UNIVERSITY OF THE WEST of SCOTLAND

THE SUMMER DISTRIBUTION, GROUP SIZE AND RELATIVE ABUNDANCE OF BOTTLENOSE DOLPHINS (*TUSIOPS TRUNCATUS*) USING THE OUTER SOUTHERN MORAY FIRTH, NORTH-EAST SCOTLAND 2009 – 2012

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B00188635

This project was carried out in association with the Cetacean Research and Rescue Unit

Photo Credit: Dr Kevin Robinson, CRRU.

“There is about as much educational benefit to be gained in studying dolphins in captivity as there would be studying mankind by only observing prisoners held in solitary confinement”.

- Jacques Cousteau

Declaration

"All work presented in this report was carried out during the course of an Honours research project undertaken in Life & Environment department of the University of the West of Scotland during the academic session 2012/2013 in fulfilment of the requirements for the module 'Bioscience Research Project' (BIOL 10006)".

Signed ……..

Date ……..

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Special thanks must go to Dr Kevin Robinson of the Cetacean Research and Rescue Unit. He introduced me to the dolphins of the Moray Firth and all their beauty. I am ever so grateful for your continued support, feedback and encouragement. Your dedication and enthusiasm for the work you do has truly been an inspiration to me.

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Abstract

The current study looks in to the distribution of the bottlenose dolphin (*Tursiops truncatus*) in the Outer Moray Firth in the northeast of Scotland. A four year dataset was analysed and Geographical Information Systems constructed. From the data a number of factors were extracted including the general distribution, group size and the presence of calves within groups. Encounter rates and abundances were calculated to examine overall spatial and temporal patterns of site fidelity and movement.

The overall aim of the present study is to investigate whether or not the outer Moray Firth is an area of importance to the bottlenose dolphin and not simply a corridor into the already protected Inner Moray Firth.

Table of Contents

Acknowledgements.....i

Abstract.....ii

Table of Contents.....iii

List of Figures.....iv

List of Tables.....v

List of Appendices.....vi

1.0 Introduction.....1

2.0 Methods.....3

2.1 Data Collection.....4

2.2 Geographical Information Systems (GIS).....5

2.3 Photo-Identification.....5

3.Results.....7

3.1 Abundance & Distribution.....9

3.2 Group Size / Composition.....12

3.3 Site Fidelity.....14

4. Discussion.....16

4.1 Abundance & Distribution.....17

4.2 Group Size / Composition.....18

4.3 Site Fidelity.....19

Summary.....21

References.....23

Appendices.....26

List of Figures

Figure 2.1. Map of Scotland showing the position of the study area along the southern coastline of the outer Moray Firth……4

Figure 3.1. Map of the Moray Firth southern coastline showing the distribution of bottlenose dolphin encounters made within the study area (n=118) and the survey effort conducted between 2009 and 2012 inclusive. The encounters for each year are colour coded accordingly……..8

Figure 3.2. Double y-axis line graph showing the abundance of animals (per km surveyed) with respect to the total annual (a) and monthly (b) survey effort (km) for 2009 to 2012 inclusive…….10

Figure 3.3. Yearly mean group sizes with ± standard deviation error bars……12

Figure 3.4. Graph showing the recapture rates for 2009 to 2012 inclusive, with 3 individuals encountered only once and 1 individual encountered 54 times……14

List of Tables

Table 3.1. The survey effort for surveys carried out from May to October 2009 to 2012 inclusive……8

Table 3.2. Showing the survey effort, number of encounters, cumulative number of animals, encounter rate and abundance of bottlenose dolphins recorded by the CRRU from 2009 to 2012 inclusive……9

Table 3.3. Showing the total annual number of encounters and encounters including calves, with the overall proportion of groups seen to contain calves for 2009 to 2012 inclusive……..13

Table 3.4. Showing the cumulative number of neonates born during survey months and the percentage of encountered groups with calves 2009 to 2012 inclusive……13

Table 3.5. Annual residency of bottlenose dolphins from 2009 to 2012 inclusive. Total animals encountered represents the total number of individuals encountered that year (sub-adults and calves included)……15

List of Appendices

Appendix 1. Maps showing a) the total annual survey effort for 2009 to 2012 inclusive and b) the total survey effort for 2009 to 2012 with annual encounters……27

Appendix 2. Map showing the annual distribution of encounters recorded from 2009 to 2012 inclusive. a) 2009 b) 2010 c) 2011 d) 2012……28

Appendix 3a. Map showing the monthly distribution of encounters from 2009 to 2012 inclusive. a) May b) June c) July d) August e) September f) October……29

Appendix 3a. Map showing the monthly distribution of encounters from 2009 to 2012 inclusive. a) May b) June c) July d) August e) September f) October……30

Appendix 4. Table marked individuals and in which years they were sighted……31

Appendix 5. Table of individual residency for the study period of 2009 to 2012 inclusive……33

1.0 Introduction

Cetaceans (the whales, dolphins and porpoises) are large, long-living and highly mobile marine mammals that show extensive migrations and high site fidelity to areas in which they aggregate for feeding, socialising, mating and calving. The marine environment in which these animals live is characterised by complex spatial and temporal heterogeneity (Pittman & Costa, 2009). The success of efforts to conserve coastally-occurring cetacean populations therefore depends upon a good understanding of the factors influencing their respective distribution and habitat use over spatial and temporal scales.

The Moray Firth in northeast Scotland is home to one of only two known resident populations of bottlenose dolphins in UK waters, the other being Cardigan Bay, Wales (Bristow and Rees, 2001). Although the species are often sighted throughout the Hebrides, on Scotland's west coast and in the Shannon Estuary, Republic of Ireland, the animals in the Moray Firth represent a population living at the most northern extreme of the species range (Robinson *et al*., 2012; Culloch 2004).

In the inshore, coastal waters of the Moray Firth, bottlenose dolphins occur in high numbers during the summer and autumnal months (Thompson *et al*., 2012). The southern coastline of the Outer Firth supports a large percentage of the 200 or so animals recorded in this region (Cheney *et al*., 2012) and is thought to provide important nursery / calving areas for the population (Robinson *et al*., 2007; Culloch and Robinson, 2008). Wilson *et al*. (1999) suggested a population decline of more than 5% a year, suggesting that the northeast Scotland population was evidently vulnerable to extinction and as such was considered to be of both national and international importance (Culloch, 2004). However, recent studies indicate not only that the population is stable, but that it is possibly increasing in recent years (Thompson *et al*., 2012).

Using sightings data collected between May and October 2009 to 2012 inclusive, the present study aims to investigate fine-scale inter-annual and seasonal changes in the abundance of the bottlenose dolphins occupying the southern coastline of the Outer Moray Firth. Far from simply providing a corridor area to the Inner Firth Special Area of Conservation, this region is believed to be particularly important for calving for the population (Culloch and Robinson, 2008). Dedicated photo-identification data from the region was subsequently examined to identify inter-annual changes in individual occurrence and site fidelity and to provide annual estimates of abundance using mark-recapture analysis.

2.0 Methods

2.1 Data Collection

The data set used for the current study was collected by the Cetacean Research & Rescue Unit (CRRU) during dedicated summer boat surveys in the outer southern Moray Firth between May and October 2009 to 2012 inclusive. The outer firth is bound on two sides by land and is generally described as the area of sea east of a line drawn from Helmsdale in the north to Lossiemouth in the south, extending to Duncansby Head in the north and Fraserburgh in the south-east (Robinson *et al*., 2007).

Inshore surveys were conducted along an 83km stretch of coastline between the ports of Fraserburgh and Lossiemouth (Figure 1.), using rigid-hulled-inflatable boats (RHIBs) at mean vessel speeds of 7 knots in visibility of ≥ 1 km and Beaufort Sea States of ≤ 3, with a crew of two experienced and up to four additional trained observers (as detailed in Robinson *et al*., 2007 and Culloch & Robinson, 2008). The available dataset represents a total of 118 encounters with the study species over 457 survey trips conducted over 193 days between 2009 and 2012 inclusive.

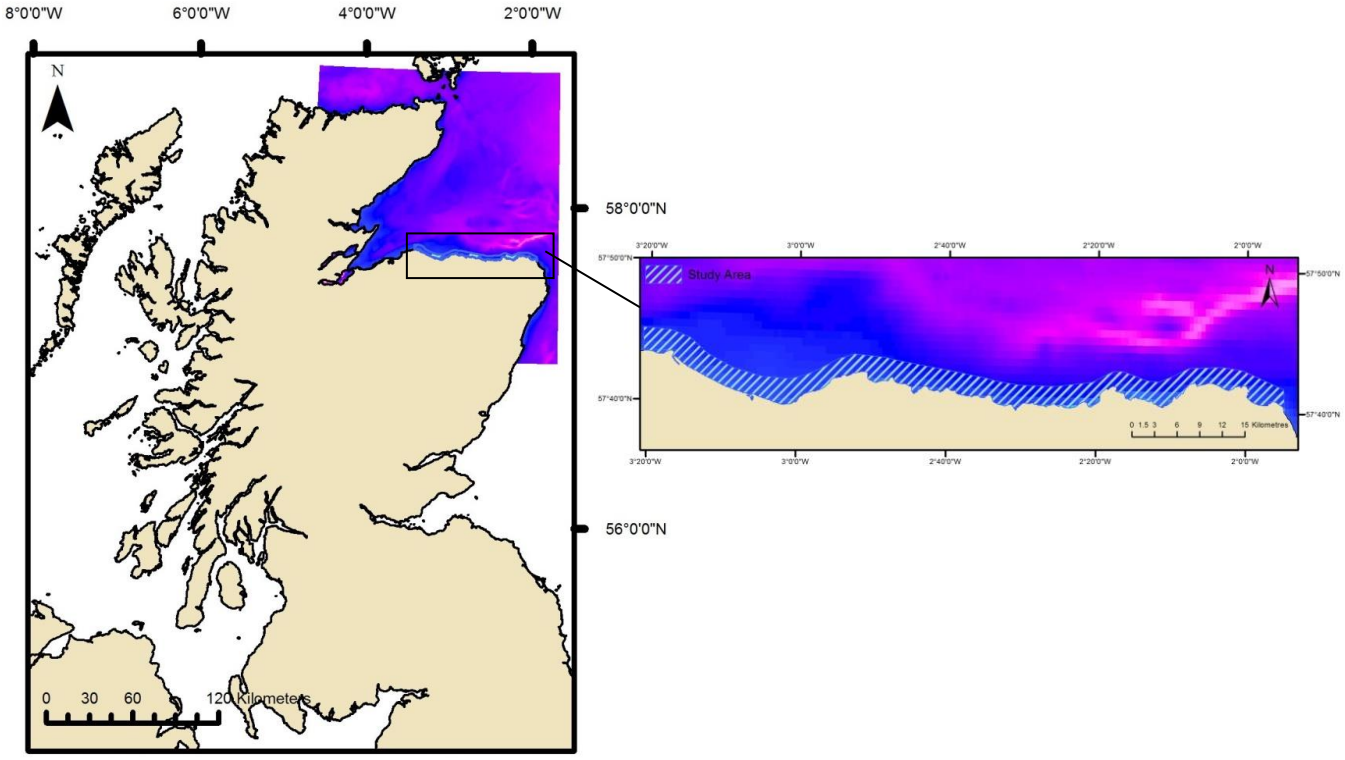


Figure 2.1. Map of Scotland showing the position of the study area along the southern coastline of the outer Moray Firth.

2.2 Geographical Information Systems (GIS)

Working in the marine environment can be complex and costly therefore knowing where to collect your data the first time could be extremely useful and GIS maps provide important information on where to collect data as it can highlight factors such as areas of high site fidelity or seabed sediment that is a favoured habitat for the study species (MacLeod, 2011).

In the following study GIS maps will be used to explore the spatial distribution and site fidelity of bottlenose dolphins. The distribution of encounters within the study area was observed by plotting the respective location of each encounter using a Geographical Information System (ArcMap version 10). The data frame was set up using the projected co-ordinate system (GCS_WGS_1984). All additional layers were also projected using the same coordinate system.

2.3 Statistical Analysis

All statistical analyses were conducted using Unistat version 6.0. The mean results are given as the mean ± the standard deviation. Analysis of variance tests (ANOVA) were carried out to test for significant difference in the encounter rates with calves between each year of the study period and also between each month (May to October). Abundance and encounter rates were manually calculated for each year using distance travelled and group size data.

2.4 Photo-Identification

The aim during each encounter was to photograph the dorsal fins of each individual present. Capturing both left and right dorsal fin shots was not considered necessary, so long as each individual was caught on at least one side. This is regarded as an important protocol to ensure that durations of encounters were kept to a minimum, thus reducing any subsequent disturbance. The most effective method of doing so was to pre-focus the camera on the sea where the individual was expected to surface, thus minimising the time required to focus on the individual. During encounters with large groups, positive identification of known marked individuals were made by eye, by experienced observers, allowing more time for the photographer to capture unknown and subtly marked individuals, again minimising the time spent on encounters. Where possible the boat was positioned adjacent to the dolphin in relation to the sun, with the sun ideally behind the photographer, allowing the sunlight to highlight the desired features on the subject.

During each encounter dedicated note takers gathered information on the numbers of adults, sub-adults, calves and neonates (new born calves) present and information on any sub-groups, mother - calve relationships and intra-group associations within the groups encountered. For the purpose of the current study animals were divided into four age groups, based on their appearance. These were; adult, sub-adult, calf and neonate, as defined in Eisfeld (2003).

At the end of each encounter a summary of the encounter was recorded, including behaviours exhibited such as foraging and direction of travel. The time, GPS end position and a visual landmark were also recorded. Finally, a photograph of something other than the dolphins or sea was taken to separate any subsequent encounters from the same day.

3.0 Result

Across the 4 year study period, a total of 457 survey trips covering a distance of 4650.76kms of survey effort were conducted, over 193 days (Table 3.1). Therein, a total of 118 bottlenose dolphin encounters were recorded, by the CRRU along the length of the study site (Figure 3.1).

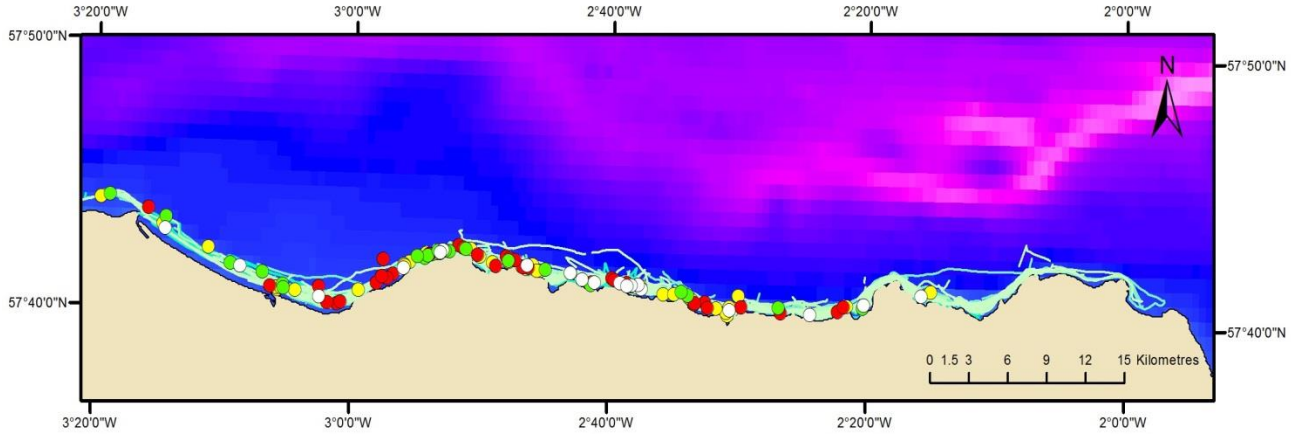


Figure 3.1. Map of the Moray Firth southern coastline showing the distribution of bottlenose dolphin encounters made within the study area (n=118) and the survey effort conducted between 2009 and 2012 inclusive. The encounters for each year are colour coded accordingly.

Table 3. 1. The survey effort for CRRU boat surveys carried out from May to October 2009 to 2012 inclusive.

Year	Total No. of Survey Days	Total No. of Survey Trips	Survey Effort (km)	Total No. of Encounters
2009	43	150	1202.24	20
2010	42	94	1003.41	22
2011	50	53	1063.40	35
2012	58	160	1381.71	41
Total	193	457	4650.76	118

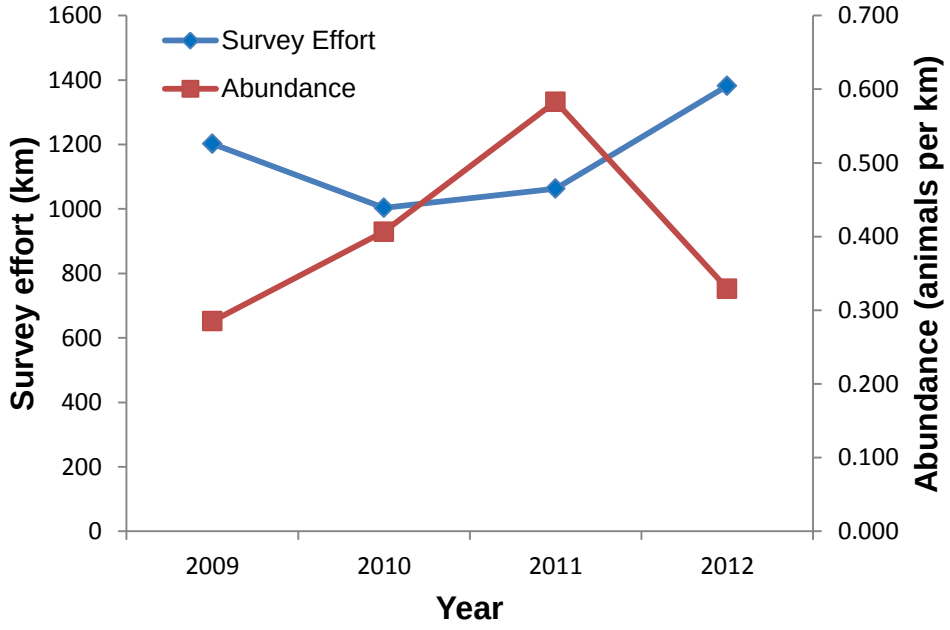
3.1 Abundance and Distribution

Encounters with bottlenose dolphins were recorded in all years and months throughout the study area during the period of study. The number of encounters recorded was greatest in 2012 with a total of 41 encounters and lowest in 2009 with a total of 20 encounters (Table 3.2). Cumulative monthly encounters were highest in July and August with 29 encounters recorded and lowest in October with only 7 encounters.

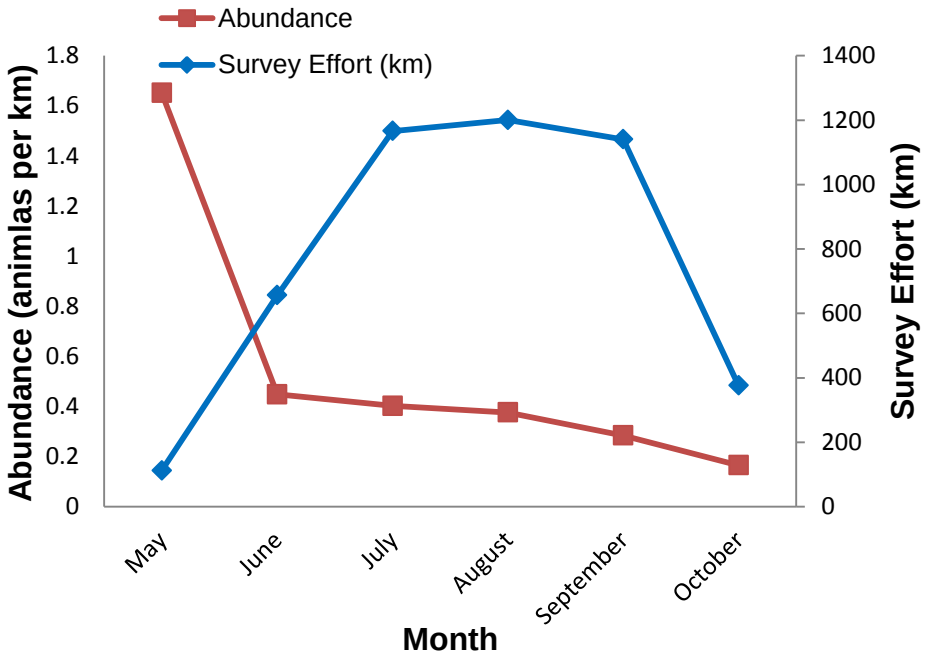
The highest encounter and abundance rate was recorded in 2011, with 0.033 encounters and 0.583 animals per km (Figure 3.2a). Conversely, the lowest annual rates were recorded in 2009, with 0.017 encounters and 0.285 animals per km. The lowest abundance and encounter rates were further recorded during the month of October, with 0.165 animals per km and 0.021 encounters per km, while the highest rates were observed in May with 0.080 encounters per km and 1.651 animals per km (Figure 3.2b). However, during the study period surveys carried out in May covered the least number of kilometres (112.04kms) and also had the second lowest number of encounters (n= 9) only after October (n=7) therefore giving the highest abundance levels. The month with the second highest abundance and encounter rates was June (0.030 encounters per km and 0.448 animals per km).

Table 3.2. Showing the survey effort, number of encounters, cumulative number of animals, encounter rate and abundance of bottlenose dolphins recorded by the CRRU from 2009 to 2012 inclusive.

Year	Survey Effort (km)	Total BND Encounters	Cumulative No. Animals	Encounter Rate per km	Animals per km
2009	1202.24	20	343	0.017	0.285
2010	1003.41	22	408	0.022	0.407
2011	1063.4	35	620	0.033	0.583
2012	1381.71	41	455	0.030	0.329
Total	4650.76	118	1826	0.025	0.401



a)



b)

Figure 3.2 Double y-axis line graph showing the abundance of animals (per km surveyed) with respect to the total annual (a) and monthly (b) survey effort (km) for 2009 to 2012 inclusive.

The distribution of sightings was seen to vary month to month. During May sightings were distributed along the survey area from Pennan, in June sightings were from Pennan to Spey Bay, during July encounters were from MacDuff to Lossiemouth, during August from Banff to Spey Bay,

in September from Gardenstown to Lossiemouth and in October from Banff to Portknockie. October sightings were the most closely distributed of all months, with July having the most widely distributed sightings (illustrated in appendix 3a & 3b). The area of MacDuff was where encounters with the largest groups occurred, with the mean number of individuals encountered at this location significantly higher than almost all other locations, with the exception of Whitehills and Buckie, along the survey area. Encounters were recorded at water depths between 4.6 and 21.1 metres.

3.2 Group Size / Composition

Group sizes were found to range between 2 and 70 animals, with only 6 solitary individuals being encountered throughout the whole study period and accounted for only 5% of the total encounters recorded. The largest group encountered was recorded on 20th May 2012 in the MacDuff area and consisted of 70 individuals.

The mean group size for each year varied, with the greatest yearly mean group size recorded in 2010 (18.6 ± 14.3) and the lowest yearly mean group size (Figure 3.3) recorded in 2012 (11.4 ± 6.8). Group size was also found to vary between months, with the largest mean groups recorded in May (20.6 ± 21.5) and the smallest mean in October (8.9 ±3.9).

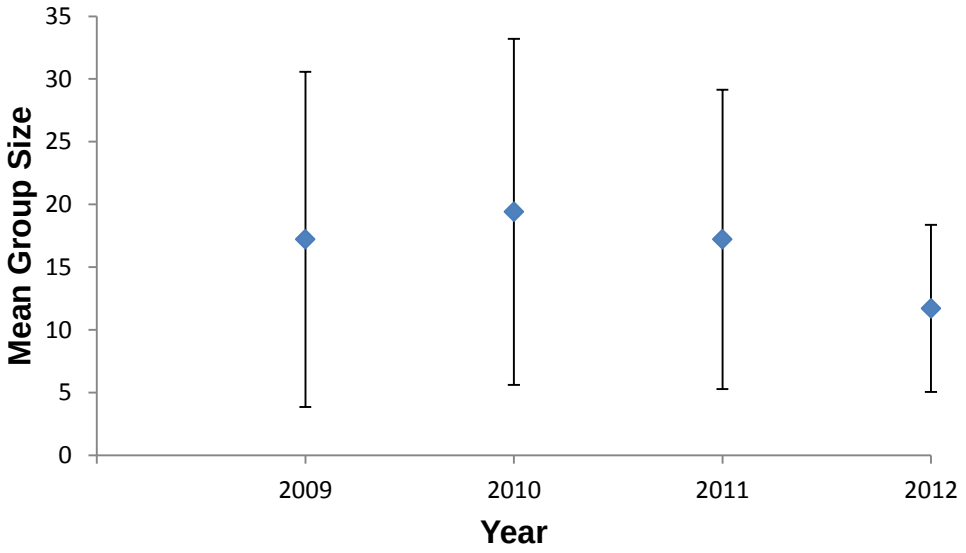


Figure 3.3. Yearly mean group sizes with ± standard deviation error bars.

Calves were found to be present in 80.51% of encounters recorded between 2009 and 2012 (Table 3.3). Calves were sighted in all months of the survey, however new born or neonatal calves were only recorded between the months of July and October, with a peak in the number sighted during the month of August (Table 3.4). One calf recorded as a neonate in September 2009 is known to be deceased as of May 2010, as a result of infanticidal behaviour, as detailed in Robinson (2013).

Table 3.3. Showing the total annual number of encounters and encounters including calves, with the overall proportion of groups seen to contain calves for 2009 to 2012 inclusive.

Year	Encounters	Encounters with calves
2009	20	14
2010	22	18
2011	35	30
2012	41	33
Total	118	95
	% of groups with calves 2009-2012	80.51

There was no significant difference found in the number of groups containing calves between years or months ($F = 0.70627$, $P = 0.43289$ and $F = 0.569395$, $P = 0.472125$ respectively).

Table 3.4. Showing the cumulative number of neonates born during survey months and the percentage of groups encountered with calves 2009 to 2012 inclusive.

	May	June	July	August	September	October
Number of encounters	9	20	29	29	23	8
Number of neonates	0	0	5	16	5	10
% of groups with calves	55.56	80.00	93.10	82.76	78.26	62.50

3.3 Site Fidelity

Photo-identification from 2009 to 2012 inclusive revealed that 134 individuals were sighted by the CRRU team within the outer firth study area. Of the 134 individuals a total of 61 "marked" adults were recorded within the study area. Recapturability was based on whether or not the dorsal edge mark (DEM) was considerably recognisable as a distinct individual, i.e. individuals exhibiting prominent distinctive or pronounced nicks, notches and / or anomalies in the trailing edge of the dorsal fin. Recapture data for the 61 marked individuals revealed that only 5 (8.2%) of the marked adults identified were sighted only once during the 4 year study period. Conversely, over 91% (91.8) of the marked individuals were re-sighted within the study area during the period of study. Of the marked and re-sighted individuals the majority showed high site fidelity, with 26 individuals (42.6%) recaptured in all 4 years, 11 individuals (18%) recaptured in 3 out of the 4 years, 14 individuals (23%) recaptured in 2 out of 4 years and 10 individuals (16.4%) of individuals recaptured in only 1 year or the 4 year study period (Appendix 4). With one adult female (ID# 506), being recaptured a total of 54 times within the 4 year study period (Figure 3.4).

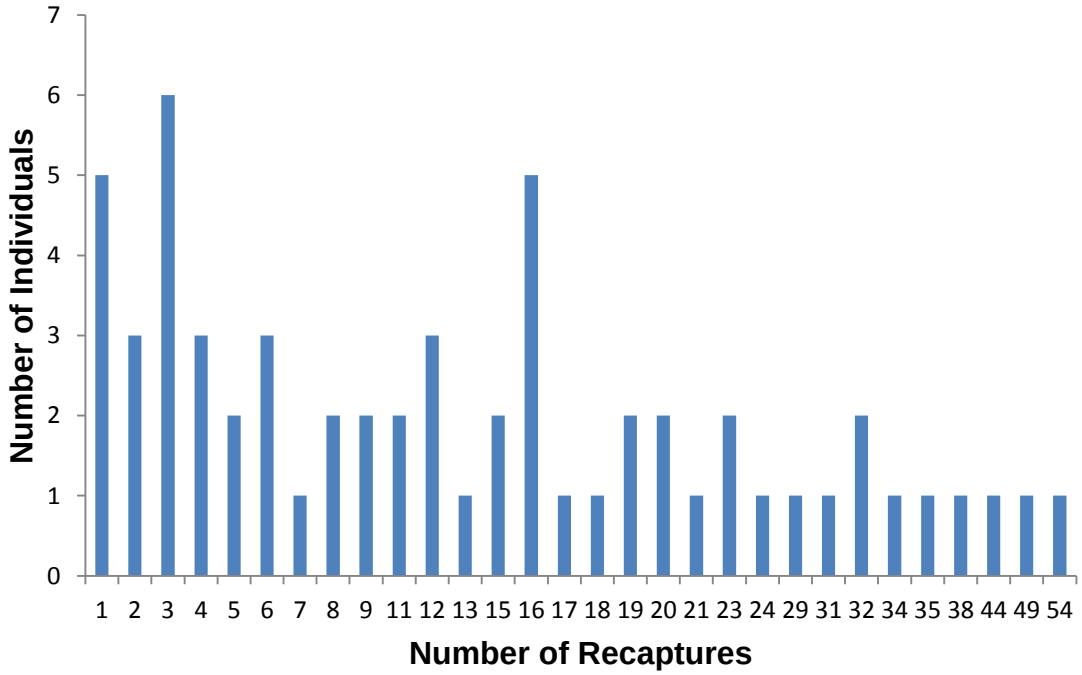


Figure 3.4. Graph showing the recapture rates for 2009 to 2012 inclusive, with 5 individuals encountered only once and 1 individual encountered 54 times.

For the purpose of the present study the criteria applied by Zolman, (2002) and Culloch, (2004) were used to examine residency patterns. Individuals re-sighted 12 or more times during the study period were classified as *common*, those recorded 8 – 11 times *frequent*, 4 – 7 times *occasional* and those recorded 3 times or less were classified as *rare*. According to the classification by Zolman, (2002) and Culloch, (2004), from the present dataset 37 individuals (60.65%) can be classified as *common* to *frequent*, 9 individuals (14.75%) can be classified as *occasional* and 15 individuals (24.59%) as *rare*.

Residency of an individual was defined as the presence of an individual within the study area during any three, or more months of the study period during any given year, these individuals were defined as seasonal residents for that given year.

Table 3.5. The annual residency of bottlenose dolphins from 2009 to 2012 inclusive. Total animals encountered represents the total number of individuals encountered that year (sub-adults and calves included).

	2009	2010	2011	2012	All Years
Total animals encountered	67	81	97	88	134
Total marked adults	37	43	52	44	61
Number of resident adults	8	19	32	20	39
% of resident marked adults	21.6	44.1	61.5	45.5	63.9

The percentage of resident adults varies between years, 39 of the 61 marked individuals were found to be resident during all study years, equating to over 63% of the marked individuals being regarded as resident to the area (Appendix 5).

4.0 Discussion

4.1 Abundance and Distribution

Findings from the present study provide evidence of high abundance in the area by the bottlenose dolphins in the outer southern Moray Firth, with encounters distributed along the entire length of the study area, suggesting that animals are utilising the entire coastline and not just using the area as a passage way to the inner firth, a special area of conservation (SAC).

The highest abundances were recorded from July to September, with a peak abundance in August, which is consistent with previous observations of seasonal variations corresponding with an increase in foraging activity and prey availability (Wilson *et al*., 1997; Culloch, 2004; Armstrong, 2010), suggesting that individuals are utilising the area during the warmer summer months. Encounters were recorded in water depths of between 4 to 21 meters, with an average depth of 11.9 meters. Conversely, the highest abundances recorded for the inner firth were found in water depths of 50 plus meters (Hastie *et al*., 2003). However the inner firth closely resembles a closed estuary with deep narrow passes, whereas the outer firth is more representative of the open ocean, with shallower coastal bays and inlets. Other studies in open ocean areas have shown a preference by the species for shallow, coastal waters, thus showing that depth preference in bottlenose dolphins is variable. For the study area and extending home range bottlnose dolphins have been recorded in relatively shallow waters (Wilson *et al*., 1999; Weir & Stockin, 2001).

The distribution of encounters varied from month to month and between all years, encounters with larger groups were generally greater to the east of the study area during the earlier and latter months of the survey year, suggesting that individuals and groups are entering or leaving the area around these times. Of the two largest groups encountered during the study period, one was recorded in May and the other in September of separate years, composed of 70 and 42 individuals respectively. This interpretation of the data is coinciding with earlier findings by Robinson that the largest group sizes are found in the earlier and latter months of the survey year, when animals are grouping and re-grouping to move in to or out of the firth accordingly. It is thought that the bottlenose dolphins travel into the firth in larger groups at the beginning of the summer and on entering the firth fragment into smaller social groups, which then travel throughout the area (Robinson,

unpublished data). To all accounts, the groups remain small until the end of the summer months when they appear to re-group and leave the area as a larger unit, of individuals and social groups. This could be a safety measure used by the animals to protect the new born calves when entering less costal/protected areas. The occurrence of the bottlenose dolphins has also been found to be closely related to the bathymetry of the outer Moray Firth, and it is thought that the dolphins follow the routes of migrating salmon returning to the river mouths to spawn (Robinson *et al*., 2009; Armstrong, 2010). Many of the bays within the study area where groups and individuals are encountered are connecting to rivers that are known to be used as spawning grounds for salmonids, a common prey species of the bottlnose population in the area (Santos *et al*., 2001).

4.2 Group Size / Composition

With a mean group size of 15.3 ± 11.4, the outer firth bottlenose population has the largest mean group size of any UK population, exceeding the mean size of 6.45 for the inner firth (Wilson, 1995), means of 8 for the Aberdeenshire coast (Weir & Stockin, 2001) means of between 3 to 5 for Cardigan Bay, Wales (Bristow & Rees, 2001) and 6.54 for the Shannon Estuary, Ireland (Duguid, 2003). Generally delphinid species which inhabit more open water habitats, as in the present study, are known to form larger groups than those groups inhabiting more estuarine habitats, and as such the groups of the outer firth would be expected to be significantly larger than those of the inner firth, as found here.

The number of groups containing calves also exceeds that of all other known bottlenose population in UK waters, with calves recorded in 80.5% of groups encountered during the study period. 80.79% of groups encountered between 2001 and 2010 inclusive also contained calves (Armstrong, 2010). These rates are also the highest recorded in UK waters, compared with 44% of groups off the Aberdeenshire coast (Stockin *et al*., 2006) and 66% of groups in Cardigan Bay, Wales, which is now deemed as an important nursery area for the population (Bristow & Rees, 2001). Therefore, after applying Bristow & Rees (2001) definition of a nursery area to the outer southern Moray Firth, it can also be determined as an important nursery / calving area, for the east coast Scotland population, as previously established by Culloch & Robinson (2008).

A total of 36 neonates were recorded during the study period. Births were recorded between the months of July and October, with a peak in the month of August for all years, again suggesting that individuals are utilising the area during the summer months, perhaps as a calving area for pregnant females as suggested by Culloch & Robinson (2008).

Infancticidal behaviours exhibited by males has been documented numerous times within the Moray Firth (e.g. Patterson *et al*., 1998; Robinson, 2013), as females only produce one calf every two to four years females may, therefore, prefer larger groups perhaps for the protection available from large groups. Although larger groups would not be optimal for foraging, they would allow for a degree of protection against male aggression, predation and can also provide alloparental care for their young (Patterson *et al*., 1998). Such behaviours could account for the high percentage of groups with calves encountered during the present study. The risk of inter-species predation in the outer Moray Firth is thought to be relatively small, as there has been no recorded evidence of predatory attacks on bottlenose dolphins by killer whales (*Orcinus orca*) or evidence of the presence of any shark species which are known to attribute to bottlenose predation worldwide, in the area (Eisfeld, 2003).

4.3 Site Fidelity

From photo-identification data collected, it was derived that 134 individuals were recorded during the 4 year study period. Recent studies for the entire northeast coast by Cheney *et al*. (2013) has estimated that a total of 195 individuals are inhabiting these waters, suggesting that almost 70% of the east coast population are utilising the southern outer firth coastline during the summer months. Of the 134 individuals that were recorded in this study, 61 adults were deemed as “marked” / recapturable from their natural markings, 39 of these were categorised as resident during the study period. Of these 39 individuals 21 were found to be female, 14 male and 4 were of unknown gender, supporting a previous hypothesis that males remain with oestrus females awaiting the opportunity to mate. The number of resident individuals was not consistent each year, however, as it ranged from 8 in 2009 to 32 in 2011. The 39 individuals classified as resident during this study are likely to represent an underestimate of the resident population of the outer Moray Firth, as surveys are only conducted for six months of the year (May to October) and

survey effort is variable year to year depending on environmental circumstances, such as bad weather. Therefore, many individuals moving through the study area in other months could be missed.

From all of the marked individuals recorded during the study period, the majority showed a marked degree of site fidelity, with over 91% being re-sighted within the area during the 4 year period. The number of recaptures ranged from 1 to 54 for the marked individuals. Twenty-six (42.6%) of the 61 marked individuals were re-sighted in all four years of the study period, 11 (18%) were re-sighted in 3 of the 4 years, 14 (23%) were re-sighted in 2 of the 4 years and 10 (16.4%) were re-sighted in only 1 year during the study. 83.6% of the marked individuals showed seasonal residence of two or more years during the study period, suggesting that individuals may use the outer southern firth waters exclusively during the summer months.

Summary

The present study has shown that the outer Moray Firth, in general, is an area of significant importance to the east coast population. The abundance estimate for the area, during the four year study period, was 134 individuals, which is a substantial proportion of the 195 individuals estimated to use the entire east coast of Scotland (Cheney *et al*. 2013).

The groups inhabiting the outer southern Moray Firth are significantly larger than those occupying other more estuarine like areas, such as the inner Moray Firth. This could be explained by the feeding and foraging ecology of the species, availability of prey species, including salmonids returning to the river mouths to spawn, around both Spey Bay and Banff Bay makes these areas prime feeding grounds. However, this could also be linked to the environmental difference between the two areas and the low risk of predation to the species. The high percentage of groups encountered containing calves and the high number of neonates recorded between July and October, indicates the importance of the outer southern Moray Firth as nursery / calving grounds.

Having established that the largest groups were encountered in the earlier and latter summer months, which then fragment into smaller groups, it could be concluded that the outer southern Moray Firth is an area in which the individuals feel relatively secure. Given that in many species the best form of defence is numbers, the larger groups encountered moving in and out of the firth respectively could be seen as a herding security measure.

Variability in the composition and number of individuals defined as resident between years was found, as 29% of the total number of animals encountered were defined as resident in at least one year of the study period and 63.9% of the marked / recapturable individuals were defined as resident in at least one year. The 39 individuals classified as resident is likely to represent an underestimate of the true / potential resident numbers. The parameters applied here to assess the residency of an individual is likely to be too narrow, as it does not account for the total number of times an individual was encountered during the study but whether or not the individual was sighted in three or more months of the study period.

The outer southern Moray Firth surveys carried out by the CRRU receive no government funding and are therefore, restricted to only six months of the year, so as a result no data is available for the months out with the study period of May to October. However, from the data, collected during these six study months, important assumptions can be drawn about the significance of the outer Moray Firth for the bottlenose dolphin population. As far as management for the area is considered the knowledge that the outer southern Moray Firth is of high importance to the bottlenose population in terms of nursing, calving and feeding must be considered. The region supports around 69% of the entire east coast population and evidence shows that that these individuals utilise the entire coastline with evidence of high site fidelity. It is therefore important that existing and future conservation programmes consider the significance of the outer Moray Firth for the existence and welfare of the Moray Firth and east coast bottlenose dolphin population.

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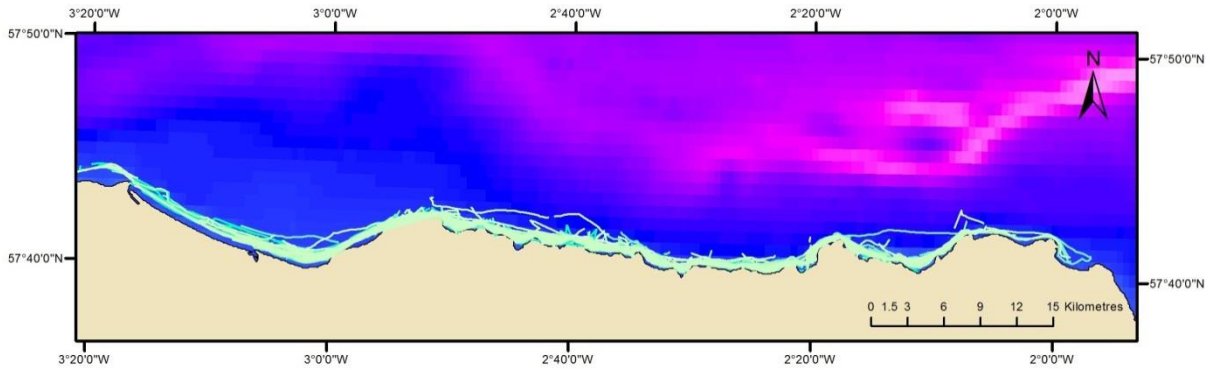
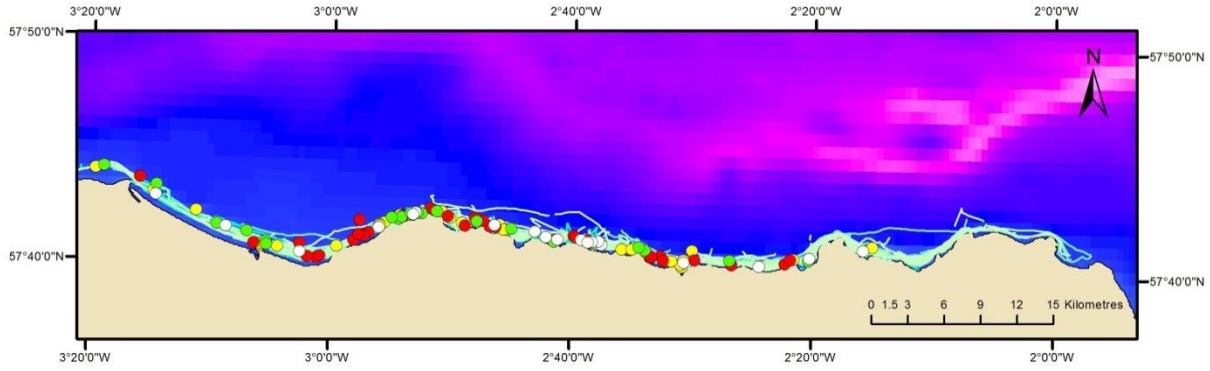
Appendices

Appendix 1. Maps showing a) the total annual survey effort for 2009 to 2012 inclusive and b) the total survey effort for 2009 to 2012 with annual encounters.

a)

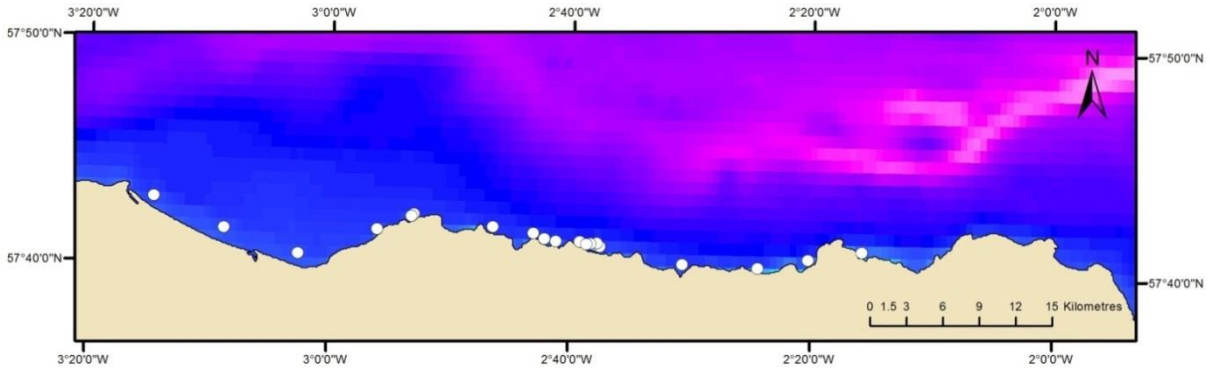


b)



Appendix 2. Map showing the annual distribution of encounters recorded from 2009 to 2012 inclusive. a) 2009 b) 2010 c) 2011 d) 2012

a)



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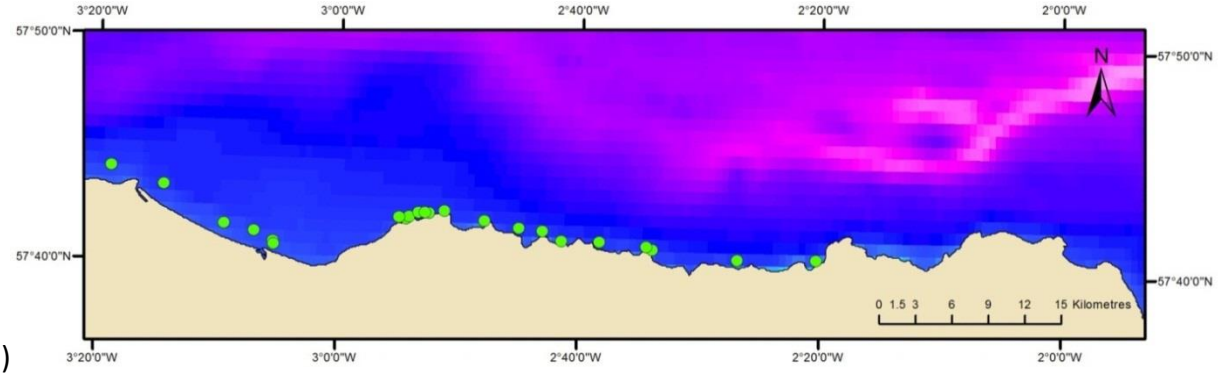

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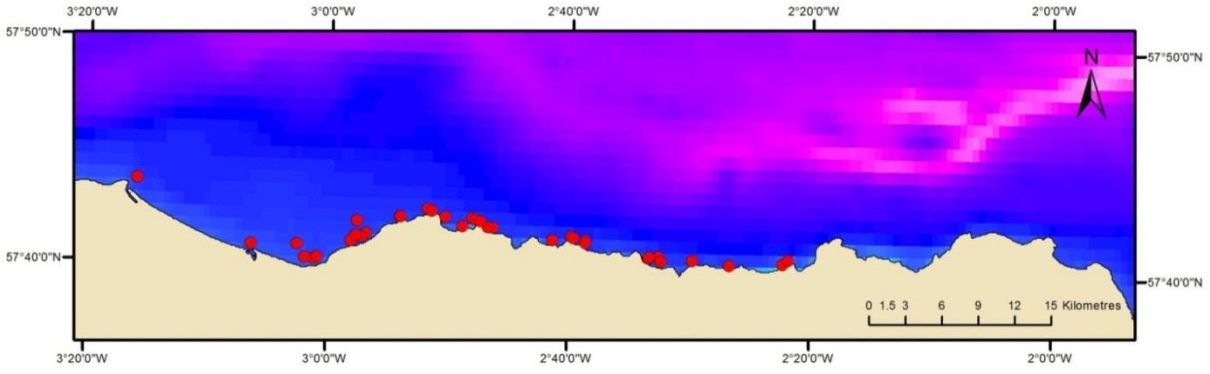
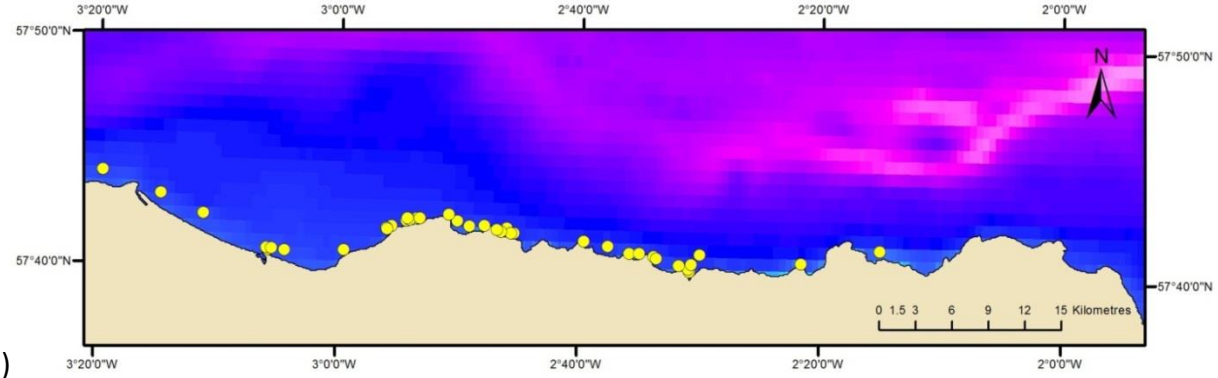
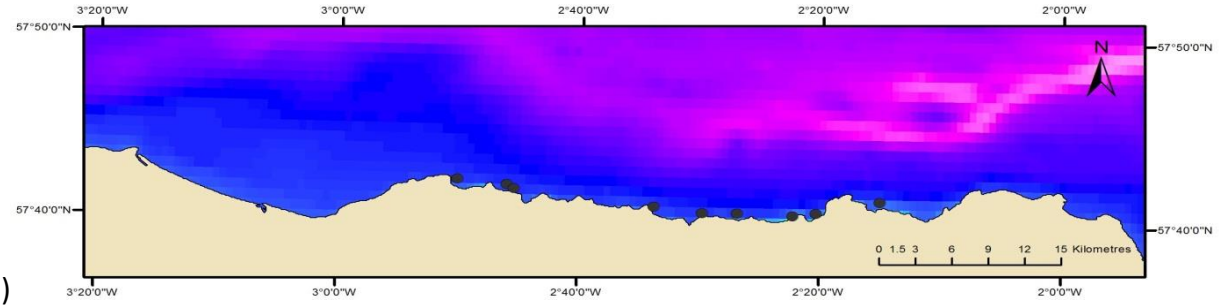


d)



Appendix 3a. Map showing the monthly distribution of encounters from 2009 to 2012 inclusive. a) May b) June c) July d) August e) September f) October.

a)



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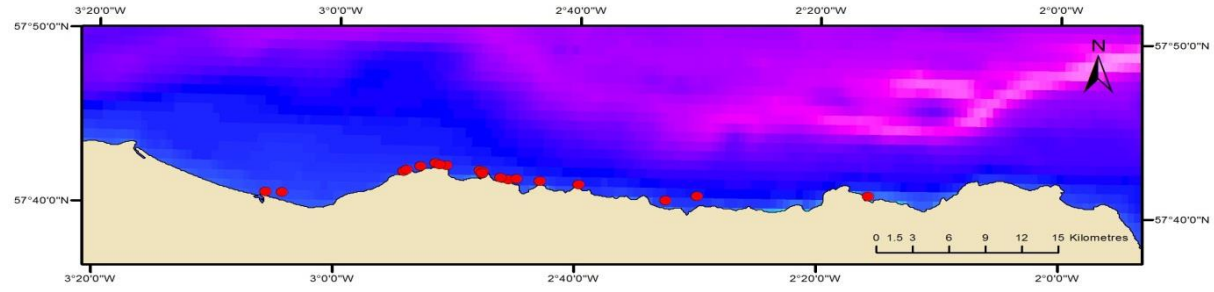
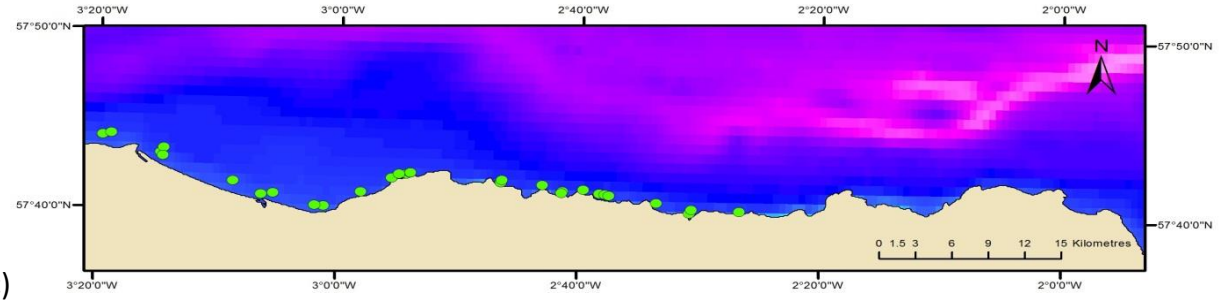


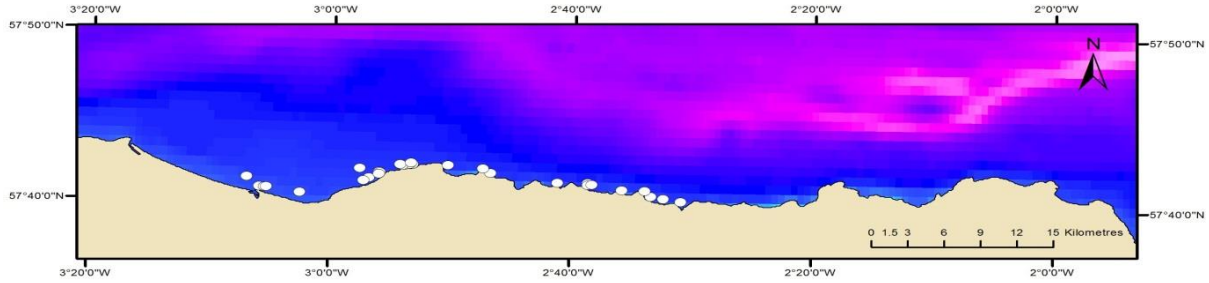
c)



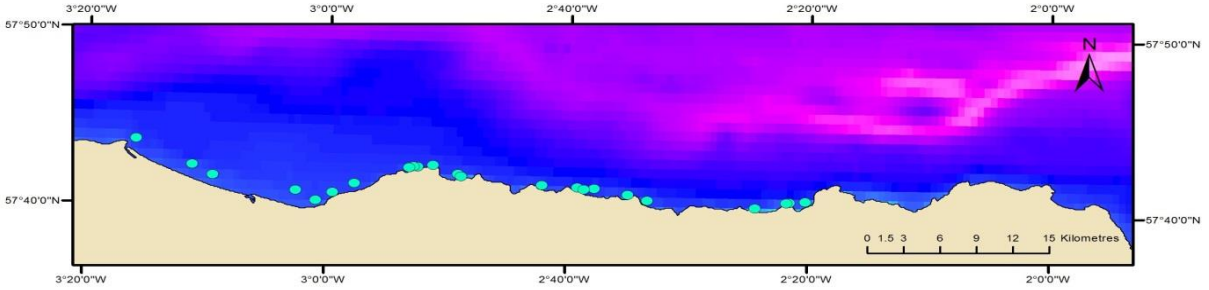
Appendix 3b. Map showing the monthly distribution of encounters from 2009 to 2012 inclusive.

a) May b) June c) July d) August e) September f) October.

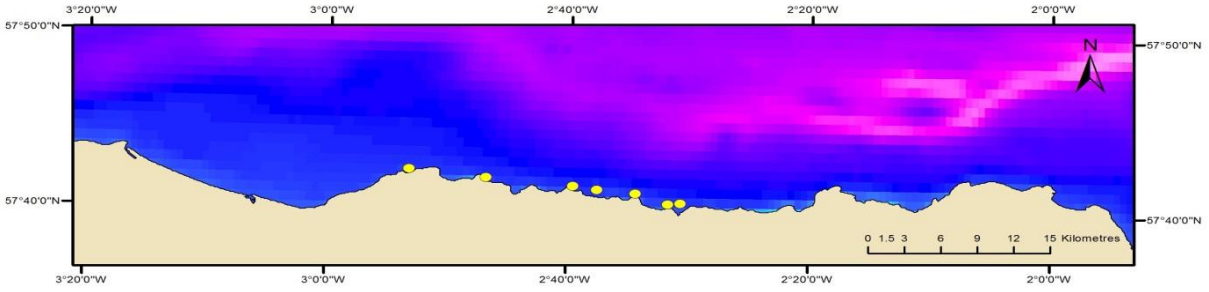
d)



e)



f)



Appendix 4. Table marked individuals and in which years they were sighted.

ID # of marked individual	2009	2010	2011	2012
01	■	■	■	■
02	■	■	■	■
03	■	■	■	■
09	■	■	■	■
10	■	■	■	■
15	■	■		
19	■	■	■	
20	■			
21	■	■	■	■
35	■	■	■	■
48	■	■	■	■
64	■	■	■	
65	■	■	■	■
69	■	■	■	■
74			■	■
85		■	■	■
88			■	■
89			■	
103		■	■	
112	■		■	■
118	■	■	■	■
119	■	■	■	■
144	■		■	
162	■	■	■	■
165	■	■	■	
187	■	■	■	■
198				■
204		■		
216	■	■	■	■
225	■	■	■	■
252	■		■	
275	■	■	■	■

Appendix 4 continued. Table marked individuals and in which years they were sighted.

ID # of marked individual	2009	2010	2011	2012
316	■	■		■
329	■	■	■	■
351	■	■	■	■
354	■	■	■	■
367	■	■		
378	■	■	■	■
379			■	
380	■	■	■	■
386		■	■	■
389			■	■
396	■	■	■	■
398	■		■	■
404		■	■	■
411			■	
418			■	
423				■
425	■	■	■	■
445		■		■
459		■	■	■
463			■	■
465				■
486	■	■	■	■
498		■	■	■
499		■	■	■
506	■	■	■	■
511		■	■	
516		■	■	
521			■	■
526			■	

Appendix 5. Table of individual residency for the study period of 2009 to 2012 inclusive.

ID # of resident individual	2009	2010	2011	2012
01	■	■	■	■
03		■	■	■
09	■	■	■	
10			■	■
15	■			
19	■	■		
21		■	■	■
35		■	■	
48			■	■
64	■		■	
65			■	
69	■	■	■	■
74			■	
112			■	
118		■	■	
119		■	■	
144			■	
162		■	■	
187		■	■	■
216		■	■	■
225			■	
252	■			
275				■
329			■	■
351	■			
354		■	■	■
378			■	
379			■	
380			■	
386		■	■	■
389				■
398			■	■
404			■	
425		■		■
486		■		■
498		■	■	■
499			■	■
506		■	■	■
521			■	■