



Bottlenose dolphins (*Tursiops truncatus*) in north-east England:

A preliminary investigation into a population beyond the southern extreme of its range.

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*“For instance, on the planet Earth, man had always assumed that he was more intelligent than dolphins because he had achieved so much—the wheel, New York, wars and so on—whilst all the dolphins had ever done was muck about in the water having a good time. But conversely, the dolphins had always believed that they were far more intelligent than man—for precisely the same reasons.”*

- DOUGLAS ADAMS, THE HITCHHIKER’S GUIDE TO THE GALAXY

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## List of Abbreviations Used

CRRU – Cetacean Research and Rescue Unit	SSSI – Site of Special Scientific Interest
AULFS – Aberdeen University Lighthouse Field Station	MCZ – Marine Conservation Zone
SAC – Special Area of Conservation	mSPA – Marine SPA
EPS – European Protected Species	SMRU – Sea Mammal Research Unit
DEMs – Dorsal Edge Marks	
StDev – Standard Deviation	
SAST – Seabirds At Sea Team	
SCANS – Small Cetacean Abundance in North Sea	
JNCC – Joint Nature Conservation Committee	
SPA – Special Protected Area	

# **Bottlenose Dolphins (*Tursiops truncatus*) in north-east England: A preliminary investigation into a population beyond the southern extreme of its range.**

*Conor Louis Aynsley*

## **1. Abstract**

Bottlenose dolphins (*Tursiops truncatus*) are a truly cosmopolitan species occurring in temperate and tropical waters globally across a wide range of habitats. The Moray Firth in Scotland contains one of only two known resident populations in the UK, although the species is known to range widely down the east coast along the Grampian coastline to Tayside and Fife, with individuals displaying a high degree of spatial and temporal variability in their distribution and movements.

Following an increase in casual sightings of bottlenose dolphins in north-east England, data was collected from a network of public sources to investigate the occurrence and site faithfulness of bottlenose dolphins utilising the region, believed to be beyond the southern extreme of the regular range of the species. Year-round sightings records and opportunistically collected photographs of dolphins were analysed in order to determine a preliminary understanding of the temporal distribution, population composition and site faithfulness within the north-east region. Individuals were matched against a long-term photo-identification catalogue collected by the CRRU in the Moray Firth, and individual variation in distribution throughout the entire east-coast range was also investigated.

Bottlenose dolphins were shown to be present year-round, displaying a level of site fidelity within the region, and approximately a quarter of the entire east coast population was recorded within the region during the three-year photo-identification study period. Dolphins recorded in north-east England were shown to be across a full range of age groups and both sexes, with calves accounting for nearly twenty percent of the regional population.

A number of individuals were discovered to have been recorded across the entirety of the east coast range, and there was a high level of connectivity between the geographically discrete subsets of the east coast population, with a particularly strong link between the animals recorded in north-east England and the Tayside subset. It is likely appropriate that the north-east can be considered to be an expansion in the range of distribution of the Tay population, rather than its own discrete population. The implications of the results of this study, and of the apparent expansion in the range of the east coast population on both the management of the species and our understanding of the population throughout the entirety of its east-coast range are discussed herein.

## 2. Introduction

Whales, dolphins and porpoises belong to the taxonomic order Cetacea, of which there are considered to be ninety species worldwide (IUCN CSG 2017). Within this order, there are two distinct suborders: the Mysticeti or baleen whales and the Odontoceti or toothed whales, the latter containing the significantly larger proportion of the species (Hoelzen 2002). Within the Odontoceti, the largest and most diverse family is the Delphinidae, containing 38 known species to date (Rice 1998).

Approximately 28 species of cetaceans occur in the waters of north-west Europe, eleven of which are members of the family Delphinidae (Reid *et al.* 2003). Of these, perhaps the most well-known and researched species is the bottlenose dolphin (*Tursiops truncatus*, Montague 1821), which is a truly cosmopolitan species found in temperate to tropical waters globally, across a wide range of habitats (Leatherwood and Reeves 1983).

In UK waters, two known resident populations of bottlenose dolphins occur coastally, in Cardigan Bay, Wales; and the Moray Firth in Scotland (Wilson *et al.* 1997, Bristow and Rees 2001). The Scottish population represents the species at the very northern extreme of its species range, with rare occasions of individuals occurring at more northerly latitudes thought to be animals belonging to offshore rather than coastal populations, which are considered geographically and genetically discrete (Wilson 1995, Skov *et al.* 1995, Hoelzel *et al.* 1998).

In the UK, bottlenose dolphins are protected by a range of both UK and European legislation. The species is listed under both Annex II and IV of the European Union Habitats Directive (92/43/EEC), categorising them as a European Protected Species (EPS), as well as being afforded additional protections under UK legislation including the Wildlife and Country Side Act (1981) and the Biodiversity Action Plan (UK BAP).

Article III of the European Habitats Directive requires the development of a network of Special Areas of Conservation (SACs), which are able to contribute towards the conservation of species listed under Annex I and II of the directive, affording them strict protection throughout the range of the SAC. (JNCC 2017). The Moray Firth was the first proposed SAC specifically for bottlenose dolphins in the UK, receiving official designation in 2005, following the full designation of the Cardigan Bay SAC in 2004.

The Moray Firth in north-east Scotland (57°41'N, 02°20'W) contains the only year-round, resident population of bottlenose dolphins in the North Sea. Studies in this region have been conducted since the late 1980s, largely focussing on the inner Firth Special Area of Conservation (SAC), and have greatly increased our understanding of these coastal delphinids and assisted in their management in Scottish waters (Thompson *et al.* 2011).

Animals are present year-round in the inner Firth and along the southern coastline of the outer Firth; however the population ranges widely along the east coast, along the Grampian coastline to Tayside and Fife (Wilson *et al.* 2004, Stockin *et al.* 2006) – with individuals exhibiting a high degree of spatial and temporal variability in their distribution and movements (Cheney *et al.* 2013).

Using photo-identification as a central methodology, Wilson *et al.* (2004) confirmed that individuals ranging south of the Moray Firth along the east coast were originally present within the Inner Firth SAC, and may be considered as a subset of the east coast population. Wilson *et al.* (2004) also noted that the timescale by which the population was apparently expanding its range was equal to the

timescale necessary to implement protective designations, potentially reducing their effectiveness from the outset.

It is accepted that distributions of highly mobile species such as bottlenose dolphins are most effectively studied at large spatial scales, however the majority of research effort is focussed upon relatively small areas (Cheney *et al.* 2012). Knowledge of an individual's use of space and habitat may provide information on residency and territoriality (Stevick *et al.* 2002), but can also relay insights regarding the distribution and availability of resources and the sensitivity to impending threats (Silva *et al.* 2008, Frantziz *et al.* 2011).

## Photo-Identification

Photo-identification is one of the most non-invasive and versatile techniques available when studying cetaceans, with a fundamentally similar methodology used for studies of bottlenose dolphins for four decades (Würsig and Würsig 1977). Identifying individual dolphins based upon natural markings, known as dorsal edge marks (DEMs) can be useful to study several aspects of the species biology, including individual and population-level movements, range sizes, social behaviour and reproductive history.

Photo-identification is a useful tool when studying cetaceans, since animals do not need to be physically captured or marked, and unlike other examples of marking used in mark-capture studies (e.g. tags, dye/paint etc.) natural markings can't be lost, although certain natural markings may change over time (Evans and Hammond 2004).

Good photo-identification studies are generally dependent upon good photographs, taken by a skilled photographer using high-quality equipment (Evans and Hammond 2004). However, modern advancements in technology have enabled photo-identification to be a more efficient and effective tool than ever, with continually increasing improvements in picture quality and ease of data-manipulation. Additionally, increasing quality in personal cameras mean that the data collection for photo-identification can be carried out external to designated researchers, allowing for a potentially greater scope of data collection across larger areas than was previously possible (Thompson *et al.* 2011).

## Public Involvement/Citizen Science

Potentially one of the more useful tools available to researchers, given the wide geographical distribution and difficult nature of monitoring species such as bottlenose dolphins, is citizen involvement. There is an inherent public interest in cetaceans in the UK, and utilising this to create a network of potential observers and data-collectors allows for a wider ranging scope for potential studies, and can help to focus and maximise the efforts of existing research infrastructure.

However, caution must be taken not to compromise data quality as a result of the desire to recruit a large network of public data collectors. Ensuring that any data collected is from skilled or trained observers and photographers increases the reliability and validity of any analysis, and allows studies to be conducted as efficiently as possible (Evans and Hammond 2004).



## Historical Distribution

The North Sea bottlenose dolphin population was shown to have expanded south of the Moray Firth, along the east coast of Scotland in the mid-1990s, resulting in what was considered to be three connected, although geographically discrete subset populations (Wilson *et al.* 2004). Following this range expansion, research effort outside the Moray Firth was increased with dedicated research into the population since 1997 in other regions along the east coast (Thompson *et al.* 2011, Cheney *et al.* 2013). The most recent estimates suggest that the east coast population consists of approximately 195 individuals, ranging from the Inner Moray Firth along the east coast of Scotland to the Firth of Forth, believed to be the southern extreme of the populations regular range (Thompson *et al.* 2011, Cheney *et al.* 2013, Quick *et al.* 2014).

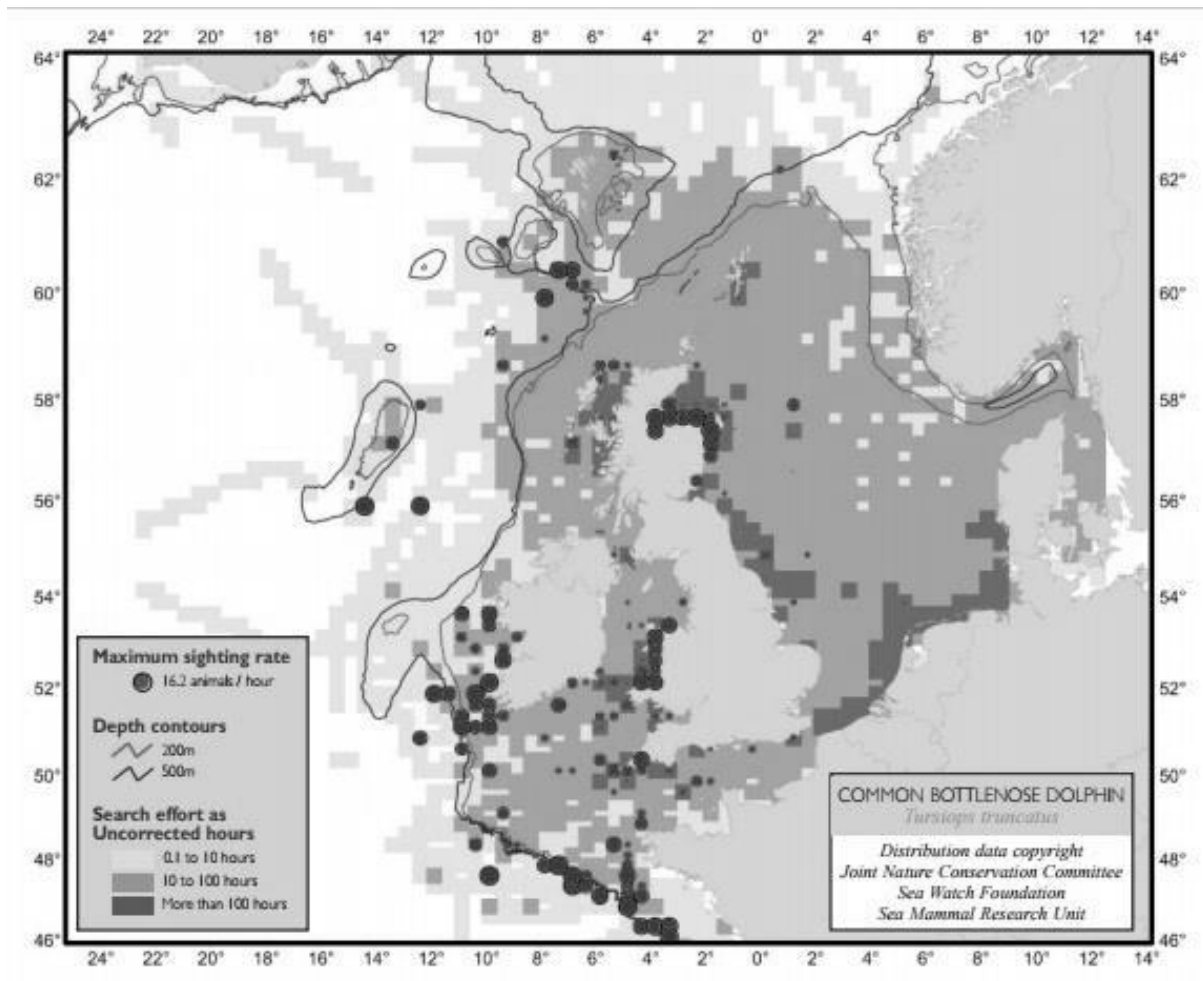
Sightings of bottlenose dolphins at more southerly latitudes have been recorded, although were generally regarded as anomalous sightings not reflective of any definitive changes in range size. For instance, Thompson *et al.* (2011) noted the confirmed sighting of a group of bottlenose dolphins near Whitley Bay in north-east England in 2007. In 2012, a photograph of a solitary bottlenose dolphin taken near Filey, North Yorkshire, was submitted to the Cetacean Research and Rescue Unit, and was matched to a known animal from the outer Firth: CRRU ID #016. Bottlenose dolphins have also been recorded as far south as North Yorkshire since 2009, with a match made with a photograph taken from Whitby with CRRU ID #078, and there have been sporadic sightings recorded in this region since then (Seawatch Foundation 2009, 2014).

Knowledge of bottlenose distribution throughout the coastal regions south of the Firth of Forth is poor, formed largely by anecdotal evidence of the presence of the species in the area, with few opportunities for dedicated studies. The results of large scale studies into country-wide cetacean distribution are useful to fill in knowledge gaps where there is a lack of dedicated research, although they offer a very limited understanding of distribution of these species.

Reid *et al.* (2003) compiled data on cetacean distribution from various sources, including the Seabirds at Sea Team (SAST), SeaWatch Foundation, and the results of the Small Cetacean Abundance in the North Sea surveys (SCANS), in order to develop the JNCC funded 'atlas of cetacean distribution in north-west European waters'. This atlas offers a broad look at the distribution of British cetaceans, and can be useful to understand the general distribution of bottlenose dolphins throughout the east coast.

As shown in Figure 1 taken from Reid *et al.* (2003), there is a clear presence of bottlenose dolphins throughout the eastern coast of northern Scotland, and a suggested absence of dolphins ranging further south, despite large amounts of survey effort.

Whilst there were occasional sightings of the species in the waters of north-east England, with rare photo-identification matches of heavily marked animals, they were considered to be anomalous movements by individuals beyond the southern extreme of the range of the east coast population. Combined with this, the absence of the species in larger scale studies such as SAST and SCANS, suggest that historically there was not a significant presence of bottlenose dolphins ranging south of the Firth of Forth into the coast of north-east England.



**Figure 1.** Bottlenose dolphin distribution in the waters of north-west Europe. Presence of dolphins is represented by dark circles, with survey effort represented by the different levels of shading. Reproduced from Reid *et al.* (2003).

### Recent Distribution in Northern England

Throughout the past decade, there has been an apparent rise in casual sightings of bottlenose dolphins along the north-east coast of England, with reports from tour boat operators, birdwatchers and the general public (Brereton *et al.* 2010). As news of dolphin sightings increased, local interest also began to increase, with a small number of members of the public managing to capture photographs of dolphins in the region, and an increasing number of people monitoring and recording sightings of the species. This publically collected data was useful to not only confirm the presence of dolphins in the region, but also presented the opportunity for potential studies into the animals in the area.

In response to this, an attempt was made to develop a public network of potential sources of both photographic and sightings data throughout north-east England, in order to allow a preliminary photo-identification study into any animals which may be present in the region.

## Study Aims

In the present study, photo-identification will be used to investigate the occurrence and site faithfulness of bottlenose dolphins utilising the Northumberland-Durham coastline, beyond the believed southern extreme of the population's regular range. Photographs collated from opportunistic encounters by tour boat operators and wildlife photographers in north-east England between 2014 to 2016 will be analysed and accordingly matched against a long-term database of approximately 200 known individuals from the east-coast population (as recorded by the CRRU research team in the Moray Firth from 1997 to 2016 inclusive).

The results, combined with year-round sightings data, will be used to establish the first photo-identification catalogue for the Northumberland region, to provide estimates of the number, composition and fidelity of the animals identified in this area, and to examine the spatio-temporal movements of matched individuals between the north-east coast of England and the Scottish Moray Firth.

As well as increasing understanding of the distribution of this species throughout the whole of its east-coast range, this study will potentially serve to increase our predictive power for potential consequences from ongoing development projects (such as wind farm installations and oil and gas activities) affecting the animals utilising the southernmost area of this populations home range, and enable more effective management for the species throughout the entirety of its current and potential future range.

### 3. Study Area

For this study, data was collected from a range of sources at different locations throughout north-east England. The study area spanned from the Scottish-English border (55°48'N 2°02'W) to the river Tees (54°38'N 1°09'W), and for the purposes of the study was termed the Northumberland-Durham region.

#### Study Area: Northumberland-Durham Region

The north-east coast of England encompasses the counties of Northumberland, Tyne and Wear and Durham, and there is a wide range in coastal habitat types, with numerous river systems, embayments and islands. There is a notable presence of certain species of cetaceans, with harbour porpoise (*Phocoena Phocoena*), white-beaked dolphin (*Lagenorhynchys albirostris*) and minke whale (*Balaenoptera acutorostrata*) sighted frequently in the waters of this region (Reid *et al.* 2003).

The Northumberland-Durham Region is an important area for a wide range of both coastal and marine species and habitats, and as such contains a number of protected designations, including marine conservation zones (MCZ) and marine special protected areas (mSPA), as well as designated SPAs, SSSIs, RAMSAR sites amongst others.

Data was sought from a range of sources throughout the region; however particular focus was paid to the area surrounding the Farne Islands. Sitting between two and three miles off the north-Northumberland coast, the Farne Islands contain one of the largest seabird colonies in the UK, and a significant grey seal breeding ground (National Trust 2017). There are numerous tour boat operators running between the mainland and the islands, as well as dive boats, and fishing vessels. Previous to this study, anecdotal sightings of bottlenose dolphins appeared to be more common around the Farne Islands, which is unsurprising given the number of potential observers present in the region, particularly during the summer. Due to the significant numbers of tourists to the area, high level of boat traffic and anecdotal frequency of sightings, there was the potential for a large amount of publically recorded data to be available from this part of the region.

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Data collected for this study from the Northumberland-Durham region was analysed and compared against the wider east-coast population, using a long-term dataset for the population in the Moray Firth as collected by the CRRU team between 1997 and 2016, as well as published sources and personal communications with active cetacean researchers.

The east coast of Scotland was divided into three sections, in accordance with the three subset populations as proposed by Wilson *et al.* (2004), Cheney *et al.* (2013), Quick *et al.* (2014) *etc.*, and was geographically separated into the Inner Moray Firth, Outer Moray Firth, and the Grampian-Fife region.

#### Inner Moray Firth Region

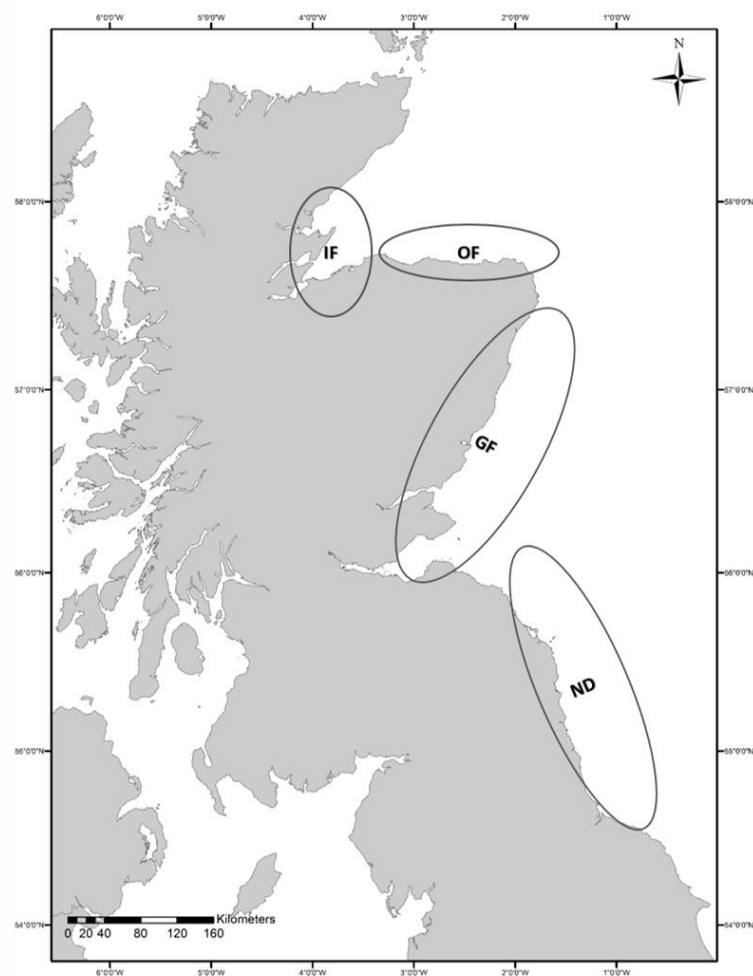
The Inner Firth is the innermost section of the Moray Firth embayment, occupying the area east of a transect line between Helmsdale on the northern shore and Lossiemouth on the southern shore. The area is entirely covered by the Moray Firth SAC. Aberdeen University have been conducting studies into the bottlenose dolphins utilising the inner Moray Firth since 1989 (Thompson *et al.* 2011).

## Outer Moray Firth Region

The Outer Firth region is the section of the Moray embayment immediately to the east of the Moray Firth SAC, with the southern coast boundaries ranging from Lossiemouth to Fraserburgh. The Cetacean Research and Rescue Unit have studied the bottlenose dolphin population throughout this region since 1997 with regular, dedicated surveys, and have collated an extensive photo-identification catalogue containing over 200 identifiable individuals over a twenty year period. The CRRU has also maintained a twenty-year database of bottlenose dolphin encounters, as well as noting aspects of the biology of the animals such as calving history. (Culloch and Robinson 2008, Robinson *et al.* In Press).

## Grampian-Fife Region

The Grampian-Fife region is, for this study, considered to be the area of coastal Scotland ranging south between Fraserburgh and the Firth of Tay. Aberdeen University and the Sea Mammal Research Unit (SMRU) have conducted dedicated studies into the bottlenose population in this area, largely focussing on the Firth of Tay since 1997 (Quick *et al.* 2014). Dedicated surveys throughout the wider region, particularly between Montrose and Aberdeen have been carried out since 2008 (Thomson *et al.* 2011, Quick *et al.* 2014).



**Figure 2.** The east coast was separated into four regions, the Inner Firth (IF), Outer Firth (OF), Grampian-Fife region (GF) and the Northumberland-Durham region (ND), representing the three subset populations as proposed by Wilson *et al.* 2004, and the north-east England study area.

## 4. Methods

### 4.1 Sightings

Sightings data was gathered from several sources across the study area. Shore sightings were collected mainly from birdwatchers, with boat-based sightings collected from tour-boat operators and wildlife photographers. Data from most sources was unsuitable for use in considering any variation in temporal distribution, since it was largely influenced by variable effort – either as a result of weather or seasonal fluctuations in activity.

A year-round sea-watching programme operated from Whitburn Bird Observatory (54°57'N 1°21'W) primarily recording seabird activity, and incidental cetacean sightings were also recorded. Due to the large amount of daily man-hours year-round from skilled observers at a static location, the bottlenose dolphin sightings data from the observatory was useful in assessing temporal distribution of the species in the region.

Sightings were collated from the records of the sea-watching programme, and the number of bottlenose dolphin sightings were pooled by month over a four-year period between January 2013 and December 2016. All sightings were made by skilled observers with extensive species identification experience, and positive species identification was also verified with photographic evidence.

### 4.2 Photo-Identification

Photographs were compiled from opportunistic encounters by tour boat operators, wildlife photographers and members of the public in the Northumberland-Durham region between 2014 and 2016. The majority of photographs submitted were from encounters which occurred near to the Farne Islands, or from the Whitley Bay-Tynemouth area.

Data was collected from twenty-eight encounter across three years, with all but one of the encounters occurring between the months of April and October. 1880 photographs were submitted in total, and there was significant variation in both photo quality and quantity across encounters.

The images were graded for photographic quality in accordance with procedures used in Wilson *et al.* (1999), Read *et al.* (2003), Culloch and Robinson (2008) Cheney *et al.* (2012) *etc.* Photographs containing dorsal fins needed to be in focus and well lit, with the dorsal fins running parallel to the camera and occupying a space greater than 10% of the total photograph.

After grading, a total of 661 photographs were eligible to be used for analysis.

Year	2014	2015	2016	Total
Photos Collected	884	106	930	1880
Photos Used After Grading	369	89	203	661
Proportion of photos used	0.44	0.84	0.22	0.35

**Table 1.** The numbers of photos submitted from opportunistic encounters with bottlenose dolphins throughout the three year study period, which were then subjected to a grading system, ensuring only the highest quality photographs were used.

A catalogue was created for the Northumberland-Durham region, with distinctly identifiable individuals given a unique identification number, with the prefix ND (e.g. ND001). Attempts were made to match individual dolphins present in the photographs against the Cetacean Research and Rescue Unit Photo-identification catalogue, containing individuals sighted over a twenty year period between 1997 and 2017 in the Moray Firth. Matching was assisted using specialised photo-identification software (CRRU Photo ID 1.1.4), designed for the Cetacean Research and Rescue Unit.

Matches were verified independently by at least two end users, including Dr Kevin Robinson with over twenty years photo-identification experience, and a third experienced end user, Barbara Cheney of Aberdeen University, was consulted on contentious or difficult matches.

Where possible, individuals added to the Northumberland-Durham catalogue were cross-referenced to the CRRU photo-identification archive and the online Aberdeen University Lighthouse Field Station photo-identification catalogue.



**Figure 3.** The software used by the CRRU to assist matching of left and right dorsal fins of individuals against the photo-identification catalogue.

For aspects of the study, individual dolphins were regarded as either 'marked', which included marked adults and well-marked subadults, and non-mature, including less well/unmarked subadults, calves, and otherwise non-recapturable individuals. Generally, individuals were designated as either recapturable or non-recapturable, and were classified into three categories: adult, sub-adult or calf.

Age was determined either through previous encounter history of matched animals, or due to body size and colour. Adults were considered large, with dark colouration whereas sub-adults were individuals of similar lengths or slightly smaller, and had paler colouration. Calves were small individuals, possessing foetal folds, and generally associated closely with the mother (Wilson *et al.* 1997).

Where possible, individual dolphins were sexed, either from cross-referencing with the CRRU catalogue where sex had been previously determined, or from images showing the genital slits of the animals.

Unlike studies which solely used markings on the trailing edge of the dorsal fin (*e.g.* Williams *et al.* 1993, Defran *et al.* 1990, Würsig and Jefferson 1990), a variety of natural markings were used to assist identification, including major scratches and dorsal edge marks (DEMs), regions of apigmentation, noticeable regions of epidermal disease, unusual dorsal shapes and skeletal deformities (Wilson *et al.* 1997).

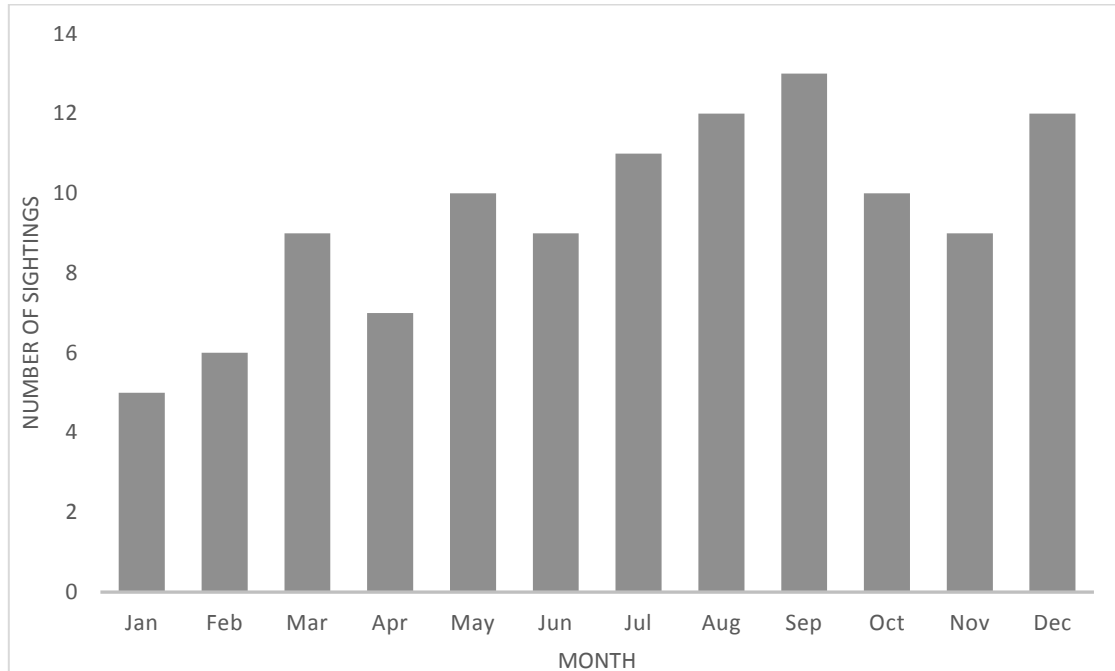


**Figure 4.** Clockwise from top left: An example of a heavily marked, mature male with multiple DEMs (ND037 'Black 'n' Decker'), extremely noticeable apigmentation outlining the dorsal fin (ND027 'Runny Paint'), spinal deformities and collapsed dorsal fin (ND045 'Floppy Fin'), regions of epidermal disease on the dorsal fin and body (ND004 'Deliah').



## 5. Results

### 5.1 Sightings



**Figure 5.** Incidental sightings of bottlenose dolphins were recorded by skilled observers between 2013 and 2016 during a year-round sea-watching programme based at Whitburn Bird Observatory. Sightings were pooled by month across the four-year period, showing temporal distribution of the species in the immediate coastal area.

When the four years of the study period were pooled together, bottlenose dolphins were recorded across every month, with a mean number of sightings of  $9.42 \pm 2.36$  ( $n=115$ ) per month. With the exception of January, February and April 2013, and May, August and November 2016, there were sightings recorded in every single month throughout the four-year study period.

Year	2013	2014	2015	2016
Number of sightings	25	30	40	20
Mean number of sightings per month	$2.1 \pm 1.93$	$2.5 \pm 1.04$	$3.3 \pm 2.01$	$1.7 \pm 1.25$

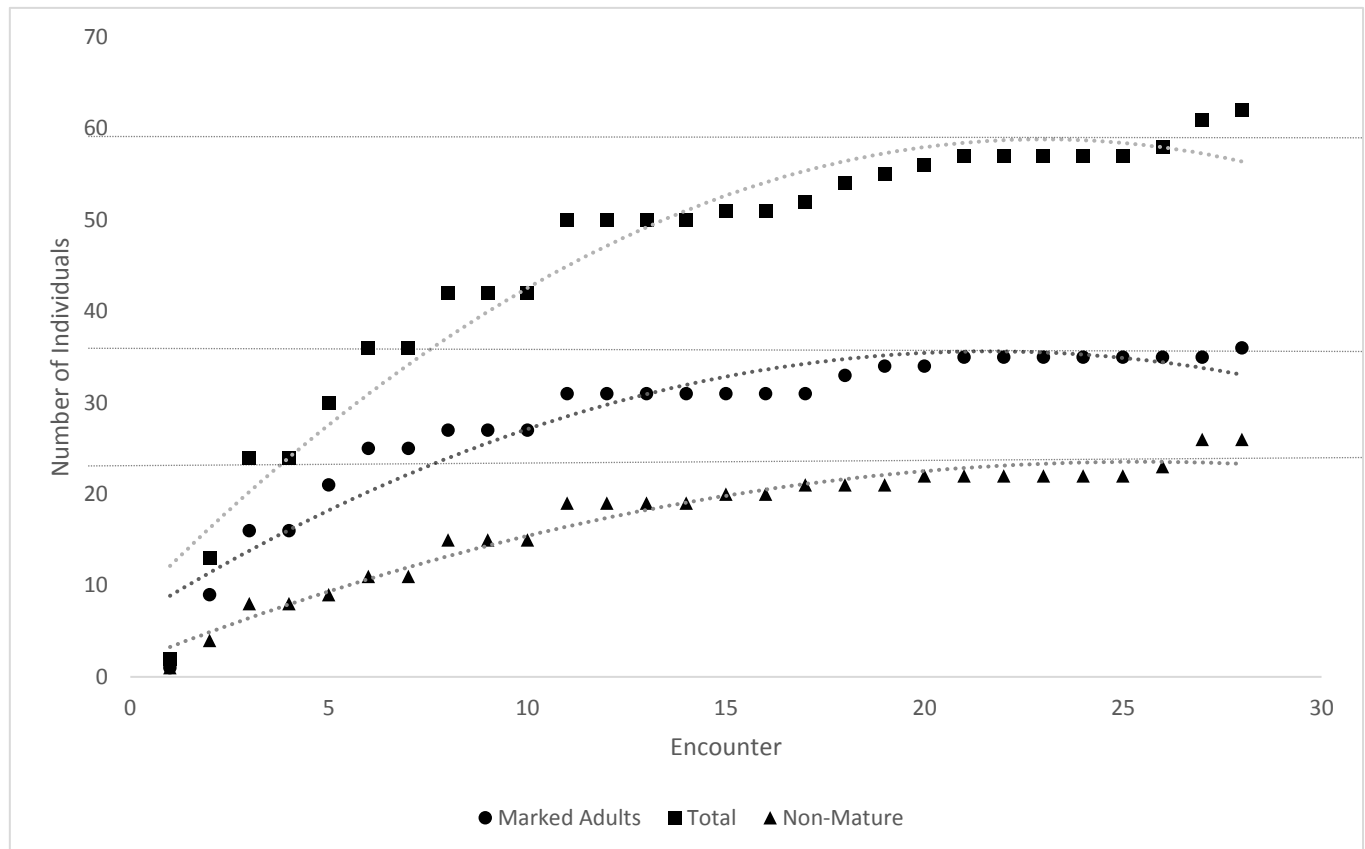
**Table 2.** Bottlenose dolphin sightings during each year of the study period as recorded from Whitburn Bird Observatory. The total number of sightings per year was calculated, as well as the mean number of sightings ( $\pm$ StDev) per month during that year.

It was not possible to consistently document the number of individuals present during every sighting from Whitburn Bird Observatory, however pod sizes were occasionally recorded, with a minimum size of one and a maximum of ten, with a mean pod size of  $4.5 \pm 2.38$  recorded during the encounters where pod size was estimated.

## 5.2 Photo Identification

### Discovery Curve

Images were sorted into separate encounters and were processed chronologically. Distinctly identifiable individuals were added to a catalogue for the Northumberland-Durham region, with a unique identification number (e.g. ND001). A cumulative total was recorded marking the discovery of new individuals during each encounter throughout the study period.



**Figure 6.** The discovery of distinctly identifiable individuals was cumulatively totalled across twenty-eight encounters during the three-year photo-identification study period. The number of marked adults (including heavily marked subadults) was calculated to determine an estimate for the number of recapturable non-juvenile animals present in the regional population. Non-mature animals include unmarked/lightly marked subadults, calves, and any non-recapturable adults. The total number of animals includes all individually distinct animals, to provide an estimate for the total number of individuals utilising the region during the period of the study, as well as determining the completeness of the photo-identification study.

In each category, (e.g. marked, non-mature and total), the discovery curve reaches a plateau, indicating that throughout the period of the study it is likely that most of the individuals utilising the study area were captured. During the period of the study, there were 37 well marked individuals (marked adults and well-marked subadults), with 62 individual dolphins identified when also considering calves and less-marked individuals. Each of the discovery curves reach a plateau, suggesting that it is unlikely that the actual population of animals present in the study area would have exceeded this by any great margin.

### *Photo-Identification Summary*

Year	Total Recapturable Individuals	Marked Adults	Marked Animals (including sub-adults)	Additional animals (e.g. calves)
2014	39	24	30	9
2015	15	11	13	3
2016	24	18	18	6
Total	48	31	37	11

**Table 3.** Once individual dolphins were identified, it was possible to recapture distinctly identifiable individuals across multiple encounters during the study period. Recapturable animals were categorised as marked adults, all marked animals (including subadults), and additional recapturable animals, including calves.

Throughout the three-year study period, there were 48 individuals designated as recapturable, including subadults and calves, 31 of which were marked adults. A total of 11 calves were also captured during the study period, constituting 23% of the total recaptured individuals.

There was variation in the numbers of recapturable individuals across all categories between years, however there are several potential variables which may have affected this. Variation in the number of images collected, number of encounters, amount of effort, weather conditions, amongst others, all could have affected the number of recapturable individuals recorded, and is therefore not necessarily indicative of any fluctuations in regional population size.

### *Site Fidelity*

Number of years seen	No. of individuals identified	No. of marked adults
1	25	14
2	17	13
3	6	4

**Table 4.** Individuals were recaptured on different encounters within each year, with several individuals also recaptured on two or more years of the study period. The number of years in which marked adults, and the total number of individuals including recapturable calves and subadults were identified was calculated across the study period. The ability to identify individual dolphins and recapture them over several encounters allowed for an investigation into the level of site faithfulness displayed by members of the population.

Of the total amount of recapturable individuals recorded during the study, 48% were recaptured on two or more years. When only the marked adults are considered, 55% of the individuals were

sighted on two or more years. The proportion of individuals re-sighted on multiple years suggests a certain level of site fidelity within members of the regional population, particularly amongst the marked adults.

### ***Encounter History***

Recapturable individuals (excluding calves) were cross-referenced with the CRRU and AULFS catalogues where possible. The number of recaptures of individuals in the Northumberland-Durham region throughout the study period was recorded, and a twenty-year database of bottlenose dolphin sightings in the Outer Firth collected by the CRRU was consulted to determine the encounter history of cross-referenced individuals in both the Northumberland-Durham region, and the Moray Firth.

Where possible, the calving history of known females was determined from a twenty-year study of the reproductive success of the Moray Firth population, outlined in Robinson *et al.* (In Press).

*Table 5 is presented on the next page*

Of the 37 total recapturable individuals (excluding calves), 19 were able to be matched and cross-referenced with the CRRU photo-identification catalogue, with a total of 33 individuals cross-referenced to either the CRRU or online AULFS catalogues.

18 individuals, equating to 49% of the total recapturable animals, were recorded in the Moray Firth by the CRRU team during the twenty-year period. There was variability in the frequency with which individuals were encountered in the Outer Firth, with individuals such as ND012 sighted regularly in the region, in contrast with ND027 which had not been encountered in the Firth since 1999.

During the period of this study (2014-2016), only 4 individuals were recorded in the Outer Firth: ND028, ND029, ND059 and ND063. In 2013, the year prior to the study period, 9 known individuals were recorded within the Outer Firth.

Only 2 individuals were recorded to have travelled to the Outer Firth during the study period after being recorded in the Northumberland-Durham region: ND028; and ND029, which was recorded in Northumberland-Durham in June and July 2014, and the Outer Firth in September and October 2014, appearing to remain in the Outer Firth during 2015.

Sex was determined for 24 individuals, including 17 females, 14 of which were known to be reproductively active and have produced calves between 1997 and 2016.

During the three-year period before the study, 8 animals were known to produce calves, and a further 4 animals giving birth during the duration of the study period. Assuming total survival of the calves, up to 70% of the known females would have had dependent or associated young at a point during the period of the study, although some calf mortality was recorded.

FI ID#	CRRU ID#	AU ID#	Sex	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
001		881	M																		2	1	
002	102	227	F		3	1	1	1●	5				2●							1●	7	1	4
004		1054	F											●					●		7		1
006		1119	F																		5●	1	
008	517	1118	F														1			1●	4		
009		1062	F																●		5	1	
011		1121	U																		2		
012	002	102	M	8	2				1	1	4	10	8	4	7	4	1	4	3		1	1	
013	387	1002	F										2	3		2●	3	●			1		
015		1115	U																		2		
016		1123	U																		1		
018		1043	F															●			1		
020		1058	F															●			3		1
023	645		U																		3		
024			U																		3		
025	178	344	F			1	1						1●							●	4	1	3
027	055	116	F	6	4	1					●										5	1●	5
028	634	1052	F																		3		1●
029	516	1037	F														1	1			4●	4	1
033			U																		3		1
035		1096	F																		2		1
037	149	020	M		1			2					1								2	1	2
038	032	068	F	1		1							2				●				5		2
039		1050	M																		2		2
041		1156	U																		1	1	

044	554	1048	M																1	1		
045		1150	U																	1	1	
046	556	1047	M																1	1	1	
050	560	1076	F																1	1		
054	529	1064	F													2			1		1	
055			U																		1	1
056	078	009	F	2●	2	1	1						1●							1		2
058			U																			3
059	384	1039	U										11					1		2	1	3
060		1089	U																			1
062	423	886	M	1	1									3				1	1			1
063	593	1091	U																1	1		1

 Northumberland-Durham Region
  Outer Moray Firth Region
 ● Known Calf Produced

**Table 5.** The encounter history of recapturable individuals (excluding calves) over the three-year study period in the Northumberland-Durham region, and a twenty-year period (1997-2016) in the Outer Moray Firth. Years in which the individual was encountered, as well as the number of encounters within each year was recorded. Encounters within the Northumberland-Durham region during the three-year study period are shaded **dark grey**, and encounters recorded by the CRRU in the Outer Firth between 1997 and 2016 are shaded **light grey**. Where encounters occurred in both regions in the same year, a split box is used. The known production of calves was noted with ●. Individuals were cross-referenced with both the CRRU and AULFS photo-identification catalogue where possible, with a Northumberland-Durham identification number provided for all individuals. Sex of the individual was noted as male (M), female (F) or unknown (U).

### Movements throughout East Coast

ID#	CRRU#	AU#	Sex	Inner Moray Firth <sup>†</sup>	Outer Moray Firth	Grampian-Fife Region <sup>†</sup>	N'land-Durham Region
001		881	M			✓	✓
002	102	227	F	✓	✓	✓	✓
004		1054	F			✓	✓
006		1119	F			✓	✓
008	517	1118	F		✓	✓	✓
009		1062	F	✓*		✓	✓
011		1121	U			✓	✓
012	002	102	M	✓	✓	✓	✓
013	387	1002	F	✓	✓	✓	✓
015		1115	U			✓	✓
016		1123	U			✓	✓
018		1043	F	✓*		✓	✓
020		1058	F			✓	✓
025	178	344	F	✓	✓	✓	✓
027	055	116	F	✓	✓	✓	✓
028	634	1052	F		✓	✓	✓
029	516	1037	F		✓	✓	✓
035		1096	F			✓	✓
037	149	020	M	✓	✓	✓	✓
038	032	068	F		✓	✓	✓
039		1050	M			✓	✓
041		1156	U			✓ <sup>‡</sup>	✓
044	554	1048	U		✓	✓	✓
045		1150	U			✓ <sup>‡</sup>	✓
046	556	1047	U		✓	✓	✓
050	560	1076	F		✓	✓	✓
054	529	1064	F	✓	✓	✓	✓
056	078	009	F		✓	✓	✓
059	384	1039	U	✓	✓	✓	✓
060		1089	U			✓	✓
062	423	886	M	✓	✓	✓	✓
063	593	1091	U		✓	✓	✓

\*2009 ‡ 2008 † Data obtained from Quick *et al.* (2014)

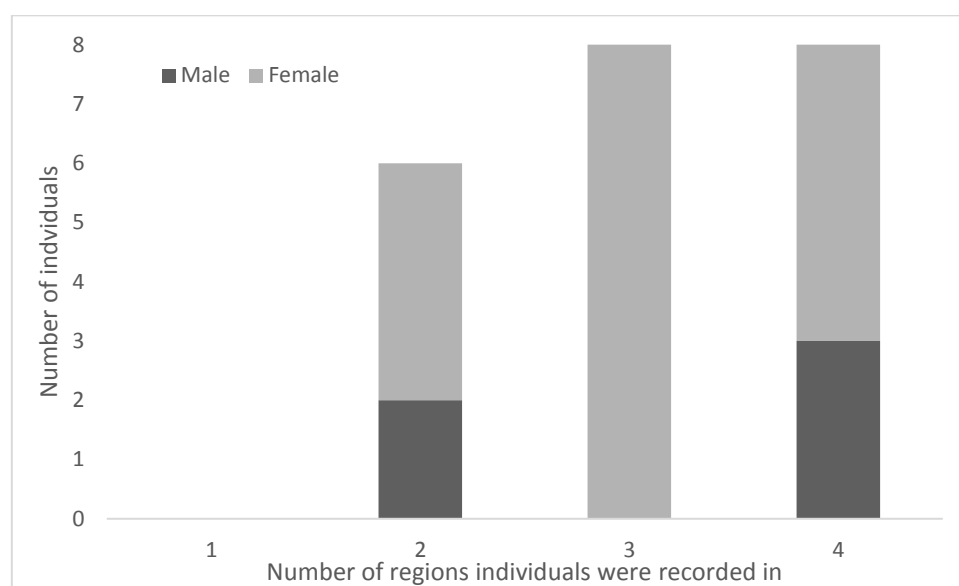
<sup>‡</sup> Barbara Cheney, pers. comm.

**Table 6.** The east coast was considered to be four distinct geographical regions, defined as the Inner Firth, Outer Firth, Grampian-Fife Region and the Northumberland-Durham Region. The presence of individual animals in the four regions between 1997 and 2016 was determined. Cross-referenced individuals were compared with published studies by Quick *et al.* (2014) considering individual ranging around the east coast, as well as the CRRU sightings database, and personal communications with researchers from Aberdeen University.

The regional encounter history of 32 individual animals cross-referenced with the online AULFS catalogue was considered between 1997 and 2016. All 32 individuals recorded in the Northumberland-Durham region during the 2014-2016 study period were recorded in the Grampian-Fife region between 1997 and 2016.

20 individuals were recorded to be present within the Moray Firth, representing 61% of the cross-referenced individuals. 18 individuals (56%) were recorded in the Outer Firth, and 11 individuals (34%) were recorded in the Inner Firth. Of the animals recorded in the Inner Firth, only two were not also recorded in the Outer Firth.

9 individuals (28%) were shown to be present in all four geographic regions, with 11 individuals (34%) recorded in three of the four regions, equating to 62.5% of the population having been encountered in three or more of the geographic regions across the east coast.

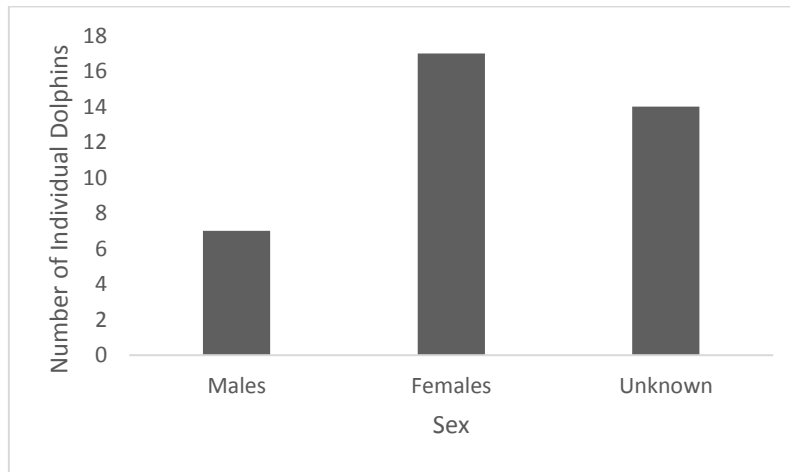


**Figure 7.** The total number of distinct geographical regions on the east coast in which individual dolphins of known sex were recorded between 1997 and 2016.

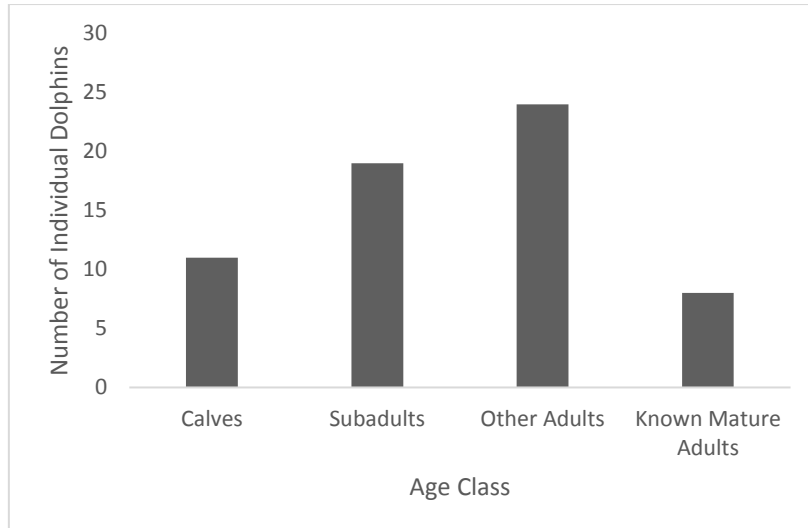
Known males and females were both recorded across multiple geographic regions between 1997 and 2016. Of the cross-referenced individuals for which sex was known, 77% were female.



### *Population Composition: Age and Sex Structure*



**Figure 8.** The sex of marked adults in the study area (including well-marked subadults), was determined from data from the CRRU archive, repeated association with dependent calves, or from photographs showing the genital slits of the animals.



**Figure 9.** Animals captured in the study area were categorised by age, as determined by body size and colour, and by matching with the CRRU photo-identification catalogue. Thirty-two individual dolphins captured during the study period were classified as adults. The age of adult dolphins was approximated from previous encounter history from the CRRU archive, and individuals known to be at least over twenty years old at the start of the study period (2014) were classified as known mature adults.

There were both male and female dolphins captured in the study area, with a larger amount of known females (71% of the individuals for which sex was determined), although there were a large number of animals for which sex was unknown (Figure 8).

Individuals across all age classifications were present in the study area (Figure 9), with adults representing approximately 52% of the total individuals captured throughout the study.

Age Class	Calf	Subadult	Adult	Mature Adult
Percentage of Total Individuals	17.7	30.6	38.9	12.9

**Table 7.** The percentage of total individuals captured during the photo-identification study in the Northumberland-Durham region represented by individuals of differing age class.

## 6. Discussion:

Bottlenose dolphins are wide ranging along the east coast of Scotland, and are present year-round between the Inner Moray Firth SAC and the coast of Tayside and Fife, with individuals within the population exhibiting a high degree of spatial and temporal variability in their distribution and movements (Wilson *et al.* 2004, Stockin *et al.* 2006, Cheney *et al.* 2013). Historically there was no significant presence of bottlenose dolphins recorded in north-east England (Reid *et al.* 2003), with sightings occurring at more southerly latitudes generally considered to be anomalous movements of the east-coast population beyond the southern extreme of their range (Thompson *et al.* 2011, Quick *et al.* 2014). Over approximately the past decade, casual sightings of bottlenose dolphins were anecdotally reported to have increased in the waters of north-east England.

Publicly collected data was collated and analysed to carry out a preliminary photo-identification study of any individuals utilising the region, in an attempt to determine the temporal distribution of the species, develop a preliminary estimate for the number of individuals present, and determine the composition and site fidelity of the population of bottlenose dolphins in north-east England.

The results of this study, and the implications thereof towards our understanding of the spatial and temporal distribution, management, and future study of the species, both in the Northumberland-Durham region and throughout its wider east-coast range, are discussed herein.

### Temporal Distribution

Bottlenose dolphins were recorded year-round during a four-year period of a sea-watching programme operating from Whitburn Bird Observatory (Figure 5). Between 2013 and 2016, incidental sightings were recorded in forty-two out of a potential total of forty-eight months, with an apparent peak for sightings in August, September and December.

Anecdotally, bottlenose dolphins are considered by many to be summer visitors to the north-east coast, with suggestions that the occurrence of the species in the regions waters may be linked to spikes in prey abundance (DBC 2017, NCAONB 2017). However, many local sources of potential sightings are heavily influenced by seasonal changes in effort, with an increased number of potential observers active around the coastal areas during summer.

Using data collected from a year-round recording scheme which could operate throughout a full range of weather conditions and seasons removed the bias resulting from seasonal effort changes, allowing for a more reliable determination of temporal distribution.

There were fluctuations in the frequency of sightings both between years and per month from the observatory, and six months during the four-year observation period where no sightings were recorded, however despite the large amount of effort from skilled observers, sightings were likely to be missed for several reasons. Whilst the purpose-built observatory allowed for observations to be carried out year-round, inclement weather conditions would still have impacted the frequency of sightings, for example rough seas, or reduced visibility due to fog or intense sunlight. Despite potentially having the largest amount of dedicated year-round survey effort at any location throughout the north-east coastal region, survey effort was still ultimately limited by observer availability.

The Moray Firth was considered to contain the only year-round population of bottlenose dolphins in the British North Sea (Wilson *et al.* 1999). Following the apparent range expansion of the east-coast population in the mid -1990s, and the subsequent increase in research effort in the Grampian-Fife region, a year-round presence was observed throughout the entire range of the species (Quick *et al.* 2014). From the results of this study, it is apparent that there is also a year-round presence of bottlenose dolphins extending south into the Northumberland-Durham region, although the extent of the population which utilises the region year-round remains unknown.

## Population Composition

Using photo-identification as a central methodology, this study was able to ascertain a preliminary understanding of the composition of the population of bottlenose dolphins utilising the coastal area of the Northumberland-Durham region.

### Population size:

There was a total of forty-eight individuals recorded during the photo-identification study period that were designated as recapturable, and an indication that most of the marked or otherwise recapturable individuals in the region were indeed captured, as shown in Figure 6.

The most recent estimates for the east-coast population suggest that there are approximately 195 individuals throughout the entirety of the species range (Cheney *et al.* 2013). Therefore, approximately a quarter of the entire east-coast population was potentially recorded in the Northumberland-Durham region during the study period, with the actual proportion likely to be higher due to the presence of non-recapturable individuals.

### Age structure:

Individuals were identified in the study area across the whole range of age classifications, ranging from first-year calves to known mature adults, with some individuals known to be over thirty years old. Over half of the animals captured in the region were adults, with the remainder of the population made up of calves and subadults.

### Sex structure:

Individuals of both sexes were captured within the study area, with a significantly larger number of females than males. There were however, many individuals of unknown sex, which will potentially contain additional males. Due to the ability to determine the sex of female individuals from associations with calves, the likelihood of determining the sex of females may be higher than males.

### Reproduction:

Many of the individuals captured in the Northumberland-Durham region were observed to be reproductively active, with a total of eleven calves detected during the study, which were born either during or just before the study period. It is unknown whether calves were birthed within the study area, due to limitations of the study data, however very young calves are present during the study. The Moray Firth is known to be an important area for calving however, and calves born in the Moray Firth in 2013 to ND002 and ND025 appeared to travel down to the Northumberland-Durham region over winter. It is possible that the other calves present in the study were born in the Moray Firth or Grampian-Fife region before travelling south.

## Site Fidelity

Temporal and spatial distribution varies greatly between individual animals (Cheney *et al.* 2013), with males considered to range more widely than females (Wilson *et al.* 1999). Animals occurring in sheltered coastal locations tend to display high levels of site fidelity, (Berrow *et al.* 1996, Wilson *et al.* 1997, Thompson *et al.* 2011), and due to the largely sheltered coastal geography of the Moray Firth and wider east-coast regions, and the geographic isolation of the population (Wilson *et al.* 1999), it is expected that individuals in the east-coast population display higher levels of site fidelity than individuals in more open populations (*e.g.* Defran and Weller 1999, Defran *et al.* 1999).

Over 50% of the individuals recorded in the Northumberland-Durham region were recaptured on two or more years of the study period, with this figure predictably higher when considering only the well-marked adults in the population. It is likely that the proportion of individuals recaptured on multiple years is under-represented in this study, with the limitations due to photographic quality and the opportunistic nature of data collection decreasing the likelihood of potentially recapturing individuals.

The level of site fidelity displayed by a population has serious implications towards the management of the species, with populations showing high levels of site faithfulness subjected to increased sensitivity and vulnerability towards disturbance, developments and habitat disruption (Gonzalvo *et al.* 2014).

## Connectivity throughout the East Coast: Moray Firth and Tayside populations

Bottlenose dolphins range widely along the east coast, with the population considered to exist in three geographically discrete subsets (Wilson *et al.* 2004, Quick *et al.* 2014). There is a high level of connectivity between these subset populations and the dolphins present throughout the entire east-coast range are considered to be part of a singular interacting population (Thompson *et al.* 2011).

All the individuals recorded in this study which were matched against the CRRU or online AULFS photo-identification catalogues were previously encountered in at least one other region throughout the Scottish east-coast. Matched individuals were all recorded in the Grampian-Fife region, the closest geographical region to the Northumberland-Durham study area, with 61% of the matched population also recorded within the Moray Firth. Individual variation in the extent of the distribution range within the population was observed, although both males and females, and individuals of different age classes were shown to range widely throughout the east coast. At least 28% of the population present in the Northumberland-Durham region were recorded in all four regions throughout the east coast, representing a recorded range of distribution of over 500km.

Thompson *et al.* (2011) suggest that the movement of individual dolphins between the geographical regions on the east-coast is high, with a greater than 75% chance that individuals captured in one region could be found in another region in the same year. The true number of individuals present in more than two geographic regions would therefore very likely be higher, with the potential for animals to have been present within regions outside of the seasonal study periods, (*e.g.* May-October for the CRRU), consequently being unrecorded. Animals recorded in areas as associated calves may have been 'lost' when they separated from the mother. Additionally, unmarked individuals recorded within in a region may have developed new or increased natural markings as

the or when increased natural markings were gained as the animal aged and moved between regions (Evans and Hammond 2004).

#### Moray Firth

There is a clear level of connectivity between the Moray Firth and the Northumberland-Durham region. In 2013, a year previous to the photo-identification study period, nine cross-referenced individuals were identified in the outer Firth, which were then recorded in the Northumberland-Durham region. Additionally, two known calves were produced in the Moray Firth in 2013 (ND003, ND026) by known mature animals ND002 'Salami' and ND025 'Chips', which were then all sighted in the Northumberland-Durham region throughout the entirety of the study period.

#### Grampian-Fife

There is evidently a close association between the populations present in the Northumberland-Durham region and the Grampian-Fife region, with all individuals captured in the study period previously recorded on Tayside. This is unsurprising given the relatively close geographic proximity, significant research efforts throughout the Grampian-Fife region, and the wide-ranging distribution of the population within the region (*e.g.* Quick *et al.* 2014).

Photographs submitted for this study taken north of the Northumberland-Durham study area from North Berwick and The Isle of May were subsequently unused in the analysis. However they did show several well marked individuals present in the Northumberland-Durham region, indicating that they ranged further north during the period of the study. Anecdotal evidence throughout the Grampian-Fife region also suggest casual sightings of extremely well known individuals (*e.g.* ND027 'Runny Paint') were present during the study period ranging as far north as Aberdeen, with indications that her most recent calf (ND057) may have been born within the Grampian-Fife region.

Whilst all of the individuals captured in the Northumberland-Durham region were recorded in the Grampian-Fife region, there is a proportion of the Tayside population which have not been observed ranging further south, though an estimated proportion of the individuals not ranging further south and the potential reasons why remain unknown.

Due to the close association with the Tayside population, it is perhaps more appropriate to consider the Northumberland-Durham region an expansion of the range of the Tay population, rather than a discrete range of a new subset population, as it is apparent that several individuals are regularly moving between the two regions. Further study into the link between the Grampian-Fife and Northumberland-Durham regions would allow for a more in-depth investigation into the connectedness of the regions, and allow for a better understanding of the role of the Northumberland-Durham region in the range of the east-coast population.

## The occurrence of dolphins in the Northumberland-Durham region

There was a significant population of bottlenose dolphins present in the Northumberland-Durham region during the study period, representing approximately a quarter of the entire east-coast population based upon the most recent estimates. The region is clearly capable of sustaining such a sizeable population, with appropriate habitat and food availability evidently present. The north-east coast of England already supports a number of other cetacean species (Reid *et al.* 2003), as well as significant populations of other marine life, including seals and seabirds. It is perhaps unsurprising therefore that the region seems capable of sustaining the population of bottlenose dolphins, at least within the period of the study. In recent years, significant restoration projects have been undertaken in many of the regions rivers, including the Tyne, Blyth, Aln and Coquet, aimed at improving water and habitat quality, as well as installing fish passes, allowing for increased numbers of trout and salmon to utilise the river systems around the north-east coast (TRT 2017, NRT 2017). This potential increase in key bottlenose dolphin prey species (Santos *et al.* 2001), may have helped to sustain the population in the region.

The east-coast population expanded south from the Moray Firth in the mid-1990s (Wilson *et al.* 2004), and individuals within the east-coast population are known to range widely. Long-distance permanent movements have also been observed in the east-coast population, with Robinson *et al.* (2012) documenting the movement of a number of individuals recorded in the Moray Firth to the west coast of the Republic of Ireland. There is therefore a precedence for significant alterations in the range of distribution of dolphins in the east coast to naturally occur.

There were several older individuals recorded in the Northumberland-Durham region, many of which had not been recorded in the Moray Firth for several years. Some of the known mature females, *i.e.* ND002 'Salami', ND025 'Chips' and ND027 'Runny Paint' were known to produce calves during the study period. However, as females mature towards reproductive senescence, interbirth intervals are known to increase (Robinson *et al.* In Press), suggesting a change in role from breeding towards a predominantly nursing role, assisting in the raising of other calves (Fruet *et al.* 2015). If mature individuals are less frequently seeking to reproduce, it may not be necessary to make long distance movements to the Moray Firth, especially from an area with plentiful resources and limited competition.

Bottlenose dolphins live in highly social, complex populations often displaying levels of intraspecific competition and aggression between individuals (Wilson *et al.* 1997, Torres and Read 2009, Herzing *et al.* 2003). The Moray Firth contains a significant proportion of the wider east-coast population (Thompson *et al.* 2011), and it is possible that high levels of agonistic intraspecific behaviour, as well as competition for resources and mates is too severe for older or less fit individuals in the population.

The Moray Firth is known to be an important calving and nursery area for the east coast population (Robinson *et al.* 2007, Culloch and Robinson 2008, Filan 2015, Wilson *et al.* 1997), with a total of 102 females producing 193 calves during a twenty-year period (1997-2016 inclusive) (Robinson *et al.* In Press). However, during the study period 17.7% of the total individuals captured in the Northumberland-Durham region were calves (Table 7). At least two of the calves captured were known to have been born in the Moray Firth, travelling to the Northumberland-Durham region in their first year (ND002, ND026). The region of origin of the other calves present in the study area is unknown, however the presence of a high number of young, and the number of reproductively

active females in the region suggest that areas outside the Moray Firth are still utilised as calving and nursery areas. Competition for resources, as well as the risk of intraspecific aggression and documented levels of infanticide by males within the Moray Firth (Patterson *et al.* 1998, Robinson 2014) may result in facets of the population resorting to raising young in regions outside of the Moray Firth.

Bottlenose dolphins generally live in fission-fusion societies, wherein individuals associate in groups of changeable composition (Connor *et al.* 2000), however, strong associations between individuals are known to occur (Lusseau *et al.* 2003). There are known links between several of the individuals present in the Northumberland-Durham region. Several animals were known to be associated in previous sightings in the Moray Firth, including ND002 'Salami' and ND025 'Chips', and ND027 'Runny Paint' and ND037 'Pilot', as determined from previous encounters recorded in the CRRU archives. Maternally linked individuals were also captured in the region, with mature previous calves recorded in the region along with the mother, for instance ND020 'Squiggle' was recorded with the now separated calf ND041 'Cocoa', and ND027 with former calf ND028 'Paint Splotch'.

There are many possible reasons why the range of the east-coast population of bottlenose dolphins appears to have expanded south into the Northumberland-Durham region, although within the limitations of this study it is not possible to suggest any definitive explanations. With further study, and increased understandings of the connectivity, distribution and habitat use of the east-coast population, it may be possible to definitively understand the reasons behind variations in temporal and spatial distribution of the species.

## Implications for Management

Bottlenose dolphins are protected by a range of both UK and European legislation, including the European Union Habitats Directive (92/43/EEC). The Directive requires the establishment of a network of SACs based around key habitats containing high densities of animals (Hoyt 2005), including the Inner Moray Firth SAC, designated to afford strict protections to the east-coast population of bottlenose dolphins. However, site protection alone is considered largely inadequate for highly-mobile, wide-ranging animals such as bottlenose dolphins (Parsons *et al.* 2007), and as such the EU Habitats Directive affords additional protection to individuals when outside the boundaries of the designated SAC (Robinson *et al.* 2012).

The east-coast population is similar in size to many coastal bottlenose dolphin populations worldwide (Wells and Scott 1990, Williams *et al.* 1993, Liret *et al.* 1994, Defran and Weller 1999), however the geographic isolation of the east-coast population raises considerable concerns about its vulnerability (Wilson *et al.* 1999).

Within bottlenose dolphins, as with many species, there is variation in the inherent value and function that each individual contributes to its population, as well as variation in the extent of individual ranging. It is possible that wider ranging animals may serve as reproductive units (Robinson *et al.* 2012), maintaining genetic diversity between subset populations around the east-coast range, therefore requiring additional protections to maintain the genetic viability of the east-coast population.

Bottlenose dolphins are highly sensitive to a range of commonly occurring developments in the North Sea, including wind farm installations and oil and gas activities, and as such mitigation measures must be undertaken to protect the species. The apparent inter-connectedness of the east-



coast population across a coastal area of over 500km at minimum, raises a number of serious challenges in managing for the conservation of the species. Negative impacts upon the population in one region along the east-coast will likely impact the rest of the population across the whole range of the species. As such, it is recommended that the east-coast bottlenose dolphins be regarded as one interactive population across the entirety of its range, and considered to be a single unit for the purposes of management, ranging between the Inner Firth SAC to the Northumberland-Durham Region (Thompson *et al.* 2011).

A thorough understanding of the temporal and spatial distribution of the species is vital for enabling effective management for conservation, and as such further studies are required into the connectedness of the east-coast population, as well as the distribution of the species outside of the areas of existing study.

### Limitations/Opportunities of the Study

Thompson *et al.* (2011) considered the possible usefulness of publicly collected photographic data, however no studies to date throughout the east-coast region have solely used data gathered entirely from publicly collected sources, making this study quite unique for the east-coast bottlenose dolphin population. In north-east England, there has been little opportunity for dedicated research into the population of animals, due to the historical absence of the species, wide-ranging and sporadic temporal and spatial distribution within the region, as well as the size of the Northumberland-Durham region.

Utilising a public network of observers and photographers allowed for year-round data collection, across an area far greater than could be covered by a dedicated researcher, and obviously eradicated the need for significant financial expenditure.

There were however several limitations, particularly within the photo-identification portion of this study. Good photo-identification studies are inherently dependent upon good photographs (Evans and Hammond 2004). Many photographs submitted for this study were discarded due to poor quality, or poor composition in terms of position in regards to the animal. Most photos taken of dolphins, particularly from the first two years of the study (many of the images taken in 2016 were captured specifically to be submitted to the CRRU), were likely not initially intended to be used for research purposes, and as such clear, parallel photos of dorsal fins would not have been attempted, as photos showing the animals head, or behavioural displays such as breaching would make for more 'exciting' photographs. When dorsal fin shots were attempted, many images were of poor photo-quality, due to the significant difficulties associated with capturing in-focus shots of dolphins, particularly whilst at sea. As well as this, there is a natural bias displayed by many photographers to focus disproportionately on the most heavily marked animals, often resulting in the underrepresentation of more subtly marked individuals within the photoset from an encounter.

There was significant variation in the number of images captured both between encounters and between years, with several factors affecting the number of encounters and the number of images submitted. Publicly collected photographs, particularly those taken from tour boats, will be highly affected by weather and seasonality of the vessels operation. Where images are taken by the operators of tour boats, it may not always be possible to physically photograph every encounter, as the captain and crew of the vessel will likely have other duties which take priority.

Pre-filtering of images before submitting them for the study also raised issues. Often images in series showing repeated surfaces of individuals are useful for identifying animals, particularly in group shots. This is not possible however if images in the series are removed before submission of the

photoset. Edited photographs which have been inappropriately cropped or adjusted also increase the difficulty of identifying individuals.

The associated limitations in the collection of data ultimately limited the analysis carried out during this study, however, despite this it was still possible to conduct a full, preliminary photo-identification study, gaining valuable knowledge of a wide range of features of the population present in the region.

The significantly increased potential scope of studies when utilising publicly collected data is highly valuable to capture the distribution of difficult to monitor species across a large geographic range, and is likely to become increasingly more frequently utilised to complement existing studies, as well as help to focus and maximise the effectiveness of existing research infrastructure.

### Northumberland-Durham Region Bottlenose Dolphin Catalogue

The first photo-identification catalogue for bottlenose dolphins in the north-east of England was compiled from the results of this study. Recapturable individuals were given a unique Northumberland-Durham identification number (e.g. ND001), and were cross-referenced with CRRU and online AULFS catalogues. A public version of this catalogue will be created, showing the left and right side of the dorsal of each individual animal (where possible), along with its recapture history in the Northumberland-Durham region. Initial sample pages from this catalogue are included in the appendix.

The public catalogue will be distributed to tour-boat operators and other potential data-collectors around north-east England, to encourage further collection of data for future studies, and increase knowledge of the regional bottlenose dolphin population, potentially increasing the quality and reliability of future collected data.

### Future Study

From this preliminary study, it was possible to gain a large amount of knowledge about the composition, fidelity and distribution of the bottlenose dolphins present in north-east England. Continuations upon this study, with increased amounts of data will enable for more in-depth analyses, and a greater understanding of the individuals in this region and throughout the entire east-coast. Increased amounts of high-quality photo-identification data would allow for statistical modelling to be undertaken, providing better estimates for the regional population size. Focus of future studies should also be targeted at the connectivity between the Northumberland-Durham region and the Grampian-Fife region, as well as the potential distribution of the species further south of the study area used herein, in order to further understand the temporal and spatial distribution of the species throughout the entirety of the east-coast range.

### Conclusions

This study demonstrates not only the power of photo-identification as a tool for understanding the distribution of a species throughout its range, but also emphasises the potential benefits of utilising a network of public data-collectors when studying a wide-ranging species which is inherently difficult to monitor and study, particularly in areas without existing research infrastructure. Continually developing our understanding of the spatial and temporal distribution, connectivity, and variations in individual movements of bottlenose dolphins throughout east-coast is vital to be able to effectively manage and protect this vulnerable population of one of nature's most iconic species.

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## 8. Appendix:

1. Database of recapturable individuals
2. Sample pages from publicly available photo-identification catalogue for the Northumberland-Durham region

Name	ND-ID	CRRU-ID	AU-ID	Recaptureable	Sex	Age	Maternal Link	Calf History	Observed NE		
									2014	2015	2016
Spinnaker	001	632	881	1	M	A			2	1	0
Salami	002	102	227	1	F	A	ND003	AU1115, CRRU400, AU457	7	1	4
Pepperami	003	577		C	U	C	ND002		7	1	4
Deliah	004	596	1054	1	F	A	ND005	AU1099, AU1170	7	0	1
C of Deliah	005	616	1170	C	U	C	ND004		7	0	1
Barbara	006	627	1119	1	F	A	ND043		5	1	0
Doosh-Doosh	008	517	1118	1	F	A	ND032		4	0	0
White Tip	009	619	1062	1	F	A	ND034		5	1	0
Munt	011	633	1121	1	U	A			2	0	0
Barracuda	012	002	102	1	M	A			1	1	0
Aye-Aye	013	387	1002	1	F	A	ND014	CRRU617, CRRU493	1	0	0
C of Aye-Aye	014	617	1148	C	U	C	ND013		1	0	0
Gelato	015	626	1115	1	U	SA			2	0	0
Dexy	016	624	1123	1	U	SA			1	0	0
	018	621	1043	1	F	A	ND019		1	0	0
	019	622	1133	C	U	C	ND018		1	0	0
Squiggle	020	625	1058	1	F	A	ND061	ND041	3	0	1
	023	645		1	U	SA			3	0	0
Eloi	024			1	U	SA			3	0	0
Chips	025	178	344	1	F	A	ND026	AU1123, CRRU401	4	1	3
	026	618		C	F	C	ND025		4	1	3
Runny Paint	027	055	116	1	F	A	ND057	CRRU634	5	1	5
Paint Splotch	028	634	1052	1	F	A		(C of ND027)	3	0	0
Doris	029	516	1037	1	F	A		CRRU592	4	0	0
Gaskin	032	579	1171	1	U	C	ND008		2	0	0
	033			1	U	A			3	0	1
	034	620		C	U	C	ND009		1	1	0



Mary-Lee	035		1096	1	F	A	ND036	AU1097	2	0	1
	036			C	U	C	ND035		2	0	1
Black 'N' Decker	037	149	002	1	M	A			2	1	2
Pilot	038	032	068	1	F	A		AU067, AU329	5	0	2
Morlock	039	623	1050	1	M	A			2	0	2
Cocoa	041	635	1156	1	U	SA		(C of ND020)	1	1	0
	043	628		C	U	C	ND006		1	0	0
	044	554	1048	1	M	A			1	0	0
Floppy Fin	045	631	1150	1	U	A		(C of CRRU636)	1	1	0
	046	556	1047	1	M	SA			1	0	0
	050	560	1076?	1	F	A		AU1149	1	0	0
Tay	054	529	1064	1	F	A	CRRU550		0	1	0
	055			1	U	A			0	1	1
Guinness	056	078	009	1	F	A		CRRU108, CRRU065, AU1094	1	0	2
C of Runny Paint	057	655		C	U	C	ND027		0	0	2
Adur	058			1	U	A			0	0	3
Illusion	059	384	1039	1	U	A			0	0	3
	060		1089	1	U	A			0	0	1
	061			C	U	C	ND020		0	0	1
Fea	062	423	886	1	M	A			0	0	1
	063	593	1091	1	U	A			0	0	1

002

Salami

CRRU#102 AULFS#227

ADULT FEMALE (4 KNOWN CALVES)



RIGHT DORSAL



LEFT DORSAL

YEAR	2014	2015	2016
SIGHTINGS	√	√	√

NO. OF RECAPTURES = 12

004

Deliah

CRRU#596 AULFS#1054

ADULT FEMALE (3 KNOWN CALVES)



RIGHT DORSAL



LEFT DORSAL

YEAR	2014	2015	2016
SIGHTINGS	√		√

NO. OF RECAPTURES = 8

025

**Chips**

CRRU#178 AULFS#344

ADULT FEMALE (3 KNOWN CALVES)



RIGHT DORSAL



LEFT DORSAL

YEAR	2014	2015	2016
SIGHTINGS	√	√	√

NO. OF RECAPTURES = 8

027

Runny Paint

CRRU#055AULFS#116

ADULT FEMALE (2 KNOWN CALVES)



RIGHT DORSAL



LEFT DORSAL

YEAR	2014	2015	2016
SIGHTINGS	√	√	√

NO. OF RECAPTURES = 11



037

Black 'n' Decker

CRRU#149 AULFS#002

ADULT MALE



RIGHT DORSAL



LEFT DORSAL

YEAR	2014	2015	2016
SIGHTINGS	√	√	√

NO. OF RECAPTURES = 5

