008	227	1.76	18	1.65	372±105.3 (216-647)	0.28	This study
Donegal bay	2008	281	2.40	8	0.88	249±111.5 (106-586)	0.45	This study
North County Dublin	2008	104	1.41	8	2.03	211±47.1 (137-327)	0.23	Berrow *et al.* (2008)
Dublin bay	2008	116	1.19	6	1.19	138±33.2 (86-221)	0.24	Berrow *et al.* (2008)
Cork coast	2008	326	2.67	0	0.53	173±56.6 (92-326)	0.33	Berrow *et al.* (2008)
Roaringwater bay	2008	128	2.21	7	1.24	159±42.0 (95-689)	0.27	Berrow *et al.* (2008)
Galway Bay	2008	547	2.15	7	0.73	402±84.1 (267-605)	0.21	Berrow *et al.* (2008)
Reference								
Blasket Islands	2007	227	2.32	2	1.33	303±76 (186-494)	0.25	Berrow *et al.* (2007)

Results from a similar survey of the Blasket Islands cSAC in 2007 were used as a reference with which to compare density estimates. Of the sites surveyed in the present study, only the Blasket Islands cSAC in 2008 (1.65) had a higher overall density than the Blasket Islands cSAC in 2007 (1.33), showing there was some consistency between years. If we consider all sites surveyed in 2008, density estimates in North County Dublin (2.01) and Roaringwater bay (1.24), which is also designated as an SAC for harbour porpoises, were also high.

The density of harbour porpoises in Donegal bay might vary depending on the presence of bottlenose dolphins. Bottlenose dolphins are known attack and kill harbour porpoises (Ross and Wilson, 1996) and the presence of bottlenose dolphins in the bay may exclude some harbour porpoises. However as the presence of dolphins may be transient harbour porpoise densities may increase when dolphins are absent. All these variables should be taken into account when short-duration surveys are conducted in a single season and year to identify sites suitable for designation as SACs.

Proportion of harbour porpoise adults to young

An important criteria for consideration of a site as a potential SAC is a "*high ratio of young to adults during certain periods of the year*". There are no guidelines as to what is considered "high". In west Greenland the proportion of porpoises less than 1 year old in the population, as determined from Growth Layer Groups in teeth, was reported as 7% (Lockyer *et al.,* 2001) and 12-13% in NE Canada (Reid and Hohn, 1995). Sonntag *et al.* (1999) summarized data from 13 aerial surveys and 10 ship-based surveys throughout the North Sea and Kattegat area including data from SCANS (Hammond *et al.,* 2002). The proportion of calves ranged from 5.1% (Inner Danish waters) to 17.9% (Isle of Sylt) from aerial surveys and 2.2-6.7% from ship-based surveys. Data from the Irish Sea recorded 5.1% calves and only 3.3% in British coastal waters.

The proportion of adults to young at the three sites surveyed ranged from 8 to 18% (Table 13). The percentage from Donegal bay was similar to that reported from four other sites surveyed in 2008 by Berrow *et al.* (2008) (Table 13). The percentage from Blasket Islands (18%) was the highest recorded at any site in Ireland to date and higher than any site reported by Sonntag *et al.* (1999). This compares to only 2% reported by Berrow *et al*. (2007) at the same site in 2007 but as this was strongly influenced by data from one day the figures should be treated with caution. The proportion of young at Carnsore Point was also high (14%) but there were few sightings overall at this site and this figure must be treated with caution. These data may be compounded by the relatively small number of sightings at each site which has led to over-estimates of the proportion of young animals.

The data presented in this survey are likely to be higher than the data from SCANS as the sites are all small and coastal. Sonntag *et al*. (1999) suggested the high proportion of calves of the Isle of Sylt in Germany (9/6-17.9%) indicated that it was a preferred calving ground for harbour porpoise in the southern North Sea. Our more limited data suggest similar elevated percentages in the Blasket Islands cSAC and Carnsore Point may indicate an important calving site but the proportion of young in Donegal bay (8%) is probably typical of Irish coastal waters (Table 13).

Photo-identification of bottlenose dolphins

One objective of the present survey was to assess the abundance of small cetaceans within these sites. For bottlenose dolphins the preferred method for assessing abundance is using mark-recapture data from individually recognizable dolphins. During the three surveys carried out at three sites bottlenose dolphins were only observed on one day and at one site (Donegal bay). Although 10 individuals from a group of 20 were recognized using photo-identification, no abundance estimate could be derived. A minimum estimate of 26 dolphins was observed on a single day in Donegal bay.

Englund *et al.* (2007) recommended a minimum of 12 surveys assuming a mean individual capture frequency of circa.2 would be necessary in the Shannon estuary to obtain an abundance estimate with a CV of approximately 0.12. The encounter rate of bottlenose dolphins in Donegal bay is not known but it is likely to be lower than the Shannon estuary, which has a known resident population. Thus to obtain a similar capture frequency it is likely that more than 12 surveys would need to be carried out. The IWDG

carried out a further five surveys in Donegal bay in 2008 between July and September and encountered bottlenose dolphins on two of these days. A catalogue of 42 individually recognizable dolphins was established during 2008, including the data presented here, of which nine (21.4%) were recaptured in Donegal bay at least once, with one dolphin recorded on all three visits with dolphin encounters.

These data were also used by O'Brien *et al.* (submitted) who analysed four bottlenose dolphin photo-id catalogues with a total of 114 individually recognizable dolphins and recorded 16 matches. This was a re-sighting rate of 14% with re-sightings ranging over distances of between c130km and c650km. Seven of the dolphins from Donegal bay matched to Galway bay and one each to Co Antrim and Cork harbour. These results suggest there is large-scale movement of transient dolphins along the western seaboard of Ireland, which includes Donegal bay and between the south, north and east coasts. This has implications for the conservation of this species, including site designation as a network of SACs might be necessary if sites can be identified that have a "regular presence" of the same individual bottlenose dolphins.

In summary:

Carnsore Point

Only harbour porpoise were recorded and number of sightings was low. Mean group size was two with wide variation and the proportion of young animals was high (14%). Overall density estimate was low with a high CV and SE and the estimate should be treated with caution.

Blasket Islands

Harbour porpoise, common dolphin and minke whale were recorded. The number of harbour porpoise sightings was high during only one survey day. Group size varied considerably and the proportion of young animals was higher (18%) than for any site surveyed in 2008. The overall density estimate was high and consistent with a similar survey in 2007.

Donegal bay

Harbour porpoise and bottlenose dolphin were recorded at this site. This was the only site where bottlenose dolphins were recorded and there is evidence of movement of dolphins between Donegal bay and other sites on the south and west coast. The number of harbour porpoise sightings and group size varied greatly between surveys and were highest when no bottlenose dolphins were recorded. The proportion of young (8%) was typical of other sites surveyed in 2008. The overall density was good but the CV and SE was large so the estimate should be treated with caution.

Recommendations

The following recommendations are made following the results of this survey:

1. Donegal bay had good densities of harbour porpoise and was the only site in which bottlenose dolphins were recorded and should be considered as a Special Area of Conservation

2. Further monitoring of bottlenose dolphins should be carried out in Donegal bay to determine if bottlenose dolphins regularly use the bay

3. Collection of more photo-identification data on bottlenose dolphins from Donegal bay is required to enable an abundance estimate to be derived using mark-recapture analysis.

4. Harbour porpoise densities in Carnsore Point were low and we do not recommend this site as a Special Area of Conservation.

5. Conventional single platform line-transect sighting surveys can be used to estimate densities of small cetaceans in coastal sites. However in order to provide robust estimates the number of

surveys and the area of the sites should be of a sufficient spatial scale to obtain sufficient sightings (n=40-60) for use in the model.

6. For monitoring purposes monthly sampling should be carried out each year between April and October, in order to take advantage of good weather conditions and obtain a good dataset for creating a reference value for each site. If the encounter rate at a site was sufficiently large, one sample day per month may have been sufficient however this was rarely achieved (see Berrow *et al.*, 2008) and twice monthly sampling may be necessary to obtain sufficient sightings to derive a robust density estimate using DISTANCE.

7. In order to determine seasonal variation in abundance we recommend single platform line-transect sighting surveys should be carried out in every month for at least one year at each site during the next reporting round of the EU Habitats Directive. These data will not only inform managers on the use of the site by small cetaceans but will assist in management of the site by identifying times of year when the impacts of activities within the site may be minimized or identify seasonally important habitats or areas.

8. Fixed track-lines should be avoided for monitoring as this will create statistical constraints. These track-lines should be randomized through the study site ensuring equal probability of coverage and enable flexibility if areas of high concentrations change between years.

9. If surveys intend to use multiple observers it is important that these observers are trained and their ability to determine important variables such as distance and group size are tested and if necessary used to derive correction factors to field data.

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Appendix I: Individually recognisable bottlenose dolphins from 23 July 2008

DB01_23072008_SB

DB03_23072008_SB

DB04_23072008_SB

DB05_23072008_SB

DB06_23072008_SB

DB07_23072008_SB

DB08_23072008_SB

DB09_23072008_SB

DB010_23072008_SB

DB20_23072008_SB