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LIFE PROJECT NAME

Small Cetaceans in the European Atlantic and North Sea (SCANS-II)

Data Project

Project location	
Project start date:	01/04/2004
Project end date:	31/12/2006
Total Project duration (in months)	33 months
Total budget	€ 3.11M
EC contribution:	€ 1.537M
(%) of total costs	49.39
(%) of eligible costs	49.39

Data Beneficiary

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2. Lists of key-words and abbreviations

Keywords

Harbour porpoise

Abundance

Surveys

Monitoring

Management

Abbreviations

ANF	Ministry of Agriculture, Nature and Food Quality, The Netherlands
CR	Conservation Research Limited, UK
CREEM	Centre for Research into Ecological and Environmental Modelling, Univ. of St Andrews, UK
DHI	DHI Water and Environment, Denmark
ESAS	European Seabirds at Sea
FNHM	Faroese Natural History Museum
FBC	Fjord & Baelt Centre, Denmark
IBTS	International Bottom Trawl Survey
ICN	Instituto da Conservação da Natureza, Portugal
IFAW	International Fund for Animal Welfare, UK
JNCC	Joint Nature Conservation Committee, UK
IWC	International Whaling Commission
MUMM	Management Unit of the North Sea Mathematical Models, Belgium
NERI	National Environment Research Institute, Denmark
SAMS	Scottish Association of Marine Science, UK
SCANS	Small Cetacean Abundance in the North Sea and adjacent waters (1994)
SCANS-II	Small Cetaceans in the European Atlantic and North Sea (2005)
SEC	Spanish Cetacean Society
SMRU	Sea Mammal Research Unit, University of St Andrews, UK
SPEA	Portuguese Society for the Study of Birds
UCC	University College Cork, Ireland
ULR	University of La Rochelle, France
UoG	University of Gdansk, Poland
UoK	University of Kiel, Germany
UoS	University of Stockholm, Sweden
UStA	University of St Andrews, UK

3. Executive Summary

The bycatch of cetaceans during fishing activities is a major threat to their conservation. Bycatch is a worldwide problem but the species most affected in European Atlantic waters including the North Sea are the harbour porpoise, *Phocoena phocoena*, in bottom set gillnet fisheries and the common dolphin, *Delphinus delphis*, in pelagic trawl fisheries.

There are three major constraints to assessing the current impact of bycatch on small cetaceans and, therefore, to determining the extent of measures that need to be taken to reduce levels to recover populations to or maintain favourable conservation status: the lack of recent abundance estimates; the lack of a management framework for setting safe bycatch limits; and the lack of well-developed and cost-effective methods for monitoring populations to determine whether or not conservation objectives are being met. If this information were available, together with information on levels of bycatch from monitoring programmes, Member States would be in a position to assess the impact of bycatch and take measures, as necessary, to ensure favourable conservation status of small cetacean populations. The SCANS-II project aimed to provide this information.

The **project objective** was to estimate small cetacean abundance in the North Sea and European Atlantic continental shelf waters, and to allow the assessment and management of bycatch and other anthropogenic threats through the development of improved methods for monitoring and a robust management framework, thus defining a clear course of action to allow populations to recover to and maintain favourable conservation status. The project followed the SCANS project in 1994 and provides an opportunity to observe how distribution and abundance has changed in the intervening decade.

The **expected results** were to provide:

- a management framework to determine safe limits to bycatch;
- robust estimates of abundance for small cetacean populations in the North Sea and European Atlantic;
- recommendations for cost-effective methods for monitoring abundance between major decadal surveys; and
- trained personnel and equipment to provide essential information for management in the future.

These results were achieved through a number of **key deliverables**:

- Review and development of visual and acoustic methods for collecting and analysing data from surveys
- Fieldwork manuals for data collection
- Trained visual and acoustic observers from many European countries
- Completion of shipboard and aerial surveys in the North Sea and European Atlantic
- Robust estimates of abundance for harbour porpoise, white-beaked, bottlenose and common dolphin, and minke whale for the entire European Atlantic continental shelf
- Recommendations for monitoring small cetacean populations, including an analysis to investigate the power of different methods to detect population trends and to assess the cost-effectiveness of these methods to achieve given power
- A management framework for determining safe limits to bycatch of small cetaceans including an application to harbour porpoise
- Dissemination of results through the project website, a final project conference, and other media

The project was **coordinated** by the University of St Andrews in the UK (the Beneficiary) and supported by eleven Partners in 10 countries. The project was Co-financed by a further seven departments and institutions in seven countries.

The project structure consisted of four preparatory Actions covering the development of acoustic, shipboard and aerial survey methods and final resolution of these methods prior to the execution of two non-recurring Actions to conduct shipboard and aerial surveys of the North Sea and European Atlantic continental shelf waters. The data from the surveys fed into the three main recurring Actions to develop a management framework to set safe limits to small cetacean bycatch, to recommend best practice for monitoring small cetacean populations, and to estimate abundance of small cetacean populations. Five Actions ensured that the project results would be widely disseminated: a project website; production of non-technical and technical reports; scientific publication of results and an end of project conference.

Technical Actions: A

A new system for the collection of acoustic data from harbour porpoises via towed hydrophones was developed, and three different hydrophone mounting options and three different lengths of towed hydrophone were explored and trialled. Shipboard survey methods (data collection and analysis) were reviewed and developed. Line transect surveys for cetaceans need to account for animals missed on the transect line and any responsive movement. The 'double platform' method used on the SCANS 1994 shipboard survey was adopted and improved. Important practical developments included the use of video cameras to measure angles and distances, the critical data for shipboard surveys. The tandem aircraft aerial survey method used on the SCANS 1994 survey was developed to use the circle-back or racetrack method with a single aircraft. The methods were trialled and refined on a 2 week pilot survey.

Technical Actions: C

A major survey for small cetaceans in the North Sea and European Atlantic continental shelf waters was carried out in July 2005, using seven ships and three aircraft. In total, 76 personnel were employed for the surveys, representing 14 European countries. Shipboard transects covered 19,614 km on searching effort in an area of 1,011,000 km^2. The aircraft flew 15,902 km on effort in good and moderate conditions in an area of 353,000 km^2. Thirteen different cetacean species were recorded and large quantities of high quality visual and acoustic survey data were produced for processing and analysis.

Technical Actions: D

A robust framework to determine safe limits to small cetacean bycatch was developed. The approach used was to test candidate management procedures with computer-based simulation models to ensure that they are robust to a wide range of uncertainties with respect to the biology of small cetacean populations (e.g. stock structure), the estimation of population size and bycatch, and environmental variability. A population model was developed for estimating the dynamics and status of harbour porpoise populations. Example safe bycatch limits for harbour porpoise were generated for SCANS-II survey blocks. The next steps required to take this work forward are described.

To develop recommendations for monitoring small cetacean populations, previously used methods were reviewed. In addition, sighting rates of cetaceans by observers on research vessels monitoring seabirds between 1980 and 2003 were analysed and their potential for providing indices of relative abundance to monitor trends in cetacean populations over time evaluated. Acoustic and 'seabird' observer cetacean data were collected on the shipboard survey to provide data to calculate indices of relative abundance. Monitoring methods were then tested, further developed and compared using power analysis and cost-benefit analysis to provide recommendations for best monitoring methods and a protocol that could be followed to make this evaluation in specific circumstances.

Estimates of abundance for harbour porpoise, bottlenose (*Tursiops truncatus*), common and white-beaked (*Lagenorhynchus albirostris*) dolphin and minke whale (*Balaenoptera acutorostrata*) were calculated from the shipboard and aerial surveys for each survey block, corrected for animals missed on the transect line and for any responsive movement. Estimates were also made using density surface modelling. Data from SCANS 1994 were reanalysed and SCANS-II 2005 estimates compared with them where possible. The main result was that total abundance of harbour porpoise in the North Sea and adjacent waters (area surveyed in 1994) had not changed in 2005 but the distribution had changed with densities lower in the north and higher in the south in 2005.

Administrative Actions: E and F

Information about the project and results from it were disseminated through a project website, non-technical and technical reports and an end of project conference. In addition, results will be published in the scientific literature.

The project was managed by scientists at the Sea Mammal Research Unit at the University of St Andrews, UK. All Actions were successfully completed.

In the After-LIFE Conservation Plan, next steps are outlined for the results to be taken up at the policy level.

4. Résumé exécutif

La capture accidentelle de cétacés au cours des activités de pêche est une menace majeure pour leur conservation. Les captures accidentelles sont un problème mondial ; les espèces les plus affectées dans les eaux européennes atlantiques, incluant la mer du nord, sont le marsouin commun, *Phocoena phocoena*, dans les pêcheries au filet maillant de fond et le dauphin commun, *Delphinus delphis*, dans les pêcheries au chalut pélagique.

Il y a trois contraintes majeures pour évaluer l'impact actuel des captures accidentelles sur les petits cétacés et donc déterminer l'étendue des mesures qui doivent être prises pour réduire les taux de captures accidentelles à des niveaux permettant de rétablir ou maintenir les populations dans des états de conservation favorables. Celles-ci sont le manque d'estimations récentes d'abondance, le manque d'un cadre de gestion permettant de définir des limites prudentes de captures accidentelles et le manque de méthodes de suivi reconnues et rentables permettant de déterminer si les objectifs de conservation sont atteints. Si ces informations étaient disponibles, ainsi que celles relatives aux niveaux de captures accidentelles fournies par les programmes de suivi, les Etats Membres seraient en situation d'évaluer l'impact des captures accidentelles et de prendre les mesures nécessaires pour assurer un état de conservation favorable aux populations de petits cétacés. Le projet SCANS-II avait pour objectif de fournir ces informations.

Les objectifs du projet étaient d'estimer l'abondance des petits cétacés dans les eaux néritiques de mer du Nord et de l'atlantique européen, et de permettre l'évaluation et la gestion des captures accidentelles et d'autres menaces d'origine humaine par le développement ou l'amélioration des méthodes de suivi et d'un cadre de gestion robuste, définissant ainsi un ensemble clair d'actions permettant aux populations de retrouver ou de se maintenir dans une état de conservation favorable. Le projet était une suite du projet SCANS réalisé en 1994 et a permis d'observer comment la distribution et l'abondance avaient changé au cours de la décennie passée.

Les résultats attendus consistaient à fournir :

- un cadre de gestion pour déterminer des limites prudentes de captures accidentelles ;
- des estimations fiables de l'abondance des populations de petits cétacés de mer du Nord et de l'atlantique européen ;
- des recommandations pour des méthodes efficaces de suivi d'abondance entre deux recensements décennaux et
- du personnel formé et des équipements pour produire les informations essentielles pour la gestion future.

Ces résultats furent réalisés au travers d'un certain nombre de produits clés:

- évaluation et développement de méthodes acoustiques et visuelles pour la collecte des données de recensements ;
- manuels de terrain pour la collecte de données ;
- observateurs visuels et acoustiques formés issus de nombreux pays européens ;
- réalisation de recensements embarqués et aériens en mer du Nord et dans l'atlantique européen ;
- estimations fiables d'abondance du marsouin commun, du dauphin commun, du dauphin à flancs blancs, du grand dauphin et du petit rorqual dans l'ensemble des eaux néritiques européennes ;
- recommandations pour le suivi des populations de petits cétacés, y compris une analyse de puissance des différentes méthodes pour détecter des tendances et évaluer l'efficacité de ces méthodes pour atteindre une puissance donnée ;
- cadre de gestion pour la détermination des limites prudentes de captures accidentelles de petits cétacés, incluant une application au marsouin commun ;
- dissémination des résultats par le site *web* du projet, une conférence de fin de projet et d'autres moyens de communication.

Le projet fut coordonné par l'Université de Saint Andrews au Royaume-Uni, (le Titulaire) et soutenu par onze partenaires de dix pays. Le projet fut co-financé par sept autres institutions provenant de sept pays.

La structure du projet consistait en quatre actions préparatoires couvrant le développement des méthodes de recensement acoustique, embarqué ou aérien et la résolution finale de ces méthodes avant l'exécution de deux actions ponctuelles que furent les recensements aériens et embarqués en mer du Nord et dans les eaux néritiques de l'atlantique européen. Enfin, les données de recensement furent utilisées dans les trois actions durables qui consistaient à développer un cadre de gestion permettant de fixer des limites prudentes de captures accidentelles de petits cétacés, de recommander des meilleures pratiques pour le suivi des populations de petits cétacés, et d'estimer l'abondance de ces mêmes populations. Cinq actions assurèrent la dissémination large des résultats du projet : un site *web* dédié au projet, un rapport technique, un rapport public, des publications scientifiques des résultats et une conférence de fin de projet.

Actions techniques: A

Un nouveau système de collecte de données acoustiques par hydrophones tractés a été développé pour le marsouin commun. Trois options différentes de montage des hydrophones et trois longueurs d'hydrophones tractés ont été explorées et testées. Les méthodes de recensement embarqué (collecte et analyse des données) furent revues et perfectionnées. Les recensements de cétacés par transect linéaire nécessitent de considérer les animaux présents mais non observés sur la ligne du transect et les mouvements des animaux en réponse à l'approche du navire. La méthode à double plateforme utilisée lors des recensements embarqués de SCANS 1994 fut adoptée et améliorée. Les développements pratiques principaux inclurent l'utilisation de caméras vidéo pour mesurer les angles et les distances, des données essentielles pour les recensements embarqués. La méthode de recensement aérien en tandem utilisée lors de SCANS 1994 a été transformée en une méthode de double passage utilisant un seul avion. Ces méthodes ont été testées et raffinées au cours d'une campagne pilote de deux semaines.

Actions techniques: C

Un grand recensement des petits cétacés des eaux néritiques de mer du Nord et de l'atlantique européen fut conduit en juillet 2005, utilisant sept navires et trois avions. Au total, 76 observateurs furent employés dans les recensements, représentant quatorze pays européens. Les transects réalisés par bateau couvrirent 19.614 km en effort de recherche dans une zone de 1.011.000 km^2. Les avions ont parcouru 15.902 km en effort d'observation en condition bonne à modérée dans une zone de 353.000 km^2. Treize espèces différentes de cétacés furent notées et une grande quantité de données acoustiques ou de recensement embarqué et aérien d'excellentes qualités fut produite en vue des analyses ultérieures.

Actions techniques: D

Un cadre de gestion fiable pour déterminer des limites prudentes de captures accidentelles de petits cétacés fut développé. L'approche suivie consistait à tester par des simulations informatiques des procédures de gestion potentielles pour s'assurer qu'elles étaient fiables dans une large gamme d'incertitude sur la biologie des populations de petits cétacés (par exemple : structure des stocks), l'estimation des tailles de populations, l'estimation des captures accidentelles ainsi que la variabilité environnementale. Un modèle de population fut développé pour estimer la dynamique et le statut des populations de marsouins communs. Des limites prudentes de captures accidentelles furent générées à titre d'exemple pour chaque bloc de recensement SCANS-II. Pour poursuivre ce travail, plusieurs étapes supplémentaires seraient nécessaires.

Les méthodes antérieures de développement de recommandations de suivi des populations de petits cétacés ont été revues et évaluées. De plus, les taux d'observation de cétacés par les observateurs chargés du suivi des oiseaux de mer sur des navires de recherche entre 1980 et 2003 ont été analysés afin d'évaluer leur potentiel pour fournir des indices d'abondance relative des petits cétacés qui permettraient de suivre les tendances qui affectent ces populations au cours du temps. Les données acoustiques et les données d'observateurs d'oiseaux ont été collectées lors des recensements embarqués afin de calculer des indices d'abondance relative. Les méthodes de suivi furent alors testées, améliorées et comparées au moyen d'analyses de puissance et d'analyses de rentabilité dans le but de fournir des recommandations quant à la meilleure méthode de suivi ainsi qu'à un protocole qui puisse être appliqué pour mener cette évaluation dans des circonstances spécifiques.

Des estimations d'abondance ont été calculées pour chaque bloc de recensement pour le marsouin commun, le grand dauphin (*Tursiops truncatus*), le dauphin commun, le dauphin à flancs blancs (*Lagenorhynchus albirostris*) et le petit rorqual (*Balaenoptera acutorostrata*) à partir des données des campagnes embarquées et aériennes, corrigées des individus présents sur la ligne de transect mais non observés ainsi que des mouvements de réponse à l'approche des navires. Les estimations furent également réalisées par modélisation spatiale des densités. Les données de SCANS 1994 furent ré-analysées et comparées avec celles de SCANS-II 2005 partout où cela était possible. La principale conclusion fut que l'abondance des marsouins communs en mer du Nord et dans les secteurs adjacents (couverts en 1994) n'avait pas changé en 2005 mais que leur distribution avait changé, avec des densités plus faibles au nord et plus élevées au sud en 2005.

Administrative Actions: E and F

Les informations et les résultats issus du projet furent divulgués au moyen du site internet du projet, de rapports technique et public et d'une conférence de fin de projet. De plus, les résultats seront publiés dans la littérature scientifique.

Le projet fut géré par des scientifiques du *Sea Mammal Research Unit*, Université de Saint Andrews, Royaume Uni. Toutes les actions furent réalisées avec succès.

Dans la perspective d'un futur plan de gestion, les prochaines étapes permettant de porter les résultats de ce projet LIFE aux niveaux opérationnel et politique sont présentées.

5. Introduction

The bycatch of cetaceans during fishing activities is a major threat to their conservation. Bycatch is a worldwide problem but the species most affected in European Atlantic waters including the North Sea are the harbour porpoise, *Phocoena phocoena*, in bottom set gillnet fisheries and the common dolphin, *Delphinus delphis*, in pelagic trawl and other fisheries. Levels of *P. phocoena* bycatch have been assessed in several areas through independent bycatch monitoring schemes. In particular, in the early 1990s, an estimated 2,200 porpoises were taken annually by English and Irish hake fishing in the Celtic Sea (Tregenza *et al.* 1997) and an estimated 6-7,000 porpoises were bycaught annually in Danish gillnet fisheries in the central and southern North Sea in the same period (Vinther 1999, Vinther & Larsen 2004). In response to concerns about the impact of this bycatch, the Commission and seven Member States supported project SCANS (Small Cetacean Abundance in the North Sea and adjacent waters - LIFE 92-2/UK/027) which, in 1994, estimated abundance of harbour porpoise, white-beaked dolphin and minke whale in these waters for the first time (Hammond *et al.* 2002). Results showed that in some areas bycatch of *P. phocoena* was likely to be unsustainable. Gillnet fishing effort on monitored vessels declined at the end of the 1990s but it is not know whether total bycatch has also declined.

By comparison, D. delphis bycatch in pelagic trawls has received relatively little attention. Large numbers were taken in the drift net fishery for albacore tuna in the 1990s (Rogan & Mackey, 2007). Average annual bycatch for 2000-2003 in the UK bass trawl fishery has been estimated at 91 animals (Northridge *et al.* 2003). More information should result from the EC-funded project PETRACET.

There are three major constraints to assessing the current impact of bycatch on small cetaceans and, therefore, to determining the extent of measures that need to be taken to reduce levels to recover populations to or maintain favourable conservation status: the lack of recent abundance estimates; the lack of a management framework for setting safe bycatch limits; and the lack of well-developed and cost-effective methods for monitoring populations to determine whether or not conservation objectives are being met. With this information, and information on levels of bycatch from monitoring programmes, Member States could assess the impact of bycatch and take measures, as necessary, to ensure favourable conservation status of small cetacean populations.

The SCANS-II project aimed to provide this information. The **project objective** was to estimate small cetacean abundance in the North Sea and European Atlantic continental shelf waters, and to allow the assessment and management of bycatch and other anthropogenic threats through the development of improved methods for monitoring and a robust management framework, thus defining a clear course of action to allow populations to recover to and maintain favourable conservation status. The project thus followed the SCANS project in 1994 and provides an opportunity to observe how distribution and abundance has changed in the intervening decade.

The **socio-economic context** of the project is that European fisheries are under increasing pressure. Total allowable catches and fleet capacities have declined. The Commission's Council Regulation laying down measures concerning incidental catches of cetaceans in fisheries and amending Regulation (EC) No 88/89 (2003/0163 (CNS)) specifies mitigation measures that will increase pressure on fisheries. The severity of such measures depends on the impact of bycatch on small cetacean populations. The results of SCANS-II will enable the bycatch of small cetaceans to be placed in a population context and the recommendations on cost-effective ways to monitor populations and on safe limits to bycatch will provide guidance to Member States and the Commission to impose management actions that are sufficient to allow populations to recover to or maintain favourable conservation status, without placing an unnecessary burden on the fisheries sector.

The three main **expected results** were:

- a management framework to determine safe limits to bycatch;
- robust estimates of abundance for small cetacean populations in the North Sea and European Atlantic;
- recommendations for cost-effective methods for monitoring abundance between major decadal surveys.

Hammond, PS *et al.* 2002. Abundance of harbour porpoises and other cetaceans in the North Sea and adjacent waters. *Journal of Applied Ecology* 39: 361-376. Northridge, S. 2003. Investigations into cetacean bycatch in a pelagic trawl fishery in the English Channel: preliminary results. Paper SC/55/SM26 presented to the Scientific Committee of the IWC. Berlin, Germany. June 2003. Rogan, E & Mackey, M 2007. Megafauna bycatch in drift nets for albacore tuna (*Thunnus alalunga*) in the NE Atlantic. *Fisheries Research* 86: 6-14. Tregenza, NJC *et al.* 1997. Harbour porpoise (*Phocoena phocoena*) by-catch in set gillnets in the Celtic Sea. *ICES Journal of Marine Science* 54:896-904. Vinther, M. 1999. Bycatches of harbour porpoises *Phocoena phocoena* in Danish set net fisheries. *Journal of Cetacean Research and Management* 1: 123-135. Vinther, M & Larsen, F. 2004. Updated estimates of harbour porpoise (*Phocoena phocoena*) bycatch in the Danish North Sea bottomset gillnet fishery. *Journal of Cetacean Research and Management* 6: 19-24.

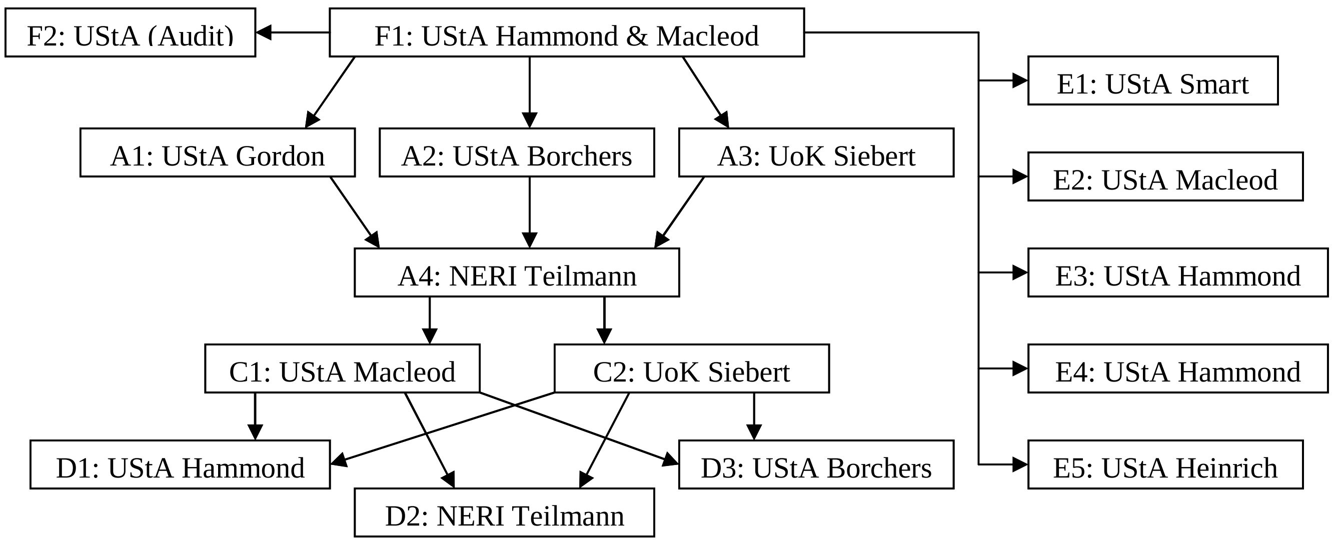
6. LIFE-project framework

Project organisation

The project was coordinated by the University of St Andrews in the UK (the Beneficiary) and supported by 11 partners: Natural Environmental Research Institute (Denmark), University of La Rochelle (France), Ministry of Environment and Sustainable Development (France), Christian Albrechts University of Kiel (Germany), University College Cork (Ireland), Ministry of Agriculture, Food and Nature Quality (Netherlands), Institute of Marine Research (Norway), University of Gdansk (Poland), Institute for Nature Conservation (Portugal), Spanish Cetacean Society (Spain) and Joint Nature Conservation Committee (UK). The project was co-financed by the Danish Forest and Nature Agency, German Federal Ministry, Department of Environment, Heritage and Local Government (Ireland), Institute for Nature Conservation (Portugal), Spanish Cetacean Society, Swedish Environmental Protection Agency and Department for Environment, Food and Rural Affairs (UK). Subcontractors were Fjord and Baelt Centre (Denmark), GDNatur (Denmark), University of Stockholm (Sweden), Alterra (The Netherlands), Conservation Research Ltd (UK) and International Fund for Animal Welfare (UK).

Project structure

Four preparatory Actions covered the development of acoustic (A1), shipboard (A2) and aerial (A3) survey methods and final resolution of these methods (A4) prior to the execution of Actions to conduct shipboard (C1) and aerial (C2) surveys of the North Sea and European Atlantic continental shelf waters. The data from the surveys fed into the three main Actions to develop a management framework to set safe limits to small cetacean bycatch (D1), to recommend best practice for monitoring small cetacean populations (D2), and to estimate abundance of small cetacean populations (D3). Five Actions ensured that the project results would be widely disseminated: project website (E1); production of non-technical (E2) and technical (E3) reports; scientific publication of results (E4) and an end of project conference (E5). An organogramme of Actions including lead organizations and persons is given below.



Project modifications

The Commission was informed of a new subcontractor, Conservation Research Limited, in December 2004.

Under Action A1, training acoustic operators on a cruise on the *Belgica* in May/June 2005 replaced the need to hold an acoustic training workshop at St Andrews as originally intended. Costs of the *Belgica* (90,000 Euro) were covered by MUMM, Belgium; the project covered travel and subsistence costs for the acoustic operators.

Under Action A2, Firestores were purchased instead of hiring laptops within the overall budget for the video-range kit, as approved by the Commission in March 2005.

Under Action A4, the length of the pilot survey reduced from 4 to 2 weeks for financial and technical reasons.

7. Results

Summary of Project Milestones

Milestone	**Reference Action**	**Expected date of delivery [1]**	**Date of completion**
Survey platforms reserved for charter	C1, C2, A4	Sept 04	Dec 04
Development of fixings for hull mounted hydrophone	A1	March 05	March 05
Existing methods for monitoring reviewed	D2	March 05	June 05
Shipboard and aerial survey methods reviewed	A2, A3	March 05	June 05
Shipboard survey completed	A4	April 05	April 05
Aerial pilot survey completed	A4	April 05	April 05
Complete workshop to evaluate monitoring methods and data collected during the pilot surveys	D2	June 05	Oct 04
Methods for analysing survey data to estimate absolute abundance from survey data established	A2	June 05	June 05
Finalise shipboard and aerial data collection methods	A2, A3	June 05	June 05
Complete field handbooks	A2, A3	June 05	June 05
Finalisation of harbour porpoise automated detection equipment	A1	June 05	June 05
Completion of training workshop for acoustic operators	A1	June 05	June 05
Complete shipboard survey	C1	July 05	July 05
Complete aerial surveys	C2	July 05	July 05
Website updated	E1	Aug 05	Aug 05
Supply shipboard and aerial survey data to D. 3	C1, C2	Aug 05	Aug 05
Complete workshop to analyse monitoring data and draft recommendations	D2	Dec 05	Oct 06
Management software completed	D1	June 06	Dec 06
P. phocoena, *D. delphis* and other cetacean abundance estimated	D3	June 06	Nov 06[2]
Recommendations for monitoring cetaceans finalised	D2	June 06	Dec 06
Safe bycatch limits for *P. phocoena* established	D1	June 06	Dec 06
Website updated	E1	Dec 06	Dec 06
Final report written	E4	Dec 06	June 07
Results disseminated and Conference held	E5	Dec 06	Dec 06
Accounts audited	F2	Dec 06	June 07

[1] As indicated in the proposal

[2] Aerial analysis completed March 2006.

A Preparatory Actions

A1: Acoustic survey development

Development of acoustic detection system

Porpoises produce regular narrow band click type vocalisations, with their dominant energy in the frequency range 115-145 kHz, which are readily discriminated from other ocean sounds. Other small cetacean species produce similar sounds. Acoustic detection can be automated using modern signal processing techniques and by exploiting the availability of considerable processing power in modern, low cost, computers. Acoustic detection systems have a number of advantages over visual ones. They are less affected by meteorological conditions, and are often more predictable and consistent in their performance than human observers. These features make acoustic data potentially valuable for monitoring cetacean populations. Part of the SCANS-II project was therefore to develop a system that could be deployed on the main surveys (Action C1) to collect data to assess a towed acoustic system as a potential monitoring method (Action D2).

It was the original intention that an acoustic detection system developed by Gillespie & Chappell should be used during the SCANS-II surveys. However, due to increases in the processing power of affordable desktop PCs coupled with advances in affordable sound digitising cards, a new system was developed by Gillespie (IFAW) in which the processing load was transferred from the analogue electronics modules used by Gillespie & Chappell to real-time signal processing software. This had considerable advantages in terms of cost (software being cheaper to replicate than specialist electronics) but also, more importantly, in the level of detail that could be extracted from each detected porpoise click. A description of the system is given in Appendix A1.1.

Prior to the main survey in July 2005 (Action C1), the system was tested on two pilot surveys. The first was the dedicated two week project pilot survey in April 2005 (Action A4, Appendix A4.1). This is an area of high porpoise density and was an ideal location for testing the online data collection system and for collecting data for development of offline click classification algorithms. Additional data were also collected on a 9-day cruise on the 51m Belgian research vessel *Belgica*, while on passage from Cádiz, Spain to the vessel's home port of Zeebrugge. This also provided an opportunity to train acoustic operators for the main survey (Action C1).

The field manual for operation of the passive acoustic detection system is given in Appendix A1.2.

Development and comparison of deployment options for collecting acoustic data from ships

To collect acoustic data on cetacean surveys (especially those for harbour porpoise) that could be used for monitoring purposes (see Action D2), hydrophone arrays are typically towed behind the survey ship; however, there are tradeoffs in using towed arrays of different lengths. Longer arrays will generally result in reduced noise levels and deeper towing depths but they are more difficult to deploy and transport than shorter arrays. The behavioural response of porpoises to the survey ship may also influence how tow length affects detection probability. Alternatively, there are advantages in being able to monitor from hydrophones positioned on or close to the bow or hull of a vessel. These include: the potential for collecting data from platforms which might find it difficult to tow hydrophones; an ability to detect animals ahead of the ship before they may respond to it; and to increase the spatial and temporal overlap between the areas monitored acoustically and visually during dual mode surveys.

As a step towards development of practical methods for collecting acoustic data for monitoring porpoises, three hydrophone mounting options were explored and trialled: Bow (two designs), Bomb (weighted depressor) and Keel mounted designs. Relative effectiveness of detecting porpoise vocalisations was assessed by deploying a traditional towed array design at the same time to allow a simultaneous comparison of both systems. In addition, the detection rates for three different lengths of towed hydrophone, 100, 200 and 400m, were explored.

The basic design and attachment method for the hull-mounted hydrophones was completed in March 2005. Trials were conducted by SMRU (UStA) in November/December 2005 on the RV *Calanus* in collaboration with the Scottish Association for Marine Science (SAMS) in Oban and in April 2005 on the RV *Scotia* in collaboration with Fisheries Research Services (FRS) in Aberdeen. Further trials were conducted on the project pilot survey in April 2005 (Action A4). Data were analysed using methods described in Appendix C2.3.

Results and conclusions are described in detail in Appendix A1.3. Fewer porpoise detections were made by both Bow mount designs than the 200m towed array, although results were only significant for one design. Both Bomb designs significantly underperformed compared to the 200m towed array. The Keel mount design was similar to the Bomb designs and the less effective of the two Bow designs. As expected, the 400m towed array performed better than the shorter 100m and 200m arrays.

Based on these results, we recommend that acoustic arrays should be towed at 400m, further work on bow and keel mount designs should be pursued and further studies of porpoise behaviour around survey ships should be conducted to improve understanding of how this affects detection rates.

A2: Shipboard survey methods development

Since 1994, when the first SCANS project was carried out, there had been several key developments in aerial and shipboard survey and analysis methods. To inform the development of methods to be used in the SCANS-II project, the CREEM (UStA) carried out a review of data collection and analysis methods for shipboard data (Appendix A2.1). The review identified new methods that had been developed since SCANS 1994, the development work carried out and the methods used in SCANS-II.

Three meetings were held at the University of St Andrews to discuss the development of visual methods that would be used on the main SCANS-II shipboard surveys (Action C1). The meetings were integral to the development and agreement of the methods that would be tested on the pilot survey (Action A4). The development focused on achieving an automated data logging method and improving methods to measure distance and angle to sightings; critical data for estimating abundance accurately.

The agreed method was a double platform shipboard survey with two teams of observers. One team, “Tracker”, searches from the higher platform using binoculars to observe far away from the ship and the second team, “Primary”, searches with naked eye closer to the ship. This method was employed on the first SCANS survey in 1994 and allows abundance estimates to be corrected for animals missed on the transect line and for movement of animals in response to the survey ship.

The existing data collection software Logger (developed by IFAW) was adapted for data collection on board the survey ships. This software allows a data recorder on the Tracker platform to record data into a laptop computer in real time. The Logger program was modified to cope more effectively with double platform survey data. In particular, a system for automating the collection of sighting angle and distance data to improve accuracy and avoids bias introduced by observer error was implemented. Observers had sighting buttons which when pressed opened the sightings page in Logger, time and date stamped the record, and triggered the reading of sighting angle and distance. The system for measuring sighting angles was based on a webcam positioned on the underside of binoculars which took snapshots of parallel lines on the deck at each button press. A program was developed to calculate angles from the snapshot. The field manual for using program Logger is given in Appendix A2.2.

A system to calculate sighting distance using a video-range technique was developed. The video operated on a buffered system so that when the sightings button was pressed, frames from the previous 6 seconds of footage were stored. This ensured that the first surfacing of the animal was captured. The button press also triggered the audio system, so that the observers recorded their sightings information via microphone to be recorded on soundcards in the data-recording laptop computer. The project benefited from a development in computer hardware, the “Firestore”, which captures and stores digital imagery from video cameras and thus simplifies the overall collection, processing and storage of images, which means the technique is more transferable for use on other surveys.

Leaper designed a data validation program for use at the end of each day by observers. The program stepped through the sighting records made throughout the day. Each sighting had an associated audio file, which allowed the observer to check what they said at the time and that it had been entered correctly. It also allowed any blank field to be completed (in high density areas, the data recorder may not have had time to fill in all data real-time). The video and webcam images for distance and angle calculation, respectively, were also linked to each sighting record and accessed through the validation program. The visual data system relied heavily on electronics and computer programming; back-up procedures were needed should any part of the system fail. Pre-prepared paper data sheets were available for each ship. Data storage on each ship was on two 300GB Maxtor hard drives. The Logger database and all video and camera imagery were backed up on both Maxtor hard drives at the end of each survey day. The acoustic data were also backed up on both hard drives. The field manual for using the validation program and video-range equipment is given in Appendix A2.3.

At the final meeting under this Action, held in April 2005, visual survey methods were finalised in time to be tested on the pilot survey (Action A4) and a trial of equipment and software was conducted. A training plan for cruise leaders on the pilot survey was developed to ensure that all elements of the survey methods were covered. Field handbooks for cruise leaders and observers are given in Appendices A2.4 and A2.5, respectively.

A3: Aerial survey methods development

In 1994, the SCANS survey had used a novel method developed by Hiby (CR) to estimate the proportion of schools that were missed on the transect line, a particularly difficult problem in aerial surveys. This method used two aircraft flying in tandem and allowed the estimation for the first time of absolute abundance of harbour porpoise from aerial surveys. Since then, the method had been further developed to use a single aircraft that circled back over sections of transect line in a “racetrack” pattern to achieve the same effect as one aircraft following another. For SCANS-II, the question was whether to use the new racetrack method that had been used successfully in surveys in Germany and the USA or to use the earlier tandem aircraft method. This was discussed at a one-day meeting in Cambridge, UK on 12 August 2004 to begin work on the aerial survey development, attended by Hammond (UStA), Donovan (IWC), Lovell and Hiby (CR). At the same time, a review of recent developments in aerial survey methods and how to implement them was carried out by UoK (Appendix A3.1).

The programs used to collect data in the SCANS project in 1994 no longer existed and would have had to be recreated if the tandem aircraft method used for SCANS were to be used in SCANS-II. This was possible but would take a considerable period of time. For the recently developed racetrack method, the co-pilot enters all effort and sightings data on a laptop in real time. The observers record times abeam with a push button connected to the laptop and give other data verbally over the intercom to the co-pilot. This avoids data entry at the end of each day but could be difficult in areas of very high density. However, users of the system had indicated that this was not a problem.

Some preliminary analyses were conducted, using recently collected German data and for data collected during SCANS 1994, to determine that the analysis program was correctly implementing the method, to investigate the properties of the method as local density increased, to compare circle-back with tandem in terms of precision of estimates, and to look for evidence that detection probability was higher on the second circle-back track. This work was completed in April 2005 and the results indicated that the racetrack method was sound. Because of this and because the data collection and analysis programs were already in use, it was agreed to use the racetrack method in the main aerial survey (Action C2).

The subcontractor Conservation Research Ltd (CR) undertook the development of the data collection and analysis software and wrote the user’s field manual Appendix A3.2). The University of Kiel (UoK) organised survey equipment, personnel and other logistics. Purchasing of equipment for the pilot and main surveys was organised through the University of St Andrews, in conjunction with UoK.

The methods were trialled on the pilot aerial survey (Action A4). Data collection and/or analysis software were modified, as necessary, post pilot survey.

A4: Resolution of survey methods

Development work completed under actions A1-A3 all fed into the pilot surveys, the aims of which were to test all field methodologies and equipment and to train all the cruise leaders so that they in turn could train observers on the main surveys (Actions C1 and C2). The shipboard survey also tested acoustic methods for future monitoring surveys. Collection of data to estimate abundance was secondary to these aims.

Shipboard pilot survey

All of the four tenders for the pilot shipboard survey were more expensive than the budget allocated; the survey period was subsequently reduced to 2 weeks, which was determined to be sufficient. The tender was awarded to Göteborg University, Sweden for the charter of RV *Skagerak*.

The shipboard pilot survey took place 17-30 April in the Kattegat, Skagerrak and Danish Belts and was coordinated by Macleod (UStA), Burt (UStA) and Teilmann (NERI). Other participants were the cruise leaders for the main surveys (Cañadas, Desportes, Leopold, Rogan, Skov, Vázquez) and personnel who had developed the visual and acoustic data collection systems (Gillespie, Gordon and Leaper).

The first two days were spent setting up survey equipment and platforms before heading to sea. When weather permitted, surveying was carried out to train cruise leaders and test equipment. Adjustments to the visual and acoustic systems were made as the need arose. Decisions were made on the best binoculars to use for the tracking platform, the final design of the platforms and on how to conduct distance and angle experiments. Each evening was spent discussing the days training and problems arising and changes to the methodology were adopted. During and after the survey, field manuals for the visual (Appendices 2.2-2.5) and acoustic (Appendix A1.2) methods were reviewed and finalised.

The acoustic “bomb” (Action A1) was trialled but resulted in extremely noisy data and it was agreed that it would not be possible to use this method on the main survey ships in July 2005.

Aerial pilot survey

From the six tenders, the aircraft charter for the pilot survey was awarded to the highly experienced Danish Air Survey. The aerial pilot survey took place 17-24 April 2005; several 2-hour flights were conducted on three of these days in the Great Belt area and north of the island of Fyn. Project participants were Hiby & Lovell (CR), Scheidat UoK), Greg Donovan (IWC) and the three cruise leaders Van Canneyt (ULR), Gilles & Lehnert (UoK). The new AudioVOR software and hardware was tested and worked well. The cruise leaders were trained to use the programs and in the survey methodology. As for the shipboard system, automated data collection was triggered through the push of a sightings button and all data were relayed verbally into an audio system. A full report of the aerial pilot survey is given in Appendix A4.2.

Further trials of the system were conducted in May 2005 on regular surveys conducted by the University of Kiel, outside the SCANS II project but lead by Scheidat (UoK).

During and after these surveys, protocols for application of the data collection methods were finalised and the aerial survey field manual was reviewed and finalised (Appendix A3.2).

An additional training flight for the French crew onboard one of the aircraft used in the main survey (Action C2) was conducted in May 2005. The pilot had no experience of conducting this type of survey and it was therefore crucial that this additional training be conducted prior to the main flights in July 2005. Van Canneyt (ULR) and Lovell (CR) led the training programme.

In conclusion, the shipboard and aerial pilot surveys, as informed by the development of acoustic (Action A1), shipboard (Action A2) and aerial (Action A3) survey methods, were essential preparation for the main surveys (Actions C1 and C2).

C Non-recurring biotope management

C1: Shipboard continental shelf surveys

Ships for the main surveys in July 2005 were selected through a European Directives Open Tender Procedure. A request for ships and specification was posted in the European Journal and tenders were chosen and finalised in December 2005. Seven ships were chartered to survey the area (Table 1) and each was assigned to a survey stratum (Figure 1). The shipboard surveys were conducted 27 June - 29 July 2005, except the *Skagerak* which finished surveying on 17 July.

Cruise leaders for each ship were personnel already involved with the project as partners or subcontractors. The remaining cetacean observers were recruited through advertisements in November 2004, distributed widely to ensure observers throughout Europe had the opportunity to apply. Forty-seven shipboard observers were employed on short-term contracts to the University of St Andrews. Cetacean observers were selected based on their experience of carrying out cetacean line-transect surveys and spending extended periods at sea. However, it was also important to ensure that a mix of nationalities took part to allow training of observers in the countries involved with the project. All ships were assigned two seabird observers with exception of *Skagerak* (one observer) and *Mars Chaser* (no observer).Seabird observers were employed through the cooperation of the European Seabirds at Sea Team (ESAS), the UK Joint Nature Conservation Committee (JNCC) and the Portuguese Society for the Study of Birds (SPEA). In total, 67 personnel were employed for the shipboard surveys, representing 14 European countries (Figure 2).

Cruise reports for all seven ship surveys are given as Appendices C1.1 - C1.7.

Table 1: Ships used and areas (blocks) surveyed during the SCANS-II surveys

Ship	Block code	Area description	Embarkation /disembarkation port	Cruise Leader
Skagerak	S	Kattegat, Skagerrak and western Baltic	Gothenburg, Sweden	Teilmann (NERI)
West Freezer	T	Northern North Sea	Aberdeen, UK	Desportes (FBC)
Gorm	V	North central North Sea	Hantsholm, Denmark	Skov (DHI)
Victor Hensen	U	South central North Sea	Bremerhaven, Germany	Leopold (Alterra)
Mars Chaser	Q	West of Scotland and Ireland	Midvagur, Faroe Islands	Macleod (UStA)
Zirfaea	P	Celtic Sea and northern Bay of Biscay	Scheveningen, Netherlands	Rogan (UCC)
Investigador	W	Iberian shelf	Vigo, Spain	Vázquez + Cañadas (SEC)

Visual surveys for estimating abundance

Advanced line transect sampling methods were used during the shipboard surveys, as described under Action A2 (data collection) and Action D3 (data analysis). The methods required two teams of observers on each ship: a primary team to search with naked eyes and a tracker team that searched further ahead of the ship through binoculars from a higher platform. There were eight cetacean observers per ship, including the cruise leader.

The data collection system on the ships was state-of-the-art, and involved specially developed equipment and software as described under Action A2. Inevitably, some technical difficulties arose on some of the ships at the start of the surveys but a shore-based “helpline” (primarily Leaper, Gillespie, Borchers , Hammond and Berggren) was available for the month so that technical expertise was at hand. Consequently, all surveying was carried out to a high standard. Survey conditions were poor at times, particularly in the western survey strata. However, ships completed, on average, greater than 70% of the planned survey coverage.

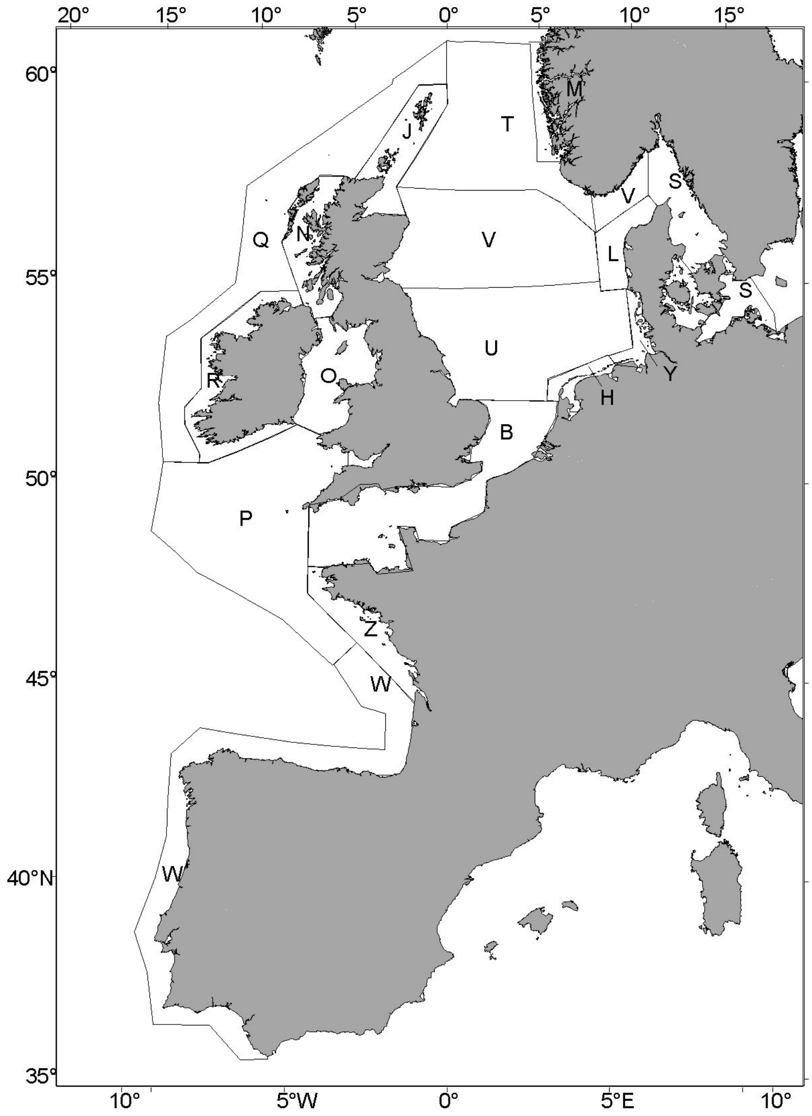


Figure 1: Survey blocks defined for the SCANS-II surveys. Those surveyed by ship were S, T, V, U, Q, P and W (see Table 1). The remaining strata were surveyed from aircraft (Action C2).

Shipboard transects covered 19,614 km on searching effort in an area of 1 011 000 km^2 (Figure 2). Thirteen cetacean species were recorded. Sightings of harbour porpoise were widely distributed throughout the North Sea and adjacent waters, Irish Sea and around the Scottish coast (Figure 3). Few sightings were made south of 47ºN, corroborating expectations of lower densities of porpoises in this area.

Common dolphin sightings were restricted to the west of the UK, Ireland, France and the Iberian Peninsula. Bottlenose dolphin sightings were also more numerous to the west. Other cetaceans recorded included minke, fin, killer and pilot whales; striped, Risso’s, Atlantic white-sided and white-beaked dolphins. The ship surveying Iberian waters (block W) also encountered Cuvier’s and Sowerby’s beaked whales.

All data were provided to the Leader of Action D3 (Borchers, UStA) in August 2005 in preparation for data validation and analysis.

Acoustic surveys

All ships towed an acoustic detection system as described under Action A1 and detailed in Appendix A1.1. The system required little or no user input other than start up and data archiving. The primary role of the acoustic operator on each ship was as a visual cetacean observer. Data were collected from all ships and 29,000 km were surveyed on acoustic effort. 705 harbour porpoise events were detected, of which 324 could be tracked. These data were analysed under Action D2.

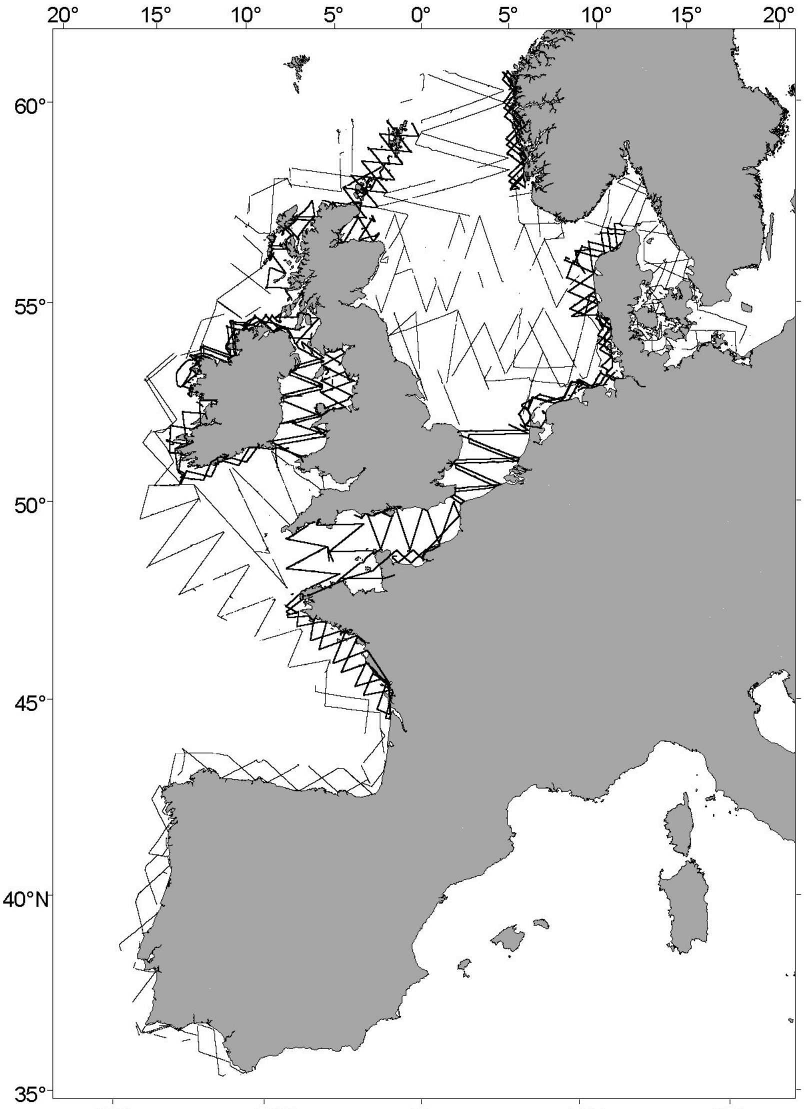


Figure 2: Transects surveyed on effort. Grey = shipboard effort; black = aerial effort.

Shipboard visual and acoustic survey in the Baltic Sea

An additional ship, *Oceanograf II*, was contributed to the survey effort by project partners University of Gdansk. This ship surveyed the Polish Baltic to collect data on relative abundance of harbour porpoises during two weeks in July. A team of four were onboard, including Cruise leader Kuklik (UoG). The aim of the survey was to use methods and collect data for monitoring harbour porpoises in an area where density is known to be very low. A single platform visual survey and an acoustic survey using the acoustic detection system developed under Action A1 were carried out. In total, the acoustic and visual survey effort amounted to 1,602km. Although no sightings were recorded of harbour porpoises, two probable acoustic detections were made. Both detections were isolated clicks characteristic of harbour porpoise. The acoustic detection system has remained at the Hel Marine Station, Gdansk with a view to it being used during future monitoring surveys of these waters.

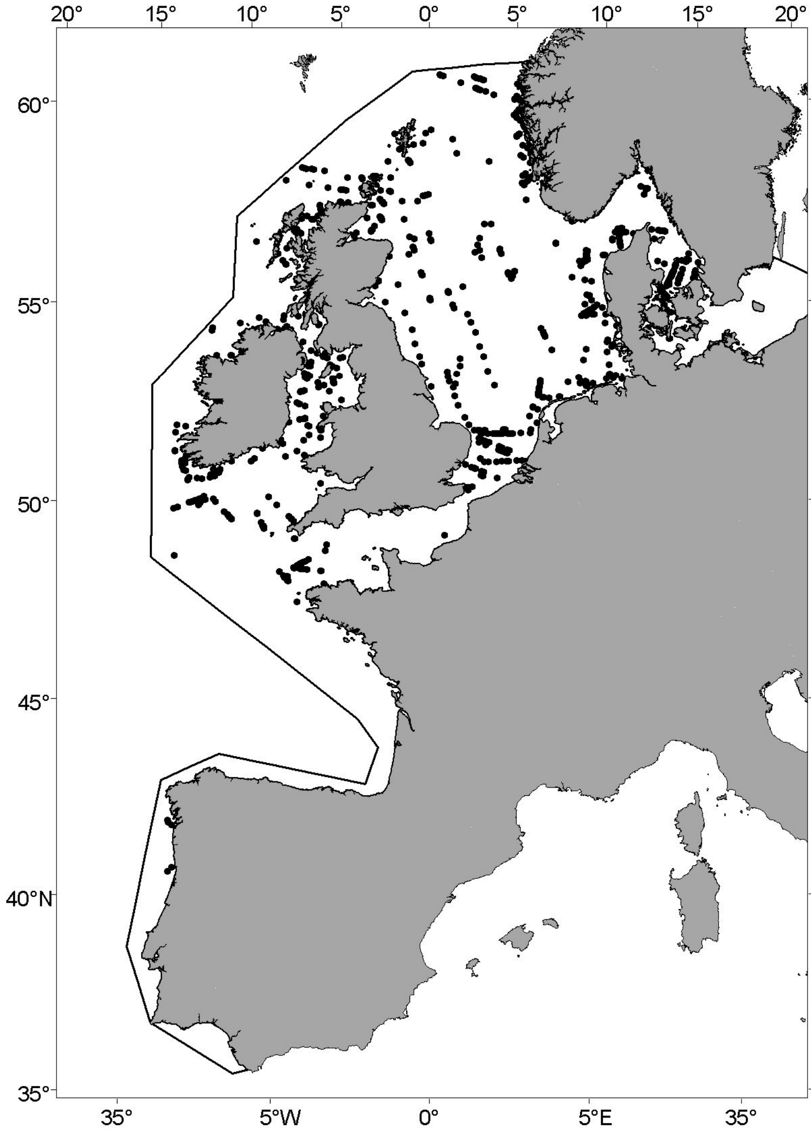


Figure 3: Sightings of harbour porpoise during the shipboard and aerial surveys.

C2: Aerial continental shelf surveys

Aircraft for the main surveys were also chosen through a tender procedure. Three aircraft from different companies were awarded contracts. The aircraft/survey teams were assigned to blocks primarily according to proximity to their home base (Table 2). Nine observers were selected from the response to the advert posted in November 2004, based on their experience of carrying out cetacean aerial surveys. Three of the nine were selected as cruise leaders (Table 2), who acted as navigators and were responsible for entering environmental and sightings data during the flight.

Table 2: Areas surveyed by aircraft and associated team leader. Block code letters refer to Figure 1.

Survey Team	Block code	Cruise Leader
I	J, N, O, R	Lehnert (UoK)
II	B, H, M, Y	Gilles (UoK)
III	B, O, R, Z	Van Canneyt (ULR)

The survey technique used was the "racetrack" method developed by Hiby & Lovell (CR), as described under Action A2. Excellent coverage was achieved; the aircraft flew 15,902 km on effort in good and moderate conditions in an area of 353,000 km^2 (Figure 2). Harbour porpoise sightings are shown on Figure 3. More detail of the survey is given in Appendix C2.1.

All data were provided to the Leader of Action D3 (Borchers, UStA) in August 2005 in preparation for data validation and analysis.

D Recurring biotope management

D1: Management modelling to determine safe bycatch limits for small cetaceans

The aim of this Action was to develop a robust framework, a fully developed and tested scientific procedure, that uses available information to determine safe bycatch limits for harbour porpoise (*Phocoena phocoena*) and other small cetacean species.

Background

In 2000, a joint International Whaling Commission (IWC)/Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) working group on harbour porpoise recommended the development of a management procedure that could be used to determine limits to bycatch that would achieve conservation objectives in the long term. This working group further recommended that computer-based simulation models be used to test the performance of the management procedure to ensure that it is robust to a wide range of uncertainties with respect to the biology of harbour porpoise (e.g. stock structure), the estimation of population size and bycatch, and environmental variability. This approach is similar to the approach taken in the development of the United States of America's Potential Biological Removal procedure (PBR) and the IWC's Catch Limit Algorithm (CLA). Work under Action D1 followed from the recommendations of the IWC/ASCOBANS working group and built upon the previously developed scientific procedures for managing removals from cetacean populations.

Conservation objectives

The first step in generating safe bycatch limits for cetacean species is the establishment of conservation/management objective(s) in quantitative terms. These are management decisions. European policymakers have not established specific conservation objectives for small cetaceans in the SCANS-II study region or, indeed, anywhere. Therefore, for the purposes of this work we adopted the interim conservation objective agreed by ASCOBANS:

- *To allow populations to recover to and/or maintain 80% of carrying capacity in the long term.*

Carrying capacity is defined as the population size that would theoretically be reached by a population in the absence of bycatch (or other anthropogenic removals); i.e. the population that can be supported by the natural environment at any point in time. Note that we do not need to know what this carrying capacity actually is to develop management procedures to set safe bycatch limits.

The ASCOBANS interim conservation objective is partially quantitative but two factors are not fully defined.

First, "long term" is not specified. We adopted a period of 200 years for the development of the management framework. This long period was chosen to allow sufficient time for heavily depleted populations to recover even in the absence of bycatch if natural rates of increase were low. However, because the status of populations in the shorter term is also of interest for conservation, it is also important to consider any delay in recovery of depleted populations due to continuing bycatch. Because of this, the performance of the management procedures with respect to recovery delay is presented in our results below.

Second, the most obvious quantitative interpretation of "recovering to and/or maintaining 80% of carrying capacity" is that this is an expected target that should be reached on average. This is important because, as described below, the management procedures developed must be "tuned" to achieve the conservation objective. Our first tuning therefore ensures that the procedures reach or exceed the conservation objective target on average (i.e. 50% of the time).

Alternatively, one could interpret the ASCOBANS interim conservation objective as meaning that the population should recover to and/or be maintained at or above 80% of carrying capacity. This could be implemented as a requirement to reach the target level a higher than average percentage of the time, although this percentage is not specified. To capture this alternative interpretation, we also developed management procedures that were tuned to achieve the conservation objective 95% of the time. This is a stricter target and this tuning produces a more conservative procedure.

In addition, although the approach used to develop the management procedures explicitly takes account of uncertainty in our knowledge, the limits to this uncertainty cannot be explicitly defined by the conservation objective and must be determined by expert judgement of the plausibility of the extent of our uncertainty. As described below, we developed management procedures that were tuned to meet the conservation objective assuming a certain level of uncertainty (values for maximum population growth rate and population level resulting in maximum productivity that were believed to be conservative) and then tested the robustness of the procedures to additional sources of uncertainty, following the approach used in the development of the IWC's CLA and the USA's PBR.

An extreme alternative is to tune the procedures to meet the conservation objective in the face of a "worst case" scenario. By definition, this scenario has lower plausibility than the scenarios for the other tunings specified above but, for comparison, we also present results for this much more conservative approach.

It is critically important to note that although the management procedures developed here are generic, the specific results presented below are entirely dependent on the conservation objective adopted. If it is determined that alternative and/or additional conservation/management objectives are appropriate, the management procedures developed can easily be tuned to the new objective(s) when a final policy/management decision is taken.

Description of management procedures

Given the adopted conservation objective, two candidate management procedures that could be used to achieve this objective were developed. The two management procedures, procedure A and procedure B, were adaptations of the PBR and CLA procedures, respectively. Full specifications of the procedures are described in Appendix D1.1. In brief, both procedures take information about a small cetacean population as input and then they output a bycatch limit. Procedure A takes a single, current estimate of absolute population size as input. Procedure B takes time-series of estimates of absolute population size and estimates of absolute bycatch as input. Both procedures explicitly incorporate uncertainty in the estimates of population size. Thus, the procedures also require estimates of the precision of the estimates of population size as input. Under procedure A, the calculation of the bycatch limit proceeds using a single, relatively simple equation. Under procedure B, the calculation of the bycatch limit is slightly more demanding computationally. Procedure B involves statistically fitting a simple population model to the input data series and then calculating the bycatch limit as a function of several quantities estimated through the model fitting.

A key element of both procedures is the ability to 'tune' the procedure, or adjust the bycatch limits, so that specific conservation/management objectives are achieved. Another important element of both procedures is a feedback mechanism: new data on the population can be used to update the bycatch limit. However, only procedure B makes use of historical data on the population. This feature of procedure B allows it to incorporate an internal protection level whereby a threshold population size (relative to carrying capacity) can be specified below which the bycatch limit is set to zero. Under procedure A, the bycatch limit is approximately a constant proportion of the estimated population size.

The management procedures are applied at the spatial resolution of defined management areas. A given procedure is applied separately to each management area resulting in a separate bycatch limit for each area.

Description of operating model

A computer-based simulation model (or operating model) was developed for testing and comparing the performance of the two management procedures and for tuning the procedures so that one would expect to meet the conservation objective in practice. Full specifications of the operating model are described in Appendix D1.1.

In brief, the operating model simulates a small cetacean population over time while periodically simulating surveys of the size of this population. Bycatch is removed from this population annually according to bycatch limits set by the management procedures. Importantly, the management procedures do not have knowledge of the true size of the population; they only have the simulated survey data and bycatch limits as input. This is the key aspect of the simulation model that mimics how the management procedures would operate in reality and thus how one would expect populations to fare under the management procedures in practice. The model of the cetacean population incorporates age structure, density dependence (in birth rate), multiple subpopulations (with dispersal among them), and environmental variation (represented by systematic changes in carrying capacity, periodic catastrophic mortality events, and random fluctuations in birth rate). Survey estimates are generated with random error and potentially directional bias. Similarly, bycatch is modelled as a random (and potentially biased) realization of the set bycatch limit. The operating model allows for multiple management areas that do not necessarily correspond to the spatial ranges of subpopulations. Thus, the model allows for flexible spatial scenarios regarding management and subpopulation structure (e.g. seasonal mixing).

Tuning of the management procedures

The operating model was used to tune the management procedures so that one would expect to achieve the conservation objective in practice. As described above, three different tunings were developed. Full specifications of the tunings are described in Appendix D1.1.

The first tuning was developed in a manner similar to the tuning of the CLA procedure by the IWC. The management procedures were tuned under this scenario so that the median population status after 200 years was 80%. This tuning is therefore appropriate for a conservation objective of maintaining the population **at 80% of carrying capacity** in the long term.

The second tuning was developed in exactly the same way except that the management procedures were tuned so that there was a 95% probability that population status was ≥80% after 200 years. This is similar to the way in which the PBR procedure was tuned in its original development except that in the PBR development case it was tuned to be ≥50% of carrying capacity, the lower limit in the range 50-70%, and not a single target level. This tuning is therefore appropriate for a conservation objective of maintaining the population **at or above 80% of carrying capacity** in the long term.

The third tuning was developed considering a “worst-case” scenario. This scenario considered worst-case biases in estimation of abundance and bycatch (Appendix D1.1). The management procedures were tuned so that there was a 95% probability that population status was ≥80% after 200 years (under this worst-case scenario). This tuning is therefore appropriate for a conservation objective of maintaining the population **at or above 80% of carrying capacity** in the long term **under a worst-case scenario**.

Figure 4 illustrates the performance of the three tunings of the management procedures with respect to the conservation objective (long-term population status) and recovery delay. Fig. 2 shows example population and bycatch trajectories under the three tunings of the procedures.

Figures 4 and 5 highlight the difference in the three tunings of the procedures in terms of the conservation objective. In the first tuning, A1 and B1, the population is maintained at 80% of carrying capacity, as defined by the objective. In the second tuning, A2 and B2, the population is maintained at a higher percentage of carrying capacity (~85-90%) because of the requirement to achieve the conservation objective 95% of the time. In the third tuning, A3 and B3, the population is maintained at an even higher percentage of carrying capacity (~95%) because of the additional requirement to achieve the conservation objective under a “worst-case” scenario. As expected, long-term population status was highest and delay in recovery was shortest under the third tuning of procedures A and B (Figure 4).

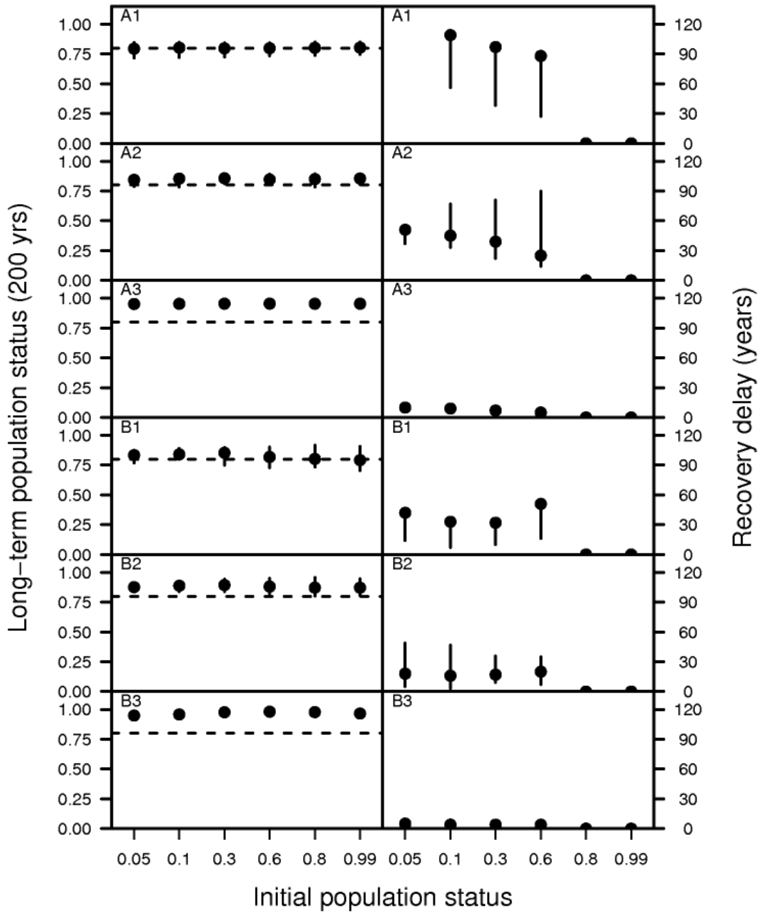


Figure 4: Performance of three tunings of management procedures A and B under the baseline scenario with respect to the conservation objective (long-term population status) and recovery delay. Points represent median results from 100 simulations and error bars represent the 90% interval of simulation outcomes. Population status is defined as population size as a proportion of carrying capacity. The horizontal dashed lines indicate the conservation objective: population status = 80%. Recovery delay is defined as the delay in recovery of a population to 80% of carrying capacity relative to a scenario without bycatch.

The delay in recovery of depleted populations to 80% of carrying capacity under procedure B tended to be shorter than under procedure A for a given tuning and initial population status (Figure 4). This was due to the faster short-term recovery of highly depleted populations under procedure B because of its internal protection mechanism (note the initial period with no bycatch in the three lower left panels in Figure 5). In addition, depleted populations recovered to higher population status after 200 years under procedure B than under procedure A for equivalent tunings (Figure 4).

Generic performance-testing simulations

To assess the robustness of the tuned procedures A and B, a series of performance-testing simulation trials were conducted using the operating model. These trials were intended to be generic and thus covered a wide range of uncertainties. The performance of the management procedures was examined with respect to uncertainty in initial population status, maximum population growth rate, shape of density dependence, survey precision and bias, bycatch precision and bias, survey frequency and environmental variability.

Results of the performance-testing simulations of the management procedures are presented in Appendix D1.1.

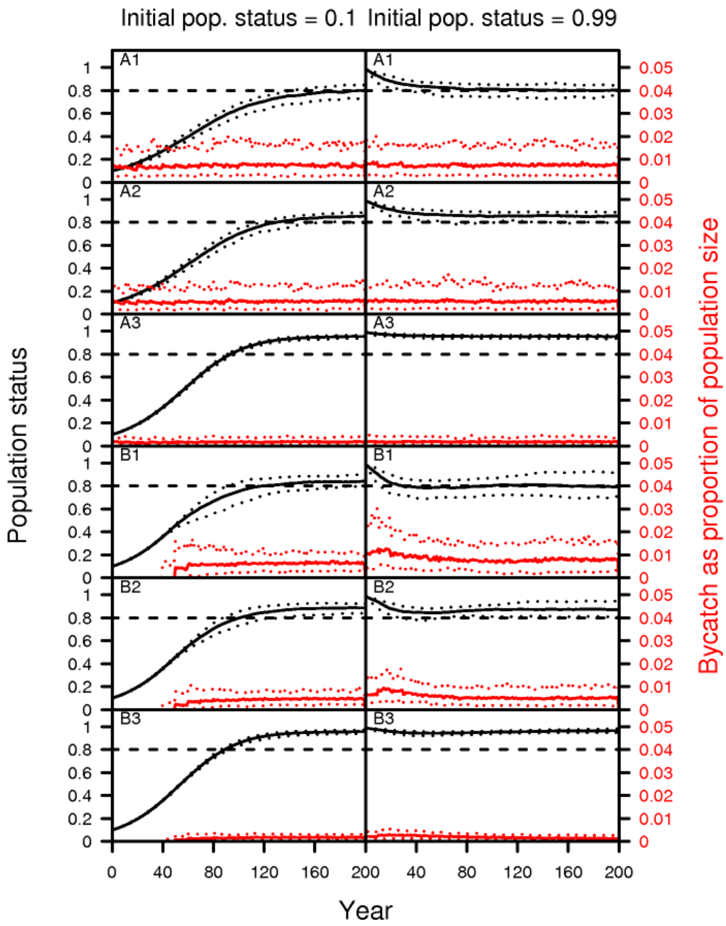


Figure 5: *Trajectories of population status and bycatch (as proportion of population size) for three tunings of management procedures A and B under the baseline scenario. Population status is defined as population size as a proportion of carrying capacity. Results are shown for two initial population statuses: 0.1 (left column) and 0.99 (right column). Solid lines represent median results from 100 simulations and dotted lines represent the 90% interval of simulation outcomes. The horizontal dashed lines indicate the conservation objective (population status = 80%).*

Implementation for harbour porpoise

Before implementing a tuned management procedure in practice it should be further subjected to species-specific simulation trials to test its performance in light of all of the information that is available for individual species. Two important biological aspects of species-specific simulation trials are life history and subpopulation structure.

With respect to subpopulation structure, a conservative approach is to create management areas no larger than the size of area within which animals are believed to mix and interbreed freely. Based on the available information about harbour porpoise population structure (reviewed in Appendix D1.1), groups of SCANS-II survey blocks represent potentially conservative management areas. To illustrate this, we ran the procedures to calculate bycatch limits for harbour porpoise for the following areas: inner Danish waters (SCANS-II block S), the northern North Sea (J, M, T), the central North Sea (L, V), the southern North Sea (B, H, U, Y), west of Britain and Ireland (N, O, P, Q, R), and the waters around southwestern France, Portugal and Spain (W).

Table 3 presents these example bycatch limits for harbour porpoise by groups of SCANS-II survey blocks based on the three tunings of management procedures A and B. Note that procedure A gives a higher limit than procedure B for some blocks and *vice versa* for other blocks. This is largely a function of the CV of the abundance estimate; procedure B gives a lower limit than procedure A if the CV is relatively high, and a higher limit if the CV is relatively low.

It is important to recognise that these bycatch limits are entirely dependent on the stated conservation objective, on the tunings that were used to achieve it under different interpretations, and on the data that were used to initiate the procedure (i.e. a single abundance estimate and no historical bycatch or abundance estimates). They are therefore indicative and should not be used for management purposes. Before that can happen a series of steps must be taken, as described below, initiated by agreeing conservation objective(s) at the policy level. The management procedures that were developed can easily be tuned to new conservation objectives when a final policy decision is taken.

Table 3: Abundance estimates and example bycatch limits for harbour porpoise by groups of SCANS-II survey blocks. Bycatch limits were calculated based solely on the SCANS-II estimates using three tunings each of the management procedures A and B. For procedure B historical estimates of abundance and bycatch were not incorporated (assumed one animal bycaught for one year prior to current abundance estimate). CVs of abundance estimates for groups of blocks were obtained using the delta method.

Area (survey blocks)	Estimate	CV	A tuning			B tuning		
			1	2	3	1	2	3
Inner Danish waters (S)	23,227	0.36	162	123	39	87	55	17
Northern North Sea (J, M, T)	37,968	0.23	305	232	73	456	287	90
Central North Sea (L, V)	58,706	0.31	434	330	104	362	228	71
Southern North Sea (B, H, U, Y)	134,434	0.19	1127	856	270	2124	1338	420
West (N, O, P, Q, R)	128,637	0.33	931	708	223	657	414	130
France, Portugal and Spain (W)	2,646	0.80	11	8	2	0	0	0

A population model (similar to the operating model) was developed for estimating the dynamics and status of harbour porpoise populations (*Phocoena phocoena*) in the North Sea and European Atlantic (Appendix D1.2). The model was fitted simultaneously to data on abundance, life history (age at sexual maturity, pregnancy rate and age at death) and bycatch rate (per unit fishing effort) with data on total fishing effort as input. The model fitting was done in a Bayesian statistical framework using Markov chain Monte Carlo methods. The model was fitted to data on harbour porpoise from the United Kingdom to illustrate the performance of the method. This will be extended to incorporate additional data from other countries.

Conclusions and recommendations

Management procedures A and B compared

The management procedures A and B developed here are similar but there are some key differences. The only input to procedure A is a single estimate of abundance, whereas procedure B makes use of information on bycatch and on multiple estimates of abundance, if available, to give a more informed assessment of population status. In waters of the North Sea and European Atlantic, there is information on bycatch from various sources and estimates of abundance from 1994 and 2005 from the SCANS surveys so there is an advantage to using procedure B. Indeed, this was one reason why the joint IWC/ASCOBANS Working Group recommended the development of such a procedure for the harbour porpoise in the North Sea and adjacent waters.

Another feature of procedure B is its internal protection mechanism, which enhances the recovery of depleted populations by setting bycatch to zero if the population is estimated to be <50% of carrying capacity. Procedure A cannot implement such an internal protection mechanism because it relies on a single estimate of population size and cannot, therefore, estimate the level of the population relative to carrying capacity.

The advantage of simplicity in the original PBR procedure, upon which procedure A is based, does not give any advantage in the context of its use within the management procedures developed here.

We conclude that the features of procedure B and the advantages that these confer are sufficient for it to be considered as the best version of the procedure.

Tuning

The three tunings developed allow for three interpretations of the conservation objective adopted from ASCOBANS (to allow populations to recover to and/or maintain 80% of carrying capacity in the long term). The first tuning of the management procedures is a robust mechanism for setting limits to bycatch to achieve the conservation objective of allowing a population to recover to and be maintained **at 80% of carrying capacity**. The second tuning achieves the conservation objective of maintaining a population **at or above 80% of carrying capacity**. Satisfactory performance of the first and second tunings depends on the availability of data series of historical and current estimates of abundance and bycatch that are essentially unbiased. The third tuning is a highly conservative approach to maintaining a population **at or above 80% of carrying capacity in a worst case situation** where time series of estimates of abundance and bycatch are considerably biased upwards and downwards, respectively.

If input data are judged to be of sufficient accuracy then either the first or the second tuning is appropriate. If consistent bias in either abundance or bycatch of the magnitude tested were considered plausible, then the third tuning would be more appropriate. We recommend that for application/implementation for a particular species in a particular region, the judgement of which tuning to use be based on an assessment of the available information. This may include conducting more simulation testing, including the generation of alternative bycatch data series to reflect plausible bias, based on the best available information in cases where it is not clear whether or not a procedure is robust to uncertainties. If the third tuning were adopted because of such uncertainty, more information on, in particular, bycatch would allow a re-evaluation in the future.

Further work

As part of the project Cetacean Offshore Distribution and Abundance in the European Atlantic (CODA), supported by the governments of France, Ireland, Spain and the UK, further work will continue to allow the management procedure to be applied to the common dolphin and other species of small cetaceans.

Next steps

Before a management procedure can be implemented for a particular species in a particular region, the following steps need to be taken:

1. Agreement by policy makers on the exact conservation/management objective(s);
2. Agreement by policy makers to implement the procedure for one or more species in one or more regions;
3. Consideration by scientists of whether or not the available information for each species indicates that there is a need to conduct further simulation testing to examine uncertainties that may not have been fully explored;
4. In particular, if there is evidence for sub-population structure, consideration by scientists of any further simulation testing required and/or identification of any sub-areas that may be considered to contain sub-populations;
5. In addition, if there is evidence of historical bycatch but no data, consideration by scientists of any further simulation testing required including the generation of appropriate data series based on the best available information;
6. Final determination by scientists, based on the results of Steps 3 - 5, of how to implement the procedure for each species/region;
7. Agreement by policy makers to implement the procedure;
8. Generation by scientists of bycatch limits for a specified period (e.g. 5 years);
9. Establishment of a mechanism for feedback of information from bycatch monitoring programmes to inform the next implementation of the procedure when the period for which bycatch limits have been set expires.

In addition, the following step will need to be considered in the future:

10. Planning for an absolute abundance survey in (approximately) 2015.

Step 1 should clearly be made at the European level. Similarly, Step 2 should ideally be made collectively although most species do not occur in all parts of the European Atlantic. Steps 3 – 6 can be done by the team of scientists that have developed the procedure or by others under their supervision/instruction. The amount of work involved depends on the species. The work accomplished here for harbour porpoise means that for this species these steps could be completed fairly rapidly; other species will take longer. Step 7 is another that should be made at the European level; Step 8 can then be taken immediately. Step 9 is very important because removals from a population need to be incorporated when the procedure is re-implemented and this new information (or lack of it) may determine which tuning of the procedure is implemented in the future.

D2: Monitoring small cetacean populations

A wide variety of management related questions might be addressed by monitoring. Here we define monitoring as repeated assessment designed to detect change in relative abundance or distribution of a small cetacean population or within a certain area. Questions that might be addressed by monitoring could be asked at two spatial scales. These are:

1) Regional monitoring where the requirement is to monitor the use of a specific area by a particular species, e.g. monitoring relative abundance between and within years in e.g. national waters, protected marine protected areas or construction sites.

2) Population level monitoring where the requirement is to monitor the status of a whole population.

The aim in both cases is to detect if relative abundance changes by more than a certain percentage over a certain time period. Monitoring to understand the impact of a particular human activity within a defined area on the distribution, abundance or behaviour of animals would be an example of the former whereas monitoring to advise on safe bycatch limits for a population would be an example of the latter.

Before conducting any type of monitoring of animal populations it is important to define the objectives. In SCANS-II the aim of the monitoring action was to "develop recommendations for the best monitoring method to be used for a particular species of small cetacean in a particular area, focusing on the harbour porpoise (*Phocoena phocoena*), the bottlenose dolphin (*Tursiops truncatus*) and the common dolphin (*Delphinus delphis*) so that trends in abundance in time and space can be determined between major decadal surveys". The main focus for the SCANS-II project was therefore to address the second category above: population level monitoring.

To address this aim, we first reviewed methods previously used in monitoring temporal and spatial trends in distribution and abundance of cetacean populations (Appendix D2.1). We further analysed sighting rates of cetaceans by observers on research vessels monitoring seabirds during the past 24 years (between 1980 and 2003) and evaluated their potential for providing indices of relative abundance to monitor trends in cetacean populations over time (see Appendix D2.2). We also analysed acoustic data collected on the main shipboard survey (Action C1) to provide data to calculate indices of relative abundance from acoustic monitoring (Appendix D2.3). Based on the review in Appendix D2.1 and the analyses in Appendices D2.2 and D2.3, we then tested, further developed and compared potential monitoring methods in order to provide recommendations for best monitoring method and a protocol that could be followed to make this evaluation in specific circumstances (Appendix 2.4). Although our data collection, analysis and contents were focussed on the harbour porpoise, the monitoring methods described may also be suitable for other species if modified to address species specific variation e.g. behaviour.

Review of monitoring methods

The most straight forward way to measure population change involves comparing two or more estimates of abundance for a specific area made at different times. If a series of estimates are available this could allow the fitting of a curve and the estimation of a rate of change. However, it is important that abundance estimates used in a trend analysis are comparable. It is therefore important to have some knowledge of the spatial and temporal movements of the population in question so that sufficiently large areas are chosen for the monitoring. If areas that are too small are covered it is possible that changes in movement patterns caused by variations in environment could have a large impact on abundance estimates and consequently on estimates of trend.

A number of approaches have been used to collect information to attempt monitoring the use of a specified area by specific species or the status of a whole population. These approaches include fixed point sampling, line transect sampling and mark-recapture sampling, and using models to estimate abundance from environment variables. There are different types of platform that can be used for each approach, e.g. fixed observation points such as headlands, or moving survey platforms e.g. ships and aircraft. There are also different methods of detection that can be applied, such as direct visual or video-based recordings of animals at the surface, and acoustic detections of vocalising animals. The methods can therefore range from very basic, yielding simple indices of abundance in limited areas, to very advanced yielding accurate (how close the estimate is to the true value) and precise (the statistical variation in estimates generated from repeated samples) estimates of absolute abundance across wide areas. Appendix D2.1 describes these different monitoring methods and indicates the strengths and weaknesses of each one.

For any type of monitoring it is necessary to ensure that the method and the study design chosen will be able to provide an answer to the question posed with a useful level of precision. If point estimates from surveys have large associated variances they will have a low power to detect a difference and there will be a high risk of failing to detect a change when one has occurred, known as a type-2 error. Generally variances can be reduced by collecting more data. A power analysis can indicate the ability of the analysis of available or planned monitoring data to detect a trend of a given magnitude. Power analysis can be used in two situations: firstly for interpretation of results of analysis of existing data; and secondly to plan studies to calculate the necessary sample size e.g. the length of time series of abundance estimates, or the coefficient of variation (CV) of those estimates, needed to detect specified rates of population change in a trend analysis.

The costs associated with research and monitoring of threatened populations or the introduction of management measures to mitigate declines of populations are often considered too large or take too long to show results. A cost benefit analysis is an essential step in designing monitoring programmes to identify the most cost-effective methods that will fulfil the monitoring objective and also to justify the funding that needs to be spent.

The review of monitoring methods concluded that the type of monitoring and which methods to use will ultimately depend on the objective, the geographical area and the species of interest. In many cases it will likely be a combination of methods that will supply the solution. A power analysis to compare methods and a cost benefit analysis should be part of the planning process for any monitoring programme. This will allow an informed choice from among the available methods that will be able to supply the answer to the stated question in the given time frame. These points are addressed further below.

Analysis of 25 years of data from platforms of opportunity to monitor cetaceans

Sighting rates of cetaceans by observers on research vessels and platforms of opportunity potentially provide indices of relative abundance that can be used to monitor trends in cetacean populations over time. The European Seabirds at Sea (ESAS) database contains a large number of such data from shipboard visual surveys that have been conducted using a rigorous protocol in European waters over the past 25 years. While the primary focus and study design of these surveys were related to seabirds, observers also recorded sightings of marine mammals.

As part of the SCANS-II project we explored whether the sighting rates of small cetaceans on these surveys might provide useful indices of relative abundance over time (Appendix D2.2). We were particularly interested in the variability of these sighting rates and thus the level of information that they would provide to an analysis of population trend. Previous studies of cetacean sighting data in the ESAS database have highlighted the complications in interpreting these data due to the use of multiple vessels and observers and the sometimes opportunistic nature of the data collection. For our analysis we focused on harbour porpoise sightings in the North Sea.

We extracted and analysed seven of the longest, most extensive, and most consistent (spatially and with respect to ships used) time-series of survey effort in the North Sea from the ESAS database. Generalized linear and generalized additive statistical models were used to describe the number of harbour porpoise sighted as a function of multiple variables that might affect detectability and abundance. The marginal predicted effects of year on number of sightings from these models (and their associated precisions) were considered as annual indices of relative abundance. The coefficients of variation (CVs) of the estimated year effects for the seven data subsets ranged from about 0.3 to 1.2. Estimates of relative abundance with CVs at the higher end of this range will provide limited information to any analysis of population trend over time. However, CVs at the lower end of this range could provide some statistical power to detect changes in population size over time.

Relative abundance indices from acoustic data

The shipboard surveys described under Action C1, provided an extensive set of acoustic data from all seven ships. These acoustic data were analysed to generate estimates of relative abundance of harbour porpoise, an important part of the work to help formulate recommendations for best practice in monitoring this particular species. Details of this work are given in Appendix D2.3.

The data were first processed and screened for harbour porpoise vocalisations using a detection algorithm. Next, vocalisation "events" were classified as single clicks, events (multiple clicks by one or more porpoises), single track (multiple clicks produced by one animal with a clear track) and multiple track (multiple clicks produced by one or more porpoises with a clear track). A tracking algorithm was used to estimate the perpendicular distance of the detections from the hydrophone (the transect line) and the effective strip half-width (*esw*) estimated to indicate the area effectively "searched" by the acoustic detection system. Noise levels on each ship were also measured

Survey effort from all 8 ships (the seven ships in the main SCANS-II survey plus the Polish Baltic ship survey) amounted to 28,917 km, during which 706 events and 324 tracked events were recorded. Sample sizes were sufficiently large to allow *esw* to be estimated for only four of ships: the *Gorm*; *Mars Chaser; Skagerak* and *Victor Hensen*. Estimated strip half-widths ranged from a minimum of 208 m (*Gorm*) to a maximum of 235 m (*Skagerak*); a pooled estimate of *esw*, calculated using data from all ships, was 221 m. Mean underway measurements of noise in the porpoise frequency band varied from a high of 77.4 dB re 1μPa^2/Hz (SD = 5.14) on the *Victor Hensen* to a low of 64.9 dB re 1μPa^2/Hz (SD = 4.23) on the *Mars Chaser*.

Detection rates were highest in the Skaggerak & Kattegat (0.043 single track detections per km) and lowest off the Iberian Peninsula (0.001 single track detections per km). The relationship between acoustic detection rate and of "true" density estimated from the analysis of visual data (Action D3) was much improved when acoustic detection rates were corrected for ship-specific noise levels.

The analysis was completed in February 2006 and the acoustic data were analysed further as part of the comparison of methods using power analysis (see below).

Comparison of the power of different monitoring methods to detect trends

There are a number of logistic considerations of using different monitoring methods. Detection methods are affected to varying extent by weather; we investigated the effect of sea state on the acoustic and visual detection rates of harbour porpoises from the SCANS-II shipboard survey data. We found that visual detection of harbour porpoises can only be maintained in Beaufort sea state ≤2, whereas during acoustic surveys detection of harbour porpoises remains unaffected in Beaufort sea state 0≤5. Furthermore, acoustic surveys are independent of light conditions and may be continued 24 hours a day whereas the number of daylight hours available for visual surveys depends on time of the year and latitude. We used climatic information on sea state and information on day length to explore the likely effects of this in different seasons and locations. In the central North Sea during July the effective survey time for harbour porpoises using visual methods (during daylight hours and in sea state ≤2) would be about 5.5 hours per day; for acoustic methods the effective survey time would be about 22 hours in sea state ≤5. Because survey ships working offshore are hired on a 24h basis, this information is important to consider in cost-benefit analysis when evaluating the results of the power analysis.

Any type of ship survey may have a bias due to responsive moments of the animals to the vessel. The response may depend on the characteristics of the vessel itself, on equipment used such as a depth sounder, or of the cetacean species under investigation. Similarly the distance at which the effect occurs may also be vessel or species specific. It is therefore important to investigate what, if any, effect the vessel may have on the behaviour of the species that will be monitored.

During the SCANS-II project we evaluated and developed methods for monitoring trends in abundance of small cetacean species between major decadal-scale surveys (for details see Appendix D2.4). Methods considered include visual shipboard surveys by cetacean or seabird researchers, acoustic surveys using towed-hydrophone arrays or static moorings (e.g. T-PODs), and visual aerial surveys. In particular, we took advantage of the shipboard surveys for estimating absolute abundance (Action C1) to collect visual cetacean data from seabird observers and acoustic data from towed hydrophone arrays. Because these two methods were conducted simultaneously on the shipboard surveys, we were able to assess the relationship between indices of relative abundance generated by these methods (detection rates) and absolute abundance as estimated from double-platform surveys by dedicated cetacean observers. This allowed us to estimate the variation in the relative indices and to use that information to calculate the power of each method to detect a trend in abundance. There were sufficient data from four vessels to make these comparisons for one species, the harbour porpoise.

Harbour porpoise detection rates for both seabird and acoustic methods were positively correlated with absolute abundance estimates on all ships. The coefficients of variation (CV) in detection rates due to sampling error were 21% and 16% for seabird observers and towed hydrophones, respectively, using data from three and four vessels, respectively. Variation in the relationship between detection rate and absolute abundance among observers/vessels adds 0-52% and 64-83% to the CV for seabird observers and towed hydrophones, respectively, depending on whether errors in the index are assumed to be uncorrelated or correlated with true density.

The power to detect an annual decline in abundance of 5% over a 10 year period with annual surveys was calculated. If the errors in detection rates and absolute density are correlated the resulting power stays low (less than 0.25) for both methods regardless of how much effort is expended. However if errors are uncorrelated, a yearly SCANS-II type effort (about 18,000 km) would result in a very high power for the seabird observer method (100%), while power remains low for the acoustic method (<20%).

Conclusions about the power of the two methods (towed acoustics and seabird observers) to detect trends in harbour porpoise abundance thus depend crucially on the correlation of errors of detection rates and absolute density. We do not know what this correlation is in reality, but it is likely higher for the seabird observer data. That is, for the seabird observer data, the power is likely better represented by assuming that errors are correlated and for the acoustic method, power is likely better represented by assuming that errors are independent. In this situation, the acoustic method would achieve only slightly less power to detect a trend in abundance compared to the seabird observer method for the same effort on a multi-vessel SCANS-II type survey. However, this power is low.

The amount of effort needed to achieve a specific power could potentially be greatly reduced for both methods if a single vessel is used so that inter-survey variation could be ignored. However, this may be over optimistic given that there may be other factors contributing to inter-survey variation than just the vessel (e.g. variation in survey conditions, equipment used on the vessel).

We also estimated the variation and calculated the power of different methods using a second approach looking only at the relative density of harbour porpoises obtained from each method without relating it to the "true" absolute abundance as was done in the approach described above. We compared data from four different methods: vessel cetacean observer, vessel seabird observer, vessel towed acoustics and aircraft visual observer. The calculations were based on data collected in Beaufort sea state ≤2 for the visual effort and Beaufort sea state ≤5 for the acoustic surveys using data from the same four ships as in the analysis above. We compared the three vessel based methods for the four ships separately and for the aerial method we used data collected in the block located nearest to where the four vessels were surveying. The acoustic detection rates were corrected for vessel noise.

In general, a higher power is achieved for the same survey effort using the cetacean ship observer and the seabird observers compared to the other two methods. The overall best performing method was the seabird observers. For one ship, *Skagerak*, the power is almost identical for all three vessel methods and almost twice the effort is needed for the aerial observers to obtain a similar power. For the other three vessels the acoustic method needs about twice the effort to achieve a similar power to that of the cetacean ship observer and the seabird observers. The results for these two latter visual methods seem independent of the vessel used. However, the acoustic method performs better on some vessels than others indicating the need to test the performance of acoustic equipment on any specific vessel to estimate the power in each case.

The main drawback with this second approach is that because there is no information about how the index of relative abundance relates to absolute abundance, we have to assume that changes in the relative abundance observed during the surveys are indicative of changes in absolute abundance. Other assumptions for this second approach are that all other (logistical, biological and environmental) factors stay the same between surveys and that there is no additional variance affecting the index from e.g. ship's equipment, observers, weather etc. Unless all these other factors do stay the same between surveys, the calculations and resulting power using this approach will likely overestimate the power to detect trends.

Cost-benefit analysis of different monitoring methods

The cost of the different methods that can be used for monitoring trends in abundance depends on the cost of renting a platform (ship or aircraft), hiring observers, the number of hours available for observations or recordings, the cost of the equipment and the cost of analysis of the data. These costs and the availability of methods may vary from country to country. In our comparison of the costs of the different monitoring methods, we use average weather conditions from the North Sea in July and fixed prices approximately according to the costs of the SCANS-II survey.

It is not possible to compare static acoustic monitoring directly to the mobile methods because the data collected are fundamentally different.

We assumed the time needed for analysis for each ship month of data might be two months for a full SCANS-II double platform absolute abundance visual survey, two weeks for a single platform relative abundance visual survey, one month for a towed acoustic survey, and one month for aerial survey.

In Table 4 we compare the costs of using different monitoring methods to detect a 5% trend in abundance over 10 years with annual surveys, using data collected from the vessel *Skagerak* in the SCANS-II survey area S and the aerial survey conducted in area L, as an example. The required effort to achieve the given power assumes that there is no change in logistical, biological and environmental factors between the annual surveys and that there is no additional variance affecting the index from e.g. ship's equipment, observers, weather etc. Given that these assumptions will not be met over a 10 year monitoring period, the required effort and resulting cost should be regarded as an absolute minimum.

Table 4: Comparison of the cost (in Euro) to detect a 5% trend over 10 years with annual surveys for different monitoring methods using harbour porpoise data from the Skagerak in block S and the aerial survey in block L. Power is taken from Appendix D2.4 Figure 9 (bottom panel). Effort costs are based on the costs of vessel charter, observer salaries and hours in a day suitable for surveying (Appendix D2.4 Table 2). Analysis costs are calculated based on the number of months needed to collect data to achieve the required annual effort, the number of months to analyse one month of data, and salary of 4,500 Euro per month. Equipment costs are for a single vessel/aircraft and assumed to last 5 years.

Method	**Power**	**Annual effort required**	**Annual effort cost**	**Annual analysis cost**	**Total equipment cost**	**Total cost to detect trend over 10 yrs**
Absolute abundance – visual ship survey – large ship	78%	2,500 km	152,334	15,000	40,000	1,713,000
Relative abundance – visual ship survey – large ship	78%	2,500 km	130,221	3,750	4,000	1,344,000
Relative abundance – visual ship survey – small ship	78%	2,500 km	56,511	3,750	4,000	607,000
Relative abundance – visual ship survey – platform of opportunity	77%	2,500 km	3,686	3,750	4,000	78,000
Relative abundance – towed acoustic survey – large ship	78%	2,500 km	31,634	1,875	20,000	355,000
Relative abundance – towed acoustic survey – small ship	78%	2,500 km	13,206	1,875	20,000	171,000
Relative abundance – towed acoustic survey – platform of opportunity	78%	2,500 km	921	1,875	20,000	48,000
Absolute abundance – aerial survey	79%	4,500 km	19,946	3,845	10,000	248,000

The costs of monitoring to detect the specified trend over 10 years are heavily driven by the costs of the survey platform. Use of a small vessel instead of a large one approximately halves the cost for both visual and towed acoustic methods, and both methods are approximately an order of magnitude cheaper if there are no ship costs compared to the use of a large ship. Caution should be exercised when considering the cheapest options because they are based on platforms of opportunity being available on a regular basis at appropriate times and covering the necessary areas. If this is not the case, as is likely, these cheaper options would not provide the necessary data.

Excluding the platform of opportunity cases, visual methods are approximately four times more expensive than towed acoustic methods, primarily because acoustic data can be collected for approximately four times longer at sea and thus ship costs are correspondingly less. However, this balance in favour of the towed acoustic methods is offset by the fact that this method is currently only appropriate for harbour porpoise, whereas visual methods are appropriate for all small cetacean species.

Recommendations

Our analyses show that three methods are suitable for monitoring trends in harbour porpoises - shipboard and aerial visual surveys and towed acoustic surveys on ships. Other methods may also be appropriate but the statistical power of these could not be tested in this study. For example, static acoustic monitoring has proven valuable in small scale monitoring and there is potential for using this method for large scale monitoring of trends; further work is needed to test the method for this application. Satellite tracking is ideal for monitoring movements (including migrations) and distribution but not trends in abundance. Mark-recapture analysis of photo-identification data is effective for coastal populations of bottlenose dolphins but is suitable neither for species without appropriate individual markings, nor for large offshore populations. Mark-recapture analysis of genetic identification data from biopsies could potentially work for all species but obtaining a sufficient sample would likely be difficult for most species and especially for large populations such as the harbour porpoise.

The costs of the shipboard methods depend on the method itself but also on the ship used. Large ships may be needed in offshore areas, whereas smaller ones could be used in more sheltered inshore areas where the vessel could overnight in port. Platforms of opportunity are cheapest but their value depends critically on whether they are operating at appropriate times in appropriate areas.

When making recommendations for best practice for monitoring trends, practicalities must also be considered and it is likely that a combination of methods will be optimal and that some methods will be better for some areas than others. For example, visual detection rates decrease with increasing sea state while acoustic detection rates are not significantly affected, however, hydrophones can only be towed in waters deeper than 10m.

In smaller areas such as SACs, photographic identification and mark-recapture analysis methods provide a viable option for bottlenose dolphins and potentially other species. An alternative for monitoring harbour porpoises in smaller areas is static acoustic monitoring using T-PODs.

The analysis presented here focuses on the harbour porpoise, the only species for which there exist sufficient data for a comparison of methods using power analysis. The issue of how relevant this analysis is to other species is an important one. Visual monitoring methods can be used for all small cetacean species but it is currently not possible reliably to distinguish species of dolphins using acoustic methods.

Based on the analysis of statistical power and cost/benefit the following recommendations apply for monitoring harbour porpoises. Comments are made on the applicability to other species where appropriate.

1) All three methods tested (visual and towed acoustic ship surveys and aerial surveys) can achieve sufficient power to detect trends in abundance with achievable effort and are therefore recommended for long term monitoring. Visual methods are also appropriate for other less abundance species (i.e. most dolphin species), but power to detect trends will be lower and, therefore, the cost to detect an equivalent trend will be higher.

2) For all species, features of the monitoring method should be kept as consistent as possible (vessel, conditions, observers, noise etc.) between surveys to reduce survey-related variation and thus increase power to detect trends.

3) Platforms of opportunity using visual and/or acoustic methods are the cheapest way to monitor harbour porpoises (and other small cetaceans using visual methods). However, the success of using such vessels depends on finding a vessel (or vessels) that can cheaply and effectively accommodate observers and equipment and that cover appropriate areas at suitable speeds. These criteria are seldom fulfilled, especially since long term monitoring ideally requires the conditions to be consistent. Ferries may be suitable in some areas but spatial coverage is likely to be poor because of the fixed routes covered. Research vessels conducting annual monitoring of e.g. oceanography or fish resources (e.g. IBTS) have the potential to be valuable platforms of opportunity for monitoring if they take place at the right time(s) in the right place(s).

4) Aerial surveys are a cost efficient way to conduct a dedicated survey in a specific area at a specific time for all species, in part because they can cover a larger area in a given time than any other method. However, they are limited by the range of the aircraft.

5) For the harbour porpoise, towed acoustic surveys are cheaper than visual surveys because they do not rely on daylight and are less weather dependent and therefore a larger area can be covered in shorter time. However, the acoustic characteristics of a vessel to be used in acoustic surveys should first be tested because some vessels are too noisy for towing hydrophones.

6) Combining visual surveys with towed hydrophones surveys on the same vessel is a cost effective to achieve two independent data sets from the same area.

In Table 5, we give a summary assessment of the value of different methods of monitoring for the most common species in European Atlantic waters. Which method should be used in practice will depend on a range of factors including: the range of species to be monitored; the area(s) to be monitored; the objectives of the monitoring programme; the costs of monitoring to achieve those objectives; and the logistical limitations of the methods.

Table 5: Overview of the most common cetacean species in European waters and the potential for using different monitoring methods. "Partly" means that the method may work in some areas and/or for some species. "?" means that the method may work potentially but this has not yet been verified.

	Visual monitoring			Acoustic monitoring[2]		Mark-recapture	
	Ship	Aerial	Land[1]	Towed	Static	Photo-id[3]	Genetic
Harbour porpoise	Yes	Yes	Partly	Yes	Yes	No	Partly
Bottlenose dolphin	Yes	Yes	Partly	Partly	Partly	Yes	Yes
Common dolphin	Yes	Yes	No	?	?	Partly	Partly
White-beaked dolphin	Yes	Yes	Partly	?	?	Yes	Yes
Minke whale	Yes	Yes	No	No	No	No	Partly
All other species	Yes	Yes	Partly	?	Partly	Partly	Partly

1. *Using observations from land to make inferences about population trends requires detailed knowledge of the movements and any migration patterns of animals. This is really only appropriate in narrow straits or off headlands where all or a known population passes within sight of land, e.g. for gray whales, bowhead or right whales.*
2. *The distinct sounds made by harbour porpoises make them easy to detect acoustically. However, it is currently not possible to distinguish different dolphin species acoustically reliably.*
3. *A limited number of species have individual markings that are appropriate for photo-identification studies to provide data for mark-recapture analyses. All species can potentially be studied using genetic markers; how well this works depends on the practicality of obtaining regular biopsy samples. However, obtaining sufficient sample sizes to estimate the size of large populations will likely be logistically impossible.*

D3: Abundance estimation

Aerial survey data analysis

Aerial survey data were first validated and the effective strip half-width (*esw*) estimated for harbour porpoise from the "race track" data collected under Action C2. Few problems were identified with the data; those that were mostly resulted from periods when GPS records were not received. The analysis was completed by Hiby (CR) in December 2005. The *esw* for harbour porpoise groups was estimated to be 0.187 km (SD = 0.0561) under good conditions and 0.107 km (SD = 0.0333) under moderate conditions. Details are given in Appendix

D3.1. The results of these analyses were passed to CREEM (UStA) in December 2005 for the next stage of analysis.

Harbour porpoise abundance for each survey block was estimated using conventional line transect methods but incorporating the above estimates of *esw*. Total abundance over all aerial survey blocks was 110,091 (CV=0.33; 95%CI=59,063-204,163). Mean group size was estimated to be 1.29 (CV=0.02; 95% CI=1.23-1.35). More detail is given in Appendix D3.2. Estimates of abundance for bottlenose dolphin, common dolphin, white-beaked dolphin and minke whale were generated using conventional line transect methods, corrected for availability bias using data from the literature. More detail is given in Appendix D3.3.

Analysis of the aerial survey data was completed in March 2006. These results were then combined with results from the analysis of the shipboard data to generate total estimates of abundance for the whole survey area (see below).

Shipboard survey data analysis

Validation and analysis of the shipboard survey data was carried out at CREEM (UStA) with assistance from SMRU (UStA). Validation was time-consuming, mainly due to missing data, but was completed in early February 2006. Data analysis used Mark Recapture Distance Sampling (MRDS) methods (as described under Action A2) to generate abundance estimates for each species in each survey block for which there were sufficient data. Appendix D3.4 gives details of the methods used to analyse the shipboard survey data and details of how the data were treated in analysis.

Estimates of absolute abundance

Estimates of abundance were calculated from the shipboard surveys for each survey block, corrected for animals missed on the transect line and for any responsive movement. These are design-based estimates that rely on the survey design to provide a representative sample (equal coverage probability) of each block. Estimates were possible for five species: harbour porpoise, bottlenose dolphin, white-beaked dolphin, common dolphin and minke whale. There were too few data to calculate estimates for white-sided dolphin or striped dolphin but estimates were made for common and/or striped dolphin (which can occur in mixed schools), and for white-beaked and/or white-sided dolphin (i.e. all *Lagenorhynchus* spp). Table 5 gives these estimates and also combines them with those from the aerial survey to give total estimates of abundance for the whole survey area. Estimates for each species in each survey block are given in Appendix D3.4.

Table 6: Estimates of abundance estimates for the SCANS-II study area from both the shipboard and aerial surveys in 2005. CVs are given in parentheses and lognormal 95% CIs are given in square brackets

Species	**Shipboard**	**Aerial**	**Total**
Harbour porpoise	275,527 (0.25)	110,090 (0.32)	**385,617** (0.20) [261,266-569,153]
Bottlenose dolphin	10,673 (0.31)	1,972 (0.45)	**12,645** (0.27) [7,504-21,307]
White-beaked dolphin	11,910 (0.26)	10,754 (0.83)	**22,664** (0.42) [10,341-49,670]
White-beaked and/or white-sided dolphin	27,227 (0.38)	10,754 (0.83)	**37,981** (0.36) [19,169-75,255]
Common dolphin	30,511 (0.35)	32,855 (0.82)	**63,366** (0.46) [26,973-148,865]
Common and/or striped dolphin	55,909 (0.28)	33,495 (0.80)	**89,404** (0.35) [46,110-173,349]
Minke whale	13,281 (0.36)	5,333 (0.55)	**18,614** (0.30) [10,445-33,171]

In 1994, harbour porpoise abundance was estimated from the SCANS survey to be 341,366 animals (CV=0.14; 95% CI = 260,000-449,000) in an area of 1,030,063 km^2. The estimate for 2005 is higher but from a larger area (1,370,114 km^2). An estimate for 2005 for the survey blocks that cover approximately the same area as surveyed in 1994 is approximately 335,000 (CV=0.21). Clearly, there was no difference in the abundance of harbour porpoises in 1994 and 2005. However, in 2005 average density in survey blocks north of 56ºN was approximately half the density estimated in 1994, and average density in survey blocks south of 56ºN in 2005 was approximately twice the density estimated in 1994. Both these differences are significant at the 5% probability level.

The estimates for white-beaked dolphins and minke whales in 2005 are also higher than those estimated in 1994. White-beaked dolphin abundance in the North Sea (the area for which estimates were available in both years) was estimated at 7,856 (CV=0.30) in 1994 and 10,562 (0.29) in 2005. For minke whale, estimated abundance in the North Sea was 8,445 (CV=0.24) in 1994 and 10,541 (0.32) in 2005. These differences are not significant.

The estimates for bottlenose and common dolphin are the first for the entire European Atlantic continental shelf. For bottlenose dolphins the estimates include the small resident populations around the coasts of Britain, Ireland, France Spain and Portugal and also animals in offshore waters, especially in the Celtic Sea but also off western Scotland and around the coasts of Spain and Portugal. Common dolphin abundance was concentrated off the coast of Ireland, in the Celtic Sea and western Channel, and the coasts of Spain and Portugal.

Density surface modelling

Conventional line transect sampling methods provide estimates of abundance for predetermined survey blocks but do not provide any information on density at a finer spatial resolution. Constructing a model in which variability in animal density is explained by physical and environmental covariates not only provides such information but also allows abundance to be estimated for areas that are different to the survey blocks originally defined for the survey. Estimates may also have greater precision. Density surface modelling is thus a useful technique to obtain additional information on distribution and abundance if suitable covariate data are available.

SCANS-II in 2005

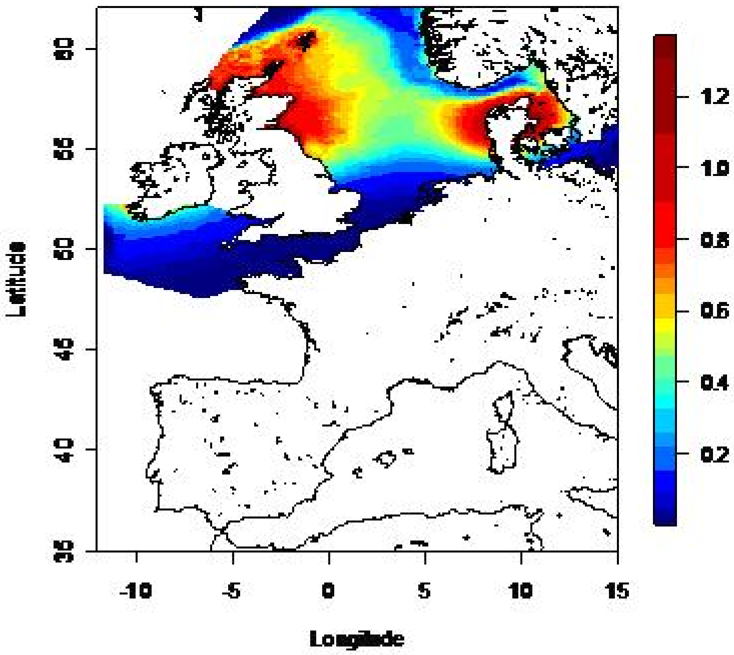
There were sufficient data to apply these methods to estimate a density surface for harbour porpoise, common dolphin and minke whale from the SCANS-II data for 2005. From these models, abundance was estimated for the whole area and (for harbour porpoise and minke whale) for the same area surveyed by SCANS 1994.

The explanatory covariates that were available and considered in the modelling were latitude and longitude, depth, distance from coast, seabed slope and aspect (the orientation of the slope). Only covariates that explained a significant amount of variability in the data were retained in the models. Details of the methods are given in Appendix D3.5

Models for all species included a two-dimensional smooth term of latitude and longitude. They explained 18%, 40% and 28% of the deviance for harbour porpoise, common dolphin and minke whale, respectively. The model for harbour porpoise showed a tendency for animals to avoid deep water and to avoid being too close to or too far from the coast. Common dolphin showed a general tendency towards being offshore. Seabed aspect was a feature of the models for common dolphin and minke whale; the fitted function for aspect for common dolphins was the inverse of that for minke whales. This latter result is difficult to interpret directly; aspect is likely a proxy for some other unmodelled variable(s).

The fitted density surfaces for harbour porpoise, minke whale and common dolphin are shown in Figures 6-8.

(a)



(b)

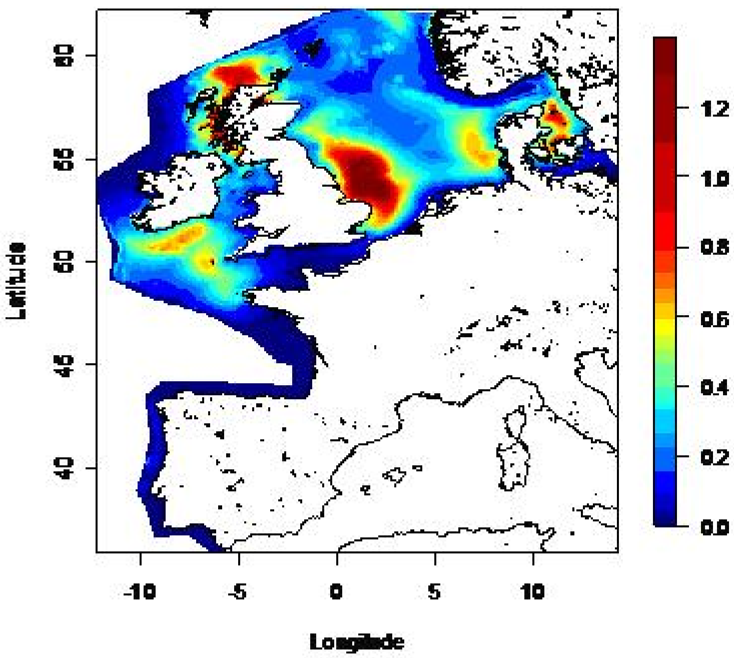
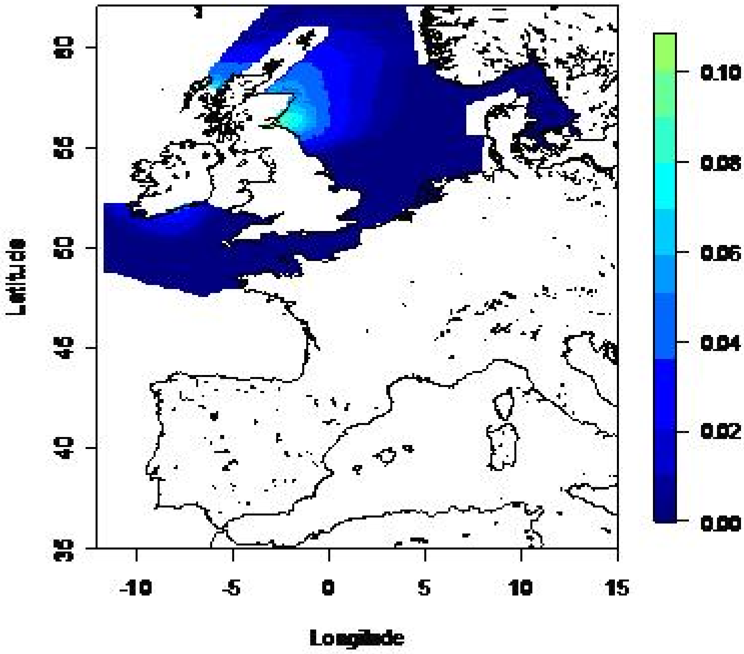


Figure 6: Harbour porpoise estimated density surface (animals per km^2) in (a) 1994 and (b) 2005.

(a)



(b)

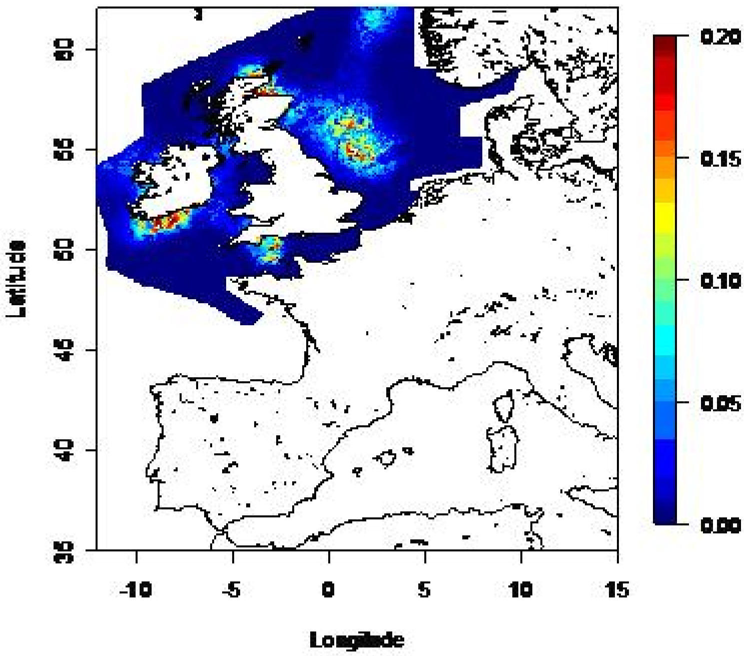


Figure 7: Minke whale estimated density surface (animals per km^2) (a) in 1994 and (b) in 2005.

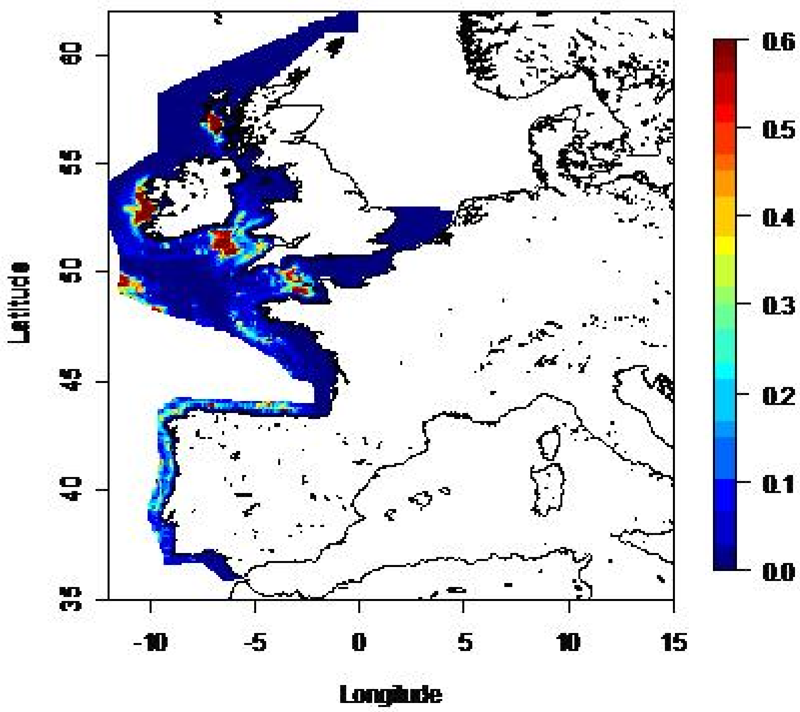


Figure 8: Common dolphin estimated density surface (animals per km^2) in 2005.

Abundance estimates for 2005 for the whole SCANS-II survey area estimated from the modelled density surface were 367,260 harbour porpoise (CV=0.14; 95%CI=248,271-429,018), 68,495 common dolphins (CV=0.67; 95%CI=39,056-257,136) and 18,790 minke whales (CV=0.44; 95%CI=7,310-38,085). These estimates compare favourably with the design-based estimates presented above, indicating that the models were robust.

<u>SCANS (1994)</u>

Data from the SCANS surveys in 1994 were also analysed using density surface modelling for comparison. There were sufficient data to do this for harbour porpoise and minke whale. Models for both species included a two-dimensional smooth term of latitude and longitude. The model for harbour porpoise explained 16% of the deviance and showed a tendency for animals to avoid deeper waters; distance from the coast was not selected in the model. The model for minke whale explained 26% of the deviance and showed a tendency for animals to avoid steeper slopes.

The fitted density surfaces for harbour porpoise and minke whale are shown in Figures 6-7.

Estimates of abundance for 1994 from the density surface models for the SCANS survey area were 345,132 harbour porpoise (CV=0.16; 95% CI=272,904-479,222) and 7,785 minke whales (CV=0.25; 95% CI=5,067-12,753). As for 2005, these estimates compare favourably with the design-based estimates presented above, indicating that the models were robust.

<u>Comparing SCANS-II (2005) with SCANS (1994)</u>

Harbour porpoise abundance in 2005 in the area surveyed by SCANS in 1994 was estimated at 315,027 (CV=0.17; 95% CI = 201,507-395,077), very similar to the estimate for 1994 for the same area. However, there is a marked difference in distribution, which is illustrated most obviously by the main concentration in the North Sea moving from the northwest in 1994 to the southwest in 2005 (Figure 6).

Minke whale abundance in 2005 in the area surveyed by SCANS in 1994 was estimated at 15,594 (CV=0.45; 95% CI=6,144-33,465). This estimate is higher than that for 1994 but is not significantly different. The weak concentration of whales off southeast Scotland in 1994 had dissipated to the central North Sea and also further north in 2005 (Figure 7).

These density surface maps show interesting differences in distribution between 1994 and 2005 but it is important not to over-interpret the results. The selected covariates did explain a reasonable amount of the model deviance but the predicted density distribution is highly dependent on the covariates available to the models. We had limited covariate information available for the whole area. Only static physical covariates were used and we might expect biological features of the environment, particularly related to prey distribution, to be better predictors of cetacean distribution and abundance. Hence, although inferences can be made about broad-scale patterns in distribution, it would be wrong to make inferences about the fine-scale details.

Similarly, although density surface modelling allows estimates of abundance to be calculated for any defined area, these areas should not be too small. As a general rule, abundance should not be estimated for areas that are smaller than the survey blocks.

The question of what could have caused the difference in distribution between 1994 and 2005, particularly for the harbour porpoise, is an interesting one. It is possible that the differences seen were simply due to inter-annual variation. However, the recent increases in sightings of harbour porpoises seen from the Dutch coast and in harbour porpoise strandings in the southern North Sea strongly suggest that the difference reflects a trend.

Bycatch is an important factor that can affect harbour porpoise abundance and potentially distribution. Bycatch of harbour porpoise in Danish fisheries is mostly in the central North Sea. Bycatch in UK fisheries is mostly in the southern North Sea. There is some Norwegian bycatch in the northern North Sea but this has not yet been quantified. There is also bycatch in UK and Irish fisheries in the Celtic Sea. Given this pattern, it seems highly unlikely that bycatch alone could have caused the observed changes in distribution. Western parts of the SCANS-II survey area were not surveyed in SCANS 1994 so another possibility is that the increase in estimated abundance in southern areas is due to immigration from west of Britain and Ireland.

Perhaps the most likely candidate reason for the changes in harbour porpoise distribution is a change in the distribution and/or availability of prey. Harbour porpoises range widely and, although their diet is varied, they feed primarily on species that are widely distributed, such as sandeel, whiting and herring. If there have been changes in the distribution or abundance of key prey species, this could have led to the changes in distribution observed for harbour porpoise.

E Public awareness and dissemination of information

E1: Website

The SCANS-II project website was launched in November 2004. The website provides an overview of the SCANS-II objectives, outputs and results. An additional information page features useful links to supporters of the project and references and downloads. The website was also used to advertise job opportunities within the SCANS-II project. Users of the website could, and continue to be able to, contact the project management with questions or comments via a dedicated portal for enquires.

The website URL is: http://biology.st-andrews.ac.uk/scans2/.

E2: Production of non-technical reports

Quarterly newsletters

A total of nine quarterly newsletters were produced over the course of the project. These maintained contact with and provide updates on project developments to representatives of the co-financing and partner Member States (see Appendix E2.0 for circulation list) and were also made available to the general public via the project website. The newsletters are included as Appendices E2.1-E2.9.

Project summary

A non-technical summary of the project is given in Appendix E2.10. This summary has been translated into Danish, French, German and Portuguese and is available on the project website.

Layman's report

The layman's report is presented under Section 11.

E3: Scientific publication of results

No papers on project results have yet been published. The papers that we intended to publish include:

Small cetacean abundance in European Atlantic shelf waters. Presentation of the stratified (design-based) and density surface (model-based) estimates of abundance for all species, and a comparison with results from 1994.

Advances in visual line transect data collection methods. Presentation of the system used to collect line transect data on SCANS-II, including angle and distance measurement, interfacing with LOGGER, etc.

Automatic detection of harbour porpoise echolocation clicks during line transect surveys. Technical description of the system used to collect acoustic data (RainbowClick software, hydrophone deployment, etc) and how it was implemented on the SCANS-II survey.

Statistical classification of small odontocete echolocation clicks: Description of the method used to classify clicks in the laboratory analysis of SCANS-II harbour porpoise analysis, plus developments made since then.

Using passive acoustics to monitor harbour porpoise populations. Presentation of acoustic analysis of the SCANS-II data and a comparison of results with those from visual surveys.

Technical advances in passive acoustic monitoring. Description and assessment of alternative methods of collecting acoustic data (bow mounts, keel mounts, bomb mounts, varying hydrophone lengths).

Using management procedures to set safe bycatch limits for small cetaceans in the North Sea and European Atlantic. Description of development of the procedures, using the operating model to test them, the results of performance-testing simulations and tuning, and preliminary results of applying tuned procedures to harbour porpoise in European waters.

Population dynamics of harbour porpoise in the North Sea and adjacent waters. Results of fitting the operating (populations) model to data on abundance, bycatch rates, age structure of stranded/bycaught animals, and reproductive/maturity rates of stranded/bycaught animals to assess status and make inferences about population dynamics.

Use of cetacean data collected on seabird surveys as indices of relative abundance: results of statistical modelling of harbour porpoise sighting rates using data from the European Seabirds At Sea (ESAS) database and assessment of the value of this approach for monitoring.

Review of methods previously used in monitoring temporal and spatial trends in distribution and abundance of cetaceans: comprehensive review indicating strengths and weaknesses of available monitoring methods, and the type of monitoring different methods can achieve.

Comparison of visual and acoustic methods for monitoring cetacean populations: results of the power analysis and cost-benefit analysis to compare different methods of monitoring, including recommendations for monitoring best practice.

E5: Dissemination of results

End of Project conference

The SCANS-II end of project conference took place at the Edinburgh Conference Centre, Heriot-Watt University, Scotland, UK on 8 December 2006. Sixty-one participants from 12 countries attended the conference. Four presentations prior to lunch focused on advances in survey methodology, abundance estimates obtained during SCANS-II and their comparison to results from the previous SCANS survey in 1994, as well as methods for monitoring cetacean populations between such decadal surveys. Two presentations after lunch addressed management models for bycatch and the implications of SCANS-II results for policy. Presentations were followed by stimulating round-room discussions among participants. Equipment used during the survey was also on display at the back of the conference room. Appendices 5.1-5.10 provide copies of the presentations, a summary of the discussion, a poster and a list of attendees. This information is also available on the project website.

Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS)

Macleod attended the April 2004 and 2005 Advisory Committee Meetings in Bonn and Brest, respectively. Hammond attended the 4th and 5th Meeting of Parties in August 2003, Esbjerg, Denmark and Egmond aan Zee, The Netherlands, September 2006, respectively. At these meetings, project plans, progress and results were presented and discussed, as appropriate.

European Cetacean Society

April 2005: 19th Annual Conference, La Rochelle, France. Poster presentation on SCANS-II: meeting European conservation objectives for small cetaceans through abundance surveys, monitoring and modelling.

April 2006: 20th Annual Conference Gdynia, Poland. Verbal presentations on estimates of abundance for small cetaceans and passive acoustic survey methods.

April 2007: 21st Annual Conference San Sebastián, Spain. Verbal presentation on final estimates of abundance for small cetaceans. A well-attended one-day workshop on SCANS-II methods, results and implications for future research was held as part of the conference agenda.

Several hundred scientists and students from Europe and further afield attend the ECS conferences. It was an important arena for raising awareness of the SCANS-II project.

Other international fora

Invited verbal presentations on abundance of small cetaceans and management procedures for determining appropriate limits to the bycatch of small cetaceans were presented to the ICES Annual Science Conference, Aberdeen, UK, September 2005 and Maastricht, The Netherlands, September 2006.

Poster presentation on determining appropriate limits for bycatch of small cetaceans in the European Atlantic and North Sea presented to 16th Society for Marine Mammalogy Biennial Conference on the Biology of Marine Mammals, San Diego, California, December 2005. More than 2000 participants from all over the world attended the conference, providing an opportunity to promote the project in an international context.

Invited presentation on the SCANS-II project to the Statusseminar on project MINOS+ (Marine Warmblüter in Nord- und Ostsee: Grundlagen zur Bewertung von Windkraftanlagen im Offshore-Bereich), Stralsund, Germany, September 2006.

Papers on project progress, the management procedure for setting safe limits to bycatch and on preliminary abundance estimates were presented and discussed at the 56th, 57th and 58th Annual Meetings of the IWC Scientific Committee, in July 2004, Sorrento, Italy, May/June 2005, Ulsan, Korea and May/June 2006, St. Kitts and Nevis, respectively.

F Overall project management

F1: Overall project operation and monitoring

Hammond was overall Coordinator and manager of the project but Macleod, as Assistant Coordinator, managed most aspects of the project on a day-to-day basis, including general administration, drafting contracts, organising meetings/workshops and managing the project budget. Hammond and Macleod oversaw the progression of the science of the project. Action leaders were responsible for ensuring that their work was on schedule and milestones were met. Hammond and Macleod endeavoured to ensure that Action outputs were delivered on time and were responsible for preparing the Interim and Final Reports.

The Interim Report on activities and financial accounts through 30 June 2005was submitted in September 2005. Questions concerning finance were raised by the Commission in December 2005 and addressed by the Beneficiary in a resubmitted report in January 2006. The Interim Report was approved in April 2006. A Progress Report was submitted in May 2006.

Project meetings were held as follows:

- Roskilde (NERI), Denmark, June 2004: to plan all project Actions, attended by 12 personnel (report given in Appendix F1.1).
- Brest, France, April 2005: to provide an opportunity for competent authorities and project partners from around Europe to contribute to how the monitoring and management objectives of the SCANS-II project will be achieved, attended by 23 participants from 9 countries (report given in Appendix F1.2).
- St Andrews (SMRU), UK, November 2005: to review progress on all Actions, attended by 16 personnel at (report given in Appendix F1.3).

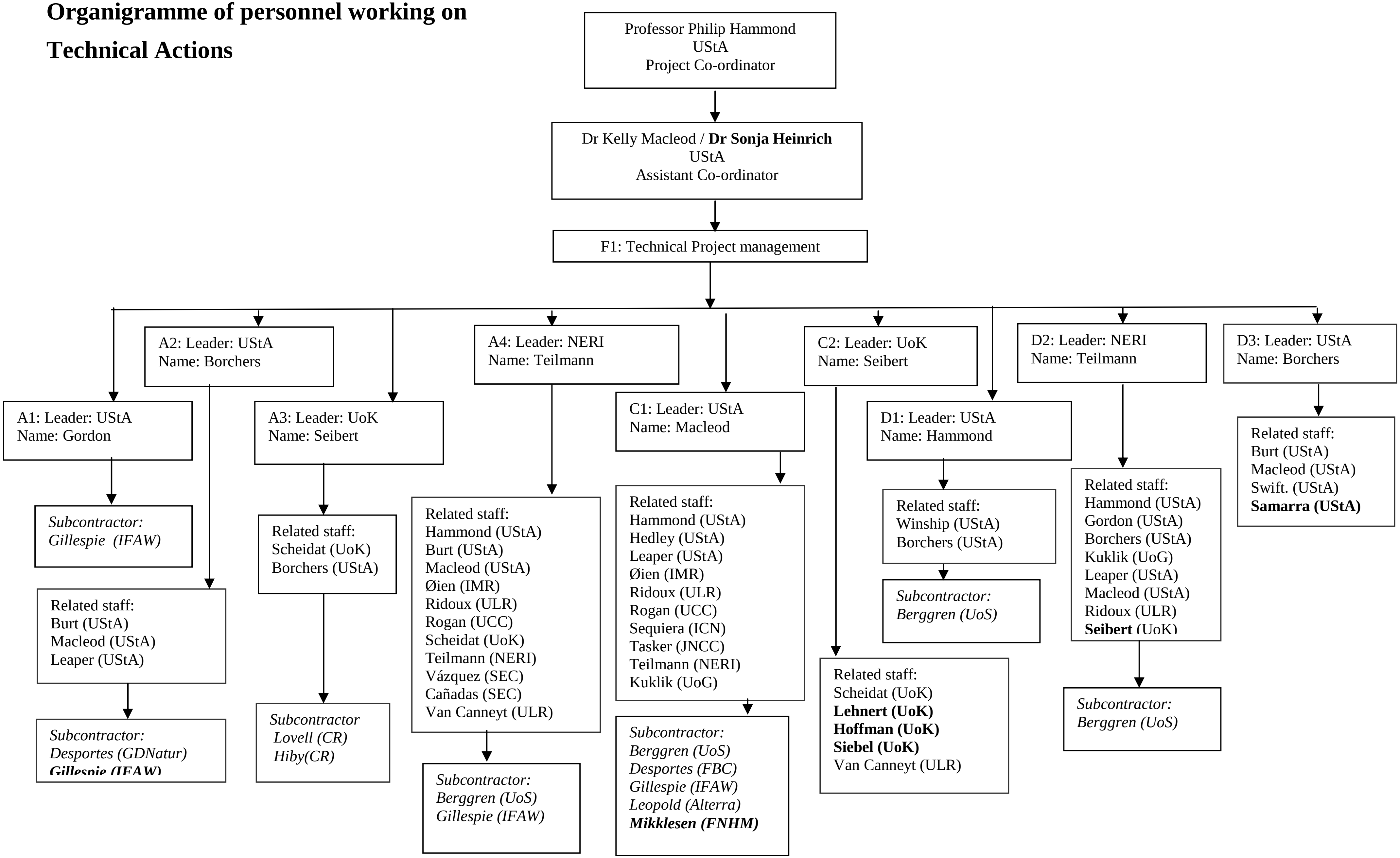
Project progress was externally reviewed at two meetings in St Andrews in March 2005, attended by Micheál O'Briain (DG Environment) and John Houston (Ecosystems - LIFE-support team), and in December 2006, attended by Jon Taylor of (Astrale - LIFE-support team).

The organigramme below highlights (in bold) changes to technical personnel that have occurred since the interim reporting date (June 2005).

F2: Project auditing

The project finances were audited on by Henderson Loggie.

Organigramme of personnel working on Technical Actions



8. Evaluation and conclusions

Implementation

The project was implemented through a series of Actions in three phases. It was necessary to complete the four preparatory A Actions before the C Actions could take place. Action A4, resolution of survey methods, was the pivot between Actions A1-A3, development of acoustic, shipboard and aerial survey methods, respectively, and Actions C1 and C2, the shipboard and aerial surveys, respectively. The timing of the pilot survey (Action A4) was crucial because of the need to give sufficient time for development of methods beforehand but also sufficient time for and revision of methods afterwards. April 2005 was determined to be the best time.

The main abundance surveys, Actions C1 and C2, took place over a single month: July 2005. They formed the heart of the project, which provided the data for the results D Actions. In particular, Action D3, estimation of abundance, relied entirely on the success of Actions C1 and C2. A major part of Action D2, comparison of monitoring methods and recommendations for monitoring, also relied heavily on Actions C1 and C2. Action D1, development of the management framework for setting safe bycatch limits, was partly independent but required the estimates of abundance resulting from Action D3. Some of the work under Action A1, development of acoustic methods, that was independent of the main surveys continued throughout the project.

Two of the Actions to disseminate information and results continued throughout the project: Action E1, the project website, and Action A2, production of non-technical reports (in the form of quarterly newsletters). Actions E5, the end of project conference, took place in December 2006. Action A3, scientific publication of results, will continue over the coming months. Action A4, final technical report, was completed in June 2007.

The implementation of the technical work of the project worked exactly according to plan. What has not yet happened is taking the results into national and European policy so that they can be used to advance conservation of small cetaceans. The meeting in April 2005 in advance of the ASCOBANS Advisory Committee meeting in Brest, France provided the opportunity for competent authorities and project partners from around Europe to contribute to how the monitoring and management objectives of the project would be achieved and to discuss how the results could be taken forward into policy (see Appendix F1.2). The End of Project conference (Action E5) was also partially successful in advancing this process but few policy representatives were able to attend. The project length was extended by 6 months from the initial proposal in part to enable the taking of results into policy to happen. That is has not is partly a result of overruns in generating results from the project and partly a lack of engagement by some policy personnel in the project.

Project management

The nature of the project dictated that its management was heavily centralised. The project focused on a major shipboard (Action C1) and aerial (Action C2) survey, the methods for which and the analysis of the resulting data needed to be implemented in exactly the same way. There were relatively few activities that could be managed in a distributed way. In addition, much of the expertise relating to this resided in SMRU and CREEM in St Andrews so it was appropriate for most of the Actions to be led by St Andrews based scientists. Nevertheless four of the five technical Actions were led by scientists from NERI and University of Kiel. Action leaders were responsible for delivering the outputs from their Actions on time.

Centralised project management makes for efficiency but can lead to feelings of isolation if participants feel of a lack of involvement in the project. There was excellent collaboration among all participants involved in all A and C Actions. Under Action D3, however, there was some criticism concerning a lack of involvement and a lack of timely communication of results to participants that were not directly involved in this activity. This was regrettable but the work under Action D3 was highly specialised and it is hard to see how other participants could have been involved more without a specific training element in the project. Action D2 did not progress according to plan and a lot of work had to be accomplished in the final stages of the project. Action D1 was a more specialised activity involving only a few participants.

More generally, the value of the partnerships was to bring all the Atlantic range states into the project (Belgium was not formally involved but contributed the use of a ship for training acoustic observers). The significance of this should not be underestimated. All European Atlantic countries can claim ownership to the outputs of the project and this should work in favour of the results being picked up at the European level, which is exactly what is needed for conservation efforts for small cetaceans to be effective. In addition, the project used observers from 14 different European countries and thus was successful in building capacity for conducting cetacean surveys widely across Europe.

Methods, results and cost-effectiveness

The methodology used in this project needed development but was mostly based on methods that had been used in the SCANS survey in 1994. The SCANS survey was the first to use the now widely accepted double-platform methods of visual data collection. There have been developments in the application of these methods (data collection and analysis) since 1994 and these were reviewed, trialled and incorporated, as appropriate, as part of the development activities in the project. The new methods of shipboard data collection developed as part of Action A2 will be a lasting legacy of the SCANS-II project. The SCANS project in 1994 had also used towed hydrophone arrays to collect acoustic data on some ships but the methods were not well developed then. Action A1 made the necessary developments to ensure that the quality and quantity of acoustic data collected was unprecedented in this project. This will also be a lasting legacy of the SCANS-II project. Overall, the survey methods were highly successful and have been only slightly modified for the CODA (Cetacean Offshore Distribution and Abundance) and TNASS (Trans-North Atlantic Sightings Survey) projects taking place in July 2007. Management modelling and data analysis methods were also developed as part of the project.

All Actions successfully generated the results anticipated. In terms of cost-effectiveness, the project involved a lot of resources (money and people) but this was necessary to achieve the end result. In particular, surveying small cetacean populations to obtain robust estimates of abundance is difficult and expensive because of the need to focus a lot of effort in a short period of time on animals that range over a wide area and spend most of the time underwater. SCANS-type surveys need only be conducted on a decadal time scale so it is worth investing the necessary resources to do the best job possible.

Comparison against project objectives

All Actions achieved their objectives and the overall project objectives were met. The task now is to take the results into the European policy arena with the aim of using the results to ensure long term favourable conservation status with respect to bycatch for small cetacean populations in the European Atlantic. Many of the methods developed and results obtained are also highly relevant to addressing threats other than bycatch and to other areas, such as the Mediterranean Sea. This point is further discussed below and in the After-LIFE Conservation Plan in section 11.

Conservation benefits and policy implications

As described above, information on small cetacean population size allows bycatch levels to be put into context. Having a management framework informed by estimates of population size allows safe limits to bycatch to be determined. Quantitative comparison of monitoring methods leads to the most cost-effective way of determining whether or not mitigation measures are achieving their conservation objectives. These tools and this information now exist for small cetacean populations in the European Atlantic continental shelf. The next step is for policy makers and conservation managers to use this information to ensure that small cetacean populations are maintained at favourable conservation status in the face of continuing pressure from fisheries.

While reducing bycatch to levels approaching zero is a clear long-term aim, fisheries bycatch will continue in the medium term. The policy aim must be to ensure that bycatch is not impacting small cetacean populations while working towards reducing bycatch to levels approaching zero. In particular, finding a way to set appropriate conservation objective(s) and implement the bycatch management framework to set limits that bycatch should not exceed is a challenge that must be taken up at the European level. This project has provided the tools but policy makers must take this forward.

A critical part of such a policy is to find a way to monitor bycatch in a cost-effective way that generates robust estimates of bycatch. The way in which the management procedures developed under Action D1 should be implemented depends on assumptions about how reliable is the information on bycatch. If information on bycatch is poor, the greater uncertainty results in a lower safe limit to bycatch, which would mean greater restrictions on fisheries. If true bycatch were high this would be entirely appropriate but if true bycatch were low this could result in unnecessarily stringent restrictions on fisheries. If information on bycatch is more reliable, more appropriate safe limits to bycatch can be set.

Innovation and demonstration value

The innovation in this project has been three-fold: the development of data collection methods for estimating absolute abundance and for monitoring relative abundance to a stage where they are genuinely state of the art; the development of a management framework that can be used to set safe bycatch limits for small cetaceans in European waters; and the first quantitative comparison using power analysis and a cost benefit analysis to guide best practice for monitoring trends in populations in between major decadal SCANS-type surveys.

The project would not have been possible without the addition of EU funding to the support of all the European Atlantic range states; the value added by EU funding is therefore very high.

The potential for application in other European areas is also very high. The Agreement on the Conservation of Cetaceans of the Black and Mediterranean Seas and contiguous Atlantic area (ACCOBAMS) is currently planning to conduct a SCANS-type survey in its region and has taken a keen interest in the SCANS-II project. SCANS-II participants Cañadas and Donovan are part of the ACCOBAMS survey planning team, Hammond is part of the steering group, and Borchers, Gillespie, Gordon and Swift have also been part of the planning process. The planning, organisation, survey data collection and analysis methods and general implementation of this project are being used as model for the ACCOBAMS survey effort.

Socio-economic effects

The socio-economic context of the project is that European fisheries are under increasing pressure. Total allowable catches and fleet capacities have declined. The Commission's Council Regulation laying down measures concerning incidental catches of cetaceans in fisheries and amending Regulation (EC) No 88/89 (2003/0163 (CNS)) specifies mitigation measures that will increase pressure on fisheries. The severity of such measures depends on the impact of bycatch on small cetacean populations.

The results of the SCANS-II project provide a means for the Commission and Member states to assess the impact of bycatch of small cetaceans and to set safe limits to bycatch so that populations can recover to or maintain favourable conservation status, without placing an unnecessary burden on the fisheries sector. This is a key element of ecosystem management of fisheries that should help the fisheries sector to move towards a stable sustainable future.

The future: sustainability

The After-LIFE conservation plan is included under section 11.

Long term indicators of project success

There should be several long term legacies of this project. First, the abundance estimates for the various species will form part of a slowly growing long term time series of such estimates that will inform conservation efforts for decades to come. Second, the developments in methodology should be taken up by others conducting major sightings surveys. In fact, in July 2007 the T-NASS surveys taking place in the northern North Atlantic and the CODA surveys taking place in offshore European waters will use the same methodology as the SCANS-II surveys, and the ACCOBAMS surveys planned for the Mediterranean and Black Seas also plan to use these methods. Third, the quantitative comparison of monitoring methods using power analysis and cost-benefit analysis should be valuable to Member States in determining how to implement programmes for monitoring cetacean populations to fulfil responsibilities under the Habitats Directive. The use of this methodology will be a measure of the success of this project. Fourth, the management framework to set safe limits to bycatch should be a valuable tool, in combination with monitoring bycatch, for assessing whether bycatch levels are too high and mitigation is needed. If EU Member States can agree that this is a valuable tool, agree on conservation objectives and agree to implement it, this will be an indicator of the success of this project.

More generally, the results will be used widely in a number of international fora that are concerned with the conservation of small cetaceans: EU, ICES, ASCOBANS, IWC. The SCANS results from 1994 are still widely used in such fora and we expect the SCANS-II results to be similarly used for a long time to come.

9. Comments on financial report

Comments on the financial report are included with the financial report.

10. Appendices

A Actions

A1.1 Acoustic detection system
A1.2 Acoustic equipment setup manual
A1.3 Comparison of deployment options for collecting acoustic data from ships

A2.1 Review of shipboard survey methods
A2.2 LOGGER manual
A2.3 Shipboard validation and video manual
A2.4 Shipboard cruise leader manual
A2.5 Shipboard observer manual

A3.1 Review of aerial survey methods
A3.2 Aerial survey field manual

A4.1 Report of shipboard pilot survey
A4.2 Report of aerial pilot survey

C Actions

C1.1 Cruise report: *Gorm*
C1.2 Cruise report: *Investigador*
C1.3 Cruise report: *Mars Chaser*
C1.4 Cruise report: *Skagerak*
C1.5 Cruise report: *Victor Hensen*
C1.6 Cruise report: *West Freezer*
C1.7 Cruise report: Zirfaea

C2.1 Aerial survey cruise report

D Actions

D1.1 Management models for safe bycatch limits
D1.2 Harbour porpoise assessment

D2.1 Review of monitoring methods
D2.2 Analysis of harbour porpoise sighting rates from the European Seabirds at Sea database
D2.3 Analysis of acoustic data
D2.4 Quantitative comparison of monitoring methods and recommendations for best practice

D3.1 Effective strip half-width estimates from aerial survey data
D3.2 Aerial survey abundance estimates for harbour porpoise
D3.3 Aerial survey abundance estimates for minke whale and dolphins
D3.4 Design-based abundance estimates
D3.5 Model-based abundance estimates

E Actions

E2.0 Newsletter circulation list
E2.1-2.9 Project newsletters: issues 1-9
E2.10 Non-technical summary

E5.1-5.10 Output from final project conference

F Actions

F1.1-1.3 Project meeting reports: June 2004, April 2005, November 2005

11. Layman's report

The printed laymans report is included as a separate document with this report. An electronic version is also available on the CD with appendices.

12. After-LIFE Conservation Plan

The technical results of the project have not yet been considered and taken up at the policy level. This is the next step that needs to be taken for the conservation benefits of the project to be fully realised, and forms the basis for our After-LIFE Conservation Plan.

Results from the project fall into three categories: abundance estimates; monitoring small cetacean populations; and a management framework for setting safe limits to bycatch.

Estimates of abundance

The abundance estimates do not need any specific action to take them forward. Their existence is already widely known through the dissemination of results as described under Actions E1-5. Robust information on population size is at the heart of conservation efforts and this will be used by members of the public, NGOs, scientific researchers, government departments and conservation agencies of European Member States, and relevant international organisations (EU, ICES, ASCOBANS, IWC). The results have already been used by some Member States in assessing the Conservation Status of cetaceans as required by the Habitats Directive.

In the longer term, it is important that the currently short series of abundance estimates is continued and it will be necessary to consider a third SCANS survey in about 2015. Approximately decadal surveys are adequate although a case could be made for surveys at a slightly greater frequency. Because of the considerable investment required, it is important that the EU and Member States keep this activity on the horizon.

Current project CODA, Cetacean Offshore Distribution and Abundance in the European Atlantic, is conducting a follow-up survey to SCANS-II in July 2007 in offshore waters of Spain, France, Ireland and the UK. The focal species are bottlenose (Annex II) and common (bycatch in pelagic trawls) dolphins, fin whale (the most abundance baleen whale in the area) and deep diving species (sperm and beaked whales). CODA is not an EU supported project but the results will add considerable value to SCANS-II by extending our knowledge of cetacean abundance out to the 200nm fisheries limit in most areas of the Atlantic. The management framework will be further developed and applied to common dolphins.

Monitoring population trends

EU Member States must implement surveillance of cetacean populations to satisfy the requirements of the Habitats Directive; surveillance is equivalent to monitoring as considered in this project. A fundamental problem with this is that, with some exceptions, cetacean populations are not limited to the waters of any particular country. Independent information on the status of a species on a country by country basis will not be informative about population trends or status if that species ranges widely across national boundaries. In these cases, the only way to obtain information that is useful for conservation at the biological population level is through coordinated monitoring efforts among Member States.

The main exception to this general rule is the bottlenose dolphin, some small coastal populations of which around the Atlantic coasts of the UK, Ireland, France, Spain and Portugal have been effectively monitored using small scale photo-identification and mark-recapture analysis within a single country. However, bottlenose dolphins also occur offshore (see Actions C1 and D3) and it is doubtful that these methods would be useful to monitor these populations for logistical reasons.

Generally, then, to obtain useful information on trends and status of small cetacean populations it is necessary for Member States to coordinate monitoring programmes and to use the methods found to be appropriate as informed by the work conducted in Action D2. This work showed that three methods are suitable for monitoring trends in harbour porpoises - shipboard and aerial visual surveys and acoustic surveys on ships. Other methods may also be appropriate but the statistical power of these could not be tested in this project; in particular, we were not able to assess the potential for static acoustic monitoring to detect population trends at large spatial scales; this needs further work.

There are a number of important additional points to take into account when considering which method(s) to use for monitoring. First, only visual methods are currently appropriate for species other than harbour porpoise. Second, there are several logistical considerations that may favour one method over another. Third, there is a wide range of costs associated with monitoring using different methods. Fourth, different Member States have a different mix of species in their waters. These practical considerations mean that it is not possible to make general recommendations for monitoring of small cetaceans. A combination of methods might be appropriate in some cases.

It should be clear from the above that to move forward Member States need to agree on a coordinated approach to monitor small cetacean populations. This would be best done under the auspices of the EU and a representative of the Commission has expressed interest in holding a meeting to discuss how the results of this project can help in this respect. Key to the success of such a meeting will be a desire to coordinate efforts and a willingness to pay attention to the technical detail so that the best and most cost-effective methods can be used. To facilitate this, project scientific participants will liaise with the policy departments in their countries.

Management framework for bycatch

In the SCANS-II project we have implicitly assumed that although a general overall aim is to reduce cetacean bycatch to levels approaching zero, fishing will continue and, therefore, that bycatch will also continue, at least in the short-to-medium term. There will therefore continue to be a need to consider the impact that bycatch has on cetacean populations and, if that impact is determined to be a threat to recovering to or maintaining favourable conservation status, a need to introduce mitigation measures to control fishing.

The management framework we have developed is a robust mechanism to identify safe upper limits to bycatch. We do not advocate using the framework to set allowable bycatch limits in the way that Total Allowable Catches are set for fisheries, that is to set limits which it is expected will be reached, although it could be used in this way. Rather we see the framework being used to determine the level of bycatch of a particular species in a particular region that, if exceeded, would signal the need for management measures over and above any mitigation already in place.

But before the management framework can be implemented, the following steps should be taken, as given under Action D1:

1. Agreement by policy makers on the exact conservation/management objective(s);
2. Agreement by policy makers to implement for one or more species in one or more regions;
3. Consideration by scientists of whether or not the available information for each species indicates that there is a need to conduct further simulation testing to examine uncertainties that may not have been fully explored;
4. In particular, if there is evidence for sub-population structure, consideration by scientists of any further simulation testing required and/or identification of any sub-areas that may be considered to contain sub-populations;
5. In addition, if there is evidence of historical bycatch but no data, consideration by scientists of any further simulation testing required including the generation of appropriate data series based on the best available information;
6. Final determination by scientists, based on the results of Steps 3 - 5, of how to implement for each species/region;
7. Agreement by policy makers to implement;
8. Generation by scientists of bycatch limits for a specified period (e.g. 5 years);
9. Establishment of a mechanism for feedback of information from bycatch monitoring programmes to inform the next implementation when the period for which safe bycatch limits have been set expires.

The management framework should thus be seen as a mechanism to be used in conjunction with bycatch monitoring and direct management action relating to fisheries, as appropriate. Such management action could include the use of pingers on nets and time/area closures.