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Monitoring cetaceans in UK and adjacent waters: current and potential uses of Atlantic Research Coalition (ARC) data (2009)

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Contents

Summary

The aim of this report is to review the past, present and planned future monitoring effort undertaken by partners of the Atlantic Research Coalition (ARC), with a view to assessing the potential of the data to regularly report on the conservation status of cetaceans in UK and adjacent (northwest European) waters.

ARC was established in 2001 as a pan-European collaborative approach to the monitoring of cetacean status using low-cost survey methods. There has been a steady growth in ARC membership, and currently (2009) there are nine partners from three UK and four other European countries. The partners are the University of Aberdeen (Scotland), Sociedad Ambar (Spain), Irish Whale and Dolphin Group (Ireland), Marinelife (Biscay Dolphin Research Programme) (UK), NORCET (Scotland), Organisation Cetacea (Orca) (UK), Plymouth to Santander Marine Survey (England), Rugvin Foundation (Netherlands) and Sea Trust (Wales).

ARC partners aim to work together by combining data annually from their ferry survey programmes. These surveys tend to operate at least monthly during the summer months, with a more patchy level of effort in the winter. In all instances, ARC partners carry out both inshore and offshore surveys on ferries that have regular 'fixed' routes that vary little from one survey to the next. These routes can be considered as fixed transects, a method which is widely used in monitoring animal abundance across a range of taxa.

The scale of recording effort by ARC partners is substantial, and is potentially one of the most important developments in cetacean survey/monitoring to have occurred in northwest Europe in recent years. Current combined survey activity per annum equates to undertaking a minimum of 165 ferry trips over 310 days by ~150 volunteer surveyors travelling 150,000 km and seeing ~20 cetacean species during a total of ~70,000km of survey effort along 7,550km of fixed transects.

ARC surveys started in 1993. By 2003 14 routes were being monitored and currently (2009) there are 17 active ferry routes. Spatial coverage is wide-scale with every UK International Council for the Exploration of the Sea (ICES) fishing area sampled by at least one route. It is estimated that collectively the ARC partners hold a database of 15,000-20,000 cetacean records, collected since 1993, with several thousand new records added per annum. Survey effort is estimated to be in excess of half a million kilometres.

Eleven cetacean species are regularly recorded by ARC ferry surveys in UK waters, with coverage particularly good for harbour porpoise (encountered on all current routes (2009)), minke whale, bottlenose dolphin and common dolphin. The level of species and area coverage is likely to increase, as ARC partners are actively seeking to expand their monitoring activities, with at least five new survey routes planned.

An investigation into the methods employed by the ARC partners highlight that there is a good deal of consistency, with key sightings and effort data collected by all groups on a monthly basis. Recording is carried out by teams of observers, usually composed of at least one very experienced observer and data are generally considered to be high quality – though this is largely based on self assessment.

ARC partners seek to overcome both cost and logistical problems in offshore survey work by working on Ships of Opportunity (ShOp) and utilising skilled volunteer recorders. With the additional help of sponsorship from the ferry companies, under this approach substantial cost savings can be made in comparison to using dedicated survey vessels. At the current level of *minimum* annual ARC survey effort it is estimated the total annual cost to a funding

body to conduct surveys with a similar spatial and temporal coverage would be in the region of £1 million.

The main conclusion from the work carried out for this report is that ARC data have potential to assess trends in the conservation status of cetaceans at a UK scale and to meet the monitoring requirements of JNCC. ARC data are considered potentially fit-for-purpose in terms of good data quality and good spatial, temporal and species coverage at a UK scale – though this requires further testing and validation, and data power needs to be more accurately assessed.

The data collected by ARC partners can be analysed in a number of ways to identify trends in cetacean occurrence, distribution and abundance. Such analyses can be conducted within each survey route or using a combination of different survey routes to provide a greater spatial coverage. These approaches include the calculation of absolute density (or density surfaces) within surveyed areas, measures of relative abundance, changes in occupancy, log-linear modelling of annual abundance and trends for individual species at a UK scale, developing multi-species measures of cetacean status, habitat modelling to identify changes in habitat use over time and changes in species ranges. Each of these approaches has its own data requirements, advantages and limitations, and identifies different aspects of changes in the status of cetacean populations. However, in all cases, repeated surveys along these relatively fixed transects, as conducted by ARC partners, are likely to allow for more accurate measures than single visits, and therefore provide a greater power to detect changes in cetacean species status over time.

There remains a question of whether the transects surveyed, and therefore changes in status identified from data collected along them, are representative of the wider area. The limited analyses presented in this report indicate that species occurrence patterns and trends detected along ARC ferry routes mirror those found through more wide ranging Atlas projects and SCANS surveys. However further research is required to more fully test this. Delivery of a suitable cost-effective monitoring tool for JNCC requires developing and testing suitable analytical procedures that are cost-effective, scientifically sound and enable rapid reporting. As an annual status measure, we recommend testing occupancy to start with, as this is the quickest, easiest and probably the most cost-effective method. A further advantage of occupancy is that it also provides a measure of both abundance and distribution and the results can be readily displayed on distribution maps. As a trend analysis procedure we recommend testing the application of log-linear modelling using the freeware program TRIM, as this is a tried and tested procedure for assessing trends in wildlife populations in the UK and Europe. A further advantage in using this modelling approach (as developed for European Bird Indicators) is that is possible to combine other data types (e.g. regional small boat surveys, aerial surveys and systematic watches from headlands) into annual analyses of species status, provided that individual surveys use consistent methods over time.

We suggest a follow up study, which would more fully (1) develop distribution and abundance indices and trends for cetacean species using ARC data, (2) assess how representative ARC data is of the wider sea area (3) complete a more wide-ranging power analysis and (4) identify priority survey routes that would fill coverage gaps. Other funding priorities include a meeting for ARC partners to discuss best practice survey methods, establishing further routes, compiling a joint database, sourcing new partners and support for the vitally important co-ordination work carried out by the survey managers of each ARC partner group. Full details of suggested work are given in Section 9.3.

There is potentially considerable added value in supporting the work of ARC, as the data has potential to be used for a number of other important conservation research purposes such as identifying and modelling critical habitat, monitoring the effectiveness of Marine Protected

Areas (MPAs), assessing and monitoring climate change impacts and testing the development of a cetacean marine biodiversity indicator. In particular, because cetaceans are iconic tope predators, we predict that there would be considerable scientific, media, public and political interest in using cetaceans to monitor climate change impacts and assess the wider health of the marine environment.

2009 update: In 2008 Oceanopolis (France) joined Arc, followed in 2009 by the Isles of Scilly Wildlife Trust (England, UK). Since 2007, at least five new routes have been established by ARC partners. There is wider interest in other organisations joining ARC, including research groups from the Mediterranean and Macronesia. Interest is likely to grow further as the potential of ferry surveys to contribute to conservation research and monitoring becomes more widely accepted.

1 Introduction

There is an obligation under Article 11 of the Habitats Directive to undertake surveillance on the conservation status of all cetacean species occurring in UK waters and report on this every six years. The purpose of the Habitats Directive is that species and habitats achieve and maintain a Favourable Conservation Status (FCS). Monitoring trends in abundance and distribution of species is one of the main ways to undertake surveillance. A preliminary document identifying potential approaches for surveillance and highlighting limitations associated with the nature of cetacean species has been produced, whilst the forthcoming Small Cetacean Abundance in the North Sea (SCANS) II report will provide recommendations for monitoring between decadal surveys, particularly in relation to cost-effective methods. All these recommendations will be considered under the development of a UK wide surveillance strategy, which also aims to contribute towards a northwest European wide strategy. Its development will be undertaken by JNCC with input from the inter-agency Marine Mammal Working Group, which should ensure that the surveillance carried out in territorial and offshore waters is complementary and provides the best cost-effective information which can be used to assess the conservation status of these species. The FCS as defined by the Habitats Directive is measured mainly by assessing changes in the three following parameters: 1) natural range, 2) population size and 3) habitat. Monitoring must therefore lead to a clear picture of the species' actual conservation status and its trends on various levels and should therefore be co-ordinated in order to better detect changes in the distribution or abundance of these species that could reflect a failure to achieve the objectives of the Habitats Directive.

Reid *et al*, (2003) in the Atlas of Cetacean distribution in north-west European waters provided a baseline dataset (with effort-related sightings data from the late 1970s to 1997) with which to report on cetacean distribution and relative abundance and is being used (with other data sources) in the completion of the FCS assessments, in the first round of reporting on the implementation of the Habitats Directive (2007). The Atlas was the product of collaboration between governmental, academic and voluntary organisations and highlighted the value of combining results from different monitoring/surveying schemes. There is a considerable amount of cetacean surveying effort carried out by NGOs that could be better co-ordinated with academic and governmental organisations in order to result in a more effective monitoring coverage with the ability to detect trends or changes in abundance and range of cetacean species.

The Joint Cetacean Protocol (JCP) has been established recently, as a follow up to the Joint Cetacean Database and Atlas, and it aims to update the Joint Cetacean Database project and customise its output in order to better enable the assessment of the FCS of cetacean species in UK and wider north-west European waters. Its valuable input to the FCS assessments can be further developed if new partners join the protocol and contribute their data. Knowledge of which organisations undertake surveying and monitoring of cetaceans, of the spatio-temporal coverage in effort, of the quality of their data and of the potential for data standardisation for the purposes of its use under the JCP is essential in the development of a surveillance strategy.

2 Aims and Objectives

This project will be a desk-based study that will aim to review the current (2009) and planned monitoring and surveying effort on cetacean distribution and abundance in UK and adjacent waters carried out by the Atlantic Research Coalition (ARC). This project will inform the development of a UK Surveillance Strategy for cetaceans.

1. Review current (since records began) and planned surveying and monitoring effort in UK and adjacent waters. This should be provided per area (ICES divisions can be used and smaller areas reported on when appropriate). This will include information on:

   - Main purpose of surveying/monitoring.
   - Species investigated.
   - Temporal coverage (by month, year, duration of surveys, how often are they carried out).
   - Spatial coverage (extent of area surveyed/monitored and how representative of the range of the species targeted this area is).
   - Methodologies used: type of observation platform, surveying method (acoustic, visual, photo-identification).
   - Data type and resolution (e.g. sightings per hour observation in a 10km grid, mark-recapture).
   - Measures for data quality control (e.g. observers' experience and training, cross-checking photos, data filtering).
   - Recommendations, for each of the data sources reviewed, on the potential for data standardisation for the purposes of including in the JCP.

2. Assessment of ARC data as a tool for conservation monitoring of cetacean status including:

   - How appropriate all current surveying and monitoring effort is at detecting changes in relative abundance, range and habitat use (i.e. are temporal and spatial scales appropriate? is data quality appropriate?)
   - How representative the sample data are of the wider interest area?
   - Give a case study example of the most cost-effective monitoring effort carried out and illustrate its suitability at detecting long term changes in relative abundance, range and habitat use. The case study should use ARC data only and a sensitivity or power analysis should be carried out (estimating the variation in encounter rate within an area and between years).

3 Development and aims of the Atlantic Research Coalition (ARC)

In recent years, a number of research groups have established low cost (volunteer-led) cetacean monitoring programmes using Ships of Opportunity (ShOp) in European waters, though individually their geographical coverage has typically been insufficient to enable annual monitoring of species status. In an effort to overcome this limitation, the Atlantic Research Coalition (ARC) was established. ARC aims to link up research groups collecting annual monitoring data by similar scientific methods, to work on project-based analyses, especially assessment of cetacean distribution and abundance changes, at a regional scale and the development of biodiversity indicators.

ARC was established in 2001 by the Biscay Dolphin Research Programme (BDRP) with the other founding partners including the Plymouth to Santander Marine Survey (PSMS), the Irish Whale and Dolphin Group (IWDG) and the Spanish group Sociedad para el Estudio y la Conservacion de la Fauna Marina (AMBAR) (Table 1).

In 2001, the specific aims of ARC were:

1. To collate and analyse cetacean sightings data from fixed-route ferry and other ShOp monitoring programmes which adopt similar methods.

2. To gather data on the diversity, distribution and relative abundance of cetacean species in region.

3. To identify and detect changes in the seasonal, annual and long-term distribution and abundance of cetaceans in West European Waters.

4. To stimulate the establishment of new monitoring programmes on ShOps in West European waters.

During 2001, ARC partners collectively carried out 34 surveys over 98 days with approximately 30,000km of search effort completed by the four research teams. Over this period, over 600 sightings were made, totalling approximately 10,000 animals of 15 species.

There has been a steady growth in ARC membership subsequently, as new ferry survey programmes have become established, including the University of Aberdeen and NORCET in 2003, the Rugvin Foundation in 2004, Sea Trust in 2005 and Organisation Cetacea (ORCA) in 2006. Oceanopolis, who collaborate on ferry surveys with ORCA, were invited to join in 2007 and there are other partners from southern Europe in the pipeline. The addition of Oceanopolis would bring the total to ten partners, from three UK and four other European countries.

There have been four joint meetings of ARC partners, chiefly at European Cetacean Society conferences, which have proved important in developing partnerships and standardisation of data collection methods.

Expertise within and between ARC survey groups is considered to be high. All of the ARC partners have recognised expertise in the varied roles required to deliver a successful scientific survey and monitoring programme. In each group, a team of skilled staff (usually volunteers) undertake the various roles required including (1) liaison with shipping companies, (2) recorder co-ordination, (3) field survey, (4) data management (5) scientific data analysis and (6) reporting/publicity.

Table 1. Summary of ARC partners.

Group	Key Contacts	Base	Join Date
ARC	Tom Brereton	England, UK	2001
Aberdeen University	Sarah Bannon, Colin MacLeod	Scotland, UK	2003
Ambar	Pablo Cermeño	Spain	2001
Irish Whale and Dolphin Group	Dave Wall	Ireland	2001
Marinelife (/BDRP)	Tom Brereton, Clive Martin	England, UK	2001
Norcet	Colin MacLeod	Scotland, UK	2003
Oceanopolis*	Sami Hassani	France	2007
Organisation Cetacea (ORCA)	Kelly Macleod, Dave Smith	England, UK	2006
Plymouth to Santander Marine Survey	Dave Curtis	England, UK	2001
Rugvin Foundation	Frank Zanderlink, Nynke Osinga	Netherlands	2004
Sea Trust	Cliff Benson	Wales, UK	2005

Since the establishment of ARC in 2001, there have been a number of significant policy developments that have gained increasing prominence within the UK and the European Union, including the need for biodiversity indicators to assess progress in addressing biodiversity loss by 2010. A number of the ARC partners are interested in the possibilities of combining the species data across routes to generate a single measure of cetacean status (a composite abundance index), as has been developed for other high profile taxa (e.g. birds, butterflies) (Gregory *et al* 2003, Brereton *et al*. in press). This would not only give a clear and simple measure of cetacean status for policy makers and the general public, but could potentially be used as a marine biodiversity indicator, to assess the overall health of the marine environment.

4 ARC Working Practices

ARC is an informal network of collaborating research groups that has been co-ordinated by Dr. Tom Brereton of Marinelife. For each group there are one or two nominated co-ordinators who are responsible for involvement in ARC (Table 1). ARC does not have any funding (though there has been an unsuccessful application in collaboration with the Centre for Research into Environmental and Ecological Modelling (CREEM), St. Andrew's University) and most of the group co-ordinators are volunteers, hence partner meetings and general progress has been sporadic. However, ARC outputs have included a 2001 report, two posters at the European Cetacean Society in 2004 and 2006 and an oral presentation in 2008.

Figure 1. Meeting of ARC partners in 2004.

5 Introduction to the ARC Partners

5.1 University of Aberdeen

Two researchers from the University of Aberdeen (Sarah Bannon and Colin MacLeod) initiated a regular survey using a passenger ferry as a research platform in the Minch in north western Scotland in 2001. This work was sufficiently successful that it was expanded in the following years to cover additional ferry routes and by 2004 up to eight ferry routes were being surveyed in summer months. In 2005, winter coverage was initiated for the original ferry route across the Minch. The aims of these surveys are to study changes in the spatio-temporal occurrence of cetaceans in this region and to examine the habitat preferences of individual species.

5.2 AMBAR

The Society for the Study and the Conservation of the Marine Fauna (AMBAR) was established by a small group of volunteers in 1996, interested in the study and the conservation of the marine fauna of the Basque coast. Initially, the focus of work was the establishment of a strandings network in the Basque Country of northern Spain. The work of Ambar has grown in the region, to include research on bottlenose dolphin *Tursiops truncatus*, dedicated offshore surveys (including ferry surveys since 2001), and the establishment of a coastal sightings network. AMBAR is affiliated to the Spanish Cetacean Society. Further details are available at www.**ambar**cetaceos.com.

5.3 Irish Whale and Dolphin Group (IWDG)

The Irish Whale and Dolphin Group (IWDG) is a charity dedicated to the conservation and better understanding of cetaceans (whale, dolphin and porpoise) in Irish waters. The Group was founded in 1990 and the primary focus is the co-ordination of both a stranding and a sighting scheme, which monitors whale and dolphin activity in Irish waters. IWDG has an active programme of ferry surveys established in 2001, through its Ship Surveys Programme (Figure 2). Further details are available at www.iwdg.ie.

5.4 Marinelife (Biscay Dolphin Research Programme)

The Biscay Dolphin Research Programme (BDRP) was established in 1995 as a cetacean and seabird monitoring programme in the English Channel and Bay of Biscay. Ferry surveys have been conducted monthly since 1995. In 2005, BDRP was subsumed into a new charity Marinelife (Charity No 1110884), established to co-ordinate and develop a growing portfolio of national and global projects, including new ferry surveys. The mission of Marinelife is to further the conservation of marine and coastal wildlife through scientific investigation and educational activities. Campaigning, advisory and policy work are supplementary aims. Further details are available at www.marine-life.org.uk.

Figure 2. IWDG surveyors on bridge of MV European Ambassador. P*hoto: Dave Wall.*

5.5 NORCET

NORCET (Northern North Sea Cetacean Ferry Surveys) ferry surveys were set up to collect data on cetacean occurrence and distribution in the northern North Sea between Aberdeen, Orkney and Shetland in summer 2002 to build on the already existing network of cetacean surveys conducted from ferries. It was originally set up as a student project through the University of Aberdeen and has since expanded into a joint project between researchers at the University of Aberdeen, the East Grampian Coastal Partnership and volunteers from the South Grampian Regional Seawatch Group.

5.6 Plymouth to Santander Marine Survey (PSMS)

The Plymouth to Santander Marine Survey (PSMS) is a voluntary research body established in 1993, which carries out monthly ferry surveys through the Bay of Biscay and English Channel. Since 1996, survey efforts have been led and co-ordinated by the PSMS Director, Dave Curtis.

5.7 Organisation Cetacea (ORCA)

Organisation Cetacea (ORCA) is a registered charity that promotes the conservation of the marine environment through research, partnership and education and provides a forum for the enjoyment of whales, dolphins, seabirds and other marine life. ORCA began conducting offshore ferry surveys in European waters in 1996, with a major focus on the Bay of Biscay and the English Channel. Since this time, the organisation has developed a network of volunteers trained to collect information on a variety of platforms and other seas (e.g. the North Sea), compiling a database of more than 3,500 cetacean sightings. Further details are available at www.orcaweb.org.uk.

5.8 Rugvin Foundation

Project Rugvin originated from collaboration between the Centre of Environmental Science (CML, Leiden University), The Dutch North Sea Foundation (SDN in Utrecht) and the overall co-ordinator Frank Zanderink. The idea of starting these monitoring activities resulted from the need to do more research on cetaceans and inform the Dutch public about the presence of cetaceans in the North Sea. Ferry surveys in the North Sea were launched in 2005. Further details are available at http://www.noordzee.nl/natuur/zeezoogdieren/projectrugvin

5.9 Sea Trust

Sea Trust is the marine arm of the Wildlife Trust South & West Wales and was formed in 2003. The aims of Sea Trust are to (1) promote awareness of the marine environment and its biodiversity amongst the community, (2) to generate a sense of pride, value and ownership/guardianship of the marine biodiversity within the community and (3) to conduct and encourage local research that will improve the knowledge of local marine biodiversity and where possible involve the community. Ferry surveys have been conducted through the Irish Sea since 2004. Further details are available at http://www.seatrust.org.uk.

6 Combined Survey Effort by ARC Partners

Whilst new partners have continued to join ARC, the existing partners including the IWDG, Marinelife and ORCA have expanded their own ferry survey efforts. In total the ARC partners have established 22 ferry surveys since 1993, covering 19 ferry routes with 17 of the routes currently active (October 2007) (Table 2). Eight ferry companies and 20 commercial ferries have been used (Table 3).

Current combined survey activity per annum equates to undertaking a minimum of 165 ferry trips over 310 days by ~150 volunteer surveyors travelling 150,000km and seeing ~20 cetacean species through achieving ~70,000km of repeat coverage along 7,550km of ferry routes. Details of this effort are given below.

Table 2. Number of ferry routes established by the ARC partners.

Survey group	No. Routes
Aberdeen University	5
Ambar	1
IWDG	5 (3 active)
Marinelife (BDRP)	2
NORCET	2
ORCA	3
PSMS	1
Rugvin foundation	1
Oceanopolis/Orca	1
Sea Trust	1

6.1 Sponsorship

Seven ferry companies sponsor the ferry surveys carried out by ARC partners (Table 3). Most groups are subsidised by ferry companies to varying degrees, though ORCA surveys on the Portsmouth-Bilbao ferry receive no sponsorship. The minimum level of sponsorship includes subsidised travel, though a number of the ferry companies provide a combination of free travel, accommodation and food for up to 3 surveyors (Figure 3). Some of the groups pay expenses to some of the volunteers (Appendix 11.2).

Table 3. Sponsoring ferry companies.

Ferry Company	No. routes
Brittany Ferries	3
DFDS	1
Irish Ferries	2
North link Ferries	2
P&O	4
Stena Line	1

For some of the groups there has been partial funding from the statutory nature conservation agencies (e.g. Countryside Council for Wales for the Sea Trust) to support the programme ferry surveys, but in general the work is supported by money raised from more general funding initiatives.

Figure 3. Whale and dolphin viewing room – part of the sponsorship and support provided to the Biscay Dolphin Research Programme by P&O Ferries. *Photo Tom Brereton.*

6.2 Spatial and Temporal Coverage

A location map of ferry route coverage (by season) is given in Figures 4 and 5. Table 5 gives the number of ferry routes in operation and includes the route, the name of the sponsoring ferry company, the year of establishment, the timing of surveys and the location (by regional sea and ICES fishing zone).

In summary, all ten ICES fishing zones present around the coast of the UK are covered by the ARC ferry routes, with the number of ferry routes per zone varying from one to five (Table 5). Six regional seas are surveyed: the Bay of Biscay, Celtic Sea, English Channel, Irish Sea, Hebridean Sea/The Minch and the North Sea, with two to four ferry routes in each (Table 5).

A cross-referencing table for regional seas (e.g. by (Convention for the Protection of the Marine Environment of the North East Atlantic) OSPAR region) is given in Appendix 11.1.

ARC surveys started in 1993 and by 2003 14 routes were being monitored and currently (2009) there are 17 active ferry routes. All 17 of the currently active routes are surveyed throughout the summer months (April to September), completing ~7,550km effort per trip (all surveys combined), whilst eight of the survey routes are surveyed throughout the winter (October to March).

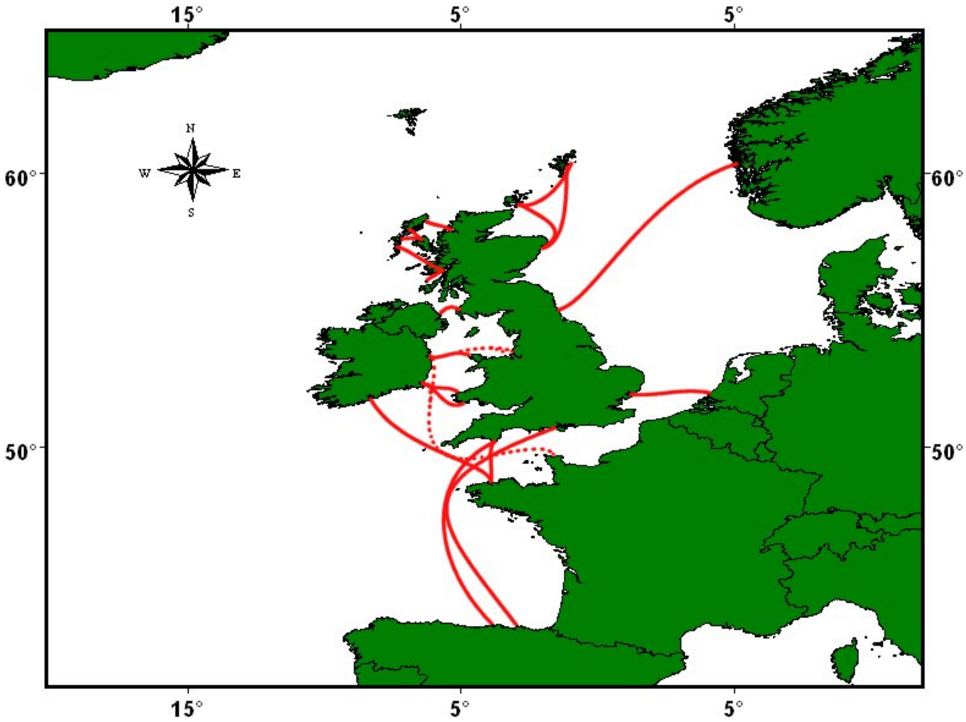

Figure 4. Current (2009) summer survey effort by ARC partners. Broken lines are defunct routes.

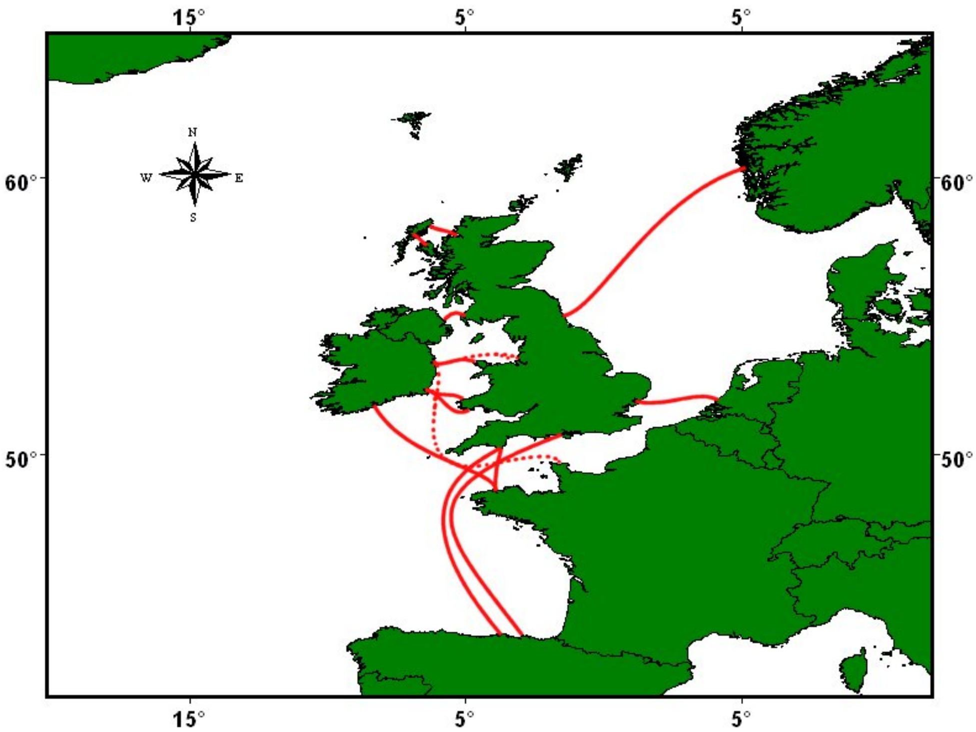

Figure 5. Current winter survey effort by ARC partners. Broken lines are defunct routes.

Table 4. Summary table of ARC partner ferry surveys, including route, sponsoring body, timing and location. (For further information see Appendix 11.2).

Group	Start date	Route	Company	Summer surveys	Winter surveys	Regional Seas surveyed	ICES fishing areas
Aberdeen University	2001	Ullapool-Stornaway	Caledonian Macbrayne	Yes	Yes	Hebridean Sea	VIa
Aberdeen University	2003	Colonsay-Oban	Caledonian Macbrayne	Yes	No	Hebridean Sea	VIa
Aberdeen University	2003	Oban-Coll/Tiree	Caledonian Macbrayne	Yes	No	Hebridean Sea	VIa
Aberdeen University	2003	Oban-Barra	Caledonian Macbrayne	Yes	No	Hebridean Sea	VIa
Aberdeen University	2003	North Uist-Skye-Harris	Caledonian Macbrayne	Yes	No	Hebridean Sea	VIa
Ambar	2001	Portsmouth-Bilbao	P&O	Yes	Yes	English Channel, Bay of Biscay, Celtic Sea	VIId,e,h, VIIIab,c,d2
IWDG	2002	Dublin – Holyhead	Irish Ferries	Yes	Yes	Irish Sea	VIIa, g
IWDG	2004	Rosslare - Pembroke	Irish Ferries	Yes	Yes	Irish Sea, Celtic Sea	VIIg
IWDG	2001-2	Dublin – Liverpool/Mostyn	P&O Irish Sea Ferries	Partial	Partial	Irish Sea	VIIa
IWDG	2002-3	Dublin/Rosslare – Cherbourg	P&O Irish Sea Ferries	Partial	Partial	Irish Sea , Celtic Sea, English Channel	VIIa,d.e,f,g,h
IWDG	2006	Larne- Cairnryan	P&O Irish Sea Ferries	Yes	Yes	Irish Sea	Via,VIIa
Marinelife (BDRP)	1995	Portsmouth-Bilbao	P&O	Yes	Yes	Bay of Biscay, Celtic Sea, English Channel	VIId,e,h, VIIIab,c,d2
Marinelife	1995	Plymouth-Roscoff	Brittany Ferries	Yes	Yes	English Channel	VIIe
Norcet	2002	Aberdeen- Orkney	Northlink ferries	Yes	No	North Sea	IVa
Norcet	2002	Aberdeen- Shetland	Northlink ferries	Yes	No	North Sea	IVa
Oceanopolis /ORCA	2006	Roscoff-Cork	Brittany Ferries	Yes	Partial	Celtic Sea, English Channel	VIIe,f,g,h
ORCA	2004	Newcastle-Bergen	DFDS	Yes	Yes	North Sea	IVa,b
ORCA	1995	Portsmouth-Bilbao	P&O	Yes	Yes	Bay of Biscay, Celtic Sea, English Channel	VIId,e,h, VIIIab,c,d2
ORCA	2006	Plymouth–Santander	Brittany Ferries	Yes	No	Bay of Biscay, Celtic Sea, English Channel	VIIe,h, VIIIab,c,d2
PSMS	1993	Plymouth–Santander	Brittany Ferries	Yes	Partial	Bay of Biscay, Celtic Sea, English Channel	VIIe,h, VIIIab,c,d2
Rugvin Foundation	2005	Hook of Holland-Harwich	Stena Line	Yes	Yes	North Sea	IVc
Sea Trust	2004	Fishguard-Rosslare	Stena Line	Yes	Yes	Irish Sea, Celtic Sea	VIIa,g

Table 5. Number of ferry routes by ICES fishing area.

ICES fishing area	No. ferry routes
UK territorial waters	
IVa	2
IVb	1
IVc	1
VIId	1
VIIe	5
VIIh	4
VIIg	3
VIIf	2
VIIa	4
V1a	4
French/Spanish territorial waters	
VIIIa	2
VIIIb	1
VIIIc	2
VIIId	2

In addition to those ferry routes currently used to conduct surveys by ARC members, the current spatial coverage could be extended through surveys on additional ferry routes. Additional surveys are currently planned on five routes (Table 6).

Table 6. Proposed ferry routes for expanded survey coverage by ARC partners.

ARC group	Route	Ferry company
Cumbria Wildlife Trust/Marinelife	Heysham-Isle of Man	Steam Packet Company
ORCA	Aberdeen to Torshavn	Smyril Line
ORCA	Harwich-Esberg	DFDS
Sea Trust	Holyhead - Dun Laoghaire	Stena Line
Rugvin Foundation	Amserdam-Newcastle	DFDS

6.3 Species Coverage

Eleven species are regularly recorded by ARC ferry surveys, these are: bottlenose dolphin (Figure 6), common dolphin, Cuvier's beaked whale, fin whale, harbour porpoise, long-finned pilot whale, minke whale (Figure 7), Risso's dolphin, sperm whale, striped dolphin and white-beaked dolphin. A further four species are occasionally recorded on surveys: Atlantic white-sided dolphin, killer whale, northern bottlenose whale and Sowerby's beaked whale. Of the rarer species, three are seen more or less annually: humpback whale, blue whale, false killer whale and sei whale.

Figure 6. Bottlenose Dolphins are regularly recorded on a number of the ferry routes. *Photo:Tom Brereton.*

Species coverage by ferry route is given in Table 7. Of the regularly occurring species, coverage is particularly good for harbour porpoise (encountered on all current routes (2009)), minke whale and common dolphin.

Table 7. Survey coverage of cetacean species by ferry route.

Sightings frequency: blue - regular, green – occasional, orange – rare. Trips are listed in clockwise order from the north of Scotland.

	Aberdeen- Orkney	Aberdeen- Shetland	Newcastle-Bergen	Hook of Holland-Harwich	Portsmouth-Bilbao	Plymouth – Santander	Plymouth-Roscoff	Roscoff-Cork	Rosslare – Cherbourg	Rosslare - Pembroke	Fishguard-Rosslare	Dublin – Liverpool/Mostyn	Dublin– Holyhead	Larne- Cairnryan	Colonsay-Oban	Oban-Coll/Tiree	Oban-Barra, Colonsay, Tiree	North Uist-Skye-Harris	Ullapool-Stornaway
Humpback Whale	orange	orange			orange	orange													
Minke Whale	blue	blue	blue		blue	blue	blue	blue	green				blue		blue	blue	blue	blue	blue
Sei Whale					orange	orange													
Fin Whale					blue	blue			orange				orange						
Blue Whale					orange	orange													
Sperm Whale					blue	blue													
Northern Bottlenose Whale					green	green													
Sowerby's Beaked Whale					green	green													
True's Beaked Whale					orange	orange													
Cuvier's Beaked Whale					blue	blue													
Bottlenose Dolphin	blue	blue	blue		blue	blue	blue	blue		green			green	orange	green	green	green	green	green
Striped Dolphin					blue	blue													
Common Dolphin	green	green			blue	blue	blue	blue	blue	blue	blue	blue	blue		blue	blue	blue	blue	blue
White-beaked Dolphin	blue	blue	blue	blue	orange	orange									green	green	green	green	green
Atlantic White-sided Dolphin	green	green			orange	orange													
Risso's Dolphin	green	green			blue	blue			green	green	blue		green		green	green	green	green	green
False Killer Whale					orange	orange													
Killer Whale	orange	orange	orange		green	green													
Long-finned Pilot Whale	orange	orange			blue	blue			green										
Harbour Porpoise	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue	blue		blue	blue	blue	blue	blue	blue	blue

The richest area for cetaceans is undoubtedly the Bay of Biscay, which is outside the conventional Exclusive Economic Zone (EEZ) of the UK. The other four main regional seas sampled tend to have up to four regularly recorded cetacean species (Table 8).

Figure 7. Minke Whales are regularly recorded on a number of the ferry routes. *Photo:Tom Brereton.*

Table 8. Survey coverage of cetacean species by regional sea.

Regional Sea	ICES areas sampled	No. ferry routes	Regular species	Occasional species	Rare species
North Sea	IVa,b,c	4	Bottlenose Dolphin, Harbour Porpoise, Minke Whale, White-beaked Dolphin.	Atlantic White-sided Dolphin, Common Dolphin, Risso's Dolphin.	Humpback Whale, Killer Whale, Long-finned Pilot Whale.
English Channel	VIId,e,h	4	Bottlenose Dolphin, Common Dolphin, Harbour Porpoise, Minke Whale	Long-finned Pilot Whale, Risso's Dolphin, Striped Dolphin.	Fin Whale, Humpback Whale, White-beaked Dolphin.
Bay of Biscay	VIIIa,b, c,d2	2	Bottlenose Dolphin, Common Dolphin, Cuvier's Beaked Whale, Fin Whale, Harbour Porpoise, Long-finned Pilot Whale, Minke Whale, Risso's Dolphin, Sperm Whale, Striped Dolphin.	Killer Whale, Northern Bottlenose Whale, Sowerby's Beaked Whale.	Atlantic White-sided Dolphin, Blue Whale, False Killer Whale, Humpback Whale, Melon Headed Whale, Pygmy Killer Whale, Sei Whale, True's Beaked Whale.
Celtic Sea	VIIe,f,g,h	4	Common Dolphin, Harbour Porpoise, Minke Whale, Risso's Dolphin.	Bottlenose Dolphin, Long-finned Pilot Whale,	Fin Whale, Killer Whale,
Irish Sea	VIa,VIIa,g	4	Common Dolphin, Harbour Porpoise, Minke Whale, Risso's Dolphin.	Bottlenose Dolphin	Fin Whale, Killer Whale.
Hebridean Sea	VIa	4	Harbour Porpoise, Common Dolphin, Minke Whale	Bottlenose dolphin, Risso's dolphin, white-beaked dolphin	Killer Whale.

6.3.1 Type of surveyors

Most of the data are collected by experienced volunteer surveyors, though in north-west Scotland, the surveys are completed by experienced (>1 years experience in marine mammal observing) research students specifically trained to conduct these ferry surveys (Table 11). Most of the groups have 'team structures' (see Appendix 11.2) with a senior surveyor, paired alongside a trainee, to ensure that there is always a highly competent and very experienced recorder to maintain data quality and to help develop junior surveyors. Most of the groups have a programme of onshore training, in addition to training on the job. There is a good deal of continuity in recording. For example, on Sea Trust surveys, the survey's manager Cliff Benson goes on virtually every trip. Similarly, the majority of surveys conducted since 2001 on the west coast of Scotland have been undertaken by Sarah Bannon. Ambar and Marinelife require an expert seabird recorder on each of their surveys.

6.3.2 Frequency and timing

Surveys are usually carried out monthly, though in the summer months several of the groups undertake several surveys per month (Table 11). Because return trips are made, a proportion and in some cases all of the route may be sampled twice (Table 11). As surveyors are on the ship anyway, in most instances they continue to survey on return legs, except in some of the less productive areas (e.g. the Central English Channel near Portsmouth). However, these areas are still surveyed at least once on the outgoing survey despite the historically low number of sightings within these regions.

Most groups achieve full coverage of the survey route in the summer months, though to achieve this may require survey effort on both outward and return legs (e.g. Portsmouth to Bilbao). Exceptions include the Plymouth-Santander ferry, where part of the English Channel is missed and the Aberdeen-Shetland ferry, where offshore coverage in the North Sea is limited by darkness (see Appendix 11.2).

Of the eight ferry routes surveyed in the winter, less of the route is available for surveying due to reduced daylight. Only three of the eight routes achieved 100% coverage of the route, whilst the remainder chiefly cover between a half and two-thirds of the route.

Overall across all ARC routes, approximately 50% of time at sea is spent surveying.

6.3.3 Methodology details

ARC partners in general have very similar methodologies, in part because several of the founding groups have helped others establish surveys, using adopted protocols. All partners collect both effort data and sightings data. The majority of surveys are characterised by having two observers (often on rotation with others), watching ahead from the ship's bridge during all available daylight hours (e.g. Figures 2 and 8).

Figure 8. A Rugvin Foundation observer recording on the bridge. *Photo: Frank Zanderink.*

All the groups also record environmental data, usually at least every 30 minutes. However, there are some differences in how sightings data are recorded. In particular, most of the ARC partners (except NORCET and Sea Trust) carry out distance sampling (recording ahead and measuring distance and angle to sighting), though most do not currently undertake a double platform or deal effectively with responsive movement of animals to the ship. NORCET and Sea Trust record sightings in a defined search area (a 'strip transect'), that varies from 500-2000m wide depending on the survey route). Determining which sightings are within this transect strip can be problematic without the measurement of distances to the actual sightings and, whilst still collecting useful data, this may limit the analysis in which data from these surveys can be used.

The commercial ferries used by ARC partners in the main provide quite different viewing conditions from other research platforms, where distance sampling is used to estimate population size/density. The main differences are in terms of the rapid speed of travel (15-33 knots, but mostly 15-20 knots), the high observation height (15-37m, mean 23m – Figure 9) and the stability of the ferries which allows an accurate estimation of distance and bearing to a sighting as well as providing a better observation platform than small research vessels with a lower eye-height and less stability.

Common variables recorded by all groups include:

For Sightings:
- Species identity and degree of certainty (definite, possible, probable) or to lowest level of taxonomic certainty (e.g. Large Rorqual sp.)
- Group size and category (e.g. best estimate, minimum, maximum).
- Behaviour (into one of a number of standard categories).

Effort data (mainly at 30 minute intervals):
- Ship's position.
- Direction of travel.
- Ship's speed.
- Sea state and other sea/weather conditions.

For rare species, most ARC groups require a photo or description. Several groups have 'rarity' forms, so that observers fill in descriptions in a standard way.

Figure 9. The 32 metre high bridge of the MV Pride of Bilbao. *Photo: Clive Martin.*

6.3.4 Additional marine wildlife recording

Several groups record seals, basking sharks and turtles and undertake casual bird recording, whilst Ambar and Marinelife carry out effort-related monitoring of seabirds on their ferry routes using multiple observers to minimise the possibility that one taxa is overlooked when the density of the other taxa is relatively high (Table 9).

Table 9. Other wildlife monitoring carried out by ARC partners.

Group	Route	Additional recording
Aberdeen University	Ullapool-Stornaway	Basking sharks, seals
Aberdeen University	Colonsay-Oban	Basking sharks, seals
Aberdeen University	Oban-Coll/Tiree	Basking sharks, seals
Aberdeen University	Oban-Barra	Basking sharks, seals
Aberdeen University	North Uist-Skye-Harris	Basking sharks, seals
Ambar	Portsmouth-Bilbao	Photo-identification of Beaked Whales. Seabirds counts per minute of effort in two distance bands. Seals, Basking Sharks, Turtles
IWDG	Dublin– Holyhead	Seabird species list. Seals, Basking Sharks, Turtles
IWDG	Rosslare - Pembroke	Seabird species list. Seals, Basking Sharks, Turtles
IWDG	Dublin – Liverpool/Mostyn	Seabird species list. Seals, Basking Sharks, Turtles
IWDG	Dublin/Rosslare – Cherbourg	Seabird species list. Seals, Basking Sharks, Turtles
IWDG	Larne- Cairnryan	Seabird species list. Seals, Basking Sharks, Turtles
Marinelife (BDRP)	Portsmouth-Bilbao	Photo-identification of Beaked Whales. Seabirds counts per minute of effort in two distance bands. Seals, Basking Sharks, Turtles
Marinelife	Plymouth-Roscoff	Seabirds counts per minute of effort in two distance bands. Seals, Basking Sharks, Turtles
Norcet	Aberdeen- Orkney	None
Norcet	Aberdeen- Shetland	None
Oceanopolis/Orca	Roscoff-Cork	?
Orca	Newcastle-Bergen	None
Orca	Portsmouth-Bilbao	Seabirds. Other marine wildlife eg. Sharks, turtles
Orca	Plymouth–Santander	None
PSMS	Plymouth–Santander	Birds
Rugvin Foundation	Hook of Holland-Harwich	Seabirds (occasionally)
Sea Trust	Fishguard-Rosslare	Rare seabirds.

6.3.5 Data Entry and Data Validation

All of the ARC partners use MS Excel and/or MS Access to enter and store data, in a standard way (sightings as rows, sighting variables as fields). A data entry template (two Excel sheets) has been developed to help ARC partners design their databases. The fields in the database are given in Table 10.

The majority of ARC groups require a description for sightings and/or a photograph (Figure 10) of rarer species to verify identification. Unidentified animals are dealt with differently, some groups classify as probable or possible for particular species, whilst others reduce the sighting to a higher taxonomic classification if the identification is potentially questionable (e.g. beaked whale spp). For some groups, unsubstantiated sightings are downgraded (e.g. to unidentified dolphin etc.).

Table 10. List of Sighting Fields in Database.

Sightings	Effort data
Date	Date
Ship	Ship
Platform	Platform
Observers	Observers
Start time	Time
End time	Latitude
Latitude	Longitude
Longitude	Course
Sea State	Speed (km)
Vis	Sea State
Ref No.	Visibility
COG	Cloud
Angle	Swell
Distance(m)	Precipitation Type
Species code (ENG)	Precipitation Intensity
Species code (LAT)	Wind Speed
Certainty	Wind Direction
Total Number	
Adult	
Juv.	
Calf	
Behaviour 1	
Behaviour 2	
Behaviour 3 etc	
Media	
Associated seabirds	
Notes	

Figure 10. For rare species, including beaked whales, the majority of ARC survey groups require descriptions or photographic evidence. *Photo: Pablo Cermeño.*

6.3.6 Data Filtering

This is uneven across groups and could be improved with further collaboration and training between ARC partners. Some groups have few formal procedures, whilst for others the position, species identification and environmental data are all checked for validity by a trained scientist (e.g. to identify unseasonal sightings or probable misidentifications of rarities) to ensure that they are consistent with other data from the same survey. For a number of the groups, transcription errors are identified by plotting data in a geographic information system (GIS), with outliers being likely errors.

6.3.7 ARC Data Situation

For most ARC groups there is a backlog of data to be input. Each database is held separately by the individual ARC partner and there is no single ARC database as such, although a number of data subsets have been collected for specific analyses.

Table 11. Summary of survey coverage, methods and effort for each survey route covered by ARC partners. *Full details are provided in Appendix 11.2.*

Survey group	Route	Type of surveyor	No. surveyors per trip (on watch)	No. man days/year (defunct)	No. trips per year (defunct)	No. trips per month (defunct)	Trip length - one way (km)	Trip length in days (Survey days)	No. hours effort per trip	% coverage of route summer	% coverage of route winter
NORCET	Aberdeen-Orkney	Volunteers	2	10	5	0-1+	~700	2	Up to 16	100	0
NORCET	Aberdeen-Shetland	Volunteers	2	10	5	0-1+	~800	2	Up to 16	~90	0
ORCA	Newcastle-Bergen	Volunteers	4 (2)	48	12	1	700	4(3)	19-40	>90	>50
Rugvin foundation	Hook of Holland-Harwich	Volunteers	2	24	12	1	180	2	9-13	>100	100-200
Ambar	Portsmouth-Bilbao	Volunteers	2	22-28	11-13	1- 2	1045	4(3)	21-36	100	~66
Marinelife (BDRP)	Portsmouth-Bilbao	Volunteers	3*	33-42	11-14	1- 2	1045	4(3)	21-36	100	~66
ORCA	Portsmouth-Bilbao	Volunteers	1-15	11-100++	11++	0-1+	1045	4(3)	21-36	100	~66
Marinelife	Plymouth-Roscoff	Volunteers	2	24	12	1	185	2(1-2)	6-12	100- 200	75- 100
ORCA	Plymouth – Santander	Volunteers	2	10	5	0-1+	780	3	10-21	>75	>50
PSMS	Plymouth – Santander	Volunteers	2	16-18	8-9	1	780	3(2)	10-21	>75	>50
Oceanopolis/ORCA	Roscoff-Cork	Volunteers		?	3+	?	~500	?	?	?	?
IWDG	Dublin/Rosslare–Cherbourg	Volunteers	1- 3	(8-24)	(8)	(1)	700	3	9– 17.5	~50	~50
IWDG	Rosslare–Pembroke	Volunteers	1- 3	12-36	12	1	125	1	4.5 -7	100	>75
Sea Trust	Fishguard-Rosslare	Volunteers	3 - 10	36-120	12	1- 4+	100	1	3.5	100-200	100-200
IWDG	Dublin–Holyhead	Volunteers	1 - 3	12-36	12	1	100	1	4.5 -7	100	>75
IWDG	Dublin–Liverpool/Mostyn	Volunteers	1 - 3	(2-6)	(2)	(1)	125	2	3-7	>50%	~50
IWDG	Larne–Cairnryan	Volunteers	2	24	12	1	50	1	3	100	100
Aberdeen University	Colonsay-Oban	Students	1	5	5	1	60	1	3	200	0
Aberdeen University	Oban-Coll/Tiree	Students	1	5	5	1	90	1	7	200	0
Aberdeen University	Oban-Barra	Students	1	5	5	1	135	1	5	100	0
Aberdeen University	North Uist-Skye-Harris	Students	1	5	5	1	100	1	4	100	0
Aberdeen University	Ullapool-Stornaway	Students	1	12-18	12-18	1-2	75	1	2.5-5	100-200	1

Table 12. Summary of ship details for each survey route covered by ARC partners.

Survey group	Route	Ferry Company	Name of ferries	Observation Height (m)	Ship speed (knots)	Location
NORCET	Aberdeen-Orkney	Northlink ferries	Hascosay	12	16	Bridge
NORCET	Aberdeen-Shetland	Northlink ferries	Hascosay	12	16	Bridge
ORCA	Newcastle-Bergen	DFDS	Queen of Scandinavia	21	21s	Bridge
Rugvin foundation	Hook of Holland- Harwich	Stena Line	Britannica & Hollandica (05)	32, 33	20-22	Bridge
Marinelife (BDRP)	Portsmouth-Bilbao	P&O	Pride of Bilbao	32	16-22	Bridge
ORCA	Portsmouth-Bilbao	P&O	Pride of Bilbao	37	16-22	Monkey Island
Marinelife	Plymouth-Roscoff	Brittany Ferries	Pont L'Abbé, Pont Aven	24, 26	17-20	Bridge
ORCA	Plymouth – Santander	Brittany Ferries	Pont Aven (04.2004 - present)	32	16-33	Bridge
PSMS	Plymouth – Santander	Brittany Ferries	Val de Loire (96-04. Pont Aven (04.2004 to present)	24	22-24	Bridge
Oceanopolis/Orca	Roscoff-Cork	Brittany Ferries				Bridge
IWDG	Dublin/Rosslare–Cherbourg	P&O Irish Sea Ferries	European Ambassador, European Diplomat (02/03)	15, 25	16-24	Bridge
IWDG	Rosslare–Pembroke	Irish Ferries	Isle of Inishmore (2004 - Present)	30	18-20	Bridge
Sea Trust	Fishguard-Rosslare	Stena Line	Stena Europe	26	17.5	Bridge
IWDG	Dublin–Holyhead	Irish Ferries	Ulysses	30	18-20	Bridge
IWDG	Dublin–Liverpool/Mostyn	P&O Irish Sea Ferries	European Ambassador (01/02)	25	20-24	Bridge
IWDG	Larne–Cairnryan	P&O Irish Sea Ferries	European Highlander & European Causeway	25	18-20	Bridge
Aberdeen University	Colonsay-Oban	Caledonian Macbrayne	Clansman	15	15	Bridge
Aberdeen University	Oban-Coll/Tiree	Caledonian Macbrayne	Clansman	15	15	Bridge
Aberdeen University	Oban-Barra	Caledonian Macbrayne	Clansman, Lord of the Isles	15	15	Bridge
Aberdeen University	North Uist-Skye-Harris	Caledonian Macbrayne	Hebridean	15	15	Bridge
Aberdeen University	Ullapool-Stornaway	Caledonian Macbrayne	Isle of Lewis	15	15	Bridge

7 Assessment of Monitoring Approach

7.1 Ferries as research and monitoring platforms

Passenger ferries have a number of advantages and disadvantages (see Table 13 for summary). Advantages include:

- They are high stable platforms (e.g. Figure 11) that help in species detection and accurate recording of data required for distance sampling such as distance and bearing to any sighted groups.
- They provide an increased survey swathe due to the increased height above sea level in comparison to other possible survey platforms.
- Many run year-round giving the potential to collect seasonal data.
- They run annually giving the potential to identify inter-annual changes.
- There is repeated coverage of the same spatial area which reduces the potential biases in assessing changes in species status resulting from spatially heterogeneous survey coverage.
- Survey route placement is not determined by cetacean distribution patterns and therefore, may be considered randomly placed in relation to the animals being surveyed.
- Given that there are many routes, they provide potential to achieve wide spatial coverage.
- Sponsorship is usually provided resulting in substantial cost savings over vessel chartering.

Figure 11. A Brittany passenger ferry. *Photo: Tom Brereton.*

Disadvantages of using passenger ferries as research platforms include:

- Because ferries travel at relatively high speeds, there is only a short period of time for the detection and identification of species,
- Groups of animals cannot be approached to confirm species identification or group size
- Spatial coverage is not randomly placed by the observers
- It is not always apparent how representative changes along a single survey transect are of the surrounding area.
- Selected survey routes are often to be biased towards areas with more species

However, many of these disadvantages can be mitigated against by providing observers with appropriate training and applying appropriate analysis to any data collected.

Table 13. Summary of advantages and disadvantages of using passenger ferries as research platforms.

Ferries	Advantages	Disadvantages
Annual	• Can identify turning points (step changes in status) – greater chance of identifying causes of change (policy drivers) • Can identify early signs of species decline – undertake conservation action before it is too late	None
Fixed routes	• Repeated coverage of the same spatial area which reduces the potential biases in assessing changes in species status resulting from spatially heterogeneous survey coverage	• Some bias possible because species-rich routes selected. • Species-poor routes can be hard to maintain, as they are not as appealing to volunteers. • Not randomly set up
Year-round	• Identifying seasonal patterns in occurrence	None
Relatively fast	• More ground cover per unit of time	• Animals on survey missed more easily • Higher proportion unidentified
Height and Stability	• Can survey in a greater range of sea states • Greater chance of detecting first point of responsive movement	• Smaller species may be more easily missed
Commercial sponsorship	• Free places often provided, reducing costs substantially	None

7.2 Costing the value of ARC survey efforts

Whilst survey efforts can be conducted from small research vessels under some circumstances, obtaining a wide spatial coverage of non-coastal cetacean occurrence and distribution for monitoring purposes can generally be relatively expensive if a larger dedicated research vessel is required. This is due to ship, crew and fuel costs. Similarly, whilst aerial surveys can provide excellent survey coverage within narrow windows of suitable weather, the use of aerial surveys is often beyond the scope of many research groups and access to suitable aircraft is often limited due to high demand from other sources. Therefore, obtaining sufficient coverage at a relatively low cost for a specific time frame can be difficult. This is one of the main limitations on assessing the non-coastal distribution of cetaceans and contributes to why non-coastal cetacean distribution and abundance has been little studied, aside from intermittent snapshot population surveys over short periods of time.

ARC partners aim overcome both cost and logistical problems in non-coastal survey work by using ShOp as research platforms and utilising skilled volunteer recorders. Using this approach, the main costs are only in terms of professional co-ordination and travel expenses for volunteers, and wide spatial coverage over long temporal periods can be achieved at a relatively low cost in comparison to other approaches.

To illustrate this, it is interesting to put a rough estimate on the monetary value of the annual survey work carried out by ARC partners in delivering effort related data on the annual distribution and status of ~20 cetacean species in NW Europe, and as if the surveys were being paid for by a funding body paying the real costs.

At the current (2009) level of annual ARC survey effort (2.5 surveyors per trip on 310 days/year, with an additional 90 days overnight travelling), a vessel suitable for cetacean research would probably cost from around £500 to £5000 per day (the first figure being for a small charter fishing vessel/sailing vessel and the second being the operating costs for an offshore research vessel), whilst the cost to hire professional surveyors might be around £200/day.

Table 14. Estimated costings for achieving a similar level of survey coverage to that achieved by ARC partners using dedicated researcher vessels and paid professional observers.

Survey Requirement	Total
Small boat charter 105 days@ £500 per day (for inshore surveys)	£52,500
Medium boat charter 100 days@ £2500 per day (for offshore surveys)	£250,000
Large boat charter 100 days@ £5000 per day (for deep sea surveys)	£500,000
Surveyor costs 2.5 observers on 310 days @£200/day	£155,000
Total cost of field surveys	**£957,500**

On the basis of these figures, the total annual cost to a funding body to conduct surveys with a similar spatial and temporal coverage could be as high as £1 million (1.43 million euros) or more (Table 14). Whilst these figures are approximate, and it is likely that cost reductions could be made in a number of areas (for example the use of volunteer observers on dedicated research vessels or the wider use of smaller research vessels), it is unlikely that sufficient cost reductions could be made to make the costs comparable with the ARC monitoring programme. Therefore, this highlights the potentially cost-effective nature of the ARC monitoring programme for collecting data to monitor region-wide trends in occurrence, distribution and abundance of a wide range of cetacean species.

7.3 How representative is the data in terms of species and area coverage?

With any survey coverage, the question of representativeness is important. However, representativeness may have different definitions under different circumstances. For example, in terms of calculating absolute abundance measures for a wide region, the survey coverage generally needs to be a spatially-random sample throughout a relatively homogenous habitat with relatively consistent densities of the target species. In contrast, when studying habitat preferences, the survey effort needs to be representative of all available combinations of the habitat variables being examined rather than necessarily being randomly distributed throughout the study area. Finally, for monitoring changes or trends in cetacean populations, representativeness can simply mean that the changes or trends detected within surveyed areas reflect those found occurring across a wider area of interest. As a result, surveys that are not randomly positioned by researchers, or survey a representative sample of available habitat, can still be representative of changes or trends in local populations. At times, this can be achieved through repeated coverage of the same area to reduce the impacts of spatial heterogeneity in species distributions over short time scales.

However, it cannot be assumed that non-randomly positioned survey coverage, such as the transects surveyed by ARC members along ferry routes, are representative without a specific assessment of whether any changes or trends will actually represent what the changes or trends are in a wider area. Whilst representativeness of changes or trends in cetacean distribution in a surveyed area in relation to a wider area of interest is difficult to assess using ARC data alone, there are some indications that the data from along a single fixed transect are indeed representative of what is occurring in the surrounding areas.

Consistent patterns in cetacean relative occurrence and distribution (by season and year) are found between neighbouring ferry survey routes suggesting that the individual surveys may be representative of the wider areas and that the power to detect trends may be substantial. For example, on the west coast of Scotland, ferry surveys recorded a dramatic decrease in the occurrence of minke whales between 2004 and 2005 (Figure 12). The same change in minke whale occurrence is obtained from two separate groupings of ferry transects with different spatial distributions (the Sea of Hebrides grouping and the Minches grouping). Therefore, while neither of these ferry survey transect groupings are randomly positioned or necessarily representative of all available combinations of the habitat, both appear to be detecting the same change or trend in minke whale occurrence. This suggests that they are both indeed representative of changes occurring over a wider area despite their limited survey coverage. This is further supported by the fact that similar decreases in minke whale occurrence have also been recorded in other studies on the west of Scotland including areas not covered by the ferry routes (Anderwald *et al*. 2006; Stevick 2007). Therefore, in this case, whilst the ferry surveys only cover a limited section of this region, the synchronous changes in minke whale occurrence detected suggest that they are detecting part of a broader pattern of change.

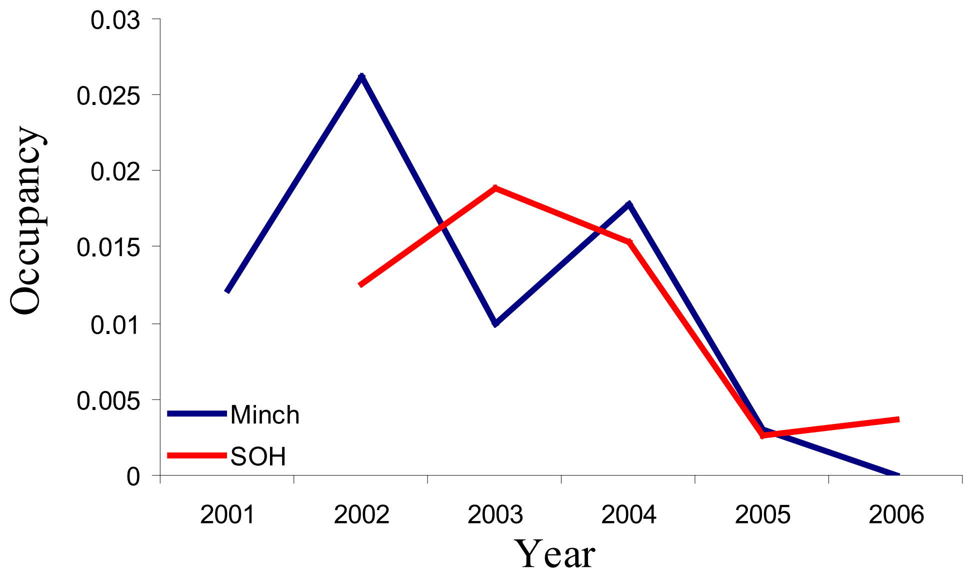

Figure 12. A comparison of the changes in occurrence of minke whales in summer months (May-September) in two groupings of ferry surveys from western Scotland. The Minch included ferry surveys between Ullapool and Stornoway, and between Skye and the Outer Hebrides. The Sea of Hebrides (SOH) included ferries travelling from Oban to Barra, Coll, Tiree and Colonsay. The same substantial change in minke whale occurrence between 2004 and 2005 was recorded along both neighbouring sets of ferry data.

Similar changes in neighbouring ferry routes have been observed in harbour porpoise occurrence in the Irish Sea and the Celtic Sea, and changes in minke whale occurrence in the northern North Sea along the transects surveyed by NORCET mirror changes in minke whale occurrence in a neighbouring study area surveyed by Cetacean Research (& Rescue) Unit (CRRU) in the outer coastal Moray Firth (Baumgartner pers. comm). Finally, and most notably, in data collected by MarineLife/BDRP, there has been a significant trend to increasing harbour porpoise occurrence in the English Channel in summer months between 1996 and 2006 (see below). This change mirrored the changes in harbour porpoise abundance in the surrounding areas between the SCANS 1994 survey and the SCANSII 2005 survey. However, to date there is too little suitable data to allow a statistical comparison of these apparent similarities.

In addition to these comparisons regarding trends or changes in individual species, the range and relative occurrence of species detected on ferry surveys are consistent with the species detected from distribution surveys across the wider, surrounding regions. For example, in the northern North Sea, the SCANS surveys found that the harbour porpoise, minke whale and white-beaked dolphins were the most common cetacean species. These three species are also the three most common species recorded during the NORCET ferry surveys.

Therefore, whilst further research is required to fully assess whether trends or changes in cetacean occurrence detected along the transects surveyed by ARC partners are indeed representative of trends over wider surrounding areas, these initial comparisons suggest that they may indeed be relatively representative of changes over a wider area. Further research into the question of whether ARC survey data are representative of a wider area, including specific statistical tests of representativeness, is one of the main priorities for future ARC research and will include a greater comparison between trends or changes identified from neighbouring ferry routes, comparisons with other studies and specific tests of whether the areas surveyed by ARC partners are representative of available habitats in surrounding areas. This research will have the additional benefit that any gaps in representativeness are identified within the ARC data and new routes for data collection can be specifically targeted to fill in these gaps when expanding ARC survey coverage.

7.4 Data quality

In a self-assessment process, each of the ARC survey groups considered that the quality of their data was high. As a context to this, most of the surveys are run by committed (but time-limited) volunteers, who do not want to spend their time co-ordinating survey effort that leads to data of low quality and of little use, hence they are highly motivated to collect data of a high standard.

There is a great deal of survey expertise within ARC. Although surveyors are volunteers, many work professionally in ecological survey, research, tour leading and conservation. A number of the surveyors on the longer running survey programmes who have been monitoring on the same routes for 10+ years are now some of the most experienced offshore cetacean observers in the UK. Therefore, the collective survey expertise within ARC is unique and probably as strong as anywhere in Europe.

Effective systems and procedures are in place by the majority of groups to ensure that data quality (species identification, methods of distance estimation etc) remains high. These include both onshore training and offshore field experience, gained alongside an experienced ‘mentor’.

The identification of most UK species occurring in shelf waters is relatively straightforward, so misidentification is unlikely to be a major issue for the majority of survey routes. However, potential misidentification is a bigger issue in deeper offshore waters, where a greater range of confusion species can occur, and for rarer species in coastal waters. One of the problems with the verification of records is that due to the relatively rapid speed of many of the ships, it is difficult to get photographs of the rare sightings.

In the Bay of Biscay difficult-to-identify species include the beaked whales (*mesoplodon species*), fin/sei/possible Bryde’s whale, and several species of blackfish (e.g. melon-headed whale/ pygmy killer whale, and pilot whale species). As a consequence, a substantial number of sightings of these species are not positively identified to species level. There have clearly been some misidentifications in the past in the early days of surveying (e.g. fin whale identified as sei whale) and time-series data need to be analysed with care. However, in other areas, such as the west of Scotland, four or five clearly distinguishable species make up the majority of sightings, reducing the number of sightings classified as unidentified. In addition, the species which are potentially of most interest for monitoring purposes (e.g. harbour porpoise, common dolphin, white-beaked dolphin, bottlenose dolphin and minke whale) are relatively commonly sighted on those routes where they occur and most observers gain experience in identifying these species during training periods.

7.5 Measures of assessing changes in the status of cetaceans

A primary aim of each ARC group is to assess the changing status of cetacean species along their ferry routes and to contribute to wider assessments. Changes in status can be assessed in a number of different ways and may require different components of the data collected. In addition, each of these approaches has its own set of limitations and advantages. An ideal monitoring programme would use several of these potential measures in conjunction to provide the greatest level of information on changes in cetacean status.

7.5.1 Absolute density estimates and density surfaces

Absolute density is the most precise measure of cetacean numbers and importantly has a measure of error (proportion of animals missed) associated with the estimation. It could be calculated for the ARC survey routes where distance sampling has been carried out to a sufficient standard. Because of the nature of cetaceans, some are inevitably missed during sighting surveys. Therefore, to estimate an absolute density along the survey transect, an estimation of the proportion of animals detected needs to be estimated: this is called a detection function $g(x)$. Conventional distance sampling methods to estimate the detection function (assuming that $g(0) = 1$) could be estimated for ferry routes. In distance sampling, absolute density estimates are used to estimate absolute abundance in both surveyed (the sample) and unsurveyed areas of interest, and this is usually possible because of a representative line transect survey design. For ferry surveys, survey design has not been planned and it is currently (2009) unknown for most of the ARC survey routes how representative the surveyed area is of the wider region in terms of the distributions of individual cetacean species. Density surface models created within a General Additive Model (GAM) framework can also be produced from distance sampling data. Density surfaces incorporate a range of environmental variables into detection functions and allow relatively unbiased and more precise estimates of species density along a survey route to be estimated. Where a number of different routes are surveyed within a specific region, it may be possible to use modelling to provide density surfaces over a wider area and over different periods of time – to account 'post hoc' for sampling biases.

Absolute density estimates and density surfaces require a high degree of analytical work to compute and a level of technical expertise that would require skills upgrading for many of the ARC survey co-ordinators. There is also an issue as to whether absolute measures can be turned around sufficiently quickly for annual reporting, with currently (2009) available resources. In addition, distance sampling is not, at present, carried out on all ARC routes (e.g. NORCET routes). Therefore, while density estimates and density surfaces are feasible to calculate for some ARC data, it may not be possible to apply them to all data sets and the entire area covered by ARC surveys.

7.5.2 Relative abundance measures

Relative abundance measures are easier to calculate than absolute abundance estimates and assume that detectability remains constant over time (*i.e.* that a consistent proportion of a population within the survey area is detected). Therefore, any changes in the relative abundance measure should reflect a change in absolute abundance. Relative abundance measures can include relative abundance of individuals, relative density measures and relative abundance/density of cetacean groups, each of which may provide different information for cetacean monitoring. However, all are calculated following similar methods and require similar data.

Relative abundance measures can be calculated from data collected on all ARC survey routes. However, due to differences in survey platforms, methods and number of observers, they may not be directly comparable between routes, though this issue may be of less importance for assessing changes in status at a larger spatial scale. Similarly, if there are any changes in the survey platform, the relative detectability may change, so affecting the comparative ability of data over time. For example, a faster ship, with a taller bridge (observation) height is likely to affect detectability and, therefore, relative abundance results.

Relative abundance values may be biased if survey coverage within an area is not sufficiently great to allow an accurate measure of density. For example, if too little survey effort is conducted, the relative abundance values may be greatly influenced by a small

number of chance events. This potential bias will be reduced with greater survey effort. As an example, this factor was investigated using common dolphin data collected by BDRP in the English Channel and the Bay of Biscay during the summer months. For each year with six or more surveys with at least some effort in sea states four or less, the surveys were randomly sampled five times using sample sizes varying from one to five surveys. From this, an average relative abundance of individuals and of cetacean groups for each repeat for each sample size along with the 95% confidence intervals was calculated. This analysis shows that for a single survey, the confidence intervals for both relative abundance of individuals and of groups of common dolphins are relatively. For example, over the 10 years examined, the average 95% confidence intervals across the years were 23.6 individuals and 0.47 groups per 100km. This equates to an average of 92% of the yearly estimated relative abundance value. Therefore, a single survey could only detect very large changes in the relative abundance of common dolphin within the surveyed area.
However, as the number of surveys included in the analysis increases, the confidence intervals decrease.

With three surveys, the average 95% confidence intervals decrease to 11.5 individuals per 100km and 0.16 groups per 100km. With five surveys, these this values further decrease to 5.41 and 0.08 per 100km respectively. This equates to an average of 20% of the yearly estimates relative abundance values. Therefore, with repeated surveys within the same period of analysis, the confidence intervals on relative abundance measures decrease, and much smaller changes in relative abundance can be detected (as little as 20% in the case of 5 repeated surveys for the example above). This decrease in confidence intervals with increasing survey effort results in an increase the ability to detect changes between time periods. This means that the repeated surveys along fixed transects conducted by ARC partners along individual ferry routes provides an approach that can potentially provide a better chance of detecting small changes in population status than single surveys through the same area.

In terms of the common dolphin example outlined above, for single yearly surveys, while the relative abundance of common dolphins changes substantially from year to year across the survey period, the confidence intervals are not sufficiently narrow to tell if these changes are due to random variation in sampling effort or due to real changes in species occurrence in the surveyed area (Figure 13). In contrast, with five surveys of the same area, the confidence intervals become sufficiently narrow to be able to separate really changes between years from random variations due to sampling effort (Figure 13). In particular, from Figure 13, we can see that there were inter-annual fluctuations in the relative abundance of common dolphin in summer months between 1996 and 2000 within the surveyed area, followed by a period of relative stability until summer 2005.

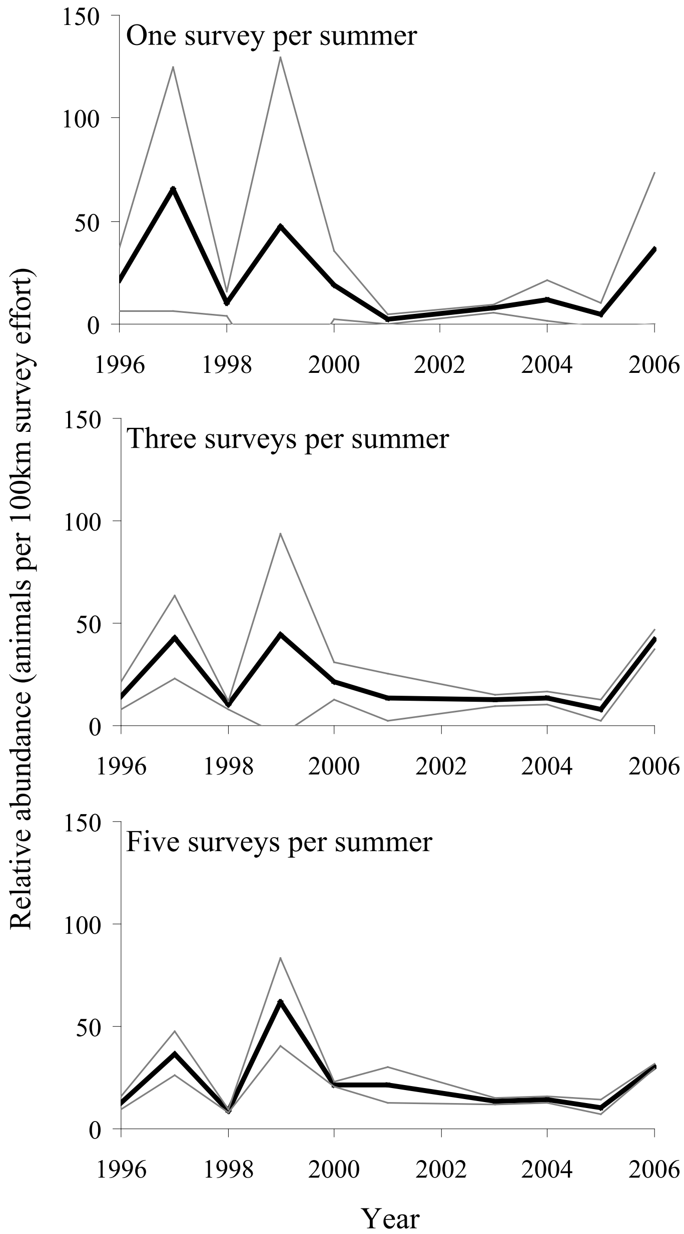

Figure 13. The effect of repeated sampling along the same route on the confidence intervals around the estimated annual summer relative abundance of common dolphin per 100 km.

Black Line: Average relative abundance per 100km from the sub-sampled surveys.

Grey Lines: Upper and lower 95% confidence intervals for this average relative abundance. With a single survey per summer, the confidence intervals are insufficiently narrow to tell whether changes in relative abundance from year to year are due to sampling errors or due to changes in relative abundance. With five repeated surveys along the same route, real changes in relative abundance between years can be detected.

Therefore, the repeated survey coverage conducted by ARC surveys along relatively fixed routes allows much smaller annual changes to be detected than would be possible from single, or a smaller number, of surveys through the same areas. This has also been found in other studies and it has been suggested that for monitoring purposes, repeated sampling of the same areas to provide estimates with narrow confidence intervals may be more important than randomly sampling a wider area on a single occasion (see Taylor *et al*. 2006).

However, care needs to be taken when combining data from separate surveys to calculate relative abundance as relative abundance may change between one survey and the next due to changes in a species distribution. Therefore, each survey may not necessarily be sampling the same relative abundance of individuals or groups. As a result, there will be a trade off between reducing sampling error by combining data from different surveys and introducing temporal heterogeneity into the analysis by increasing the time period over which the data were collected. In particular, it is known that large differences in species distribution may occur between winter and summer months for many species and as a result data from these different time periods should not be combined in some cases.

However, whether data from within each of these time periods can be combined or whether shorter time periods should be used will require further research. The results of such analysis may also help inform how frequently individual ferry routes should be surveyed to provide the best information on changes in relative abundance with the lowest amount of effort. Finally, repeated survey coverage of an individual route within a given time period will be, to some extent, weather dependent and in some time periods it may not be possible to obtain sufficient survey coverage to obtain a relatively accurate estimate of relative abundance. This is an issue for almost all cetacean research programmes and is not restricted to ARC surveys, however its potential implications for allowing the calculation of a relatively accurate relative abundance measure should be considered when assessing relative abundance data for changes or trends over time.

7.5.3 Using occupancy statistics to assess changes in occurrence and abundance

While the use and calculation of absolute and relative abundance measures are relatively familiar to many cetacean researchers, occupancy is a relatively new concept. Therefore, this report will provide a detailed assessment of the potential for using occupancy to assess trends in cetacean distribution and abundance. This does not imply that occupancy is necessarily a better measure of cetacean species status than absolute or relative abundance measures. However, it may provide additional information and/or allow the extraction of information on changes in status from data that may not be suitable to calculate absolute or relative abundance. In addition, unlike density or relative abundance, it also allows an assessment of spatial changes in distribution within a study area and can be used to examine whether these changes are related to changes in habitat use. Relatively quick processing time of results is a further advantage.

In theory, occupancy is a relatively simple measure, representing the proportion of locations surveyed where a species was recorded. These locations are usually defined as grid cells of a size relative to the survey being conducted. Occupancy can be used to measure two components of a species status. Firstly, as individual grid cells where a species is recorded can be identified, it can be used to assess changes in fine-scale spatial distribution. This can include examining how the occurrence in specific spatial areas, habitats or habitat types varies over time. Secondly, occupancy has been found to relate to species abundance across a wide range of taxa, and it has been described as one of the most widespread relationships in ecology. Whilst the exact cause of this relationship is unknown, it is thought that the number of locations where a species occurs is dependent on its abundance. When this is the case, occupancy can be used as an index of abundance and any changes in abundance will be reflected in a change in occupancy. While it is theoretically possible that a species may change its density, meaning that occupancy would change without an associated change in abundance, this seems relatively rare in reality. However, the possibility of such changes need to be assessed if changes in occupancy are to be used to infer changes in abundance.

Similarly, determining which cells are actually occupied can be difficult, particularly for hard to detect species. In terms of cetaceans, a species may use a grid cell but not be detected in it because it is not visible at the surface or is simply missed by the observers conducting the surveys. These problems with detectability can be accounted for by setting a minimum level of survey effort required to define a cell as surveyed but unoccupied. For example, in a study of harbour porpoises, Hall (2006), required that individual cells had to be surveyed at least three times and have at least 10% of the total area surveyed before it could be considered surveyed but unoccupied. Alternatively, occupancy can be modelled and estimated using the techniques developed by MacKenzie *et al*. (2006) to take account of issues with detectability and differing levels of effort in different locations. As a result, as with the calculation of abundance and/or density measurements, these potentially confounding variables can be taken into account to produce an unbiased measure of occupancy.

Occupancy statistics are used by the British Trust for Ornithology (BTO) to monitor changes in the occurrence of birds across the UK through the Breeding Birds survey (Newson & Noble, 2006). It is straightforward to assess increases or decreases in occupancy over time within the surveyed areas by testing for the significance of the correlation between year and occupancy, and this is easy for stakeholders to understand. Whilst occupancy can be used to detect trends in occurrence over time with relative ease, it is more complicated to quantify the percentage level of change between time periods, because a measurement of change in the probability of presence/absence in the range from 0-1 is required. For this a change in odds ratio (odds of being present) needs to be calculated, which is less intuitive for stakeholders to understand. In the BTO's mammal monitoring programme, to avoid misinterpretation of graphs of the odds ratio, simple figures showing the percentage occurrence of species over time are presented (Newson & Noble, 2006).

However, as with any measure of changes in species status, whilst occupancy may be a good index of changes in abundance along an individual ferry route, whether the changes along this route are representative of a wider area of interest needs to be investigated. Hall (2006) conducted a study of the viability of using occupancy as an index of changes in abundance in cetaceans using data collected over a four year period in the west of Scotland. This study found a strong positive relationship between occupancy and sightings rate per km^2. This relationship did not differ between the four species examined - harbour porpoise, minke whale, common dolphin and bottlenose dolphin. There was also a strong positive relationship between occupancy and relative density of individuals per km^2 for three of the species, but not for common dolphin. This study also found that the strength of the occupancy-abundance relationship varied with grid cell size used.

Therefore, whilst occupancy in general terms is likely to be useable as surrogate for abundance, the relationship needs testing for species and regions and the spatial scale of sampling needs to be accounted for.

Case study: using BDRP data to assess trends in occupancy

To demonstrate how data collected by ARC could be used to monitor trends in the abundance and distribution of cetacean populations using occupancy, data on harbour porpoises collected on surveys conducted by Marinelife (Biscay Dolphin Research Programme, BDRP) over an 11 year period (1996-2006) were analysed as a case study. This data set was chosen because it is the longest running ARC data set and therefore provides a good demonstration of the usefulness of this type of data for long-term monitoring of cetacean species status. For BDRP data, occupancy strongly correlates with both sightings rate per km of survey effort (R^2 = 0.84 – Figure 14a) and relative abundance per km of survey effort (R^2 = 0.69 – Figure 14b,) for harbour porpoises.

Calculation of occupancy

Data on cetacean occurrence were collected during regular BDRP monthly ferry surveys from Portsmouth to Spain. This route allowed regular surveys along approximately the same transect, reducing the potential effects of variations in spatial coverage on temporal changes in occurrence. All surveys were conducted from the bridge of the ferry (approximately 30m above sea level), allowing good visibility of a field ahead and to the sides of the ferry. Surveys were conducted by a team of three experienced observers, with at least two being on duty at any one time. Distance sampling survey methods were employed.

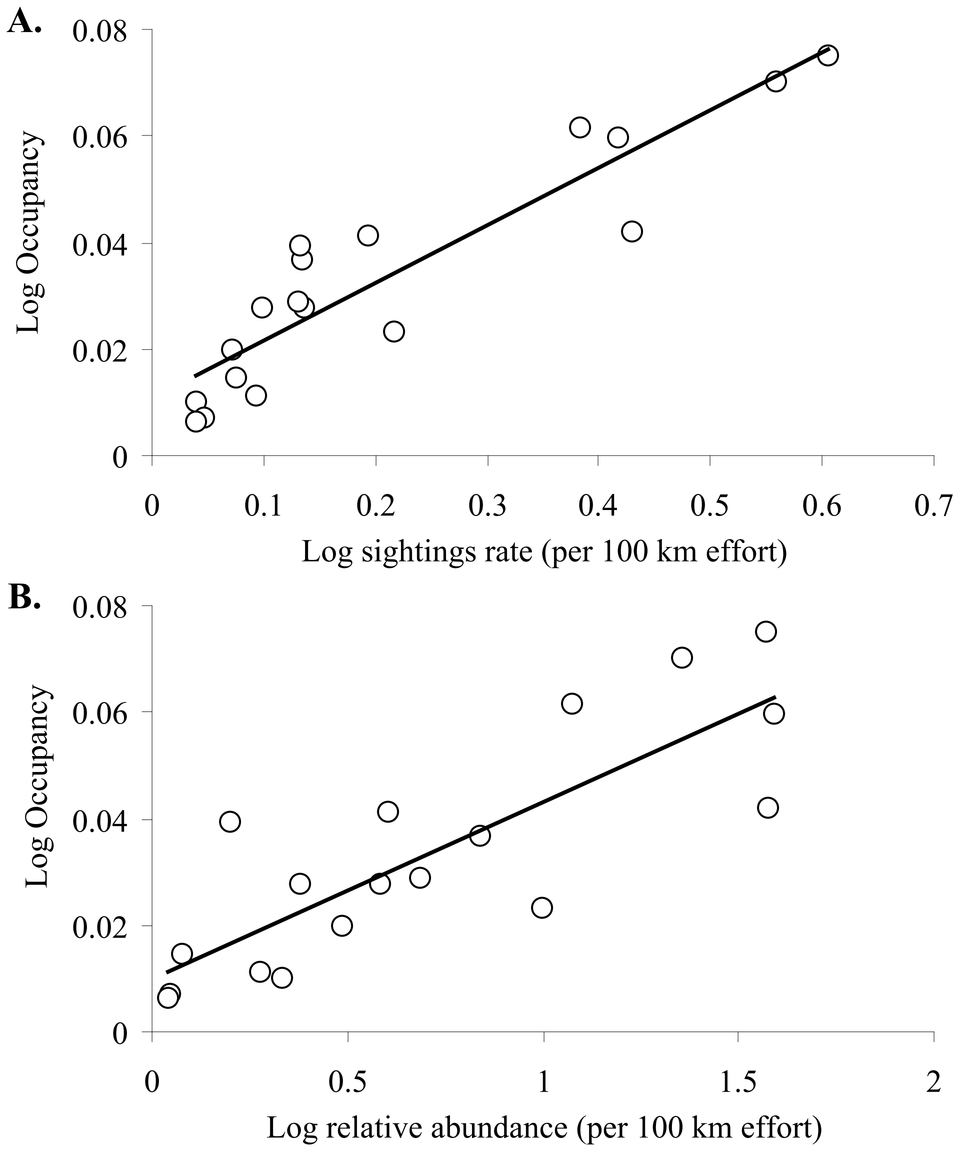

Figure 14. A comparison of sightings rate (A), relative abundance (B) and occupancy for the BDRP survey data harbour porpoises in summer and winter months for the BDRP survey area between 1996 and 2006.

These data were entered into a geographic information system (GIS) created in ESRI ARCview 3.3. The survey track was re-constructed from the recorded positions of the ship and the appropriate sea state was assigned to each survey leg. The data were then divided into summer (April-September) and winter (January-March and October-December) periods and then separated into individual years. Sightings of harbour porpoise were plotted and similarly separated into seasons and years. The study area was then divided into a grid with cells having a resolution of 0.125^{o} latitude by 0.125^{o} longitude, and the cells surveyed during each time period were identified as those through which one or more survey legs passed during the appropriate time period. Only survey legs conducted in sea states of three or less were used in the analysis. While some studies use lower sea state thresholds when analysing data for these cetacean species, these thresholds were used here as the eye height of the observers on the *Pride of Bilbao* is substantially higher than most vessels used for cetacean research (~30m vs <10m or less), increasing detectability around the vessel, particularly at higher sea states. Surveyed cells with harbour porpoise were then identified and classified as presence cells. All other surveyed cells were classified as absence cells.

Once the status of harbour porpoise in each survey cell was classified, the distribution and occupancy rates were compared between seasons and years for sampled areas of the English Channel and the Bay of Biscay separately, and for both areas combined. Occupancy rates were calculated by dividing the number of presence cells for harbour porpoise by the total number of cells surveyed for a specific time period (Hall, 2006). A Spearman rank correlation co-efficient (which can test for non-linear as well as linear trends) was used to test whether any increases or decreases in occupancy over the whole time series were significant.

Yearly changes in harbour porpoise occupancy in the Bay of Biscay and English Channel from 1996 to 2006

In total, 58,821km of survey effort was conducted in sea states 3 or less, with 129 sightings of harbour porpoises recorded. On average, 202 separate grid cells (Standard Deviation: 34) were surveyed in the summer period of each year for harbour porpoises (Figure 14). In winter, 25,249km of effort were conducted in sea states 3 or less, with 19 sightings of harbour porpoises recorded. In winter months of each year, on average, 122 separate grid cells (Standard Deviation: 25) were surveyed for harbour porpoises.

Harbour porpoise were restricted to the shelf waters of the northern Bay of Biscay and the English Channel in both summer and winter months. In summer months, there was an overall increase in the occurrence of this species from 1996 to 2006, primarily driven by a seven-fold increase in occurrence of harbour porpoise in the English Channel from 0.02 in 1996 to 0.14 in 2006 (Figure 15). Furthermore while occurrence in this area was generally low (with an occupancy of around 0.04) in summer months until 2003, an increase to an occupancy rate of over 0.10 in summer 2005 and summer 2006 was observed. This apparent trend to increasing occupancy of harbour porpoise occurrence in the English Channel between 1996 and 2006 is significant (r_s=0.882, n=11, p<0.01). There is no obvious trend in the summer occurrence of harbour porpoises in the Bay of Biscay, however. It has varied from as low as zero in 1996 and 2005, to as high as 0.05 in 2001. There was no relationship between the occupancy of harbour porpoise in the Bay of Biscay and the English Channel in the same summer.

Harbour porpoise occurrence in the sampled areas of both the English Channel and Bay of Biscay was generally lower in winter than in summer, with no apparent trends over time (Figure 15). There was no relationship between summer and winter occurrence of harbour porpoise in the same year. Therefore, as the increased occurrence of harbour porpoise in summer months over time, particularly in the English Channel, has not been matched by a similar increase in occurrence in winter months. This suggests a recent increase in seasonal movements of harbour porpoises in to the surveyed areas of the English Channel in summer months, particularly since 2003.

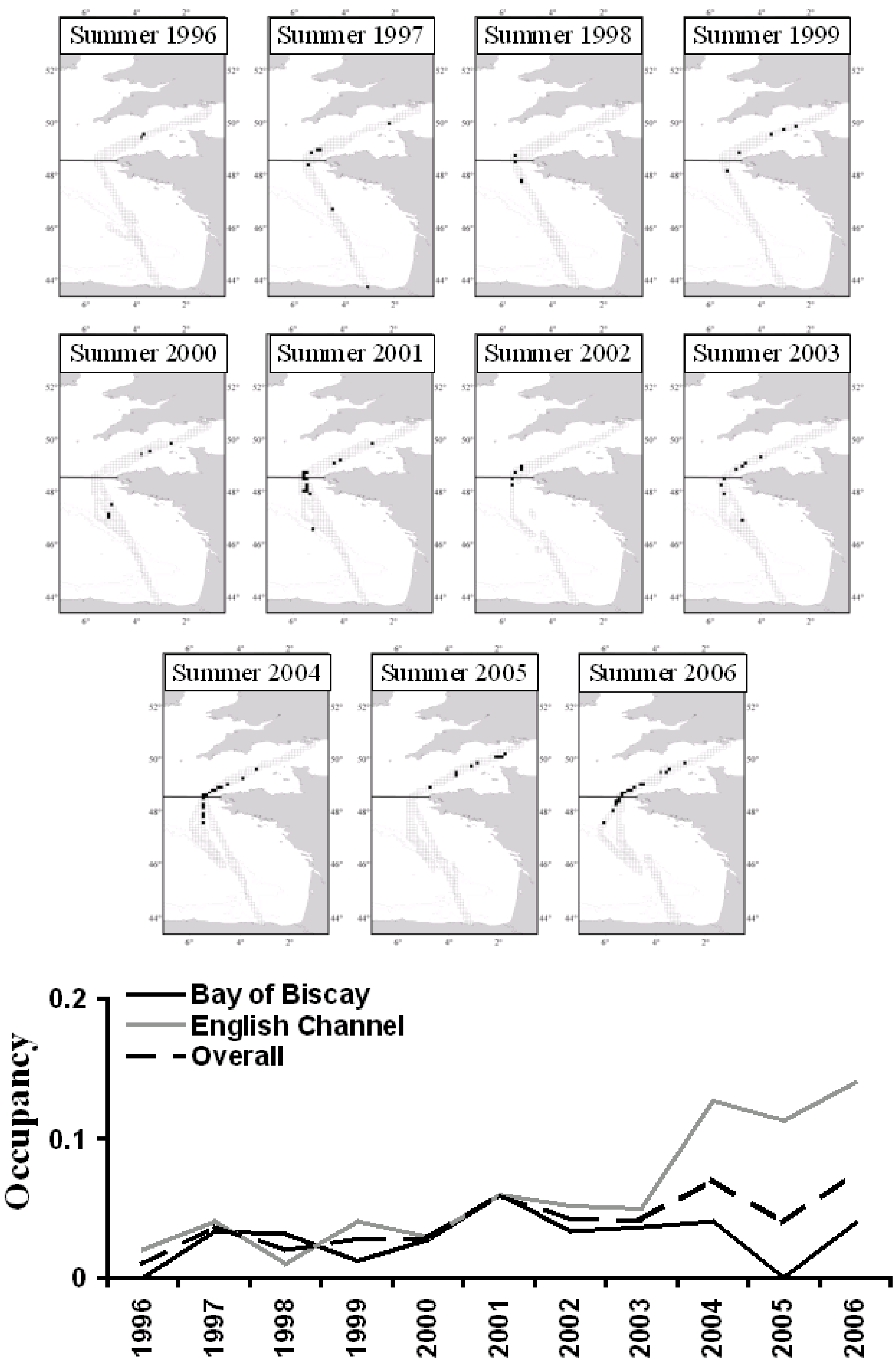

Figure 15. The changes in the occurrence of harbour porpoise in the Bay of Biscay and English Channel in summer months (April to September) from 1996 to 2006. Clear cells represent those surveyed at least once in sea states 3 or less in a year and filled cells represent those where this species was recorded at least once. The lower graph shows the changes in occupancy (the proportion of all cells surveyed in a year where a species was recorded) for the whole study area and separately for the Bay of Biscay and the English Channel.

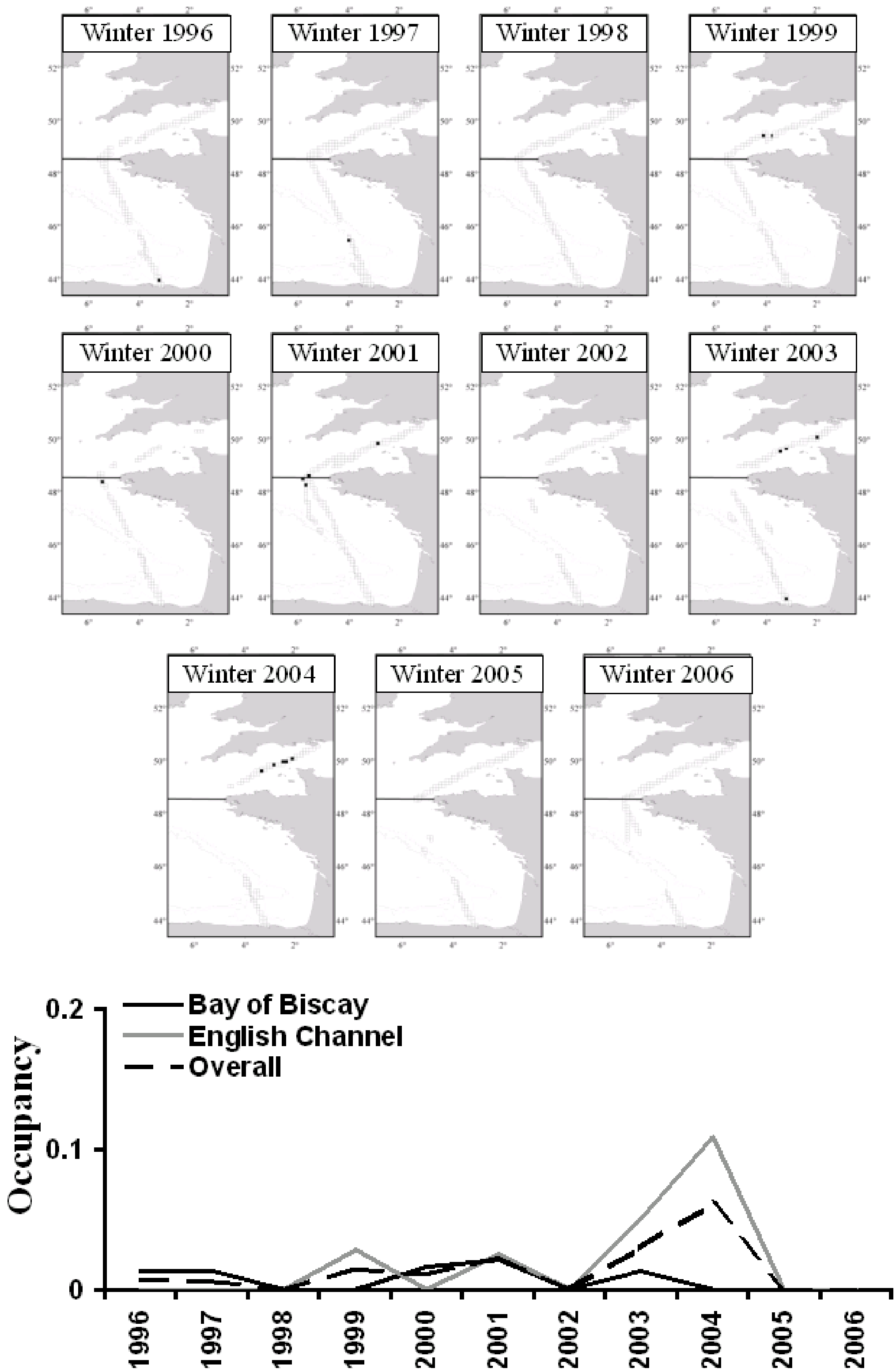

Figure 16. The changes in the occurrence of harbour porpoise in the Bay of Biscay and English Channel in winter months (January to March and October to December) from 1996 to 2006. Clear cells represent those surveyed at least once in sea states 3 or less in a year and filled cells represent those where this species was recorded at least once. The lower graph shows the changes in occupancy (the proportion of all cells surveyed in a year where a species was recorded) for the whole study area and separately for the Bay of Biscay and the English Channel.

How do trends within the area surveyed by BDRP compare to the surrounding waters?

The significant increase in summer harbour porpoise occurrence in the English Channel from 1996 to 2006 described in the previous section is consistent with abundance changes detected by more wide-ranging surveys conducted in summer 1994 (SCANS) and summer 2005 (SCANS II) as part of a project to estimate cetacean abundance throughout shelf waters of northern Europe. These surveys found that whilst harbour porpoise were not recorded in the English Channel in summer 1994, their abundance in this region was substantially greater in summer 2005 (Hammond *et al*, 2002; http://biology.st-andrews.ac.uk/scans2/). An increase in occurrence of harbour porpoise in the English Channel has also been noted in other studies (Evans *et al*., 2003). These results provide some supporting evidence to suggest that the changes in occurrence along the fixed transect used in this study may indeed reflect changes in abundance across a wider area.

Implications for monitoring changes in cetacean abundance and distribution around North Western Europe using the ARC Network

If data on occurrence (or indeed other indices of population status such as relative abundance) along fixed transects are found to be representative of wider regions, this offers the potential for constructing a low cost monitoring programme to provide regular updates on the status of cetaceans.

The value of such a monitoring programme is likely to increase as spatial coverage increases. There is further scope to improve spatial coverage as there are a number of other ferry services connecting the islands of the UK, the Republic of Ireland and the Faeroes to each other and to mainland Europe that are not currently (2009) monitored by ARC partners. Priority routes to establish ferry surveys need to be identified.

An expanded ferry network has the potential to complement more intensive periodic surveys (e.g. SCANS) by providing information on status changes in the intervening years, including in better alignment with Habitats Directive reporting cycles.

By using changes in occupancy as an index for changes in occurrence and abundance, these updates can be calculated so providing annual feedback to conservationists, policy makers, managers and other stakeholders. This approach also has the additional advantage that changes in graphs of occupancy in conjunction with maps showing changes in distribution within each year, as presented in this study, provide information on changes in species status in a format that is relatively easy for non-specialists to interpret and understand. However, this may not rule out the need to also use other indices to assess other aspects of cetacean status, such as relative abundance.

Limitations of using occupancy as an index of changes in cetacean abundance and distribution

Whilst occupancy was used as an index of changes in cetacean status for this study, it is potentially sensitive to two factors. These are sample size and spatial coverage. The smaller the number of grid cells surveyed and the smaller the number of grid cells where a species is recorded, the greater the potential impact of chance events. For example, if only 20 grid cells are surveyed, 10 sightings in 10 separate grid cells will give an occupancy of 0.5. If the number of occupied cells varies by 5 cells from one time period to the next, the occupancy values would range from 0.75 to 0.25. In contrast, if 200 cells were surveyed, a variation of five surveyed cells around ten occupied cells would only give a variation in occupancy of 0.025 (Figure 17). Similarly, the higher the number of occupied cells, the smaller the effect of a small number of additional occupied cells on the occupancy values

(Figure 17). Therefore, the larger the sample size, the greater the likelihood that any changes in occupancy are due to actual changes in abundance rather than random variation in sample size. The second factor is spatial coverage. If spatial coverage varies greatly between two successive time periods, the occupancy values will not be comparable because changes in occupancy driven by spatial structuring in species distribution patterns (driven by habitat preferences) may out-weigh any changes in population status.

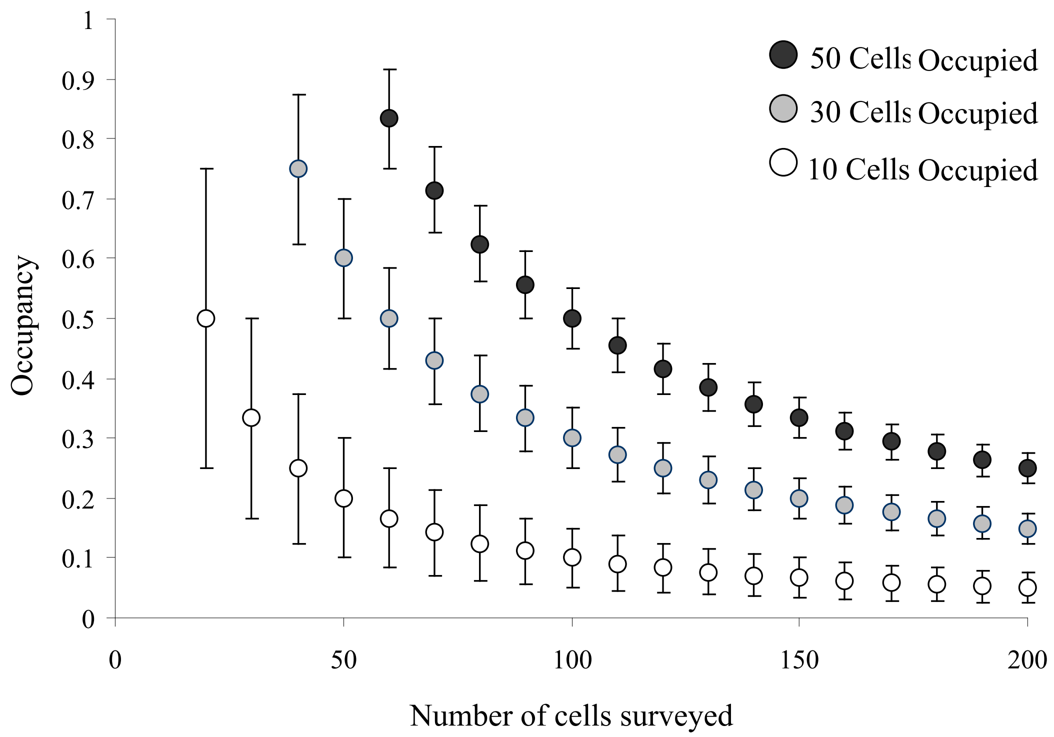

Figure 17. The effect of a variation of five occupied cells on the occupancy value for number of surveyed cells between 20 and 200 cells and 10, 30 and 50 occupied cells (error bars represent 95% confidence intervals).

These two factors, sample size and spatial coverage, are not necessarily an issue for surveys conducted using ferries as research platforms. Firstly, these surveys usually repeatedly cover relatively long distances. This increases both the number of grid cells surveyed and the number surveyed in good sighting conditions. For example, the sample size of grid cells surveyed by the BDRP surveys were typically over 100 grid cells in winter months and more than 200 grid cells in summer months. Therefore, even relatively small changes in occupancy are likely to reflect a true change in species occurrence within the study area, and therefore a change in species abundance, within this data set. Secondly, because ferries typically follow the same (relatively) fixed transect on each passage, the spatial coverage of the surveys are fairly consistent over long periods of time. Therefore, any detected changes in occupancy are unlikely to be due to variations in spatial coverage. However, as noted in section 6.2 further research is required to fully test the validity of this assumption.

7.5.4 Log-linear modelling of annual abundance and trends for individual species at a UK scale

In this method, log-linear modelling (Poisson Regression) as implemented by the freeware program Trends and Indices for Monitoring Data (TRIM) (Pannekoek and van Strien 1996), would be used to determine: (1) annual indices for each species across all 'sites' (routes or route segments) and (2) the trend over time expressed as a mean percentage increase or decrease per year over the monitoring period (3) the significance of the trend described by Confidence Limits. The effects of co-variates on trends (e.g. regional differences) can also be tested.

TRIM was developed by Statistics Netherlands (Pannekoek & Van Strien, 2003) for modelling count data on a range of taxa (e.g. fungi, birds, butterflies, dragonflies) and has been used successfully in a number of national monitoring schemes and at a European level for European Birds (Gregory *et al* 2003) and Butterfly Conservation Europe for European butterflies (Brereton *et al.* in press).

The modelling procedure accounts for many common problems of abundance data recorded at 'sites' including (1) site and year effects, (2) missing data (e.g. due to trips missed or bad weather on trips), (3) serial correlation (the fact that an abundance measure in one year may be related to the abundance in the next year), (4) over dispersion (data a poor fit to the statistical model) and (5) excess zeros (species more often absent than present). Missing counts along particular routes in particular years are estimated ('imputed') from changes in all other sites, or sites with the same characteristics by using co-variates (e.g. region).

The modelling procedure uses abundance data from each year and each route/route segment. If sites are increasing or decreasing simultaneously in abundance over time, a statistically significant change will be detected. A breakthrough in this method is that relative abundance indices for each route do not have to be calculated in exactly the same way, overcoming problems of slightly differing survey methodologies between ARC survey groups. The model uses abundance indices that have already been calculated by the ARC survey partners separately.

A crucial point to understand here is that the aim is to assess the changing status of species at a UK level. In other words, the primary purpose is not to describe the status of species along the individual routes, but rather to use those data to contribute to the assessment of status over a bigger area (UK scale). As a consequence, the issue of how representative the route is of the sample area assumes less importance. If synchronous changes occur across routes the power to detect trends will be high.

A weighting factor accounting for the difference in national population size of each regional sea can be added (e.g. obtained from SCANS surveys) or the range proportion that each region holds of the UK distribution for the species (e.g. obtained from the Joint Cetacean Database).

Another important point is that the aim of the analysis is to detect rates (%) of change in relative abundance rather than changes in absolute abundance, e.g. to identify a 20% decrease (population size unknown), rather than a decrease from 100 individuals to 80 individuals. For scientists and policy makers involved in conserving other taxa (eg bird, higher plants and butterflies), it is deemed sufficient information to know that there has been a substantial change increase/decrease in order to make a conservation decision. For this process, alerts (levels of % change) can be set which highlight the limits of acceptable change, before an alarm is raised and a response is required (e.g. research, conservation action/policy change). For developments in birds, see Baillie & Rehfisch, 2006.

In the method, ferry routes can be considered as either single transects or a series of separate multiple transects (considering statistical independence), the latter of which have been identified on the basis of differences in geographical, physical and/or political boundaries. It is better to have more rather than less transects. For example, the Colonsay - Oban ferry route might be classed as a single transect as it is short and the habitat is fairly uniform. In contrast, the much longer Plymouth-Santander ferry might be sub-divided into a series of separate transects due to greater climatic, topographical and political complexity (eg Transect 1 – Western English Channel, Transect 2 – Shelf waters of Northern France etc.).

The building block for the analysis is to generate an annual abundance measure for each species along each transect in each year. This annual measure could be derived from all year data or from summer only data (e.g. if the population is resident) – this can differ across routes. The most important point is that for each route, it must be calculated in the same way each year. The annual abundance index is an integer (whole number) and must be in one of three forms (1) A positive value – the abundance/surrogate abundance index (2) 0 = none were seen (3) -1 = missing data (status not calculable because of insufficient survey effort). Example data formats are given in Tables 15 and 16.

These analysis techniques described also make it possible to combine other data types (e.g. regional small boat surveys, aerial surveys and systematic watches from headlands) into annual analyses, provided that survey methods are consistent between years.

7.5.5 Developing Multi-Species Measures Of Cetacean Status

In assessment of the conservation status of cetacean species, it is likely that some species will be faring badly (decreasing in abundance), whilst for others the opposite will be true (stable/increasing abundance). This presents a complicated story to communicate to policy makers and the general public, who may want a simple message and to know how cetaceans are doing overall.

To satisfy this demand, one possibility is to develop a composite index of cetacean abundance by combining data across species, as has been developed in recent years for other taxa including birds, butterflies and bats. The methodology was developed for birds (Gregory *et al*. 2003) and involves calculating the geometric mean index across each species grouping/assemblage. The process is easy to compute - the log of each species index in each year is taken, then averaged across selected species and the exponential of the result calculated. If there are missing year indices, the multi-species index needs to be calculated by a modeling procedure.

Assessing trends in composite indices over short time periods is an area of active research; with for example different methods used for UK birds, UK butterflies and European birds. For the latter, smoothed trends in each indicator have been calculated by structural time series modelling using the program TrendSpotter (Soldaat *et al* 2006) with confidence limits calculated using the Kalman filter.

It would be possible to disaggregate an all-species cetacean indicator to satisfy different policy demands. Example species assemblages could include (1) polar/cold water versus warm/temperate water species (2) UK versus NW Europe as a whole (3) by regional sea (e.g. North versus Celtic Sea) (4) toothed versus baleen whales and (5) habitat specialists versus generalists.

Table 15. Example data table – using relative abundance.

Species	Route	Region	Transect	Year	Abundance Index (#/km)	Covariate 1 - Regional sea	Weighting Factor 1 - Size of sample region	Weighting Factor 1 – Regional population size
Common Dolphin	Aberdeen-Orkney	Not applicable	1	2000	-1	1		
Common Dolphin	Aberdeen-Orkney	Not applicable	1	2001	-1	1		
Common Dolphin	Aberdeen-Orkney	Not applicable	1	2002	5	1		
Common Dolphin	Aberdeen-Orkney	Not applicable	1	2003	0	1		
Common Dolphin	Portsmouth-Bilbao	Bay of Biscay shelf	2	2000	5	2		
Common Dolphin	Portsmouth-Bilbao	Bay of Biscay shelf	2	2001	12	2		
Common Dolphin	Portsmouth-Bilbao	Bay of Biscay shelf	2	2002	10	2		
Common Dolphin	Portsmouth-Bilbao	Bay of Biscay shelf	2	2003	9	2		
Common Dolphin	Portsmouth-Bilbao	Bay of Biscay slope	3	2000	-1	2		
Common Dolphin	Portsmouth-Bilbao	Bay of Biscay slope	3	2001	-1	2		
Common Dolphin	Portsmouth-Bilbao	Bay of Biscay slope	3	2002	0	2		
Common Dolphin	Portsmouth-Bilbao	Bay of Biscay slope	3	2003	7	2		

Table 16. Example data table – using occupancy as surrogate abundance measure.

Species	Route	Region	Transect	Year	Abundance Index - # occupied cells)	Covariate 1 - Regional sea	Weighting Factor 1 # unoccupied cells	Weighting Factor 2 - # km travelled in good sea conditions	Weighting Factor 3 - Size of sample region	Weighting Factor 4 – Regional population size measure
Common Dolphin	Aberdeen-Orkney	Not applicable	1	2000	-1	1				
Common Dolphin	Aberdeen-Orkney	Not applicable	1	2001	-1	1				
Common Dolphin	Aberdeen-Orkney	Not applicable	1	2002	5	1				
Common Dolphin	Aberdeen-Orkney	Not applicable	1	2003	0	1				
Common Dolphin	Portsmouth-Bilbao	Bay of Biscay shelf	2	2000	5	2				
Common Dolphin	Portsmouth-Bilbao	Bay of Biscay shelf	2	2001	12	2				
Common Dolphin	Portsmouth-Bilbao	Bay of Biscay shelf	2	2002	10	2				
Common Dolphin	Portsmouth-Bilbao	Bay of Biscay shelf	2	2003	9	2				
Common Dolphin	Portsmouth-Bilbao	Bay of Biscay slope	3	2000	-1	2				
Common Dolphin	Portsmouth-Bilbao	Bay of Biscay slope	3	2001	-1	2				
Common Dolphin	Portsmouth-Bilbao	Bay of Biscay slope	3	2002	0	2				
Common Dolphin	Portsmouth-Bilbao	Bay of Biscay slope	3	2003	7	2				

7.5.6 Monitoring changes in species range

Changes in species range are one of the main predicted impacts of climate change on cetaceans. Therefore, it is important to monitor the range of individual cetacean species to assess whether they are changing over time. Monitoring changes in species range over time can be difficult. However, by using a network of fixed transects across a region to sample different areas where a species currently occurs as well as neighbouring areas where is currently does not, it is possible to detect changes over time. For example, data collected in western Scotland along ferry survey transects has been used to show that the range of common dolphins has expanded in recent years in this region, while the range of white-beaked dolphins has declined (see MacLeod *et al*. 2005 for details). This expansion in the range of common dolphins has been hypothesised to be related to increases in water temperature. If this is the case, it would be expected that similar changes would be occurring in other regions, and this is indeed the case. In particular, ferry surveys conducted in the northern North Sea since 2002 have started regularly recording common dolphin in small numbers in this region, consistent with a continued expansion of this species range (MacLeod *et al*. 2007).

Similarly, surveys conducted by BDRP in the Bay of Biscay have detected changes in the occurrence of two beaked whale species that suggest a northward expansion of the range of Cuvier's beaked whale and a northward contraction in the range of the northern bottlenose whale as local water temperatures have increased (Figure 18). Once again, these changes are consistent with predictions of how these two species are likely to react to climate change (MacLeod 2005), and with changes in strandings pattern around the UK and the Republic of Ireland (MacLeod and Smith, In Preparation). Without the repeated surveys along fixed routes it would have been difficult to determine whether these changes were due to a change in species range or differences in survey coverage between different sampling periods. However, repeated sampling of the same route allows these two potentially confounding factors to be separated and real changes in species range to be identified.

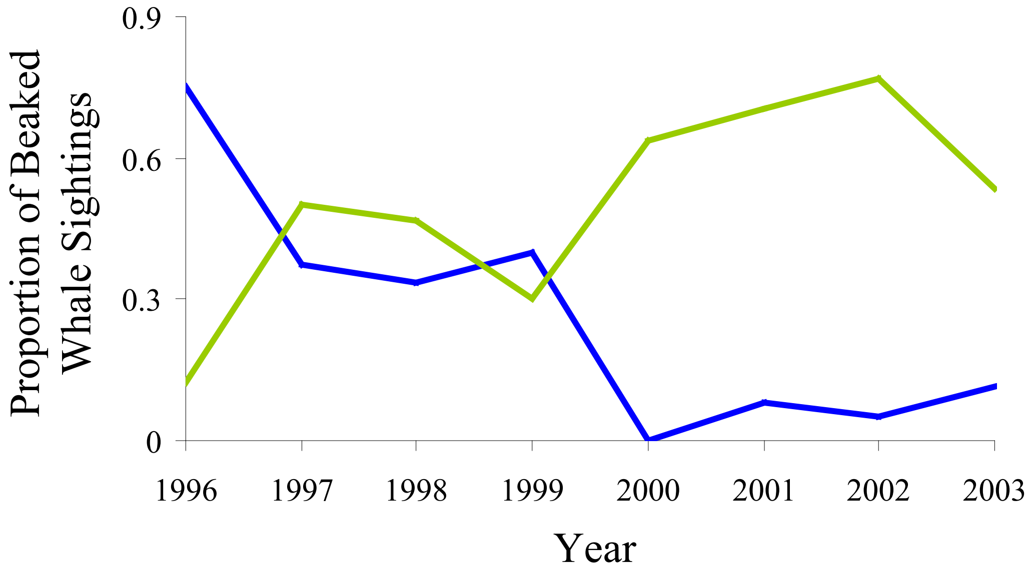

Figure 18. Proportion of beaked whale sightings identified as Cuvier's beaked whale (green) and northern bottlenose whale (blue) recorded during monthly BDRP surveys. A change in dominance between these two species occurred between 1997 and 1999, this compares to a similar change in the strandings data between 1997 and 1998 (see MacLeod and Smith In Preparation).

Using the full network of surveys conducted by ARC members, the ranges of most species of cetaceans that occur in the northeast Atlantic can be monitored by comparing the relative occurrence of individual species across the different routes. In particular, northward expansions of warm water species and contractions in range of cooler water species that are predicted to result from climate change can be monitored by comparing their occurrence along fixed transects ranging from the Bay of Biscay in the south to the Northern Isles in the north.

7.5.7 Monitoring changes in habitat use

As well as monitoring changes in species abundance and range, it is important to monitor habitat use. Change in habitat use may be indicitive of changes in a species status that are not detectable in other ways. One of the most obvious ways to monitor changes in habitat use is to repeatedly sample the same transect or set of transects over a prolonged period of time. If this transect or set of transects is representative of a wider area, any changes identified along them can be extrapolated to the surrounding area. In particular, using predictive habitat modelling, habitat use, and any changes within it, can be visualised across a wide region as long as the sampled area is representative of the combinations of habitat available within it. As they repeatedly survey a relatively fixed area, the ferry surveys conducted by ARC members are ideally suited to examining habitat preferences and monitoring if and how they change over time. With the repeated sampling within the same year, these surveys also allow changes in species habitat use within a year to be separated from inter-annual changes.

Within the ARC data sets, the most detailed work on habitat use has been conducted in northwest Scotland. Data collected along ferry routes in this region has been used to develop habitat modelling techniques for cetaceans, identify seasonal changes in habitat use and identify key habitat variables for a variety of cetacean species (e.g. MacLeod *et al*. 2008; Bannon Pers. Comm.). The repeated sampling of the same areas has been crucial for identifying how temporal aspects of habitat preferences, such as tidal currents, time of day, sea temperature and primary productivity, affect cetacean distribution as such factors cannot easily be studied without such repeated sampling.

Here harbour porpoises in northwest Scotland will be used as an example of the ability of ferry surveys to identify habitat preferences of cetaceans, including dymanic variables, model species distribution and monitor how these may change over time. Data on the occurrence of harbour porpoise were collected along eight ferry routes in summer months across the region (Figure 19) at weekly intervals over a seven year period. These data were entered into a geographic information system and linked to a number of environmental variables. These included water depth, seabed type, seabed topography, water temperature and primary productivity. Generalised Additive Modelling (GAM) was used to identify the relationship between harbour porpoise occurrence and these environmental variables. Finally, the identified habitat preferences were used to predict the distribution of harbour porpoise across the study area and how this changes over time.

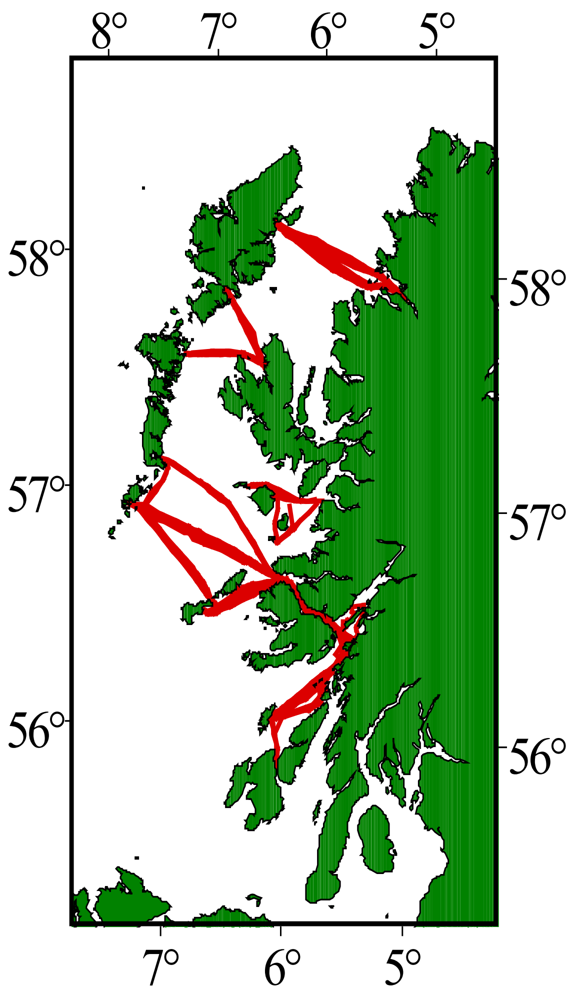

Figure 19. The study areas and survey tracks conducted during the study.

This analysis showed that in each of the summer months, there was a strong relationship between harbour porpoise occurrence and environmental variables (table 17). However, harbour porpoises shift their habitat preferences across the summer months within the study area, with different environmental variables being important at different times of the year (Table 16). In addition, within individual habitat variables, different ranges are preferred at different times of year. For example, for water depth, the most preferred depth shifted from around 50m in May and June to around 100m later in the summer in August and September (Figure 20). As a result, moving for a more coastal occurrence to a more widespread and less coastal distribution (Figure 21).

Table 17. A comparison of the key habitat variables important for determining the occurrence of harbour porpoises in Western Scotland across summer months.

Model	Eco-Geographic Variables	% Deviance Explained
May	**Dist. to Coast****, **Aspect Cos****, Depth and SD of Slope (Around Cell)	29.7
June	**Dist. To Coast*****, **Depth*****, **SD Aspect Sin***, Aspect Sin, Slope, SD of Slope (Around Cell)	39.9
July	**Dist. to Coast****, SD of Slope (Around Cell) and Slope (Within Cell)	12.7
August	**Depth****, **SD of Slope (Around Cell)*** and Slope	17.2
September	**Depth*** and Slope (Within Cell)	40.9

This analysis of harbour porpoise data demonstrates the ability for repeated surveys along a relatively fixed transect, as conducted by ARC members, to detect changes in habitat use of a cetacean species over time. While this analysis has concentrated on intra-annual changes, similar analyses can be conducted to identify changes in habitat use over time. Given the distribution of ferry surveys conducted by ARC members, the habitat preferences, and changes in them, can be monitored for most cetacean species which occur in UK waters. In many cases, habitat use can be monitored in multiple locations to assess whether any changes detected are restricted to specific locations or whether similar changes are occurring in consort across a much wider region. Therefore, the ARC ferry surveys provide one of the best networks of surveys to monitor changes in habitat use in cetaceans around the UK that is currently available (2009).

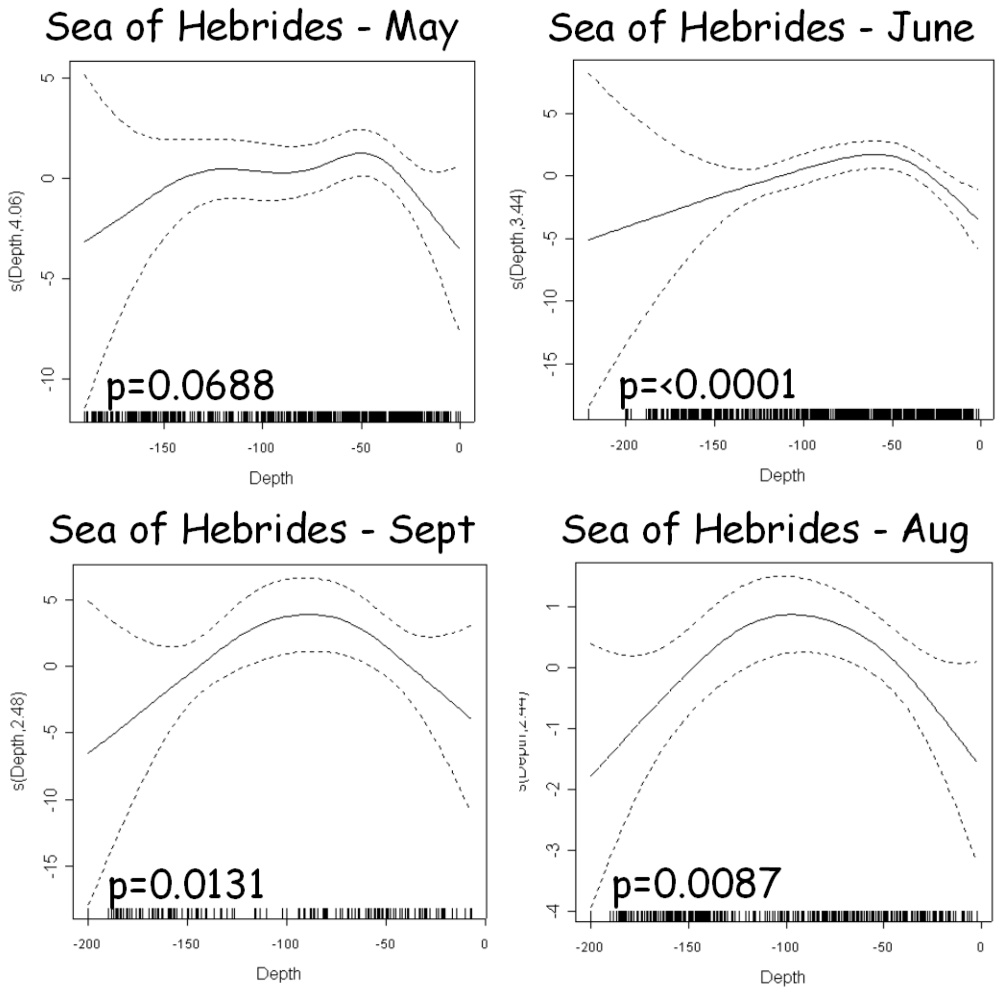

Figure 20. Changes in preferences for water depth by harbour porpoises in summer months in western Scotland as identified through analysis of data from ferry surveys.

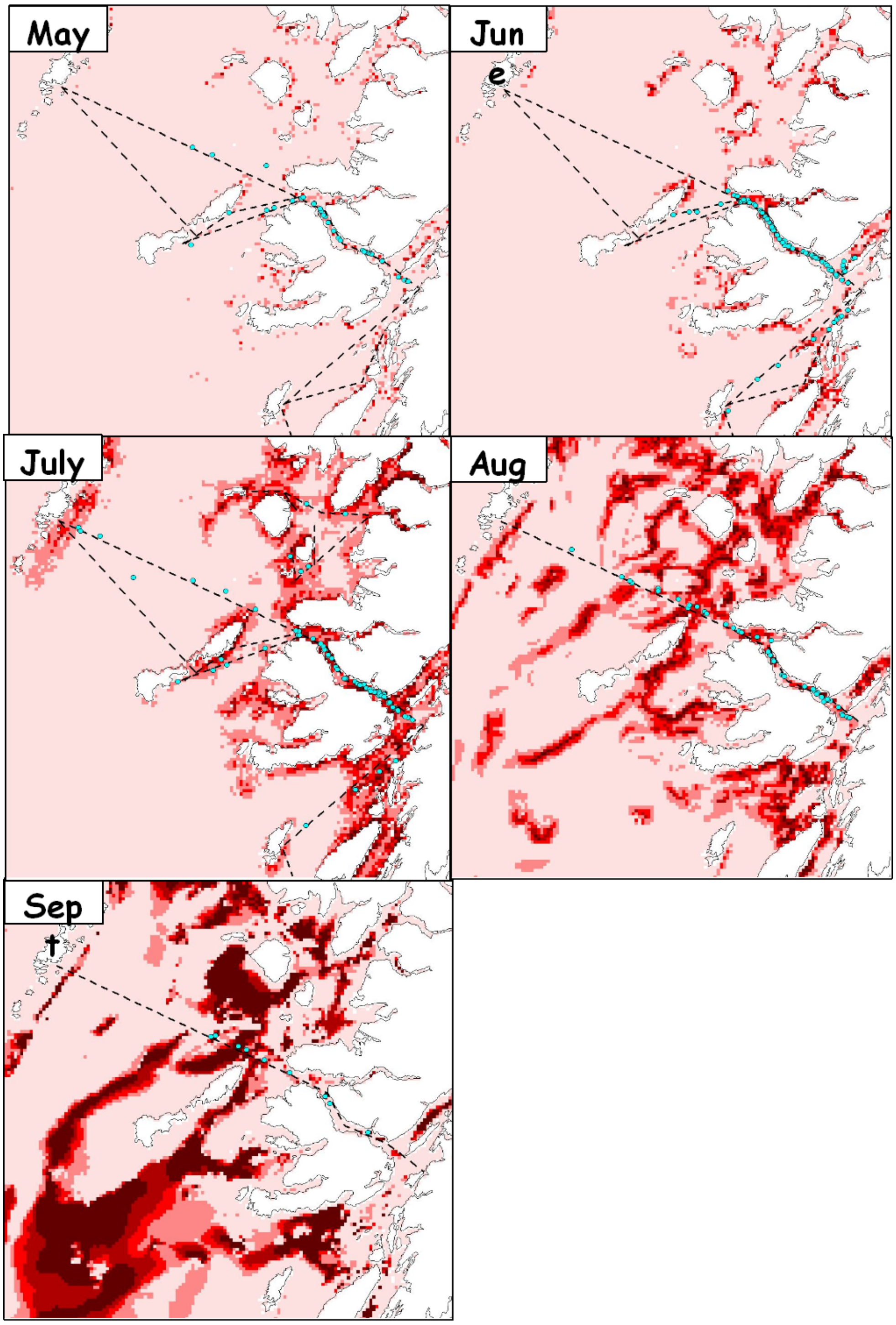

Figure 21. Visualisation of changes in the occurrence of harbour porpoises resulting from changes in habitat preferences across summer months in western Scotland. Light red indicates areas of low occurrence, while areas of dark red indicate areas of high occurrence.

8 Other potential uses of ARC data

It is important to emphasise that there are many potentially valuable policy-relevant uses of ARC data other than status assessment, some of which have already been carried out by ARC partners to varying degrees (See Appendix 11.2). The possibilities include (1) identifying important areas and critical habitat, including spatial modelling and temporal changes in habitat use; (2), monitoring the effectiveness of MPAs; (3) monitoring climate change impacts on biodiversity (e.g. range shifts, changes in the timing of occurrence, changes in the proportion of cold versus warm water species), and (4) a multispecies indicator of marine biodiversity.

For example, data collected during ferry surveys on the west coast of Scotland have been used to model the habitat preferences of harbour porpoises in the Sea of Hebrides (see Section 6.5.7). Through repeated monthly surveys along the same fixed ferry routes over a five-year period, this work has allowed the identification of intra-annual shifts in habitat use, and therefore distribution, across the summer months. These shifts in habitat use mirror intra-annual changes in diet in western Scotland identified by Santos *et al*. (2003) and suggest that care must be taken when using temporally-limited data for identifying critical habitat for this species.

Similarly, while climate change monitoring is still a relatively new aspect of cetacean monitoring programmes due to our poor understanding of how climate change may affect cetaceans, ferry surveys have been integral in assessing changes in the cetacean community of northwest Scotland. While strandings data suggest that this community is changing from one dominated by cooler water species to one dominated by warmer water species, ferry surveys provide evidence that these strandings data reflect actual changes in cetacean occurrence. In particular, ferry surveys in the Sea of Hebrides and the Minch conducted since 2001 have found that the occurrence of white-beaked dolphin, which were once the most commonly seen dolphin species in these waters (Reid *et al*. 2003), has declined dramatically, while the occurrence of common dolphin has increased (MacLeod *et al*. 2005).

While these data only cover a single area, meaning that it is difficult to be certain that these changes represent a region-wide change driven by changes in climate, the network of surveys conducted by ARC partners means than comparative studies can be conducted over a wide area, providing a mechanism to investigate whether these changes are local variations or part of a pattern of wider geographical scope. In particular, this network of surveys will be particularly useful for detecting shifts in species distribution over time. Similarly, climate change may also affect the timing of events within a species, such as migration, life history and prey availability. Detecting such phenological changes can be very difficult, but may be critical for understanding how cetaceans are affected by climate change. By conducting monthly (or more frequent) surveys along fixed transects, the ARC data set potentially provides a fertile testing ground for identifying such phenomena and monitoring any phenological changes that occur.

Finally, a multi-species cetacean status index could potentially act as a marine biodiversity indicator. Recent years have seen global political consensus on the need to address loss of biodiversity. The 1994 Convention on Biological Diversity put an obligation on individual Governments to develop national strategies for the conservation and sustainable use of biological diversity. As part of the response, in 2001 the European Union set an ambitious target to halt biodiversity loss across Member States by 2010, which was backed up by agreement under international law in 2002 through the Convention on Biological Diversity. The UK Government is fully signed up to this target. In 2006, the EU published an Action Plan as a road map to delivering the 2010 target, including concrete measures and outlining the responsibilities of EU institutions and Member States. An important component of the Action Plan was the requirement to develop biodiversity indicators (surrogate measures for a wider range of biodiversity) to enable timely assessment of conservation progress towards the target. Components of biodiversity requiring assessment include trends in the abundance and distribution of species.

Unfortunately, at both a UK and European scale, the development of species indicators is problematic because systematic monitoring of biodiversity is scant, with birds and insects providing the best available datasets. In the marine environment, the situation is far worse than the terrestrial environment, with no species indicators, although a seabird indicator is currently being developed (2009). Cetaceans have considerable potential to be used as flagship indicators to monitor the changing state of the marine environment and marine biodiversity because:

- They are predators at or near the top of the food chain. They may act as umbrella species, and as representatives for the diversity and responses of other marine wildlife
- They occupy a wide range of habitats
- They are amongst the most popular of all wildlife taxa
- They are highly sensitive and react quickly to environmental changes (e.g. due to changing fishery practices, climate change, chemical pollution and anthropogenic noise)
- There is a growing body of annual population data available

Current limitations in using cetaceans as indicators include

- The assumption that a cetacean indicator would reflect changes in overall cetacean abundance cannot be easily tested
- There is no direct evidence to confirm that changes in cetacean abundance reflect overall changes in biodiversity
- The potential methods of analysis require development and testing

A meeting has been held with Arco van Strien of Statistics Netherlands (who has helped develop biodiversity indicators for European birds and butterflies through the European Environment Agency) to discuss the possibilities of using ARC data to develop a marine biodiversity indicator. Having discussed the available data, initial conclusions from the meeting were that the data has considerable potential in terms of the development of indicators. Arco van Strien is interested in helping ARC to develop and test a cetacean indicator.

9 Overall assessments, recommendations and future work

9.1 Overall assessment of ARC data

An investigation into the methods employed by the ARC partners highlights that there is a good deal of consistency, with key sightings and effort data collected by all groups on a monthly basis. Recording is conducted by teams of observers (usually composed of at least one very experienced observer) and data quality is generally considered to be high.

Table 18. Summary assessment of spatial, temporal and species coverage through ARC survey efforts.

	Coverage rating
Marine Protected Areas	Low to medium
Spatial coverage – ICES fishing areas	Low to high
Spatial coverage - Regional Seas	Moderate to High
Spatial coverage - UK	Moderate to High
Species coverage – ICES fishing areas	Low to high
Species coverage - Regional Seas	Moderate to High
Species coverage - UK	High
Annual coverage - < 2003	Low to medium
Annual coverage - ≥ 2003	High

ARC surveys started in 1993, and by 2003 14 routes were being monitored. Currently (2009) there are 17 active ferry routes. Spatial coverage is wide-scale with for example every UK ICES fishing area sampled by at least one route, although individual fishing areas may have low spatial coverage.

All the expected species (known from distribution surveys) found along these routes are being regularly detected, and in particular substantial amounts of consistent effort related data are being collected for harbour porpoise, bottlenose dolphin, minke whale and common dolphin.

ARC data provide the possibility to assess changes in distribution and abundance both seasonally and across years. It is possible to calculate absolute density estimates for the majority of routes, and relative abundance and occupancy statistics for all routes.

A conclusion from the work carried out for this report is that ARC data have considerable potential to be analysed to assess trends in the conservation status of cetaceans at a UK scale, and to help meet the monitoring requirements of JNCC.

These conclusions are somewhat tentative, as they have not been fully scientifically tested or validated. In particular a power analysis is required to assess the power of ARC data to detect given levels of change over set periods of time for JNCC reporting. This was not possible under the current (2009) contract as all the ARC processed survey data was not available.

Furthermore there are important coverage gaps, including in the Eastern English Channel, off Eastern England and in deep waters beyond the shelf off western Britain. There is considerable potential to improve coverage, especially in shelf waters and a ‘shopping list’ of target ferry routes needs to be produced to help target new monitoring effort.

9.2 Monitoring recommendations

The data collected by ARC partners can be analysed in a number of ways to identify trends in cetacean occurrence, distribution and abundance, both within each survey route and through a combination of different survey routes to provide a greater spatial coverage. These approaches include the calculation of absolute density or density surfaces within surveyed areas, measures of relative abundance, changes in occupancy, log-linear modelling of annual abundance and trends for individual species at a UK scale, and developing multi-species measures of cetacean status. Each of these approaches has its own data requirements, advantages and limitations, and identifies different aspects of changes in the status of cetacean populations.

Delivery of a suitable cost-effective monitoring tool for JNCC requires developing and testing a suitable analytical procedure that is cost-effective, scientifically valid and enables rapid reporting.

As an annual status measure, we recommend testing occupancy to start with, as this is the quickest, easiest and therefore most cost-effective method. A further advantage of occupancy is that it also provides a measure of both abundance and distribution and can be visualised through distribution maps.

As a trend analysis procedure we recommend testing the application of log-linear modelling using the freeware program TRIM, as this is a tried and tested procedure for assessing trends in wildlife populations. A further advantage in using this approach is that is possible to combine other data types (e.g. regional small boat surveys, aerial surveys and systematic watches from headlands) into annual analyses of species status, provided that individual surveys use consistent methods over time.

9.3 Future work - a follow up study

We suggest a follow up study, which would (a) fully develop distribution and abundance indices and trends for cetacean species using ARC data and (b) cost future development of the ferry network to meet JNCC reporting needs. This would be over the whole time series (since 1993), although there was a step change increase in monitoring effort in 2003, so this may be a more suitable baseline.

Work which would need to be delivered through this study includes:

1. Develop a single database of ARC sightings and effort data (with all partner data input up to the current year (2009)).

2. Identify which species have sufficient survey coverage to estimate UK status.

3. Conduct annual training/expertise-sharing meeting for current and future potential ARC partners to increase data quality and comparability.
4. Compartmentalise each route into a series of independent transects. Sub-division of longer survey routes into separate ‘transects’ which should consider national boundaries and/or biogeographical regions.

5. Assess the representativeness of ARC survey routes for wider regions in terms of habitat combinations surveyed and trends in occurrence over time.

6. Identify priority ferry routes requiring new monitoring programmes.

7. Identify non-ferry survey data that could be combined with ferry data to determine the annual status of cetacean species at a UK level.

8. Calculation of occupancy statistics (and direct relative abundance measures as time allows) for each route/route segment over the time series using ARC data. For occupancy analyses, determine cell size and minimum survey effort required to classify a cell as having been surveyed. Investigate methods to account for the proportion missed, including testing the assumption of constant detection probabilities.

9. Investigate the development of an automated software procedure to generate annual occupancy statistics (and other relative abundance measures) from ARC ferry route data.

10. Testing the development of a multi-species annual status measure of cetacean status.

11. Testing the use of TRIM and Trendspotter to model trends in occupancy, including:

    - Determine which monthly data to use – summer only (available from all routes), or a mixture of summer only and all months (for the ferry routes which collect year round data).
    - Identify appropriate weighting procedures.
    - Identify the most appropriate base time year (when sufficient data is available), from which to assess trends.
    - Compare regional differences and trends over time with other available datasets.
    - Investigating the most appropriate way of assessing short-term trends.

12. Complete a power analysis to determine the power of ARC data and the number of ferry routes required to detect significant levels of change within JNCC reporting cycles.

13. As resources allow, test the development of absolute density estimates and density surfaces using ARC data.

9.4 Other funding priorities

1. A meeting for ARC partners to discuss best practice survey methods, establishing further routes, joint database development, new partners etc.

2. Resources to support co-ordination work of ARC partner survey managers. The key to success in each ARC survey programme is effective co-ordination by the survey manager. All of these posts are currently (2009) carried out in a voluntary capacity, and are thus vulnerable. A funding priority should be to ensure within each country that resources are made available so that this co-ordination work can be secured.

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11 Appendix 1

ARC regions, survey groups and cross-referencing to

ARC Survey groups	Regional seas	Geographical name(s)	National waters & EEZ* zones	ICES fishing areas	OSPAR regions	NOAA/Pan-European Large Marine Ecosystems (LMEs)	Proposed ICES eco-regions**
Ambar, BDRP/Marinelife, Orca, PSMS	Bay of Biscay	Bay of Biscay	France, Spain	VIIIa,b, c,d2	IV. Bay of Biscay	24. Celtic-Biscay Shelf; 25. Iberian Coast	G South European Atlantic Shelf, K Oceanic northeast Atlantic
IWDG, Sea Trust, Oceanopolis/Orca	Celtic Sea	Celtic Sea, St George's Channel, Western Approaches	England, Wales, France Ireland	VIIe,f,g,h	III. Celtic Sea	24. Celtic-Biscay Shelf	E Celtic Seas
IWDG, Sea Trust	Irish Sea	Irish Sea	Wales, Northern Ireland, Ireland	VIa,VIIa,g	III. Celtic Sea	24. Celtic-Biscay Shelf	E Celtic Seas
IWDG, Aberdeen University,	Hebridean Sea	The Minch, Sea of Hebrides	UK	VIa	III. Celtic Sea	24. Celtic-Biscay Shelf	E Celtic Seas
Ambar, Marinelife, Marinelife (BDRP), Orca, PSMS, Oceanopolis/Orca	English Channel	English Channel	England, France	VIId,e,h	II. North Sea	24. Celtic-Biscay Shelf	E Celtic Seas, F North Sea
Aberdeen University, Orca, Rugvin Foundation	North Sea	North Sea	Belgium, Denmark, France, Norway, Sweden, Netherlands, UK,	IVa,b,c	II. North Sea	22. North Sea	F North Sea

***EEZ=200 nautical mile Exclusive Economic Zone**
US National Oceanic and Atmospheric Administration (NOAA)
** Classification devised for EU to aid an ecosystem approach to marine conservation

Aberdeen University

Type of survey	*Survey group*	Sarah Bannon, University of Aberdeen
	Route	Ullapool to Stornorway
	Name of ships (years)	MV Isle of Lewis
	Paid surveyors of volunteers?	Ph.D. and M.Sc students
	Sponsoring bodies	dstl
	Form of sponsorship	Payment of studentship/field costs
Main purpose of surveying/monitoring	*Specific objectives*	Examining habitat use, occurrence and distribution of cetaceans in western Scotland
Temporal coverage	*Years sampled*	2001-2007
	Months sampled	May-September (year round since 2005)
	Fine-scale timing of surveys	Two surveys per month in summer and one per month in winter
	Duration of surveys	5 hours
	Effort per survey – no. hours	5 hours
	Effort per survey – spatial coverage	
Spatial coverage	*Length of transect*	75km
	ICES cells surveyed	VIa
	Regional seas	NE Atlantic
	How representative of the range of the species targeted is the survey area?	Not currently known.
Methodologies used	*Type of observation platform*	Passenger ferry
	No. and type of observers	1 observer surveying left side of the ship
	Height of observation	15m
	Ship speed	23km/h
	Position on the ship	On Bridge
	Type of survey	Distance sampling
	Key sightings data collected	Location, distance, bearing, species identification, group size, behaviour and environmental variables
	Key effort data collected	Ship's position, direction of travel, speed of travel, environmental conditions
	Use of logger software	No
	Additional recording 1	
	Additional recording 2	
	Recoding of effort data	Data recorded every fifteen minutes and whenever ship changes direction of travel.
Species investigated	*Regular species*	Harbour porpoise, minke whale, common dolphin
	Occasional species	White-beaked dolphin, Risso's Dolphin, Bottlenose dolphin
	Rare species	None
Measures for data quality control	*Observers experience and training*	All observers are experienced cetacean observers who are trained in the methods used on these surveys
	Sightings categories	All sightings are recorded to lowest level of taxonomic certainty
	Data validation	All data are processed, checked and verified by the observer, and rechecked by lead researcher
	Cross-checking photos	No
	Data filtering	No
Types of analyses completed on status	*Distribution*	Habitat models of species distribution and seasonal changes in habitat preferences
	Relative abundance	Sightings and animals per km effort.
	Absolute abundance	No (but could be calculated from data)
Reporting	*Annual reporting, including websites and grey literature reports.*	None to date (but report/papers in progress)
	Scientific papers	Macleod *et al*. 2005. Biological Conservation.
Any other information		

AMBAR

Type of survey	*Survey group*	AMBAR. Society for the Conservation and Study of the Marine Fauna.
	Route	Bilbao (Spain) to Portsmouth (England)
	Name of ships (years)	Pride of Bilbao (2001-present)
	Paid surveyors of volunteers?	Volunteers
	Sponsoring bodies	P&O Ferries
	Form of sponsorship	P&O Ferries provide passage, accommodation, food for 3 surveyors. Volunteers support their own expenses
Main purpose of surveying/monitoring	*Specific objectives*	Identify important areas for cetaceans. Detect changes in cetacean status at different temporal and spatial scales. Develop overall measures (multi-species) of changing cetacean status.
Temporal coverage	*Years sampled*	Every year 2001-present (n=7)
	Months sampled	Every month - February to December (n=11).
	Fine-scale timing of surveys	Usually the first week of each month.
	Duration of surveys	Trips last 4 days, with surveys on 3 of the days.
	Effort per survey – no. hours	21-36 hours of effort per trip according to season.
	Effort per survey – spatial coverage	The whole route is covered on two thirds of the trips, with shelf-edge and deep water area missed in months with shorter daylight length.
Spatial coverage	*Length of transect*	1045 km
	ICES cells surveyed	VIId, VIIe, VIIh, VIII
	Regional seas	English Channel, Bay of Biscay, Western Approaches
	How representative of the range of the species targeted is the survey area?	Generally relatively low, though there is some evidence to suggest that trends on the route do reflect the wider area (comparison with SCANS results).
Methodologies used	*Type of observation platform*	P&O cruise-ferry
	No. and type of observers	Three volunteer observers – senior surveyor, bird recorder, trainee/data recorder
	Height of observation	32m
	Ship speed	Mostly 16-22 knots
	Position on the ship	Forward viewing - ship's bridge
	Type of survey	Distance sampling
	Key sightings data collected	Species and certainty (see below), Number seen (usually a best estimate, but can be a minimum or maximum) by age category (adult, juvenile, calf). Latitude, Longitude, Distance to sighting, Angle to sighting, Sea state and other sea/weather variables. Behaviour at first point of observation (7 coded types)
	Key effort data collected	Recorded at least every 30 minutes: Ships position (lat + long), course, speed, sea state and other sea/weather variables.
	Use of logger software	No
	Additional recording 1	Photo-identification of Beaked Whales
	Additional recording 2	Seabirds counts per minute of effort in two distance bands.
	Recoding of effort data	Effort data collected at 15-30 minute intervals and for each sighting.
Species investigated	*Regular species*	Bottlenose Dolphin, Common Dolphin, Cuvier's Beaked Whale, Fin Whale, Harbour Porpoise, Long-finned Pilot Whale, Minke Whale, Risso's Dolphin, Sperm Whale, Striped Dolphin.
	Occasional species	Killer Whale, Northern Bottlenose Whale, Sowerby's Beaked Whale.
	Rare species	Atlantic White-sided Dolphin, Blue Whale, False Killer Whale, Humpback Whale, Sei Whale, White-beaked Dolphin, Melon Headed Whale, Pygmy Killer Whale, True's Beaked Whale.
Measures for data quality control	*Observers experience and training*	On and offshore training programmes in small boats. Each trip requires a senior surveyor to manage the survey.
	Sightings categories	Identification assigned to one of three levels of certainty in identification (1) definite (2) probable (3) possible.
	Data validation	Description required for rare species.
	Cross-checking photos	Yes, when available. Room for improvement.
	Data filtering	We don't have validation rules built into electronic data entry.

AMBAR (Cont'd)

Types of analyses completed on status	*Distribution*	Occupancy in grid cells of differing sizes.
	Relative abundance	(1) No. animals per km effort and (2) No. animals per hour of observation - both in grid cells of differing sizes.
	Absolute abundance	Density per km Some spatial modelling of density
Reporting	*Annual reporting, including websites and grey literature reports.*	ECS posters and papers.
	Scientific papers	One in the JMBA
Any other information		

IWDG Surveys: Dublin to Holyhead

Type of survey	*Survey group*	Irish Whale and Dolphin Group – Ship Surveys Programme
	Route	Dublin, Ireland – Holyhead, Wales
	Name of ships (years)	MV Ulysses (2002 - Present)
	Paid surveyors of volunteers?	Volunteers
	Sponsoring bodies	Irish Ferries, IWDG
	Form of sponsorship	Irish Ferries provide passage and food for up to 3 surveyors. IWDG provide some travel expenses
Main purpose of surveying/monitoring	*Specific objectives*	Identify important areas for cetaceans. Detect changes in cetacean status at different temporal and spatial scales. Develop overall measures (multi-species) of changing cetacean status.
Temporal coverage	*Years sampled*	2002 - Present (n=6)
	Months sampled	Every month – but not all months in all years
	Fine-scale timing of surveys	Variable within month.
	Duration of surveys	Trips conducted during 1 day.
	Effort per survey – no. hours	4.5 -7 hours of effort per trip according to season.
	Effort per survey – spatial coverage	The whole route is covered with exception of winter where shorter daylight hours cut 1hr from start of morning leg and 1-1.5hrs from end of return leg.
Spatial coverage	*Length of transect*	c100 km
	ICES cells surveyed	VIIa
	Regional seas	Irish Sea
	How representative of the range of the species targeted is the survey area?	Low but route acts as a significant indicator of species trends within a regional sea.
Methodologies used	*Type of observation platform*	Ro-Ro Ferry
	No. and type of observers	1 - 3 volunteer observers
	Height of observation	30m
	Ship speed	Mostly 18-20 knots
	Position on the ship	Ship's bridge – Port Side Wing
	Type of survey	Distance sampling
	Key sightings data collected	Species and certainty (see below), Number seen (usually a best estimate, but can be a minimum or maximum). Latitude, Longitude, Distance to sighting, Angle to sighting, Sea state and other sea/weather variables. Behaviour at first point of observation (7 coded types)
	Key effort data collected	Recorded every 15 minutes: Ships position (lat + long), course, speed, sea state and other sea/weather variables.
	Use of logger software	IFAW Logger 2000
	Additional recording 1	Seabird species list
	Additional recording 2	Seals, Basking Sharks, Turtles
	Recoding of effort data	Effort data collected at 15 minute intervals and for each sighting.
Species investigated	*Regular species*	Harbour Porpoise; Minke Whale; Common Dolphin
	Occasional species	Risso's Dolphin, Bottlenose Dolphin.
	Rare species	Fin Whale
Measures for data quality control	*Observers experience and training*	Each trip requires a senior surveyor to manage the survey. Senior surveyors come from a small pool of reliable, experienced surveyors known to the project manager. Most survey members come from a background with land-based whale watching experience.
	Sightings categories	Identification assigned to one of three levels of certainty in identification (1) definite (2) probable (3) possible.
	Data validation	Description or photo required for rare species. Unsubstantiated sightings downgraded as per IWDG validation system. (e.g. to unidentified dolphin etc.)
	Cross-checking photos	Rare due to speed of vessel
	Data filtering	Logger has been set up with compulsory data fields for environment and sightings.
Types of analyses completed on status	*Distribution*	Per quarter ICES grid square also mapped using ArcView
	Relative abundance	No. animals per hour of observation – per quarter ICES grid square (RA data in process of being updated).
	Absolute abundance	None, however data collection allows for this.
Reporting	*Annual reporting, including websites and grey literature reports.*	Last 3 survey summaries on www.iwdg.ie/shipsurveys/
	Scientific papers	6 year review in preparation incorporating all ferry surveys on Irish Sea
Any other information		

IWDG Surveys: Rosslare to Pembroke

Type of survey	*Survey group*	Irish Whale and Dolphin Group – Ship Surveys Programme
	Route	Rosslare, Ireland – Pembroke, Wales
	Name of ships (years)	MV Isle of Inishmore (2004 - Present)
	Paid surveyors of volunteers?	Volunteers
	Sponsoring bodies	Irish Ferries, IWDG
	Form of sponsorship	Irish Ferries provide passage and food for up to 3 surveyors. IWDG provide some travel expenses
Main purpose of surveying/monitoring	*Specific objectives*	Identify important areas for cetaceans. Detect changes in cetacean status at different temporal and spatial scales. Develop overall measures (multi-species) of changing cetacean status.
Temporal coverage	*Years sampled*	2004 - Present (n=4)
	Months sampled	Every month – but not all months in all years
	Fine-scale timing of surveys	Variable within month.
	Duration of surveys	Trips conducted during one day.
	Effort per survey – no. hours	4.5 -7 hours of effort per trip according to season.
	Effort per survey – spatial coverage	The whole route is covered with exception of winter where shorter daylight hours cut 1hr from start of morning leg and 1-1.5hrs from end of return leg.
Spatial coverage	*Length of transect*	c125 km
	ICES cells surveyed	VIIa, VIIg
	Regional seas	Irish Sea
	How representative of the range of the species targeted is the survey area?	Low but route acts as a significant indicator of species trends within a regional sea.
Methodologies used	*Type of observation platform*	Ro-Ro Ferry
	No. and type of observers	1 - 3 volunteer observers
	Height of observation	30m
	Ship speed	Mostly 18-20 knots
	Position on the ship	Ship's bridge – Port Side Wing
	Type of survey	Distance sampling
	Key sightings data collected	Species and certainty (see below), Number seen (usually a best estimate, but can be a minimum or maximum). Latitude, Longitude, Distance to sighting, Angle to sighting, Sea state and other sea/weather variables. Behaviour at first point of observation (7 coded types)
	Key effort data collected	Recorded every 20 minutes: Ships position (lat + long), course, speed, sea state and other sea/weather variables.
	Use of logger software	No
	Additional recording 1	Seabird species list
	Additional recording 2	Seals, Basking Sharks, Turtles
	Recoding of effort data	Effort data collected at 20 minute intervals and for each sighting.
Species investigated	*Regular species*	Common Dolphin; Harbour Porpoise
	Occasional species	Risso's Dolphin, Bottlenose Dolphin
	Rare species	-
Measures for data quality control	*Observers experience and training*	Each trip requires a senior surveyor to manage the survey. Senior surveyors come from a small pool of reliable, experienced surveyors known to the project manager. Most survey members come from a background with land-based whale watching experience.
	Sightings categories	Identification assigned to one of three levels of certainty in identification (1) definite (2) probable (3) possible.
	Data validation	Description or photo required for rare species. Unsubstantiated species downgraded as per IWDG validation system. (e.g. to unidentified dolphin etc.)
	Cross-checking photos	Rare due to speed of vessel
	Data filtering	-
Types of analyses completed on status	*Distribution*	Per quarter ICES grid square also mapped using ArcView
	Relative abundance	No. animals per hour of observation – per quarter ICES grid square (RA data in process of being updated).
	Absolute abundance	None, however data collection allows for this.
Reporting	*Annual reporting, including websites and grey literature reports.*	Last 3 survey summaries on www.iwdg.ie/shipsurveys/
	Scientific papers	6 year review in preparation incorporating all ferry surveys on Irish Sea
Any other information		

IWDG Surveys: Dublin – Liverpool to Mostyn

Type of survey	*Survey group*	Irish Whale and Dolphin Group – Ship Surveys Programme
	Route	Dublin, Ireland – Liverpool, England & Mostyn, Wales
	Name of ships (years)	MV European Ambassador (2001 - 2002)
	Paid surveyors of volunteers?	Volunteers
	Sponsoring bodies	P&O Irish Sea Ferries.
	Form of sponsorship	P&O Irish Sea Ferries provided passage, accommodation and food for up to 3 surveyors.
Main purpose of surveying/monitoring	*Specific objectives*	Identify important areas for cetaceans. Detect changes in cetacean status at different temporal and spatial scales. Develop overall measures (multi-species) of changing cetacean status.
Temporal coverage	*Years sampled*	2001 - 2002 (n=2)
	Months sampled	2001 (Jul, Aug, Sep, Nov), 2002 (Jan)
	Fine-scale timing of surveys	Variable within month.
	Duration of surveys	Trips conducted over 2 days.
	Effort per survey – no. hours	3 -7 hours of effort per trip according to season.
	Effort per survey – spatial coverage	Partial coverage of route mostly between Dublin and to just east of Anglesey.
Spatial coverage	*Length of transect*	c125 km
	ICES cells surveyed	VIIa
	Regional seas	Irish Sea
	How representative of the range of the species targeted is the survey area?	Low but route acts as a significant indicator of species trends within a regional sea.
Methodologies used	*Type of observation platform*	Ro-Ro Ferry
	No. and type of observers	1 - 3 volunteer observers
	Height of observation	c25m
	Ship speed	Mostly 20-24 knots
	Position on the ship	Ship's bridge – Port Side Wing
	Type of survey	Distance sampling
	Key sightings data collected	Species and certainty (see below), Number seen (usually a best estimate, but can be a minimum or maximum). Latitude, Longitude, Distance to sighting, Angle to sighting, Sea state and other sea/weather variables. Behaviour at first point of observation (7 coded types)
	Key effort data collected	Recorded every 15 minutes: Ships position (lat + long), course, speed, sea state and other sea/weather variables.
	Use of logger software	No
	Additional recording 1	Seabird species list
	Additional recording 2	Seals, Basking Sharks, Turtles
	Recoding of effort data	Effort data collected at 20 minute intervals and for each sighting.
Species investigated	*Regular species*	Common Dolphin
	Occasional species	-
	Rare species	-
Measures for data quality control	*Observers experience and training*	Each trip required a senior surveyor to manage the survey. Senior surveyors came from a small pool of reliable, experienced surveyors known to the project manager. Most survey members come from a background with land-based whale watching experience.
	Sightings categories	Identification assigned to one of three levels of certainty in identification (1) definite (2) probable (3) possible.
	Data validation	Description or photo required for rare species. Unsubstantiated species downgraded as per IWDG validation system. (e.g. to unidentified dolphin etc.)
	Cross-checking photos	Rare due to speed of vessel
	Data filtering	-
Types of analyses completed on status	*Distribution*	Per quarter ICES grid square also mapped using ArcView
	Relative abundance	No. animals per hour of observation – per quarter ICES grid square (RA data in process of being updated).
	Absolute abundance	None, however data collection allows for this.
Reporting	*Annual reporting, including websites and grey literature reports.*	Last 3 survey summaries on www.iwdg.ie/shipsurveys/
	Scientific papers	6 year review in preparation incorporating all ferry surveys on Irish Sea
Any other information		

IWDG Surveys: Dublin / Rosslare to Cherbourg

Type of survey	*Survey group*	Irish Whale and Dolphin Group – Ship Surveys Programme
	Route	Dublin / Rosslare, Ireland – Cherbourg, France
	Name of ships (years)	MV European Ambassador / MV European Diplomat (2002-2003)
	Paid surveyors of volunteers?	Volunteers
	Sponsoring bodies	P&O Irish Sea Ferries.
	Form of sponsorship	P&O Irish Sea Ferries provided passage, accommodation and food for up to 3 surveyors.
Main purpose of surveying/monitoring	*Specific objectives*	Identify important areas for cetaceans. Detect changes in cetacean status at different temporal and spatial scales. Develop overall measures (multi-species) of changing cetacean status.
Temporal coverage	*Years sampled*	2002 - 2003 (n=2)
	Months sampled	2002 (Mar, May, Jun, Jul, Aug, Sep. Nov, Dec), 2003 (Mar, Apr, May, Jun, Jul, Aug, Sep, Oct)
	Fine-scale timing of surveys	Variable within month.
	Duration of surveys	Trips conducted over 3 days.
	Effort per survey – no. hours	9 – 17.5 hours of effort per trip according to route and season.
	Effort per survey – spatial coverage	Partial coverage of routes in all seasons, areas of route covered dependent on ship and season. Best coverage in spring and summer.
Spatial coverage	*Length of transect*	c600 - 700 km dependent on route
	ICES cells surveyed	VIIa, VIIg, VIIe, VIId, VIII
	Regional seas	Irish Sea, Celtic Sea, English Channel
	How representative of the range of the species targeted is the survey area?	Low but route acts as a significant indicator of species trends within a number of regional seas.
Methodologies used	*Type of observation platform*	Ro-Ro Ferry
	No. and type of observers	1 - 3 volunteer observers
	Height of observation	c15m / c25m
	Ship speed	16 knots / 20-24 knots
	Position on the ship	Ship's bridge – Port Side Wing
	Type of survey	Distance sampling
	Key sightings data collected	Species and certainty (see below), Number seen (usually a best estimate, but can be a minimum or maximum). Latitude, Longitude, Distance to sighting, Angle to sighting, Sea state and other sea/weather variables. Behaviour at first point of observation (7 coded types)
	Key effort data collected	Recorded every 20 minutes: Ships position (lat + long), course, speed, sea state and other sea/weather variables.
	Use of logger software	No
	Additional recording 1	Seabird species list
	Additional recording 2	Seals, Basking Sharks, Turtles
	Recoding of effort data	Effort data collected at 20 minute intervals and for each sighting.
Species investigated	*Regular species*	Common Dolphin, Harbour Porpoise
	Occasional species	Minke Whale, Risso's Dolphin, Pilot Whale
	Rare species	Fin Whale
Measures for data quality control	*Observers experience and training*	Each trip required a senior surveyor to manage the survey. Senior surveyors came from a small pool of reliable, experienced surveyors known to the project manager. Most survey members come from a background with land-based whale watching experience.
	Sightings categories	Identification assigned to one of three levels of certainty in identification (1) definite (2) probable (3) possible.
	Data validation	Description or photo required for rare species. Unsubstantiated species downgraded as per IWDG validation system. (e.g. to unidentified dolphin etc.)
	Cross-checking photos	Rare due to speed of vessel
	Data filtering	-
Types of analyses completed on status	*Distribution*	Per quarter ICES grid square also mapped using ArcView
	Relative abundance	No. animals per hour of observation – per quarter ICES grid square (RA data in process of being updated).
	Absolute abundance	None, however data collection allows for this.
Reporting	*Annual reporting, including websites and grey literature reports.*	
	Scientific papers	6 year review in preparation incorporating all ferry surveys on Irish Sea
Any other information		

IWDG Surveys: Larne to Cairnryan

Type of survey	*Survey group*	Irish Whale and Dolphin Group – Ship Surveys Programme
	Route	Larne, Northern Ireland – Cairnryan, Scotland
	Name of ships (years)	MV European Highlander & MV European Causeway (2006 – Present)
	Paid surveyors of volunteers?	Volunteers
	Sponsoring bodies	P&O Irish Sea Ferries.
	Form of sponsorship	P&O Irish Sea Ferries provide passage, accommodation and food for 2 surveyors.
Main purpose of surveying/monitoring	*Specific objectives*	Identify important areas for cetaceans. Detect changes in cetacean status at different temporal and spatial scales. Develop overall measures (multi-species) of changing cetacean status.
Temporal coverage	*Years sampled*	2006 - Present (n=2)
	Months sampled	All months
	Fine-scale timing of surveys	Variable within month.
	Duration of surveys	Trips conducted over 1 day.
	Effort per survey – no. hours	3 hours of effort per trip
	Effort per survey – spatial coverage	Full coverage of route in all seasons.
Spatial coverage	*Length of transect*	c50 km
	ICES cells surveyed	VIIa
	Regional seas	Irish Sea
	How representative of the range of the species targeted is the survey area?	Low but route acts as a significant indicator of species trends within a regional sea.
Methodologies used	*Type of observation platform*	Ro-Ro Ferry
	No. and type of observers	2 volunteer observers
	Height of observation	c25m
	Ship speed	18-20 knots
	Position on the ship	Ship's bridge – Port Side Wing
	Type of survey	Distance sampling
	Key sightings data collected	Species and certainty (see below), Number seen (usually a best estimate, but can be a minimum or maximum). Latitude, Longitude, Distance to sighting, Angle to sighting, Sea state and other sea/weather variables. Behaviour at first point of observation (7 coded types)
	Key effort data collected	Recorded every 20 minutes: Ships position (lat + long), course, speed, sea state and other sea/weather variables.
	Use of logger software	No
	Additional recording 1	Seabird species list
	Additional recording 2	Seals, Basking Sharks, Turtles
	Recoding of effort data	Effort data collected at 20 minute intervals and for each sighting.
Species investigated	*Regular species*	Harbour Porpoise
	Occasional species	-
	Rare species	Bottlenose Dolphin
Measures for data quality control	*Observers experience and training*	Each trip required a senior surveyor to manage the survey. Senior surveyors came from a small pool of reliable, experienced surveyors known to the project manager. Most survey members come from a background with land-based whale watching experience.
	Sightings categories	Identification assigned to one of three levels of certainty in identification (1) definite (2) probable (3) possible.
	Data validation	Description or photo required for rare species. Unsubstantiated species downgraded as per IWDG validation system. (e.g. to unidentified dolphin etc.)
	Cross-checking photos	Occasional
	Data filtering	-
Types of analyses completed on status	*Distribution*	Per quarter ICES grid square also mapped using ArcView
	Relative abundance	No. animals per hour of observation – per quarter ICES grid square (RA data in process of being updated).
	Absolute abundance	None, however data collection allows for this.
Reporting	*Annual reporting, including websites and grey literature reports.*	
	Scientific papers	6 year review in preparation incorporating all ferry surveys on Irish Sea
Any other information		

BDRP (Marinelife) Surveys: Portsmouth to Bilbao

Type of survey	*Survey group*	Marinelife under the project banner – the *Biscay Dolphin Research Programme*
	Route	Portsmouth, England to Bilbao, Spain
	Name of ships (years)	Pride of Bilbao (95-present)
	Paid surveyors of volunteers?	Volunteers
	Sponsoring bodies	P&O Ferries, Marinelife
	Form of sponsorship	P&O Ferries provide passage, accommodation, food for 3 surveyors. Marinelife provide some travel expenses
Main purpose of surveying/monitoring	*Specific objectives*	Identify important areas for cetaceans. Detect changes in cetacean status at different temporal and spatial scales. Develop overall measures (multi-species) of changing cetacean status.
Temporal coverage	*Years sampled*	Every year 1995-present (n=13)
	Months sampled	Every month - February to December (n=11).
	Fine-scale timing of surveys	Usually the middle/end of each month.
	Duration of surveys	Trips last 4 days, with surveys on 3 of the days.
	Effort per survey – no. hours	21-36 hours of effort per trip according to season.
	Effort per survey – spatial coverage	The whole route is covered on two thirds of the trips, with shelf-edge and deep water area missed in months with shorter daylight length.
Spatial coverage	*Length of transect*	1045 km
	ICES cells surveyed	VIId, VIIe, VIIh, VIII
	Regional seas	English Channel, Bay of Biscay, Western Approaches
	How representative of the range of the species targeted is the survey area?	Generally relatively low, though there is some evidence to suggest that trends on the route do reflect the wider area (comparison with SCANS results).
Methodologies used	*Type of observation platform*	P&O cruise-ferry
	No. and type of observers	Three volunteer observers – senior surveyor, bird recorder, trainee/data recorder
	Height of observation	32m
	Ship speed	Mostly 16-22 knots
	Position on the ship	Forward viewing - ship's bridge
	Type of survey	Distance sampling
	Key sightings data collected	Species and certainty (see below), Number seen (usually a best estimate, but can be a minimum or maximum) by age category (adult, juvenile, calf). Latitude, Longitude, Distance to sighting, Angle to sighting, Sea state and other sea/weather variables. Behaviour at first point of observation (7 coded types)
	Key effort data collected	Recorded at least every 30 minutes: Ships position (lat + long), course, speed, sea state and other sea/weather variables.
	Use of logger software	Yes
	Additional recording 1	Photo-identification of Beaked Whales
	Additional recording 2	Seabirds counts per minute of effort in two distance bands.
	Recoding of effort data	Effort data collected at 15-30 minute intervals and for each sighting.
Species investigated	*Regular species*	Bottlenose Dolphin, Common Dolphin, Cuvier's Beaked Whale, Fin Whale, Harbour Porpoise, Long-finned Pilot Whale, Minke Whale, Risso's Dolphin, Sperm Whale, Striped Dolphin.
	Occasional species	Killer Whale, Northern Bottlenose Whale, Sowerby's Beaked Whale.
	Rare species	Atlantic White-sided Dolphin, Blue Whale, False Killer Whale, Humpback Whale, Sei Whale, White-beaked Dolphin, Melon Headed Whale, Pygmy Killer Whale, True's Beaked Whale.
Measures for data quality control	*Observers experience and training*	On and offshore training programmes. Offshore includes surveyor progression structure from – trainee to surveyor to senior surveyor. Each trip requires a senior surveyor to manage the survey. Additional ongoing appraisal process for all surveyors by BDRP Senior staff.
	Sightings categories	Identification assigned to one of three levels of certainty in identification (1) definite (2) probable (3) possible.
	Data validation	Description required for rare species.
	Cross-checking photos	Yes, when available. Room for improvement.
	Data filtering	We don't have validation rules built into electronic data entry.
Types of analyses completed on status	*Distribution*	Occupancy in grid cells of differing sizes.
	Relative abundance	(1) No. animals per km effort and (2) No. animals per hour of observation - both in grid cells of differing sizes.
	Absolute abundance	Density per km. Some spatial modelling of density
Reporting	*Annual reporting, including websites and grey literature reports.*	BDRP *Ecological Studies* series – with 20+ papers. Several MSC theses. ECS posters and papers. Sightings loaded weekly onto http://www.marine-life.org.uk/past-projects/biscay-dolphin-research-programme
	Scientific papers	Several in JMBA
Any other information		

BDRP (Marinelife) Surveys: Plymouth to Roscoff

Type of survey	*Survey group*	Marinelife
	Route	Plymouth, England to Roscoff, France
	Name of ships (years)	Pont L'Abbé and Pont Aven
	Paid surveyors of volunteers?	Volunteers
	Sponsoring bodies	Brittany Ferries
	Form of sponsorship	Brittany Ferries provide passage, accommodation. Marinelife provide some travel expenses
Main purpose of surveying/monitoring	*Specific objectives*	Identify important areas for cetaceans. Detect changes in cetacean status at different temporal and spatial scales. Develop overall measures (multi-species) of changing cetacean status.
Temporal coverage	*Years sampled*	2006 - present
	Months sampled	Monthly
	Fine-scale timing of surveys	Usually the middle of each month.
	Duration of surveys	Trips extend over 2 days,
	Effort per survey – no. hours	6 hours of effort each way.
	Effort per survey – spatial coverage	The same route is covered once, occasionally twice according to season.
Spatial coverage	*Length of transect*	185km
	ICES cells surveyed	VIIe
	Regional seas	English Channel
	How representative of the range of the species targeted is the survey area?	It's a reasonable sample of the habitat variation found in the western English Channel, with all the expected species detected except for Risso's Dolphin.
Methodologies used	*Type of observation platform*	Brittany passenger ferry
	No. and type of observers	Two volunteer observers – senior surveyor, bird recorder, trainee/data recorder
	Height of observation	16-21.75m
	Ship speed	Mostly 17-20 knots
	Position on the ship	Forward viewing - ship's bridge
	Type of survey	Distance sampling
	Key sightings data collected	Species and certainty (see below), Number seen (usually a best estimate, but can be a minimum or maximum) by age category (adult, juvenile, calf). Latitude, Longitude, Distance to sighting, Angle to sighting, Sea state and other sea/weather variables. Behaviour at first point of observation (7 coded types)
	Key effort data collected	Recorded at least every 30 minutes: Ships position (lat + long), course, speed, sea state and other sea/weather variables.
	Use of logger software	Yes
	Additional recording 1	Seabirds counts per minute of effort in two distance bands.
	Additional recording 2	
	Recoding of effort data	Effort data collected at 15-30 minute intervals and for each sighting.
Species investigated	*Regular species*	Bottlenose Dolphin, Common Dolphin, Harbour Porpoise, Minke Whale.
	Occasional species	None
	Rare species	None
Measures for data quality control	*Observers experience and training*	On and offshore training programmes. Offshore includes surveyor progression structure from – trainee to surveyor to senior surveyor. Each trip requires a senior surveyor to manage the survey.
	Sightings categories	Identification assigned to one of three levels of certainty in identification (1) definite (2) probable (3) possible.
	Data validation	Description required for rare species.
	Cross-checking photos	Yes, when available. Room for improvement.
	Data filtering	We don't have validation rules built into electronic data entry.
Types of analyses completed on status	*Distribution*	Occupancy in grid cells of differing sizes.
	Relative abundance	(1) No. animals per km effort and (2) No. animals per hour of observation - both in grid cells of differing sizes.
	Absolute abundance	Density per km.
Reporting	*Annual reporting, including websites and grey literature reports.*	Sightings loaded monthly onto http://www.marine-life.org.uk/sightings/prnewslatest.html
	Scientific papers	None as yet. Report in progress.
Any other information		

NORCET

Type of survey	*Survey group*	NORCET (Northern North Sea Cetacean Ferry Surveys).
	Route	Aberdeen to Shetland and Orkney
	Name of ships (years)	MV Hascosay
	Paid surveyors of volunteers?	Volunteers and university students
	Sponsoring bodies	Northlink ferrries
	Form of sponsorship	Provide free passage, accommodation and food for 2 surveyors per survey
Main purpose of surveying/monitoring	*Specific objectives*	To monitor changes in the occurrence and distribution of cetaceans along the transect line, with specific reference to potential impacts of climate change.
Temporal coverage	*Years sampled*	2002-2007
	Months sampled	At least one survey a month between May and September.
	Fine-scale timing of surveys	Monthly, with more than one surveys in some months depending on surveyor availability.
	Duration of surveys	36 hours
	Effort per survey – no. hours	Up to 16 hours depending on available daylight.
	Effort per survey – spatial coverage	Coverage primarily consist of an area along the Aberdeenshire coast, an area approaching Shetland and the outer Moray Firth between the mainland and Orkney, with occasional coverage between Orkney and Shetland
Spatial coverage	*Length of transect*	~700km (actual coverage varies with day length).
	ICES cells surveyed	Primarily ICES area IVa, with small coverage of IVb
	Regional seas	Northern North Sea
	How representative of the range of the species targeted is the survey area?	Currently unknown
Methodologies used	*Type of observation platform*	Freight ferry.
	No. and type of observers	Two per trip, at least one of which is experienced and all recieve training in species identification and survey methods
	Height of observation	~12m
	Ship speed	~16 knots
	Position on the ship	On the ship's bridge
	Type of survey	Transect survey (but not distance sampling).
	Key sightings data collected	Identification to lowest taxonomic certainty, group size, ship's position and environmental conditions.
	Key effort data collected	Ship's position, direction of travel and speed are recorded every 15 minutes along with environmental conditions.
	Use of logger software	No
	Additional recording 1	None
	Additional recording 2	None
	Recoding of effort data	
Species investigated	*Regular species*	Harbour porpoise, bottlenose dolphin, white-beaked dolphin and minke whale.
	Occasional species	Atlantic white-sided dolphin, Risso's dolphin, common dolphin.
	Rare species	Humpback whale, long-finned pilot whale, killer whale.
Measures for data quality control	*Observers experience and training*	Observers come from a pull of volunteers with some experience of cetacean watching. All observers are trained and inexperienced observers are paired with an experienced observer for their first trip.
	Sightings categories	Sightings assigned to lowest level of taxonomic certainty (e.g. cetacean spp., dolphin spp., bottlenose dolphin.
	Data validation	Sightings of rarer species are followed by by asking for a full description to verify identification and are reduced to a higher taxomonic classification if the identifaction is potentially questionable.
	Cross-checking photos	No
	Data filtering	The position, species identification and environmental data are all checked for validity by a trained scientists to ensure that they are consistent with other data from the same survey.
Types of analyses completed on status	*Distribution*	Occupancy of species as well as models of habitat preferences and spatial distribution.
	Relative abundance	Rank of species in comparison to other species seen, and relative abundance per km of survey effort.
	Absolute abundance	No
Reporting	*Annual reporting, including websites and grey literature reports.*	The first NORCET report was produced in 2007 covering the first five years of data collection. Annual reports will be produced from 2007 onwards.
	Scientific papers	None to date.
Any other information		

ORCA: DFDS Survey, Newcastle to Bergen

Type of survey	*Survey group*	Organisation Cetacea
	Route	Newcastle to Bergen
	Name of ships (years)	Queen of Scandinavia
	Paid surveyors of volunteers?	Volunteers
	Sponsoring bodies	DFDS
	Form of sponsorship	Limited number of free cabins
Main purpose of surveying/monitoring	*Specific objectives*	Monitoring cetacean relative abundance
Temporal coverage	*Years sampled*	2004 – present
	Months sampled	All months
	Fine-scale timing of surveys	At least one survey per month. Try to make it around the 10th of each month.
	Duration of surveys	3 days
	Effort per survey – no. hours	Variable. Shorter in winter due to poor daylight/bad weather.
	Effort per survey – spatial coverage	Most of the transect covered when outward and return journey combined.
Spatial coverage	*Length of transect*	~ 700km (one-way)
	ICES cells surveyed	IVa and Ivb
	Regional seas	North Sea
	How representative of the range of the species targeted is the survey area?	The North Sea is the major habitat for harbour porpoise, our target species, in European waters.
Methodologies used	*Type of observation platform*	Ferry
	No. and type of observers	Four observers per trip, with two on effort at any one time.
	Height of observation	22m bridge, 16m deck 9
	Ship speed	21 knots
	Position on the ship	Bridge for survey, deck 9 for training
	Type of survey	Distance sampling
	Key sightings data collected	Lat, Long, species, group size estimates, distance, angle, behaviour
	Key effort data collected	Lat, Long, sea state, swell, visibility,
	Use of logger software	No
	Additional recording 1	No
	Additional recording 2	No
	Recoding of effort data	Every 30 minutes and when conditions change.
Species investigated	*Regular species*	Harbour porpoise, whitebeaked dolphin, bottlenose dolphin, minke whale
	Occasional species	
	Rare species	Killer whales
Measures for data quality control	*Observers experience and training*	Training courses onshore and in the field. Most experienced become team leaders
	Sightings categories	Definite, Probable, Possible
	Data validation	Will be carried out by data manager assigned to this route (currently recruiting)
	Cross-checking photos	NA
	Data filtering	NA
Types of analyses completed on status	*Distribution*	Mapping.
	Relative abundance	None as yet as only 2-years of data.
	Absolute abundance	None as yet as only 2-years of data.
Reporting	*Annual reporting, including websites and grey literature reports.*	Website www.orcaweb.org.uk Planned abstract for ECS 2008
	Scientific papers	None as yet.
Any other information		

ORCA: P&O SURVEY, Portsmouth to Bilbao

Type of survey	*Survey group*	Organisation Cetacea
	Route	Portsmouth to Bilbao
	Name of ships (years)	Pride of Bilbao (1995 – present)
	Paid surveyors of volunteers?	Volunteers
	Sponsoring bodies	None
	Form of sponsorship	None
Main purpose of surveying/monitoring	*Specific objectives*	Temporal Monitoring of cetacean relative abundance and habitat
Temporal coverage	*Years sampled*	1995 – present
	Months sampled	All months
	Fine-scale timing of surveys	At least one survey per month but peaks in the summer
	Duration of surveys	4 days, surveying on 3
	Effort per survey – no. hours	Variable. Shorter in winter due to poor daylight/bad weather.
	Effort per survey – spatial coverage	Most of the transect covered when outward and return journey combined.
Spatial coverage	*Length of transect*	~1000km
	ICES cells surveyed	VIId, e, h; VIIId2, VIIIa, b, c
	Regional seas	Western Channel and Bay of Biscay
	How representative of the range of the species targeted is the survey area?	Target species are common dolphins, beaked whales, large baleen whales and the route passes through a range of habitat types, typical of these species.
Methodologies used	*Type of observation platform*	Ferry
	No. and type of observers	Variable because most data from whale watchers. However, majority of sightings made by experienced guide.
	Height of observation	37m
	Ship speed	16-33knots
	Position on the ship	Monkey Island
	Type of survey	Line transect, some Distance sampling
	Key sightings data collected	Lat, Long, species, group size estimates, distance, angle, behaviour
	Key effort data collected	Lat, Long, sea state, swell, visibility, precipitation
	Use of logger software	No
	Additional recording 1	Seabirds
	Additional recording 2	Other marine wildlife eg. Sharks, turtles
	Recoding of effort data	Every 30 minutes and when conditions change.
Species investigated	*Regular species*	Bottlenose Dolphin, Common Dolphin, Cuvier's Beaked Whale, Fin Whale, Harbour Porpoise, Long-finned Pilot Whale, Minke Whale, Risso's Dolphin, Sperm Whale, Striped Dolphin.
	Occasional species	Killer Whale, Northern Bottlenose Whale, Sowerby's Beaked Whale.
	Rare species	Atlantic White-sided Dolphin, Blue Whale, False Killer Whale, Humpback Whale, Sei Whale, White-beaked Dolphin, Melon Headed Whale, Pygmy Killer Whale, True's Beaked Whale.
Measures for data quality control	*Observers experience and training*	Tour guides are very experienced and make the majority of sightings. However, some is made by whalewatchers and effort is variable
	Sightings categories	None
	Data validation	Data entry carried out by Science officer and basic checks carried out. Further errors eliminated at analysis stage,
	Cross-checking photos	
	Data filtering	
Types of analyses completed on status	*Distribution*	Seasonal changes and relation to habitat
	Relative abundance	Seasonal and annual at a variety of scales (numbers per km by grid cells)
	Absolute abundance	None

ORCA: P&O SURVEY, Portsmouth to Bilbao (Cont'd)

Reporting	*Annual reporting, including websites and grey literature reports.*	Some years were summarised in ORCA Annual Reports 1, 2 and 3 – www.orcaweb.org.uk.
	Scientific papers	1. Kiszka, J, Macleod, K., Van Canneyt, O, Walker, D. and Ridoux, V. 2007. Distribution, encounter rates, and habitat characteristics of toothed cetaceans in the Bay of Biscay and adjacent waters fromplatform-of-opportunity data. *ICES Journal of Marine Science* 64(5):1033-1043. 2. Macleod, K. Walker, D. 2004. Highlighting potential common dolphin-fisheries interactions through seasonal relative abundance data in the western Channel and Bay of Biscay. *18th Annual Conference of the European Cetacean Society, Sweden.* 3. Chaudry, F,A , Clark, N, M, Reay, N, Scullion, R, G, Macleaod, K. 2005. The Distribution Of Fin Whales In The Bay Of Biscay In Relation To Bathymetry And Sea Surface Temperature *19th Annual Conference of the European Cetacean Society, France.* 4. Walker, D., McHenry, M., Hickey, R., Clemente, S., Beaumont, E.S., & Macleod, K 2005. Mapping Cetacean Biodiversity in the Bay of Biscay. *19th Annual Conference of the European Cetacean Society, France*
Any other information		

ORCA: Brittany Ferries, Plymouth to Santander

Type of survey	*Survey group*	Organisation Cetacea
	Route	Plymouth – Santander
	Name of ships (years)	Pont Aven (2006 – present)
	Paid surveyors of volunteers?	Volunteers
	Sponsoring bodies	Brittany Ferries
	Form of sponsorship	One free cabin per month.
Main purpose of surveying/monitoring	*Specific objectives*	Temporal Monitoring of cetacean relative abundance and habitat
Temporal coverage	*Years sampled*	2006 – present
	Months sampled	May – September
	Fine-scale timing of surveys	One survey per month. Leaving on Sunday's closest to the 10th of each month.
	Duration of surveys	3 days
	Effort per survey – no. hours	Variable. Shorter in winter due to poor daylight/bad weather.
	Effort per survey – spatial coverage	Most of the transect covered when outward and return journey combined.
Spatial coverage	*Length of transect*	~1000km
	ICES cells surveyed	VIId, e, h; VIIId2, VIIIa, b, c
	Regional seas	Western Channel and Bay of Biscay
	How representative of the range of the species targeted is the survey area?	Target species are common dolphins, beaked whales, large baleen whales and the route passes through a range of habitat types, typical of these species.
Methodologies used	*Type of observation platform*	Ferry
	No. and type of observers	2 surveyors on effort.
	Height of observation	32m?
	Ship speed	16-33knots
	Position on the ship	Bridge
	Type of survey	Distance sampling
	Key sightings data collected	Lat, Long, species, group size estimates, distance, angle, behaviour
	Key effort data collected	Lat, Long, sea state, swell, visibility,
	Use of logger software	No
	Additional recording 1	No
	Additional recording 2	No
	Recoding of effort data	Every 30 minutes and when conditions change.
Species investigated	*Regular species*	Bottlenose Dolphin, Common Dolphin, Cuvier's Beaked Whale, Fin Whale, Harbour Porpoise, Long-finned Pilot Whale, Minke Whale, Risso's Dolphin, Sperm Whale, Striped Dolphin.
	Occasional species	Killer Whale, Northern Bottlenose Whale, Sowerby's Beaked Whale.
	Rare species	Atlantic White-sided Dolphin, Blue Whale, False Killer Whale, Humpback Whale, Sei Whale, White-beaked Dolphin, Melon Headed Whale, Pygmy Killer Whale, True's Beaked Whale.
Measures for data quality control	*Observers experience and training*	
	Sightings categories	Definite, Probable, Possible
	Data validation	None at present
	Cross-checking photos	NA
	Data filtering	NA
Types of analyses completed on status	*Distribution*	None as yet as only 2-years of data.
	Relative abundance	None as yet as only 2-years of data.
	Absolute abundance	None as yet as only 2-years of data.
Reporting	*Annual reporting, including websites and grey literature reports.*	Website www.orcaweb.org.uk Planned abstract for ECS 2008
	Scientific papers	None as yet.
Any other information		

Plymouth to Santander Marine Survey

Type of survey	*Survey group*	Plymouth to Santander Marine Survey
	Route	Plymouth to Santander and return
	Name of ships (years)	Val de Loire (03.1996 to 03.2004) Pont Aven (04.2004 to present)
	Paid surveyors of volunteers?	Volunteers
	Sponsoring bodies	Brittany Ferries
	Form of sponsorship	Subsidised fares for two persons
Main purpose of surveying/monitoring	*Specific objectives*	Record all cetacean and bird sightings
Temporal coverage	*Years sampled*	1996 to present
	Months sampled	March to October/November
	Fine-scale timing of surveys	Originally mid month depending on availability of bookings. Now beginning or end month also subject to availability
	Duration of surveys	Three days, includes two part days
	Effort per survey – no. hours	All daylight hours whilst underway. 10 to 21 hours depending on season.
	Effort per survey – spatial coverage	Part English Channel plus southern Biscay area each trip. Plus north Biscay during mid-summer
Spatial coverage	*Length of transect*	780km approx.
	ICES cells surveyed	Not known
	Regional seas	English Channel/Bay of Biscay
	How representative of the range of the species targeted is the survey area?	Not known
Methodologies used	*Type of observation platform*	Brittany Ferries vehicle/passenger ferry
	No. and type of observers	Two volunteer observers including one as recorder.
	Height of observation	Estimated at approx. 80ft
	Ship speed	22 to 24 knots
	Position on the ship	Inside bridge – one observer per side.
	Type of survey	Recording all cetacean/bird life.
	Key sightings data collected	Species – as definite/probable/possible. Group size – minimum and maximum Sub adults. Distance off/bearing to sighting. Lat/Long. Ship heading/speed. Sea state. Wind direction/force. Swell height/direction. Precipitation. Visibility. Fishing boat/seabird activity.
	Key effort data collected	Originally recorded hourly, now half hourly.
	Use of logger software	No
	Additional recording 1	Bird sightings.
	Additional recording 2	
	Recoding of effort data	60/30 min. intervals and when conditions dictate.
Species investigated	*Regular species*	Any/all cetacean species.
	Occasional species	Ditto
	Rare species	Ditto
Measures for data quality control	*Observers experience and training*	One observer constant throughout eleven year period. 2nd observer one of eight regular observers. Training: On ship familiarisation.
	Sightings categories	Def/Prob/Poss
	Data validation	Non other than on ship i/d.
	Cross-checking photos	N/A
	Data filtering	None
Types of analyses completed on status	*Distribution*	Dmap
	Relative abundance	None carried out
	Absolute abundance	None carried out
Reporting	*Annual reporting, including websites and grey literature reports.*	None.
	Scientific papers	No submissions
Any other information		

Rugvin Foundation

Type of survey	*Survey group*	**Stichting Rugvin /Rugvin foundation** (former Project Rugvin)
	Route	Hook of Holland, the Netherlands to Harwich, England
	Name of ships (years)	Britannica and Hollandica (2005)
	Paid surveyors of volunteers?	Volunteers
	Sponsoring bodies	Stena Line and WWF/INNO / Rugvin foundation
	Form of sponsorship	Stena provides passage, food for two surveyors. WWF/INNO/ Rugvin foundation provides travel cost, accommodation and office costs.
Main purpose of surveying/monitoring	*Specific objectives*	To study cetacean species diversity, abundance and population dynamics in the North Sea.
Temporal coverage	*Years sampled*	2005-present. (n=3) A gap from January 2007 till August 2007 due to reconstruction of both ships.
	Months sampled	Every month Jan to Dec. (n=12)
	Fine-scale timing of surveys	Usually the beginning/middle of the month.
	Duration of surveys	Two days
	Effort per survey – no. hours	9-13 hours of effort per trip depending on season.
	Effort per survey – spatial coverage	The last 0-4 hrs are missed in the season Nov – Febr. on the first survey day due to lack of daylight. The second day is always by full daylight (6 ½ hrs)
Spatial coverage	*Length of transect*	180 km per stretch whole trip 360 km.
	ICES cells surveyed	IVc
	Regional seas	Dutch and English North Sea
	How representative of the range of the species targeted is the survey area?	Species abundance is thought to be representative for the southern North Sea. Results are in line with other monitoring initiatives in the Southern North Sea.
Methodologies used	*Type of observation platform*	Stena Line ferry, monitoring platform is the bridge.
	No. and type of observers	Two volunteer observers, one senior and one junior.
	Height of observation	Britannica 33m,Hollandica 32 m.
	Ship speed	20-22 knots
	Position on the ship	Forward viewing from ship's bridge.
	Type of survey	Distance sampling
	Key sightings data collected	Species and certainty (see below), Number seen (usually a best estimate, but can be a minimum or maximum) by age category (adult, juvenile, calf). Latitude, Longitude, Distance to sighting, Angle to sighting, Sea state and other sea/weather variables. Behaviour at first point of observation (7 coded types).
	Key effort data collected	Each 30 minutes, ships position, speed, heading, sea state and weather circumstances,
	Use of logger software	No
	Additional recording 1	Occasionally, the presence of seabirds
	Additional recording 2	-
	Recoding of effort data	Recorded at least every 30 minutes: Ships position (lat + long), course, speed, sea state and other sea/weather variables.
Species investigated	*Regular species*	Harbour porpoise and White beaked dolphin
	Occasional species	Bottlenose dolphin and common dolphin.
	Rare species	Minke whale
Measures for data quality control	*Observers experience and training*	Partly they are trained at CRRU in Gardenstown, Scotland. Additional training at Rugvin's surveys with small vessels at the North Sea.
	Sightings categories	Identification assigned to one of three levels of certainty in identification (1) definite (2) probable (3) possible.
	Data validation	Description required for rare species.
	Cross-checking photos	None
	Data filtering	None
Types of analyses completed on status	*Distribution*	GIS maps are made of the distribution.
	Relative abundance	No. animals per km effort.
	Absolute abundance	None yet.
Reporting	*Annual reporting, including websites and grey literature reports.*	Since 2005 every year an annual report. News articles release. Msc thesis. Presentation/poster admission in preparation for the next ECS conference. Website with sightings information will be developed in coming winter.
	Scientific papers	In preparation.
Any other information		

Sea Trust

Type of survey	*Survey group*	Constant Effort Transects
	Route	Fishguard- Rosslare
	Name of ships (years)	Stena Europe.
	Paid surveyors of volunteers?	Volunteers.
	Sponsoring bodies	Stena Line provide free tickets, cabins and some food, an office etc. Sea Trust supplies some volunteer expenses with some intermittent grant aid from CCW and Environment Wales
	Form of sponsorship	
Main purpose of surveying/monitoring	*Specific objectives*	Seasonal presence and distribution
Temporal coverage	*Years sampled*	April 2004 to present
	Months sampled	All
	Fine-scale timing of surveys	Whenever suitable weather. Often once per week in summer at least once per month in winter.
	Duration of surveys	3.5 hours per leg
	Effort per survey – no. hours	3.5 hours
	Effort per survey – spatial coverage	
Spatial coverage	*Length of transect*	54 nautical miles berth to berth
	ICES cells surveyed	?
	Regional seas	St Georges Channel/South Irish Sea.
	How representative of the range of the species targeted is the survey area?	?
Methodologies used	*Type of observation platform*	Stena Ferry.
	No. and type of observers	Varies 3-10 occasionally 2 very rarely one.
	Height of observation	87 feet +- depending on load.
	Ship speed	Service speed 17.5 Knots
	Position on the ship	Bridge / Bridge Wings
	Type of survey	Constant Effort Transects
	Key sightings data collected	Species (no poss' prob' either def' or UNID Number seen (usually a best estimate, by age category (adult, calf). Latitude, Longitude, Distance to sighting,
	Key effort data collected	Usual stuff, SS,CC WD WS etc of survey recorded start and if practical as changes. Recently supplemented by relevant tidal, At'pressure, wind charts, etc for days of survey
	Use of logger software	Nope
	Additional recording 1	Some video
	Additional recording 2	Some unusual bird
	Recoding of effort data	As above we record right through survey
Species investigated	*Regular species*	Common Dolphin, Porpoise, Risso's
	Occasional species	Minke, Bottlenose
	Rare species	Orca and Fin Whale have been sighted as casual but reliable sightings by crew.
Measures for data quality control	*Observers experience and training*	I have led on all but two Surveys. We now have plenty of regular/senior surveyors. New volunteers are given ID materials to study and on-board training.
	Sightings categories	Definite or unidentified
	Data validation	If not sure = unidentified, but notes taken for future reference and video consulted where possible. Oddly we expected occasional LF Pilot's or perhaps Striped Dolphin but have not encountered or suspected either as yet
	Cross-checking photos	Prefer video.
	Data filtering	Point of entry.
Types of analyses completed on status	*Distribution*	In process
	Relative abundance	In process
	Absolute abundance	In process
Reporting	*Annual reporting, including websites and grey literature reports.*	Website, UK Cetnet and in process
	Scientific papers	In process
Any other information		Our survey methods have evolved to suit the short duration and often frenetic periods of recording. Our main aim is to get maximum observation and minimum entry of pedantic or irrelevant data. In order that we do not miss sightings and what we do enter is repeatable and relevant to the objectives of our surveys. We believe we could improve several aspects of survey technique with better technology /funding.