

Bottlenose Dolphin SAC Survey 2010



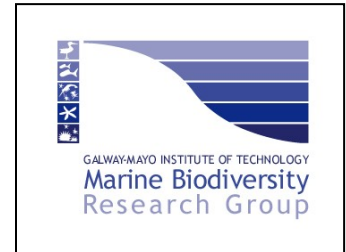
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Cover image: Bottlenose dolphins in the Lower River Shannon cSAC © DEHLG

Bottlenose Dolphin SAC Survey 2010

Summary

A population assessment of the bottlenose dolphins in the Lower River Shannon cSAC was undertaken between July and October 2010. Dolphins were located on each transect. During 12 transects a total of 64 dolphin groups were encountered with 547 individuals recorded. Group sizes ranged from 1-50 overall. Lone dolphins were reported on two occasions. Dolphins were located throughout the survey area with concentrations off Kilcredaun Head, Kilbaha, Leck Point in the outer estuary and Carrig buoy in the middle estuary.

A total of 273 dolphins were photographed during the 12 transects. The proportion of dolphins identified from those observed ranged from 41-100% with a mean of 54%. Of these, 175 dolphins were photographed from the left, 169 from the right and 97 from both sides of their dorsal fin. Of these 71 were categorized as with Severity Grade 1 marks, 21 Severity Grade 2 marks and 24 from Severity Grade 3 marks, resulting in the identification of 116 unique individuals. The discovery curve of Grade 1 dolphins had not plateaued out suggesting that we have not quite captured all the dolphins occurring in the estuary. There were 50 dolphins with permanent marks recorded on both sides of the fin, 64 on the left hand side only and 57 from the right hand side only, which provided the most robust dataset available for mark-recapture analysis.

Of the 43 occasions when calves were recorded, 6 were photographed with a well-marked adult. Of the 116 individual dolphins recorded during this survey 47% (55 out of 116) were considered resident (i.e. they had been recorded previously in the Shannon Estuary) and 53% were "new" dolphins not recorded previously but none had been previously recorded outside of the Lower River Shannon cSAC and were thus considered new dolphins to the existing SDWF catalogue and not immigrants.

Estimates of abundance were calculated using left side, right side and both side identifications. The effect of photo quality of abundance estimates was small so only images of Grade 1 Quality were used minimizing the potential of dolphins losing their identifying marks during the sampling period all maximizing the probability that marks are correctly recorded in each capture

The proportion of dolphins with identifiable marks (Grade 1 only) ranged from 0.60 to 0.63. The estimated abundance of marked individuals was elevated depending on the estimated proportion of marked individuals in the population to give a final estimate of 107 ± 12 , CV = 0.12 (95% CI 83 - 131).

Previous abundance estimates for bottlenose dolphins in the Lower River Shannon cSAC ranged from 114 in 2008 to 140 in 2006. The present estimate is lower but lies within the 95% Confidence Intervals for all surveys carried out to date. This suggests that, within the power of the survey technique, the population of bottlenose dolphins in the Lower River Shannon cSAC is relatively stable

Introduction

The Shannon Estuary is an important habitat for bottlenose dolphins (*Tursiops truncatus*). Research since 1993 has shown that the dolphins are resident, occur throughout the year and it is an important calving area (Berrow *et al.* 1996; Ingram 2000). Historical references suggest the dolphins have been in the estuary since at least 1835 (Knott 1997) and probably much longer. A recent study on genetics of bottlenose dolphins in Ireland suggested that the bottlenose dolphins in the Shannon Estuary are genetically discrete and thus of very high conservation value (Mirimin *et al.* in press).

The Lower River Shannon is the only candidate Special Area of Conservation (cSAC) for bottlenose dolphins in Ireland. Under the EU Habitats Directive (92/43/EEC) the Irish government has a legal obligation to monitor key marine habitats and species and to report on their conservation status to the EU. Several population assessments of bottlenose dolphins have been carried out in the Shannon Estuary since 1997 with the most recent in 2008 (Ingram 2000; Ingram and Rogan 2003; Englund *et al.* 2007; 2008). In order to fulfill the requirements for monitoring set out within the Habitats Directive a population assessment was undertaken between July and October 2010.

The objectives of the present survey were to:

1. derive an updated population estimate for Bottlenose dolphins in the Lower River Shannon cSAC using mark-recapture photographic identification of individual dolphins.
2. collect ancillary information that is readily available during population surveys concerning ecological/life history parameters of scientific interest (e.g., the numbers of resident or transient dolphins in the area, stability of natural markings, presence of calves)

Methods

The survey route is shown in Figure 1. Each transect was approximately 42nmls (80km) in length and took around 5-6 hours to complete, including time for carrying out photo-identification of dolphin groups.

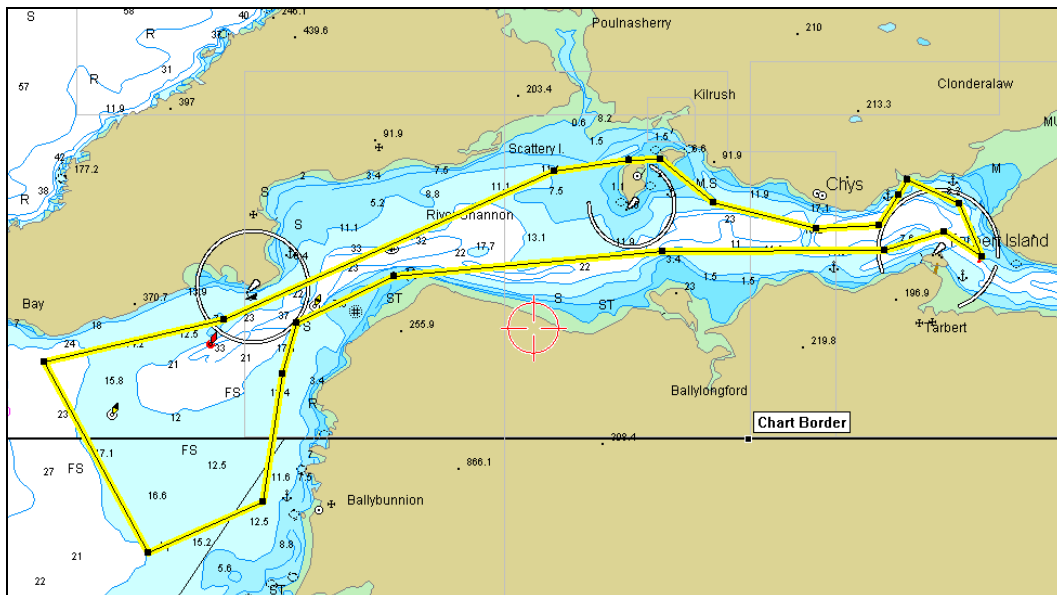


Figure 1. Standard transect route carried out during the Bottlenose Dolphin SAC Survey 2010.

Survey Vessel

A 6m XS Rigid Inflatable Boat with a 115hp Mercury engine will be used to carry out transects. This vessel was equipped with Garmin 126 GPS, ICOM M 401 VHF, navigation and deck flood light etc. It has a P3 passenger licence from the Marine Mercantile Office in compliance with the Passenger Boat Regulations 2002 (valid until April 2011) to carry three passengers in inshore waters for research purposes.

Survey methodology

Dedicated line transects were carried out on fixed, pre-determined routes in the Shannon Estuary. The route was consistent with that described as *long* in Berrow *et al.* (1996) and *full* by Ingram (2000). Occasionally an extension to this route was surveyed if it was felt dolphins could be located, but the vessel returned to the departure point of the standard transect each time. Transects were carried out by between 3-5 persons with SB acting as coxswain on all transects. The vessel is fitted with three seats; one for the coxswain in the middle of the vessel, behind the console and two parallel seats immediately behind the coxswain, enabling each observer to scan to port or to starboard. Transects were only carried out in sea-state 2 or less and at a velocity of 20km hr⁻¹. The route of the survey vessel and position of dolphin schools encountered was recorded on a hand-held Garmin 72 GPS and tracks and waypoints downloaded using Garmin MapSource® software. Three transects were carried out each month from July to October.

Data collection

All dolphin schools, defined as all dolphins within 100m radius of each other (Irvine et al., 1981), were recorded and a waypoint entered on the GPS at the start and end of a group encounter. This recorded time as well as location. Each group was approached slowly and group size recorded as the total number of individuals present. The number of adults, juveniles (sub-adults) and calves within the group were recorded. A juvenile was defined as approximately two-thirds the size of an adult and generally more pale than adults, calves as smaller than juveniles and thought to be <1 year old. Neonates were determined from the presence of neonatal folds. Behaviour was recorded using the definitions provided by Shane (1990). An attempt was made to photograph all dolphins in each school and to obtain images of both left and right sides of each dorsal fin while remaining cognizant of the potential disturbance to the dolphins created from the close presence of a RIB. If dolphins showed signs of disturbance (formed a tight group, excessive tail slapping, moved off in a group at high speed) photo-identification was ceased and the vessel continued on the transect. Otherwise photo-id continued until it was thought all individuals in the group had been photographed.

Photo-identification

A minimum of two high quality cameras were carried on all surveys. On eight occasions three high quality cameras were used and on two occasions four cameras were used, increasing the likelihood of obtaining images of all dolphins present. Canon EOS D20 digital cameras, one with a Canon 70-200mm f2.8USM lens and Canon 2x converter and one with a Canon f3.0 300mm lens were used to acquire images. This equipment can collect up to 280 high resolution images (up to 4MB) on a 1.6GB card. Images were downloaded into a Btech AMD2800 Sempron Workstation and edited using Adobe Photoshop.

Handling and sorting of data and dolphin images

All dolphin images were sorted and graded from 1 to 3 following criteria published by Ingram (2000).

- Grade 1:** Well lit and focused shots taken perpendicular to the dorsal fin at close range;
- Grade 2:** More distant, less well lit or slightly angled shots of dorsal fins
- Grade 3:** Poorly lit or out of focus shots taken at acute angles to the dorsal fin

Mark Severity Grade 1:



ID 15L



ID 33R



ID 8R

Mark Severity Grade 2:



ID 113L



ID 119L

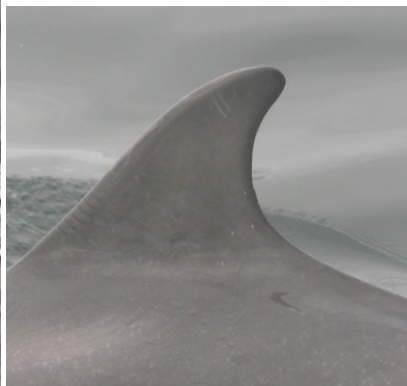


ID 78R

Mark Severity Grade 3:



ID 38L



ID 57L



ID 76R

Figure 2. Examples of Mark Severity Grade 1-3 fins used in the Shannon Dolphin SAC Survey 2010

Images of dorsal fins were recorded as “left-side”, “right-side” and “both sides” if both sides were photographed for each encounter. The severity of marks on identified dolphins was also graded (see Fig. 2) following definitions in Ingram (2000).

Grade 1: marks consisting of significant fin damage or deep scarring that were considered permanent

Grade 2: marking that consist of deep tooth rakes and lesions with only minor cuts present

Grade 3: superficial rakes and lesions

A catalogue of dorsal fins was established for this project and cross-referenced with the Shannon Dolphin ID catalogue held by the Shannon Dolphin and Wildlife Foundation (SDWF). This catalogue contains images of around 200 individual identified dolphins recorded since May 1993.

In order to compare the numbers of “resident” and “transient” dolphins, we defined “resident” as individuals that had previously been recorded by SDWF in the Lower River Shannon cSAC (i.e. currently included in the SDWF Shannon Dolphin Photo-id Catalogue), “potential transient” as those individuals only recorded during the present survey (i.e. new individuals to the SDWF Shannon Dolphin Photo-id Catalogue) and “transient” as those dolphins recorded outside of the SAC (i.e. recorded in catalogues available from outside of the estuary - Inshore Coastal Bottlenose Dolphin Catalogue, see O’Brien *et al.* 2009).

Deriving an abundance estimate using CAPTURE

A fully validated data set of all sightings/re-sightings of individual dolphins was created for the modelling. Only images depicting well-marked features from photo-ID Grade 1 images were used as there were sufficient numbers available and to minimize violating assumptions ii) and iii) below. They were incorporated into a closed model incorporating heterogeneity in capture probability (Chao M(th)) (Chao *et al.* 1992) using the software programs MARK and CAPTURE (Version 5.1, Build 2600).

Multiple sample capture-recapture abundance estimates of closed populations depend on the assumptions that (from Ingram (2000)):

- i) the population is closed during the sampling period
- ii) animals do not lose their identifying marks during the sampling period
- iii) all marks are correctly recorded in each capture
- iv) each animal has an equal and constant probability of being captured

It was possible either to constrain one or more parameters, or set the model to estimate all parameters. The program (MARK) then ranked the likelihood of each model on the basis of best fit, using the Akaike Information Criterion (AIC) value. The key parameters are S (probability of survival), gamma" (probability of emigration), gamma' (probability of an emigrated animal staying outside the study area) and N (population size within the study area). Together, these were used to obtain overall population size estimates, using biased corrected estimate using the delta method recommended by Wilson *et al.* (1999) after taking account of the (weighted) mean proportion of well-marked animals and some measure of survival/migration obtained from the model.

Maps and shape files

The GPS data was used to create ArcView (Version 9) shape files of the survey track and location of all sightings recorded during each survey. Maps were created using Irish Grid (TM65_Irish Grid). Data used in the creation of the maps of transects, effort, location of visual and acoustic detections, abundance and density estimates were stored in a single MS Access database, which was queried from within the GIS to produce maps.

Results

Survey Effort

All 12 transects were carried out in full between 5 July and 21 October in favourable weather conditions (Table 1). This resulted in a large number of groups and individual dolphins being recorded. Dolphins were located on each transect. If the same group was encountered twice, for example during a course west and then on the way back while travelling east it was treated as only one group. All track-lines are shown in Figure 3. For individual track-lines, and the locations of dolphins observed during each survey, see Appendix I.



Figure 3. All track-lines from 12 surveys of the Lower River Shannon cSAC carried out in 2010.

A total of 64 dolphin groups were encountered with a total of 547 individuals (Table 1). A single sighting of a harbour porpoise (*Phocoena phocoena*) on 25 September off Kilbaha was not included in the analysis.

The overall mean group size (\pm SD) was 8.5 ± 1.0 with a median of 6.0 (range 4 - 12.5). Group sized ranged from 1-50 overall. Lone dolphins were reported on two occasions. Although there appeared to be a trend to increased group size from July-August to September-October, this was not significant ($F = 0.93$, 10 df, $P = 0.52$). There was no significant difference in the mean (Kruskall-Wallis $H = 4.86$, df = 5, $P = 0.43$) or median (Kruskall-Wallis $H = 3.71$, df = 4, $P = 0.45$) group size if early transects (July-August) were compared to late transects (September-October).

Table 1: Sea-state and group details recorded during the Bottlenose Dolphin SAC Survey 2010.

Transect Number	Date	Sea-state	No. groups	No. Individuals ¹	Mean Group size \pm SE (range)	No. of individuals photographed ²	% dolphins identified in group
1	9 July	2	1	12	12	12	100
2	12 July	0-1	11	78	7.0 \pm 0.9 (3-13)	34	43
3	23 July	1-2	8	43	5.4 \pm 2.0 (2-19)	22	51
4	2 August	0-1	5	35	7.0 \pm 2.2 (2-13)	17	48
5	14 August	1-2	4	29	7.3 \pm 1.3 (4-10)	12	41
6	15 August	1	10	59	5.9 \pm 1.3 (1-15)	26	44
7	6 September	0-2	4	36	9.0 \pm 3.8 (4-20)	18	50
8	12 September	2	3	17	5.7 \pm 1.5 (3-8)	11	65
9	25 September	1	4	59	14.8 \pm 11.8 (1-50)	27	45
10	14 October	1-2	6	81	13.5 \pm 4.45 (6-35)	37	46
11	16 October	0-1	4	49	11.8 \pm 4.1 (4-23)	32	65
12	21 October	2	4	49	12.3 \pm 4.5 (4-20)	25	51
Total			64	547		273	

¹ estimated visually

² estimated from photo-ID catalogue

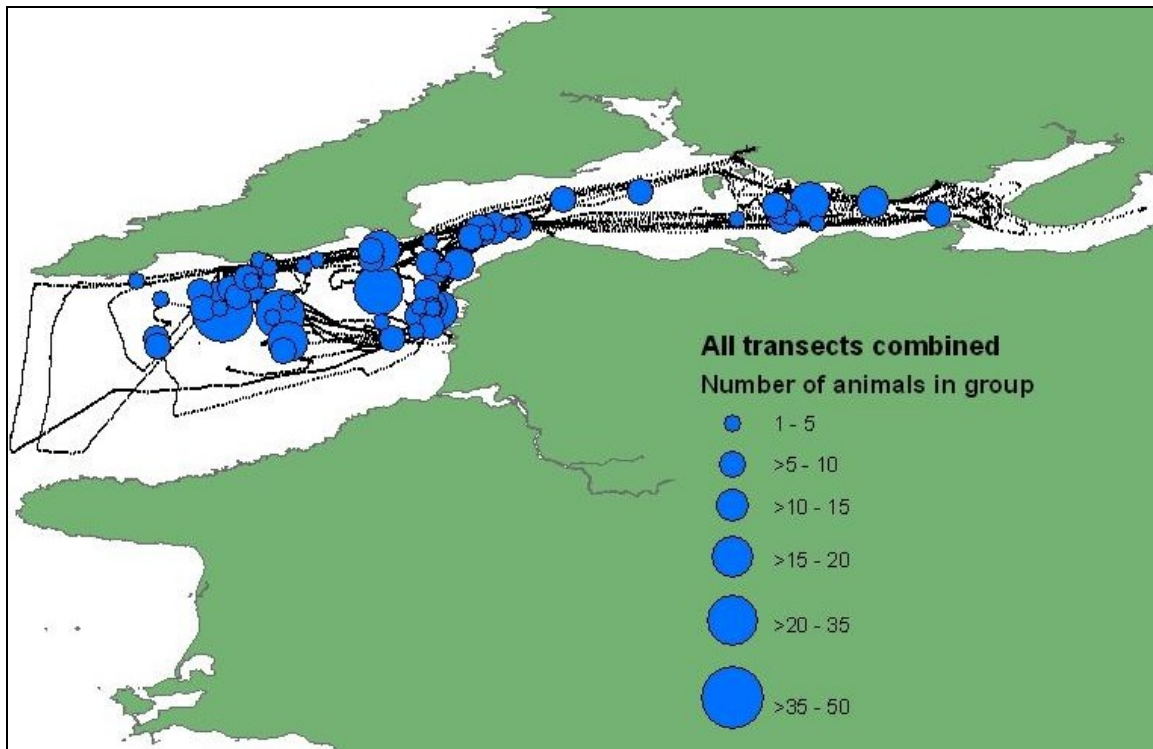


Figure 4. Location of all dolphin sightings recorded during the Bottlenose Dolphin SAC Survey 2010.

Dolphins were located throughout the survey area with concentrations off Kilcredaun Head, Kilbaha, Leck Point in the outer estuary and Carrig buoy in the middle estuary (Fig. 4). Interestingly no dolphins were recorded during extensions to the standard transects. The 20m contour which defines the Ballybunnion Bank is an important area for bottlenose dolphins in the Lower River Shannon cSAC.

Photo-identification

A total of 273 dolphins were photographed during the 12 transects (Table 1). The proportion of dolphins identified from those observed ranged from 41-100% with a mean of 54% (Table 1). No encounters were terminated early due to disturbance during photo-identification.

A total of 175 dolphins were photographed from the left, 169 from the right and 97 from both sides of their dorsal fin (Table 2). Of these 71 were categorised as with Severity Grade 1 marks, 21 Severity Grade 2 marks and 24 from Severity Grade 3 marks, resulting in 116 identifiable individuals in total. Only 27 dolphins photographed could not be allocated to one of the three grades as the images were too poor. This included 17 dolphins photographed from the left side and 13 from the right.

Table 2. Number of individual bottlenose dolphins photographed.

Transect	No. Individuals Photographed from left hand side	No. Individuals Photographed from right hand side	No. Individuals Photographed from both sides	Cumulative number of individuals identified
1	7	6	3	10
2	20	22	12	36
3	15	11	5	52
4	11	10	6	56
5	8	6	2	60
6	7	17	2	69
7	9	13	4	74
8	6	2	0	77
9	20	22	15	93
10	28	25	21	101
11	24	21	17	109
12	20	14	10	116
Total	175	169	97	

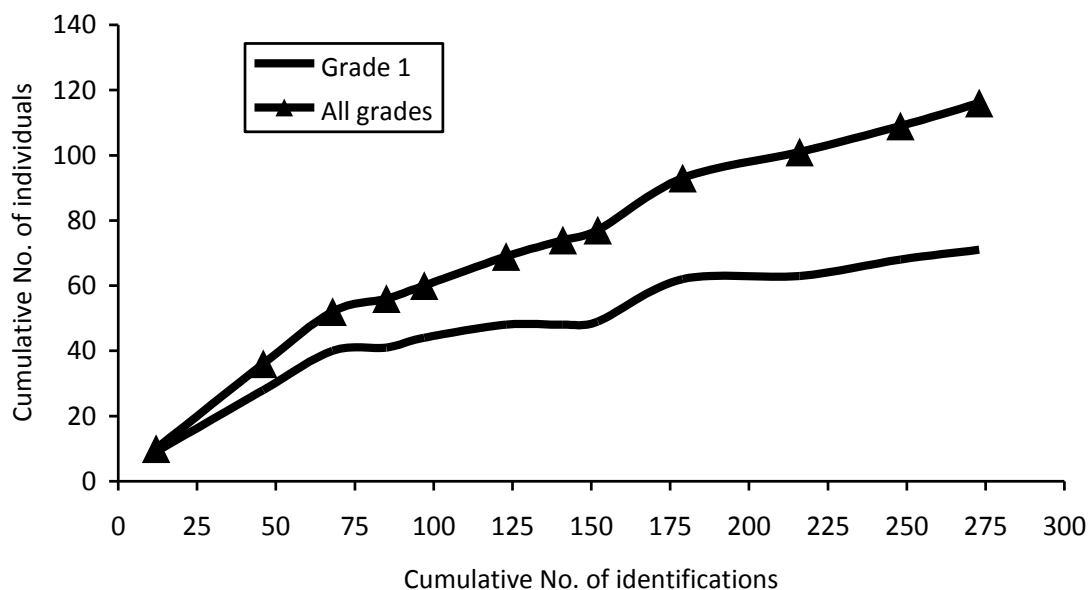


Figure 5. Discovery curve of well marked (Mark Severity Grade 1) dolphins recorded during the Shannon Dolphin Survey 2010

The discovery curve of Grade 1 new dolphins (Fig. 5) has not quite plateaued out suggesting we have not quite captured all the dolphins in the estuary. There were 13 new individuals recorded on Transect 9 (25 September) in a large group off Kilcloher Head. Although these were new to the study and caused a step on the discovery curve, 9 had been recorded previously in the Lower River Shannon cSAC so it is unlikely that this indicated immigration into the site rather just that these dolphins had not been encountered, or photographed, before in the estuary during this survey.

The photo-id results are presented as dolphins identified by permanent (Grade 1), temporary (Grade 2) and superficial marks (Grade 3) on the left side of the dorsal fin, right side and from both sides (Table 3). Thus there were 50 dolphins with permanent marks recorded on both sides of the fin, 64 with Grade 1 marks on the left hand side and 57 with Grade 1 marks on the right hand side. These were the most robust datasets available for mark-recapture analysis. **A total of 21 dolphins were rejected if temporary marks are excluded from the model and 24 dolphins if superficial marks are rejected, making 45 in total.** This reduces the probability of false negatives such as not correctly recording all dolphins in each capture event (sighting), or animals losing their marks during the duration of sampling.

Table 3. Severity of marks on individual bottlenose dolphins photographed.

Side	Mark Severity			Total
	Grade 1 Permanent	Grade 2 Temporary	Grade 3 Superficial	
Both	50	3	0	53
Left	64	14	12	90
Right	57	10	12	79

Calves and Juveniles

The number of juveniles and calves recorded on each survey date are shown in Table 4. Calves were recorded on 10 of the 12 transects and juveniles on 11 of the 12 transects. A total of 25 groups of the 64 groups recorded (39%) had calves present.

Table 4. Number of adult, juvenile and calf bottlenose dolphins recorded during the 2010 survey.

Transect Number	Date	No. Adults	No. Juveniles	No. Calves	Total
1	9 July	12	0	0	12
2	12 July	62	11	5	78
3	23 July	35	4	4	43
4	2 August	27	7	2	36
5	14 August	26	2	1	29
6	15 August	38	11	7	56
7	6 September	27	6	3	36
8	12 September	7	8	2	17
9	25 September	52	1	6	59
10	14 October	73	3	5	81
11	16 October	30	14	3	47
12	21 October	34	15	5	54

Of the 43 occasions when calves were recorded, 6 were photographed with a well-marked adult, presumably its mother (Table 5). Of these dolphin no. 31 was photographed with a calf on two transects (12 July and 14 October) and dolphin no. 41 was photographed with a calf on three transects (2 August, 15 August and 16 October). Seven calves were photographed with unmarked adults. Thus there was a minimum of six and a maximum of 13 calves present. The true number was probably around 10.

Table 5. Well-marked adults recorded with neonates during the Shannon Dolphin Survey 2010.

Date of first sighting	Associated adult ID number
12 July	31
23 July	43
23 July	45
2 August	41
25 September	91
25 September	96

Presence of “resident” and “transient” dolphins

The occurrence of putative “resident”, “transient” and “potential transient” dolphins is presented in Table 6. Using the definitions presented in the methods, there were 61 dolphins (19 Grade 1; 19 Grade 2; 23 Grade 3) new to the SDWF Photo-id catalogue that could thus be described as potential transients. This

may be over-estimated due to the difficulties in matching the images from 2010 to those images taken during the early studies (1993-1998) when print and slide film was used and dolphins were photographed from a distance, thus fin images were of poor quality.

However none of these dolphins were matched to catalogues from outside the Lower River Shannon cSAC so it is more likely that they were unidentified Shannon Dolphins. These animals will now be added to the SDWF Catalogue.

Table 6. The cumulative number of “resident”, “transient” and “potentially transient” dolphins recorded in 2010.

Transect	Resident	Potentially Transient	Transient	Total
1	8	2	0	10
2	25	11	0	36
3	33	19	0	52
4	33	23	0	56
5	34	26	0	60
6	38	31	0	69
7	38	36	0	74
8	40	37	0	77
9	50	43	0	93
10	51	50	0	101
11	53	56	0	109
12	55	61	0	116

Abundance estimates

Estimates of abundance were calculated using left side, right side and both side identifications. Only dolphins with Severity Grade 1 marks were used, which provided the most robust data set and reduced the possibility of false negatives (i.e. dolphins were present but not recaptured). We found the CAPTURE model M(th) for a closed population incorporating capture probability heterogeneity (Chao *et al.* 1992) provided the best fit (i.e. lowest AIC value). The estimated total number of marked individuals in the population (N_{hat}) was calculated by the model.

We calculated estimates using dolphins recaptured from the left side of the dorsal fin (Left), dolphins recaptured from the right side of the dorsal fin (Right) and dolphins recaptured from both sides of the dorsal fin (Both) (Table 7). We also calculated estimates using Photo Grade 1, Photo Grade 1+2 and Photo Grade 1+2+3 images to explore the effect of photo quality of model estimates (Table 7).

CAPTURE derives confidence intervals under the assumption that the number of individuals not captured in the population is log normally distributed resulting in the upper estimate being larger than if assumed to be normally distributed.

Table 7. Abundance estimates of marked dolphins identified from Severity Grade 1 marks on the left side and right side of dorsal fin and on both sides from CAPTURE model from Photo quality Grade 1 – 3. (n= number of animals captured for estimate).

Photo quality	Dorsal fin	AIC	n	Nhat	Standard Error	95% Confidence Intervals
Grade 1	Both	161.90	41	55	6.7	47-75
	Left	148.82	50	77	12.9	61-115
	Right	146.24	45	62	7.6	53-84
Grade 1+2	Both	372.18	52	59	4.2	59-72
	Left	358.13	61	79	8.3	69-103
	Right	374.62	57	67	5.5	61-84
Grade 1+2+3	Both	393.52	52	56	3.35	53-67
	Left	385.16	64	85	9.0	74-111
	Right	405.77	57	65	4.6	60-79

The estimates of the marked population varied depending on which set of dorsal fin images were used. The lowest AIC for Grade 1 images was for estimates using the right side, while for Grade 1+2 and Grades 1+2+3 was for estimates using the left side which was likely due to the greater sample size used in these estimates. However these differences associated with photo quality were small overall (Table 7). In order to minimize violations of the assumptions that all marks were correctly recorded and that animals do not lose their identifying marks, we selected only Grade 1 photo quality images. Thus abundance was estimated using the most robust dataset of Grade 1 images of Severity Grade 1 fins. The estimated population of the subset of marked individuals varied from 55 to 77 depending on which fin side was used.

Table 8. The proportion of dolphins with identifiable marks (Mark Severity Grade 1 only).

Side	Long-lasting marks		Total	Proportion (θ)
	Number with	Number without		
Left	64	42	106	0.60
Right	57	34	91	0.63

The proportion of dolphins with Severity Grade 1 identifiable marks is shown in Table 8. This ranged from 0.60-0.63 depending on which side of the dorsal fin was used. The variance of each estimate was calculated using the delta method recommended by Wilson *et al.* (1999) where:

$$\text{Var } N = N^2 (\text{varNhat}/\text{Nhat}^2 + 1 - \theta/n\theta)$$

where N = estimated total population size
 Nhat = estimate of the subset of marked individuals
 θ = estimated proportion of animals with grade 1 marks in the population
 n = total number of animals from which θ was estimated

Table 9. The proportion of dolphins with identifiable marks (Mark Severity Grade 1 only).

Side	Nhat	Proportion of animals with marks (θ)	Abundance estimate	SE	Coefficient of variation	95% Confidence Interval
Both	55	0.61	89.6	12.0	0.13	66-113
Left	77	0.60	127.5	23.6	0.19	81-174
Right	62	0.63	99.0	14.5	0.15	70-127

The estimated abundance of marked individuals is increased according to the estimated proportion of marked individuals in the population (Table 9). Thus the population estimate varied from 89.6 ± 12.0 , $CV=0.13$, (95% CI 66-113) for both sides to 127.5 ± 23.6 , $CV=0.19$, (95%CI 81-174) for left only. The estimates for right sides was 99.0 ± 14.5 , $CV=0.15$, (95%CI 70-127) (Table 9).

The data from left side and right side were combined as an inverse variance weighted average, assuming independence following the recommendations described by Wilson *et al.* (1999). Data from the combined (right, left, both) average uses the data in right and left twice in the weighted average (once each and then both of them in 'both') thus we have excluded this from the calculation. These two values were combined to give a final estimate of 107 ± 12 , $CV = 0.12$ (95% CI 83 - 131).

Discussion

This is the fifth dedicated study using mark-recapture to estimate the abundance of bottlenose dolphins in the Lower River Shannon cSAC. The present survey of the Lower River Shannon cSAC was carried out in very favourable conditions which resulted in a large number of groups ($n=64$) being recorded. This success was a consequence of being able to take full advantage of any suitable weather windows during the survey period. On three occasions the survey team was on the water before first light to start transects as soon as it became bright enough enabling full transects to be completed in narrow (<8 hour) weather windows.

Encounter rate

The encounter rate with groups of bottlenose dolphins per transect in the present study (mean 5.3 groups per transect) was higher than reported by Englund *et al.* (2007; 2008) but similar to Ingram and Rogan (2003) (Table 9). This may be due in part to the definition of a group. We kept to the definition of 100m as the minimum distance between groups which at times is hard to implement clearly as groups were highly mobile and individuals or sub-groups regularly deviated from the main group. Bottlenose dolphins in the Lower River Shannon cSAC have been shown to demonstrate classic fission-fusion social structure with individuals mixing throughout the population (Foley *et al.* 2010). Thus the concept of a group, outside adult-calf pairings, is an artificial construct and associations between individuals may be comparatively weak. The median group size reported here was 6.0 which was similar to that reported previously (Table 9).

Residents and Transients

Of the 116 identifiable dolphins recorded during this survey 55 (47%) were considered resident (i.e. they had been recorded previously in the Shannon Estuary). There were 61 (53%) "new" dolphins not recorded previously by SDWF (only 19 of these were with Grade 1 marks) and while they could be considered

“transient” none had been recorded outside of the Lower River Shannon cSAC. This number of “new” animals encountered may be an artifact of the Shannon Dolphin Photo-id catalogue as a high proportion of images contained therein were obtained from tour boats and may be sampling different parts of the estuary compared to dedicated transects. This was not unexpected as O’Brien *et al.* (2009) found a similar result when analyzing images of bottlenose dolphins recorded around the Irish coast. While they had a high re-sighting rate (20-40%) of individuals between coastal sites they found no matches with the Shannon Dolphin Photo-id catalogue which suggested that the bottlenose dolphin population in the Shannon Estuary may be relatively distinct. The furthest re-sighting of dolphins from the Shannon Estuary was a group of 30 individuals recorded 24km west of the boundary of the Lower River Shannon cSAC off Sauce Creek, near Brandon, Co. Kerry (Ryan and Berrow, in press). This is further supported by genetic studies (Mirimin *et al.* in press).

Table 10. Summary of principal statistics from all abundance estimates carried out in the Shannon Estuary.

	Ingram (2000)	Ingram and Rogan (2003)	Englund <i>et al.</i> (2007)	Englund <i>et al.</i> (2008)	This Survey
Total No. groups encountered	-	66	80	22	64
No. of groups per transect	-	4.7	3.1	2.2	5.3
Median group size	-	6.0	-	6.5	6.0
No. individuals photographed	363	239	640	215	273
No. of G1 individuals identified	53	99 ¹	82 ¹	60 ¹	71
No. Grade 1 fins (both sides)	36	31	25	31	50
No. Grade 1 fins (left)	45	36	43	16	64
No. Grade 1 fins (right)	44	34	43	12	57
% dolphins with identifiable marks	59	67	63	63	61
CV of estimate	0.14	0.12	0.08	0.15	0.12
Abundance estimate (95% CI)	113 (94-161)	121 (103-163)	140 (125-174)	114 (85-152)	107 (83-131)

¹ Severity Grade 1 and 2 were used

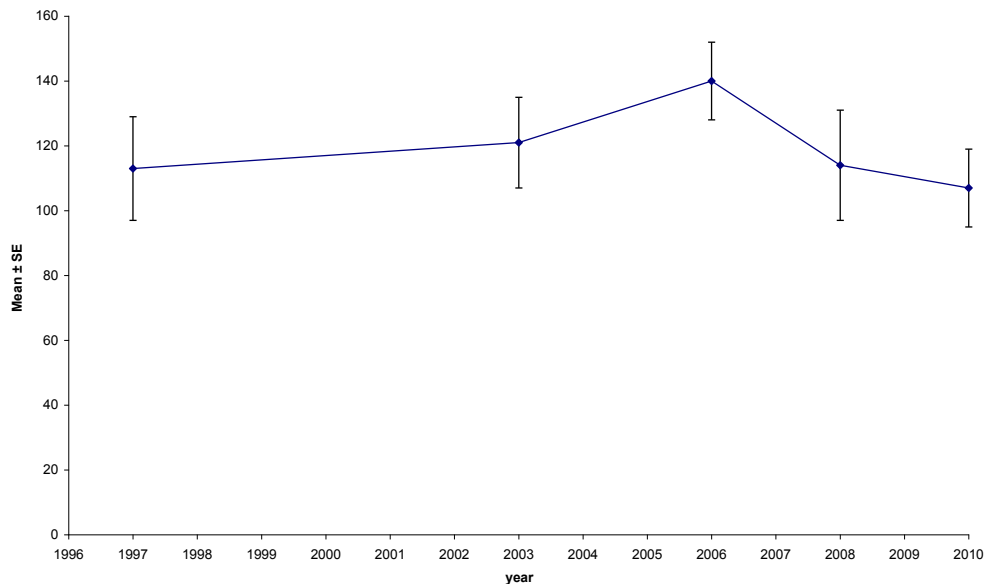


Figure 6. Trend in dolphin abundance estimates (mean ± SE) from 1997 – 2010

Abundance Estimates

There were four previous abundance estimates of bottlenose dolphin and the present one is the lowest recorded to date (Fig. 6). Previous abundance estimates for bottlenose dolphins in the Lower River Shannon cSAC ranged from 113 in 1997 (Ingram 2000) to 140 in 2006 (Englund *et al.* 2007). The present estimate is lower but lies within the 95% Confidence Intervals for all surveys carried out to date (Table 10).

There are a number of possible reasons to explain these differences. One possibility is that we did not capture all the dolphins in the population. This possibility is supported by the discovery curve of new individuals which had not quite plateaued out (Fig. 5). The proportion of dolphins identified from those observed during each transect ranged from 41-100%, with a mean of 54% (Table 1) which does suggest not all identifiable animals in each group were captured (photographed). All bottlenose dolphins encountered in a similar study in the Moray Firth, Scotland (except some neonates) possessed sufficient markings so that they could be identified from a Grade 3 photograph (Wilson *et al.* 1999). Clearly this is not the case in the Shannon Estuary, however the overall proportion of marked individuals in the present study varied from 0.60 to 0.63, which was consistent with previous studies (Table 10) which suggests this was not a major source of variability between studies.

Englund *et al.* (2007) suggested that the estimate of 140 ± 12 reported in 2006 indicated an upward trend in the abundance of bottlenose dolphins in the Lower River Shannon cSAC. However a further study in 2008 did not support this (Englund *et al.* 2008) although they attributed this lower estimate in 2008 to lower sampling effort rather than a reflection of a true decline in abundance (Englund *et al.* 2008). However, if we consider the estimate of 140 ± 12 in 2006 was elevated all other estimates, including the present one are within 6-14 individuals or 5.3-11.5% of each other, which is remarkably consistent. This suggests that, within the power of the survey technique, the population in the Lower River Shannon cSAC is relatively stable.

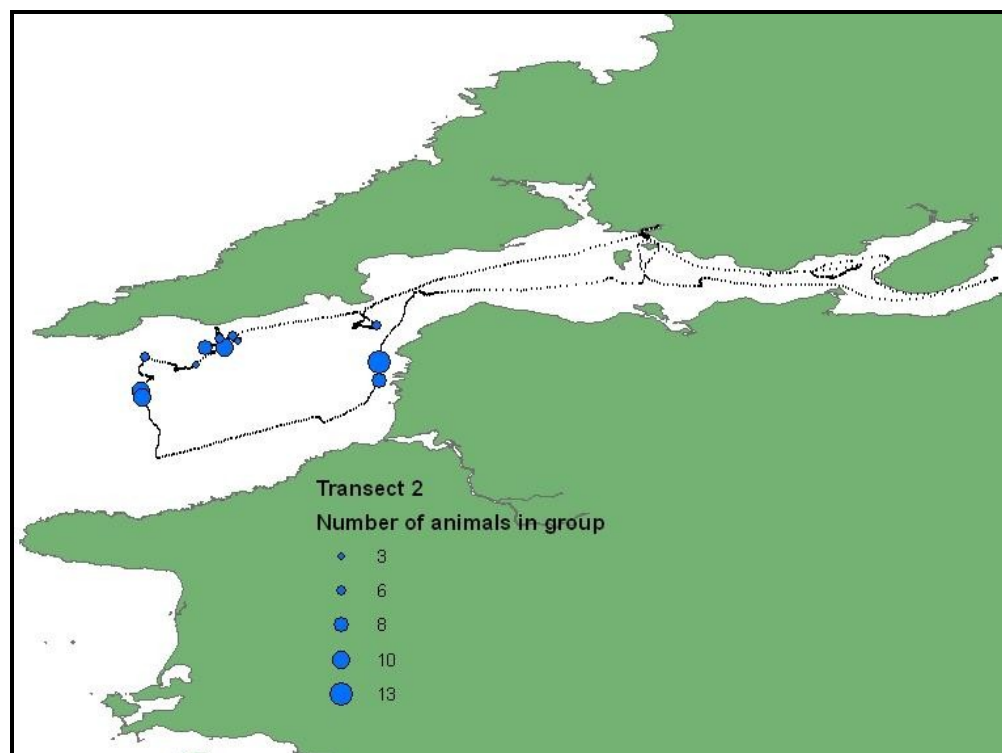
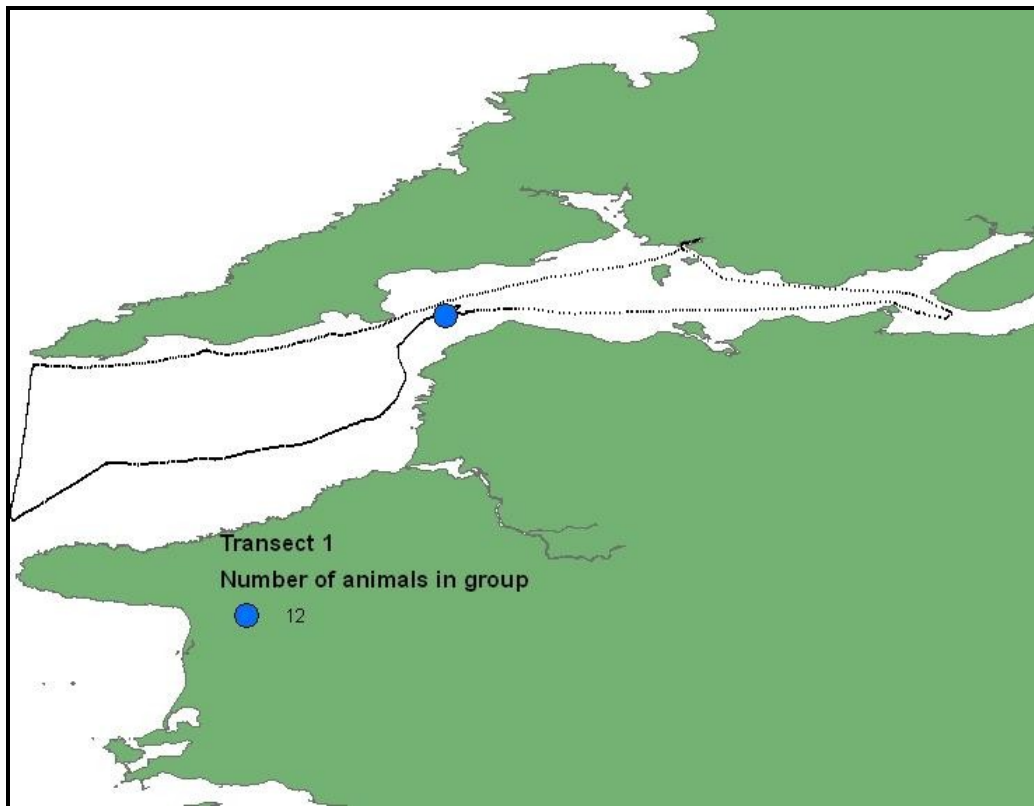
Acknowledgements

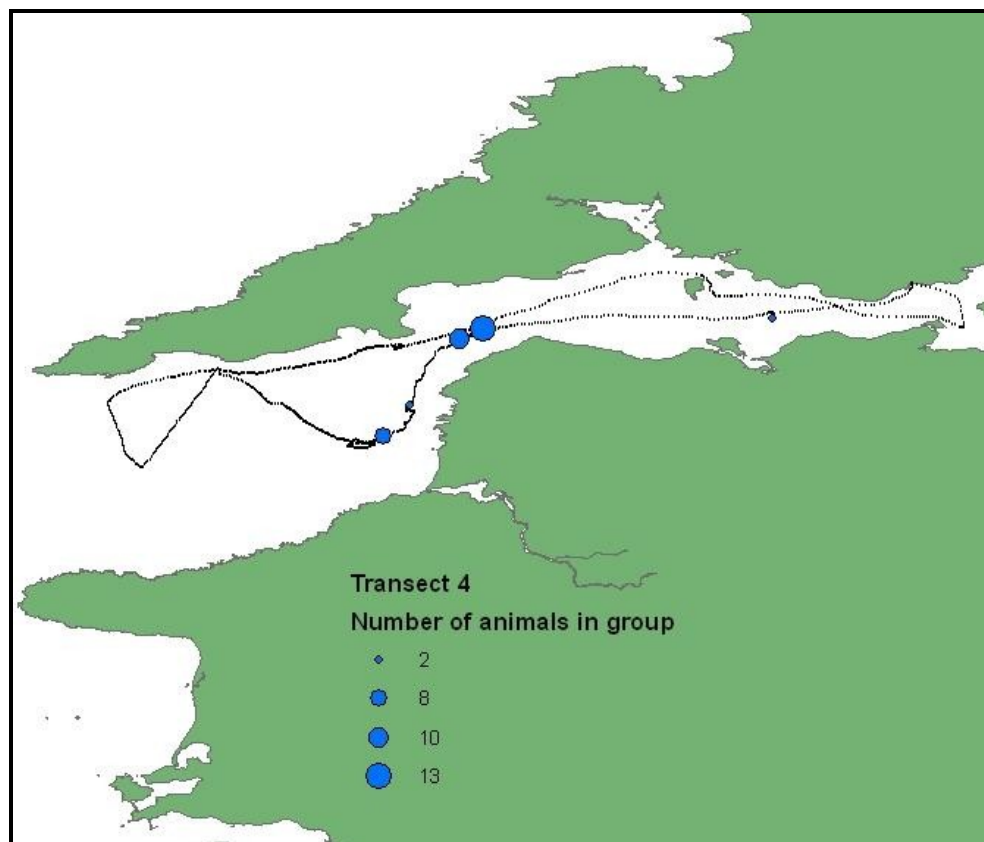
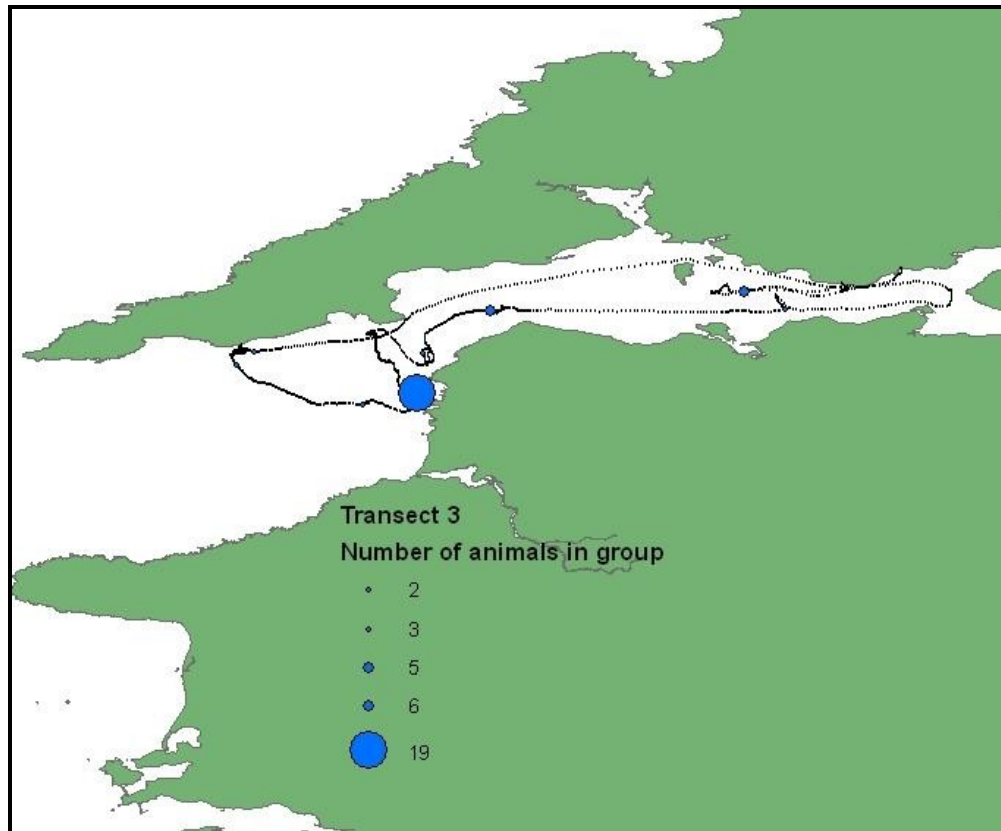
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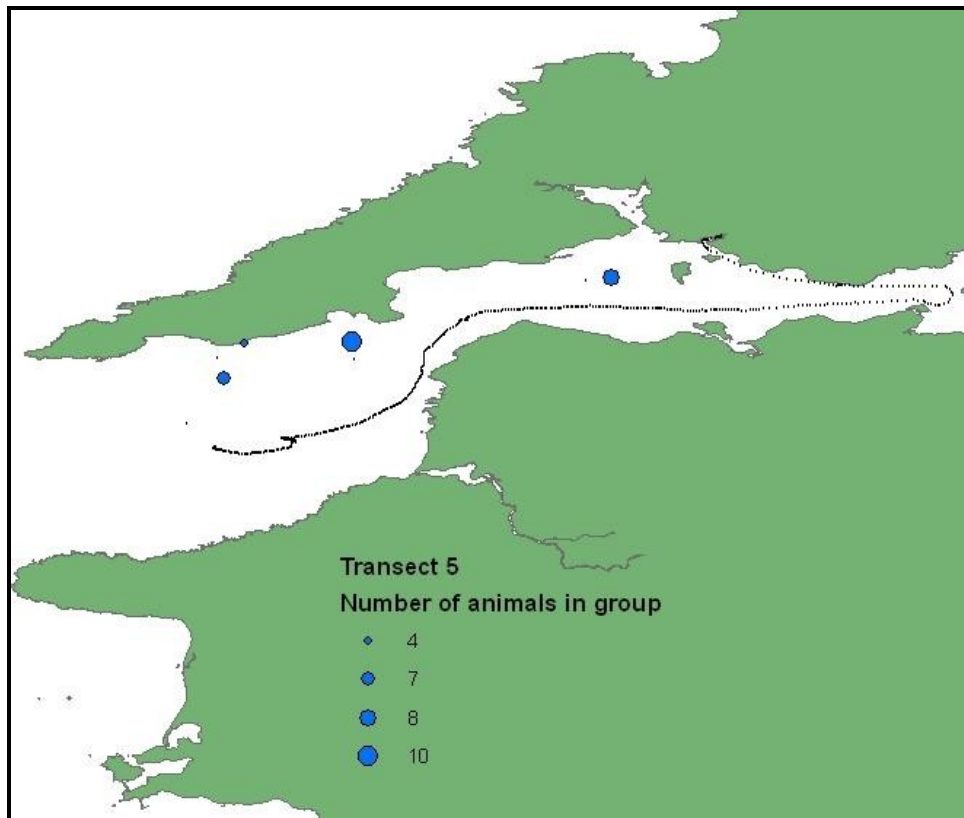
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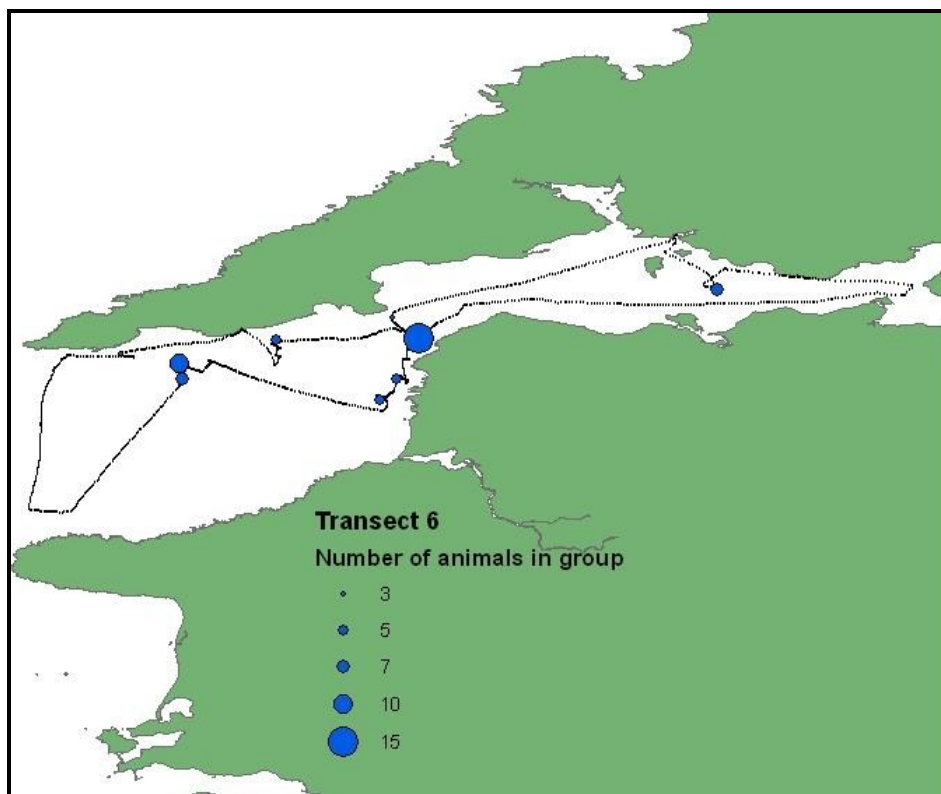
Appendix I: Track-lines and locations of sighting encounters during the Bottlenose Dolphin SAC Survey 2010.

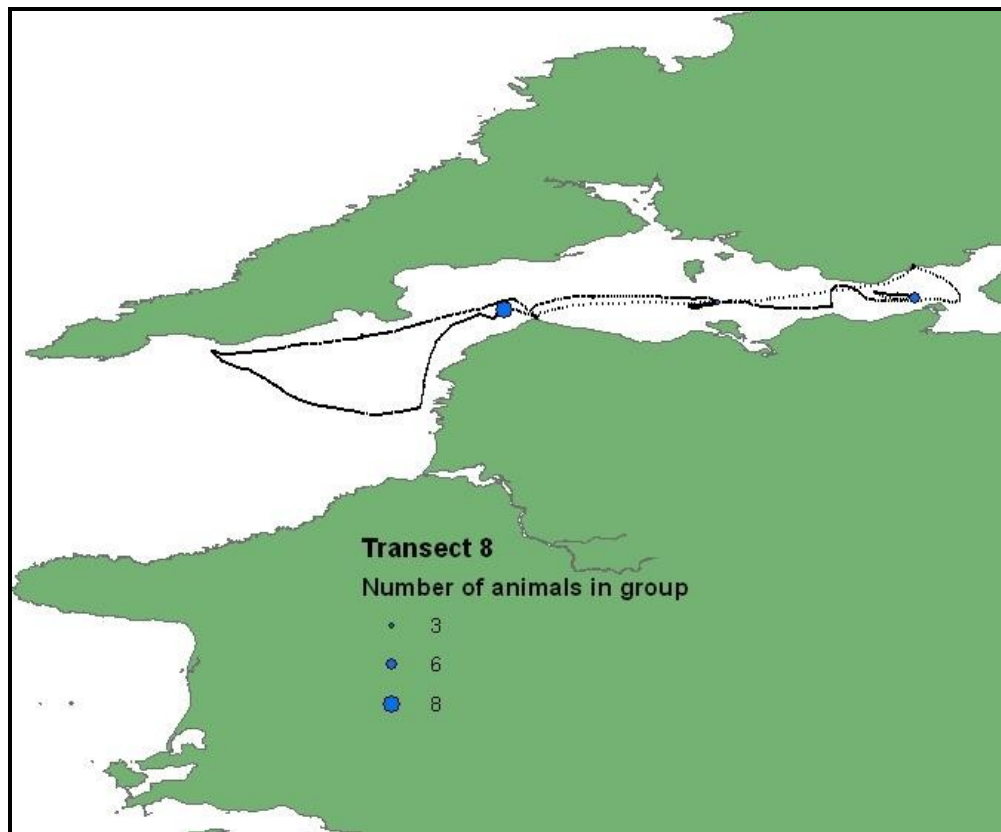
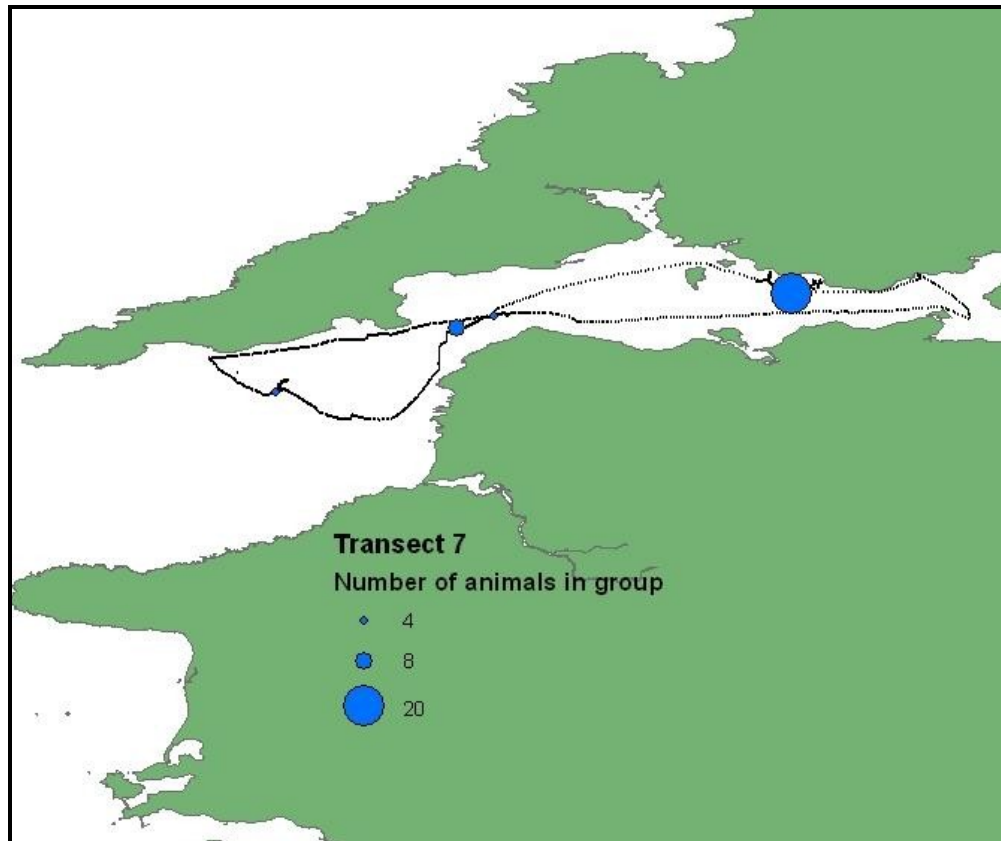


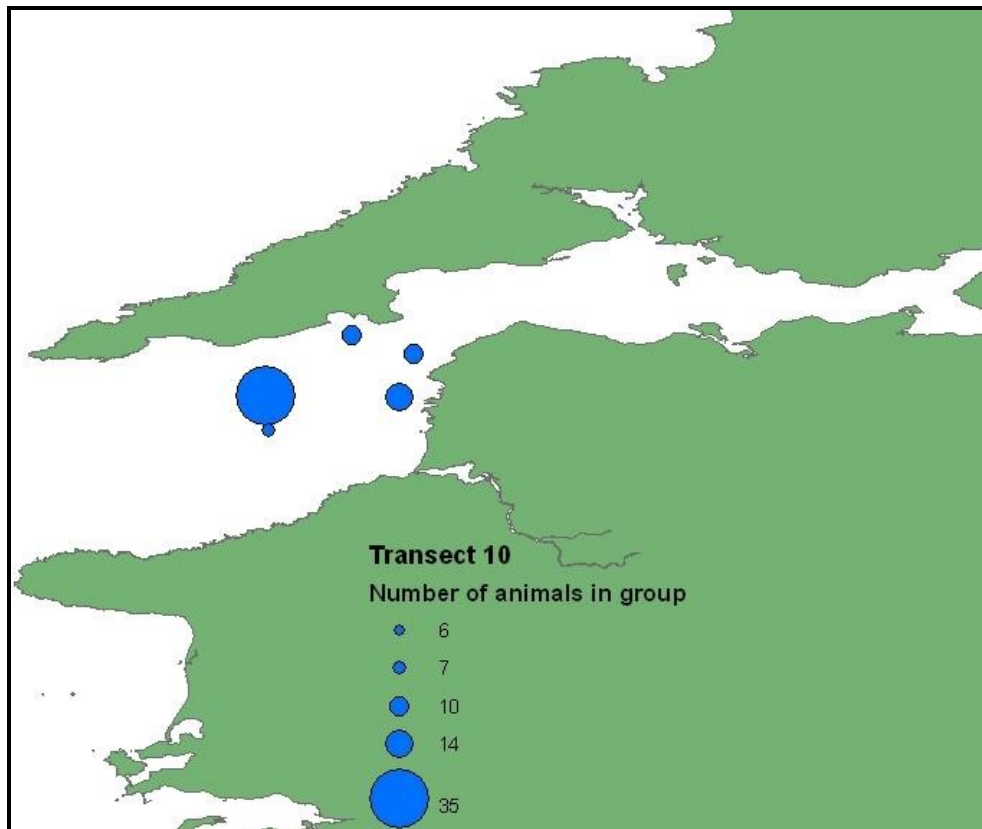
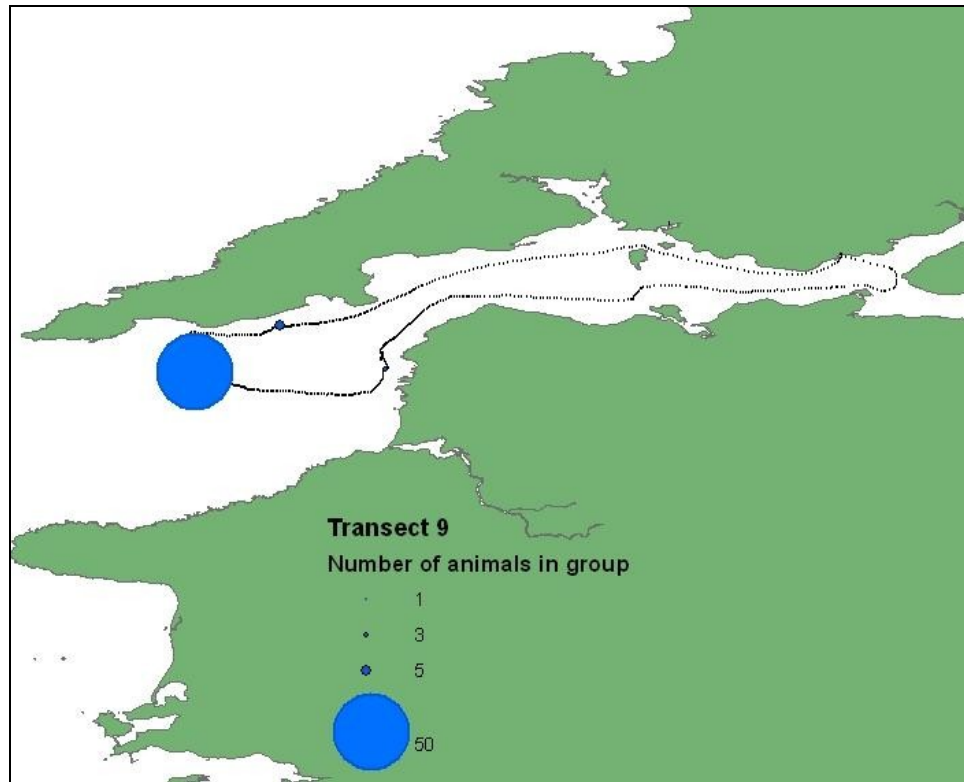




Note: GPS failed for some of the transect







Note: GPS failed but position recorded from boat GPS. Track-line as above

