SCOTTISH NATURAL HERITAGE

COMMISSIONED REPORT

Commissioned Report No. 175

An assessment of the current condition of the Moray Firth bottlenose dolphin population

(ROAME No. F02AC409)

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SCOTTISH NATURAL HERITAGE

COMMISSIONED REPORT

Summary

An assessment of the current condition of the Moray Firth bottlenose dolphin population

Commissioned Report No. 175 (ROAME No. F02AC409)

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Background

The Moray Firth SAC is one of two UK areas that have been proposed as part of the Natura 2000 series to conserve bottlenose dolphins (*Tursiops truncatus*). The SAC extends from the inner firths to Helmsdale on the north coast and Lossiemouth on the south coast (Figure 1), and includes areas that are regularly used by the population of bottlenose dolphins occurring along the East coast of Scotland. As a result of this designation, Scottish Natural Heritage (SNH) has a responsibility to report on the condition of bottlenose dolphins within the Moray Firth SAC every six years.

Since 1989, this population of bottlenose dolphins has been the focus of an intensive research programme, carried out by the University of Aberdeen in collaboration with the Sea Mammal Research Unit at the University of St Andrews. In 2004, SNH entered into a Memorandum of Agreement with the University of Aberdeen to support these photo-identification studies and use these data to report on the condition of the site. This report presents the results from the first round of SNH funded surveys, together with the results of similar surveys made in 2002 and 2003 that were carried out with support from the Whale & Dolphin Conservation Society and Talisman Energy (UK) Ltd.

Main findings

- Mark–recapture analysis of photographs collected during 23 surveys indicated that an estimated 102 individual dolphins used the SAC during the summer of 2004.
- Annual estimates of the number of dolphins using a core-study area within the SAC showed considerable variability from year-to-year. There was a reduction in the use of the area by dolphins during the late 1990s, but there appears to have been a slight increase in the numbers of animals using the SAC during the 2002–2004 reporting period.
- Using annual estimates of total population size from the period 1990–2002, these data indicate that a high proportion (75–80%) of this population of bottlenose dolphins used the SAC in the summer of 2004. Methodology is now being developed to provide better information on trends in the extent to which these animals use the SAC.

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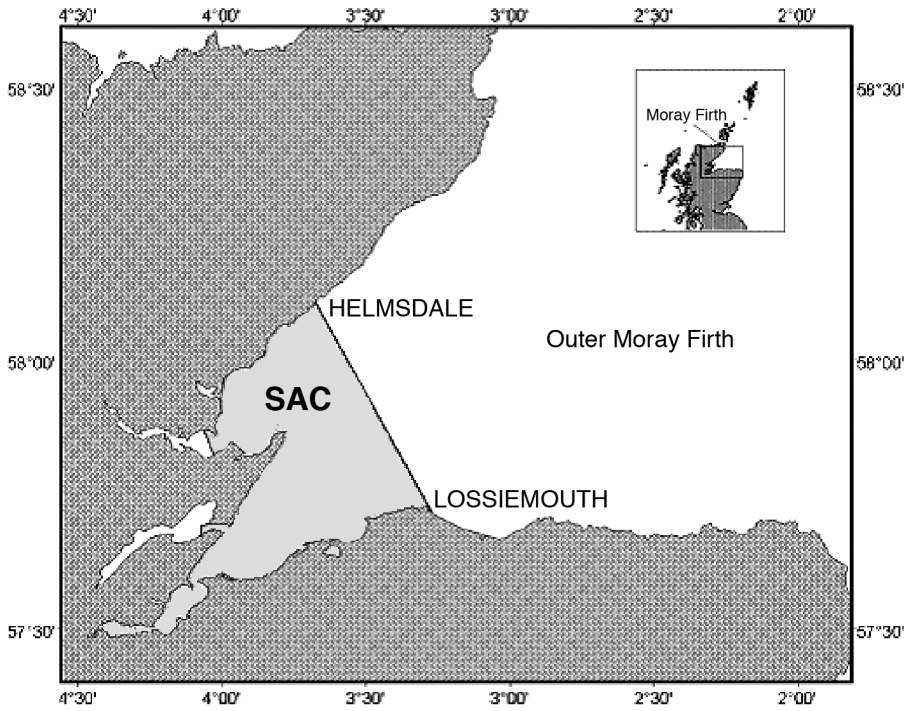
1 INTRODUCTION

The Moray Firth SAC is one of two UK areas that have been proposed as part of the Natura 2000 series to conserve bottlenose dolphins (*Tursiops truncatus*). The SAC extends from the inner firths to Helmsdale on the north coast and Lossiemouth on the south coast (Figure 1), and includes areas that are regularly used by the population of bottlenose dolphins occurring along the east coast of Scotland.

Since 1989, this population of bottlenose dolphins has been the focus of an intensive research programme, carried out by the University of Aberdeen in collaboration with the Sea Mammal Research Unit at the University of St Andrews. Research has been conducted throughout the known range of this population, but the core programme has consisted of boat-based photo-identification studies within the Moray Firth SAC. As a result, these studies have provided information on abundance, distribution and behaviour patterns that have supported the development and management of the SAC.

As a result of this designation, Scottish Natural Heritage (SNH) has a responsibility to report on the condition of bottlenose dolphins within the Moray Firth SAC every six years. In 2003, SNH contracted the Universities of Aberdeen and St Andrews to review existing information on the distribution and abundance of this population of bottlenose dolphins, and to explore the different options for monitoring bottlenose dolphins within the SAC (Thompson *et al.* 2004). Subsequently, SNH entered into a Memorandum of Agreement with the University of Aberdeen to support these photo-identification studies and use these data to fulfil SNH's requirement to report on the condition of the site. This report presents the results from the first round of SNH funded surveys, together with the results of similar surveys made in 2002 and 2003 that were carried out with support from the Whale & Dolphin Conservation Society and Talisman Energy (UK) Ltd. We then discuss these results in relation to earlier data, and data collected outside the SAC, to provide a current assessment of the condition of this bottlenose dolphin population.

Figure 1 A map showing the location of the Moray Firth and the boundaries of the Moray Firth SAC (shaded)



2 METHODOLOGY

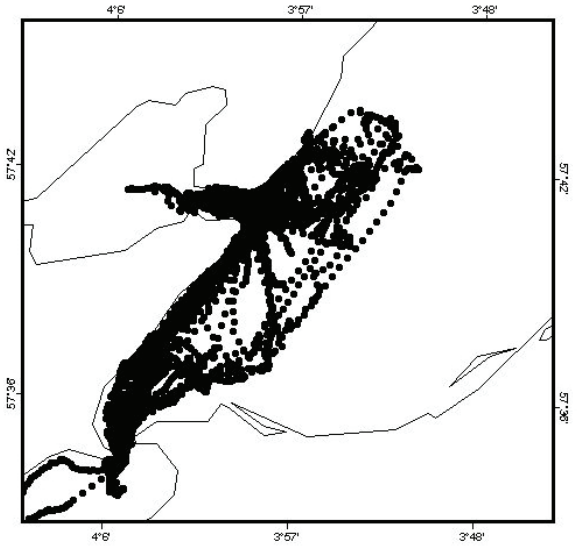
Detailed discussion of the different options for monitoring bottlenose dolphins in the Moray Firth SAC can be found in Thompson *et al.* (2004). Following this work, it was decided that the main requirement in this situation is to estimate the number of dolphins using the SAC. Given this, we recommended that mark–recapture analysis of photo-identification data was the most appropriate method for estimating the abundance of this well-marked population of coastal dolphins. However, there still remained a number of different sampling options that could provide estimates of this kind. In particular, given the large size of the SAC, it was recommended that sampling be restricted to a core-area that can be used as a proxy for the SAC. Furthermore, because of the need for good weather conditions for boat-based photo-identification work, it was recommended that surveys be restricted to the summer period, when earlier year-round studies had also indicated that abundance within the Moray Firth SAC was highest (Wilson *et al.* 1997). The resulting survey strategy was therefore based on Option A in Thompson *et al.* (2004), and further details of the protocols are given below.

2.1 Survey protocols

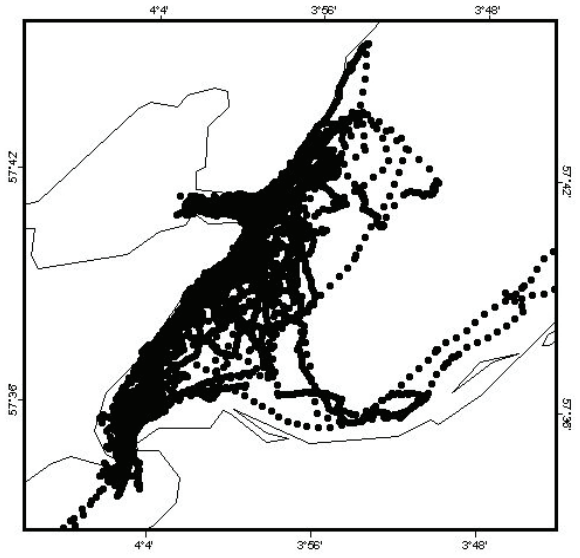
Surveys focussed on a core-area that included the sectors identified as Three Kings, Sutors, Eathie and Chanonry in Figure 2. All surveys were made from an MCA certified 5.4m Rigid Inflatable Boat, based from Cromarty Harbour. Survey effort was spread through the period May–September, but restricted to days with low sea state (< Beaufort 3), to maximise sighting probability, and good light conditions to maximise photographic quality. Survey routes (Figures 3a, b & c) were chosen to maximise sighting probability whilst also providing reasonably wide coverage of the core-area. However, surveys in the Chanonry area were reduced in recent years to avoid conflicts with increasing levels of land and boat based wildlife tourism in that area. Surveys were made with a minimum crew of three, including an appropriately qualified skipper and at least one of the personnel named on the Animal Scientific Licence (Licence Number 6161) granted to the University of Aberdeen by SNH.

Figure 2 A map showing the inner Moray Firth showing the location of the different sub-areas mentioned in the text. The core study area for surveys included the Three Kings, Sutors, Eathie and Chanonry areas

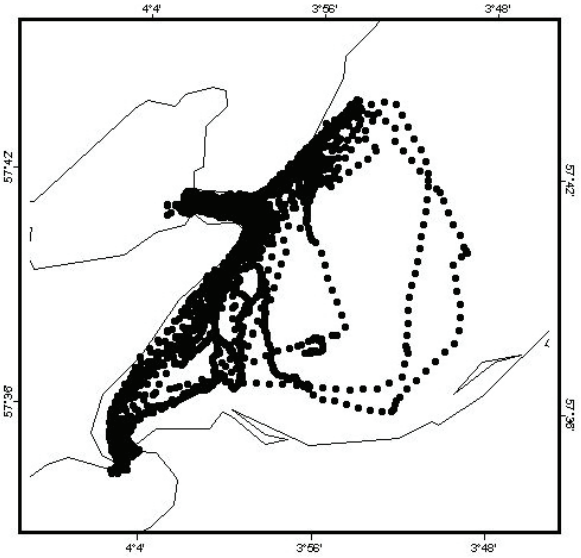
Figure 3 A map showing the areas covered by surveys in a) 2002 b) 2003 and c) 2004



a) 2002



b) 2003



c) 2004

Throughout the survey, the survey route was recorded automatically from the boat's GPS, and later downloaded to a GIS. Whenever a group of dolphins was encountered, the position and time was noted, a waypoint entered on the GPS log, and an estimate made of the size of the group (Wilson *et al.* 1997; Lusseau *et al.* 2004). The boat was then carefully manoeuvred at slow speed around the dolphins to allow dorsal fin photographs to be taken with a Canon D30 and 200mm lens. In doing so, every effort was made to minimise disturbance to the group, and to obtain pictures that were of sufficient quality for subsequent mark–recapture analyses. In particular, it was important to ensure that: dorsal fins were parallel to the camera; the whole fin was in the picture; the height of the fin image was >10% of the field of view; and that pictures were taken such that there was an equal probability of photographing different members of the group.

2.2 Photographic analysis

Following the survey; the survey and each encounter within it were allocated unique "Trip" and "Encounter" numbers. Photographs were downloaded to a PC, and the pictures from each encounter were stored in individual folders. All pictures were then backed up to CD before renaming the original image files with a name that included the trip number (see Appendix 1).

All the pictures taken on each encounter were then graded for photographic quality according to the criteria in Figure 4, adapted from Wilson *et al.* 1999. Subsequent analyses were restricted to the subset of high quality (Grade 3.1, 3.2 & 3.3) pictures to avoid biasing mark–recapture estimates of abundance (see Wilson *et al.* 1999). Analyses were also restricted to the sub-set of animals bearing distinctive marks, ie those with nicks in their dorsal fin. Each of these dorsal fin pictures was initially matched against the existing catalogue (see Appendix 2) by one experienced project team member. At the end of the season, each of these matches was then confirmed by a second experienced person. In 2004, initial matches were made by Susan Lusseau, and confirmed either by Paul Thompson or Kim Parsons.

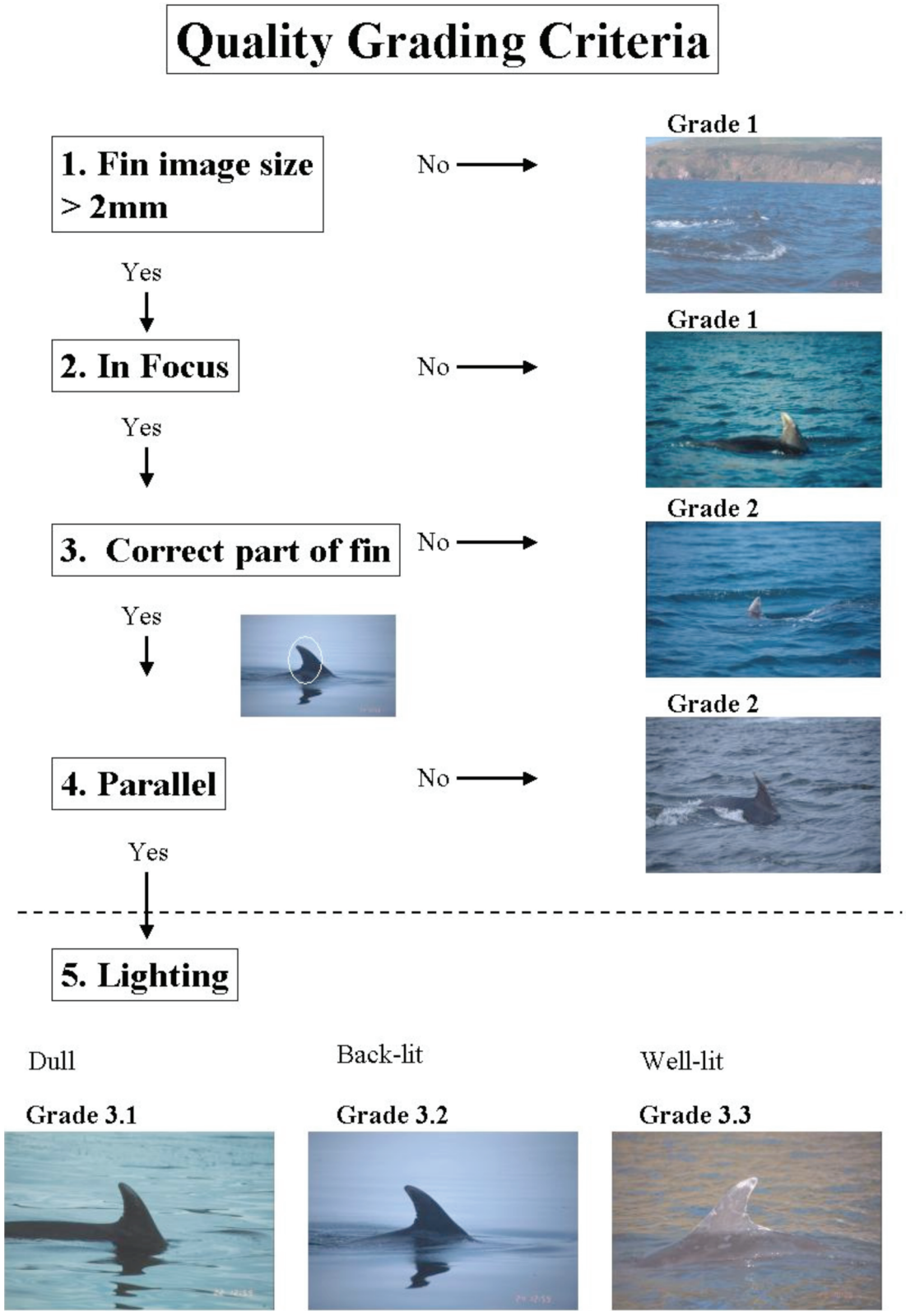
Confirmed sightings of different well-marked dolphins were then recorded in an Access Database, linking that sighting with information on which side of the dolphin had been photographed, and the trip and encounter information (see Appendix 1). Using this information, a capture matrix was then constructed containing either a 1 or 0, to represent whether or not a high quality photograph had been obtained for each individual on each trip. Separate matrices were produced for photographs of the left or right hand sides of the animals (see Appendix 1).

In addition, we used all grade 3 pictures to estimate θ, the proportion of animals that were distinctively marked. For each trip, we recorded the number of photographed individuals that had distinctive marks, and the number of individuals lacking distinctive marks, and recorded this information in a separate database table.

2.3 Mark–recapture analysis

These capture matrices were then used to estimate the number of distinctively marked individuals using the study area during the summer survey period. Following Wilson *et al.* 1999, we used Chao *et al.'s* (1992) M_{th} model, implemented in the program CAPTURE (Rexstad & Burnham 1991). Separate estimates were made for both left and right hand side photographs. We then inflated the mean estimates and their confidence intervals using our estimate of θ, thereby producing two (left and right hand side) estimates of the total number of dolphins using the study area during each summer.

Figure 4 Schematic showing the criteria used to quality grade the photographs taken during photo-ID surveys. Only sightings confirmed from pictures of quality 3.1, 3.2 or 3.3 were used in mark-recapture analyses to estimate abundance



To investigate trends in the number of dolphins using the SAC, we produced an annual estimate of abundance by taking the mean of left and right hand estimates and their confidence limits. Prior to 2002, greater effort was put into identifying dolphins that lacked dorsal fin nicks. These individuals could be identified within a single season from more subtle marks such as rakes and lesions. Whilst they could not be included in the sample of distinctively marked animals that we used for our mark re-capture analysis, this did sometimes provide a higher estimate of the minimum number of different individuals seen within a season. Thus, we used the maximum value for left or right hand side data as the lower confidence interval where this was higher than the estimated value.

In addition, we present preliminary results from a Bayesian re-capture model that uses a state-space approach by incorporating an underlying population model and an observation model. Detailed information on this approach is provided in Corkrey *et al.* (Submitted). Here we apply this model to the data collected within the SAC to provide a second estimate of trends in the number of individuals using the SAC. The underlying data are the same as those used for the annual mark–recapture estimates, except that the Bayesian model only uses information on whether well-marked animals were seen in each year of the study. Here, we compare our current assessment of abundance trends using the full data set (1990–2004), with two reduced datasets representing data from 1990–2001 and 1990–1998. This comparison therefore provides an indication of how trends can be compared between the three-year reporting periods that have been adopted for condition monitoring.

Although survey routes varied, all surveys passed through the Sutors sub-area (see Figure 2). To provide a crude indication of the usage of the SAC by these dolphins, we therefore estimated the probability of encountering dolphins within this sub-area during the May–September survey period.

3 RESULTS

3.1 Survey details

In 2004, 23 photo-ID surveys were carried out within the inner Moray Firth under contract from SNH. These surveys resulted in a total of 63 encounters with dolphin groups. Information on these surveys, and those made in 2002 and 2003 are presented in Table 1.

Estimated group sizes during these encounters varied between 1 and 40, with no significant differences (Kruskall-Wallis ANOVA, p=0.44) in the sizes of groups seen in each year (Figure 5). The locations of encounters with dolphins in each year, based upon the position of the survey boat at the start of each encounter, is given in Figures 6a, b & c.

Table 1 Summary data on the numbers of photo-ID surveys conducted during the 2002–2004 reporting period

Year	No. of surveys	Mean survey duration (hours)	No. of encounters	% of survey time with dolphins
2002	30	3.7	71	41
2003	28	3.7	82	42
2004	23	2.5	63	50

Figure 5 Frequency distribution of different dolphin group sizes encountered during photo-ID surveys in 2002, 2003 & 2004

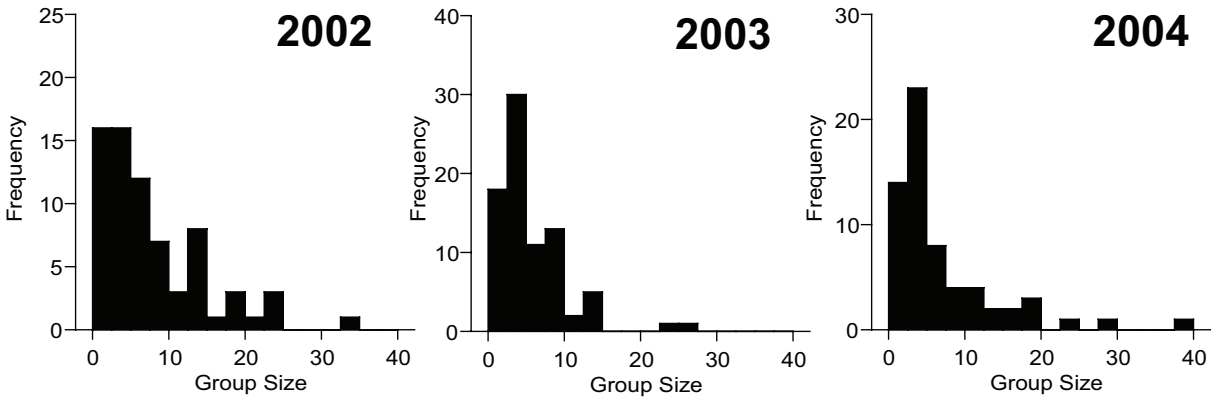
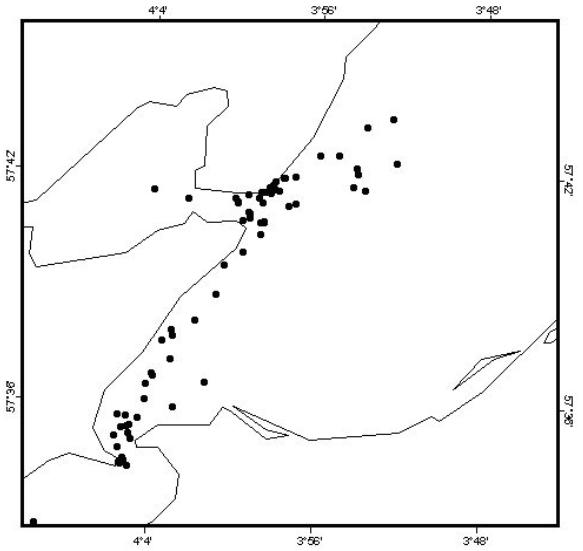
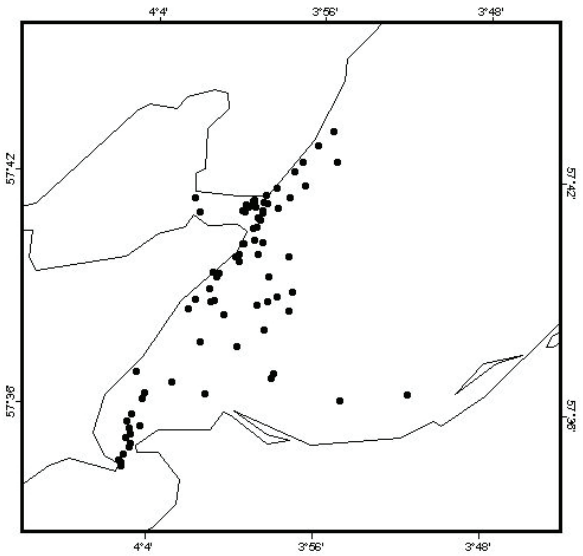


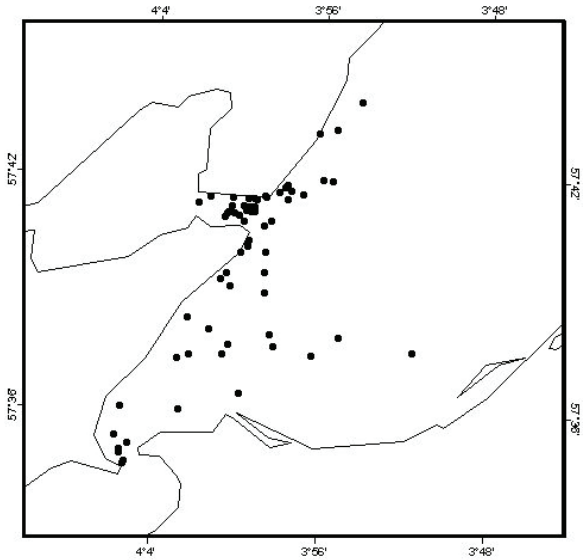
Figure 6 A map showing the location of all encounters with groups of dolphins during surveys conducted in a) 2002 b) 2003 and c) 2004



a) 2002



b) 2003



c) 2004

3.2 Estimate of the number of dolphins using the SAC

High quality pictures were obtained from at least 46 well-marked individuals during the 2004 surveys. Using photographs of left hand sides, the mark–recapture estimate of the total number of well-marked individuals was 63 (95% CI = 53–90). The equivalent estimate using photographs of right hand sides was 60 (95% CI = 51–83). Estimates of the proportions of well-marked individuals photographed (q) were 0.569 and 0.632 for left- and right-hand side pictures respectively. The resulting estimates of the number of dolphins using the core-study area in the summer of 2004 were 111 (95% CI = 92–160) and 95 (95% CI = 81–133). Equivalent estimates for 2003 and 2002 are presented in Table 2.

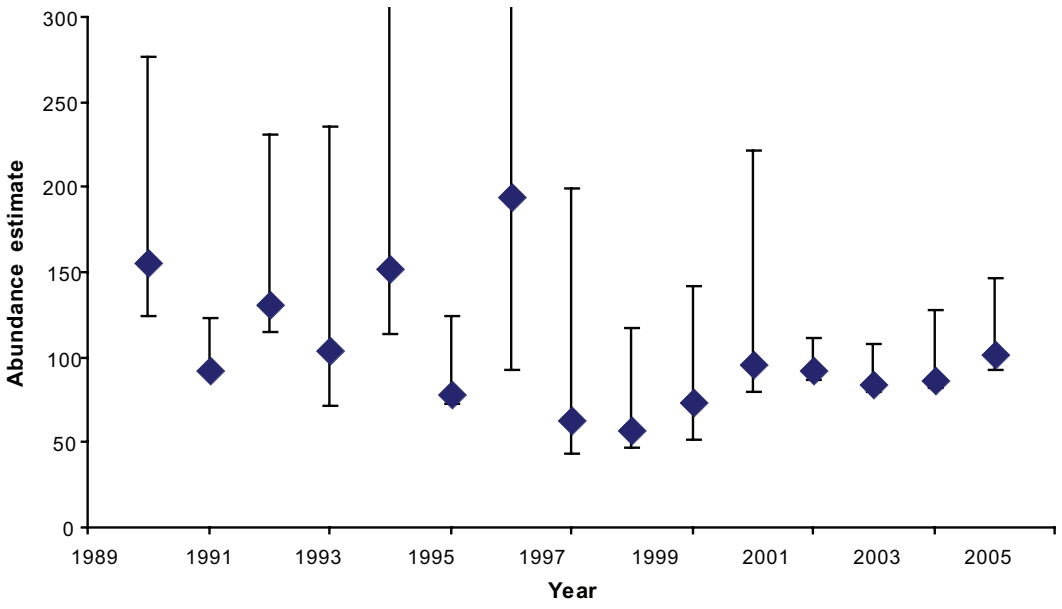
Table 2 Dolphin population data from mark recapture analysis using the M_{th} model.

Year	Side	Minimum Number	$\hat{N}$	95% CI	θ	Total abundance	95% CI
2002	Left	45	49	47–60	0.604	82	78–101
	Right	43	50	46–65	0.574	88	80–115
2003	Left	36	51	42–76	0.508	100	82–151
	Right	39	46	42–60	0.568	81	73–106
2004	Left	46	63	53–90	0.569	111	92–160
	Right	45	60	51–83	0.632	95	81–133

3.3 Trends in the number of dolphins using the SAC

Annual estimates of the number of dolphins using the SAC in summer show considerable variability from year to year (Figure 7). Similarly, there is marked year-to-year variation in the precision of these estimates. Overall, there is no significant linear trend in these annual estimates ($F_{1,13}$ = 2.85, p = 0.12). However, the data do suggest that there may have been a reduction in the number of animals using the SAC during the late 1990s, and a slight increase in more recent years.

Figure 7 Trends in annual estimates of the number of dolphins using the Moray Firth SAC, based upon surveys conducted during the core-study inner Moray Firth study area. Estimates are based upon annual mark-recapture estimates using Chao *et al.'s* (1992) M_{th} model



Results from the Bayesian modelling also indicate that the addition of photo-ID survey data from the last three years provides evidence that there is now less of a decline in the number of dolphins using the SAC than anticipated from analyses of datasets ending in1998 and 2001. To compare these trends, we fitted a linear regression to our abundance estimates and obtained a posterior distribution for the regression slope. Inspection of the trend lines in Figure 8 and the slope parameters in Table 3 shows that, whilst there appeared to be a marked decline in the numbers of animals using the SAC between 1990 and 1998, this decline has not continued at the same rate.

Table 3 Bayesian estimates of the slope statistics from the linear regressions fitted to the abundance data illustrated in Figure 8. Different rows represent the full data set (ending in 2004) and truncated data sets vending in 2001 and 1998. Data presented are the mean and median slope, together with the 95% highest posterior density interval (HPDI)

Last Year	Mean	Median	95% HPDI	
2004	–2.86	2.86	–5.41	–0.03
2001	–5.61	–5.6	–10.34	–1.66
1998	–10.69	–10.59	–16.67	-4.55

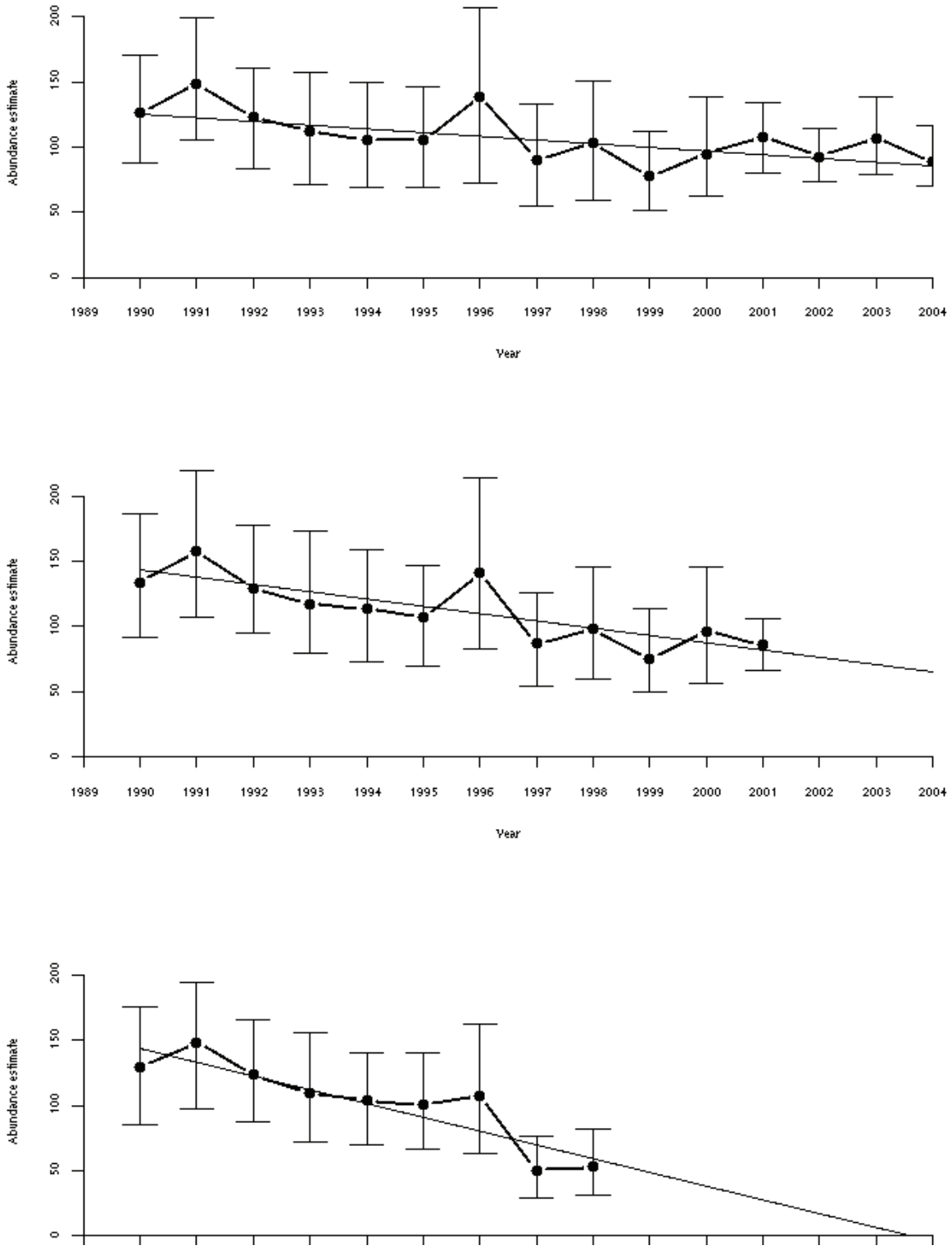
3.4 Usage of the SAC

Survey effort in different sub-areas varied between surveys and years (Figure 3). However, the Sutors sub-area was visited during every survey, and the probability of encountering groups of dolphins within this area averaged 0.63 over the whole reporting period (Table 4).

Table 4 Estimates of the usage of the core-area within the SAC based upon the probability of encountering groups of dolphins within the Sutors sub-area

Year	Total number of trips	Proportion of trips encountering dolphins in the Sutors sub-area
2002	30	0.53
2003	28	0.64
2004	23	0.74
Total	**81**	**0.63**

Figure 8 Trends in annual estimates of the number of dolphins using the Moray Firth SAC. Estimates are based upon Corkrey *et al.'s* (Submitted) Bayesian population model, and are based upon analyses of the full data set, and truncated datasets that end in 2001 and 1998



4 DISCUSSION

Currently, there are four attributes and associated targets for this SAC, as outlined in the Site Attribute Table presented in Appendix 2. The existing monitoring programme focuses on providing data to monitor the first of these attributes, but can also be used in conjunction with data collected during related studies outside the SAC to monitor other attributes.

Because of the large size of the SAC, efforts to monitor changes in the number of dolphins using the SAC (Attribute 1.1.1) have been based upon photo-ID surveys within a core-study area in the inner Moray Firth. This has the advantage that sighting probability is higher in this intensively used area, and abundance estimates are therefore more precise. Furthermore, data collected during this monitoring programme can be more clearly related to the existing time series of data from this site (Thompson *et al.* 2004). Using data collected in the 2004 surveys, we estimated that 102 different bottlenose dolphins used the SAC during the period May–September. It remains possible that other individuals use other parts of the SAC, but are never recorded within the core study area in the inner Moray Firth. However, two lines of evidence support our assumption that this core-study area provides a good proxy for use of the whole SAC. First, during extensive visual and acoustic surveys conducted across the whole of the SAC in the summers of 2004 and 2005, 84% of dolphin encounters were within our core inner firth study area (Helen Bailey In Prep.) Second, most remaining sightings were along the southern Moray Firth coast, and related photo-ID studies have shown that animals using these areas also use the core-study area (Wilson *et al.* 1999; Durban *et al.* 2005).

A key aim of monitoring is to determine whether the number of dolphins using the SAC is changing over time. Using data collected throughout the population's range, Wilson *et al.* (2004) suggested that there had been a decline in the use of the Moray Firth SAC over the period 1990–2000. More recent work has shown that this situation is more complex, because the population is socially structured into two units that differ in their ranging patterns and have limited interactions (Lusseau *et al.* In Press). Individuals from Group 1 have only been observed within the SAC, whereas those from Group 2 form an outer community that range more widely. Thus, whilst animals from both communities may use the core study area within the SAC, the trend recorded by Wilson *et al.* (2004) appears to result from changes in the frequency with which Group 2 visit the SAC.

Our results from the period 2002–2004 suggest that the decline in the extent to which dolphins were using the SAC over the period 1990–2000 has not continued. Instead, it appears that there has been a slight upturn in annual estimates of the number of dolphins using the SAC (Figure 7). In 2004, this pattern was further supported by sightings of several individuals from Group 2 (eg ID # 60, 102, 344) that had not been observed in the inner Moray Firth for eight or nine years. These analyses of data using annual abundance estimates from Chao *et al.* (1992) M_{th} model are further supported by analyses using the Bayesian population model (Figure 8).

The second site attribute is the importance of the SAC to the dolphin population. Whilst mark–recapture analysis of photo-ID data provides an estimate of the number of animals using the area, it does not give an indication of the extent to which those individuals use the area. Data from additional surveys outside the SAC could be used to provide an indication of changes in use, as illustrated in Wilson *et al.* (2004), but similar data for the period 2003–2004 are not currently available. The most recent estimates of total population size, based upon photo-ID data collected throughout the population's range, are for the period

1990–2002. Using both the Chao M_{th} model (Thompson *et al.* 2004) and a Bayesian capture–recapture population model (Corkrey *et al.* Submitted), annual estimates during this period ranged from 74–181 and 96–144 respectively. Despite variability in these estimates, it is clear that the 102 individuals estimated to have used the SAC in 2004 represents a high proportion of the total population. This highlights the general importance of the SAC to the population. Estimates of sighting probability are available from the mark–recapture analyses, but these are also influenced by variability in survey effort. In Table 4, we provide a crude estimate of usage of the core-area, based upon the proportion of surveys through the Sutors area in which dolphins were encountered. This provides a useful baseline that, given a long enough time-series, could detect major changes in use of an area. However, these values are also affected by variations in sighting conditions and effort. In 2005, pilot studies using ™"T-POD"s to detect dolphins acoustically indicate that this may provide a more standard approach for monitoring seasonal and inter-annual variation in the use of core areas such as the Sutors. We therefore intend to continue these studies through the next reporting cycle and develop protocols for monitoring usage of these areas that are independent of the photo-ID surveys.

The third and fourth site attributes relate to the size of the dolphin population and its future viability. Monitoring to address these attributes requires photo-ID data to be collected both within and outside the SAC. As discussed above, the most recent data available from areas outside the SAC are from 2002. Using these data, Thompson *et al.* (2004) summarise current understanding of trends in total population size, which remain uncertain as a result of the variations in ranging behaviour highlighted in Wilson *et al.* (2004). Nevertheless, these analyses, and those using Corkrey *et al.'s* (Submitted) Bayesian model, suggest that earlier predictions of a 5% annual decline in population size are not being realised. Further work is now underway to analyse and incorporate more recent field data from other areas, and to refine methods for assessment of population viability.

In summary, as anticipated following selection of monitoring option A (Thompson *et al.* 2004) the quality of data available for completing the Site Attribute Table is high for Attribute 1.1.1, Medium for Attribute 1.1.2 and Low for Attribute 1.1.3 & 1.1.4. Due to changes in reporting timetables, the Condition Monitoring Form was initially completed in May 2005, before final analyses of photo-ID data from 2003 and 2004. Based upon the Site Attributes Table completed at that time, it was concluded that the current condition of the site was "Unfavourable (no change)". The subsequent analysis of monitoring data from 2003 and 2004 indicates that there is now a higher probability that targets 1.1.1 and 1.1.2 are being met which is reflected in an updated version of the Site Attribute Table presented in Appendix 2. In the light of the additional data, the condition status has been changed to "Unfavourable (recovering)". Further monitoring, together with an improved understanding of the factors influencing observed year-to year variability in the number of dolphins using the SAC, is now required to determine whether this assessment is accurate or should be subject to further revision.

References

Chao, A., Lee, S.M. and Jeng, S.L. (1992). Estimating population size for capture–recapture data when capture probabilities vary by time and individual animal. *Biometrics*, **48**, 201–216.

Corkrey, R., Brooks, S., Lusseau, D., Parsons, K., Durban, J.W., Hammond, P.S. and Thompson, P.M. (Submitted). A Bayesian capture–recapture population model with simultaneous estimation of heterogeneity. *Journal of the American Statistical Association*.

Durban, J.W., Elston, D.A., Ellifrit, D.K., Dickson, E., Hammond, P.S. and Thompson, P.M. (2005). Multi-site mark–recapture population estimates with Bayesian model determination. *Marine Mammal Science*, **21**, 80–92.

Lusseau D., Williams R., Wilson B., Grellier K., Barton T., Hammond P.S. and Thompson P.M. (2004). Parallel influence of climate on the behaviour of Pacific killer whales and Atlantic dolphins. *Ecology Letters*, **7**, 1068–1076.

Lusseau D., Wilson B., Hammond P.S. Grellier, K., Durban, J.W., Parsons, K.M., Barton T.R. and Thompson P.M. (In Press). Quantifying the influence of sociality on population structure in bottlenose dolphins. *Journal of Animal Ecology*.

Rexstadt, E. and Burnham, K.P. (1991). User's Guide for Interactive Program CAPTURE Colorado Cooperative Fish and Wildlife Research Unit, Colorado State University, Fort Collins, CO, USA.

Thompson, P.M., Lusseau, D. Corkrey, R. and Hammond, P.S. (2004). Moray Firth bottlenose dolphin monitoring strategy options. Scottish Natural Heritage Commissioned Report No. 079 (ROAME No. F02AA409).

Wilson, B., Thompson, P.M. and Hammond, P.S. (1997). Habitat use by bottlenose dolphins: seasonal distribution and stratified movement patterns in the Moray Firth, Scotland. *Journal of Applied Ecology*, **34**, 1365–1374.

Wilson, B., Hammond, P.S. and Thompson, P.M. (1999). Estimating size and assessing trends in a coastal bottlenose dolphin population. *Ecological Applications*, **9**, 288–300.

Wilson, B., Reid, R.J., Grellier, K., Thompson, P.M. and Hammond, P.S. (2004). Considering the temporal when managing the spatial: a population range expansion impacts protected areas based management for bottlenose dolphins. *Animal Conservation*, **7**, 331–338.

APPENDIX 1 Raw data tables

Overview

This appendix contains five tables of the raw data used in this project to produce estimates of the number of dolphins using the Moray Firth SAC. Full Tables are provided in electronic format. Only the first few rows of each Table are displayed as an illustration the format of each file. In all cases, "-99" is an identifier for no data.

1 **Surveys** – containing basic information on the date and timing of surveys, with a unique "trip number" that links these data to those from any encounters with groups of dolphins during that survey.

TRIP_NO	DATE	Start time	End time	No of Encounters	No Pictures	No Q3 pictures
424	01/05/2002	9.00	12.15	3	203	53
425	03/05/2002	10.05	15.47	6	293	76
426	08/05/2002	9.00	11.09	1	117	37
427	09/05/2002	9.12	14.53	3	44	12
428	16/05/2002	8.50	11.30	–99	–99	–99
429	21/05/2002	9.27	12.08	1	44	9
430	09/06/2002	9.10	10.30	–99	–99	–99
431	14/06/2002	9.48	12.48	2	56	15
432	20/06/2002	10.30	14.20	7	244	50
433	24/06/2002	9.11	12.10	2	40	5
434	01/07/2002	9.38	11.35	2	107	19
435	02/07/2002	9.12	13.20	3	212	72
436	04/07/2002	8.19	11.13	3	367	86
437	05/07/2002	9.14	12.50	5	626	147
438	09/07/2002	10.45	13.37	2	284	56

2 Encounters – containing information on the location of the start of the survey, estimates of group size, and a unique "encounter number" that links these data with any photographs and sightings of individually recognisable dolphins.

TRIP_NO	ENCOUNTER #	GROUP SIZE	START_LAT	START_LONG	YEAR
424	1011	12	57.57323333	–4.08868333	2002
424	1012	10	57.61241667	–4.06506667	2002
424	1013	2	57.63108333	–4.04926667	2002
425	1014	7	57.57541667	–4.08653333	2002
425	1015	1	57.58903333	–4.08286667	2002
425	1016	7	57.57441667	–4.08511667	2002
425	1017	7	57.54625000	–4.15488333	2002
425	1018	2	57.69321667	–3.96850000	2002
425	1019	11	57.69398333	–3.97341667	2002
426	1020	15	57.59410000	–4.09148333	2002
427	1021	3	57.60881667	–4.02190000	2002
427	1022	2	57.69495000	–3.97070000	2002
427	1023	3	57.69055000	–3.99068333	2002
429	1024	4	57.69855000	–3.95316667	2002
431	1025	1	57.58508333	–4.09376667	2002

3 Pictures – containing information on all Quality 3 pictures and the confirmed ID numbers of any dolphins in that picture.

ENCOUNTER #	FRAME	SIDE	ID
1011	AU02/424–012	L	672
1011	AU02/424–016	R	866
1011	AU02/424–018	L	580
1011	AU02/424–019	L	733
1011	AU02/424–021	L	–99
1011	AU02/424–025	L	105
1011	AU02/424–027	R	672
1011	AU02/424–029	R	551
1011	AU02/424–030	R	551
1011	AU02/424–032	L	105
1011	AU02/424–036	R	580
1011	AU02/424–041	L	866
1011	AU02/424–046	L	580
1011	AU02/424–048	R	926
1011	AU02/424–055	L	–99

4 Inflation factor – containing the number of well-marked and unmarked dolphins photographed on each trip, and the resulting estimate of θ.

Year	Trip	L_Marked	L_total	θ	R_Marked	R_total	θ
2002	424	7	12	0.583	6	13	0.462
2002	425	7	12	0.583	7	16	0.438
2002	426	1	1	1	5	10	0.5
2002	427	3	5	0.6	3	4	0.75
2002	429	2	3	0.667	1	2	0.5
2002	431	–99	–99	–99	2	5	0.4
2002	432	5	11	0.455	9	16	0.562
2002	433	2	4	0.5	–99	–99	–99
2002	434	5	8	0.625	3	4	0.75
2002	435	11	20	0.55	8	15	0.533
2002	436	12	20	0.6	10	15	0.667
2002	437	22	42	0.524	17	31	0.548
2002	438	14	17	0.824	8	18	0.444
2002	439	6	12	0.5	5	9	0.556
2002	440	5	6	0.833	5	5	1

5 Mark–recapture matrices – containing the input matrices for programme CAPTURE that were used to provide the left and right hand side estimate of abundance in each of the three reporting years. Each row represents one well-marked dolphin (with the ID number in the first column). Subsequent columns represent each survey in the year, with a 0 or 1 representing whether or not there was a confirmed sighting from a quality 3 picture for that individual.

eg. Left hand sides for 2003

1 0000000100110010000000000
6 0000000000000000011000000
8 0000000001110010000000100
19 0000000010110000000000000
22 0100001010000001000010000
23 0100000000101001001000000
31 1000000000100001000000000
36 1110000010101000000010000
49 0000000000000000000000100
59 1000000000101000000000000
61 0000000001110000000000000
64 0000010110010000000000000
129 0000010001000010000000000
137 0000010000000010000000000
192 0100100010101101001000000
209 0000000000000010000000000
210 0000000110110010000000000
234 0000000000000000010000000
307 0000000001010000000000000
357 0001000010100101000000000
435 0000000001010010000000000
456 0000000010100000000000100
573 1101100000100000001100000
580 1101000010100100000010000
589 0000000001010010001000000
652 0000000001000000000000000
672 1000000010101101001010000
744 1100001000101001000000000
745 0000010001010000000000000
760 0000000001100010101100000
769 0000000000000000010000000
789 0000000110000111110100101
800 0000000001100000000000000
817 0000000001110011110000100
818 0000000000001001000000000
820 0000000000000000001100000
856 0000000000110010000000000
862 0000000101110000010100101
880 0000000000000010000000000
885 0000000000000000011000000
901 0000000000000000011000000
905 0000000000000000000000100
907 0000000000000000000010001
908 0000000000000000010000000
914 0000010000100010010000000

APPENDIX 2 Site attribute table

Site	Reporting Category	Interest Feature	Interest level	Attribute	Target	Prescription	Result of Monitoring	Target met? (Y/N)
Moray Firth	1 Mammals	1.1 Bottlenose dolphin (*Tursiops truncatus*)	SAC	1.1.1 Number of individual dolphins using the SAC	1.1.1 A stable or increasing number of dolphins using the SAC.	Apply photo-ID and mark -recapture extrapolation techniques to annual observations.	Between 1990 and 2002, annual estimates of the number of dolphins using the SAC ranged between 58 and 195 individuals (Thompson *et al.*, 2004). Modelling indicates that there is a high probability that the number of individuals using the SAC has declined over this period, but on addittion to subsequently collected data there is evidence of a slight increasing trend between 1998 and 2002, with numbers remaining relatively stable between 2000 and 2004.	Y
				1.1.2 Importance of SAC to dolphin population	1.1.2 Maintain or increase the level of use of the SAC.	Over a three-year period determine the probability of sighting different individuals and social groups within the **core areas** of the SAC using photo-ID and mark–recapture. Other methods may be subsequently developed.	Photo-ID data collected across the east coast of Scotland indicate that some dolphins have only been observed within the SAC (Group 1) whilst others range over a much wider area (Group 2). Between 1990 and 2000 there was a statistically significant decline in the proportion of animals observed within the SAC that were members of Group 2. Between 2002 and 2004 there was an increase in the number of dolphins using the SAC concurrent with increased observations of Group 2 members. On balance, this suggests that the decline in use of the SAC by Group 2 has not continued. The status of Group 1 is unclear at this time.	Y
				1.1.3 Dolphin population size	1.1.3 Maintain a stable or increasing bottlenose dolphin population.	Every three years evaluate trends in population size using photo-ID and mark–recapture.	Data in the process of collection.	Target not assessed
				1.1.4 Dolphin population viability	1.1.4 Maintain the probability of population extinction within 100 years at less than 10% (following IUCN category)	Carry out population viability analyses (PVA) by estimating mortality rate, birth rate & population size. Methods will incorporate photo-ID, mark–recapture and analysis of strandings.	Refined methods of assessment are under development. This attribute may be revised in the next reporting cycle.	Target not assessed

APPENDIX 3 Photo-ID catalogue

Example page of the electronic version of the Photo-Identification catalogue of all well-marked dolphins recorded in the SAC during the reporting period.

CORDUROY 23

LEFT
1

RIGHT
1
4

SIMILAR DOLPHINS: none

SIGHTINGS	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
INNER FIRTH																
OTHER AREAS																

APPENDIX 4 GIS project

The GIS Project "snh2005" contains GPS derived tracks of all surveys conducted by AULFS as well as location of all encounters with bottlenose dolphins during these surveys in the Inner Moray Firth between May 2002 and September 2004. The project should run from the CD if used on any PC running ArcView, as long as the CD drive is designated as the D: drive.

Each survey track is provided as an individual theme labelled with trip number and the date of the trip is included in the attribute table. Encounters are grouped by year and provided as one theme each and in the attribute table of these themes there is information on individual encounters. This information includes encounter number, latitude and longitude of the start of each encounter, date, trip number and the number of dolphins in the encounter.

The Project consists of four views; one for each year (Surveys 2002, surveys 2003, surveys 2004), each containing all individual trips conducted in that year and a theme with all encounters that year. The last view (Summaries) contains six themes, a summary theme of all tracks by year and all encounters by year.