

**Site assessment of the waters of northwest Connemara.
A survey of bottlenose dolphins (*Tursiops truncatus*).**



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Abstract

This study examined the distribution, site fidelity and abundance of bottlenose dolphins using the waters of northwest Connemara during 2008-9. In total, 21 photo-identification boat surveys were conducted between Clare Island in the North of the study area and Mannin Bay in the South. Bottlenose dolphin schools were encountered during eight surveys between 1st June and 18th September 2009. All encounters were located close to the mainland coast despite survey effort extending to the open waters between the numerous coastal Islands.

School sizes ranged from 2 to 25 animals with a median school size of 15 dolphins. A minimum of 86 uniquely marked dolphins were identified from photographs of their dorsal fins. On average, catalogued individuals were sighted on 1.6 surveys during the study and four animals were resighted on a maximum of four different days. Intervals between resightings extended the full duration of the study indicating at least seasonal site fidelity in the area.

The dolphins using the waters of Connemara appear to belong to a single, wide ranging coastal community. School membership was mixed, typical of the fission-fusion societies found in other dolphin communities, and all schools were linked by common members. Five dolphins were previously identified from surveys around Connemara in 2001 to 2003 and 10 catalogued dolphins were known from surveys at other coastal sites from Youghal to Donegal.

Using a sightings matrix of marked animals from high quality photo-identification data a mark-recapture model was used to calculate an estimate of abundance. 171 ± 48 (se) dolphins were estimated to be using the survey area during June to September 2009. The estimate is imprecise with a large coefficient of variation (CV) of 0.28, and a 95% confidence interval of 100-294. The point estimate indicates that these animals comprise the largest community of animals known to use Irish waters and exceed the number of animals estimated to use the Shannon estuary, Ireland's only bottlenose dolphin SAC.

Despite the number of animals encountered, no neonates were observed during surveys. Three animals with acute spinal deformities were repeatedly seen in the survey area, two of which have been known in Connemara since 2001 and 2002.

1. INTRODUCTION

1.1 Bottlenose dolphins

Bottlenose dolphins (*Tursiops truncatus*) are found worldwide in temperate and tropical waters. They are one of 24 species of cetacean found in Irish waters (Berrow and Rogan, 1997; Ó Cadhla *et al.*, 2004; Wall *et al.*, 2006). Bottlenose dolphins are a relatively robust dolphin with a short beak - hence the name "bottlenose". The colour of the bottlenose dolphin is generally dark slate to light grey on the upper part of the body shading to lighter sides and pale grey or white on the belly (Plate 1). They exhibit sexual dimorphism, with males growing larger than females. Females reach sexual maturity at approximately 10 years of age (Sergeant *et al.*, 1973) and give birth to a single calf, approximately 1m in length, after a gestation period lasting 12 months (Leatherwood & Reeves, 1983).



Plate 1: A bottlenose dolphin photographed in Connemara waters in 2009

1.2 Conservation Status

Bottlenose dolphins are listed in Annex II of the EU Habitats Directive and are protected in Ireland under the Irish Wildlife Acts of 1979 and 2000. To date, only one Special Area of Conservation (SAC) has been designated for bottlenose dolphins in Irish waters, in the lower Shannon estuary.

1.3 Distribution in NE Atlantic waters

In Europe, resident communities of bottlenose dolphins are widely distributed throughout Atlantic coastal waters from the Moray Firth in Scotland, Cardigan Bay in Wales, Brittany and Normandy in France and the Sado Estuary in Portugal (Arnold, 1993; Dos Santos & Lacerda, 1987; Liret *et al.*, 1998; Wilson *et al.*, 1999; Liret, 2001; Baines *et al.*, 2002; Kiszka *et al.*, 2004; Pesante *et al.*, 2008). In addition to these coastal communities, sightings from dedicated surveys and platforms of opportunity (e.g. SIAR, SCANS 2, CODA) show that bottlenose dolphins are widely distributed in the NE Atlantic shelf and shelf edge waters and in the deeper waters of the Rockall Trough, and on the Rockall Bank (Figure 1) (Reid *et al.*, 2003; Hammond *et al.*, in review; CODA, 2008).

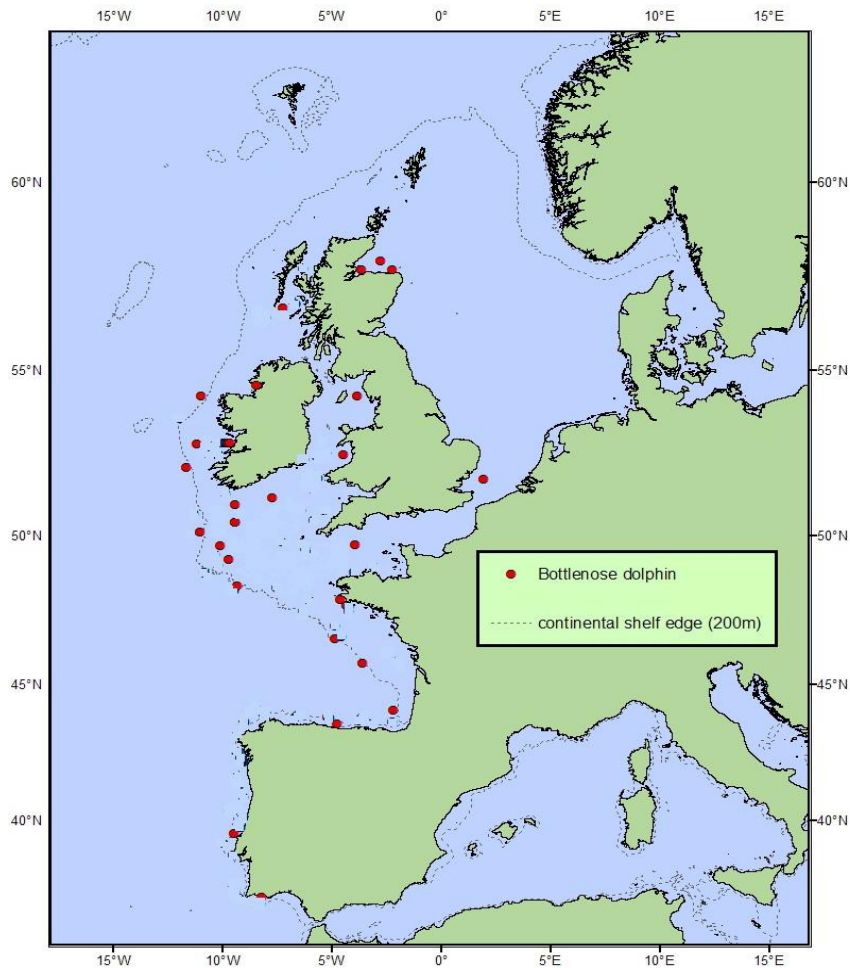


Figure 1. The location of observations of bottlenose dolphins during SCANS 2 survey (adapted from Hammond *et al.*, in review).

For management and conservation measures to be effective it is vital that up-to-date information on the population sizes, ranging patterns and spatial and temporal variations in abundances are obtained. Such information is essential for detecting and understanding trends in population numbers, changes in distribution and habitat use, and the effects of human activities on these populations. This information is also necessary for determining what management actions are required and the effectiveness of any actions implemented.

Bottlenose dolphins, especially coastal animals, are subjected in many parts of their range, to anthropogenic disturbances from a wide variety of sources, including contaminants, boat traffic (commercial, recreational and dolphin watching vessels), habitat deterioration, noise, fisheries, inshore and coastal development. Mortalities associated with interactions with fisheries, harmful algal blooms and disease outbreaks have also been reported in parts of their range. Determining ranging patterns and habitat use are therefore an important part of conservation and management of this species, and an important element in SAC designation.

1.4 Bottlenose dolphins on the west coast of Ireland

Previous survey effort (Ingram *et al.*, 2001, Ingram *et al.*, 2003, O'Brien *et al.*, in press) and casual sightings (www.IWDG.ie) have shown bottlenose dolphins to be a commonly sighted species around Irish coasts.

A well studied, resident population of an estimated 114 to 140 animals are known to occur in the Shannon Estuary (Ingram, 2000; Ingram & Rogan, 2002; Ingram and Rogan 2003; Englund *et al.*, 2007; Englund *et al.*, 2008). The Shannon estuary is used by dolphins year round, with a seasonal increase in numbers during summer months (Ingram, 2000, Englund *et al.*, 2007). In addition, the Shannon is an important breeding area, with small numbers of neonates recorded each year, from May – November. There is also a high degree of site fidelity, with some animals recorded on an almost annual basis in the Shannon since 1996.

Recent studies have indicated some degree of site fidelity at several other locations on the west and south coasts, including the waters of Connemara, Co. Galway; Cork Harbour; Kenmare River and Brandon Bay, Co. Kerry; Donegal Bay; and Broadhaven Bay, Co. Mayo (Ingram *et al.*, 2001; Ó Cadhla *et al.*, 2003; Ingram *et al.*, 2003; Ryan, *et al.*, in review). Movements of bottlenose dolphins across national boundaries have also been reported, with a small number of animals sighted in Ireland also reported in Scotland and Cornwall (O’Brien *et al.*, in press; Ryan *et al.*, in review).

1.5 Previous surveys of bottlenose dolphins in Connemara

Previous studies, using dedicated photo-identification surveys of bottlenose dolphins in Connemara waters were conducted during 2001, 2002 and 2003. This survey effort was funded during 2001 and 2003 by Heritage Council Wildlife Grants (Ingram *et al.*, 2001 & 2003) and by the National Parks and Wildlife Service in 2003 (Ingram & Rogan, 2003). Details of the survey effort & photo-identifications are given in Table 1.

Table 1. Summary of survey effort and photo-identification data from surveys in northwest Connemara in previous years.

Date	Number of schools encountered	Number of dolphins identified
15 Jul 2001	2	8
16 Jul 2001	0	-
9 Aug 2001	0	-
20 Sep 2001	1	8
19 Sep 2002	1	50
20 Sep 2002	2	19
21 Sep 2002	1	26
24 Aug 2003	0	-
27 Sep 2003	1	20
28 Sep 2003	0	-

Dolphins were encountered on 60% of boat surveys and all dolphin schools were encountered close to the coast between Killary Harbour and Mannin Bay (Figure 2).

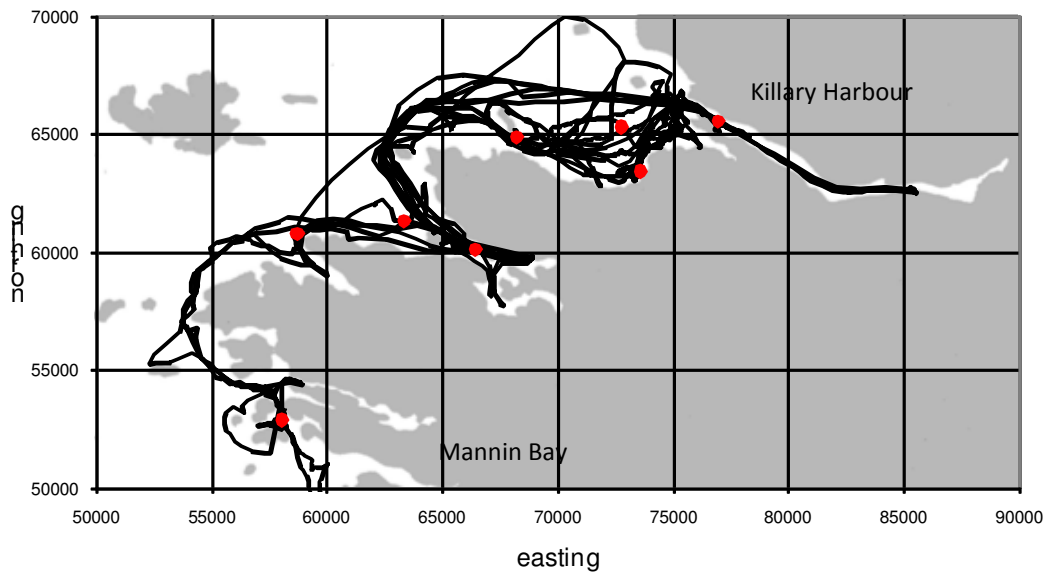


Figure 2. Survey tracks and the locations of bottlenose dolphin schools encountered during surveys conducted in 2001, 2002 and 2003.

Following multiple encounters and identifications of a minimum of 45 dolphins in 2001 and 2002, during 2003, dedicated watches and moored acoustic detectors (T-PODS) were used to provide extended data on the presence of bottlenose dolphins in the waters from Killary Harbour to Mannin Bay (Figure 2). This area was clearly of importance to bottlenose dolphins and re-sights of animals between years indicated a degree of inter-annual site fidelity. Acoustic and shore watch data showed that dolphins remained in the area for extended periods of time. Acoustic detectors were installed at three locations in the survey area; the entrance to Ballynakill Harbour; Crump Island, Renvyle; and Inishbarna at the entrance to Killary Harbour. Out of 115 days of acoustic surveillance during June to October 2003, there were 66 different days with acoustic detections. These data indicated a presence of dolphins during at least 57% of days surveyed at these three sites and since the combined area of surveillance amounted to only approximately 5km³ the actual value is likely to have been much higher within the larger study area. Acoustic surveillance data showed that dolphins remained in the area for extended periods rather than simply transiting

through, and the longest period of continuous detections lasted for 23 days (Ingram *et al.*, 2003)

1.6 Aims of this project

The aims of this project were to:

- i) conduct a minimum of eight photo-identification surveys in the waters of northwestern Connemara between Clare island and Mannin Bay;
- ii) to establish whether bottlenose dolphins using the waters of Connemara belong to a discrete coastal community of animals or are part of a larger pelagic population;
- iii) to estimate the abundance of bottlenose dolphins using this coastal area;
- iv) compile a photo-identification catalogue of animals encountered in the Connemara waters;
- v) compare photo-identification images with previous images to examine site fidelity and long-term habitat use.

2. METHODS

2.1 Boat based photo-identification surveys

Dedicated photo-identification boat surveys were conducted using a 6m rigid hull inflatable (RIB) in September 2008 and between June 1st and September 30th 2009. The surveys followed two standardised routes (one north and one south) covering the waters between Clare Island and Mannin Bay (Figure 3).

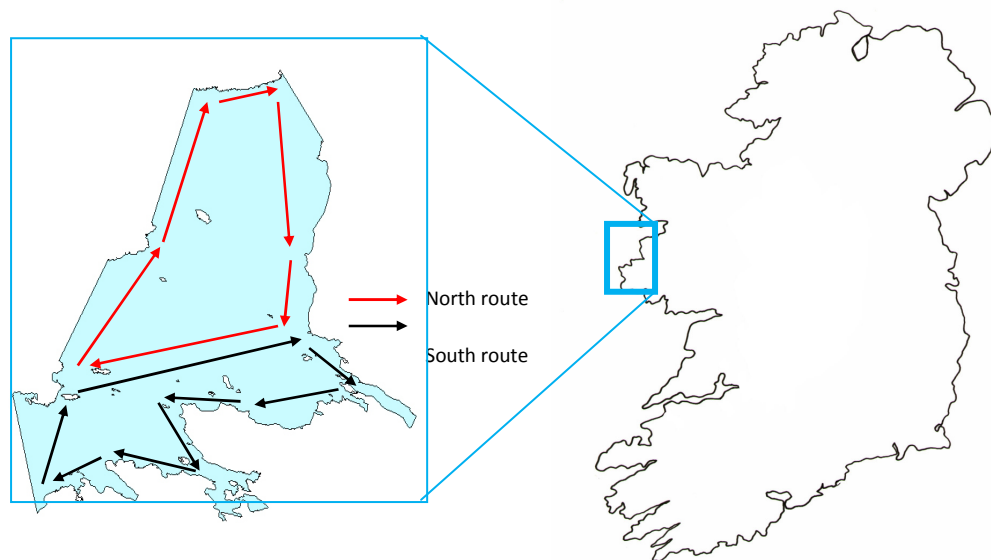


Figure 3. The location of the study site showing the generalised survey routes.

Survey speed was maintained at approximately 20km/hr for the duration of the surveys, with a reduction in speed during encounters with dolphins. Surveys were conducted in Beaufort sea-states <4, with suitable ambient light and swell conditions, in order to minimise the effect of weather and sea conditions on the probability of sighting dolphins and obtaining high quality photographs. If weather conditions deteriorated during a survey, the survey was abandoned.

During surveys a continuous watch was kept for dolphins, and survey routes were followed until dolphins were encountered. A dolphin school was defined ‘as all dolphins within a 100m radius of each other’ (Irvine *et al.*, 1981) and hereafter encounters refer to periods of data collection whilst with dolphin schools. When sighted, dolphins were approached slowly and carefully, minimising speed and direction changes to reduce disturbance, and attempts were made to photograph all school members. GPS coordinates were recorded at the beginning of encounters, the number of animals present was estimated and the presence of juveniles, calves and neonates was also recorded. The behaviour of dolphins towards the survey vessel was monitored and recorded including any signs of distress or evasive behaviours. If strong avoidance behaviours, for example aggressive approaches or rapid avoidance, were observed, the survey protocol was to suspend the encounter and to avoid approaching within 50m of dolphins 5 minutes. The protocol was to terminate an encounter if such avoidance behaviours were repeated on resuming the encounter.

Dolphin identification photos were taken perpendicular to the dorsal fin and within a distance of <20m of the animal, using an auto-focus digital SLR camera (Canon EOS 1DS mark II) with a 70-200mm f2.8 telephoto zoom lens. Each encounter continued until all animals had been photographed, preferably from both sides, or until the school was lost. Following the end of an encounter the survey route was resumed.

2.2 Photograph analysis

The best photographs of each side of every dolphin identified from each encounter were selected and the quality of these photographs was scored from 1 to 4 (Table 2) with no consideration to the degree of marking of the individual. Selected photographs were then matched between encounters and surveys and with the archive catalogue of known dolphins maintained by UCC since 1996. When a match was made, the selected photographs were renamed with the appropriate catalogue number and added to the archive. If a match was not found in the archive the animal was given a new catalogue number and subsequently added to the catalogue. Since it was not always possible to match left and right identifications and since photographs were

frequently only obtained from one side, there were effectively two separate catalogues of ‘right-side’ and ‘left-side’ identifications.

Table 2: Criteria used to score the quality of all photographs taken of dorsal fins (independent of degree of marking of individuals)

Grade	Criteria
1	Well lit & focused photo taken perpendicular to the dorsal fin at close range
2	More distant & less well lit or slightly angled photo of the fin
3	Poorly lit or to some extent out of focus photo, or photo taken at an acute angle to the fin
4	Poorly focused, backlit or angled photo taken at long distances to the dolphin

2.3 Severity of identifying marks

Individual bottlenose dolphins can be identified using their natural marks. These marks mostly consist of scars and nicks from interactions with conspecifics and include permanent marks, such as deep nicks on the trailing edge of the dorsal fin, as well as other types of marks, which may or may not be permanent, such as fin shape, scratches or skin lesions on the dorsal fin, flank or peduncle. Some of these marks may last for several years, thus remaining useful for long-term identification of an individual, while others may fade and heal within a relatively short period of time. Animals acquire marks with time and younger animals are added to the catalogue of known individuals as they gain distinguishing scars or nicks. Long-term, regular dedicated survey effort is required to ensure that individuals’ changing marks are recorded accurately. In this study, catalogued dolphin fins were graded from 1 to 3 according to the severity of their markings (Plate 2).



a)

b)

c)

Plate 2: Examples of dolphin dorsal fins photographed in 2009 showing the three grades of mark severity used in analysis: a) grade 1 marks, consisting of significant fin damage or deep scarring that were considered permanent; b) grade 2 marks, temporary markings that consisting of deep tooth rakes and lesions, with only minor cuts present; c) grade 3 marks, consisting of superficial rake marks and lesions.

In addition to marks on the dorsal fin, some animals during this study presented with unusual skeletal features, such as spinal deformities, likely a form of scoliosis, and mis-aligned jaws. These features were also used for individual recognition (Plate 3).

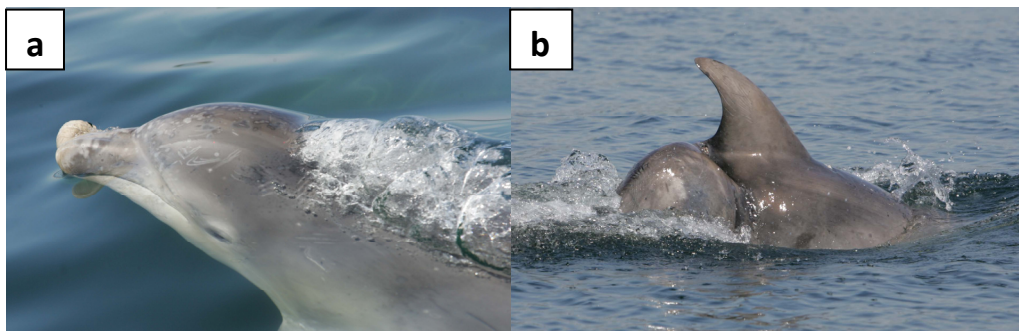


Plate 3: Photographs of a) a bottlenose dolphin with a mis-aligned upper jaw and b) spinal abnormality

2.4 Capture-recapture analysis

Photo-identification data was used to model dolphin abundance in the Connemara waters surveyed using the 'mark-recapture' software CAPTURE (Rexsted and Burnham, 1991). Such multiple survey 'sighting-resighting' estimates depend on the following assumptions (Otis *et al.*, 1978; Seber, 1982):

1. The population is closed for the duration of sampling
2. Animals do not lose their identifying marks during the sampling period
3. All marks are correctly recorded in each sighting
4. Each animal has an equal and constant sighting probability

The first assumption refers to geographic and demographic closure in which there is no immigration or emigration in the population or changes due to birth or death or change of marking during the course of sampling. The short duration of the sampling period (June to September) and exclusion of calves from the analysis reduces the probability of violating this assumption. In addition we examined the social structure of the encountered schools to evaluate whether the dolphins identified appeared to belong to a single intermixing community.

Using identifications based on animals' natural markings risks violating assumptions two and three because of the differences in the severity of markings between individuals, making some members of a population more easily recognised than others (Gunnlaugsson & Sigurjonsson, 1990). Additionally, incorrect matches may result from poor photographic quality or comparison of insufficiently marked individuals. In order to reduce the likelihood of such matching errors, poor quality photographs (lower than score 3) and poorly marked grade 3 animals (Plate 1) were excluded from capture-recapture analysis.

Only data relating to sightings of animals recognisable from both their left and right sides were included in the analysis to prevent over inflation of the estimate due to duplicates of dolphins who's left and right sides were not linked in the database.

Consequently, the dolphins included in the mark-recapture analysis represent a ‘marked’ subset of the animals using the Connemara waters surveyed. Each individual included in the subset is considered sufficiently marked to enable identification from all selected photographs from either the left or right side.

2.5 Proportion of marked dolphins

Since the data set used for the estimate is restricted to well-marked animals recognisable from both sides and does not include poorly marked individuals, the capture estimates were subsequently increased according to the proportion this marked subset of animals represented in the whole population. All identifications were examined in order to derive the proportion of dolphins that belonged to the marked subset used in the ‘mark-recapture’ analysis. This proportion was calculated by comparing the total number of identifications from good quality photographs (quality grade 1, 2 or 3) of all dolphins with the number of identifications of dolphins from the marked subset (after Wilson *et al.*, 1999). The following formula was used to increase the estimates according the proportion of marked animals in the population:

$$N = \frac{N_{\text{hat}}}{\theta}$$

where; N = estimated total population size, N_{hat} = estimate of the subset of marked animals, θ (theta) = proportion of the population with identifiable markings.

The variance of the total estimate (varN) was obtained using the delta method as follows:

$$\text{varN} = N^2 \times \frac{\text{varN}_{\text{hat}}}{N_{\text{hat}}^2} + \frac{1 - \theta}{n \theta}$$

2.6 Long term site fidelity and ranging behaviour

We integrated the identification data collected during this study with an existing catalogue and database of dolphins identified during previous surveys conducted by the authors in Irish

coastal waters since 1996. These data include identifications resulting from 36 dedicated bottlenose dolphin surveys conducted in several west coast sites between Killybegs, Co. Donegal to Youghal, Co. Cork as well as an extensive data set from over 100 surveys conducted in the lower Shannon Estuary SAC since 1996. Using these data we were able to examine ranging behaviour and long term site fidelity within northwest Connemara waters and movement between different coastal sites. These data also provided indications of mixing between dolphin groups encountered between sites and between years.

3. RESULTS

3.1 Survey effort

A total of 21 surveys were conducted during the project, four during September 2008 and 17 between June and September 2009, details of which are presented in Table 3. All of these surveys followed one or both of the generalised survey routes described above (see Figure 3), with the exception of one survey conducted on the 16th September 2009 which was conducted in the waters immediately to the South and East of Slyne Head in response to a sighting report of bottlenose dolphins in that area in the preceding days. A total of 130 hours were spent on the water (Figure 4).

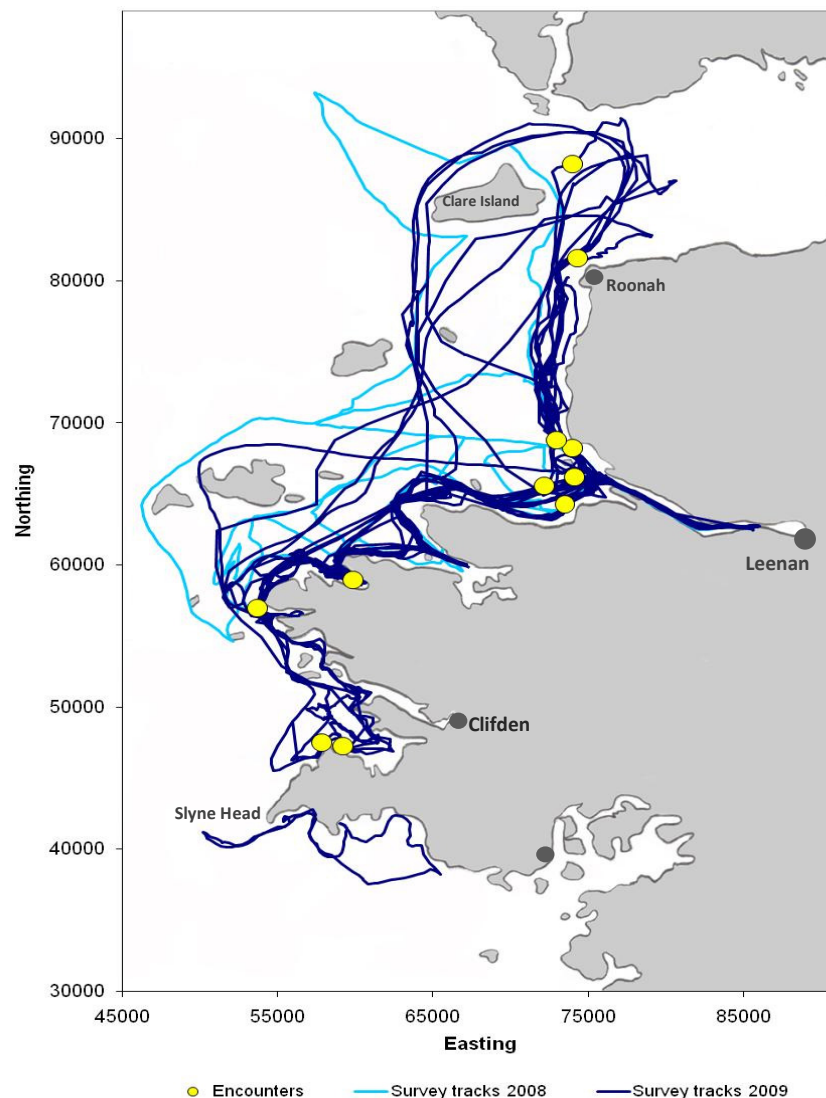


Figure 4. Map showing all survey GPS tracks completed during the study and the location of encountered bottlenose dolphin schools (yellow circles). The axes show metric OSI easting and northing.

3.2 Encounters with dolphin schools

Survey effort resulted in a total of 11 encounters with bottlenose dolphin schools recorded on 8 survey days, and no dolphins encountered on 11 days of full survey effort (Table 3). School sizes ranged from 2 to 25 individuals (Table 3) with a median school size of 15. Five encounters included more than 20 individuals and there were no encounters with lone animals (Table 3). A total of 20 hours were spent with dolphins during encounters. A number of other cetacean species were encountered during surveys in 2008 and species and sighting locations are given in Appendix 1.

3.3 Distribution of encountered dolphin schools

Encounters with bottlenose dolphins were distributed throughout the survey area but were concentrated within approximately 1km of the mainland coast (Figure 4).

Table 3. Summary of survey effort and encounters (* denotes incomplete surveys which were cut short due to deteriorating conditions).

Survey date	Survey route	Number of encounters	Field estimates of school sizes	Number of dolphins identified
19/09/08	South *	0	-	-
24/09/08	South	0	-	-
25/09/08	North and South	0	-	-
26/09/08	South	0	-	-
01/06/09	South	1	20	17
02/06/09	South	1	20	17
03/06/09	South	1	10	11
04/06/09	South *	0	-	-
22/06/09	North	2	25, 25	53
23/06/09	North & South	0	-	-
24/06/09	North & South	1	10	8
29/06/09	North & South	0	-	-
07/08/09	North	0	-	-
12/08/09	North & South	3	15, 10, 2	28
13/08/09	North & South	0	-	-
10/09/09	North & South	0	-	-
11/09/09	South	1	2	0
12/09/09	South	0	-	-
16/09/09	South	0	-	-
17/09/09	South	0	-	-
18/09/09	North & South *	1	20	9

3.4 Results of photo-identification analysis

A total of 1174 photographs taken during encounters yielded 149 identifications of a minimum of 86 uniquely marked dolphins. This minimum value is derived by counting all dolphins known from both sides with all dolphins known only from the right side and those dolphins only known from their left side with distinctive trailing edges. This minimum estimate avoids double counting dolphins with unmatched identifications from the left and right side (there were more dolphins known only from their right sides than from only their left, see Table 4).

In total, there were 97 catalogued dorsal fins (corresponding to the maximum number of identified dolphins if none of the left-only dolphins correspond with the right-only dolphins). Out of these 97 catalogued dorsal fins, 25 had permanent (grade 1) marks, 42 had temporary (grade 2) marks and 30 had superficial (grade 3) marks. Out of the 86 dolphins identified, a total of 61 dolphins were identifiable from both sides of their dorsal fin, 15 were identified from their left and 36 from their right side (Table 4).

Table 4. Number of dolphin dorsal fins identified from their left side, right side and from both sides. These identifications were made from high quality photographs. The degree of mark severity of identified dolphins is also shown.

Side	Mark severity			Totals
	Permanent marks	Temporary marks	Superficial marks	
Both	15	25	6	46
Left	1	7	7	15
Right	9	10	17	36
Totals	25	42	30	97*

* note the minimum estimate is less than the totals presented here due to animals having separate left and right side entries in the catalogue.

3.5 Disturbance of dolphins during encounters

No evidence of evasive behaviour was noted during the surveys in 2008 or 2009. If weak avoidance behaviours were noted the survey team moved away from the encountered group for 5 minutes and did not observe any continuation of such behaviours when the encounter was resumed. Total encounter durations ranged between 10 and 322 minutes with a median duration of 78 minutes.

3.6 Sightings of juveniles, calves and neonates

Juveniles are defined as subadults <two-thirds the size of adults, calves (≤ 1 year) and neonates (<1 month old) were recognised due to their smaller size, the presence of foetal folds or lines and their close association with a larger animal assumed to be the mother.

Five calves/juveniles estimated to be at least one year old were identified during all surveys. Interestingly, no neonates were sighted in any of the schools encountered during this study.

3.7 Recruitment of marked dolphins

The rate at which well-marked individuals were recruited into the marked subset ('discovered') was maintained throughout the study as shown in a discovery curve below (Figure 5). This indicates that the population was significantly larger than our sampled subset and as the number of 'new' individuals continues to increase, it suggests that new animals were being detected using the area and that the animals were likely ranging well beyond our surveyed area during sampling. The dataset used in capture-recapture analysis included 77 sightings of 47 marked individuals.

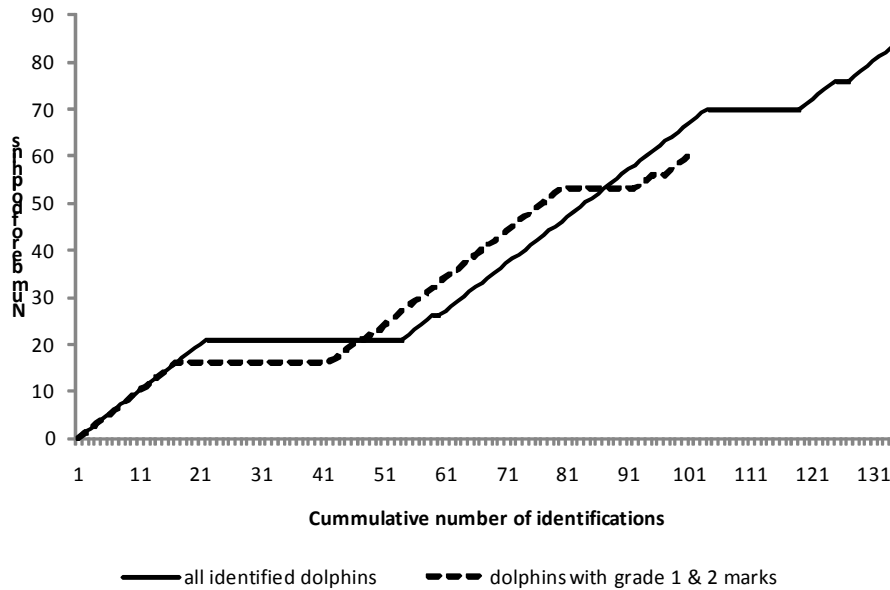


Figure 5. Plot showing the cumulative number of individuals identified with increased survey effort during 2009. The dashed line shows recruitment of the more strongly marked animals into the catalogue to reduce the effects of missed matches of poorly marked dolphins over the duration of the survey period.

3.8 Estimate of the number dolphins using the survey area

Photo-identification data from the eight surveys with encounters were used in a mark-recapture procedure. A total of 77 high quality images of 47 well-marked individuals recognisable from both sides (approximately 60% of the dolphins encountered) were used to construct a presence/absence sightings matrix for all surveys. This matrix was used to estimate the abundance of marked dolphins using model M_{th} (Chao *et al.*, 1992) within the dedicated software programme CAPTURE (Table 5). Model M_{th} was chosen due to its tolerance of sources of heterogeneity in capture probabilities between individual animals and between surveys. The resulting estimate (Table 6) was inflated according to the proportion of all identifications represented by marked dolphins (θ) to give an estimate of 171 ± 48 (se) $CV=0.28$, $95\% CI= 100-294$ using the surveyed waters of north-western Connemara during June to September 2009.

Table 5. Estimate of abundance of dolphins using the waters of northwest Connemara during June to September 2009 where n = number of identified marked dolphins, s = number of sightings of marked dolphins, N_{hat} = estimated total number of marked dolphins, θ = proportion of marked dolphins in the sampled population, N = estimated total abundance, se = standard error of the estimate, CV = coefficient of variation of the final estimate.

n	S	N_{hat}	θ	N	Se	CV	95% CI
47	77	118	0.69	171	48	0.28	100-294

Table 6. The proportion of marked dolphins (grade 1 and 2 markings) in the sampled population. Theta (θ) is the proportion of all identifications which are of the marked subset of dolphins.

Total number of ids	Number of ids of marked animals	Proportion of animals with marks, theta (θ)
112	77	0.69

3.9 Resightings of dolphins during the survey period

The mean individual resighting rate of all marked animals included in the abundance estimate was 1.64, and ranged from 32 animals seen only once, to 5 animals seen on 4 surveys (Figures 6, 7). Of all identified dolphins from all photographs there were 52 resightings in total. Of these, 32 occurred on surveys conducted on the following days; however some animals were resighted over the entire study period indicating a degree of site fidelity of these animals within a single summer.

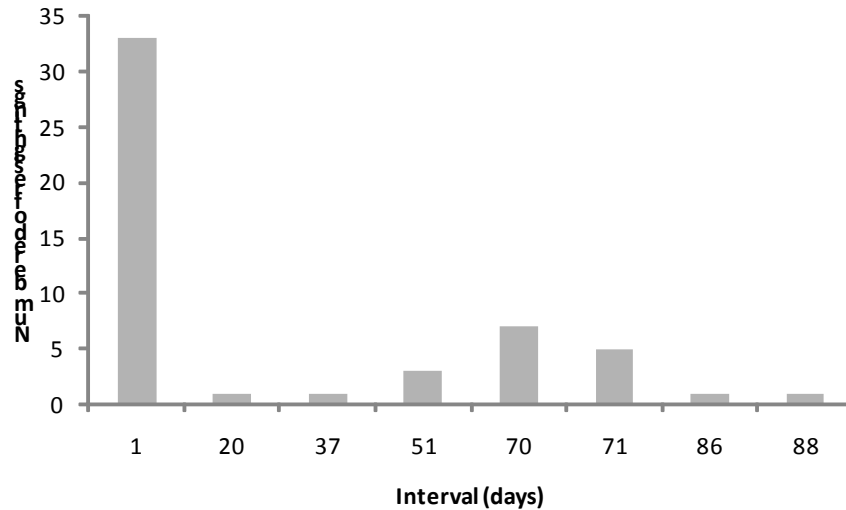


Figure 6. The number of days between subsequent resightings of individually identified dolphins.

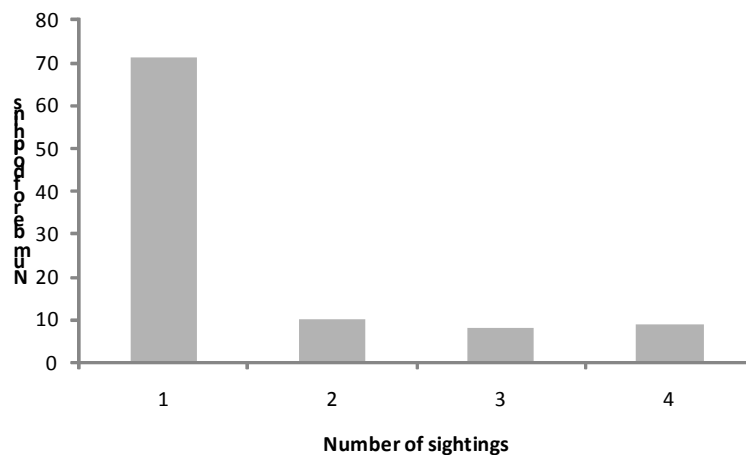


Figure 7. The sighting frequency of individually identified dolphins.

3.10 School structure and mixing between schools

The membership of dolphin schools changed between encounters with only encounters on the 1st and 2nd of June being comprised of the same dolphins. Importantly, all schools shared at least one member with other encountered schools (Figure 8) indicating that all dolphins encountered during surveys belonged to the same socially integrated community/sub-population.

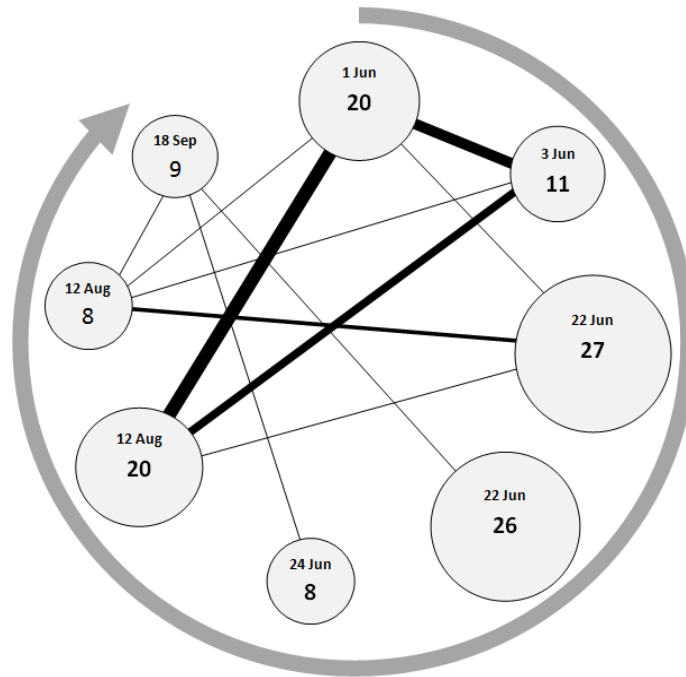


Figure 8. A sociogram showing school membership of all identified dolphins in schools encountered during the study. Each circle represents an encountered school with the date of the encounter and the number of individuals identified. The size of the school is represented by the size of the circle. The links between the circles denote shared school members and the weight of these links represents the number of shared school members. The grey circle represents the progression of time through the survey period.

3.11 Site fidelity and long range movement patterns

Of all dolphins identified during 2009, 10 were previously catalogued dolphins. Of these 10 dolphins, five had been sighted in previous years in Connemara and seven had been identified during surveys of different coastal sites. These resightings demonstrate the large scale ranging movements of some of the dolphins using the Connemara coast from Cork to Donegal and also illustrate a degree of long term site fidelity to Connemara waters with previous sightings of some animals in 2001 and 2002. Of interest is an encounter of four animals in Broadhaven Bay, Co. Mayo on the 14th September which included two animals subsequently resighted in a school of 9 dolphins in Connemara four days later. No dolphins recorded during surveys reported here are known from the Shannon estuary photo-identification catalogue.

Table 7. Dolphins recorded in Connemara in 2009 and in other years and at other coastal sites (* denotes dolphins with spinal deformities).

Year	Location	Catalogue number									
		1037	1067	1084	1087	1099*	1094	1131	1153*	1274	1277
2009	Connemara										
2003	Connemara										
2002	Connemara										
2001	Connemara										
2009	Broadhaven Bay, Mayo										
2005	Cork Harbour										
2004	Kenmare River										
2003	Cork Harbour										
2002	Youghal										
2001	Donegal Bay										

3.12 Dolphins with spinal malformations

Of note was the presence of three animals with spinal abnormalities (id #1099, #1153 and #1185). These animals tended to show a swelling posterior to the dorsal fin, usually accompanied by a lateral deflection of the spine. These animals were adults and all appeared to be in good health and travelled amongst other dolphins during encounters. These individuals were seen on a number of occasions in this region during 2009 and two of these dolphins (id # 1153 and 1099) were first sighted in Connemara during surveys in 2002 and one (#1099) was sighted in 2003 (Table 7). These sighting histories indicate the relatively long term survival and site fidelity of these deformed animals. Although uncommon, Berrow and O'Brien (2006) reported the occurrence of a similar dolphin with scoliosis in Galway Bay in 2005 and an additional bottlenose dolphin calf with scoliosis was identified during UCC surveys of the Shannon estuary in 2002 and 2003 but apparently did not survive weaning.

4. DISCUSSION

4.1 Survey effort and encounter rate

In total, 130 hours of effort were spent conducting 21 surveys during September 2008 and between June and September 2009. No sightings of bottlenose dolphins were made during surveys conducted during September 2008. Bottlenose dolphin schools were encountered during eight of these surveys amounting to approximately 50% of the 17 surveys conducted during 2009. This encounter rate is similar to survey results in this area during previous years indicating that the site is used inter-annually at a consistent level of intensity. In total, eleven schools of between 2 and 25 dolphins were encountered with a median school size of 15. School sizes were on average larger than those encountered during surveys in the Shannon where the median school size is approximately 6 animals (Englund *et al.*, 2008).

4.2 Use of Connemara as breeding area

There were no neonatal calves observed in schools encountered during these surveys. This is surprising given the numbers of animals using this site and the timing of field effort during the breeding season for Irish bottlenose dolphins (Ingram, 2000). Five young animals were observed accompanied closely by an escorting adult, and were likely ≤ 1 year old.

4.3 Population closure inference from photo-identification data

It is important to understand the integrity of the population or community of dolphins being sampled during surveys such as this. The west coast of Ireland is close to European pelagic shelf and offshore waters inhabited by an estimated 19,295 (0.25 CV) bottlenose dolphins (CODA, 2008). During this study it was important to ascertain whether the animals using Connemara waters represent inshore migrations of this large pelagic population of Atlantic animals or constitute a discrete coastal community. Population closure affects the choice of abundance estimation model and also has implications for future management and monitoring. Photo-identification provides detailed knowledge at an individual scale and provides inference on the social structure and cohesion of the population. The number of dolphins identified from photographs during surveys reported here continued to rise throughout the study (Figure 5) indicating that the population size was considerably larger than the identified sample. In addition, the absence of dolphins on 70% of all surveys indicates that dolphins were ranging beyond the limits of the survey area. However, 27% of all identified dolphins (regardless of mark severity) were resighted on more than one survey (Figure 7) and nine dolphins were seen on four different days. The mean sighting frequency of marked dolphins (grade 1 and 2 marks) was 1.65 sightings per individual. Furthermore, resightings of identified dolphins occurred throughout the duration of the project with some animals identified on the first and last encounters, a

period of 88 days between sightings (Figure 6). These results indicate a degree of site fidelity of individuals, with individual animals moving into and out of the survey area during the study period. The individuals all appear to belong to a socially mixing community (Figure 8) with all schools connected by shared membership of one or more members to other encountered schools. If the animals using the coastal area of Connemara belonged to a large pelagic population we would expect no, or very low numbers of, resightings and some encounters with schools comprised of entirely unknown individuals.

4.4 Abundance of dolphins using the waters of northwest Connemara

Satisfied that the sampled population did not violate population closure assumptions, we selected a multiple survey mark-recapture model using the programme CAPTURE tolerant of between-animal and between-survey capture probability heterogeneity. This closed capture-recapture model resulted in an estimate of $171 \pm 48(\text{se})$ bottlenose dolphins using the waters of northwest Connemara during June to September 2009. The estimate has a relatively large cv of 0.28 and a 95% confidence interval of 100-294. The imprecision of this estimate is most likely due to the number of surveys without encounters and hence the relatively low number of identifications together with the continued recruitment of individuals into the photo-identification throughout the study. Connemara is clearly used by a large number of animals and the estimate exceeds all previous estimates of the number of bottlenose dolphins using the lower Shannon SAC (Ingram, 2000; Ingram and Rogan, 2003; Englund *et al.*, 2007, Englund *et al.*, 2008).

4.5 Site fidelity and ranging behaviour

In addition to resightings of individual dolphins in multiple surveys conducted during 2009, six individuals were encountered during previous surveys of Connemara conducted during 2001, 2002 and 2003. Mark changes over time confound long term photo-identification matches but the identification of these animals over a period of up to 8 years indicates a degree of long term site fidelity amongst at least some of the dolphins using Connemara waters.

Bottlenose dolphins are highly mobile animals and may cover hundreds of kilometres in a few days. The large range size of animals using Connemara is illustrated by matches of seven dolphins identified in Connemara during 2009 in other sites during the current and previous years (Table 7). Two of the dolphins identified in Connemara in 2009 were also sighted in Broadhaven Bay on the 14th September 2009 and one of these animals was subsequently identified again four days later after returning to Connemara (Table 7). These long-distance movements of bottlenose dolphins between sites in Ireland (excluding the Shannon) have also been reported by O'Brien *et al.* (in press) and Ryan *et al.*, (in review).

4.6 Population structure

Despite patchy survey coverage and relatively few photographic data, identification matches between sites and between years indicates a highly mobile community or sub-population of animals use the coastal waters of western Ireland. Interestingly, none of the dolphins sighted in other coastal locations have ever been recorded in over 100 surveys conducted in the lower Shannon Estuary since 1996. This indicates social segregation between these communities and early results of recent molecular genetics work show a degree of reproductive isolation also exists between Shannon dolphins and animals using other areas of the west-coast (Mirimim, in prep.). Analysis of biopsy samples taken from dolphins using the waters of Connemara during 2009 may improve this understanding but further data are necessary from future biopsy effort and strandings retrieval to adequately explore stock structure of bottlenose dolphins in Irish waters.

4.7 Distribution of encounters and suitable areas for SAC designation

The estimate of $171 \pm 48(\text{se})$ dolphins using the waters of north-western Connemara is considerably larger than all previous estimates of the abundance of dolphins using the Shannon SAC. However, none of the dolphins using Connemara, or any other coastal location surveyed, appear to use the lower Shannon SAC and are therefore offered no protection from current designations. Clearly there is a strong case for designating an additional coastal SAC outside the Shannon for bottlenose dolphins and the waters of north-western Connemara are used frequently by a considerable number of animals that appear to represent a discrete coastal community. Whilst the dolphins surveyed in this study range far more widely than the waters of Connemara, the area surveyed appears to represent a suitable site for SAC designation. All dolphin schools encountered during surveys conducted in 2001-2003 and 2009 were located within a kilometre or two of the mainland coast. An SAC consisting of a coastal strip of water less than 5km wide between Slyne Head in Co. Galway and Roonagh in Co. Mayo would accommodate almost all recorded sighting locations. An SAC of this size in this location could be monitored using coastal boat surveys. These waters are relatively shallow and would also be suitable for acoustic monitoring with an array of moored detectors (cPODS). Such an SAC could protect animals in at least part of their coastal range as dolphins travelling north-south along the west-coast between Donegal, Mayo to Galway Bay and the waters of Clare, Kerry and Cork coast are likely to pass through this inshore area. Slyne Head, Aughross Point and Renvyle Point are promontories that dolphins will pass close to as they follow the coast. In addition, Killary Harbour, Cleggan Bay and Ballynakill Bay are frequently visited by passing dolphins and acoustic surveillance resulted in detections over extended periods of time at these sites (Ingram *et al.*, 2003).

4.8 Site monitoring

Previously, we modelled the effects of survey effort and photo-identification data on resulting abundance estimates using data from Shannon surveys (Englund *et al.*, 2008). Detecting population change is essential if conservation status is to be accurately reported. Ideally, survey effort should target cv values of less than 0.15 in order to provide estimates with precision levels necessary for detecting medium term population changes. Mean recapture frequencies of identified individuals below $\cong 2$ leads to high cv values and reduced estimate precision (Englund *et al.*, loc. cit.). Clearly, in order to estimate the abundance of dolphins in Connemara more precisely using photo-identification data, more survey effort would be required, increasing the effort and expense of monitoring studies. Survey effort for this study was considerable less than usually used to estimate the numbers of dolphins using the Shannon SAC which is a smaller more discrete area with higher dolphin encounter rates. Because there are more animals using Connemara and the encounter rate per survey was lower, in order to gain levels of estimate precision consistent with Shannon estimates considerably more survey effort would be required than currently calculated for Shannon. A relatively small SAC covering the coastal strip where encounters were located in this and previous studies would increase survey sightings rate and improve survey efficiency. Monitoring may also be improved by combining photo-identification surveys with acoustic monitoring. These methods could be used in combination to produce a more accurate picture of the use, distribution, occupancy rate and abundance of the site than either of these methods alone. Deployment of acoustic detectors has yielded useful data in past studies in Connemara (Ingram & Rogan, 2003). These data give an indication of the occupancy of selected areas of the site by dolphins over extended periods and provide useful measures of site use. They could also provide information on seasonal use of the area and in particular winter use.

In summary, we suggest that if the site is designated, for monitoring purposes that:

- i) the site be confined to a narrow coastal strip;
- ii) a power analysis be conducted to ascertain the number of photo-identification trips required to obtain suitably precise abundance estimates with a low coefficient of variation;
- iii) a year round acoustic monitoring programme be put in place to assess occupancy rates year round, and to provide information on winter site use;
- iv) genetic sampling and analysis be continued in order to examine population structure in this area and the wider area of NW Ireland.

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Appendix 1 Location of other cetacean sightings encountered during surveys in 2008. No other cetacean species were encountered during 2009.

