

Stephanie Levesque
(corresponding
author: salevesq@
gmail.com), Shannon
Dolphin and Wildlife
Foundation,
Merchants Quay,
Kilrush, Co. Clare,
Ireland; Irish Whale
and Dolphin Group,
Merchants Quay,
Kilrush, Co. Clare,
Ireland; Katharina
Reusch, Shannon
Dolphin and
Wildlife Foundation,
Merchants Quay,
Kilrush, Co. Clare,
Ireland; Isabel Baker,
Joanne O'Brien, and
Simon Berrow,
Shannon Dolphin
and Wildlife Founda-
tion, Merchants
Quay, Kilrush, Co.
Clare, Ireland; Irish
Whale and Dolphin
Group, Merchants
Quay, Kilrush, Co.
Clare, Ireland;
Marine and Fresh-
water Research
Centre, Galway-
Mayo Institute of
Technology, Dublin
Road, Co. Galway,
Ireland.

Cite as follows:
Levesque, S., Reusch,
K., Baker, I., O'Brien,
J. and Berrow, S.
2016 Photo-Identifi-
cation of Bottlenose
Dolphins (*Tursiops
truncatus*) in Tralee
Bay and Brandon
Bay, Co. Kerry:
A Case for SAC
Boundary Extension.
*Biology and
Environment:
Proceedings of
the Royal Irish
Academy* 2016. DOI:
[http://dx.doi.org/
10.3318/BIOE.2016.
11](http://dx.doi.org/10.3318/BIOE.2016.11)

Received 5 May 2016.
Accepted 19 October
2016.
Published 29 November
2016.

PHOTO-IDENTIFICATION OF BOTTLENOSE DOLPHINS (*TURSIOPS TRUNCATUS*) IN TRALEE BAY AND BRANDON BAY, CO. KERRY: A CASE FOR SAC BOUNDARY EXTENSION

**Stephanie Levesque, Katharina Reusch, Isabel Baker,
Joanne O'Brien and Simon Berrow**

ABSTRACT

The Lower River Shannon is a Special Area of Conservation (SAC) with bottlenose dolphins (*Tursiops truncatus*) as a qualifying interest, and is one of only two SACs for this species in Ireland. Bottlenose dolphins in the Shannon Estuary are present year-round and genetically discrete from other populations in Ireland. They have regularly been reported from Tralee Bay and Brandon Bay, Co. Kerry, adjacent to the Lower River Shannon SAC boundary. In order to determine the provenance of these dolphins, photo-identification data collected between 2008 and 2016 from both bays were used to identify individuals and match them to existing bottlenose dolphin catalogues in Ireland. Bottlenose dolphins were observed on over 90% of the 13 trips carried out, with photo-identification data collected on 11 of these trips. A total of 70 individual dolphins were identified, of which 67 have been regularly recorded within the Lower River Shannon SAC, confirming them to be from this population. Shannon dolphins represented an average of 98% of dolphins photographed during each survey. Of the estimated 108 individual adult dolphins extant in the Shannon population, 62% were identified in Brandon Bay and/or Tralee Bay during the study period. A discovery curve of individuals identified did not reach a plateau, suggesting that not all dolphins occurring in these bays were photographed during the study. Results suggest that these areas are of high importance to the Shannon dolphin population and support the need to extend the current boundary of the Lower River Shannon SAC to include Brandon Bay and Tralee Bay.

INTRODUCTION

Bottlenose dolphins (*Tursiops truncatus*) are widespread in Irish coastal waters and are particularly abundant along the western seaboard (Berrow *et al.*, 2010). Three genetically discrete populations have recently been described in Ireland; one resident in the Shannon Estuary, one inshore or coastal population and one offshore population (Mirimin *et al.*, 2011; Louis *et al.*, 2014). The coastal population is highly mobile with resightings of the same individuals reported all around the Irish coast, including Northern Ireland (O'Brien *et al.*, 2009), with some individuals also reported from Scotland and England (Ryan *et al.*, 2010; Robinson *et al.*, 2012).

European member states under the European Union Habitats Directive are required to designate Special Areas of Conservation (SACs) for bottlenose dolphins to protect a representative range of habitats used by this species. The Lower River Shannon SAC (Site Code 002165) was designated in 2000 and

includes bottlenose dolphins as a qualifying interest, particularly the Shannon Estuary's resident population. The West Connacht Coast SAC (Site Code 002998) was designated in 2013 solely for bottlenose dolphins and covers an area from North Mayo to West Galway.

SACs, which incorporate marine habitats or species, can be considered as Marine Protected Areas (MPAs). The International Union for Conservation of Nature (IUCN) defines an MPA as 'a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values' (IUCN, 2012). In order for the MPA to be an effective conservation tool, its boundaries must reflect the biological needs of the focal species (Wilson *et al.*, 2004). Managers must have a thorough knowledge of a population's entire distribution in order to allow for the development of successful management and monitoring programmes (Hastie *et al.*, 2003).

Monitoring programmes may assist in identifying distribution patterns and thus provide vital information to support and advise management decisions (Hastie *et al.*, 2003). Furthermore, they may aid in the identification of critically important habitats, which consist of ‘functioning ecological units required for successful breeding and foraging’ (Harwood, 2001) whose existence are vital for the species to persist (Jax *et al.*, 1998). In addition to key feeding and breeding sites, critical habitats also include important migration corridors and should be prioritised when considering the placement of MPAs (Hooker and Gerber, 2004). In more recent years, conservation efforts regarding marine species have begun to focus more on the protection of these areas (Agardy, 1994).

MPAs must be large enough to provide suitable protection for the species, yet small enough to allow for effective management of anthropogenic activities within their borders (Ashe *et al.*, 2010). Potential threats to the species within the area must be evaluated in the initial stages of MPA development, and regulations established for how these threats will be managed (Hooker and Gerber, 2004). The management of the Lower River Shannon SAC has been successful in modifying human behaviour through requiring consent for any activity occurring within its boundaries which may have a negative

impact on the bottlenose dolphin population (SIFP, 2013).

Current evidence suggests that the population of bottlenose dolphins in the Shannon Estuary is restricted to the estuary and genetically discrete from the inshore population (Mirimin *et al.*, 2011). These Shannon dolphins have rarely been recorded outside of the estuary with the furthest report coming from Sauce Creek, Co. Kerry, *c.* 30km to the west of Kerry Head (Fig. 1) (Montagu, 1821). There are regular reports of bottlenose dolphins to the north of the Shannon Estuary from Kilkee Bay, Doonbeg Bay and Lahinch Bay, Co. Clare and to the south from Tralee Bay and Brandon Bay, Co. Kerry (Fig. 1) (Berrow *et al.*, 2010) although it is not known if these are Shannon dolphins or members of the inshore population. It is essential to determine which population they are from and the range of the Shannon population outside the SAC boundary, which extends between Loop Head and Kerry Head (Fig. 1).

Although it is generally considered that bottlenose dolphins in Tralee Bay and Brandon Bay in North Kerry are most likely from the Shannon population, there have been no studies to validate this hypothesis or to establish their occurrence and use of the bays. The present study used photo-identification

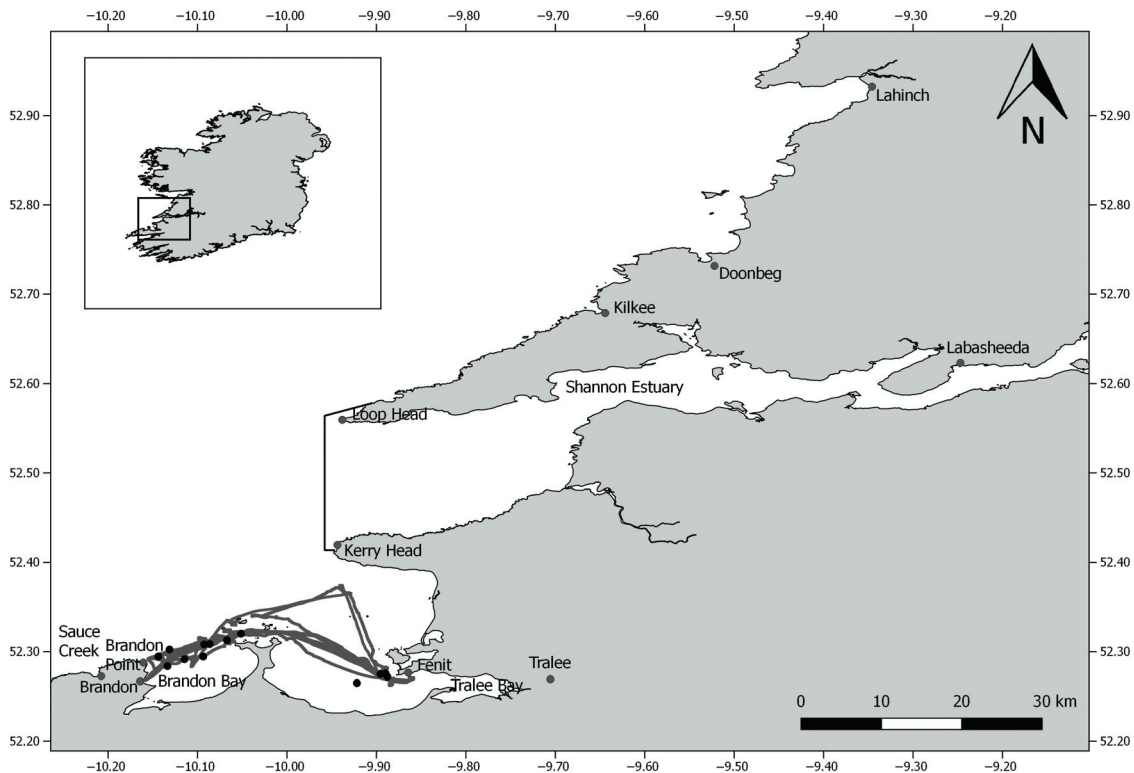


Fig. 1—Bottlenose dolphins are seen regularly from Doonbeg Bay, Kilkee Bay and Lahinch Bay, although no studies have been done to discern which population they are from. Some individuals seen in Brandon/Tralee were also observed as far east as Labasheeda Bay; a distance of 100–120km. Study area is shown with group sightings (black points) and survey tracklines. The black line between Loop Head and Kerry Head represents the boundary of the Lower River Shannon SAC.

PHOTO-ID OF BOTTLENOSE DOLPHINS

(photo-ID) data to discern if dolphins occurring in Brandon Bay and Tralee Bay are indeed part of the Shannon population.

Photo-ID is a non-invasive method of monitoring individuals in a wild population that relies upon the presence of unique markings on the animal (Würsig and Jefferson, 1990). This technique has been widely used in the study of a range of cetacean species worldwide (Berrow *et al.*, 2012) and was first applied to bottlenose dolphins by Würsig and Würsig (1977). Bottlenose dolphins are a suitable species for photo-ID as they frequently acquire markings such as nicks and notches, located primarily on the dorsal fins, allowing them to be identified as unique individuals. This method allows for individual dolphins to be monitored over time and can provide useful information regarding life histories, habitat preferences, distribution, movements, behaviour and associations (Hammond *et al.*, 1990; Kerr *et al.*, 2005).

The Shannon Dolphin and Wildlife Foundation (SDWF) has been collecting images of dolphins in the Shannon Estuary since 1993 (Berrow *et al.*, 1996). Over this period, they have built up a photo-ID catalogue of 204 individual dolphins recognisable by unique markings on their dorsal fins. The best estimate of the current population size according to SDWF records is 136 individuals (108 adults, 28

calves). Due to the availability of long-term data on the population, all individuals in the catalogue can be identified when resighted as any changes in appearance have been tracked over time—a prime example of the value of long-term monitoring. This allows researchers to identify animals that otherwise may be considered too poorly marked for re-identification and result in the loss of data on the population.

The aim of this study was to survey Tralee Bay and Brandon Bay in an attempt to locate and photograph bottlenose dolphins in order to determine if they were from the Shannon population by comparing them to individuals from the SDWF catalogue. In doing so, we hoped to provide evidence that these bays are regularly used by the protected Shannon bottlenose dolphin population and represent important habitats that should be included as part of the Lower River Shannon SAC.

MATERIALS AND METHODS

STUDY AREA

Tralee Bay and Brandon Bay in Co. Kerry are located 20–30km southwest of the mouth of the Shannon Estuary (Fig. 2). Eight dedicated surveys departing from and returning to Fenit, Co. Kerry (Fig. 2) were carried out in the bays onboard Celtic Mist, a

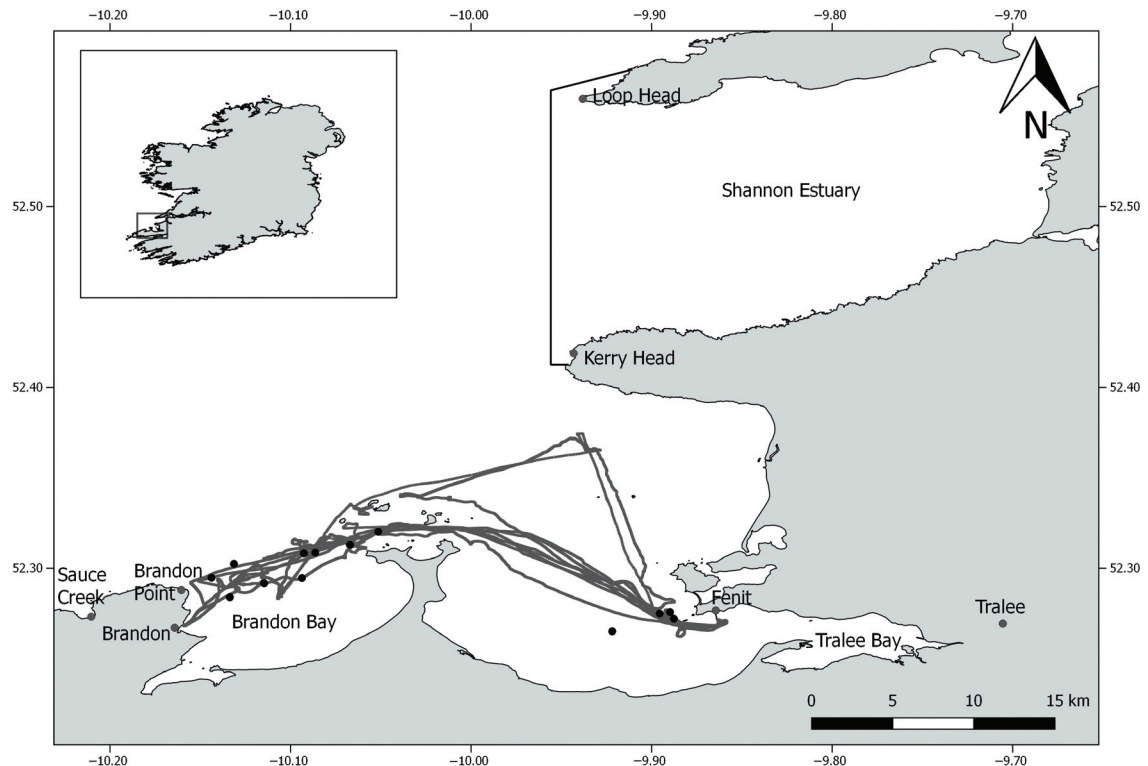


Fig. 2—Brandon Bay/Tralee Bay study area with group sightings (black points) and tracklines from opportunistic and dedicated bottlenose dolphin surveys. The black line between Loop Head and Kerry Head represents the boundary of the Lower River Shannon SAC. See Table 1 for GPS sighting and trackline trip details.

17m sailing yacht with a 360hp caterpillar diesel engine, in search of bottlenose dolphins from 18 May to 25 August 2013 (Berrow and O'Brien, 2013). Efforts were made to conduct surveys on days with favourable sea conditions, i.e. 5km visibility or more and Beaufort Sea State 2 or less. During dolphin encounters, Marine Notice No. 15 of 2005 was adhered to as the vessel remained on a steady course travelling parallel to the animals at a speed of no more than 7 knots (Maritime Safety Directorate, 2005).

Survey tracks were chosen in such a way as to maximise chances of locating dolphins using local knowledge and past experience rather than to provide equal coverage of the area. Most of the survey effort was concentrated in Brandon Bay (Table 1) as the encounter rate with bottlenose dolphins was higher than elsewhere and collection of photo-ID data was a critical aspect of this study. For our purposes this was acceptable as the survey aim was not to estimate abundance but to locate as many dolphins as possible. Upon encountering a group of dolphins, a best estimate of group size was recorded as well as the presence of any calves. Groups were defined using McHugh's (2011) definition: 'All animals sighted at one time moving in the same general direction, engaged in similar activities, or interacting with each other within a radius of approximately 100m'. Whenever possible, attempts were made to photograph all individuals in the group in order to obtain images suitable for photo-ID.

In addition to these dedicated surveys, images of dolphins collected opportunistically while carrying out other activities in the bays were available to this study and used to identify individual dolphins (Table 1).

PHOTO-IDENTIFICATION

Photo-ID data were collected from a variety of platforms and equipment including Canon EOS D20 and EOS 7D cameras with Canon EF 70–200 F USM lenses. Images obtained from dedicated boat surveys and opportunistic sightings between 2008 and 2016 were processed by the SDWF using their standard protocol (Baker, 2015) in an attempt to recognise individual dolphins.

Two SDWF observers graded images on photo quality using a Q-scale (1–3) based on criteria described by NOAA (2011). Grade 1 images were of excellent quality, Grade 2 images were of average quality and Grade 3 images were of poor quality. Quality was graded by taking into account factors such as image focus/clarity, contrast, angle of the dorsal fin, proportion of the fin visible in the frame and proportion of the frame filled by the fin. Only images of Grades 1–2 were deemed suitable for photo-ID and used for analysis in order to reduce the risk of error. Calves and poorly marked juveniles were excluded from analyses.

Photos were then analysed to determine how many different dolphins were present during each survey and compared to images in the SDWF catalogue to see if individuals could be matched. Photographs were considered a match if the markings on the dorsal fins provided enough evidence to show beyond any doubt that the two were of the same dolphin. Dolphins which could not be matched to the SDWF catalogue were then compared to images in the Irish Whale and Dolphin Group's (IWDG) Coastal Bottlenose Dolphin Catalogue.

One photograph of each unique dorsal fin was then cropped using Microsoft Paint and allocated to one of two categories; A or B. Category A included

Table 1—Summary of trips used in the present study including the date, location of survey, survey type and if photo-ID and GPS data were available.

<i>Date</i>	<i>Tralee/ Brandon</i>	<i>Survey Type</i>	<i>Photo ID</i>	<i>GPS sighting location</i>	<i>GPS trackline</i>
17 Sept 2008	B	Opportunistic Sea	Yes	No	No
22 Jun 2009	B	Opportunistic Sea	Yes	Yes	No
18 May 2013	T*	Dedicated Sea	No	No	No
19 May 2013	T,B	Dedicated Sea	Yes	Yes	Yes
25 May 2013	T	Dedicated Sea	Yes	Yes	Yes
22 Jul 2013	T,B	Opportunistic Sea	Yes	Yes	Yes
07 Aug 2013	T,B	Dedicated Sea	Yes	Yes	Yes
17 Aug 2013	B	Dedicated Sea	No	No	No
22 Aug 2013	B	Dedicated Sea	Yes	Yes	Yes
24 Aug 2013	T,B	Dedicated Sea	Yes	No	Yes
25 Aug 2013	B	Dedicated Sea	Yes	No	No
07 Sep 2015	B	Dedicated Land	Yes	No	No
05 Aug 2016	B	Opportunistic Land	Yes	Yes	No

*No dolphins were observed on this day

dolphins that were identified as Shannon dolphins after being matched with an individual in the SDWF catalogue. Category B included images of dolphins that were given a Brandon unknown (BRUNK) ID code. These photos were of sufficient quality to be used for photo-ID but were unable to be matched to any dolphin in the SDWF catalogue.

Dorsal fins in categories A and B were then given a score from 1 to 3, reflecting the severity of their markings based upon criteria used by Berrow *et al.* (2012):

- *Grade 1:* Marks consisting of significant fin damage or deep scarring that were considered permanent
- *Grade 2:* Marks consisting of deep tooth rakes and lesions with only minor cuts present
- *Grade 3:* Marks consisting of superficial rakes and lesions

Grade 3 animals were included in the final analysis as the longitudinal data on the Shannon population allowed us to confirm if individuals, although poorly marked, were in the Shannon catalogue.

RESULTS

Bottlenose dolphins were sighted on seven of the eight dedicated surveys from 2013, revealing a very

high encounter rate. One survey (18 May 2013) failed to locate dolphins; this was most likely due to unfavourable changes in sea conditions that day (Beaufort Sea State 3–4). Most sightings occurred in Brandon Bay, as that was where the majority of the surveys were carried out, with two sightings of three and four individuals recorded just off Fenit in Tralee Bay.

Photo-ID data were collected during six of the dedicated surveys carried out in 2013 as well as from four additional opportunistic boat-based trips, one each in 2008, 2009, 2013 and 2016, and during a land-based watch in 2015, resulting in photo-ID data available from eleven separate occasions (Table 1). No photo-ID data were collected on 17 August 2013 due to the large minimum distance (> 800m) the dolphins remained from the vessel.

A total of 156 identifiable dolphins were photographically captured throughout the 11 encounters resulting in the identification of 70 unique individual dolphins. The number of individual dolphins captured per trip ranged from one to 34 (M: 14.2, SD: 9.6) (Table 2). Of the 70 individual dolphins photographed, 96% (n = 67) were matched to the SDWF catalogue indicating that they have also been recorded on a regular basis within the boundaries of the Lower River Shannon SAC and are therefore considered Shannon dolphins. Shannon

Table 2—Trip number, group number and estimate, total number of individuals identified per trip, number of animals in category A (identified as Shannon dolphins), percentage of class A dolphins out of total IDs, number of animals in category B (unable to be identified as Shannon dolphins) and percentage of class B dolphins out of total IDs.

<i>Trip no.</i>	<i>Group no./estimated group size in the field</i>	<i>Total no. individuals identified per trip</i>	<i>A</i>	<i>% of total identified</i>	<i>B</i>	<i>% of total identified</i>
1	G1. 20	14	14	100	0	0
2	G1. 30	28	27	96	1	4
3	G1. 2	1	1	100	0	0
4	G1. 15	15	15	100	0	0
5	G1. 2	17	17	100	0	0
	G2. 12					
6	G1. 4	34	33	97	1	3
	G2. 60					
7	G1. 6	6	6	100	0	0
8	G1. 15	11	11	100	0	0
9	G1. 10	11	11	100	0	0
	G2. 10					
10	NA	6	5	83	1	17
11	G1. 20	13	13	100	0	0
	G2. 7					
<i>Total</i>	213	156	153	98	3	2
<i>Mean</i>	15.2	14.2	13.9	98	0.27	2
<i>STDEV</i>	15.1	9.6	9.3	5	0.46	5

dolphins represented 83 to 100% (M: 98%, SD: 5%) of the individuals identified during each trip (Table 2). Sixty-two percent of the SDWF's current adult dolphin population estimate of 108 was identified in Brandon and Tralee Bay.

Of the 67 Shannon dolphins identified, 37% ($n = 25$) were seen during more than one survey. Eight individuals, representing 12% of all identified Shannon dolphins, were sighted on five occasions and one individual was resighted six times. The three BRUNK individuals were sighted only once (Fig. 3). Of the 67 Shannon matches, 37 individuals have been sighted 10 or more times in the Shannon Estuary since 1993 and 11 individuals have been sighted more than 5 times—a strong indication that dolphins recorded in Brandon Bay and Tralee Bay are part of the Shannon population.

Interestingly, seven of these individuals have also been observed in the inner Shannon Estuary, suggesting that some individuals have a large home range which extends as far east as Labasheeda Bay, Co. Clare and as far west as Kerry Head/Brandon Bay/Tralee Bay (a distance of 100–120km) (Fig. 1). Two individuals sighted in both Brandon and the Shannon were first sighted in the estuary in 1993. Of the dolphins identified between 18 May and 25 August 2013 in Brandon Bay/Tralee Bay, 56% ($n = 27$) were also sighted in the Shannon between 1 May and 1 September 2013, indicating a high level of movement between the areas.

We were unable to match 4% ($n = 3$) of the 70 dolphins identified in this study to dolphins in the SDWF catalogue, which received BRUNK ID codes. None of the dolphins photographed in this study could be matched to the coastal catalogue managed by the IWDG (O'Brien *et al.*, 2009).

When grading the severity of the markings on the dorsal fins, 49% ($n = 33$) of the Shannon

dolphins and 33% ($n = 1$) of the BRUNKS were considered well marked (Table 3) i.e. significant nicks, notches and other identifiable markings such as unique pigmentation, rake marks, algal staining, skin lesions and deformities (PI. I).

A discovery curve where the cumulative number of new individuals was plotted against the cumulative number of identifications did not reach a plateau, suggesting that not all dolphins which occur in Brandon Bay/Tralee Bay were photographed during this study (Fig 4).

DISCUSSION

Gaining an understanding of a target population's entire range is essential for conservation tools such as MPAs to be effective (Weir *et al.*, 2008), especially for mobile marine species like bottlenose dolphins. This understanding has yet to be achieved with regards to the Shannon bottlenose dolphin population. The use of photo-ID as a technique for studying individual dolphins is a very powerful tool that may be used to further explore their distribution. Using this technique, we were able to match individual dolphins photographed in Tralee Bay and Brandon Bay to individuals from the Shannon Estuary, and provide evidence of their regular presence during the summer months. A monitoring programme may be useful in gathering data which could then help us understand how they are using these habitats.

In the Lower River Shannon SAC, the SDWF's long-term monitoring programme of the resident bottlenose dolphin population has provided large amounts of data regarding the identification of key foraging grounds and prey species. In addition, the frequent presence of neonates during

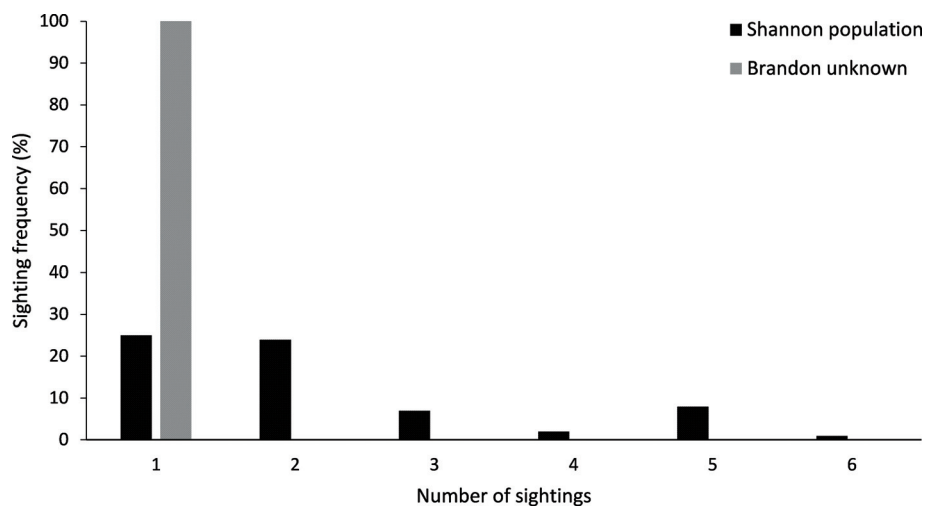


Fig. 3—Sighting frequency (1–6 number of sightings) of individual bottlenose dolphins from the Shannon population ($n = 67$) and Brandon unknown dolphins ($n = 3$) during 11 surveys carried out between 2008 and 2016.

Table 3—Severity (percentage in group) of markings assigned to dolphins identified in this study.

	<i>BRUNKs</i>	<i>Shannon</i>	<i>All</i>
<i>Grade 1</i>	1 (33)	33 (49)	34 (49)
<i>Grade 2</i>	2 (67)	24 (36)	26 (37)
<i>Grade 3</i>	0 (0)	10 (15)	10 (14)
<i>Total</i>	3	67	70

the summer months provides evidence that the Shannon Estuary may also be an important calving area (Baker, unpublished data). Behavioural data were not collected as part of the current study, although 15 different mother-calf pairs from the Shannon population were photographed within Brandon Bay and Tralee Bay, indicating they may also be used as calving or nursing grounds.

Successful long-term management and conservation plans require knowledge of the size, status and spatio-temporal distribution of a population (Evans and Hammond, 2004). An SAC that also includes bottlenose dolphins as a qualifying interest has been designated in the inner Moray Firth, Scotland (Weir *et al.*, 2008). Before its establishment, a number of studies were carried out (Evans, 1992; Mudge *et al.*, 1984; Wilson *et al.*, 1997) to determine where the boundaries of the Moray Firth SAC should be drawn. They were to include the entrances to the firths that were considered important foraging areas. Since designation, Hastie *et al.* (2003) gathered more data on dolphin distribution and habitat use, and confirmed a high level of activity in the small, deep entrances to the firths during the summer months as well as a long-term persistence in the use of these sites (Hastie *et al.*, 2003; MFP, 2001). Incorporating such behavioural data into the development of conservation plans

plays a vital role in the protection of a population (Anthony and Blumstein, 2000).

More recent studies have revealed a possible expansion to the Moray Firth population’s known range with dolphins spending more time outside the SAC boundary (Wilson *et al.*, 2004; Stockin *et al.*, 2006) and have suggested that the designation of a single protected site, the inner Moray Firth SAC, may not provide as much protection as once believed. Weir *et al.* (2008) investigated site fidelity and movements between dolphins photographed in the Moray Firth SAC and those photographed outside the boundaries of the SAC off Aberdeenshire in Scotland. Opportunistic photo-ID data gathered between 1999 and 2008 recorded an extremely high number of matches with dolphins between Aberdeenshire and the Moray Firth SAC with over half of the known northeast Scotland population occurring off Aberdeenshire, suggesting that the majority of dolphins seen in Aberdeenshire were from the population for which the Moray Firth SAC was designated to protect. Weir *et al.* (2008) stressed the importance of the ongoing assessment of a population throughout its entire range and the need for a dynamic approach to defining SAC boundaries (Hyrenbach *et al.*, 2000) in order to examine their long-term effectiveness.

The only other study of cetaceans in Brandon Bay and Tralee Bay was carried out by Ingram *et al.* (2005) as part of a study to explore the feasibility of marine-based tourism. They conducted three boat-based surveys in Tralee Bay and its surrounding waters in September and November 2004, and 25 land-based watches from three vantage points at Brandon Point, Kerry Head and the Maharees peninsula between July and October 2004. Bottlenose dolphins were seen from Brandon Point and Kerry Head on six occasions in groups ranging from

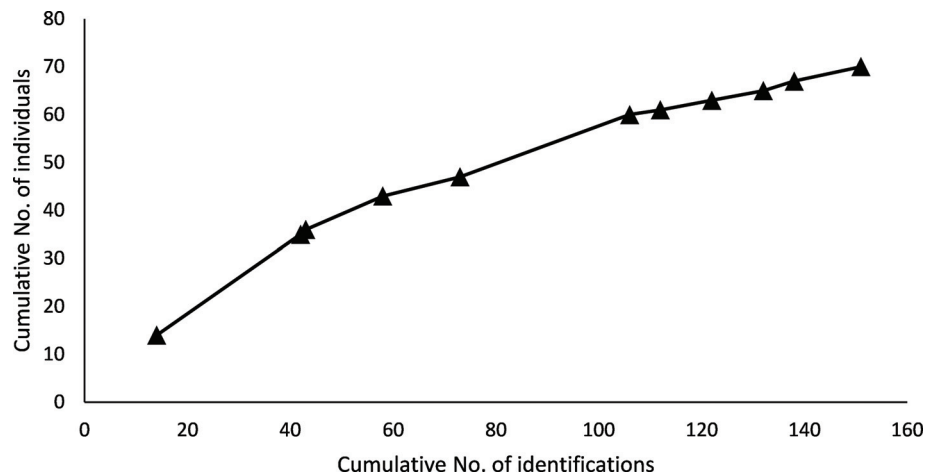


Fig. 4—Discovery curve representing all bottlenose dolphins identified (n = 70) from photo-ID data collected in Brandon Bay/Tralee Bay over the course of 11 trips between 2008 and 2016. The triangles represent the individual trips one to eleven.



PI. 1 - Images of individual ID 086, a well-marked individual assigned a Grade 1 on the marking severity scale, taken during the 2008 GMIT training course in Brandon Bay (left) and in the Shannon Estuary in 2012 (right).

three to fifteen individuals. Sightings during boat-based surveys were limited to a single bottlenose dolphin that was observed on each survey.

In the summer of 2013, a concurrent study carried out static acoustic monitoring in Tralee Bay and Brandon Bay revealing very high dolphin detection rates, especially in Brandon Bay (Murphy *et al.*, submitted), suggesting the regular presence of bottlenose dolphins in the area. Bottlenose dolphins have also been reported outside the summer period, as demonstrated by Ingram *et al.* (2005). They also noted that the dolphins were frequently sighted within the study area by locals. However, it is unknown if these were Shannon dolphins or individuals from the highly mobile inshore population.

The current study represents the largest dataset collected within Brandon Bay and Tralee Bay to determine the origin of the bottlenose dolphins that regularly occur in these areas and provides important information from an understudied area of the Shannon population's range. Photo-ID from eleven different occasions ranging from 2008 to 2016 yielded extremely high numbers of matches to Shannon dolphins, as well as several resightings throughout the duration of the study. These photo-ID encounters also included data from random opportunistic sightings over the years; all providing evidence supporting the hypothesis that the Shannon dolphins are habitually using Brandon Bay and Tralee Bay.

Over half of the current adult individuals in the Shannon Estuary bottlenose dolphin population were identified within Brandon Bay and Tralee Bay over the course of this study, and over half of those sighted during the dedicated 2013 surveys were also seen within the Shannon Estuary around the same time.

This indicates a high level of movement between the two areas, and provides strong evidence that the bottlenose dolphins occurring in Brandon Bay and Tralee Bay are predominantly from the Shannon population.

The Lower River Shannon SAC was designated under the EU Habitats Directive to protect the Shannon dolphin population. Therefore, its boundaries should include areas where these dolphins are known to regularly occur. As the results from this study have shown, the high percentage of Shannon dolphins identified and resighted within the bays over the study period provides evidence that they represent a significant area of the population's distribution. We therefore recommend the boundary of the Lower River Shannon SAC be extended to include both Brandon Bay and Tralee Bay. We also suggest that additional surveys be carried out using a more conventional survey design providing more equal spatio-temporal coverage of the area in order to increase our understanding of the importance and significance of these bays to the Shannon Estuary bottlenose dolphin population.

ACKNOWLEDGEMENTS

We would like to thank North East Kerry Development for funding these surveys in 2013 as part of a marine wildlife training course from which the majority of the data were collected, as well as all those who participated in the course: John Moriarty, Mike O'Neil, John Moriarty, Colin Heaslip, Stephen O'Sullivan, Kevin Williams, Thomas Sheehan, Lesley Collins, Sibéal Regan,

Louise Overy, Sophie Price, Kilian Kelly, Abbey Cummings, Ed Lacey, Fiona Tobin, Michael Moriarty and John Deady. We would like to thank Michael Marrinan, Clodagh Russell and Rebecca Treacy for assisting in fieldwork during the summer of 2013, as well as Sean O'Callaghan for sending us photographs from his land-based watch in 2015 and contributing to the IWDG cetacean sighting scheme. We would also like to thank Finbarr O'Connell and Ray McGibney for skipping Celtic Mist.

REFERENCES

- Agardy, M.T. 1994 Advances in marine conservation: the role of marine protected areas. *Trends in Ecology and Evolution* **9** (7), 267–270.
- Anthony, L.L. and Blumstein, D.T. 2000 Integrating behaviour into wildlife conservation: the multiple ways that behaviour can reduce Ne. *Biological Conservation* **95** (3), 303–315.
- Ashe, E., Noren, D.P. and Williams, R. 2010 Animal behaviour and marine protected areas: incorporating behavioural data into the selection of marine protected areas for an endangered killer whale population. *Animal Conservation* **13** (2), 196–203.
- Baker, I. 2015 Researcher's guide to protocols for fieldwork and data entry. *Shannon Dolphin and Wildlife Foundation*, unpublished, 32.
- Berrow, S. and O'Brien, J. 2013 Marine Wildlife Training Course: Training Report to North East Kerry Development. *Irish Whale and Dolphin Group*, 1–14.
- Berrow, S., O'Brien, J., Groth, L., Foley, A. and Voight, K. 2012 Abundance estimate of bottlenose dolphins (*Tursiops truncatus*) in the Lower River Shannon candidate Special Area of Conservation, Ireland. *Aquatic Mammals* **38** (2), 136–144.
- Berrow, S., Whooley, P., O'Connell, M. and Wall, D. 2010 Irish Cetacean Review (2000–2009). *Irish Whale and Dolphin Group*.
- Berrow, S.D., Holmes, B. and Kiely, O.R. 1996 Distribution and abundance of bottle-nosed dolphins *Tursiops truncatus* (Montagu) in the Shannon Estuary. *Biology and Environment: Proceedings of the Royal Irish Academy* **96B** (1), 1–9.
- Maritime Safety Directorate. 2005 Marine Notice No. 15 of 2005: Guidelines for correct procedures when encountering whales and dolphins in Irish coastal waters. *Department of Communications, Marine and Natural Resources*. Dublin.
- Evans, P.G.H. and Hammond P.S. 2004 Monitoring cetaceans in European waters. *Mammal Review* **34** (1), 131–156.
- Evans, P.G.H. 1992 Status review of cetacean sightings in the British Isles, 1958–1985. *Sea Watch Foundation, Oxford, UK*, 100.
- Hammond, P.S., Mizroch, S.A. and Donovan, G.P. 1990 Individual Recognition of Cetaceans: Use of Photo-Identification and Other Techniques to Estimate Population Parameters. *Report of the International Whaling Commission. International Whaling Commission, Cambridge, UK* (12), 440.
- Harwood, J. 2001 Marine mammals and their environment in the twenty-first century. *Journal of Mammology* **82** (3), 630–640.
- Hastie, G.D., Barton, T.R., Grellier, K., Hammond, P.S., Swift, R.J., Thompson, P.M. and Wilson, B. 2003 Distribution of small cetaceans within a candidate Special Area of Conservation; implications for management. *Journal of Cetacean Research and Management* **5** (3), 261–266.
- Hooker, S.K. and Gerber, L.R. 2004 Marine reserves as a tool for ecosystem-based management: the potential importance of megafauna. *BioScience* **54** (1), 27–39.
- Hyrenbach, K.D., Forney, K.A. and Dayton, P.K. 2000 Marine protected areas and ocean basin management. *Aquatic conservation: marine and freshwater ecosystems* **10** (6), 437–458.
- International Union for Conservation of Nature 2012 When is a Marine Protected Area really a Marine Protected Area [ONLINE] Available at <http://www.iucn.org/?uNewsID=10904> (Accessed 7 April 2016).
- Ingram, S., Englund, A., O'Donovan, M., Walshe, L., and Rogan, E. 2005 A survey of marine wildlife in Tralee Bay and adjacent waters. *Report to Tuatha Chiarrai Teo. University College Cork*, 20.
- Jax, K., Jones, C.G. and Pickett, S.T. 1998 The self-identity of ecological units. *Oikos* **82** (2), 253–264.
- Kerr, K.A., DeFron, R.H. and Campbell, G.S. 2005 Bottlenose dolphins *Tursiops truncatus* in the Drowned Caves, Belize: group size, site fidelity and abundance. *Caribbean Journal of Science* **4** (1), 172–77.
- Louis, M., Viricel, A., Lucas, T., Peltier, H., Alfonsi, E., Berrow, S., Brownlow, A., Covelo, P., Dabin, W., Deaville, R. and Stephanis, R. 2014 Habitat-driven population structure of bottlenose dolphins, *Tursiops truncatus*, in the North-East Atlantic. *Molecular Ecology* **23** (4), 857–874.
- McHugh, K., Allen, J., Barleycorn A., Wells, R. 2011 Severe *Karenia brevis* red tides influence juvenile bottlenose dolphin (*Tursiops truncatus*) behavior in Sarasota Bay, Florida. *Marine Mammal Science* **27** (3), 622–643.
- MFP. 2001 The Moray Firth Candidate Special Area of Conservation Management Scheme. *The Moray Firth Partnership, Inverness*, 119.
- Mirimin, L., Miller, R., Dillane, E., Berrow, S., Ingram, S., Cross, T.F., and Rogan, E. 2011 Fine-scale population genetic structuring of bottlenose dolphins using Irish coastal waters. *Animal Conservation* **14** (4), 342–353.
- Mudge, G.P., Crooke, C.H. and Barrett, C.F. 1984 The offshore distribution and abundance of seabirds in the Moray Firth. *Unpublished report to BritOil*, 212. [Available from RSPB, Munloch Scotland]
- Murphy, E., McMahan, B., Berrow, S. and O'Brien, J. submitted Acoustic monitoring of bottlenose dolphins (*Tursiops truncatus*) in Tralee and Brandon Bays, Kerry: a case for SAC boundary extension. *Biology and Environment*.
- O'Brien, J., Berrow, S., Ryan, C., McGrath, D., O'Connor, I., Giovanna, P., Burrows, G., Massett, N., Klotzer, V. and Whooley, P. 2009 A note on

- long-distance matches of bottlenose dolphins (*Tursiops truncatus*) around the Irish coast using photo-identification. *Journal of Cetacean Research and Management* **11** (1), 71–76.
- Robinson, K.P., O'Brien, J.M., Cheney, B., Mandleberg, L., Eisfeld, S., Ryan, C., Whooley, P., Oudejans, M.G., O'Donovan, M., Berrow, S.D., Costa, M., Haberlin, D., Stevick, P.T. Thompson, P.M. 2012 Discrete or not so discrete: Long distance movements by coastal bottlenose dolphins in UK and Irish waters. *Journal of Cetacean Research and Management* **12** (3), 365–371.
- Rosel, P.E., Mullin, K.D., Garrison, L., Schwacke, L., Adams, J., Balmer, B., Conn, P., Conroy, M.J., Eguchi, T., Gorgone, A., Hohn, A. 2011 Photo-identification capture-mark-recapture techniques for estimating abundance of bay, sound and estuary populations of bottlenose dolphins along the US East Coast and Gulf of Mexico: A workshop report. *NOAA Technical Memorandum NMFS-SEFSC 621*, 30.
- Ryan, C., Rogan, E. and Cross, T.F. 2010 The use of Cork Harbour by bottlenose dolphins (*Tursiops truncatus* (Montagu, 1821)). *Irish Naturalists Journal* **31** (1), 1–9.
- Ryan, C. and Berrow, S. 2013 An extension to the known range of Shannon Estuary bottlenose dolphins (*Tursiops truncatus* [Montagu, 1821]). *Irish Naturalists Journal* **32** (1), 77–78.
- SIFP 2013 *Strategic Integrated Framework Plan for the Shannon Estuary* (2013–2020). Report Published by Clare County Council.
- Stockin, K.A., Weir, C.R. and Pierce, G.J. 2006 Examining the importance of Aberdeenshire (UK) coastal waters for North Sea bottlenose dolphins (*Tursiops truncatus*). *Journal of the Marine Biological Association of the United Kingdom* **86** (1), 201–207.
- Weir, C.R., Canning S., Hepworth K., Sim, I., Stockin K.A. 2008 A long-term opportunistic photo-identification study of bottlenose dolphins (*Tursiops truncatus*) off Aberdeen, United Kingdom: Conservation value and limitations. *Aquatic Mammals* **34** (4), 436–447.
- Wilson, B., Thompson, P.M. and Hammond, P.S. 1997 Habitat use by bottlenose dolphins: seasonal distribution and stratified movement patterns in the Moray Firth, Scotland. *Journal of Applied Ecology* **34**, 1365–1374.
- Wilson, B., Reid, R.J., Grellier, K., Thompson, P.M. and Hammond, P.S. 2004 Considering the temporal when managing the spatial: a population range expansion impacts protected areas-based management for bottlenose dolphins. *Animal Conservation* **7** (4), 331–338.
- Würsig, B. and Würsig, M. 1977 The photographic determination of group size, composition, and stability of coastal porpoises (*Tursiops truncatus*). *Science* **198** (4318), 755–756.
- Würsig, B. and Jefferson, T.A. 1990 Methods of photo-identification for small cetaceans. *Report of the International Whaling Commission* (12), 23–52.