Agenda Item 4.1	Review of New Information on Other Matters Relevant for Small Cetacean Conservation Population Size, Distribution, Structure and Causes of Any Changes
Document 4.1.c	**Proceedings of the ECS / ASCOBANS / WDC Workshop** ***Towards a Conservation Strategy for White-beaked Dolphins in the Northeast Atlantic***
Action Requested	• Take note
Submitted by	Whale and Dolphin Conservation

NOTE:
DELEGATES ARE KINDLY REMINDED TO BRING THEIR OWN COPIES OF DOCUMENTS TO THE MEETING

Proceedings of the

ECS / ASCOBANS / WDC Workshop

Towards a Conservation Strategy for White-beaked Dolphins in the Northeast Atlantic

Held at the European Cetacean Society's 27th Annual Conference

The Casa da Baía, Setúbal, Portugal, 6th April 2013

Conveners and Editors:

Michael J. Tetley and Sarah J. Dolman

ECS SPECIAL PUBLICATION SERIES
NO. XXX
2013

PROCEEDINGS OF THE WORKSHOP ON

TOWARDS A CONSERVATION STRATEGY FOR WHITE-BEAKED DOLPHINS IN THE NORTHEAST ATLANTIC

Held at the

European Cetacean Society's 27th Annual Conference,

The Casa da Baía, Setúbal, Portugal, 6th April 2013

Conveners and Editors:

Michael J. Tetley[1, 2] and Sarah J. Dolman[2]

[1] Consultant to Whale and Dolphin Conservation (WDC), Marine and Ecological Science, Montague House, Durham, DH1 2LF, UK
[2] WDC, Brookfield House, 38 St Paul Street, Chippenham, Wiltshire, SN15 1LJ, UK

ECS Reviewer - *Lagenorhynchus sp.* Working Group:

Marianne H. Rasmussen

The University of Iceland's research center in Húsavík, Hafnarstétt 3, 640 Húsavík, Iceland

Citation: Tetley, M.J. and Dolman, S.J. 2013. Towards a Conservation Strategy for White-beaked Dolphins in the Northeast Atlantic. Report from the European Cetacean Society's 27th Annual Conference Workshop, The Casa da Baía, Setúbal, Portugal. European Cetacean Society Special Publication Series No. XX, 121pp.

Front Cover Photo: Michael J. Tetley

Contents

Workshop Summary, Conclusion and Recommendations

I. Introduction to Proceedings

Sarah J. Dolman[1] & Michael J. Tetley[1, 2]

[1] Whale and Dolphin Conservation (WDC), Brookfield House, Chippenham, SN15 1LJ, UK
[2] Consultant, Marine and Ecological Science, Montague House, Durham, DH1 2LF, UK

SUMMARY

The following proceedings represent the work presented at, and contributed to, the European Cetacean Society (ECS) / ASCOBANS / WDC white-beaked dolphin *Lagenorhynchus albirostris* species workshop, held in Setubal Portugal, as part of the 27th Annual ECS Conference. The workshop entitled *Towards a Conservation Strategy for White-beaked Dolphins in the NE Atlantic* was a follow up to the first joint white-beaked and Atlantic white-sided workshop held in Stralsund Germany in 2010. Primarily the workshop aim was to address those aspects not covered in Stralsund, namely the legislation, threats and current status of the species which inform the necessary policy underlying its present conservation. After the workshop the participants, and researchers who had submitted abstracts but were unable to be present at the workshop in Portugal, were invited to submit extended summaries of their research to the workshop proceedings for wider circulation and submission to ASCOBANS.

Fourteen people attended the half day workshop with eleven presentations in the first session given across a wide range of topics including policy and legislation and threats to conservation status, as well as updated research presentations pertaining to new findings on the acoustics, ecology, photo-identification, population structure and physiology of *L.albirostris*. Furthermore, the workshop held a second discussion session on the threats facing the species conservation status in the NE Atlantic and the basis for recommending action points for promoting future collaboration and a species conservation strategy.

Ten extended summaries were submitted for inclusion in the proceedings covering *L.albirostris* conservation and research activities from across the NE Atlantic including sites in Iceland, Norway, Scotland and England, representing a significant proportion of the estimated population size of 100,000 (95% CI:31,000-265,000) occurring throughout its Northeast Atlantic range (Figure 1.)

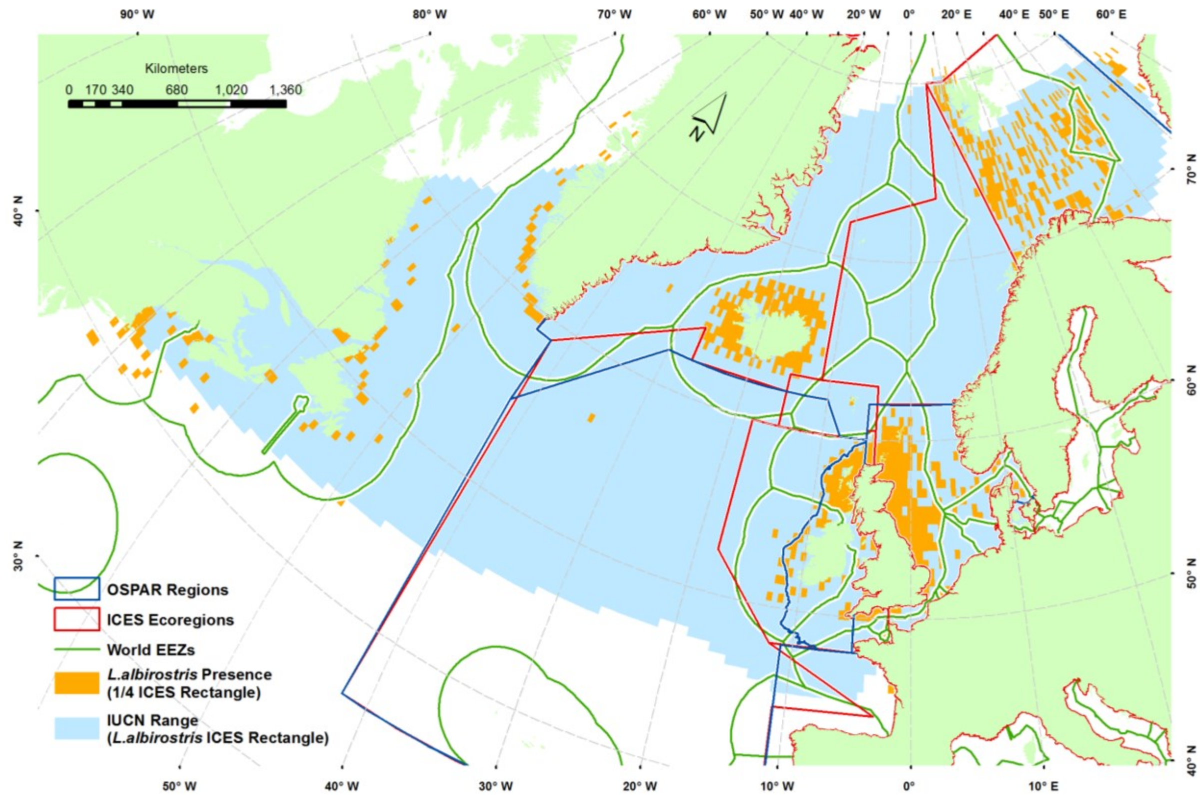


Figure 1. Known presence distribution of white-beaked dolphin within the North Atlantic from publications available (1980-2013). Northeast Atlantic population abundance quoted as 100,000 from Hammond *et al.,* 2012 and is based on Øien, 1996. See Annex 5 for full species bibliography and above references. Geo-political boundaries for the region focusing on the Northeast Atlantic are shown.

Information submitted to the proceedings is separated into two main sections, 1) the assessment of current conservation status, protective agreements and legislation as well as the identification of threats and 2) updated research on the species acoustics, ecology and population dynamics.

White-beaked dolphins are protected through many international agreements and national legislation, of which a main aspect is the determining and maintaining of species Favourable Conservation Status (FCS). Examples of agreements and assessments relating to *L.albirostris* FCS are the EU Habitats Directive, the IUCN Red List and the Convention of Migratory Species (CMS). Currently these agreements consider *L.albirostris* to be Annex IV thereby requiring strict protection (Habitats Directive); Least Concern – LC and thereby not deemed threatened or near threatened globally (IUCN Red List); and Unfavourable within the North and Baltic Seas (CMS). Due to being Unfavourable and Appendix II under CMS, white-beaked dolphins are a feature of conservation concern within the CMS regional Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS). ASCOBANS obliges Parties to focus on: habitat conservation and management; Surveys and research; evaluation of bycatch and stranding data; improving legislation; and providing information and education. At present threats thought to be at a sufficient level to affect *L.albirostris* FCS within the NE Atlantic include climatic changes, noise and chemical pollution, prey depletion and habitat degradation, with smaller impacts resulting from bycatch and small scale hunting. For further information on the assessment of threats and FCS please see *Sections II-IV. Background: assessing conservation status*.

Knowledge of many aspects of white-beaked dolphin life history, distribution, abundance and population dynamics remain either partial or limited. There is some knowledge regarding overall population size within the NE Atlantic, as well as the presence of distinct regional aggregations which may serve as appropriate management units (including Western North Atlantic mainly in Canadian waters, Icelandic waters, Northern Norway and a continuous management unit including the British Isles and all of the North Sea).

However, further information presented within this report demonstrates important new findings. These include:

- This species broadscale habitat appears constrained in its distribution to cooler waters < 18°C, yet specifically seems to be located in shelf waters in areas of high bathymetric relief and complexity;
- Although capable of long range regional movements, individuals can also show repeated inter-annual site-fidelity;
- Within potential management units there may be a further number of discreet populations within those units worthy of further investigation;
- The species acoustically distinct signatures can potentially make the species easily identifiable via passive acoustic monitoring, providing the potential for increased accuracy in at sea monitoring and population delineation.

Further information on new findings from across the species NE Atlantic range can be found in *Sections V-XI. Case Studies: workshop summaries and invited other research activity.*

The ECS/ASCOBANS/WDC species workshop on white-beaked dolphins *Lagenorhynchus albirostris,* and the resulting extended material presented herein, indicates that since the species listing in many international agreements (Habitats Directive, IUCN Red List, CMS) significantly more knowledge pertaining to the species life history, ecology and population structure is available. Furthermore, in the light of increased knowledge of the threats to the species conservation status throughout its NE Atlantic range, particularly through predicted changes in climate, further action is required to readdress the current policy for the species conservation.

RECOMMENDATIONS

As a result of this synthesis of current knowledge, and concerns for the species in some parts of its range, a number of recommendations are made by the community of white-beaked dolphin researchers and conservation practitioners to assist in ensuring the species future Favourable Conservation Status (FCS). These are detailed below:

1) Further multi-national research collaboration

A limiting factor raised through the course of the workshop was that evidence for application to the assessment of FCS was either a lack of information on key life history, ecology and population traits for the species, but more importantly a lack of consistent knowledge of these traits between the species proposed management units. As a output of the 1st species workshop including *L.albirostris* in 2010, a collaborative research project to compare physiological datasets from a collective of North Sea countries successfully provided new knowledge of life expectancy, reproduction and age of maturity (now published in Galatius *et al.,* 2013 – See Annex 3 this in proceedings). As a result it is recommended that further trans management unit research for monitoring of the species regional movements, acoustic characteristics and range changes in response to climatic variation become a priority in future research endeavour.

2) Consensus approach to the assessment of threats on FCS

At present the level of threat to *L.albirostris* FCS in the NE Atlantic is not fully understood, though the identification of particular threats most common for the species appear clear (e.g. climate change, habitat and prey depletion, noise and chemical pollution). Therefore without clear evidence from extensive monitoring activity our primary means for the assessment of these threats is through expert opinion. Therefore, a recommendation that a suitable method by which to sample the *L.albirostris* research and conservation practitioner community be developed to provide much needed advice to global, regional and local management programmes for the species conservation. MacLeod (these proceedings Section IV.) proposes a method of qualitative assessment using multi-level ranks (through population and geographical scale determinants) to ascertain this information. After discussions of the methods propped at the workshop, those in attendance agreed that such a method could be employed via a consensus approach to provide a mean qualitative assessment (with confidence intervals in each category) after development and wider circulation amongst experts.

3) Revision of status listing in international agreements and conservation strategy

White-beaked dolphins for the most part appear either fairly low or absent in assessment of their conservation status within several key international conservation agreements (e.g. CMS/ASCOBANS, IUCN Red List, Habitats Directive). However, *L.albirostris* was added to these agreements from the 90's to early 2000's and as such assessments were made from limited evidence at those times, particular in relation to the species predicted susceptibility to climatic change impacts.

Therefore, it is recommended that new assessments be made for the species FCS and the degree of its threatened status within international conservation agreements and strategies within the NE Atlantic. In particular these include:

CMS – At present the species is listed as Annex II for that population(s) occurring in the North and Baltic Seas (under ASCOBANS regional agreement). However, after the workshop and material submitted within the proceedings concerning the species distribution contraction/retraction in responses to climatic change, the FCS of the species could be severely impacted throughout its N Atlantic range. Therefore an expansion of the listing to cover the entire range of the species should be developed as an official proposal for the consideration of the CMS Scientific Council and then the Conference of the Parties (COP). Such a listing proposal should follow the outline provided in CMS Resolution 1.5 for which details on the biology and range of the species, the threats and the protection status are needed.

EU Habitats Directive – Currently the species is listed as having an Unknown FCS within its Marine Atlantic range, with the UK national assessment being only Favourable. As of 2013, at the time of the species workshop and production of the proceeding, all cetacean FCS are under reassessment under Article 17 of the Directive. Should the outcome of such an assessment be deemed to meet FCS for the UK and other countries (without consideration of potential influences of climatic change or other identified threats discussed in this proceedings) then it is recommended that that further effort and resources be used to monitoring the effects of threats upon *L.albirostris* over the course of the next Article 17 reporting cycle (2012-17) or that those FCS assessments be contested by the ECS or workshop participants.

OSPAR – The Convention for the Protection of the marine Environment of the North-East Atlantic (the 'OSPAR Convention') was open for signature at the Ministerial Meeting of the Oslo and Paris Commissions in Paris on 22 September 1992. This is the mechanism by which fifteen Governments of the western coasts and catchments of Europe, together with the European Community, cooperate to protect the marine environment of the North-East Atlantic. A key aspect of OSPAR is the production of the Threatened and Declining list of species and habitats in need of monitoring and protection via sectorial and area-based protection i.e. OSPAR MPA Network. *L.albirostris* does not currently feature in the list, which currently contains harbour porpoise, blue whale and north Atlantic right whale.

CONCLUSION OF WORKSHOP

White-beaked dolphins are an endemic species to the North Atlantic, with the majority of its core distribution areas within the NE around Western Europe and Scandinavia. Until recently little was known regarding the species life history, abundance, population dynamics and ecology. As such they have been included in many international conservation agreements in the blanket of 'small cetaceans' without much targeted research or conservation focus. However, after the 1st and 2nd ECS/ASCOBANS workshops on the species it is recommended that enough evidence is available for a reassessment of the species Conservation Status across its range, in particular related to ever increasing threats of climatic change, pollution, prey depletion and habitat degradation.

ACKNOWLEDGEMENTS

The workshop organisers and proceedings editor would like to thank all those who took part in the workshop *Towards a Conservation Strategy for White-beaked Dolphins in the NE Atlantic* including the ECS workshops organising committee, all presenters, participants, submitting authors to the proceedings. Furthermore, Heidrun Frisch is thanked for her attendance and much appreciated assistance representing ASCOBANS and the ECS working group on NE Atlantic *Lagenorhynchus* species for support of the workshop and production of the proceedings.

<u>Background: assessing conservation status</u>

II. Assessing *L.albirostris* Conservation Status – CMS, EU and IUCN Approaches

Michael J. Tetley

Consultant to the WDC Critical Habitats and Marine Protected Areas Programme / Ecological and Marine Sciences, Montague House, Durham, DH1 2LF, UK

The white-beaked dolphin (*Lagenorhynchus albirostris)* is protected to varying degrees throughout its North Atlantic range by international agreements and national legislations. However, in the north eastern part of that distribution three primary agreements affect the species protection through the assessment of their conservation or threatened 'Status' and whether that meets a defined threshold. In this synthesis of key aspects pertaining to *L.albirostris* conservation, the three agreements reviewed include the Convention on Migratory Species (CMS), the EU Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora, or Habitats Directive (92/43/EEC) and the IUCN Red List. The purpose of this review is to assess the utility of these agreements for assessing species status and the measures these provide, or need to if require updating, to protect *L.albirostris.*

CURRENT STATUS

<u>Convention on Migratory Species (CMS)</u>

The Convention on the Conservation of Migratory Species of Wild Animals (also known as CMS or Bonn Convention) aims to conserve terrestrial, aquatic and avian migratory species throughout their range. It is an intergovernmental treaty, first signed in 1979, concluded under the aegis of the United Nations Environment Programme, concerned with the conservation of wildlife and habitats on a global scale. Since the Convention's entry into force, its membership has grown steadily to include 118 (as of 1 January 2013) Parties from Africa, Central and South America, Asia, Europe and Oceania. Fundamentally the agreement provides signed parties with a definition within the agreement of 'Favourable Conservation Status - FCS' for species listed. Should species be found to not meet this definition parties agree to take action to ensure species are conserved (Prideaux, 2003; Frisch, 2010). This is presented within the agreement as:

"The Parties acknowledge the importance of migratory species being conserved and of Range States agreeing to take action to this end whenever possible and appropriate, paying special attention to migratory species the <u>conservation status</u> of which is

unfavourable, and taking individually or in co-operation appropriate and necessary steps to conserve such species and their habitat."

Therefore the definition of FCS is crucial to the mechanics of the agreement and that Conservation Status will be taken as "favourable" when:

1) *Population dynamics* data indicate that the migratory species is maintaining itself on a long-term basis as a viable component of its ecosystems;
2) The *range* of the migratory species is neither currently being reduced, nor is likely to be reduced, on a long-term basis;
3) There is, and will be in the foreseeable future *sufficient habitat* to maintain the population of the migratory species on a long-term basis; and
4) The *distribution and abundance* of the migratory species approach *historic coverage and levels* to the extent that potentially suitable ecosystems exist and to the extent consistent with wise wildlife management.

Conservation status will be taken as "unfavourable" if any of the conditions set out in the above paragraph are not met. At this stage there is an option to list any "unfavourable" species within either Appendix I or II of the agreement. At present, since its initial assessment as "unfavourable", *L.albirostris* is listed in Appendix II of the agreement but for the North and Baltic Seas only. Appendix II species and the required action by parties are described in the agreement as:

"Appendix II shall list migratory species which have an unfavourable conservation status and which require international agreements for their conservation and management, as well as those which have a conservation status which would significantly benefit from the international cooperation that could be achieved by an international agreement."

"Parties that are Range States of migratory species listed in Appendix II shall endeavour to conclude AGREEMENTS where these should benefit the species and should give priority to those species in an unfavourable conservation status."

Within the Northeast Atlantic, The ASCOBANS Conservation and Management Plan, which forms part of the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (and includes *L.albirostris*), obliges Parties to focus on: habitat conservation and management; surveys and research; evaluation of bycatch and stranding data; improving legislation; and providing information and education. Further information regarding the work of the ASCOBANS agreement can be found in this review (*Section III. ASCOBANS and White-beaked Dolphins - Heidrun Frisch*) and as such is not reviewed further here.

Further to the formation of the ASCOBANS agreement, *L.albirostris* conservation is also addressed in three additional CMS COP resolutions on cetaceans including Resolution 9.7 (2008) on Climate Change Impacts on Migratory Species, Resolution 9.18 (2008) on By-Catch and Resolution 9.19 (2008) on Adverse Anthropogenic Marine/Ocean Noise Impacts on Cetaceans and other Biota. However, at present in Resolution 10.15 (2012) on the Global Programme of Work for Cetaceans (2012-2024), *L.albirostris* is not specifically named for concerted action within the regions it occurs.

<u>EU Habitats Directive</u>

The EU Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) agreed in 1992, in partnership with the Birds Directive 2009/147/EC on the conservation of wild birds (codified version of Council Directive 79/409/EEC as amended), aims to improve the status of natural habitats and species in Europe through necessary conservation measures. Within the agreement these points pertaining to 'Conservation Status' are described as follows:

"In the European territory of the Member States, natural habitats are continuing to deteriorate and an increasing number of wild species are seriously threatened; given that the threatened habitats and species form part of the Community's natural heritage and the threats to them are often of a transboundary nature, it is necessary to take measures at Community level in order to conserve them."

"Conservation means a series of measures required to maintain or restore the natural habitats and the populations of species of wild fauna and flora at a favourable status…"

"Favourable conservation status of a species means the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations…"

Therefore the definition of FCS is crucial to the mechanics of the directive and as such the agreement describes that the conservation status of any species will be taken as "favourable" when:

1) Population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats
2) The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future
3) There is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis

At present *L.albirostris* is listed on Annex IV of the agreement, meaning that they are considered to be a species of community interest in need of strict protection. As such they are affected by two articles of the agreement (Articles 12 and 17).

Within Article 12 Member States shall take the requisite measures to establish a system of strict protection for the animal species listed in Annex IV in their natural range, prohibiting: all forms of deliberate capture or killing of specimens of these species in the wild; deliberate disturbance of these species, particularly during the period of breeding, rearing, hibernation and migration; deliberate destruction or taking of eggs from the wild; and the deterioration or destruction of breeding sites or resting places. Member States are required to establish a system to monitor the incidental capture and killing of the animal species listed in Annex IV. Furthermore in the light of the information gathered, Member States shall take further research or conservation measures as required to ensure that incidental capture and killing does not have a significant negative impact on the species concerned.

In this regard the monitoring of cetacean bycatch is also specifically required for certain fisheries under fishery regulation EC 812/2004 of 24 April 2004.

Within Article 17 of the agreement Member States are required to monitor the conservation status of habitats and species covered by the Directive and to report their findings to the Commission every 6 years. Within the Directive this is described as;
'Member States shall undertake surveillance of the conservation status of the natural habitats and species referred to in Article 2 with particular regard to priority natural habitat types and priority species.'

These are then assessed by the European Environment Agency (EEA) at two regional levels including all biogeographic regions (Marine Atlantic, Baltic, Black Sea, Macaronesian, and Mediterranean) and by each Member State (Evans and Arvela, 2012).

At the time of this review white-beaked dolphin FCS are listed as 'Unknown' throughout the Biogeographic regions it occurs (Marine Atlantic), and 'Unknown' throughout all member states besides a classification of 'Favourable' within the United Kingdom (Figure 1). Assessments were based on a baseline of dedicated surveys undertaken in 1994 SCANS which generated information on summer distribution and abundance estimates for a range of species and/or the Cetacean Atlas. This was supplemented by data collected in 2005 during SCANS II and additional CODA survey work undertaken in 2007 off the continental shelf, as well as continued collection of strandings and bycatch data.

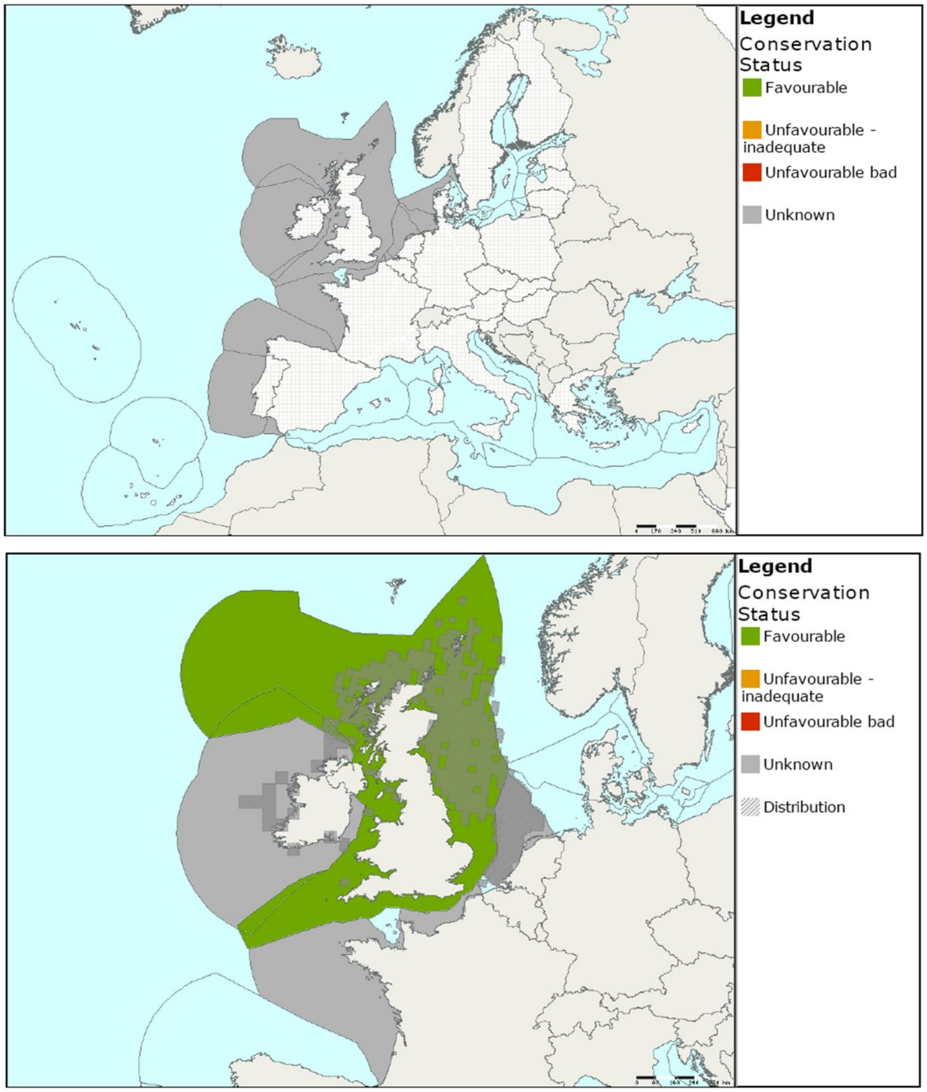
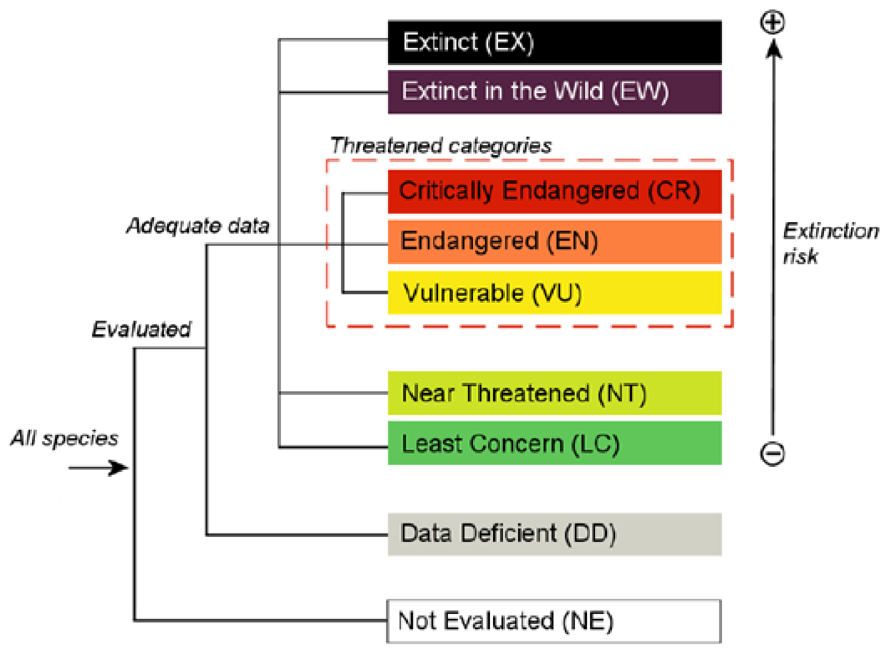


Figure 1. Favourable Conservation Status (FCS) of white-beaked dolphins for 2001-2006 in TOP: at a European level and BOTTOM: at member state level (Source - EU TOPIC Centre http://bd.eionet.europa.eu).

International Union for Conservation of Nature (IUCN) Red List

The IUCN Species Programme, working with the IUCN Species Survival Commission (SSC), has for over four decades assessed the Conservation Status of species and selected subpopulations on a global scale in order to highlight taxa threatened with extinction, thereby promoting their conservation via the IUCN Red List (IUCN, 2012). The Red List, first conceived in 1963 by the IUCN Species Programme, working with the SSC and many partners, provides the most objective, scientifically-based information on the current status of globally threatened biodiversity. Species assessed for the IUCN Red List are the bearers of genetic diversity and the building blocks of ecosystems, and information on their conservation status and distribution provides the foundation for making informed decisions about conserving biodiversity from local to global levels.

To achieve this goal the Categories (Figure 2) and Criteria (Figures 3 and 4) developed for the IUCN Red List have several specific aims including: to provide a system that can be applied consistently by different people; to improve objectivity by providing users with clear guidance on how to evaluate different factors which affect the risk of extinction; to provide a system which will facilitate comparisons across widely different taxa; to give people using threatened species lists a better understanding of how individual species were classified.



CRITICALLY ENDANGERED (CR)
A taxon is Critically Endangered when meeting criteria A to E for Critically Endangered, and is facing an extremely high risk of extinction in the wild.

ENDANGERED (EN)
A taxon is Endangered when meeting criteria A to E for Endangered, and is facing a very high risk of extinction in the wild.

VULNERABLE (VU)
A taxon is Vulnerable when meeting criteria A to E for Vulnerable, and is facing a high risk of extinction in the wild.

NEAR THREATENED (NT)
A taxon is Near Threatened when after considering criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying in the near future.

Figure 2. IUCN Red List categories and definitions used assigning species status (IUCN 2012)

A. Population size reduction. Population reduction (measured over the longer of 10 years or 3 generations) based on any of A1 to A4	Critically Endangered	Endangered	Vulnerable
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3 & A4	≥ 80%	≥ 50%	≥ 30%

A1 Population reduction observed, estimated, inferred, or suspected in the past where the causes of the reduction are clearly reversible AND understood AND have ceased.

A2 Population reduction observed, estimated, inferred, or suspected in the past where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

A3 Population reduction projected, inferred or suspected to be met in the future (up to a maximum of 100 years) *[(a) cannot be used for A3]*.

A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

based on any of the following:

(a) direct observation *[except A3]*
(b) an index of abundance appropriate to the taxon
(c) a decline in area of occupancy (AOO), extent of occurrence (EOO) and/or habitat quality
(d) actual or potential levels of exploitation
(e) effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

B. Geographic range in the form of either B1 (extent of occurrence) AND/OR B2 (area of occupancy)	Critically Endangered	Endangered	Vulnerable
B1. Extent of occurrence (EOO)	< 100 km²	< 5,000 km²	< 20,000 km²
B2. Area of occupancy (AOO)	< 10 km²	< 500 km²	< 2,000 km²
AND at least 2 of the following 3 conditions:			
(a) Severely fragmented **OR** Number of locations	= 1	≤ 5	≤ 10
(b) Continuing decline observed, estimated, inferred or projected in any of: **(i)** extent of occurrence; **(ii)** area of occupancy; **(iii)** area, extent and/or quality of habitat; **(iv)** number of locations or subpopulations; **(v)** number of mature individuals			
(c) Extreme fluctuations in any of: **(i)** extent of occurrence; **(ii)** area of occupancy; **(iii)** number of locations or subpopulations; **(iv)** number of mature individuals			

Figure 3. Criteria A and D from Red List Guidance Manual (IUCN 2012)

C. Small population size and decline	Critically Endangered	Endangered	Vulnerable
Number of mature individuals	< 250	< 2,500	< 10,000
AND at least one of C1 or C2			
C1. An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future):	25% in 3 years or 1 generation (whichever is longer)	20% in 5 years or 2 generations (whichever is longer)	10% in 10 years or 3 generations (whichever is longer)
C2. An observed, estimated, projected or inferred continuing decline AND at least 1 of the following 3 conditions:			
(a) **(i)** Number of mature individuals in each subpopulation	≤ 50	≤ 250	≤ 1,000
(a) **(ii)** % of mature individuals in one subpopulation =	90–100%	95–100%	100%
(b) Extreme fluctuations in the number of mature individuals			

D. Very small or restricted population	Critically Endangered	Endangered	Vulnerable
D. Number of mature individuals	< 50	< 250	**D1.** < 1,000
D2. *Only applies to the VU category* Restricted area of occupancy or number of locations with a plausible future threat that could drive the taxon to CR or EX in a very short time.	-	-	**D2.** typically: AOO < 20 km² or number of locations ≤ 5

E. Quantitative Analysis	Critically Endangered	Endangered	Vulnerable
Indicating the probability of extinction in the wild to be:	≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)	≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)	≥ 10% in 100 years

Figure 4. Categories C, D and E from Red List Guidance Manual (IUCN 2012)

Over the last decade there has been growing interest in countries using the IUCN Red List Categories and Criteria for national Red List assessments. In response to this interest, guidelines on how to apply the IUCN Red List Criteria appropriately for sub-global level assessments were developed. Since the first version of these guidelines was published in 2003, these guidelines have been reviewed. In 2012, the *Guidelines for Application of the IUCN Red List Criteria at Regional and National Levels* (version 4) were released.

At present the Red List categorises *L.albirostris* as Least Concern - LC (assessed 2012 version 3.1 – Hammond *et al.,* 2012) meaning that the species have been evaluated but does not qualify for any other category. Justification used in the Red List for LC status is that the species is widespread and abundant (with current population estimates exceeding 100,000 individuals) and that from evidence assessed there have been no reported population declines or major threats identified.

The Red List account goes on to state that at present threats upon *L.albirostris* include small-scale hunting of the species in certain countries, particularly Canada and Greenland, although these are unregulated or not monitored; incidental capture and bycatch in fishing gear throughout its range but that this, despite high fishing effort appears to be low or not detected; likely contamination by organochlorines, other anthropogenic compounds and heavy metals; although the effects of pollutants are not well understood in this species, they may affect reproduction or render them susceptible to other mortality factors (Hammond *et al.,* 2012). Conservation actions for the species across its range include a listing in Appendix II of the Convention on the Trade in Endangered Species (CITES) and that at present existing direct takes are not regulated by any hunting quotas. Although known to occur, bycatch rates seem to be poorly documented and warrant more intensive research. The impact of combined anthropogenic removals should be assessed.

At the time of this review no Regional or National level assessments for *L.albirostris* had been made within the NE Atlantic using the *Guidelines for Application of the IUCN Red List Criteria at Regional and National Levels.*

REFERENCES

Evans, D. and Arvela, M. (2011) Assessment and reporting under Article 17 of the Habitats Directive: Explanatory Notes & Guidelines for the period 2007-2012. European Topic Centre on Biological Diversity. 123pp.

Frisch, H. (2010) Cetacean Conservation under the Convention on Migratory Species. UNEP/CMS Secretariat, Bonn, Germany (http://tinyurl.com/lzhw7uj). Gland, Switzerland and Cambridge, UK: IUCN. iv + 32pp.

Hammond, P.S., Bearzi, G., Bjørge, A., Forney, K.A., Karkzmarski, L., Kasuya, T., Perrin, W.F., Scott, M.D., Wang, J.Y., Wells, R.S. and Wilson, B. (2012) Lagenorhynchus *albirostris*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1.

IUCN (2012) IUCN Red List Categories and Criteria: Version 3.1. Second edition.

Prideaux, M. (2003) Conserving Cetaceans: The Convention on Migratory Species and its relevant Agreements for Cetacean Conservation, WDCS, Munich, Germany. 24pp.

III. ASCOBANS and White-beaked Dolphins

Heidrun Frisch

ASCOBANS Coordinator and CMS Marine Mammals Officer UNEP/CMS/ASCOBANS Secretariat, UN Campus, Hermann-Ehlers-Str. 10, 53113 Bonn, Germany

The North and Baltic Sea populations of white-beaked dolphins are at present listed on Appendix II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS – www.cms.int). This geographical area corresponds to that originally covered by the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS – www.ascobans.org), which in line with the purpose of a CMS Appendix II listing serves as a regional coordination mechanism for achieving or maintaining a favourable conservation status for all small cetacean species.

Given that the species' main range does not extend to the waters of the majority of the countries participating in the Agreement, white-beaked dolphins have not been a focal species of ASCOBANS so far. However, ASCOBANS Parties have considered some information on the species and its status in recent years.

In 2007, ASCOBANS held a workshop on small cetacean population structure in the Agreement Area, with the objectives of establishing a definition of population units of management interest for as many species as possible. Participants identified the strengths and limitations of different approaches used in discriminating between populations; agreed a set of criteria for investigating population structure; and reviewed sampling protocols, methodologies, laboratory techniques and statistical techniques for identifying population units. In follow-up of the workshop, management units were defined for five species, including the white-beaked dolphin.

Four management units were proposed for white-beaked dolphins (Figure 1):

1) Western North Atlantic (mainly Canadian waters)
2) Icelandic waters
3) Northern Norway
4) A continuous management unit including the British Isles and all of the North Sea

Only the British Isles/North Sea management unit coincides well with the Agreement Area of ASCOBANS (Figure 2). The Agreement therefore is a suitable coordination mechanism for the conservation of this unit.

For the information of the 18th Meeting of the ASCOBANS Advisory Committee (AC18), Evans (2011) summarised the results of data sets of different stakeholders and countries in order to provide Advisory Committee (AC) members with an accessible overview of trends in status and distribution of as well as impacts on small cetaceans within the Agreement Area. This document draws mainly on a more detailed overview presented to AC17 in 2010, which took into account information published over the period 1990-2010. The review covers 17 species, out of which 12 are small cetaceans that occur regularly in the Agreement Area.

The knowledge of the population size of white-beaked dolphins in the British Isles/North Sea management unit is generally considered fair, whereas the level of information on trends is considered poor (Table 1). This is also reflected in Table 2, indicating the high level of uncertainty on the population trend in all regions of the Agreement Area.

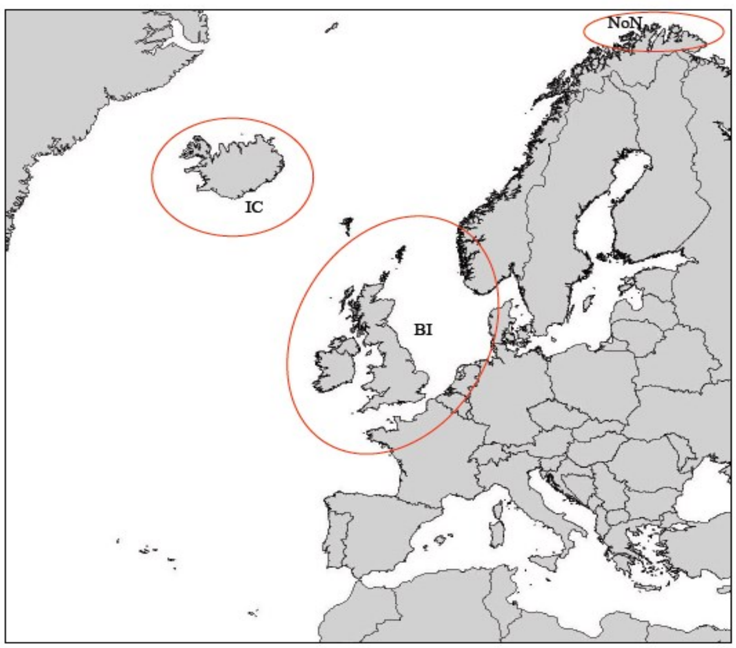


Figure 1. Recommended Management Units for white-beaked dolphin in the ASCOBANS Agreement Area and surrounding waters (Evans and Teilmann, 2009)

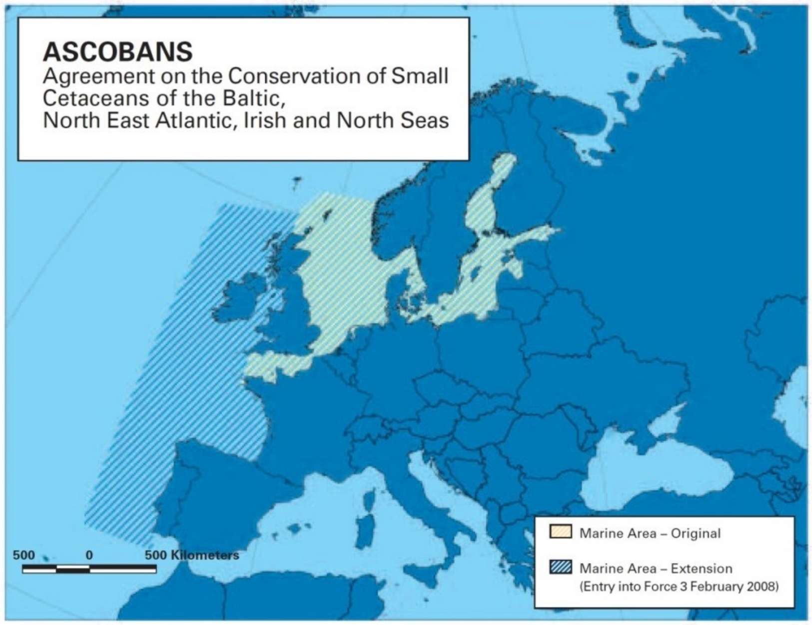


Figure 2. Agreement Area of ASCOBANS

Species	Popn Size	Popn Trend
Northern bottlenose whale	+	-
Sowerby's beaked whale	-	-
Cuvier's beaked whale	-	-
Short-beaked common dolphin	++	-
Long-finned pilot whale	+	-
Risso's dolphin	-	-
Atlantic white-sided dolphin	+	-
White-beaked dolphin	++	+
Killer whale	-	-
Striped dolphin	+	-
Bottlenose dolphin	++	++
Harbour porpoise	+++	+++

Level of information across the region: - = none; + = poor; ++ = fair; +++ = good
Red = none; Amber = poor; Gold = fair; Green = good

Table 1. Status of knowledge on population size and trends for the 12 small cetacean species regularly occurring in the ASCOBANS Agreement Area (Evans, 2011)

Species	Northern East Atlantic	Central East Atlantic	Bay of Biscay	N. North Sea	Inner Danish Waters	Baltic Sea	S. North Sea	English Channel	Irish Sea
Northern bottlenose whale	?	?	?	?	n/a	n/a	n/a	n/a	n/a
Sowerby's beaked whale	?	?	?	n/a	n/a	n/a	n/a	n/a	n/a
Cuvier's beaked whale	?	?	?	n/a	n/a	n/a	n/a	n/a	n/a
Short-beaked common dolphin	↑?	↑?	↑?	↑	↑?	↑?	n/a	?	?
Long-finned pilot whale	?	?	-	?	n/a	n/a	n/a	n/a	n/a
Risso's dolphin	?	?	?	↑	n/a	n/a	n/a	n/a	n/a
Atlantic white-sided dolphin	↓	n/a	n/a	↓	n/a	n/a	n/a	n/a	n/a
White-beaked dolphin	?	n/a	n/a	↓?	↑?	n/a	-?	-	n/a
Killer whale	?	?	n/a	?	n/a	n/a	n/a	?	?
Striped dolphin	↑	?	?	↑	n/a	n/a	n/a	↑	↑
Bottlenose dolphin	?	?	↑	-	n/a	n/a	n/a	-	-
Harbour porpoise	?	?	↑	↓	↓?	↓?	↑	↑	↑

↑ = increase; ↓ = decline; '?' = unknown; - = no apparent change; n/a = not applicable (rare or absent)
Red = decline; Amber = uncertain or no apparent change; Green = increase; Blue = unknown

Table 2. Status trends (1990-2010) by region for the 12 small cetacean species occurring regularly in the ASCOBANS Agreement Area (Evans, 2011)

In the same management unit, documented causes of mortality of the species include infectious disease, ship strikes, starvation and live strandings, all of which are recorded at low levels (Table 3).

Table 4 illustrates that the habitat of white-beaked dolphins within the ASCOBANS Agreement Area is subject to intense human-induced pressures. Especially climate change and disturbance through ship traffic and recreational activities, noise pollution and other habitat changes are highlighted as being on the increase in the regions in which the species is known to occur (Table 5).

Species	Infectious disease	By-catch	Ship strike	Bottlenose dolphin kill	Starvation	Gas Embolism	Live stranding
Northern bottlenose whale	+	-	-	-	+	-	++
Sowerby's beaked whale	-	-	+	-	-	+	+
Cuvier's beaked whale	-	-	-	-	+	+	+
Short-beaked common dolphin	+	+++	+	-	+	+	++
Long-finned pilot whale	+	+	+	-	+	-	++
Risso's dolphin	-	+	+	-	+	+	+
Atlantic white-sided dolphin	+	++	-	-	+	-	++
White-beaked dolphin	+	-	+	-	+	-	+
Killer whale	-	-	+	-	+	-	+
Striped dolphin	+	+++	-	-	+	-	++
Bottlenose dolphin	+	+	+	+	+	-	+
Harbour porpoise	+++	+++	+	++	++	+	+

- = not recorded; + = low; ++ = moderate; +++ = high importance
Red = known high importance; Amber = known medium importance; Gold = recorded in region

Table 3. Causes of mortality identified from post-mortem examinations of cetaceans in the ASCOBANS Agreement Area (Evans, 2011)

Human Activity	Northern East Atlantic	Central East Atlantic	Bay of Biscay	N. North Sea	Inner Danish Waters	Baltic Sea	S. North Sea	English Channel	Irish Sea
Hunting	+*	-	-	-	-	-	-	-	-
Fisheries – direct	+++	++	+++	++	++	++	+++	+	+
Fisheries - indirect	++	++	++	+++	++	++	++	+	+
Pollution	+	+	++	++	++	+++	+++	++	++
Climate change	++	++	++	++	++	++	+++	++	++
Ship traffic	+	+++	++	++	+++	+++	+++	+++	++
Pile driving	+	+	+	++	++	++	+++	++	+++
Seismic exploration	++	++	+	++	-	+	++	+	++
Military sonar	++	++	+	++	-	-	-	++	+
Recreational	+	+	+	+	+++	+++	+++	+++	+++
Habitat change	+	+	+	++	+	+	++	++	++

- = no activity; + = low; ++ = medium; +++ = high activity
Red = high; Amber = medium; Gold = low; Green = no activity
* no legal hunting for small cetaceans occurs within the ASCOBANS Area,
but Faroese shore drives probably affect small cetacean populations from that area

Table 4. Human Activities in the ASCOBANS Agreement Area known to affect small cetaceans (Evans, 2011)

Human Activity	Northern East Atlantic	Central East Atlantic	Bay of Biscay	N. North Sea	Inner Danish Waters	Baltic Sea	S. North Sea	English Channel	Irish Sea
Hunting	-*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Fisheries – direct	↑?	↓?	-?	↓	↓?	↓?	↑	↓	↓
Fisheries - indirect	↓	↓	↓?	↓	↓?	↓?	↑?	↓	↓
Pollution	-	-	-	-	-	↓	-	-	-?
Climate change	-**	-**	-**	↑	↑	↑	↑	↑	↑
Ship traffic	↑?	↑	↑	↑	↑	↑	↑	↑	↑?
Pile driving	-	-	-	↑	↑	↑	↑	-	↑
Seismic exploration	↓	↓	-	↓	n/a	↓	↓	↓	↓
Military sonar	-?	-?	-?	-?	n/a	n/a	n/a	n/a	-?
Recreational	↑?	↑?	↑	↑?	↑	↑	↑	↑	↑
Habitat change	-	-	-	↑	↑?	↑?	↑	↑	-?

↑ = increase; ↓ = decline; '?' = uncertain; - = no apparent change; n/a = not applicable (rare or absent)
Red = increase; Amber = uncertain or no apparent change; Gold = decrease
* no legal hunting for small cetaceans occurs within the ASCOBANS Area,
but Faroese shore drives probably affect small cetacean populations from that area
** small increase in sea surface temperatures

Table 5. Trends in the ASCOBANS Agreement Area of Human Activities known to affect small cetaceans (Evans, 2011)

ASCOBANS Parties have passed a number of resolutions dealing with these issues and highlighting the need to address these threats to small cetaceans (see http://www.ascobans.org/aims_activities.html#mop), and upon receiving the Evans 2011 review acknowledged both the scarcity of knowledge on most species and the need to address the identified threats.

The Advisory Committee Work Plan requires attention to threats such as bycatch, noise, ship strikes and climate change. Accordingly, the AC has established working groups to provide information and advice on several relevant issues and established a standing working group on the Atlantic region. While not specific to white-beaked dolphins, this thematic and regional approach is currently the key way in which ASCOBANS contributes to the conservation of the species.

Experts on white-beaked dolphins in the ASCOBANS Agreement Area are encouraged to contribute to these processes.

One way to achieve policy support for the conservation of white-beaked dolphins in the other proposed management units, i.e. the western North Atlantic, Icelandic waters and northern Norway (see Figure 1) would be to expand the geographical scope of the listing of the species on CMS Appendix II. Such an expansion of the listing to cover the entire range of the species requires the development of an official proposal for the consideration of the CMS Scientific Council and then the Conference of the Parties (COP).

Such a listing proposal should follow the outline provided in CMS Resolution 1.5 (http://www.cms.int/bodies/COP/cop1/English/Res1.5_E.pdf), for which details on the biology and range of the species, the threats and the protection status are needed. While proposals can be developed by anyone, the official submission to the COP needs to be channelled through the government of a CMS Party, and the deadline for this is 150 days before the COP. The date of the next CMS COP is not known but it is expected to be in late 2014.

For the development of such a proposal, the close involvement of the CMS Scientific Council Aquatic Mammals Working Group is recommended.

REFERENCES

Evans, P.G.H. and Teilmann, J. (Editors) (2009) ASCOBANS/HELCOM Small Cetacean Population Structure Workshop. ASCOBANS; Bonn, Germany, 141 pp.

Evans, P.G.H. (2011) Cetacean Trend Analysis Summary for the ASCOBANS Agreement Area. ASCOBANS AC18/Doc. 6-05 rev.1. 10pp.

IV. White-beaked Dolphins in the Northeast Atlantic: A brief review of their ecology and potential threats to conservation status

Colin D. MacLeod

GIS In Ecology, 120 Churchill Drive, Broomhill, Glasgow, G11 7EZ, UK

The white-beaked dolphin (*Lagenorhynchus albirostris*) is endemic to the cold temperate and sub-polar waters of the North Atlantic. The global population size of the species has been estimated as between the high tens of thousands to low hundreds of thousands of individuals (Reeves *et al.,* 1999). Its distribution is primarily restricted to shelf waters, and consequently is divided into a number of seemingly unconnected geographic areas. These include the shelf waters of: 1. Eastern North America between Cape Cod and the Davis Strait; 2. Southern Greenland; 3. Iceland; 4. The Barents Sea; and 5. Northwest Europe, which consists of the contiguous area between northern France and southern Norway and includes the North Sea and adjacent waters to the north, west and south of the British Isles (Reeves *et al.,* 1999). The latter two are by far the two largest aggregations of this species. In total, European waters probably contain between 50% and 75% of the global population for this species, meaning these waters are of major conservation importance for white-beaked dolphins as a species. Despite this, white-beaked dolphins remain relatively poorly known and there is no cohesive conservation strategy for this species. This paper will summarise what is currently known about the ecology of white-beaked dolphins and the threats they face in European waters.

DISTRIBUTION

White-beaked dolphins occur in shelf waters around the UK, the Republic of Ireland, the English channel coast of France , Belgium, the Netherlands, Denmark, the North Sea coast of Germany, Norway and Iceland. In general, this species is only found in waters cooler than around 18°C and is most common in waters below about 13°C. There is evidence that its range is currently declining with marked changes in occurrence along the west coast of the UK, especially western Scotland, and possibly in the southern North Sea since about the year 2000.

ABUNDANCE

The main surveys which have estimated abundances for a population of white-beaked dolphins are the SCANS surveys which have covered the waters of the North Sea and surroundings shelf waters. While these surveys were primarily designed to estimate the abundance of harbour porpoises, they have also been used to estimate abundances of white-beaked dolphins. SCANS (1994) estimated there were 7,856 (CV: 0.30) in the North Sea and the shelf waters to the North of Scotland, while SCANS II (2005) estimated there were 22,664 (CV: 0.42) in a wider area including western Scotland (Hammond *et al.,* In Press). However, the numbers in some areas, the abundances estimated by SCANS II directly conflict with almost all other data sources on species occurrence. For example, SCANS II estimated an abundance of around 4,000 animals in a survey block in western Scotland (Hammond *et al.,* In Press), while more extensive surveys have failed to find any evidence of the regular occurrence of this species throughout much of this block (MacLeod *et al.,* 2007a; Weir et al 2009; Bannon Pers. Comm). This means the SCANS II abundance estimates are almost certainly an over-estimate and are unreliable for this species (and as a result probably should not be used as the basis for conservation decisions). This almost certainly arose because the surveys are designed for harbour porpoises and do not take specific aspects of the ecology of white-beaked dolphins, such as marked discontinuities in its distribution in some survey blocks, into account.

HABITAT USE

There have been surprisingly few studies that have directly investigated habitat use in white-beaked dolphins (rather than just try to map/model distribution). However, those studies which have been undertaken have found that in the northeast Atlantic white beaked dolphins are generally restricted to shelf waters (Northridge *et al.,* 1995; Hammond *et al.,* 2002; Reid *et al.,* 2003; MacLeod *et al.,* 2007a; Hammond *et al.,* In Press) and prefer waters less than 120m deep (MacLeod *et al.,* 2007a). In such habitats, the most important variable defining their preferred habitat is water temperature, with their occurrence decreasing substantially in water temperatures greater than ~12-14^{o}C (MacLeod *et al.,* 2007a; 2008; Figure 1). As a result, whilst white-beaked dolphins are the dominant (in terms of both sightings and individuals) neritic dolphin species in cooler waters they become much rarer in water temperatures above ~12-14^{o}C and are replaced by the common dolphin (*Delphinus delphis*) as the dominant neritic dolphin species in areas and times where this species is present (MacLeod *et al.,* 2007a; 2008). At temperatures above ~18^{o}C, white beaked dolphins seem to be very rare or absent altogether. These key temperature thresholds appear to contribute towards defining whether white-beaked dolphins are classified as common (<~13^{o}C), uncommon (~13-18^{o}C) or rare/absent (>~18^{o}C) within particular regions during the summer months (Figures 1, 3). Where water temperatures are cooler than these key values, other habitat variables, such as slope and seabed aspect, become the most important factor in driving occurrence (MacLeod *et al.,* 2007a; Canning *et al.,* 2008; Weir *et al.,* 2009). We don't know why white-beaked dolphins are restricted to cooler waters but it's most likely a combination of competition from other species and direct physiological effects rather than any indirect effects related to the distribution of prey.

DIET

Given its prevalence in the stranding records in some areas, there is remarkably little information available on the diet of white-beaked dolphins. Individuals stranded in Britain had a diet consisting of whiting (*Merlangius merlangus*), haddock (*Melanogrammus aeglefinus*), cod (*Gadus morhua*), *Trisopterus* sp., hake (*Merluccius merluccius*), herring (*Clupea harengus*), mackerel (*Scomber scombrus*), scad (*Trachurus trachurus*), sandeel (*Ammodytes* spp.), long rough dab (*Hippoglossoides platessoides*) and the octopus (*Eledone cirrhosa*) (Evans, 1991; Santos *et al.,* 1994). In the stomachs of 16 individuals found stranded on the coasts of Scotland, the main prey species represented were benthic species, such as gadoids (Canning *et al.,* 2008). In particular, haddock and whiting made up 43% and 24% of prey body mass, with cod making up 11%. In contrast, pelagic species such as mackerel and herring made up less than 1% of prey biomass (Canning *et al.,* 2008). Gadoids are also the predominant prey species in the eastern and southern North Sea (Kinze *et al.,* 1997).

SOCIAL STRUCTURE

Whilst white-beaked dolphins are occasionally recorded in large aggregations, they primarily occur in relatively small groups of up to 10-20 individuals (Weir *et al.,* 2007; Canning *et al.,* 2008; Weir *et al.,* 2009; MacLeod unpublished data; Brereton unpublished data). Off the east coast of Scotland, the average group size in two studies was 5.7 and 4.2 individuals respectively (Weir *et al.,* 2001; Canning *et al.,* 2008), to the north and west of Scotland it was 3.5 (Weir *et al.,* 2001), while in western Scotland it was 7.0 (Weir *et al.,* 2009) and in Lyme Bay it was 4.9 (Brereton unpublished data). However, group sizes of four or fewer animals comprise the majority of sightings (e.g. Small Cetacean Abundance in the North Sea (SCANS) II unpublished data: 71%; Northern North Sea Cetacean Ferry Surveys (NORCET) unpublished data: 62% - Figure 2a). Canning *et al.,* (2008) found that smaller groups were recorded at higher water temperatures. This may be indicative of a seasonal change in group size, which would co-vary with temperature during the summer months. Certainly, in the northern North Sea, the group size of white-beaked dolphins is significantly greater in early summer than in late summer (Mann-Whitney Test: $W = 374.5$; $p = 0.002$ - Figure 2b). Whether this reflects seasonal changes in prey preferences or indicates a more direct effect of temperature on white-beaked dolphin social behaviour is unknown. However, this decrease in group size coincides with an increased use of coastal waters (MacLeod *et al.,* 2007b).

CONSERVATION THREATS TO WHITE-BEAKED DOLPHINS

White-beaked dolphins face a number of potential threats. These include over-fishing of prey species, bycatch in fisheries, habitat degradation, acoustic pollution, biocontaminants and climate change. Each of these will be considered here in turn, and the scale of threat to white-beaked dolphins based on current knowledge will be assessed based on two interacting components. These are the spatial nature of the threat (e.g. whether its impact occurs at local, regional and/or global scales) and the demographic nature of the threat (e.g. whether it affects individuals, aggregations, geographically-isolated 'populations' and/or the entire species). When combined, these two components can be used to define how a particular threat is likely to affect a species across a range of spatial and demographic scales (MacLeod, 2009b). The interaction between different levels of the demographic components and the spatial scales can be visualised using a 'bubble' diagram, where the size of the 'bubble' represents the extent of the threat for a particular combination of spatial and demographic levels (figure 1). Such a 'bubble' diagram system is particularly useful because it allows the overall extent of very different types of potential threats to be compared, and the greatest threats across all levels to be identified.

1. **Over-fishing of Preferred or Required Prey:** While relatively little is known about the diet of white-beaked dolphins, they appear to feed primarily on bentho-pelagic fish and cephalopods including a variety of gadoid species. These species are some of the main targets of commercial fisheries. As a result, the over-fishing of preferred or required prey has the potential to impact upon white-beaked dolphins. However, as yet there is no evidence of such effects occurring. While this may be because such threats are difficult to assess, it is also possible that while they target the same species, fisheries and dolphins do not necessarily target these species in the same locations. Therefore, in terms of spatial scales and demographic levels, white-beaked dolphins are likely to face intermediate effects at individual to population levels in local areas and at regional scales (where local aggregations of specific prey species are reduced by specific fisheries). However, the threat at other combinations of demographic levels and spatial scales, and particularly the population and species levels at larger spatial scales are thought to be low or absent at the current time (figure 1).

2. **Bycatch in Fisheries:** Bycatch in fisheries is a major threat to a number of species and populations of small cetaceans around the world. However, there appears to be relatively little evidence of large numbers of white-beaked dolphins occurring as bycatch in fisheries (e.g. Couperus, 1997; Morizur *et al.,* 1999). As a result, the threat of bycatch to white-beaked dolphins appears to be absent at most combinations

of spatial scales and demographic levels at the current time, although it may be a low threat to individuals at the local scale in some places (Figure 1).

3. **Habitat Degradation:** Habitat degradation in the marine environment can be difficult to assess. In the shelf waters where white-beaked dolphins occur, the main cause of habitat degradation is likely to result from trawl fisheries, although pollution from fish farms, oil extraction, coastal development and offshore renewables may also have contributing impacts. The effect of such degradation on cetaceans remains poorly understood but it could affect them by changing the composition of local fish communities and/or by destroying preferred foraging habitats. At present such damage is likely to be relatively localised and the areas where white-beaked dolphins predominantly occur are generally not extensively affected at this current time. As a result, while little is known about it, at the current time, habitat degradation is likely to have an intermediate impact on some individuals across all spatial scales through the destruction of local habitats across the range of the species and on local aggregations where habitat degradation is particularly intense or widespread (figure 1). However, it is likely to have a low or no impact at population and species levels across all spatial scales or on local aggregations throughout the range of the species.

4. **Acoustic Pollution:** Like many other odontocete species white-beaked dolphins rely on sound for many aspects of their lives, producing broadband echolocation clicks for navigation and locating prey, and a variety of tonal sounds with communicative roles. Little is known about how white-beaked dolphins are likely to be affected by acoustic pollution or whether they are particularly vulnerable to any specific sound sources. However, at present, acoustic pollution is likely to only have a intermediate level impact on individuals and local aggregations and at local and regional scales rather than at other spatial or demographic scales (Figure 1).

5. **Biocontaminants:** As top predators, white-beaked dolphins are likely to accumulate any contaminants, such as heavy metals, which enter the food chain. If these contaminants reach sufficient levels within individual dolphins, they can potentially cause a reduction in reproductive output and/or an increased risk of disease. However, while some individual animals may have sufficiently high levels of biocontaminants to cause negative effects, there is insufficient information at the moment to suspect that this is sufficiently widespread to have impacts at higher demographic scales (Figure 1). In addition, it is currently unclear what levels are sufficient to cause a high risk to individuals and it seems that the overall threat of biocontaminants to the conservation status of white-beaked dolphins is relatively low. However, this assessment may require amending as new research results in an improved understanding of the typical levels of biocontaminants in individual white-beaked

dolphins, how they affect cetaceans in general (e.g. Jepson *et al.,* 2005), and what levels are sufficient to cause these effects.

6. **Climate Change:** There are two reasons to expect that white-beaked dolphins will be, and may already have been, negatively affected by climate change. Firstly, their distribution is closely linked to water temperature at both a local (e.g. MacLeod *et al.,* 2007a) and regional (e.g. MacLeod *et al.,* 2008) scale at least during the summer months. Secondly, MacLeod *et al.* (2005) specifically assessed whether cetacean species composition in the waters off northwest Scotland had changed in response to a known increase in water temperature and found that the occurrence of white-beaked dolphins (as measured independently by strandings and sightings data) had declined dramatically as local water temperatures increased. Due to the relationship between white-beaked dolphin occurrence and water temperature, the most likely impact of climate change on this species will be a northward shift in the species range (Learmonth *et al.,* 2006; MacLeod 2009a). Because it is a global threat, climate change is likely to affect white-beaked dolphins at all spatial scales, from local to global, and most demographic levels, from local aggregations to species (Figure 1). Given the apparent inevitability and predicted extent of changes in climate in the foreseeable future, the strong relationship between the occurrence of white-beaked dolphins and water temperature and the limited availability of suitable alternative habitat further north for displaced animals to move into, this threat must be considered high in all cases.

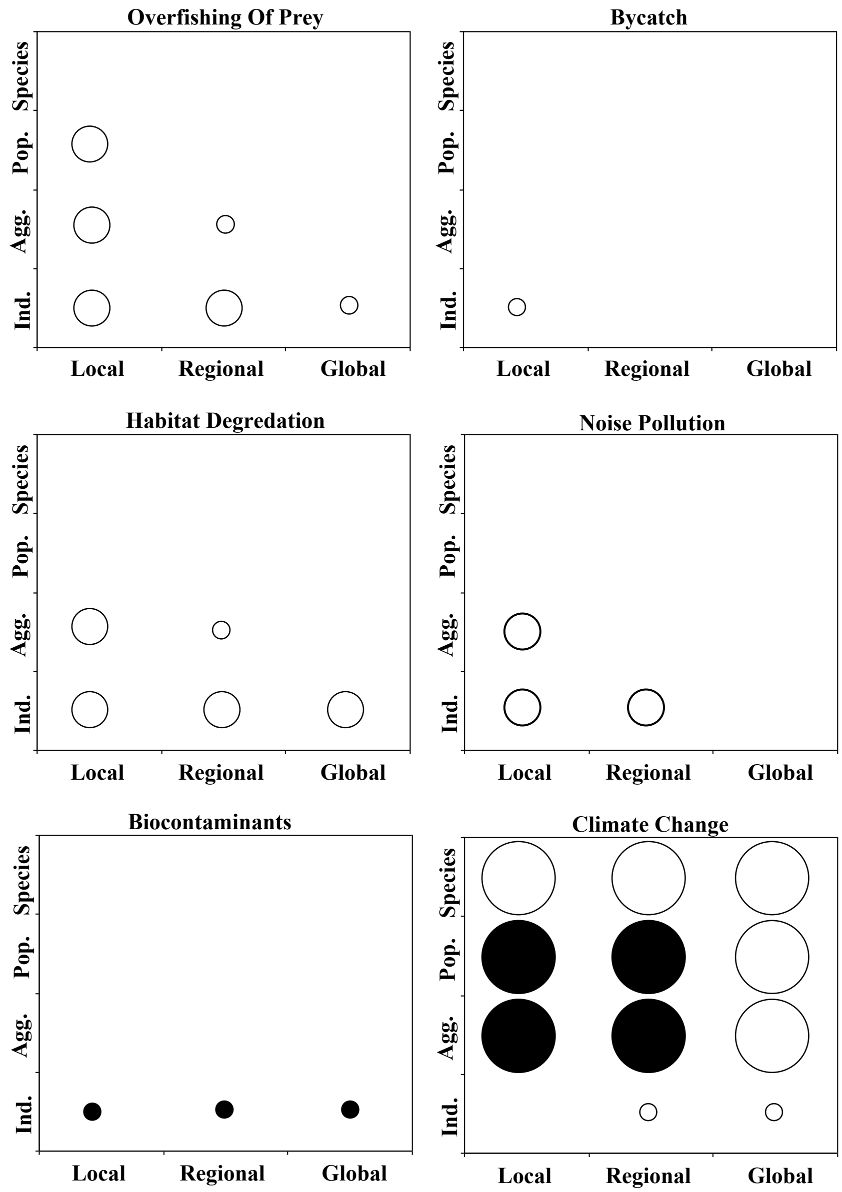


Figure 1: An assessment and comparison of the combinations of spatial and demographic levels of threats to the white-beaked dolphin in European waters. **Open 'Bubbles':** Potential effect; **Closed 'Bubbles':** Documented effect. Size of the 'bubble' indicates the intensity of the threat (high, medium, low). When no 'bubble' is present, there is currently no known or suspected effect at that particular combination of demographic and spatial levels. **Spatial Component (x-axis):** *Local:* Affects a species across the range of up to 100s of km^2; *Regional:* Impacts a species across a range between to 100s to 1000s of km^2; *Global:* Impacts a species throughout its range. **Demographic Component (y-axis):** *Ind:* Affects the survival of individual animals; *Agg:* Affects the persistence of local aggregations of the species; *Pop:* Affects the likelihood of extirpation of genetically-distinct or geographically-isolated populations of a species; *Species:* Affects the likelihood of extinction of the species as a whole.

REFERENCES

Canning, S.J., Santos, M.B., Reid, R.J., Evans, P.G.H., Sabin, R.C., Bailey, N. and Pierce, G.J. (2008) Seasonal distribution of white-beaked dolphins (*Lagenorhynchus albirostris*) in UK waters with new information on diet and habitat use. *JMBA* 88: 1159–1166.

Couperus, A.S. (1997) Interactions Between Dutch Midwater Trawl and Atlantic White-sided Dolphins (*Lagenorhynchus acutus*) Southwest of Ireland. *J. Northw. Atl. Fish. Sci.,* 22: 209–218.

Evans, P.G.H. (1991). Whales, dolphins and porpoises: Order Cetacea. In Corbet GB and Harris S (eds) The handbook of British mammals, 3rd Edition. British Mammals Society, Blackwell, Oxford. Pages 299-350.

Hammond, P.S., Berggren, P., Benke, H., Borchers, D. L., Collet, A., Heide-Jorgensen, M.P., Heimlich, S., Hiby, A.R., Leopold, M.F. and Øien, N. (2002) Abundance of harbour porpoise and other cetaceans in the North Sea and adjacent waters. *J. App Ecol*., 39: 361-376.

Hammond, PS, *et al.,* (In Press) Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management. *Biological Conservation,* xx: xx-xx.

Jepson, P.D., Bennett, P.M., Deaville, R., Allchin, C.R., Baker, J.R., Law, R.J. (2005) Relationships between polychlorinated biphenyls and health status in harbor porpoises (*Phocoena phocoena*) stranded in the United Kingdom. *Environmental Toxicology and Chemistry,* 24: 238–248.

Kinze, C., Addink, M., Smeenk, C., García, Hartmann, M., Richards, H.W., Sonntag, R.P. and Benke, H. (1997) The white-beaked dolphin (*Lagenorhynchus albirostris*) and the white-sided dolphin (*Lagenorhynchus acutus*) in the North and Baltic Seas: Review of available information. *Rep Int Whal Comm* 47: 675-681.

Learmonth, J.A., MacLeod, C.D., Santos, M.B., Pierce, G.J., Crick, H.Q.P. and Robinson, R.A. (2006) Potential effects of climate change on marine mammals. *Oceanog Mar Biol Ann Rev*, 44: 431-464.

MacLeod, C.D. (2009a) Climate change, species range and implications for conservation of marine cetaceans: A review and synthesis. *Endangered Species Research,* DOI 10.3354/esr00197.

MacLeod, C.D. (2009b) Understanding the impacts of human activities on beaked whales: From individuals to species and local to global. Proceedings of the ECS workshop on beaked whale research. ECS Special Publication Series 51: 6-10.

MacLeod, C.D., Bannon, S.M., Pierce, G.J., Schweder, C., Learmonth, J.A., Reid, R.J. and Herman, J.S. (2005) Climate change and the cetacean community of north-west Scotland. *Biol Conserv*, 124: 477-483.

MacLeod, C.D., Weir, C.R., Pierpoint, C. and Harland, E. (2007a) The habitat preferences of marine mammals west of Scotland (UK). *JMBA,* 87:157-164.

MacLeod, C.D., Hepworth, K. and Hay, I. (2007b) Northern North Sea Cetacean Ferry Surveys (NORCET): An Analysis of Cetacean Information Collected In The First Five Years (2002-2006). Available from c.d.macleod@abdn.ac.uk.

MacLeod, C.D., Weir, C.R., Santos, M.B. and Dunn, T.E. (2008) Temperature-based summer habitat partitioning between white-beaked and common dolphins Around the United Kingdom and Republic of Ireland. *JMBA,* 88: 1193-1198.

Morizur, Y., Berrow, S.D., Tregenza, N.J.C., Couperus, A.S. and Pouvreau, S. (1999) Incidental catches of marine-mammals in pelagic trawl fisheries of the northeast Atlantic. *Fish Res*, 41: 297-307.

Northridge, S.P., Tasker, M.L., Webb, A and Williams, J.M. (1995) Distribution and relative abundance of harbour porpoise (*Phocoena phocoena* L.), white-beaked dolphins (*Lagenorhynchus albirostris* Gray) and minke whales (*Balaenoptera acutorostrata* Lacepede) around the British Isles. *ICES Journal of Marine Science*, 52: 55–66.

Reeves, R., Smeenk, C., Kinze, C.C., Brownell, R.L. and Lien, J. (1999) White-beaked dolphin *Lagenorhynchus albirostris,* Gray 1846. In: *Handbook of Marine Mammals, Volume 6*, pp. 1-30. Academic Press

Reid, J.C., Evans, P.G.H. and Northridge, S.P. (2003) Atlas of cetacean distribution in Northwest European waters. Joint Nature Conservation Committee, Peterborough, UK.

Santos, M.B., Pierce, G.J., Ross, H.M., Reid, R.J. and Wilson, B. (1994) Diets of small cetaceans from the Scottish coast. International Council for the Exploration of the Sea, CM1994/N11.

Weir, C.R., MacLeod, C.D. and Calderan, S.V. (2009) Fine-scale habitat selection by white-beaked and common dolphins in the Minch (Scotland, UK): evidence for interspecific competition or coexistence? *JMBA,* 89: 951-960.

Weir, C.R., Pollock, C., Cronin, C. and Taylor, S. (2001) Cetaceans of the Atlantic Frontier, north and west of Scotland. *Continental Shelf Research*, 21: 1047–1071.

Weir, C.R., Stockin, K.A. and Pierce, G.J. (2007) Seasonal occurrence of the harbour porpoise, white-beaked dolphin and minke whale in coastal Aberdeenshire (UK) waters, western North Sea. *JMBA*, 87:327-338.

Case Studies: new research findings from the workshop

V. Identifying white-beaked dolphins from click characteristics

Susannah Calderan, Anja Wittich, Olivia Harries, Jonathan Gordon, Russell Leaper

Hebridean Whale and Dolphin Trust (HWDT), Tobermory, Isle of Mull, PA75 6NU, Scotland

The Hebridean Whale and Dolphin Trust (HWDT) has conducted visual and acoustic line-transect surveys off the west coast of Scotland since 2003 using its dedicated research vessel, *Silurian*. Passive acoustic monitoring (PAM) plays a key role in these surveys. HWDT has used newly-developed techniques to analyse white-beaked dolphin acoustic data collected from *Silurian* and from other survey platforms around the UK. The aim of this analysis was to assess whether white-beaked dolphins could be reliably detected and identified to species level by their clicks. The intention was not to describe detailed acoustic properties of individual clicks, but to focus on practical applications for passive acoustic monitoring, and to explore whether the acoustic characteristics of clicks received under typical survey conditions could be used for reliable classification.

Preliminary analysis which took place prior to this study suggested that there were spectral characteristics in white-beaked dolphin clicks which could identify them to species level. These characteristics comprised distinct spectral peaks and troughs at consistent frequencies in their clicks. Previous work by Soldevilla *et al.* (2008) had demonstrated such frequency banding for another *Lagenorhynchus* species, the Pacific white-sided dolphin. This suggested the possibility of banding also being present in white-beaked dolphins, although work on this species in Iceland did not report evidence of such acoustic characteristics (Rasmussen and Miller, 2002). However, Rasmussen and Miller (2002) generally focused on the peak frequency of white-beaked dolphin clicks, which they report as >100kHz, whereas in this study we focus on the lower frequencies.

Recordings from 61 white-beaked dolphin encounters collected at a sample rate ≥192,000 samples per second during towed array surveys on the west coast of Scotland and North Sea were batch-processed then analysed using PAMGUARD. Encounters varied greatly in duration and number of clicks. To provide equivalent samples of clicks for analysis, each encounter was divided into sub-events of comparable number of clicks.

We found that white-beaked dolphin clicks could be readily detected, and that the properties of clicks were highly variable. Clicks could be divided into those where the energy was restricted to a narrow frequency range (narrowband) and those that had energy across a wide frequency range (broadband). Some of these broadband clicks showed evidence of spectral banding or harmonics. Initial ‘model’ templates were generated for typical broadband and narrowband clicks. The average frequency spectrum from each sub-event was then compared with these model templates. Sub-events with sufficient similarity to the model templates were used to create overall templates for broadband and narrowband clicks. The overall broadband and narrowband templates were then used to classify the clicks into each category.

Plots of the bearings of clicks from the hydrophone showed that the majority of sub-events dominated by narrowband clicks were astern of the vessel. This may indicate that narrowband clicks are either produced in specific behavioural contexts, or that this was an effect related to the relative orientation of the animals towards the hydrophone.

Analysis of broadband clicks showed that they could be identified to species level by their banding. The overall templates of average spectra of broadband clicks showed consistent periodic patterns of energy at frequencies between 40 and 80kHz. A sinusoidal template showed a periodicity equivalent to harmonics at a consistent frequency spacing of 8.83kHz. Over 70% of events had at least one sub-event which showed a significant ($p<0.05$) positive correlation with the sinusoidal template. Although not all white-beaked dolphin clicks showed these banding characteristics, most events contained some clicks which did. Where such banded clicks occurred, the location and spacing of peaks in the frequency spectra would appear to be diagnostic. The harmonics present in the broadband clicks of white-beaked dolphins therefore allow for the possibility of the development of an automated classifier.

A comparison of the overall templates of narrowband and broadband clicks between the North Sea and west coast demonstrated that both click types were recorded from white-beaked dolphins on both coasts. Although there was some indication that spectral characteristics of broadband clicks in the 80-100kHz band varied between regions, and also that narrowband clicks were produced at different frequencies, these differences were not sufficiently distinct to propose separate populations based on click characteristics.

This use of clicks in addition to whistles in species detection and identification lends further support to the use of passive acoustics as a means of surveying for these species, either in conjunction with visual surveys or independently. The findings of this study demonstrate that passive acoustic monitoring could make a key contribution to the current requirement to understand the distribution of white-beaked dolphins in UK waters and identify sites for Marine Protected Areas.

REFERENCES

Rasmussen, M.H. and Miller, L.A. (2002) Whistles and clicks from white-beaked dolphins, Lagenorhynchus albirostris, recorded in Faxaflói Bay, Iceland. *Aquatic Mammals*, 28: 78-89.

Soldevilla, M.S., Henderson, E.E., Campbell, G.S., Wiggins, S.M. and Hildebrand, J.A. (2008) Classification of Risso's and Pacific white-sided dolphins using spectral properties of echolocation clicks. *Journal of the Acoustical Society of America*, 124: 609-624.

VI. Lyme Bay: A recently discovered hotspot for white-beaked dolphins in the English Channel

Tom Brereton[1], Kate Lewis[1], Colin MacLeod[1,2]

[1] MARINElife, 12 St Andrews Road, Bridport, Dorset. DT6 3BG
[2] GIS in Ecology, 120 Churchill Drive, Broomhill, Glasgow. G11 7EZ, UK

A large amount of cetacean survey work has been undertaken in the western English Channel by MARINElife from ferries since 1995 and small boats since 2007, whilst public sightings have been collated from 2004 onwards. There have been more than 70 sightings of White-beaked Dolphin since 2006, with encounters in all months and subsequent years. The majority of sightings have been in an 820km^2 area of central-western Lyme Bay, with re-sightings from photo-identification images proving a high degree of site fidelity. Lyme Bay is now considered to form the southern range margin of regular occurrence for this dolphin species in Europe. The number of animals utilising Lyme Bay is in excess of 200 animals since 2007, which may qualify the area to be nationally important. Central-western Lyme Bay has a number of features that are thought to be important in determining presence and concur with results from the few habitat studies completed on this dolphin species in other parts of the UK. These include (1) Water depths of >50m (2) Stratification of the water column in the summer (3) A gently sloping, predominantly sandy seabed (4) Plentiful stocks of Cod and Whiting (key known prey items), especially in the summer (5) A general absence of Bottlenose Dolphin and (6) Sea surface temperatures below 18°C. The species may benefit from protection and management measures through Marine Conservation Zones (MCZs), though climate change remains a severe long-term threat.

INTRODUCTION

White-beaked Dolphin *Lagenorhynchus albirostris* is a species of conservation concern. Populations are afforded a level of protection and subject to conservation action in UK waters under the following: the BONN Convention, the BERN Convention on the Conservation of European Wildlife and Natural Habitats, Annex IV of the EU Habitats Directive (1992), the Marine Strategy Framework Directive, Appendix II of CITES and national biodiversity strategies that evolved from the UK Biodiversity Action Plan following devolution.

White-beaked Dolphin has a more limited global range than most other cetacean species present in UK waters, being found only in cool temperate and subarctic waters of the north Atlantic (Reid *et al.,* 2003). The populations in the eastern Atlantic are thought to be larger than those in the west, with a range extending from northern Norway and

Iceland to the British Isles and North Sea. The species is found mostly in continental shelf waters of the northern and central North Sea and west of Britain and Ireland, where water depth is chiefly between 50 m and 100m, and more rarely out to the 200 m depth contour (Northridge *et al.,* 1995; Weir *et al.,* 2001; Reid *et al.,* 2003). The species is described as rare in the English Channel. In the *Atlas of Cetacean distribution in north-west European waters* covering a 25- year period up to the early 2000s (Reid *et al.,* 2003), there were sightings from only one grid cell, located in French waters off the coast of Brittany. Sampling effort in English waters from West Sussex to west Cornwall was relatively high over this period (>100 hours per grid cell). There have been a few sightings in the Bay of Biscay and as far south as the Straits of Gibraltar (Pollock *et al.,* 1997, 2000, MARINElife unpublished data).

Since publication of the 2003 Atlas there have been further Channel sightings. Seven animals were off Dungeness Kent in December 2004 (the first record for reserve warden David Walker who has been seawatching almost daily at the site since 1989). Seven sightings were made in coastal areas off the Cornish coast between 1990 and 2004. The records spanned from Gwennap Head in the west to Looe in the east and were all made in July and August (Goodwin *et al.,* 2007). Records supplied to the Seaquest Southwest project included 8-10 individuals in the middle of Lyme Bay (DWT) in August 2004, and 20 in Fal Bay, Cornwall and 2 off Nare Head, Cornwall both on the 29th September 2005. On the French side, there were just five sightings up to 2002, although there were reports of regular sightings by fishermen in northern France, especially during the winter months (Kiszka *et al.,* 2004). Three were seen off Cap Gris-Nez, Nord pas de Calais in October 2008 (Source: (http://www.trektellen.nl). The sole report off the Normandy coastline (where there are hundreds of sightings of other species) relates to a group of ~100 off Jersey in January 1985 (François Gally, Groupe d'Etude des Cétacés du Cotentin, pers. comm.) From 2005 onwards, year-round ferry surveys in the Southern North Sea between Essex and Holland have detected regular occurrence from March to June (F. Zanderink pers. comm.).

In summer 2007, the conservation research charity MARINElife (www.marine-life.org.uk) recorded several sightings of White-beaked Dolphin in the middle of Lyme Bay (located off the coasts of Devon and Cornwall) during effort-related marine mega-vertebrate surveys. A number of White-beaked Dolphins had unique markings, highlighting the potential to develop a photo-identification catalogue for this species. The sightings prompted an expansion in survey effort in the region targeted at the species, followed by more wide-ranging surveys in the Channel, a photo-identification project and collation of public sightings.

In this paper we describe the range of surveys and citizen science projects undertaken by Marinelife in the western English Channel and southern North Sea between 1995 and

2011, the White-beaked Dolphin sightings recorded centred in Lyme Bay, describes insights into population structure and mobility from photo-identification studies highlight the likely reasons for occurrence and assess the importance of the region for the species.

METHODS

Marinelife effort related sea surveys in the Channel and southern North Sea 1995-2010

Marinelife has undertaken a broad range of effort-related boat surveys for cetaceans and other large marine mega-vertebrates within Lyme Bay, the wider English Channel and adjacent southern North Sea between 1995 and 2011, through a range of projects (Table 1). For the majority of surveys, skilled volunteer surveyors were used.

Monthly, year-round ferry surveys undertaken by volunteers and sponsored by the hosting shipping companies have been ongoing since 1995, including the Portsmouth-Bilbao ferry which ran from 1995-2010, together with regular sampling along four other routes from 2008-2011 and occasional surveys on a further eight routes over that period. Between 2005 and 2008 small boat surveys undertaken by volunteers were made off the coasts of south-west England sponsored by the owners of dive, angling, eco-tourism and fishing boats, with the majority of sampling chiefly in and around Lyme Bay. In winter 2009/2010 a systematic transect survey funded by Natural England was completed across Lyme Bay, with the main purpose being to assess the winter status of White-beaked Dolphins in the region. Since 2009 surveys have also been through ecotourism trips into Lyme and Weymouth Bays during July and August, with the surveys sponsored by Naturetrek.

Table1. Summary of MARINElife survey data within the English Channel and adjacent Southern North Sea

Survey	Period	No. survey days	Km travelled
Effort-related ferry surveys			
Boulogne – Dover Ferry	2010	2	<10
Caen-Portsmouth	2008-2009	3	592
Felixstowe-Vlaardingen	2008-2011	28	4234
Portsmouth-Bilbao ferry	1995-2010	330	62514
Pool-Santander ferry	2008-2011	79	26734
Plymouth-Roscoff ferry	2006-2011	52	11876
Portsmouth-St Malo	2010	2	466
Poole – Cherbourg	2007-2010	4	NR
Portsmouth – Caen	2007-2010	3	592
Portsmouth-Le Harvre	2010-2010	1	NR
Portsmouth – Fishbourne	2010	2	18
Rosyth – Zeebrugge	2008-2011	24	2807
Weymouth – Guernsey	2010	2	102
Effort-related small boat surveys			
Volunteer surveys	2007-2010	107	11086
Lyme Bay winter survey	2009	10	1410
Western Channel summer survey	2009	18	3476
Targeted surveys	2010	14	2198
Effort-related Totals	**1995-2011**		
Casual (public) surveys	2007-2010	>600**	
Grand total			

** minimum estimate 607 days

Though the Channel integrated Approach for marine Resource Management project (Charm III), funded by the European Union (INTERREG IV A) a step change increase in sampling intensity was possible between 2009 and 2011 across the entire western English Channel. The sampling programme included (1) further volunteer surveys on dive, angling, eco-tourism and fishing boats from 2009-2011 off south west England (2) a systematic survey (stratified random design) of the entire western Channel in summer 2009, totalling 1,655 km repeating SCANS II aerial survey tracklines (http://biology.st-andrews.ac.uk/scans2/) (3) targeted surveys in 2010 within 10 km^2 grid squares not previously surveyed by any of the above methods. For a summary of survey programmes see Table 1.

For all ferry and small boat surveys at sea effort-related recording for cetaceans was undertaken. Effort-related data was collected at 15-30 minute intervals (or whenever the course of the ship changed) and included direction of travel, speed and position of the ship, and sea and weather conditions. On recreational dive and angling boat surveys, the time, location and duration of stopping points (for dive or angling efforts) was also noted.

Survey methods were consistent across platforms, though vessels varied in terms of height at which observation was possible and speed. The majority of surveys were characterised by having two experienced observers (occasionally 1 or 3 observers), watching ahead during all available daylight hours. On ferries all recoding was made from the ship's bridge.

White-beaked dolphins and other cetaceans were sampled by Distance Sampling (Buckland *et al.,* 2001), although a double platform was not employed. Sightings data collected for each cetacean encounter included: species identity, age and number of individuals, distance (estimated using a Heinemann stick or with laser range finder binoculars) and angle (using graticule binoculars or by angle board) to the sighting, position (using a GPS), and behaviour and weather/sea conditions (including sea state). Behaviour categories (following Evans, 1995) were (1) Slow/normal swim: leisurely surfacing with no splash (2) Feeding: prey seen in vicinity or animal changing direction as if in pursuit (3) Fast swim: rapid surfacing, possibly with white water (4) Leap/splashing: leaping out of the water, tail or fin slapping; (5) Bow-ride: coming to boat and riding bow wave (6) Rest/milling: lying motionless at surface (logging) or slow, synchronous surfacing.

Effort data was collected simultaneously with sightings data, to enable the number of sightings to be scaled to recording effort. The speed, direction of travel, the position of the ship and environmental conditions, such as sea state and visibility, were recorded on a regular basis (at every 15-30 minutes or whenever the ship changed course).

Analysis of effort-based data

Effort and white-beaked dolphin sightings data from all surveys (1995-2011) were combined into a single database, with each record representing information about a single survey leg; defined as the period between subsequent records of the ship's position. These ship's positions either represented points at which environmental data were recorded or a white-beaked dolphin sighting was made. Hence, each record contained information on the position of the ship at the start of a survey leg, position at the end of a survey leg, the survey route, environmental conditions at the start of the leg, whether the starting position of the leg represented a white-beaked dolphin sighting or an environmental record point, the time, day, month and year, and where appropriate, the number of white-beaked dolphins counted. A blank record was used to mark any breaks in survey effort during an individual survey.

This database was then plotted in a geographic information system (GIS) created in ArcMap 9.3.1, and the path of each survey recreated from the positional information. These re-constructed surveys were then checked for errors, such as erroneous GPS records. Any survey legs which were found to have errors were then removed from the database. As sightings were used as points to define survey legs, any sightings associated with potentially erroneous survey positions were also removed in this process.

The data were subsequently divided into a grid of 10 km X 10 km for the western English Channel and southern North Sea with the boundaries of these sea areas delimited as defined in the Charm III project (Brereton *et al.,* 2012). In total 681 surveys were completed on 606 days with ~128,000 km of trackline sampled (two thirds undertaken from ferries, one third small boats). Sailings were made from 26 English, seven French and single Belgium and Dutch ports, using 45 different vessels with 727 10km^2 grid cells of the western English Channel and southern North Sea sampled (40% of the total). The spatial distribution of MARINElife survey effort at 10-km^2 resolution is given in Figure 1. In spite of the large amount of survey effort there were biases in the sampling. The most intensively sampled area was the western English Channel, with 80% of 10-km^2 squares west of the Cotentin (Cherbourg) Peninsula sampled. In comparison, only 20% of squares were sampled in the Eastern Channel (east of the Cotentin Peninsula).

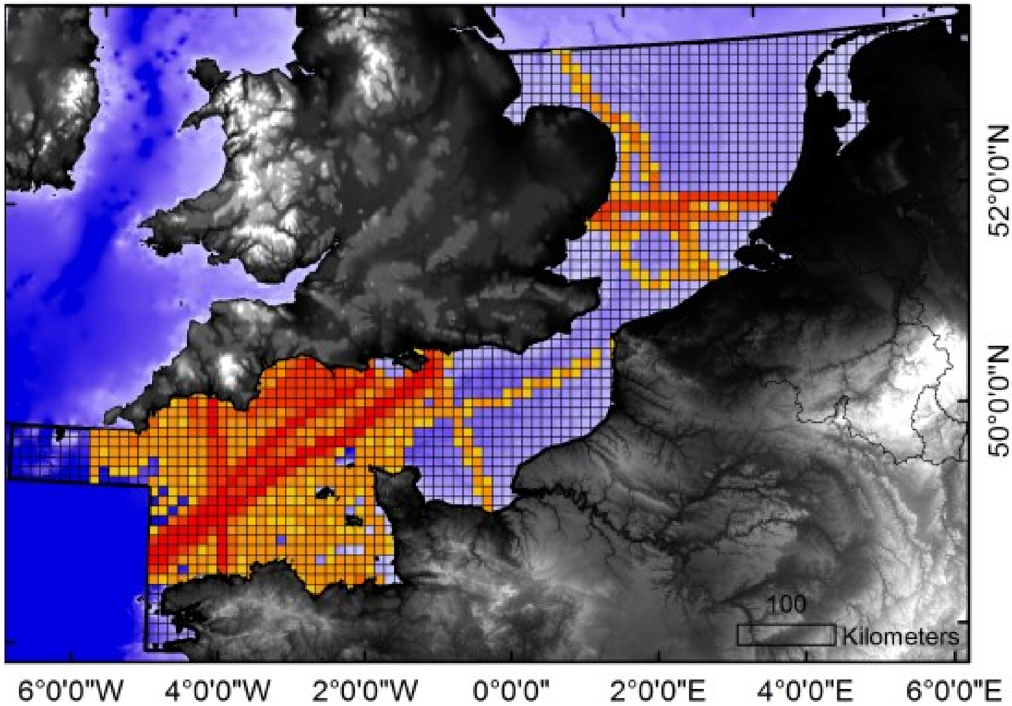


Figure 1. MARINElife survey effort in the Channel Charm III sea zone 1995-2011 at 10km2 resolution. Grid effort (Km travelled) categories: no effort (hollow cells) 1-250km (light orange), 251-500 (orange), 501-1000 (dark orange), >1000 (red).

A single measure of white-beaked dolphin abundance was derived for each grid cell using data pooled across all MARINElife effort-related surveys. Given that different recording methods were used (with density estimates not directly comparable for all surveys) data were amalgamated into a simple measure of relative abundance (number counted per km travelled). Sea state was not accounted for in the analysis, given that the majority of surveys sightings were completed in calm to moderate seas, so relatively few dolphins near to the vessel were likely to have been missed.

Collation and analysis of public sightings data

In order to improve spatial coverage and quantity of sightings data, a postcard survey funded by Natural England was launched in 2009 to encourage skippers of commercial fishing boats, dive boats, anglings boats, yachtsmen and other members of the public to submit records of white-beaked and other dolphins. In addition, a website was established to enable online submission of data whilst a sightings blog was established to stimulate an interest in and further encourage submission of sightings. This blog was redesigned and developed through the Charm III project http://marinelife-charm3.blogspot.co.uk/. In total more than 600 casual cetacean sightings were collated from the Channel between 2009 and 2011. In the majority of instances contact was made with recorders in an attempt to validate identification from non-specialist recorders, including from photographic evidence. Very few misidentifications were apparent through this process. These data were entered into a single Access database and the sightings subsequently plotted using ArcMap 9.3.1.

Photo-identification of dolphins

For white-beaked dolphin observed on small boat surveys, where possible sampling was suspended and the group followed in an attempt to photograph each animal present for photo-identification purposes. Once this was completed, the boat would return to the track line to complete the days sampling. Information was collected about each group and each individual photographed and stored in separate tables in a MS Access database. Information collected about the group included: Survey Date; Location (latitude and longitude); Time; Group Code, Number of animals present; Number of adults; juveniles and calves present; Number of recognisable animals photographed; Number of recognisable animals present but not photographed; Number of animals present without marks.

For each individual, where possible multiple images were taken to capture the full range of recognisable features present. Information collected for each image included: Survey Date; Location (latitude and longitude); Time; Group Code; Animal Code; and Photographer Name together with details on recognisable features. Images were graded with a quality rating based on the focus, angle, and size of the fin within the image with 1 = Poorly-marked to 3 = Well-marked (Würsig and Jefferson, 1990). Photographs of grades 2 and 3 were primarily used to identify and catalogue individuals using standard methods (following Parsons, 2003). However, some grade 1 images were used when highly distinctive animals could be recognised. Recognisable individuals were identified according to whether they exhibited permanent (e.g., nicks, notches, damaged fins, or diagnostic fin shape) or temporary (e.g., depigmentation, skin lesions, scars, scratches, tooth rakes) features on their dorsal fins and bodies. Best right and left side images of individual white-beaked dolphin were compiled into a catalogue that included information on mark type, data of first capture, description of similar animals, the months and regional locations of photographic captures and associations with other animals.

Because data collection was uneven between years only crude analyses were possible including plotting the distribution of re-sighted animals, calculating minimum distances between re-sightings, and generating a broad abundance estimate of the number of animals utilising Lyme Bay over the sampling period (2007-2011). The latter estimate was calculated from the total number of recognisable animals and the proportion of recognisable animals present in all the groups photographed.

RESULTS

Distribution, relative abundance and behaviour

Effort-related surveys

On effort-related surveys there were 29 sightings totalling 208 animals made between August 2007 and July 2011. Group sizes ranged from two to 35 animals, with a mean eight. All of the sightings were from small boat surveys, with none seen on ferries in spite of ~111,000km of search effort in suitable viewing conditions (≤ sea state 3). Sightings were made in all seasons though 70% of encounters were during the summer, this in part reflecting the increased level of small boat sampling effort in this season. Effort-related sightings were almost exclusively restricted to offshore waters in the middle of Lyme Bay (Figure 2).

White-beaked dolphins were the second most frequently recoded cetacean species in Lyme Bay, after harbour porpoise. Harbour porpoises were regularly recorded in the central areas of Lyme Bay on the same days as white-beaked dolphin, whilst there were similar but more occasional sightings of co-occurrence with minke whale and common dolphin. There were no sightings of white-beaked dolphins on days when bottlenose dolphins were seen. The occurrence of large pod of bottlenose dolphins in the middle of Lyme Bay in January 2009 coincided with the disappearance of white-beaked dolphin from the area, following a period of regular sightings.

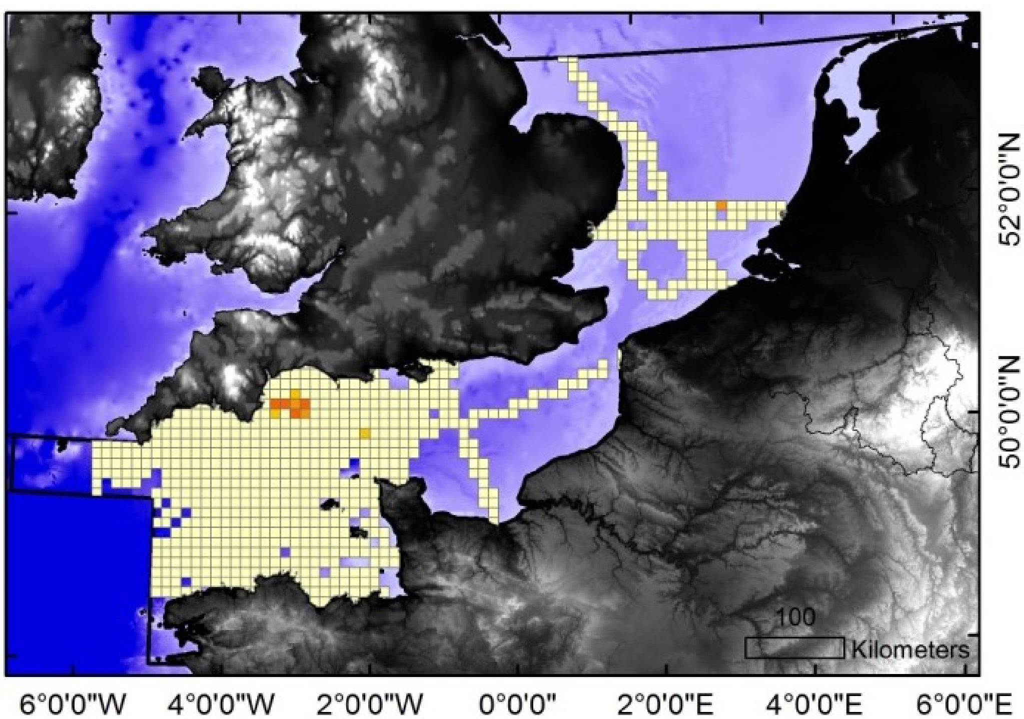


Figure 2. see page 47 for legend.

Figure 2. Relative abundance at 10 km^2 scale of White-beaked Dolphin 1995-2011. Relative abundance categories in squares are: none seen (white cells), <0.01 counted per km (light orange), 0.01-0.049 per km (orange), 0.05-0.49 (dark orange), 0.5-0.99 per km (light red), >1/km (red). Cetacean sightings categories: 1 (smallest circle), 2 - 9, 10 - 49, 50 - 99, 100 - 999, >1000 (largest circle). Yellow circles are sightings from MARINElife surveys, red circles are casual sightings submitted to MARINElife.

There were few instances of foraging seabirds associating with white-beaked dolphins. Exceptions being presence in association with large mixed gatherings ('feeding frenzies') of gannet, Manx shearwater and auks. These flocking birds were suspected to be feeding on large shoals of pelagic fish especially the clupeids, herring *Clupea harengus* and sprat *Sprattus sprattus*. The presence of herring was confirmed on several occasions, with dead specimens seen on the water surface. Whilst feeding, white-beaked dolphins followed a repeat pattern of diving and disappearing for three to five minutes before resurfacing within 500m of the last dive, then surface regularly over the next two to five minutes. Feeding groups with this 'subdued' behaviour were easy to overlook in seas with white caps.

2012 white-beaked dolphin sightings have yet to be analysed in detail, though there were a further 12 sightings of 82 animals recorded in the middle of Lyme Bay in group sizes of up to 15 animals, confirming continued presence in the area. A recently born calf was noted in early August in a group that had been seen in the preceding days, providing proof of birth in August.

Casual sightings

There were 26 'casual' sightings of 344 animals collated from members of the public from 2006-11, representing 5% of all public cetacean sightings submitted to MARINElife over this period. The sightings were over a broader geographical area than effort sightings confirming a wider distribution. The majority of casual sightings (and) were from central Lyme Bay, with the largest single group also being recorded here. Coastal sightings were extremely rare (one record, Berry Head), in spite of many sites receiving high levels of seawatching effort over the period (e.g. Portland Bill, Durlston Country Park, Dawlish Warren, Seaton, Prawle Point). Group sizes ranged from 2-200 animals, with calves noted in some of the groups. There were 3-5 casual sightings in each month from February to August, with a further record in November, suggesting year-round presence. The distribution of casual (and effort) sightings is presented in Figure 3.

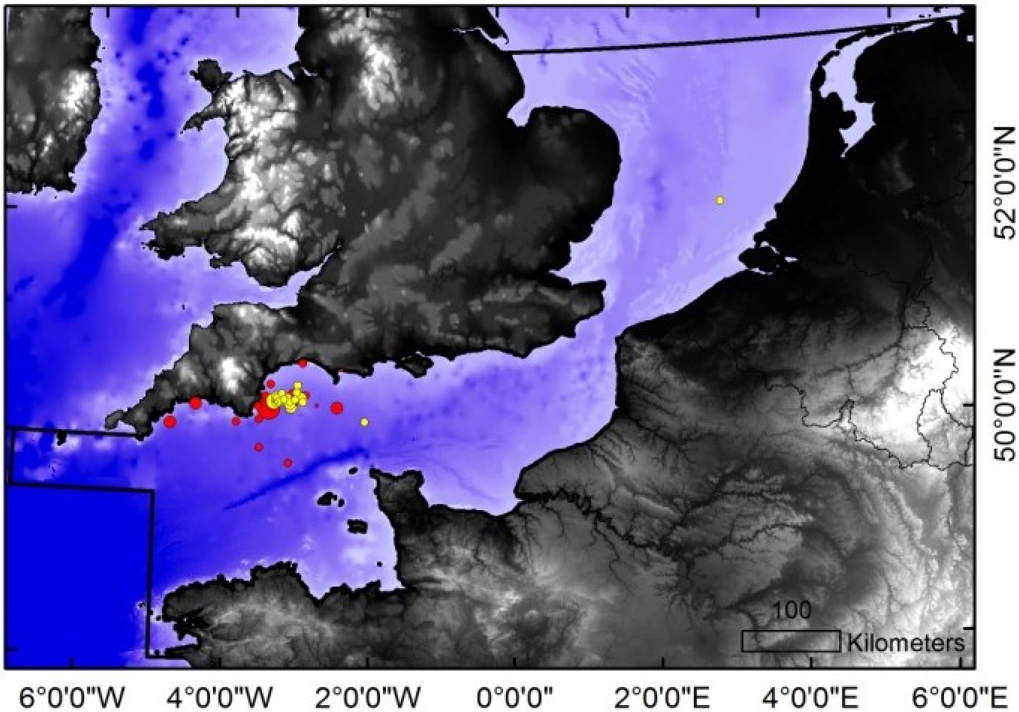


Figure 3. Relative abundance at 10 km^2 scale (left side plot) and mapped sightings (right side plot) of White-beaked Dolphin 1995-2011. Relative abundance categories in squares are: none seen (white cells), <0.01 counted per km (light orange), 0.01-0.049 per km (orange), 0.05-0.49 (dark orange), 0.5-0.99 per km (light red), >1/km (red). Cetacean sightings categories: 1 (smallest circle), 2 - 9, 10 - 49, 50 - 99, 100 - 999, >1000 (largest circle). Yellow circles are sightings from MARINElife surveys, red circles are casual sightings submitted to MARINElife.

Environmental conditions at sightings locations

The central-western part of Lyme Bay which represented the core area of white-beaked dolphins distribution was characterised by water depths of more than 50m, a gently sloping predominantly sandy seabed and an area of high front density (PML Unpublished data, Peter Miller pers. comm.). Sea surface temperatures in the vicinity of sightings recorded over the 2007-2009 period (n=20 sightings) ranged from 8.8 to 17.3ºC, with the model class being 15ºC and no records in the 11-12 ºC category. The central-western part of Lyme Bay supports some of the highest densities of sprat (key prey item) in the western English Channel scale (CEFAS, unpublished data)

Population size, structure and mobility

On effort-related surveys, more than 50% of white-beaked dolphin groups encountered exhibited feeding behaviour, whilst calves were found in 20% of groups. Images were obtained and processed for 20 white-beaked dolphin encounters from Lyme and Plymouth Bays over the period 2007-2011. The proportion of animals identifiable (when the majority of animals in the group were photographed) by fin and other damage was highly variable (range 0-100%). As expected, groups with a higher proportion of adults had more animals that were recognisable, whilst some groups comprised exclusively of juveniles showed little or no evidence of fin scarring. In total 69 individuals were photographed between 2007 and 2011, with 20 animals re-sighted on one or more occasions (29% of the total) amongst a total of 98 'captures'/'recaptures' (Figure 4). One animal was observed on five occasions, whilst six animals were observed on three occasions.

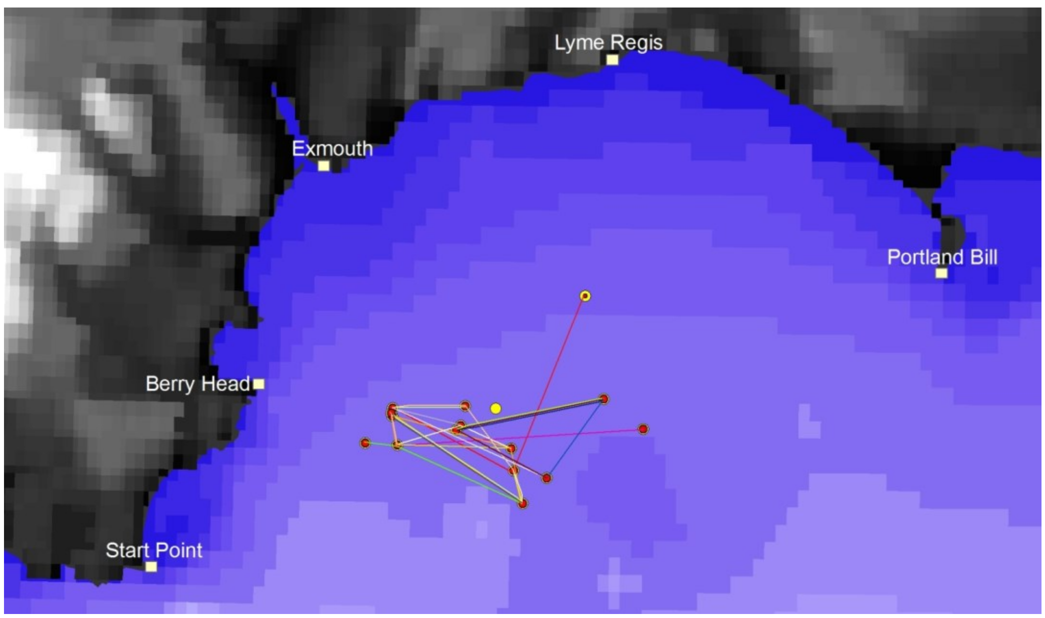


Figure 4. Movements of individual White-beaked Dolphins in Lyme Bay off the Devon and Dorset coast of south west England from 2007-2011. Yellow circles are of animals seen once only, smaller red circles are for animals re-sighted on one or more occasions. Lines represent minimum movements between re-sighting events, with the different colours being movements of individual animals.

There was interchange between groups, with recognisable animals being seen both within and between years in groups of different sizes and with differently scarred individuals. For example an animal first photographed in a group of three in August 2007, was seen again amongst a group 20 on 8th August 2009, then with seven in October 2011.

Following this the individual was observed in a group of 16 in July 2012, then a group of 10 in September 2012 (that included a newborn calf). Linear movements between all recapture events for each recognisable individual varied from between four and 40 km (Figure 4). 97% of recaptures were in a 50-60m water depth zone extending over $500km^2$. The short distances between recaptures suggesting that the centre of Lyme Bay is an important hotspot for this species, with a high degree of site fidelity apparent.

Analysis of photo-identification data would indicate a crude population estimate of more than 200 animals utilising Lyme Bay since 2007. This estimate being based on ~70 animals identifiable, just under a third of these animals re-sighted and approximately a third of animals photographed being recognisable by photo-identification.

DISCUSSION

Status in the western English Channel

More than 70 white-beaked dolphin sightings were recorded or collated by MARINElife between 2006 and 2012, with sightings from all years and seasons. The maximum group size recorded in Lyme Bay has been ~200 animals, whilst photo-identification analyses suggest a rather crude, provisional estimate of more than 200 animals utilising the area since 2007. Public sightings submitted to MARINElife were of value in confirming the wider distribution of the species in the western English Channel including off the coasts of west Devon and Cornwall and mid-Channel (away from the main shipping lane).

The majority of effort-related sightings were of feeding groups in Lyme Bay and this area most likely represents the most southerly location in Europe where the species is regularly seen. Improved knowledge on behaviour and occurrence, yield white-beaked dolphins on ~90% of targeted surveys in Lyme Bay in 2012 confirming continued presence. Regular occurrence in Lyme Bay and the Channel conflicts with published assessments of status, with the species formerly being considered rare/absent in the Channel (Reid *et al.,* 2003, Hammond and Macleod 2006, and Leeney *et al.,* 2008). The most recent (draft) assessment of UK distribution considered the Channel as out-with the regular range of the species based on predicted distribution, actual sightings and expert judgement (JNCC, 2013).

Regular presence of white-beaked dolphins in the western Channel, may indicate that the animals have been overlooked in the past or that there has been recent colonisation that post dates survey data used in previous assessments. Evidence that animals may have been overlooked include (1) relatively high number of strandings from the south-west at levels comparable with the east coast of England (Canning 2007), which is considered part of the species regular range (Reid *et al.,* 2003, Hammond and Macleod, 2006, JNCC 2013) and (2) comments from skippers dive and angling boats, when shown white-beaked dolphin's by MARINElife surveyors onboard have commented that they may have overlooked the animals in the past (Chris Caines and Ian Cornwell pers. comm.) Reasons for recent colonisation may include an increased abundance of key prey items (e.g. white fish) following the introduction of quotas and reduction in inter-specific competition following declines in abundance of coastal bottlenose dolphin populations (Wood, 1998).

The highest numbers of sightings were observed in the summer months, with calves a frequent component of groups over this period. Canning (2007) found white-beaked dolphin to be primarily a summer visitor to the deeper waters off Aberdeen, north-east Scotland with occurrence coinciding with calving and groups containing calves.

Importance of Lyme Bay

A population of in excess of 200 animals would qualify Lyme Bay as being nationally important for white-beaked dolphin, as the area would support ~1% of the total population found in European Atlantic continental shelf waters, which has been estimated at ~22,000 animals (Hammond and Macleod 2006).

In photo-identification studies 19% of animals were re-sighted, 97% of re-sighting were in a 820km^2 area of central Lyme Bay, whilst some re-sightings spanned the entire period of the study (2007-2012); with these statistics indicating a high degree of site fidelity. Lyme Bay was found to be used extensively for foraging (>50% of encounters of feeding animals) and calves were found in 20% of groups, further highlighting the importance of the area in providing critical habitat.

The available data suggest that Lyme Bay may be the most important locality in the English Channel for white-beaked dolphin, though this cannot be confirmed due to under-sampling of other areas of the Channel. Recent ferry surveys in the Eastern English Channel are finding white-beaked dolphins, in areas where they were considered rare/absent (MARINElife unpublished data), likely highlighting that the Channel 's cetacean fauna is under-recorded. The few available reports of white-beaked dolphins stranded on the French side of the English Channel suggest presence during the winter months (Collet *et al.,* 1981; Duguy, 1984; 1987; 1988).

Reasons for occurrence in Lyme Bay

White-beaked Dolphin distribution in UK waters has been linked to sea surface temperature, local primary productivity, prey abundance and absences of other dolphin species including common dolphin (MacLeod *et al.,* 2007; Weir *et al.,* 2007). A recent study of the Minch, found white-beaked dolphin in a restricted area in waters 107-122m deep and in temperatures from 13.2-13.5ºC and 22-32km from the shore (Weir *et al.,* 2007).

The core area of occurrence in central Lyme Bay is characterised by water depths of >50m, distances from the shore of 8-50km and a gently sloping predominantly sandy seabed. A study by Canning (2007) off the coast of north-east Scotland similarly found white-beaked dolphins to be associated with sandy sediments, deeper waters and gentler slopes. A habitat suitability modelling study of white-beaked dolphin in Lyme Bay using MARINElife data (Edwards 2010) indicated that distribution could largely be explained by two environmental variables – seabed type and water depth. Areas of high suitability were characterised by water depths of more than 50m and seabed habitats with a sandy component (Figure 5). Adding frontal data into the analysis may have improved model fit (i.e. by excluding central-eastern parts of Lyme Bay).

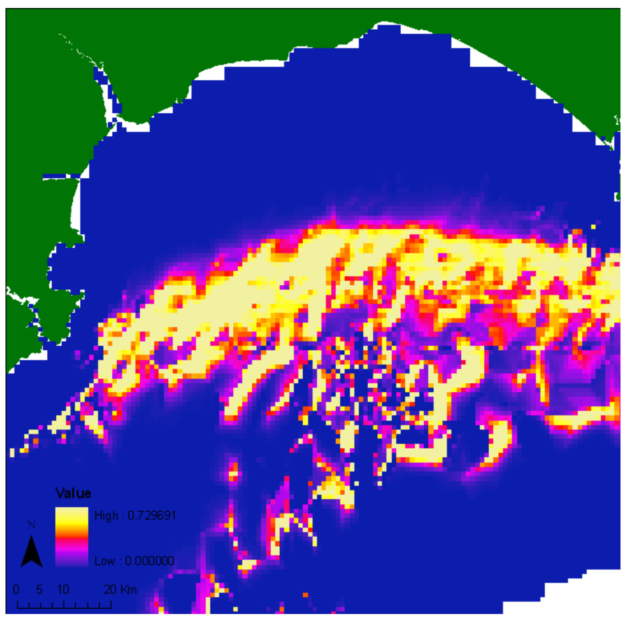


Figure 5. Habitat suitability model for White-beaked Dolphin in Lyme Bay produced by GAM without SST data (from Edwards, 2010)

The most important explanatory variable defining the preferred habitat of white-beaked dolphin at a UK scale is considered to be water temperature, with species occurrence decreasing substantially in water temperatures greater than 12-14°C (MacLeod *et al.,* 2007, 2008). As a result, while white-beaked dolphins are the most dominant neritic (shelf water) dolphin species in UK cooler waters, they become much rarer in water temperatures above ~12-14°C and are replaced by the common dolphin as the dominant neritic dolphin species when this species is present (MacLeod *et al.,* 2007; 2008). At temperatures above ~18°C, white-beaked dolphins seem to be very rare or absent altogether. Modelled sea surface temperatures recorded white-beaked dolphins sightings location were within <18^{o}C, though summer records were towards the upper limit. Sea surface temperature was not found to be an explanatory variable in the study by Edwards (2010), though this may have been due to the uniformity of temperatures over what is a relatively small geographical area.

There were few instances of flocks foraging seabirds associating with schools of white-beaked dolphin, indicating that the species does not principally feed on shoals of fish near the surface. The presumed main prey items, white fish and shellfish, are thought mainly to occur in the lower half of the water column (i.e. >25m deep), which are not targeted by plunge diving/surface feeding seabirds. Fine-scale data on the distribution of fish and other prey sources in the study area was not available, though the area is known by local sea anglers to be a productive fishing area for whiting (*Merlangius merlangus)*, cod (*Gadus morhua),* pout whiting (*Trisopterus luscus)* and other gadoids, especially in the vicinity of First and Second World War wrecks, which it is speculated may provide safe havens from commercial fishing activity. These white fish are known to be key prey items for *Lagenorhynchus albirostris* in UK waters (Santos *et al.,* 1994, Canning *et al.,* 2008). White-beaked dolphins were occasionally recorded amongst feeding frenzies of seabirds presumably feeding on large shoals of pelagic fish. Herring was suspected to be one of the prey items in these situations, as this is also a known food source (Evans 1980, Canning *et al.,* 2008). The high densities of sprats present of Lyme Bay may also be a driver of distribution as Camphuysen *et al.,* (1995) recorded large numbers of white-beaked dolphins actively feeding in regions where trawl catches were dominated by concentrations of herring and Sprat.

An absence of bottlenose dolphins from central Lyme Bay may also be an important factor in determining white-beaked dolphin presence. The available data suggest habitat partitioning between white-beaked dolphin and bottlenose dolphin in Lyme Bay based on proximity to land and water-depth, with bottlenose dolphins being a shallow-water, coastal species (Edwards 2010). Similar habitat partitioning has been demonstrated in other regions of the UK e.g. Northumberland (Martin Kitching pers. comm.) and north-east Scotland (Ian Sim pers. comm.).

The occurrence of white-beaked dolphin in Lyme Bay and other south-west waters in recent years has coincided with a corresponding decrease in sightings of bottlenose dolphins (Doyle *et al.,* 2007). This finding may be significant although as previously mentioned under-recording of white-beaked dolphin due to its preference for offshore waters cannot be ruled out. Coastal bottlenose dolphins will inevitably use offshore waters from time to time. During the Natural England surveys, a large pod of bottlenose dolphins (with a high proportion of young calves) were present in the offshore central waters of Lyme Bay from February 2009, coinciding with the sudden disappearance of white-beaked dolphins (which had been present for at least nine months previously).

Conservation

The relatively high numbers of white-beaked dolphin that have utilised Lyme Bay in recent years and the high degree of site fidelity shown, support the case for regional conservation efforts targeted at this species. Site-specific potential threats to white-beaked dolphin which may require management measures include (1) damage to feeding habitat (wrecks) through dredging/trawling (2) relaxation in current quotas for white fish i.e. increase fishing pressure especially from French fleets, leading to reductions in key prey items and the areas carrying capacity to support the species (3) increased recreational disturbance and (4) bycatch, although levels of the latter are unlikely to represent a serious threat to this species (Jefferson *et al.,* 1993).

As part of the latest round of consultation on Marine Protected Areas (Marine Conservation Zones - MCZs) in England (March 2013), MARINElife submitted a case for the designation of an 820km^2 area of central Lyme Bay as a hotspot for White-beaked Dolphin's and for an associated assemblage of marine mega-vertebrate species, including a number of Priority Species identified at National, UK and European scales.

Though white-beaked dolphin may potentially benefit both from protection and appropriate management measures in MCZs and wider sea areas over the short-term, climate change poses a severe long-term threat to the species due to the close association between water temperature and distribution. White-beaked dolphin rarely occurs in waters >18ºC and currently waters temperatures regularly reach 17-18 ºC in Lyme Bay in the summer months. A modest 1-2 ºC rise in SST could lead to the disappearance of white-beaked dolphins during the summer months. Given the current predicted increases of water temperature around north-western Europe of up to 0.5^{o}C per decade (Fisheries Research Service, 2003) sea temperatures could become generally too warm in the summer months within 20-40 years.

ACKNOWLEDGEMENTS

MARINElife's survey work in the Channel has been part-funded by Natural and by the EU as part of the Channel Integrated Approach for Marine Resource Management (CHARM) Phase 3 project. We would like to thank MARINElife volunteers for collection/entry of observation data and P&O Ferries, Brittany Ferries and DFDS Seaways for providing free passage and board whilst on ferry surveys. We also greatly appreciate the generosity of the many skippers of dive, fishing, ecotourism and angling boats that provided sightings and free passage onboard their vessels for surveys, especially Chris Caines, Dave Sales, Douglas Lanfear, Ian Cornwell, Ian Noble, Geordie Dickson and David Paddock.

REFERENCES

Brereton, T., Lewis, K. and MacLeod, C. (2012) Surveys for cetaceans, seabirds and other large marine animals in the English Channel. MARINElife Charm III Final Report submitted to Ifremer. Marinelife, Dorset.

Buckland, S.T., Anderson, D.R., Burnham, K.P. and Laake, J.L. (1993) Distance Sampling: Estimating Abundance of Biological Populations. Chapman and Hall, London. 446pp.

Camphuysen, C.J., Heeson, H.J.L., and Winter, C.J.N. (1995) Distant feeding and associations with cetaceans of gannets *Morus bassanus* from the Bass Rock, May 1994. Seabird17: 36-43.

Canning, S.J. (2007). Cetacean distribution and habitat use along the east coast of Scotland. Ph.D. Thesis. University of Aberdeen, Scotland. 199pp.

Canning, S.J., Santos, M.B., Reid, R.J., Evans, P.G.H., Sabin, R.C., Bailey, N. and Pierce, G.J. (2008) Seasonal distribution of white-beaked dolphins (*Lagenorhynchus albirostris*) in UK waters with new information on diet and habitat use. *Journal of the Marine Biological Association of the United Kingdom*, 88, 1159-1166.

Collet, A. and Duguy, R. (1981) *Lagenorhynchus albirostris* (Cetacea, Odontoceti): espèce nouvelle pour la faune de France. *Mammalia,* 45(3), 387-8.

Colombé, S.V. and Chown, D. (1995) Marine Vertebrates: Seabird Distributions. Lyme Bay Environmental Survey vol. 10. (Kerr-McGee)

Doyle, J., Goodwin, L. and Loveridge, J.E. (2007) The Decline of Inshore Bottlenose Dolphins (*Tursiops truncatus*) in Southwest England. Poster: European Research on Cetaceans, 21. San Sebastian, Spain.

Edwards, D.L. (2010). Habitat selection of dolphin species in Lyme Bay. MSc Environmental Management by Research, Bournemouth University.

Evans, P.G.H. (1980) Cetaceans in British waters. *Mammal Review*, 10, 1–52.

Evans, P.G.H. (1995) Guide to the Identification of Whales, Dolphins and Porpoises in European Seas. Sea Watch Foundation, Sussex.

Goodwin, L. and Edwards, J. (2007) The South West Dolphin Report. Marine Connection and the Wildlife Trusts, London.

Hammond, P.S. and Macleod, K. (2006) SCANS II – Report on Progress. Document Paper prepared for ASCOBANS 5th Meeting of the Parties, Netherlands, September 2006. MOP5/Doc. 26.

Jefferson, T.A., Leatherwood, S. and Webber, M. (1993) Marine Mammals of the World: FAO Species Identification. Rome, Italy: Food and Agricultural Organization of the United Nations & United Nations Environment Programme.

JNCC (2013) DRAFT Third Report by the United Kingdom under Article 17 on the implementation of the Directive from January 2007 to December 2012. Species: S2032 - White-beaked dolphin (*Lagenorhynchus albirostris*) JNCC, Aberdeen.

Kiszka, J, Hassani, S. and Pezeril, S. (2004) Status and distribution of small cetaceans along the French Channel coast: using opportunistic records for a preliminary assessment. *Lutra,* 47 (1): 33-46.

Leeney, R. H., Amies, R., Broderick, A. R., Witt, M.J., Loveridge, J., Doyle, J. and Godley, B. J. (20080 Spatio-temporal analysis of cetacean strandings and bycatch in a UK Fisheries hotspot. *Biodiversity & Conservation,* 17:2323–2338

MacLeod, C.D., Weir, C.R., Pierpoint, C. and Harland, E. (2007) The habitat preferences of marine mammals west of Scotland (UK). *Journal of the Marine Biological Association of the UK*, 87: 157-164.l.

MacLeod, C.D., Weir, C.R., Santos, M.B. and Dunn T.E. (2008) Temperature-based summer habitat partitioning between white-beaked and common dolphins around the United Kingdom and Republic of Ireland. *Journal of the Marine Biological Association of the United Kingdom*, 88, 1193-1198.

Parsons, K.M. (2003) Procedural guideline No. 4-5. In using photographic identification techniques for assessing bottlenose dolphin (*Tursiops truncatus*) abundance and behaviour. Peterborough, UK: Joint Nature Conservation Committee. 21pp.

Pollock, C.M., Reid, J.B., Webb, A., and Tasker, M.L. (1997) The distribution of seabirds and cetaceans in the waters around Ireland. JNCC Report, No. 267.

Pollock, C.M., Mavor, R., Weir, C. R., Reid, A., White, R. W., Tasker, M. L., Webb, A., and Reid, J. B. (2000). The distribution of seabirds and marine mammals in the Atlantic Frontier, north and west of Scotland. Joint Nature Conservation Committee. Aberdeen. 92pp.

Reid, J.B., Evans, P.G.H. and Northridge, S.P. (2003) Atlas of Cetacean distribution in north-west European waters. JNCC, Aberdeen.

Santos Vázquez, M.B., Pierce, G.J., Ross, H.M. and Reid, R.J. (1994) Diets of small cetaceans from the Scottish coast. ICES Marine Mammal Committee C.M.1994/No. 11, 1-16.

Weir, C.R., Pollock, C., Cronin, C., Taylor, S. (2001) The Marine Environment of the North East Atlantic Margin Cetaceans of the Atlantic Frontier, north and west of Scotland. *Continental Shelf Research*, 21(8–10): 1047–1071.

Weir, C.R., Stockin, K.A. and Pierce, G.J. (2007) Spatial and temporal trends in the distribution of harbour porpoises, white- beaked dolphins and minke whales off Aberdeenshire (UK), North-Western North Sea. *J Mar Biol Assoc UK,* 87: 327-338.

Wood, C.J. (1998) Movement of bottlenose dolphins around the south-west coast of Britain. *Journal of Zoology*, 246: 155-163.

Würsig, B., and Jefferson, T.A. (1990) Methods of photo-identification for small cetaceans. Reports of the International Whaling Commission, 12, 43-52.

VII. White Beaked Dolphin Distribution in Skjálfandi Bay, North East Iceland during the feeding season (May-September)

Ann Coral Vallejo

University of Iceland, Sæmundargötu 2, 101 Reykjavík, Iceland

Iceland represents a hotspot for cetacean diversity, especially during the feeding season (May-September). White-beaked dolphin (*Lagenorhynchus albirostris*) distribution patterns in Skjálfandi Bay were investigated by analysing sightings data collected on-board whale watching platforms between 2004-2012. White-beaked dolphin presences and survey effort were incorporated into a Geographical Information System (GIS) and relationships between environmental variables and presences/absences were determined using General Additive Models (GAMs). To build the models, the presence/absence of this species was considered a response variable while a set of eco-geographical variables (depth, distance to coast, slope, standard deviation of slope, prey and sea surface temperature) were considered as explanatory variables together with month and year. The results from this study will be essential for conservation and management purposes if we are to understand local and temporal patterns of white-beaked dolphin distribution and ecology in an area widely used by whale watching platforms such as Skjálfandi Bay.

INTRODUCTION

White-beaked dolphins (*Lagenorhynchus albirostris*) distribution includes temperate and cold shelf waters of the North Atlantic from Cape Cod (USA), southwest and central East Greenland to the extreme western Barents Sea (Shirihai and Jarrett, 2006) and the Bay of Biscay (Fernandez, Pers. Comms). Iceland represents a hotspot for white-beaked dolphins, congregating in Icelandic waters due to relatively productive areas, rich in nutrients and prey species. White-beaked dolphins are one of the most commonly found species in Icelandic waters, being found all year round depending on their migration patterns. However, atmospheric and other physical parameters such as sea surface temperature and salinity changes may influence the spatial distribution of this species.

Icelandic physical oceanography - topography and current circulation

Iceland is located between the connection of large marine ridges (Valdimarsson and Malmberg, 1999) including the Reykjanes Ridge and Kolbeiney Ridge (southwest-northeast) and the Greenland-Iceland Ridge and Iceland-Faroe Ridge (northwest-Southeast) (Figure 1.). Prevalent patterns of water circulation includes the East Greenland current, East Iceland current, Irminger Current and Coastal current which promote a complex hydrodynamic system. This system generates great water mixing, making nutrients available to the surface via upwelling. Icelandic circulation patterns are influenced by bottom topography (Greenland-Iceland and Reykjanes Ridge to the west and the Jan Mayen and Iceland-Faeroe Ridge to the east).

Study Areas - Skjálfandi Bay

Skjálfandi Bay is located North East of Iceland comprising 10 km wide at the bottom and around 51 km wide between Gjögurtá and Tjörnnestá. Skjálfandi bay is approximately 25 km long and the maximum depth is around 220 m (Figure 1).

Figure 1. Study Area. Skjálfandi Bay, located in northeast Iceland

Aims

The purpose of this study is to: (i) determine preference of eco-geographical variables and habitat use for white-beaked dolphins through the period 2004-2012 in Skjálfandi Bay (ii) consider management recommendations for conservation.

METHODS

Cetacean sightings and effort data (including environmental conditions) were gathered from the whale watching platform "North Sailing" and scientific research between 2004-2012. Tours and/or sightings were depended upon weather conditions effecting sightability. Sightings include the following information: vessel, date (day/month/year), time (start/end), latitude and longitude, species and species number. Effort data included vessel, date (day/month/year), wind direction, wind speed, sea state (Beaufort scale), visibility, cloud cover, weather and swell. Environmental data with Beaufort scale > 3 was removed from the data set.

Analysis and Statistics

A Geographic Information System (GIS) (ESRI ArcView 10.1) was used to extract satellite data (grids of 4km sea surface temperature (SST) obtained from the NASA Earth Data Centre http://disc.sci.gsfc.nasa.gov/Giovanni. A depth grid of one arc-minute (approximately 1km) resolution was obtained from the General Bathymetric Chart of the Oceans (GEBCO). Depth and sea surface temperature grids were converted into a 1km grid using ArcInfo (ESRI). Binomial Generalized Additive Models (GAMs) were used to determine and quantify the relationships between environmental variables (explanatory variables) and cetacean presences/absences (response variable). To build the model, the presence/absence of the white-beaked dolphins was considered a response variable while 7 eco-geographical variables considered as explanatory variables (depth, distance to coast, slope, standard deviation of slope, sea surface temperature (SST), month, and prey spawning stock biomass (SSB). SSB of all available potential prey species will be included as an explanatory variable, these include cod (*Gadus morhua*), and herring (*Clupea harengus*) and capelin (*Mallotus villosus*) retrieved from the Marine Research Institute in Iceland annual report. The explanatory variables were denominated as fixed and non-fixed parameters. Fixed parameters (depth, slope, standard deviation of slope (SD Slope), distance to coast and month) are characterized by near constant states while the non-fixed parameters (SST, prey abundance spawning stock biomass of cod (*Gadus morhua*) and capelin (*Mallotus villosus*) (MAR – Marine Research Institute, annual reports) tend to change greatly through time.

GAM highlights which environmental variables are more related white-beaked dolphin presence indicating the nature of any apparent relationship (e.g. positive, negative, linear, non-linear). For both these techniques, the Akaike's Information Criterion (AIC) was used within R to select the most parsimonious model amongst all possible variable combinations.

RESULTS

The data presented here were collected during months between April and October from 2004-2012. The number of tours and sightings per year varied depending of the weather conditions and are summarized in Table 1. White-beaked dolphins were seen in 331 tours, this was counted every time a dolphin and/or group of dolphins were seen from the boat. For analysis, sightings that were recorded within 10 minutes of each other were counted as a single sighting in order to reduce the chance of duplication. Therefore in total 301 sightings (Table 1) were analysed.

Table 1. Total number of tours (all species), tours with white-beaked dolphin, total Sightings and white-beaked dolphin sightings survey under favourable conditions

Year	Total tours (all species)	Tours with WBD	Total Sightings	WBD Sightings
2004	28	13	97	18
2005	70	44	201	20
2006	84	29	256	12
2007	99	35	427	16
2008	106	27	250	12
2009	110	24	492	23
2010	135	56	618	60
2011	74	32	212	31
2012	174	71	707	109
Total	880	331	3260	301

Generalized additive model

The data was analysed compiling all the years together (2004-2012). The best model explained 24.6 % and included the following parameters: depth, slope, standard deviation of slope, SST, month and prey abundance from cod spawning stock biomass.

White-beaked dolphin abundance was generally found over a large range of depths with a relatively higher peak in waters between 40-100m and fewer in deeper waters (100-250) (Fig. 2a). Additionally, it was found that the greater the variability in seabed the higher the presence of white-beaked dolphins (Fig. 2b and c). The SST contribution to the white-beaked dolphin model proved to be influential. While the range of SST values differs greatly across the SST temporal scales selected, white-beaked dolphins were generally observed between 2.1-12 °C range with higher numbers at 8-9.5 °C (Fig. 2d). Prey abundance for cod spawning stock biomass was also significant.

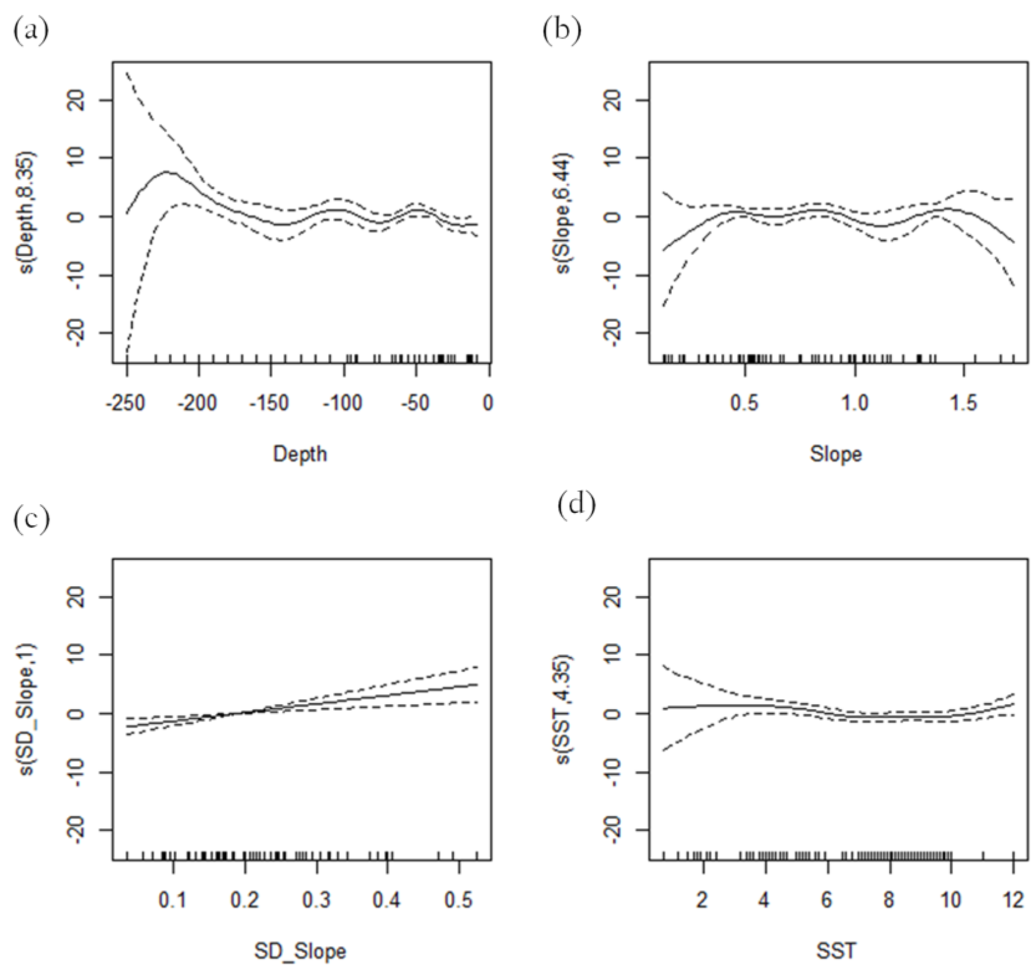


Figure 2. Relationships between visual detections of white-beaked dolphin groups and (a) depth (d.f. = 8.4), (b) slope (d.f. = 6.4), (c) standard deviation of slope (d.f. =1) and (d) sea surface temperature (SST) (d.f. =4.4). The estimated 95% confidence intervals are shown by the dotted lines around the smoothed lined.

DISCUSSION

White beaked dolphins are known to be a year-round resident species but which might show spatial and temporal fluctuations in their habitat range; occupies different areas around Iceland waters and it is constantly sighted through the entire summer around Icelandic coasts specifically at one of their hot spots in Skjálfandi Bay. It was found that usually the dolphins are sighted close to the shoreline and of the western and eastern side of the bay (Cecchetti, 2006).

This study presents information on habitat use of white-beaked dolphins in Skjálfandi Bay from 2004-2012. The model used demonstrates that some of the environmental parameters tested were of great significance for the white-beaked dolphins, with observations of dolphin presence in waters between 40-100m and there were a few sighting over a deep area from (100-200m). This was similar to other findings in Skjálfandi Bay where white beaked dolphins were observed over a large range of depths with a relatively higher peak in shallower waters (40-50m) and deeper waters (110-120m)(Cecchetti, 2006 and Cooper, 2007). The few sightings found in this study in deeper water can be attribute to random areas where the whale watching would normally not sample. Another reason for the sightings observed could be due to vertical mixing and upward movements of the water column, identified as important dynamic features in influencing the distribution of dolphins within Skjálfandi bay. It is likely the dolphins exploited the "best conditions" for feeding and thus were also found distributed in other depth ranges (Cecchetti, 2006). However, Weir (2009) suggested that *L. albirostris* occurred in waters around Scotland significantly deeper with a range from 106.5 to 134.5 m and with no sightings in waters of less than 70 m, indicating the preference to inhabit open waters located outside of the immediate coastal zone.

From the eco-geographical variables tested the most important was the fixed parameter slope; this was not only seen in this study but also corroborated by previous studies done in the bay (Cecchetti, 2006). The positive correlation was thought to be associated with the importance of sea bottom topography in influencing food distribution and availability (Hastie et al, 2004). Skjálfandi Bay is characterized by a wide area of steep slope extending along the coast and following the bay's shape. It is likely that near areas of steep sea floor dynamic oceanographic features such as upwelling currents and vertical mixing might occur contributing in relocation of nutrients in the water column, promoting primary production and bottom up food chains. White-beaked dolphins can benefit from this transport and aggregation of productivity, creating easier scenarios for feeding predators (Allen et al, 2001). Also seamounts might be implicated in prey concentration, and thus food supply, lessen their energy expenditure required to feed (Cooper, 2007). A positive relationship with steeper slope was found, in particular for dolphin species such as short-beaked dolphin, striped dolphin, bottlenose dolphin, Risso's dolphin and white-beaked dolphin (Cecchetti, 2006).

Even though sea surface temperature was not significant in the model, the absence of this parameter increased the AIC value, thus, sea surface temperature was included for the best fit. While the range of SST values differs greatly across the SST temporal scales selected, white-beaked dolphins were generally observed between 2.1–12 °C range with higher numbers at 8 -9.5°C which similar result (4 - 11.5°C) were found at Skjálfandi bay between the years 2004-2007(Cecchetti, 2006 and Cooper, 2007). Other studies have found white–beaked dolphins to be dominant in SST below 13˚C in UK and Irish waters (MacLeod, 2008).

Prey abundance was significant for cod spawning stock biomass, suggesting changes in prey distribution might drive white-beaked dolphins to switch prey or move away following that prey. Cod has previously been recorded in UK waters as part of white-beaked dolphin diet, representing 11% of the stomach contents (Canning et. al, 2008). In Icelandic waters there have been few studies mentioning Cod as one of their main prey (Rasmussen, 2004, Vikingson and Ólafsdóttir, 2004). Nevertheless, the lack of studies investigating white-beaked dolphin distribution with respect to environmental variables in specific prey abundance makes such results and interpretation more difficult.
In light of this study white-beaked dolphin distribution might indicate that within Skjálfandi Bay there is potential partitioning of habitat and resources where white-beaked dolphins interact differently with environmental variables.

Research limitations and Bias

The present study includes some bias and limitations that need to be highlighted. The first bias refers to sea surface temperature data. The process to extract the data utilises ArcGIS 10.1 and the aim is to standardise the datasets to the same measurements as all the other parameters. In the present study all the grids were set up to 1km area. Unfortunately, the data used in this model, was set to a larger area even though the process done was aimed to be for 1km. Most likely the resulting values from sea surface temperature did not vary from the ones used in this model, the difference was in the amount of values gathered per data set. This model used only a few values which were extracted per month (composite images) while the process of arranging the data would of have sea surface data for all point in the dataset. The addition of these values to the data set most likely would present sea surface temperature as significant in the model. Additionally, benefit and limitation using whale watching platforms include: data inconsistency as different observers every year and time and effort spend on sightings since the main objective of a whale watching is finding cetaceans to satisfy customers.

CONCLUSION

In conclusion, from the eco-geographical variables test, the most important influence was the fixed parameter slope. Once the habitat of the white-beaked dolphins is determined, as pointed out by other studies (Cecchetti, 2006; Hastie et al, 2004), may give additional insight for a better conservation management. Further discussions about a proposal for Skjálfandi Bay as a marine protected area (MPA) would benefit from spatially explicit information for white-beaked dolphin. In addition, due to the rapid growth of whale watching in the area (companies, boats, and tours), the habitat preference of the white-beaked dolphin could be further restricted by disturbance.

Further studies

Further studies include determining global warming effects over the current habitat use observed, to find possible changes and prediction in white-beaked dolphin distribution. More research of stomach content and/or stable isotopes to provide further evidence on the diet around Iceland. Lastly, the incorporation of other parameters to determine habitat use such as primary production, salinity, a finer-scale SST resolution of the study area (1km) and standard deviation of sea surface temperature.

ACKNOWLEDGEMENTS

The author would like to thank the North Sailing whale watching company, the Húsavík Whale Museum and a special thank you to all the hard work volunteers who throughout the years have helped collect data. Additionally many thanks to the University of Iceland.

REFERENCES

Allen, S.E., Vindeirinho, C., Thomson, R.E., Foreman, M.G.G. and Mackas, D.L. (2001) Physical and biological processes over a submarine canyon during an upwelling event. *Canadian Journal of Fisheries and Aquatic Sciences,* 58: 671-684.

Canning, S.J., Santos, B., Reid, R.J., Evans, P.G.H., Sabin, R., Bailey, N., and Pierce, G.J. (2008) Seasonal distribution of white-beaked dolphins *(Lagenorhynchus albirostris)* in UK waters with new information on diet and habitat use. *Journal of the Marine Biological Association of the United Kingdom*, 88: 1159–1166.

Cecchetti, A. (2006) The Spatial and Temporal Distribution of Cetaceans within Skjálfandi Bay, North East Iceland. Master Thesis. University of Wales, Bangor, UK School of Biological Science.

Cooper, D. (2007) Cetacean Habitat Modelling in Skjálfandi, Eyjafjörður and Öxarfjörður Bays, North East Iceland. Masters Thesis. University of Wales, Bangor, UK.

Hastie, G.D., Wilson, B., Wilson, L.J., Parsons, K.M. and Thompson, P.M. (2004) Functional mechanisms underlying cetacean distribution patterns: hotspots for bottlenose dolphins are linked to foraging. *Marine Biology,* 144: 397-403.

MacLeod, C.D., Weir C., Santos, B. and Dunn, T. (2008) Temperature-based summer habitat partitioning between white-beaked and common dolphins around the United Kingdom and Republic of Ireland. *Journal of the Marine Biological Association of the United Kingdom*. 88: 1193–1198.

Rasmussen, M. (2004) A study of communication and echolocation sounds recorded from free-ranging white-beaked dolphins (*Lagenorhynchus albirostris)* in Icelandic waters. Ph.D. Thesis. 109pp.

Shirihai, H. and Jarrett, B. (2006) Whales, dolphins and seals. A field guide to the marine mammals of the world. London. A&C Black Publishing, pp 199-200.

Valdimarsson, H. and Malmberg, S.A. (1999) Near-surface circulation in Icelandic waters derived from satellite tracked drifters. *Rit Fiskideildar* 16: 23–39.

Víkingsson, G.A. and Ólafsdóttir, D. (2004) Hnýðingur (white-beaked dolphin). In: Páll Hersteinsson (ed) Íslensk Spendýr (Icelandic Mammals). Vaka-Helgafell, Reykjavik, p 154–157.

Weir, C., MacLeod, C. and Calderan, S. (2009) Fine-scale habitat selection by white-beaked and common dolphins in the Minch (Scotland, UK): evidence for interspecific competition or coexistence? *Journal of the Marine Biological Association of the United Kingdom*. 89: 951–960.

VIII. Conservation biology of white-beaked dolphins off Iceland

Chiara G. Bertulli

Biology Department, University of Iceland, Sturlugata 7, 101 Reykjavik, Iceland / Elding whale-watching, Ægisgata 7, 101 Reykjavik, Iceland

The objectives of the present study are to highlight specific findings on photo-identification rate of white-beaked dolphins *Lagenorhynchus albirostris* and the potential movement of individuals of the population between two Icelandic bays, Faxaflói (southwest) and Skjálfandi (northeast).

INTRODUCTION

In the southwest of Iceland, *L. albirostris* is the second most frequently encountered species (Bertulli, 2010) and present year-round (Magnúsdóttir, 2007). In the northeast, it is the third most commonly sighted (Cecchetti, 2006). The only available abundance estimate for white-beaked dolphins dates back to the year 2001 (NASS survey conducted from 1986–2001), resulting in an estimated 31,653 animals in 2001 (95% CI: 17,679 - 56,672) (Pike *et al.,* 2009). This species is primarily distributed approximately 10–12 nm west from Kollafjörður and the Garður area in Faxaflói Bay (Magnúsdóttir, 2007; Bertulli, 2010). In 2004 two images of a white-beaked dolphin (one taken off the coast from Ólafsvík in Breiðafjörður and one in Skjálfandi) were matched indicating that it was the same individual in both locations (Tetley, 2006). Three individuals were matched between Faxaflói and Skjálfandi in 2010 (Bertulli, 2010), up to eighteen matches were confirmed during additional analysis (Bertulli *et al.,* Submitted) and one more individual was matched between Breiðafjörður and Faxaflói Bay. In August 2006, one male white-beaked dolphin captured in Faxaflói was tagged with a satellite transmitter (Rasmussen *et al.,* 2013). It travelled between Faxaflói, Breiðafjörður and the Westfjords several times between August and January. On one occasion, the tagged dolphin ventured as far as the Westman Islands.

METHODS

Whale-watching vessels departing from Reykjavik and Húsavík harbours were used to collect data within both study areas, enabling the comparison between photo-ID catalogues in order to study abundance and movement of *L.albirostris*. The two main study sites were Faxaflói Bay (64° 24'N, 22° 00'W, SW coast) and Skjálfandi Bay (66° 05'N 17° 33'W, NE coast) (Figure 1). Data were collected from April-September (2002–2010) in Faxaflói Bay and from May-October (2002–2010) in Skjálfandi Bay. Data collection was concentrated during daytime and pooled into three categories: (1) morning 9.00–11.30 (2) afternoon 13.00–16.00, and (3) evening 17.00–20.00. During the years 2005 in Faxaflói and the year 2003 in Skjálfandi Bay IDs were not collected. Fieldwork was carried out in wind speeds of less than 10 m/s (20 knots) or less and sea state of zero to four (majority below three) on the Beaufort scale. During on-effort survey periods, the survey team would record effort data including time, position GPS (*Garmin 60CSx*), and weather condition at 15min intervals.

When animals were sighted the time and position were recorded immediately. Then the vessel was diverted from its searching course to approach the animals for species identification, group size estimation, assessment of group composition, and behavioral observations.

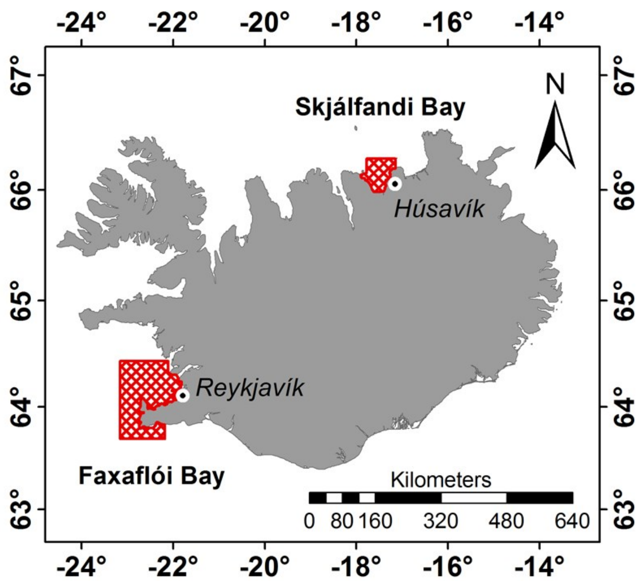


Figure 1. Map of the study area showing Faxaflói Bay area located on the southwest coast and Skjálfandi Bay located on the northeast coast of Iceland. Photo-id surveys were conducted within the red cross-hatched areas.

Both species were photographed using Nikon digital SLR cameras fitted with AF Nikkor lenses (AF Nikkor lens 70–300 mm VR f4–5.6) and Sigma lenses (70–200 mm f2.8 DG HSM II Macro zoom Lens, 120–400 mm f4.5-5.6 DG APO HSM). To minimize erroneous documentation of markings (i.e. individual identity), all photographic identifications were subject to a quality grading process (based on a combination of image size, focus, angle and clarity). Therefore, scores of the markings present on each individual were used to determine which were distinctively marked. In order to identify individual white-beaked dolphins from photographs, we used a previously adopted classification (Tscherter and Morris, 2005) incorporating dorsal fin edge marks (DEMs) followed by distinctive fin shapes or body marks. All images were viewed using Adobe *Photoshop CS2/CS3* imaging software to identify unique markings.

The shortest distance between the two bays for the re-sighted white-beaked dolphins identified was determined using the 'ruler' tool provided by *Garmin MapSource* (version 6.14) as the direct route by sea (avoiding land) between Reykjavik (Faxaflói Bay) and Húsavík (Skjálfandi Bay).

RESULTS

Dolphin encounters were distributed throughout the surveyed coastline, with particular clusters of sightings in the Garður and Kollafjörður areas in Faxaflói Bay and in the inner coastal part of Skjálfandi Bay. As a result, a minimum abundance of 379 individuals could be identified in Faxaflói Bay, and 301 in Skjálfandi Bay (Figure 2). The largest majority of dolphins were identified from DEM (Dorsal fin Edge marks) in both Faxaflói (n=279 73.6%) and Skjálfandi (n=225, 74.8%), which increased in number throughout the years. Overall the cumulative number of identified individuals ('rate of discovery' curve) of white-beaked dolphins did not decrease with time, suggesting the population was open for the duration of the study in both study areas (Figure 2).

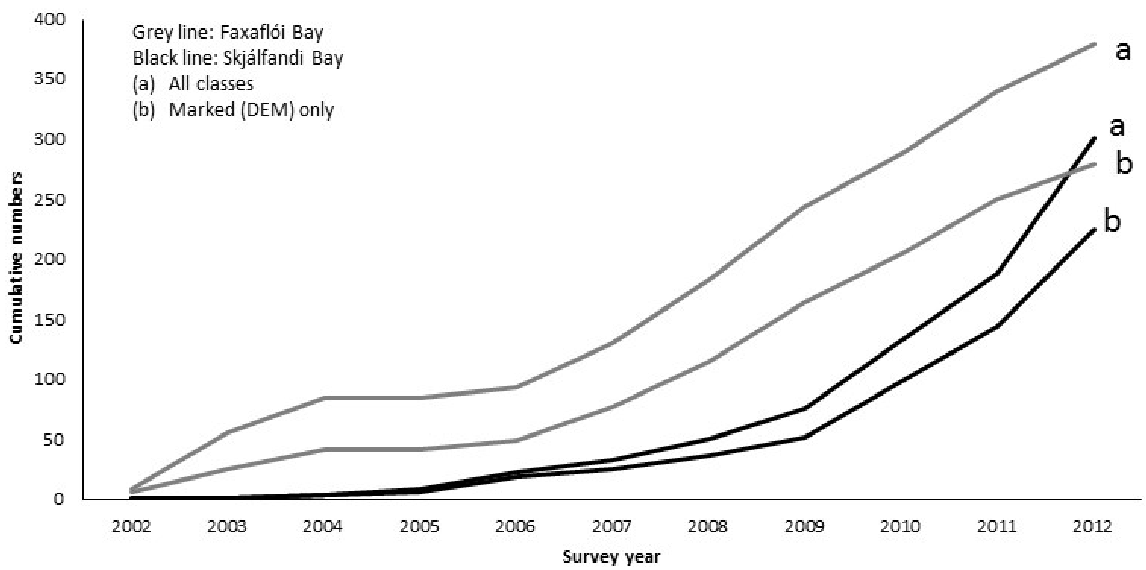


Figure 2. Identification rate of white-beaked dolphins along the southwest and northeast coasts of Iceland. The discovery curve is established by plotting the cumulative number of newly identified and catalogued white-beaked dolphins each year, from 2002 to 2012 in (1) Faxaflói Bay (black line) and (2) in Skjálfandi Bay (grey line), (a) cumulative number of all classes individuals (b) cumulative number of marked (DEM) individuals.

Both photo-ID catalogues include images of 680 individually recognisable dolphins (n=379 in FB, n=301 in SB) and of these 31 individuals have been seen in both areas. This equates to an overall *re-sighting proportion* of 4.6%. The observed distances between re-sightings ranging up to and around 600 km.

DISCUSSION

Despite the opportunistic nature of survey platform used, this study has provided an insight into the population of white-beaked dolphins occurring on the SW and NE of Iceland. Photo-identification indicates that there have at least been ~680 individuals using the Faxaflói and Skjálfandi areas from 2002 to 2012. The absence of a plateau in the discovery curve further suggests that the white-beaked dolphins found in the waters of the southwest and northeast coasts of Iceland are likely part of a larger population. By 2012 in both areas, the discovery curve was still on an incline which indicates that further photo-identification effort is still required within these waters.

In comparison to the other white-beaked dolphin catalogues the photo-id results presented in this study represent the largest existing photo-id catalogue of white-beaked dolphins within its North Atlantic range.

Results of the study also indicated that the most successful identification criteria used for individuals was mainly based upon the presence of large and small DEMs which are promising mark types with low gain and loss rates (Bertulli, unpublished data) although their permanence should be formally investigated (Auger-Méthé *et al.,* 2010).

Lastly, the present dataset has shown that photo-identification is a feasible technique for the individual recognition of white-beaked dolphins in the coastal waters of Iceland, contrary to what has been found in the Scottish waters by Weir *et al.,* (2008). However, some limitations have to be taken into account, such as the small sampling size and the opportunistic nature of this project. This problem has been solved by restricting all quality-grading of the ID images to a single, experienced person, or through periodic double grading of images (grading by more than one person) throughout the season (Parsons, 2004).

This study provides evidence that *L. albirostris* inhabits a large-scale coastal range of the Iceland coastline.

The reasons for the repeated distances travelled by the Icelandic white-beaked dolphins are unknown. However, one possible explanation may involve foraging strategies (Würsig *et al.,* 1991) and the unpredictability of prey species (Defran *et al.,* 1999). The warming of the Icelandic marine environment (increased water temperatures and salinity) in the last decade (Astthorsson *et al.,* 2007) appears to have led to pronounced changes in distribution and abundance of several fish species in Icelandic waters (Víkingsson *et al.,* 2009) some of which (*e.g.,* haddock, cod pollock, sandeel, capelin and herring) are known to be part of *L.albirostris's* diet (Sigurjónsson and Víkingsson, 1997, Rasmussen and Miller, 2002, Víkingsson and Ólafsdóttir, 2004). Possibly these recent findings of movement of individual dolphins from the southwest to the northeast of Iceland support this recent changes in the Icelandic coastal marine environment.

CONCLUSION

The present study documents that, while white-beaked dolphins in coastal Icelandic waters may display a certain degree of site fidelity to an area, they can also move extensively across different geographical areas.

Finally, these results demonstrate the potential of photo-ID as a technique for studying long-distance movements in this species. It is therefore suggested that the continual use of this technique for future studies be promoted and used to facilitate further inter-regional collaboration between different research centres in Iceland, thereby improving the understanding of white-beaked dolphin abundance, movement patterns and distribution in the region. It is also suggested the expansion of the study area into other similar coastal areas on the west coast, which could represent an important connecting area between the southwest and the northeast territories. A focused, long-term year-round study is therefore needed to verify suggestions about dolphin movements as observed opportunistically from whale-watching boats.

ACKNOWLEDGEMENTS

The surveys that have contributed to this work were supported by the Elding Whale-watching Company (special thanks to G. Vignir Sigursveinsson and Rannveig Grétarsdóttir) and the University of Iceland. Thanks to North Sailing Whale-watching in Húsavík and to Dolphin and Whale Spotting in Keflavík (special thanks to Helga Ingimundardóttir). We are grateful to CSI for funding the data collection in the year 2010, to the Faxaflói Cetacean Research volunteers who helped out in the field from 2007 to 2012 in Faxaflói Bay, and all volunteers that from 2001 have kept the research project working in Húsavík. We are grateful to Arianna Cecchetti, for her precious help in the analysis of data from Húsavík and Christian Schmidt of the Húsavík Whale Museum for his assistance with the identification of individual animals and for facilitating matches between catalogues.

REFERENCES

Auger-Méthé, M., Marcoux, M. and Whitehead, H. (2010). Nicks and notches of the dorsal ridge: Promising mark types for the photo-identification of narwhals. *Mar. Mam. Sci.* 26(3): 663–678. doi: 10.1111/j.1748-7692.2009.00369.x

Astthorsson, O.S., Gislason, A. Jonsson, S. (2007). Climate variability and the Icelandic marine ecosystem. *Deep-Sea Research Part II* 54:2456–2477.

Bertulli, C.G. (2010). Minke whale (*Balaenoptera acutorostrata*) and white-beaked dolphin (*Lagenorhynchus albirostris*) feeding behaviour in Faxaflói Bay, south-west Iceland. Master thesis, University of Iceland, Reykjavik, Iceland. 216 pp.

Bertulli, C.G., Tetley, M.J., Magnúsdóttir, E. and Rasmussen, M.H. Submitted. Observations of movement and site fidelity of white-beaked dolphins (Lagenorhynchus albirostris) in Icelandic coastal waters using photo-identification. Journal of Cetacean Research and Management.

Cecchetti, A. (2006). The spatial and temporal distribution of cetaceans within Skjálfandi bay, north-east Iceland. Master thesis, University of Wales, Bangor, UK. 115 pp.

Defran, R.H., Weller, D.W., Kelly, D. L. and Espinosa, M.A. (1999). Range of characteristics of Pacific coast bottlenose dolphins (*Tursiops truncatus*) in the southern California bight. *Mar. Mam. Sci.* 15(2):381-393.

Magnúsdóttir, E. (2007). Year round distribution and abundance of white-beaked dolphins (*Lagenorhynchus albirostris*) off the southwest coast of Iceland. M.Paed. thesis, University of Iceland, Reykjavik, Iceland. 149 pp.

Parsons, E.C.M. (2004). Seasonal distribution of minke whales *Balaenoptera acutorostrata* in relation to physiography and prey off the Isle of Mull, Scotland. *Mar. Ecol. Progr. Ser.* 277:263–274.

Pike, D.G., Paxton, C.G.M., Gunnlaugsson, Th. and Víkingsson, G.A. (2009). Trends in the distribution and abundance of cetaceans from aerial surveys in Icelandic coastal waters, 1986-2001. *NAMMCO Scientific Publications*, *7*, pp. 117–142.

Rasmussen, M.H. and Miller, L. (2002). Whistles and clicks from white-beaked dolphins, *Lagenorhynchus albirostris* recorded in Faxaflói Bay. *Aquat. Mam.* 28:78–89.

Rasmussen, M.H., Akamatsu, T., Teilmann, J., Víkingsson, G. and Miller, L.A. (2013) Biosonar, diving and movements of two tagged white-beaked dolphins in Icelandic waters. *Deep-Sea Research II*, 88-89(2013): 97-105.

Sigurjónsson, J. and Víkingsson, G. (1997). Seasonal abundance of and estimated food consumption by cetaceans in Icelandic and adjacent waters. *J. Northwest Atl.* **fish**. *sci.* 22:271–287.

Tetley, M. J., Wald, E. and Björgvinsson, Á. (2006). White-Beaked Dolphin Movements around Iceland: Evidence from Photo-Identification Studies. *Proceedings of the American Cetacean Society Conference*, Ventura, California, USA, 10–12 November 2006.

Tscherter, U. and Morris, C. (2005). Identifying a majority of minke whales (Balaenoptera acutorostrata) in the St. Lawrence based on the presence of dorsal fin edge marks. Proceedings of the Nineteenth European Cetacean Society Conference, La Rochelle, France.

Víkingsson, G. and Ólafsdóttir, D. (2004). Hnýðingur (white-beaked dolphin). *In:* P. Hersteinsson (ed.) *Íslensk spendýr* (Icelandic mammals). Vaka-Helgafell, Reykjavík, Iceland. (in Icelandic). 154–157 pp.

Víkingsson, G.A., Gunnlaugsson, Th., Pike, D. G., Galan, A., Chosson-P, V., Valdimarsson, H. and Ástþórsson, Ó. S. (2009). Recent changes in distribution of cetaceans and the marine environment around Iceland. Proceedings of the Eighteenth Biennial Conference on the Biology of Marine Mammals, Québec City, Canada.

Weir, C.R., Calderan, S. Unwin, M., Pitman, R.L., Booth, C., Photopoulos, T. and Robinson K.P. (2008). White-beaked dolphin (*Lagenorhynchus albirostris*) occurrence in the Minch (Scotland, UK), August 2007. Proceedings of the Twenty-second European Cetacean Society Conference, Egmond ann Zee, Holland.

Würsig, B., Cipriano, F. and Würsig, M. (1991). Information from radio tracking and theodolite tracking studies. *In:* K. Pryor and K.S. Norris (eds.) *Dolphin societies: discoveries and puzzles.* University of California Press, Berkeley, CA. 79–111 pp.

IX. Predicting the likely effects of climate change on the range of white-beaked dolphins in the ICES area (2000-2099)

Ruth Fernández[1*], Emily Lambert[2], Inigo Martínez[3], Colin D. MacLeod[4]

[1] Centre for GeoGenetics, University of Copenhagen, ØsterVolgade 5-7, 1350, Copenhagen, Denmark
[2] Institute of Biological and Environmental Sciences (IBES), University of Aberdeen, Tillydrone Avenue, Aberdeen, AB24 2TZ
[3] Mjøsensgade 11, 3tv, 2300, Copenhagen, Denmark.
[4] GIS in Ecology, 120 Churchill Drive, Broomhill, Glasgow, G11 7EZ, UK

The white-beaked dolphin (*Lagenorhynchus albirostris*) is at high risk of being negatively affected by climate change in the decades to come, most likely through a reduction in range extent and the fragmentation of previously continuous aggregations. In the NE Atlantic, its distribution is limited to waters cooler than ~18ºC and changes in distribution consistent with the effects of climate change that have already been observed in some parts of its range, such as western Scotland (MacLeod *et al.,* 2007). In addition, following current climate change predictions, a pole ward habitat shift is predicted for the species (MacLeod, 2009) very similarly to what has been already observed for a closely-related species, the Pacific white-sided dolphin (*Lagenorhynchus obliquidens* - Salvadeo *et al.,* 2010).

Europe holds a potentially significant proportion of the global population of white-beaked dolphins and, consequently, efforts towards its conservation should be expected from European countries. Further investigating the habitat preferences of white-beaked dolphins in the NE Atlantic will help making informed conservation decisions, which will be instrumental for implementing ASCOBANS (Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas) advice that listed genetic, ecological, distribution and abundance studies of white-beaked dolphin populations as a priority.

METHODS

In this study, white-beaked dolphin habitat niche models developed by Lambert (2012) for Western European waters have been implemented to estimate changes in white-beaked dolphin likelihood of occurrence over time for the ICES (International Council for the Exploration of the Sea) Area (85N69E, 36N44W).

The dataset consisted of white-beaked dolphin presences (i.e. species' sightings) and absences (i.e. presences of other species but not of white beaked dolphins) that were obtained from three publicly available data sources (Irish Whale and Dolphin Group, Joint Nature Conservation Committee and MARINElife). Sightings were recorded between 1974 and 2007 and only those recorded during the summer months (June-September) were used for model development in order to reduce potential seasonal variation in the species' habitat preferences. A total of 579 white-beaked dolphin presences and 15,221 absences were used in our analysis.

Projected monthly SST data (2030-2099) was obtained from the HadCM3 model under three different economic scenarios proposed by the International Panel for Climate Change (IPCC): A1b, A2 and B1. Those three scenarios differ on their global surface warming predictions based on different assumptions regarding technological change, overall population growth and fossil energy use. Scenario A2 assumes a high population growth, slow economic development and slow technological change which will derive in a 2-5° C global surface warming. Scenario Ab1 predicts a global population that peaks in mid-century, together with rapid economic growth and the use of new and more efficient technologies (i.e. a balance between fossil and non-fossil energy sources). Under this scenario, global surface warming is expected to be between 1.5 and 4° C. Scenario B1 forecasts a global population that peaks in mid-century that is paired with rapid changes in economic structures towards a service and information economy. Global surface warming is anticipated to be between 1 and 3° C under scenario B1 (IPCC, 2007). The obtained monthly SST grids (under the three scenarios) were averaged between June and September and for 3 decades (2030-2039, 2060-2069 and 2090-2099).

Three steps were followed in order to apply our model. Firstly, Classification and Regression Trees (CART), based on three fixed environmental variables (depth, seabed slope and standard deviation of slope) were generated (see Lambert, 2012) for the whole ICES area. This was derived in a fixed habitat model based on non-dynamic variables. Secondly, thermal niche models for white-beaked dolphins were constructed based on the range of temperatures frequented by the species around the research area. The tools and protocol followed to achieve this are available at GIS in Ecology website developed by Dr. Colin D. MacLeod (http://www.gisinecology.com/useful_tools.htm). The final thermal niche model for white-beaked dolphins was developed assuming that the white-beaked dolphin is a cold-water limited species (Lambert, 2012). Thirdly, the fixed niche model (CART output) was coupled with the dynamic thermal niche models. As three different IPCC scenarios and three different decades were used, nine different habitat suitability predictions are presented here for the whole ICES area examined. The resolution size chosen for our predictions is a 1/4 of the ICES statistical squares similarly to that used previously in the JNCC Cetacean Atlas (Reid *et al.,* 2003).

RESULTS

Classification Trees highlighted depth and slope as the main variables explaining white-beaked dolphin occurrence, which was highest over the continental shelf between water depths of 35m and 182m (Figure 1; Lambert, 2012). At the same time, the modelled threshold between unsuitable and marginal temperature was approximately 16° C and approximately 12° C between marginal and core temperature ranges (Figure 2; Lambert, 2012).

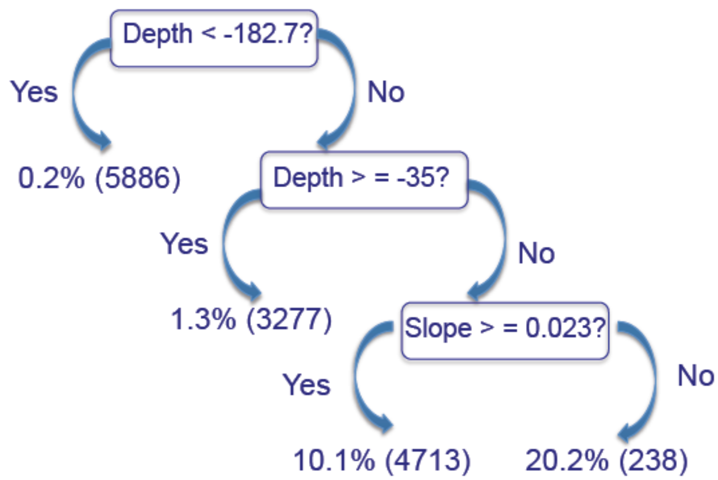


Figure 1. Classification tree representing white-beaked dolphin habitat preferences based on depth and slope. For each terminal node, the estimated likelihood of occurrence based on presence and absence data points which fall within that specific habitat classification is provided, in addition to the total number of data points shown in brackets.

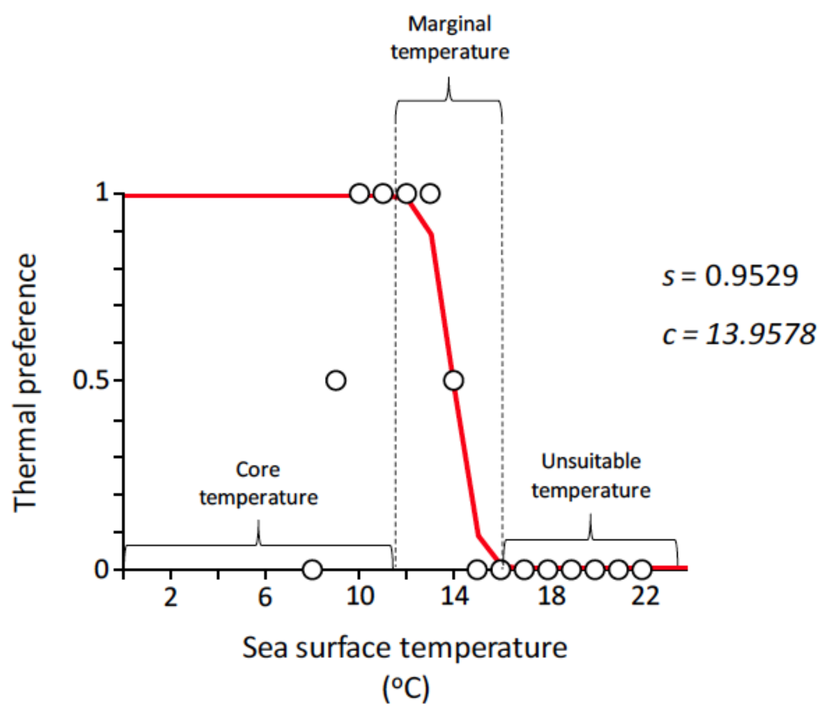


Figure 2. Best fitting thermal niche function using the Cold Water Limited group function (see www.gisinecology.com/useful_tools). This function has a slope (s) of 0.95 and a central point (c) value of 13.95.

Forecasted predictions for the decades of 2030-2039, 2060-2069 and 2090-2099 under the IPCC scenarios A1b, A2 and B1 are shown in Figures 3, 4 and 5.

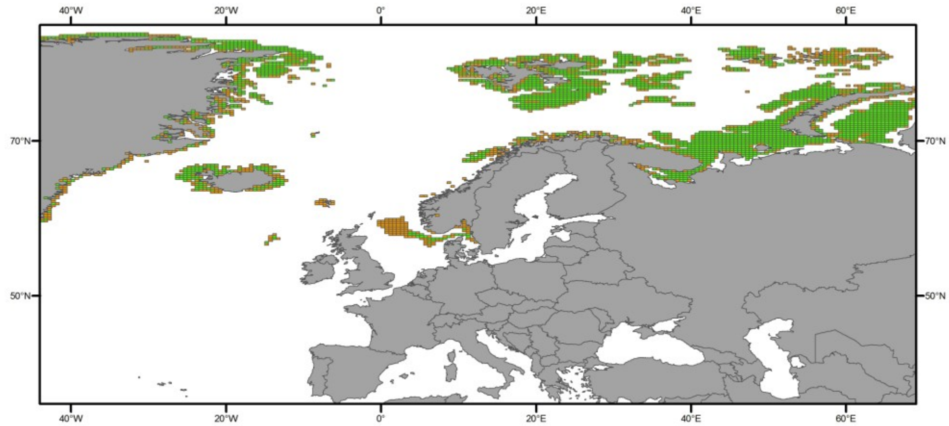


Figure 3a.

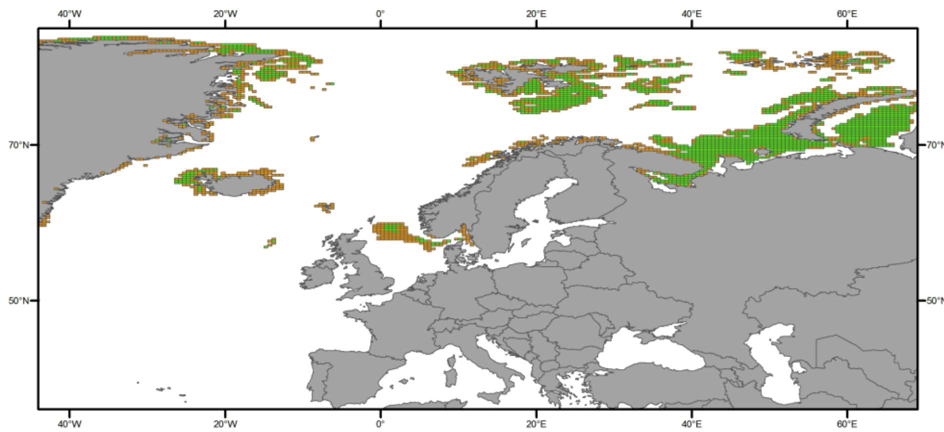


Figure 3b.

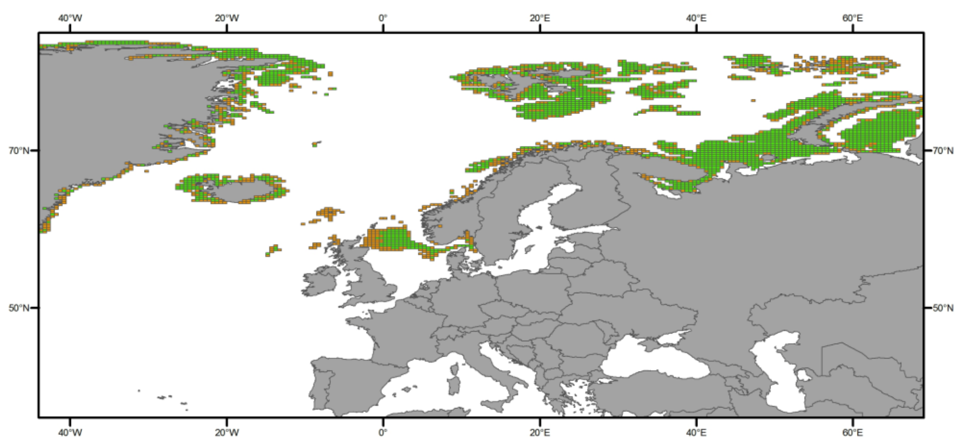


Figure 3c.

Figure 3. Forecasted habitat suitability for white-beaked dolphins (2030-2039). Figure 3a) IPCC scenario A2. Figure 3b) IPCC scenario Ab1. Figure 3c) IPCC scenario…

Figure 3. *Continued*… B1. Orange ¼ ICES grid cells; likelihood of occurrence 0.2-0.35. Green ¼ ICES grid cells; likelihood of occurrence >0.35.

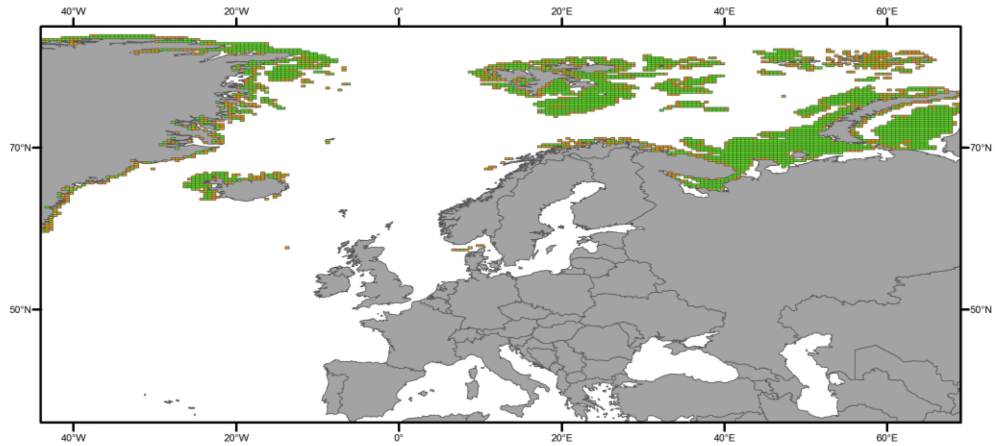


Figure 4a.

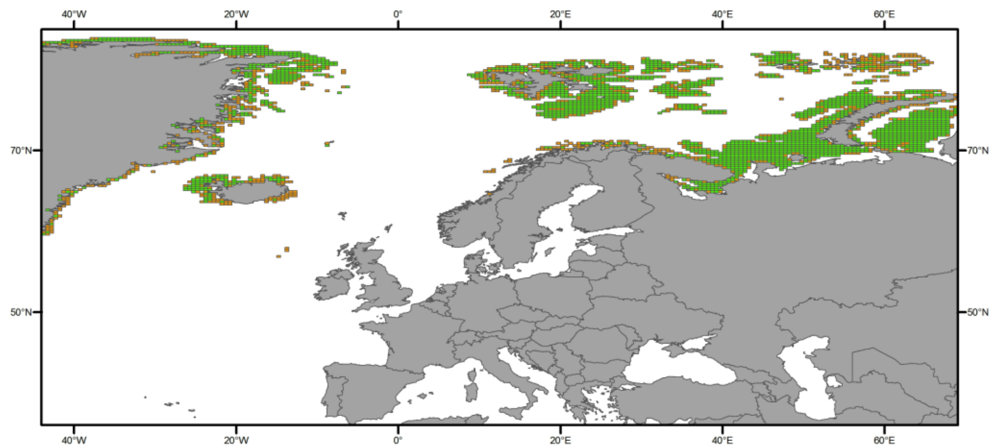


Figure 4b.

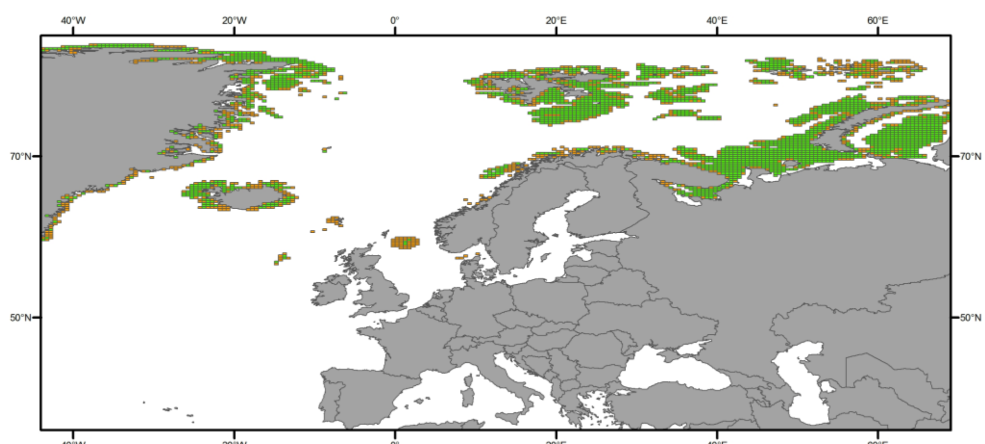


Figure 4c.

Figure 4. Forecasted habitat suitability for white-beaked dolphins (2060-2069). Figure 4a) IPCC scenario A2. Figure 4b) IPCC scenario Ab1. Figure 4c) IPCC scenario…

Figure 4. *Continued*… B1. Orange ¼ ICES grid cells; likelihood of occurrence 0.2-0.35. Green ¼ ICES grid cells; likelihood of occurrence >0.35

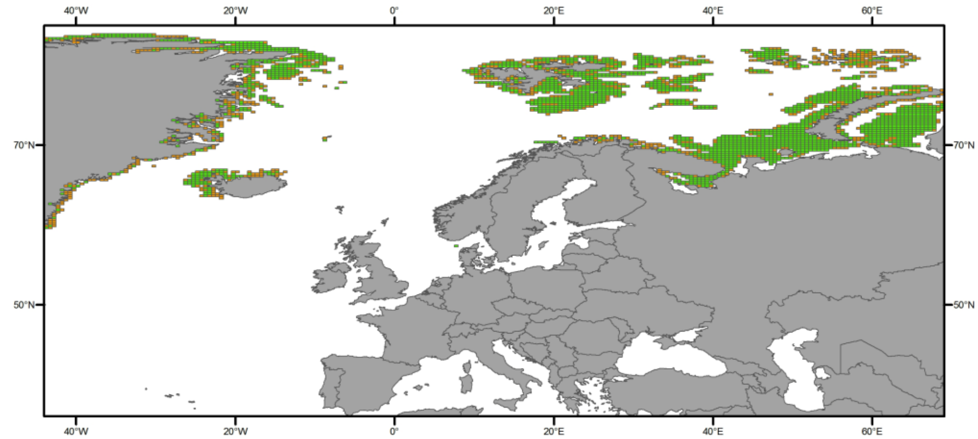


Figure 5a.

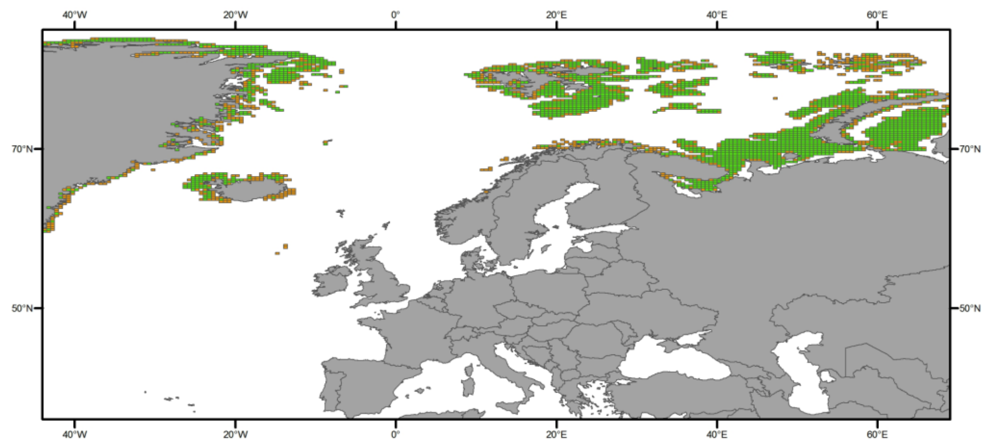


Figure 5b.

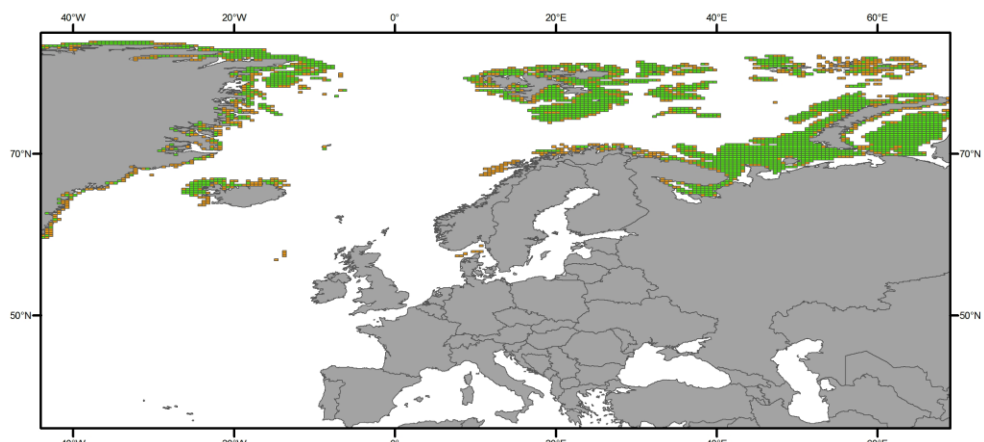


Figure 5c.

Figure 5. Forecasted habitat suitability for white-beaked dolphins (2090-2099). Figure 5a) IPCC scenario A2. Figure 5b) IPCC scenario Ab1. Figure 5c) IPCC scenario…

Figure 5. *Continued*… B1. Orange ¼ ICES grid cells; likelihood of occurrence 0.2-0.35. Green ¼ ICES grid cells; likelihood of occurrence >0.35.

Figures 3, 4 and 5 show a major retreat of the suitable habitat for white-beaked dolphins around the North Sea, currently a hotspot for the species. Another area to be particularly affected by climate change is the SE coast of Iceland where much of the suitable range for white-beaked dolphins is predicted to be lost 80 years from now.

CONCLUSION

Climate change can be considered a major threat for white-beaked dolphins, especially given that the IPCC is expected to release new SST predictions of even more accelerated global surface warming.

Habitat patches situated towards the northern distribution range of the species, such as NW Iceland and N Norway, could be considered more stable for the species and, therefore, conservation efforts should be focused on these areas. This can be used as an additional argument to back up the establishment of Marine Protected Areas in Iceland such as the one proposed in Skjálfandi Bay.

Our models were built based on sighting data recorded around the British Isles, Ireland and the Bay of Biscay and its performance was validated using independent datasets gathered around the same geographic areas (Lambert, 2012). A more complete dataset, such as data from the Trans North Atlantic Sightings Survey (T-NASS), would be required to validate model performance throughout the whole ICES area. However, within the area of interest there are regions (i.e. Russian coastline) from where available data on white beaked dolphin distribution is remarkably scarce and validation of model performance in these areas may be unfeasible.

This approach allows us to provide management advice per ICES square or ICES Area, similarly to advice currently given for fisheries management. Therefore, it may be a most appropriate way to approach managers and policy makers.

REFERENCES

IPCC - Intergovernmental Panel on Climate Change (2007) Summary for policymakers. In: Solomon, S., Qin, D., Manning, M., Chen, Z. and others (eds) Climate change 2007: the physical science basis. IPCC, Cambridge University Press, Cambridge, 18pp.

Lambert, E. (2012) The resilience of whale watching tourism to climate change impacts on cetacean distribution. Ph.D. thesis. University of Aberdeen.

MacLeod, C.D. (2009) Global climate change, range changes and potential implications for the conservation of marine cetaceans: a review and synthesis. *Endangered Species Research*, 7: 125-136.

MacLeod, C.D., Weir, C.R., Pierpoint, C. and Harland, E.J. (2007) The habitat preferences of marine mammals west of Scotland (UK). *Journal of the Marine Biological Association of the United Kingdom,* 87: 157-164.

Reid, J.B., Evans, P.G.H., and Northridge, S.P. (2003) Atlas of Cetacean distribution in north-west European waters, Joint Nature Conservation Committee, Peterborough. 77pp.

Salvadeo, C., Lluch-Belda, D., Gómez-Gallardo, A., Urban-Ramírez, J., MacLeod, C.D. (2010) Climate change and a poleward shift in the distribution of the Pacific white-sided dolphin in the northeastern Pacific. *Endangered Species Research*, 11: 13-19.

Case Studies: invited submissions from other research activity

X. Decreasing sightings rates of Icelandic white-beaked dolphins in the Southwestern part of Iceland – possible threats to the population?

Marianne H. Rasmussen

The University of Iceland‘s research center in Húsavík, Hafnarstétt 3, 640 Húsavík, Iceland

INTRODUCTION

Whale watching first started in Iceland during 1991. In Keflavik this began in 1994 and then later in Húsavík in 1995. Since then whale watching has and is still increasing every year. Today Húsavík is called the whale watching capital of Europe with three companies operating with a total fleet of 16 boats and more than 60,000 tourists visiting every year. In the high peak of the season in July the total number of trips offered is 25 trips per day from 08:50 to 23:00. Whale watching started operating from Reykjavik in 2000 and today at least six different companies are operating from Reykjavik harbour with the highest number of tourists are going whale watching from Reykjavik. Some of the larger whale watching companies have six daily tours in the peak season operating from 9:00 to 23:30. Whale watching stopped operating from Keflavik in 2007 but started operating again in the summer of 2013.

From the beginning of the whale watching history in Iceland the most common species to watch has been the minke whale (*Balaenoptera acutorostrata*) and the white-beaked dolphin (*Lagenorhynchus albirostris*). In the recent years greater numbers of larger whales have been sighted from Húsavík such as humpback whales (*Megaptera novaeangliae*) and blue whales (*Balaenoptera musculus*). North Atlantic Sighting Surveys (NASS) have been conducted in Iceland since 1982 organized in Iceland by the Icelandic Marine Research Institute. The target species have been the larger whales as these have been the target species for whaling around Iceland. The only current estimate of white-beaked dolphins from Icelandic waters is determined from these surveys, resulting in an estimated 31,653 animals in 2001 (95% CI: 17,679-56,672) (Pike *et al.,* 2009). It should be noted here that the surveys were not designed for dolphins and not all dolphins were recognized to species level, with potential over-counting of white-beaked dolphins versus white-sided dolphins (*Lagenorhynchus acutus*).

METHODS

Data were collected on board whale watching vessels starting from Keflavik (63° 58' 60.00"E, 22° 33' 0.00"W) off the Reykjanes Peninsula on the South western part of Iceland. Size and type of whale watching vessel varied from year to year (with increasing vessel size from the early years to the later years). Data collected included GPS position, information on group size and photo-identification (as described in Rasmussen, 1999; Rasmussen, 2001; Rasmussen and Jacobsen, 2003 and Rasmussen, 2004). The whale watching boat travelled the same route within a 3 hour trip from Keflavik, travelling at an average speed of 8 knots. Figure 1 shows a typical sailing route with the whale watching vessel from Keflavik. Data were collected from the years 1997 – 2007 and again in the summer 2013.

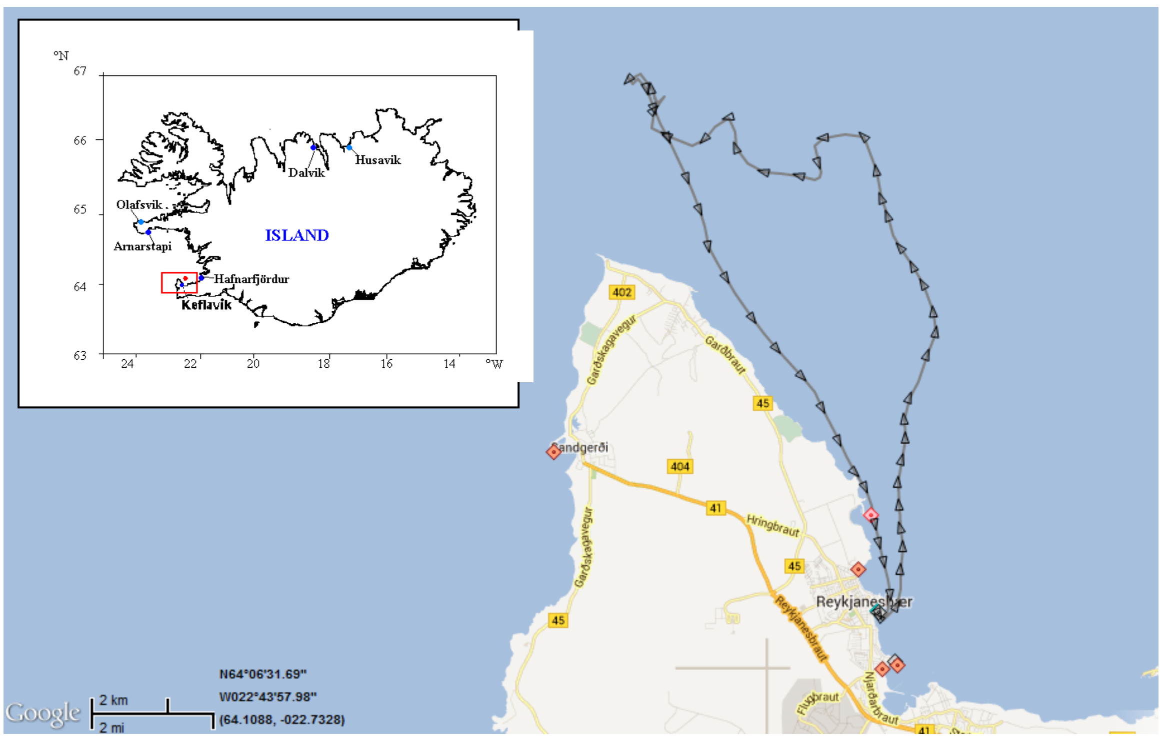


Figure 1. The figure shows a typical sailing route with the whale watching company operating from Keflavik harbour (here showing a track from the summer 2013).

PRELIMINARY RESULTS

During the early years of whale watching from Keflavik, sighting rates of white-beaked dolphins were always very high. For example the sighting percentages were 100 % sightings of Cetaceans and 92 % sightings of white-beaked dolphins in July 1999 (n=26 trips), 100 % sightings of Cetaceans and 96 % sightings of white-beaked dolphins in July 2000 (n=23 trips), 100 % sightings of Cetaceans and 100 % sightings of white-beaked dolphins n July 2001 (n= 21 trips), 100 % sightings of Cetaceans and 86 % sightings of white-beaked dolphins in July 2002 (n = 36 trips) and 100 % sightings of Cetaceans, but only 23 % sightings of white-beaked dolphins in July 2013 (n= 13 trips). Figure 2 shows a diagram of the decreasing in sighting rate of white-beaked dolphins in July from 1999 to 2013.

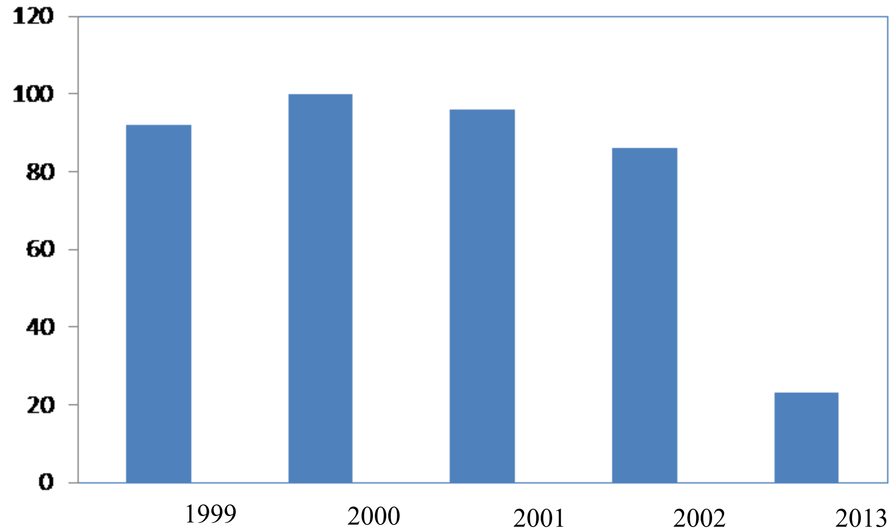


Figure 2. The figure shows changes in sightings percentages (%) of white-beaked dolphins in July from 1999 to 2013 off Reykjanes Peninsula in the Southwestern part of Iceland.

DISCUSSION

Preliminary results show a decline in sighting percentages of white-beaked dolphins off Keflavik and the Reykjanes Peninsula. The sighting percentages have decreased from 100 % sightings in July in 2000 to only 23 % sightings in July in 2013. During the same time period no evident increase in the sighting numbers off Húsavík have been observed in the Northeastern part of Iceland. Many changes have been documented in Faxaflói Bay in the Southwestern part of Iceland which could explain this low sighting rate. White-beaked dolphins have been documented to feed on sandeels (*Ammodytes* sp.) (Rasmussen and Miller, 2002; Rasmussen *et al.,* 2013) and sandeels have been declining in numbers in Faxaflói bay. Monitoring of sandeels were not started in Iceland until 2006 (Bogason and Lilliendahl, 2009). Currently the low abundance of sandeels have also been a concern for declining numbers of puffins (*Fratercula arctica*) and other seabirds known to feed on sandeels. During the same time period a number of changes have also occurred in Icelandic waters, for example mackerel (*Scomber scombrus*) is now a common fish species in Faxaflói Bay, which did not occur in Faxaflói Bay before 2004. Mackerel has not been previously documented to be a food resource for white-beaked dolphins. Canning *et al.,* (2008) noticed that gadoids were the most common prey species for white-beaked dolphins in Scottish waters and mackerel made up less than 1 % of the prey biomass.

Other considerations are the increased number of whale watching boats and ship traffic. Recent results have documented behavioural differences of minke whales around whale watching vessels compared to a control site with no boats (Christiansen *et al.,* 2013). We do not have observations of whether whale watching vessels are effecting the behaviour of white-beaked dolphins, but we know from other locations that dolphins are affected by whale watching traffic and behavioural changes in response to disturbance have been documented for bottlenose dolphins (*Tursiops truncatus*) in Doubtful Sound, New Zealand (Lusseau, 2006; 2004) or that their relative abundance have declined because of long term exposure in Australia (Bejder *et al.,* 2006). Similar situations may now have occurred in Faxaflói Bay for white-beaked dolphins with 6 whale watching companies and many trips currently occurring every day. In the past Faxaflói Bay was a known mating and breeding site for white-beaked dolphins (Rasmussen, 1999; 2004), however this may have also changed as well in response to the factors considered above. The increased number of whale watching boats cause an increase in the noise level in Faxaflói Bay and thereby the communication distance of white-beaked dolphins is decreased. A maximum communication distance of 10.5 Km for white-beaked dolphin whistles were documented in Rasmussen et al (2006), but with higher noise level the communication distance will decrease. Dolphins are known to live in a fission–fusion society (Leatherwood and Reeves, 1990) and if communication distance is lowered, it will be more difficult for the white-beaked dolphins to meet other dolphin groups for mating and other key social activities etc.

Finally, at present there is little to no knowledge or evidence of how many white-beaked dolphins are by-caught in fishermen net‘s or how many white-beaked dolphins in Icelandic waters are killed for local consumption.

CONCLUSION

Preliminary results show a major decline of sightings of white-beaked dolphins from 100 % sightings in July 2000 to only 23 % sightings in July 2013. More data will be needed to confirm this trend. There is no evidence of increased sighting rates at other locations in Iceland. It is therefore highly recommended that a new sighting survey, focusing on white-beaked dolphins around Iceland, be conducted to document the current population estimate. Furthermore, it is recommended that a possible conservation strategy for the species be a considered.

REFERENCES

Bejder, L., Samuels, A., Whitehead, H., Gales, N., Mann, J., Connor, R., Heithaus, M., Watson-Capps, J., Flaherty, C. and Krutzen, M. (2006) Decline in Relative Abundance of Bottlenose Dolphins Exposed to Long-Term Disturbance. Conservation Biology, 20: 1791–1798.

Bogason, V. and Lilliendahl, K. (2009) Rannsóknir á sandsíli / an initiation of sandeel monitoring in Iceland. Hafrannsóknir nr. 145. Þættir úr vistfræði sjávar 2008. Environmental conditions in Icelandic waters 2008, pp 36-41.

Canning, S.J., Santos, M.B., Reid, R.J., Evans, P.G.H., Sabin, R.C., Bailey, N. and Pierce, G.J. (2008) Seasonal distribution of white-beaked dolphins (*Lagenorhynchus albirostris*) in UK waters with new information on diet and habitat use. *Journal of the Marine Biological Association of the United Kingdom*, 88: 1159-1166.

Christiansen, F., Rasmussen, M.H. and Lusseau, D. (2013) Whale watching disrupt feeding activities of minke whales on a feeding ground. *Mar. Ecol. Prog. Ser.,* 478: 239-151.

Leatherwood, S. and Reeves, R.R. (1990) The Bottlenose Dolphin, Academic Press. San Diego, 653 pp.

Lusseau, D. (2006) The short-term behavioral reactions of Bottlenose dolphins to interactions with boats in Doubtful Sound, New Zealand. *Mar. Mamm. Sci.* 22: 802-818.

Pike, D.G., Paxton, C.G.M., Gunnlaugsson, T. and Víkingsson, G.E. (2009) Trends in the distribution and abundance of cetaceans from aerial surveys in Icelandic coastal waters, 1986-2001 Paper in NAMMCO Scientific Publication 7. sc/59/48.

Rasmussen, M.H., Akamatsu, T., Teilmann, J., Vikingsson, G. and Miller, L.A. (2013) Biosonar, diving and movements of two tagged white-beaked dolphin in Icelandic waters. *Deep Sea Research Part II: Topical Studies in Oceanography*, 88–89, 97–105

Rasmussen, M.H., Lammers, M., Beedholm, K. and Miller, L.A. (2006) Source levels and harmonic content of whistles in white-beaked dolphins (*Lagenorhynchus albirostris*). *The Journal of the Acoustical Society of America,* 120: 510-517.

Rasmussen, M. (2004) A study of communication and echolocation sounds recorded from free-ranging white-beaked dolphins (*Lagenorhynchus albirostris)* in Icelandic waters. Ph.D thesis. 109pp.

Rasmussen, M.H. and Jacobsen, T. (2003) Photo-identification of White-beaked dolphins in Icelandic waters. In: ECS-proceedings 2003, Las Palmas, Gran Canaria.

Rasmussen, M.H. and Miller, L.A. (2002) Whistles and clicks from white-beaked dolphins, *Lagenorhynchus albirostris* recorded in Faxaflói Bay. *Aquatic Mammals,* 28:78-89.

Rasmussen, M.H. (2001) Behaviour of free-ranging white-beaked dolphins. In: ECS-proceedings 2001, Rome, Italy.

Rasmussen, M.H. (1999) Hvidnæsens lydproduktion, adfærd samt udbredelse. (The behaviour, sound production and distribution of white-beaked dolphins). Master thesis (in Danish), 85pp.

Acknowledgements

Thanks to Dolphin and Whale Spotting (now Airport whale watching Iceland) with special thanks to Helga Ingimundardóttir.

XI. Determining the Status of White-beaked Dolphin off Northern England through the Northeast Cetacean Project

Martin Kitching[1], Tom Brereton[1], Colin MacLeod[1, 2] Catherine Scott[3]

[1] MARINElife, 18 Frances Ville, Scotland Gate, Northumberland, NE62 5ST
[2] GIS in Ecology, 120 Churchill Drive, Broomhill, Glasgow. G11 7EZ, UK
[3] Natural England, 1 East Parade, Sheffield, S1 2ET

The Farne Deeps is a deep glacial tunnel located 20 miles offshore from the Northumberland Coast. Its deep channels result in areas of nutrient upwelling and changes in tidal currents which bring with them rich supplies of food. The area has described by local fisherman as an important area for white-beaked dolphins in the winter months but few surveys have been undertaken to confirm this.

A MARINElife research project, the *North East Cetacean Project* (NECP), was launched in winter 2009/10 through funding from Natural England, MARINElife and the Northumberland and Tyneside Bird Club. The aim of the project was to describe the status of White-beaked Dolphin and other are marine mega-vertebrates of Conservation Concern in the Farne Deeps and surrounding Northumbrian waters. A systematic survey of the Farne Deeps and surrounding waters was undertaken in winter 2009/10 using Distance Sampling. In total 744km of survey effort was completed on six dates, including 473km on 14 separate transects. The only cetaceans observed were singles of harbour porpoise and common dolphin.

Historical effort-related and casual cetacean sightings data for Northumberland and surrounding waters were collated and reviewed from a variety of sources. Assessment of historical data indicates that white-beaked dolphins are chiefly recorded offshore, where group sizes that represent nationally important numbers have been recorded in recent years. Combining data from all available historical sources across all months and years indicates that the Farne Deeps is the most important area off the Northumberland coast for this species, although there are sightings from many other areas, local occurrence is unpredictable. Across the region increased sightings rates are positively associated with sandy sediments, deeper, offshore waters yet negatively associated with warm waters above 13-14ºC - results broadly consistent with studies made elsewhere in the UK.

Sightings data suggests recent changes in the cetacean community, with increases in occurrence of bottlenose dolphin (occasionally present in nationally important aggregations), common dolphin and Risso's dolphin and declines in white-beaked dolphin and harbour Porpoise. Climate change, changing prey distributions, changing fishing practices and interactions between these factors are likely to be the principal causes of change.

Since 2010 the NCEP has developed, with further effort-related and casual sightings of white-beaked dolphin obtained and a photo-identification catalogue of over 20 animals established. Few white-beaked dolphins have been found during winter months though there is a pronounced arrival to near shore in the final week of June. Further details are available from http://www.northeastcetaceans.org.uk/

XII. White-beaked dolphin distributions and prey associations in the Barents Sea

Johanna Fall[1] and Mette Skern-Mauritzen[2]

[1] University of Bergen, Thormøhlens gate 53 A/B, 5006 Bergen, Norway
[2] Institute of Marine Research, P.O. Box 1870 Nordnes, 5817 Bergen, Norway

The white-beaked dolphin *Lagenorhynchus albirostris* is one of the more numerous marine mammals in the Barents Sea, with an estimated population of 60,000-70,000 individuals (Øien 1996). In other shelf systems of the North Atlantic, white-beaked dolphins forage predominantly on clupeids and small bentho-pelagic gadoids (Hai *et al.,*1996, Canning *et al.,* 2008, Jansen *et al.,* 2010). In the Barents Sea, their distribution and associations with prey is little studied. However, along the shelf edge in the western Barents Sea, Skern-Mauritzen *et al.,* (2009) found that the white-beaked dolphins were spatially associated with capelin, and that a northward shift in the dolphin distribution coincided with a northward shift in the capelin distribution. White-beaked dolphins have also been observed foraging in association with guillemots (*Uria spp.*) that were preying on capelin and polar cod (Mehlum *et al.,*1998). Hence, the dolphins may interact more with pelagic fish, and with capelin, in the Barents Sea than in other North-Atlantic shelf systems. Nevertheless, the diversity of prey species recorded across these ecosystems indicates a flexible predator with abilities to utilise a range of both pelagic and demersal prey species depending on availability.

The pelagic system in the Barents Sea is a typical wasp-waist system; four species of small pelagic fish stocks at the middle, 'wasp-waist' trophic level, are crucial for the trophic transfer from the plethora of species among the secondary producers, the zooplankton, to the diverse top predator community that includes gadoids, seabirds and marine mammals (Johannesen *et al.,* 2012, Ciannelli *et al.,* 2005). Among the small pelagic fish, particularly capelin *Mallotus villotus* is viewed as a key prey species for the top predators (Ciannelli *et al.,* 2005, Stiansen *et al.,* 2009, Gjøsæter *et al.,* 2009). The capelin abundance has varied dramatically during the last decades, with stock collapses in the mid 1980s and 1990s, and again in 2003-2006 (Gjøsæter *et al.,* 2009). The first stock collapses had profound effects on cod, seabirds and marine mammals, including reduced survival, growth and recruitment, and large-scale distribution shifts (Gjøsæter *et al.,* 2009). However, the latter capelin stock collapse appeared to have no negative effects on the top predators, possibly due to greater availability of alternative prey species (Gjøsæter *et al.,* 2009, Sunnanå *et al.,* 2010).

METHODS

The collapse of the capelin stock in 2003 coincided with the onset of the joint Russian-Norwegian Ecosystem survey, which synoptically collects spatial data on white-beaked dolphins and potential prey species including small gadoids (haddock and cod) and the four main pelagic fish species in the system (capelin, herring, blue whiting and polar cod). We applied these ecosystem survey data to investigate the spatial distribution of white-beaked dolphins in the western Barents Sea, and the dolphins' spatial associations with potential prey species. More specifically, we analysed the spatial distribution of the dolphins and dolphin-prey associations in a period of low capelin abundance, following the stock collapse (2003-2006), and in a period of high capelin abundance, following the stock recovery (2007-2009). As predator-prey associations may be scale dependent, we ran the analyses at two spatial scales. First, we identified the spatial extent of dolphin and prey distributions at the scale of *habitats* by fitting Generalised Additive Models (GAM) for each species and estimating the averaged species distributions across years within the study period. Secondly, we explored the spatial associations between dolphins and prey at this habitat scale with the help of a Principal Component Analysis (PCA). Finally, we analysed the spatial associations between dolphins, prey, and habitat at *meso-scale*, using densities within 50 x 50 km grid cells in a Generalised Additive Mixed Model (GAMM).

RESULTS AND DISCUSSION

In total 2,764 white-beaked dolphins were observed in the western Barents Sea from 2003 to 2009. The dolphin distribution at habitat scale covered the warm and deep areas of the southern Barents Sea and extended to and slightly above the Polar Front. The highest average dolphin densities across years were found in the eastern part of the study area, partly corresponding to the Central and Great Banks, as well as along the shelf edge, the edges of the Spitsbergen Bank, the northern part of the Bear Island Trough, and between the North Cape bank and mainland Norway. Dolphins were hence observed throughout the western Barents Sea, with the exception of the northernmost Arctic waters.

The PCA on the predicted species distributions at habitat scale revealed no clear associations with any specific prey species at habitat scale. However, the dolphins overlapped with different prey species in different parts of their habitat, suggesting that the dolphins feed on a variety of prey species. For instance, in the south-western part of their habitat the dolphins overlapped with blue whiting and haddock, and in the frontal areas they overlapped with cod and capelin.

The GAMMs performed at mesoscale demonstrated a bimodal response from the dolphins to both depth and temperature during the period with low capelin abundance;

dolphin density peaked at depths around 150 m and 400 m, and temperatures around 2˚C and >8˚C. During the period with high capelin abundance, fewer dolphins were observed in the deeper, southern areas, reducing dolphin densities in this habitat. In addition, the dolphin density peak around 2˚C was higher, and dolphin densities also peaked at relatively higher temperature gradients. The temperature of 2˚C has been used to loosely define the location of the Barents Sea Polar Front (Parsons *et al.,* 1996), and these results indicate a distributional shift towards the colder waters in and around the Front in the latter, capelin rich period. In addition, based on the results from the PCA, this distributional shift increased the general overlap between dolphins and cod and capelin in the latter period.

At meso-scale, significant dolphin-prey associations were found. The most robust positive association was between dolphins and blue whiting; this association was positive irrespective of time period and thus the capelin abundance in the system. Hence, blue whiting may have been an important prey species for the dolphins throughout the study period, although the dolphins' use of the southern blue whiting habitats decreased in the latter, capelin rich period. The abundance of blue whiting in the Barents Sea also decreased during this latter period, possibly impacting the dolphin distribution shift (Belikov *et al.,* 2011). Blue whiting is not particularly rich in energy (Dolgov *et al.,* 2009) but was present in high numbers in the south-western Barents Sea during most of the study years (Heino *et al.,* 2008). In addition, there may be a relatively low predation pressure on large blue whiting from other fish and marine mammals in this system (Dolgov *et al.,* 2009, Skern-Mauritzen *et al.,* 2011). The blue whiting could hence be available as prey for dolphins. Nevertheless, since blue whiting is primarily distributed in the southern part of the Barents Sea while dolphins also occurred farther north in the Polar Front, it is unlikely to be the only prey species targeted by the dolphins. We were, however, unable to identify any spatial associations between the dolphins and prey species in the Front.

It is possible that the dolphins in the front target other species than those included in this study. However, we find that unlikely since we have included the dominant species in terms of availability, as well as those prey species found to be important in other ecosystems (Canning *et al.,* 2008, Skern-Mauritzen *et al.,* 2009, Jansen *et al.,* 2010). Another possibility is that we are observing the spatial interactions at the wrong scale. Limitations in scaling and spatial resolution of the data is particularly relevant for the gadoid densities included in our analyses, as catches in one single trawl haul were taken to represent the density in a 50 x 50 km grid cell. However, with regards to capelin, we ran the meso-scaled analyses down to a scale of 1 nautical mile, which includes scales where significant predator-capelin associations have been observed, including white-beaked dolphin-capelin associations (Fauchald *et al.,* 2000, Skern-Mauritzen *et al.,* 2009). Hence, while scaling and sampling resolution could significantly impact the observed dolphin-gadoid fish associations, it is less likely to explain the lack of dolphin-capelin associations in the frontal areas.

The dolphins could also experience a reduced ability to track prey populations in the frontal areas due to spatial constraints that prevent the dolphins from foraging in areas with the highest prey densities. A possible spatial constraint has to do with competition with other species. Although the Arctic waters are less productive than the Atlantic, strong pulses of high primary production follow the northwards sea ice retreat in summer, as nutrient rich waters are exposed to sunlight (Wassmann *et al.,* 2006). Many species follow the northern displacement of this marginal ice zone through extensive feeding migrations, including the major top predators in terms of consumption, the larger cod, baleen whales and harp seals, foraging extensively on both zooplankton and pelagic fish (Bogstad *et al.,* 2000, Skern-Mauritzen *et al.,* 2011, Johannesen *et al.,* 2012). At the time of the ecosystem survey in late summer, these predators are predominantly located along the front and northwards (Skern-Mauritzen *et al.,* 2011, Johannesen *et al.,* 2012). In the frontal areas, the highest densities of these predators occur on shallow banks at depths < 100 m (Skern-Mauritzen *et al.,* 2011, Johannesen *et al.,* 2012), whereas the white-beaked dolphins were found in slightly deeper areas along the bank slopes. Hence, interspecific competition and niche partitioning could anchor dolphins to specific areas in the front, and reduce the dolphins' ability to spatially match prey distributions.

In addition, prey availability may be more predictable in a productive area such as the Polar Front, and prey predictability has indeed been suggested to impact the distribution of pelagic predators (Gende & Sigler, 2006, Skern-Mauritzen *et al.,* 2011). The position of the Polar Front and the associated productivity gradients are to a large degree determined by the bathymetry, particularly within our study area in the western Barents Sea (Johannesen & Foster, 1978, Gawarkiewicz and Plueddemann, 1995, Harris *et al.,* 1998, Ingvaldsen, 2005). Hence, productive areas in the Front may be quite predictable in space and over time, and potentially serve as suitable foraging areas for white-beaked dolphins but without holding the highest densities of prey.

CONCLUSION

Since the white-beaked dolphins overlapped with different prey species in different habitats, they likely have a diverse diet in the Barents Sea at this time of year. We demonstrated no strong spatial associations with capelin, but some circumstantial evidence point to capelin as potential prey species for the dolphins; i) they overlap in the frontal areas, ii) the dolphins shifted towards the frontal areas in the latter capelin rich period, iii) there was an apparent increase in average dolphin density in the ecosystem in the latter capelin rich period. However, the distribution shift could also be caused by other factors, such as declining densities of blue whiting in the south-western areas. The increase in dolphin densities also coincide with a northward distribution shift reported from the southern part of their distribution range, the North Sea (MacLeod *et al.,* 2005, Evans & Teilmann, 2009). This northward distribution shift is possibly due to the recent warming of the ocean (Levitus *et al.,* 2009, Eriksen *et al.,* 2011), and could lead to higher dolphin abundances in the Barents Sea in the future.

Notably, other recent studies have also found surprisingly weak top predator responses to the changing capelin abundance following the latest capelin collapse (Skern-Mauritzen *et al.,* 2011, Johannesen *et al.,* 2012, Fauchal pers. comm.). Combined, these studies demonstrate that the spatial organisation of the Barents Sea top predator community in late summer is more complex and perhaps more rigid than expected from simple top predator aggregative responses to prey densities in general, and capelin densities and distributions in particular. Moreover, these results also suggest that the top predators experienced sufficient availability of alternative prey within their restricted habitats during the latest capelin collapse. This contrasts to the previous capelin collapses that resulted in significant top predator distribution shifts (Johannesen *et al.,* 2012). Thus, the top predators' spatial constraints, whether due to particular physical habitat attributes, competitors, or prey, have to be resolved before their responses to changing prey distributions and abundances can be understood and predicted.

REFERENCES

Belikov, S.V., Oganin, I.A. and Høines, Å. (2011) Blue whiting. Chapter 5.13 in: Jakobsen, T., Ozhigin, V.K., editors. The Barents Sea. Ecosystem, resources, management. Trondheim: Tapir Academic Press, 825 pages.

Bogstad, B., Haug, T. and Hatlebakk, E. (2000). Who eats whom in the Barents Sea? In: Vikingsson, G.A., Kapel, F.O., editors. Minke whales, harp and hooded seals: Major predators in the North Atlantic ecosystem, Vol 2. Tromsø: NAMMCO Scientific Publications, p 98–119.

Canning, S.J., Santos, M.B., Reid, R.J., Evans, P.G.H., Sabin, R.C., Bailey, N., Pierce, G.J. (2008) Seasonal distribution of white-beaked dolphins (*Lagenorhynchus albirostris*) in UK waters with new information on diet and habitat use. *Journal of the Marine Biological Association of the United Kingdom*, 88:1159-1166.

Ciannelli, L., Hjermann, D.O., Lehodey, P., Ottersen, G. and Duffy-Anderson, J. (2005). Climate forcing, food web structure and community dynamics in pelagic marine ecosystems. Chapter 12 in: Belgrano U, Scharler J, Dunne J, Ulanowicz R, editors. Aquatic Food Webs: An Ecosystem Approach. Oxford: University Press, p 143-169.

Dolgov, A.V., Johannesen, E., Heino, M. and Olsen, E. (2009) Trophic ecology of blue whiting in the Barents Sea. *ICES Journal of Marine Science*, 67:483-493.

Eriksen, E., Bogstad, B. and Nakken, O. (2011) Ecological significance of 0-group fish in the Barents Sea ecosystem. *Polar Biology*, 34:647-657.

Evans, P.G.H. and Teilmann, J. (2009) ASCOBANS/HELCOM Small Cetacean Population Structure Workshop. Bonn, Germany: ASCOBANS, 141 pp.

Fauchald, P., Erikstad, K.E. and Skarsfjord, H. (2000) Scale-dependent predator-prey interactions: The hierarchical spatial distribution of seabirds and prey.6 *Ecology*, 81:773-783.

Gawarkiewicz, G. and Plueddemann, A.J. (1995) Topographic control of thermohaline frontal structure in the Barents Sea Polar Front on the south flank of Spitsbergen Bank. *Journal of Geophysical Research: Oceans*, 100:4509-4524.

Gende, S.M. and Sigler, M.F. (2006) Persistence of forage fish 'hot spots' and its association with foraging Steller sea lions (*Eumetopias jubatus*) in southeast Alaska. *Deep-Sea Research Part II-Topical Studies in Oceanography*, 53:432-441.

Gjøsæter, H., Bogstad, B. and Tjelmeland, S. (2009) Ecosystem effects of the three capelin stock collapses in the Barents Sea. *Marine Biology Research*, 5:40-53.

Hai. D.J., Lien, J., Nelson, D. and Curren, K. (1996) A contribution to the biology of the White-beaked Dolphin, *Lagenorhynchus albirostris*, in waters off Newfoundland. *The Canadian Field-Naturalist*, 110:278-287.

Harris, C.L., Plueddemann, A.J. and Gawarkiewicz, G.G. (1998) Water mass distribution and Polar Front structure in the western Barents Sea. *Journal of Geophysical Research: Oceans*, 103:2905-2917.

Heino, M., Engelhard, G.H. and Godø, O.R. (2008) Migrations and hydrography determine the abundance fluctuations of blue whiting (*Micromesistius poutassou*) in the Barents Sea. *Fisheries Oceanography,* 17:153-163.

Ingvaldsen, R.B. (2005) Width of the North Cape Current and location of the Polar Front in the western Barents Sea. *Geophysical Research Letters*, Vol. 32, L16603, doi:10.1029/2005GL023440.

Jansen, O.E., Leopold, M.F., Meesters, E. and Smeenk, C. (2010) Are white-beaked dolphins *Lagenorhynchus albirostris* food specialists? Their diet in the southern North Sea. *Journal of the Marine Biological Association of the United Kingdom,* 90:1501-1508.

Johannessen, O.M. and Foster, LA. (1978) Note on topographically controlled oceanic Polar Front in Barents Sea. *Journal of Geophysical Research: Oceans*, 83:4567-4571.

Johannessen, E., Lindström, U., Michalsen, K., Skern-Mauritzen, M., Fauchald, P., Bogstad, B. and Dolgov, A. (2012) Feeding in a heterogeneous environment: spatial dynamics in summer foraging Barents Sea cod. *Marine Ecology Progress Series*, 458:181-197.

Levitus, S., Matishov, G., Seidov, D. and Smolyar, I. (2009) Barents Sea multidecadal variability. *Geophysical Research Letters*, 36(19): L19604.

MacLeod, C.D., Bannon, S.M., Pierce, G.J., Schweder, C., Learmonth, J.A., Herman, J.S. and Reid, R.J. (2005) Climate change and the cetacean community of north-west Scotland. *Biological Conservation*, 124:477-483.

Mehlum, F., Hunt, G.L., Decker, M.B. and Nordlund, N. (1998) Hydrographic features, cetaceans and the foraging of thick-billed murres and other marine birds in the northwestern Barents Sea. *Arctic*, 51:243-252.

Parsons, A.R., Bourke, R.H., Muench, R.D., Chiu, C.S., Lynch, J.F., Miller, J.H., Plueddemann, A.J. and Pawlowicz, R. (1996) The Barents Sea Polar Front in summer. *Journal of Geophysical Research: Oceans,* 101:14201-14221.

Skern-Mauritzen, M., Skaug, H.J. and Øien, N. (2009) Line transects, environmental data and GIS: Cetacean distribution, habitat and prey selection along the Barents Sea shelf edge. In: Øien, N., Pike, D., editors. North Atlantic sighting surveys. Counting the whales in the North Atlantic, 1987-2001. Tromsø: NAMMCO Scientific Publications Vol. 7, p 179-200.

Skern-Mauritzen, M., Johannesen, E., Bjørge, A. and Øien, N. (2011) Baleen whale distributions and prey associations in the Barents Sea. *Marine Ecology Progress Series*, 426: 289-301.

Stiansen, J.E., Korneev, O., Titov, O., Arneberg, P., editors, Filin, A., Hansen, J.R., Hoines, Å., Marasaev, S., co-editors. (2009) Joint Norwegian-Russian environmental status 2008. Report on the Barents Sea Ecosystem. Part II - Complete report, 375 pp.

Sunnanå, K., Fossheim, M. and Olseng, C.D., Editors. (2010) Forvaltningsplan Barentshavet - rapport fra overvakningsgruppen 2010. Fisken og Havet, særnr. 1b-2010, 111 pp.

Wassmann, P., Reigstad, M., Haug, T., Rudels, B., Carroll, M.L., Hop, H., Gabrielsen, G.W., Falk-Petersen, S., Denisenko, S.G., Arashkevich, E., Slagstad, D. and Pavlova, O. (2006) Food webs and carbon flux in the Barents Sea. *Progress in Oceanography*, 71: 232-287.

Øien, N. (1996) *Lagenorhynchus* species in Norwegian waters as revealed from incidental observations and recent sighting surveys. Paper SC/48/SM15 to the IWC Scientific Committee, Aberdeen.

Annex 1. List of workshop participants

A list of those persons in attendance at the workshop in Setubal, Portugal, 2013

Michael J. Tetley	–	WDC
Sarah J. Dolman	–	WDC
Heidrun Frisch	–	ASCOBANS/CMS/UNEP
Anders Galatius	–	Aarhus University
Rob Deaville	–	CSIP
Chiara Bertulli	–	University of Iceland
Ann Coral Vallejo	–	University of Iceland
Ruth Fernandez	–	University of Copenhagen
Olivia Harries	–	HWDT
Anja Wittich	–	HWDT
Sally Hamilton	–	ORCA
Stephen Marsh	–	ORCA/BDMLR
Tom Brereton (via Skype)	–	MARINELife
Colin D. Macleod (via Skype)	–	GIS in Ecology

Annex 2. Workshop Programme

09:00 – Registration and Introductions

OBJECTIVE 1

09:30 – Presentation Session: **Chair - Sarah Dolman, WDC**

09:35 – **Presentation:** ASCOBANS and white-beaked dolphins -**Heidrun Frisch, ASCOBANS**

09:40 – **Presentation:** Summary of the first white-beaked dolphin Workshop - Stralsund 2010 - **Anders Galatius, Aarhus University**

09:45 – **Presentation:** Assessing L.albirostris Conservation Status –CMS, EU and IUCN Approaches - **Michael J. Tetley, WDC**

10:00 – **Presentation:** White-beaked dolphins in the Northeast Atlantic - A brief review of their ecology and potential threats to conservation status - **Colin D. MacLeod, GIS in Ecology**

10:15 – Invited speed presentations (~7mins) from relevant white-beaked researchers on regional project information:

Olivia Harries, HWDT - Identifying white-beaked dolphins from click characteristics

Tom Brereton, MARINELife - A new hotspot for white-beaked dolphins in the English Channel

Rob Deaville, CSIP - White-beaked dolphin strandings in the UK

Ann Carole Vallejo, University of Iceland - White-beaked dolphin distribution in Skjálfandi Bay, NE Iceland, during the feeding season

Chiara Bertulli, University of Iceland - Conservation biology of white-beaked dolphins off Iceland

Anders Galatius, Aarhus University - Parameters of growth and reproduction of white-beaked dolphins (Lagenorhynchus albirostris) from the North Sea

Ruth Fernandez, University of Copenhagen - Predicting the likely effects of climate change on the range of white-beaked dolphins in the ICES area (2000-2099)

11:15 – **Coffee Break** (15 minutes)

OBJECTIVE 2

11:30 – Discussion Session: **Chair - Michael J. Tetley, WDC**

11:30 – **Discussion** with the floor of the main threats which could affect L.albirostris conservation status internationally and regionally including by-catch, climate change, industry development, marine pollution, noise etc. and rank their likely influence.

12:15 – **Discussion** with the floor of the methods and tools available to address issues of knowledge gaps and identified threats. Discussion cumulates in a consensus of how these could be assessed or addressed in a draft advisory International Conservation Strategy for L.albirostris.

12:45 – Short panel discussion and summary of workshop Objectives 1 and 2
13:00 – Finish and informal discussion

Annex 3. Workshop presentation abstracts

Olivia Harries – UK

The white-beaked dolphin (Lagenorhynchus albirostris) has a restricted range, being endemic to the North Atlantic Ocean. An estimated 80% of the European population is in UK waters, mostly in areas off Scotland and northeast England. Whistles have often been used to monitor and identify dolphin vocalisations, but white-beaked dolphins have very low whistle rates. We have therefore been exploring the use of dolphin clicks for species classification. White-beaked dolphin clicks are highly variable and complicated, making acoustic identification more challenging. However, their clicks often show a multi-pulsed spectrum. Clicks from the east coast of the UK and west coast of Scotland were analysed to assess whether they had sufficiently consistent and characteristic attributes to enable species classification. Banding in frequencies <80 kHz is present in white-beaked dolphins from both the east and west coast of the UK. Our preliminary analysis provides evidence that sub-populations may be discernible from click structure, with a difference in the spectral characteristics between white-beaked dolphins on the west and east coasts of the UK. The implications of population structure within UK waters are of considerable conservation relevance for a species with such a limited global distribution.

Anders Galatius – DENMARK

Abstract not provided but results presented published at time of workshop:

Galatius, A., Jansen, O. E., & Kinze, C. C. (2013). Parameters of growth and reproduction of white-beaked dolphins (Lagenorhynchus albirostris) from the North Sea. *Marine Mammal Science* DOI: 10.1111/j.1748-7692.2012.00568

Rob Deaville – UK

Between 1990 and 2011, 249 white beaked dolphins were reported stranded around the UK coast to the Defra funded UK Cetacean Strandings Investigation Programme. Of these, the majority stranded in Scotland (n=154), with smaller numbers in England (n=94) and Northern Ireland (n=1). There were two mass stranding events during this period that involved three or more animals. Analysis of inter-annual trends over this period indicated a reduction of strandings on the North Sea coast of England, coincident with an increase in strandings of warmer water species like the short-beaked common dolphin (Delphinus delphis) and striped dolphin (Stenella coeruleoalba) in northern parts of the UK. Systematic post-mortem examinations were conducted on eighty nine stranded white-beaked dolphins, of which 29 died as a result of live stranding, 14 from starvation (including four neonates), nine from a variety of infectious diseases, eight as a result of incidental entanglement in fishing gear (by-catch), seven from physical trauma of unknown origin, five resulting from dystocia/stillborn and seven from a variety of other causes of death. A cause of death was not established in 10 animals.

Ann Carole Vallejo – ICELAND

Iceland represents a hotspot for cetacean diversity, especially during the feeding season (May-September). White-beaked dolphins (Lagenorhynchus albirostris) are present all year round in Icelandic waters and are one of the main target species from the whale watching vessels operating in Iceland. White-beaked dolphin distribution patterns in Skjálfandi Bay (NE Iceland) were investigated by analysing sighting data collected by dedicated observers' on-board whale watching platforms between 2001-2002 and 2004-2012. Dolphin presences and absences (derived from survey effort tracks) were incorporated into a Geographical Information System (GIS). General Additive Models (GAMS) were used to investigate relationships between the presence/absence of white-beaked dolphins and a set of eco-geographical (i.e. depth, distance to coast, seabed slope, standard deviation of slope, prey biomass, sea surface temperature, Chlorophyll-a) and temporal variables (i.e. month, year). The results from this study will be essential for conservation and management purposes if we are to understand local and temporal patterns of white-beaked dolphin distribution and ecology in an area widely used by whale watching platforms such as Skjálfandi Bay.

Chiara Bertulli – ICELAND

The white-beaked dolphin (Lagenorhynchus albirostris) is the most commonly sighted delphinid species in Icelandic coastal waters. However, little is known about the species' abundance and movements throughout its range. Lagenorhynchus albirostris was studied by photo-identification during whale-watching operations in 2002-2012 in Faxaflói Bay and Skjálfandi Bay in the southwest and northeast of Iceland, respectively. Minimum abundance and movement between bays were calculated. A total of 379 individuals were identified in Faxaflói Bay, and 302 in Skjálfandi Bay. The largest majority of dolphins were identified from DEM (Dorsal fin Edge marks) in both Faxaflói (n=279 73.6%) and Skjálfandi (n=225, 74.5%), which increased in number throughout the years. A total of 31 dolphins (4.6%) were matched between Faxaflói Bay and Skjálfandi Bay. The observed distances between re-sightings ranging up to and around 600 km. The matches between bays suggest that Lagenorhynchus albirostris inhabits large-scale coastal range of the Iceland coast and can be considered highly mobile and transient possibly due to scarce and patchy resources or to its large population size. Finally, a focused, long-term year-round study is therefore needed to verify suggestions about dolphin movements as observed opportunistically from whale-watching boats.

Tom Brereton – UK

Since 2007, MARINELife cetacean surveys from ferries and small boats have covered 80% of the sea of the western English Channel at 10 km^2 resolution. Public sightings have also been collated. There have been more than 50 sightings of White-beaked Dolphin, with records in all years and seasons. The middle of Lyme Bay holds 80% of *sightings, yet this area represents only 1% of the surface area of the western Channel. Habitat modelling work has determined that presence in this area can largely be explained by water depths of more than 50 m and the seabed having a sandy component, whilst the area is known to support high concentrations of Whiting, Cod and other likely white fish prey items. Up to 200 animals have been counted on a single occasion, whilst photo-identification studies also roughly indicate around 200 individuals are likely to have been present over the sampling period (~70 individuals identified, with 25-30% of individuals having identifiable marks), equating to ~1% of the NW European shelf waters total. The high degree of site fidelity demonstrated through photo-identification studies, and the presence of breeding (20% of groups with calves) and feeding animals (>50% of encounters) further highlights regional importance.*

Ruth Fernandez – DENMARK

In this study, white-beaked dolphin habitat niche models developed by Lambert (2012) for Western European waters have been implemented to estimate changes in white-beaked dolphin likelihood of occurrence over time for the whole ICES Atlantic Area (85N69E, 36N44W). To do this, projected monthly SST data (2000-2099) was obtained from the HadCM3 model under 3 different economic and demographic development scenarios proposed by the International Panel for Climate Change: A1b, A2 and B1. Monthly SST was averaged during the summer months (June-September) and per decade. Classification and Regression Trees (CART), based on three fixed environmental variables (depth, seabed slope and standard deviation of slope), as proposed by Lambert (2012), were generated. Thermal niche models obtained from SST projections were coupled with CART outputs to generate predictions of occurrence of white-beaked dolphins across the NE Atlantic. The resolution size chosen for our predictions was a 1/4 of the ICES statistical squares. Preliminary analyses anticipate a major retreat of white-beaked dolphins from North Western Europe. The proposed approach enables us to predict how much climatic change is likely to affect the current species distribution and to identify geographic areas with strong conservation potential as zones that will mainly keep stable during the next decades.

Annex 4. Methods and results of online SurveyMonkey Questionnaire

Background

Before the workshop was convened on April 6th in Setubal, Portugal, the workshop organisers posted a SurveyMonkey on-line questionnaire to determine the opinions of those interested parties unable to attend the ECS conference towards white-beaked dolphin conservation status.

An outline of the Questions asked and results summary of the survey can be found below. The original survey is available to view at http://www.surveymonkey.com/s/X86PLY7

Please note no names or contact information for respondents are included in this summary.

Survey Design

White-beaked dolphin survey - Your knowledge of species

Observation of wild white-beaked dolphins

Whales and dolphins can be observed from a number of platforms and vessel types. Please use the section below to provide information on which types of platforms you have observed wild white-beaked dolphins.

Q1. Have you observed white-beaked dolphins in the wild on any of the below platforms?

	YES	NO
Whale watching boat	☐	☐
Other wildlife watching activity	☐	☐
Passenger Ferry	☐	☐
Cruise ship	☐	☐
Research vessel	☐	☐
Commercial vessel	☐	☐
Private or charter vessel	☐	☐
Aircraft	☐	☐
From land	☐	☐

Participation in activity involving white-beaked dolphins

There are many activities, such as academic research, citizen science projects and management programmes which aim to improve our understanding and the future conservation status of whales and dolphins internationally. Please use the following section to provide information about the sorts of activity you have previously or currently been involved with.

Q2. Have you previously or currently participate in activities listed below which have involved white-beaked dolphins?

	YES	NO
Sightings Surveys	☐	☐
Distribution and Abundance	☐	☐
Acoustics and Noise	☐	☐
Behaviour and Diet	☐	☐
Habitats and Ecology	☐	☐
Physiology and Pathology	☐	☐
Genetics	☐	☐
Management	☐	☐

Threats to white-beaked dolphin conservation status

Many threats currently affect the conservation status of many whales and dolphins worldwide. Use the following section to provide your opinion of which common threats listed below would affect white-beaked dolphins.

Q3. Please rank using the boxes below the order in which you believe the current conservation status of white-beaked dolphins may be adversely affected by the named threats (1 is greatest - 9 is least). Only one answer can be given for each threat. All threats must be given an answer before proceeding further

	9	8	7	6	5	4	3	2	1
Hunting	○	○	○	○	○	○	○	○	○
Bycatch	○	○	○	○	○	○	○	○	○
Vessel collision	○	○	○	○	○	○	○	○	○
Marine pollution	○	○	○	○	○	○	○	○	○
Noise pollution	○	○	○	○	○	○	○	○	○
Disease	○	○	○	○	○	○	○	○	○
Habitat loss or degredation	○	○	○	○	○	○	○	○	○
Prey depletion	○	○	○	○	○	○	○	○	○
Climatic change	○	○	○	○	○	○	○	○	○

Other knowledge of white-beaked dolphins

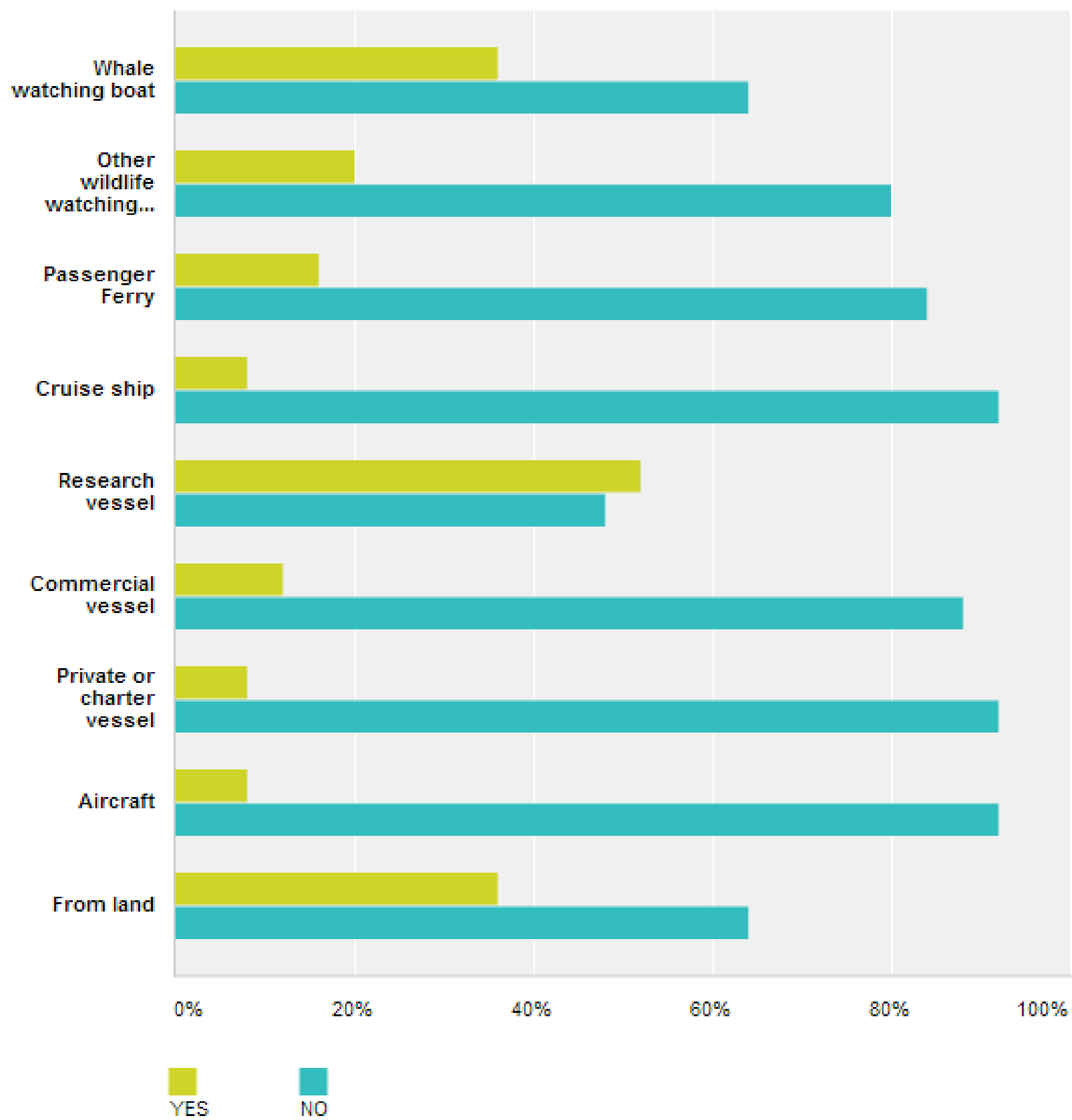
Please use the section below to provide information of any knowledge regarding the possible sightings, research activity or possible threats relating to white-beaked dolphins. This can be through personal accounts, references to publications or links to specific websites.

Q4. Please provide information on your knowledge of sightings, research, or threats relating to white-beaked dolphins.

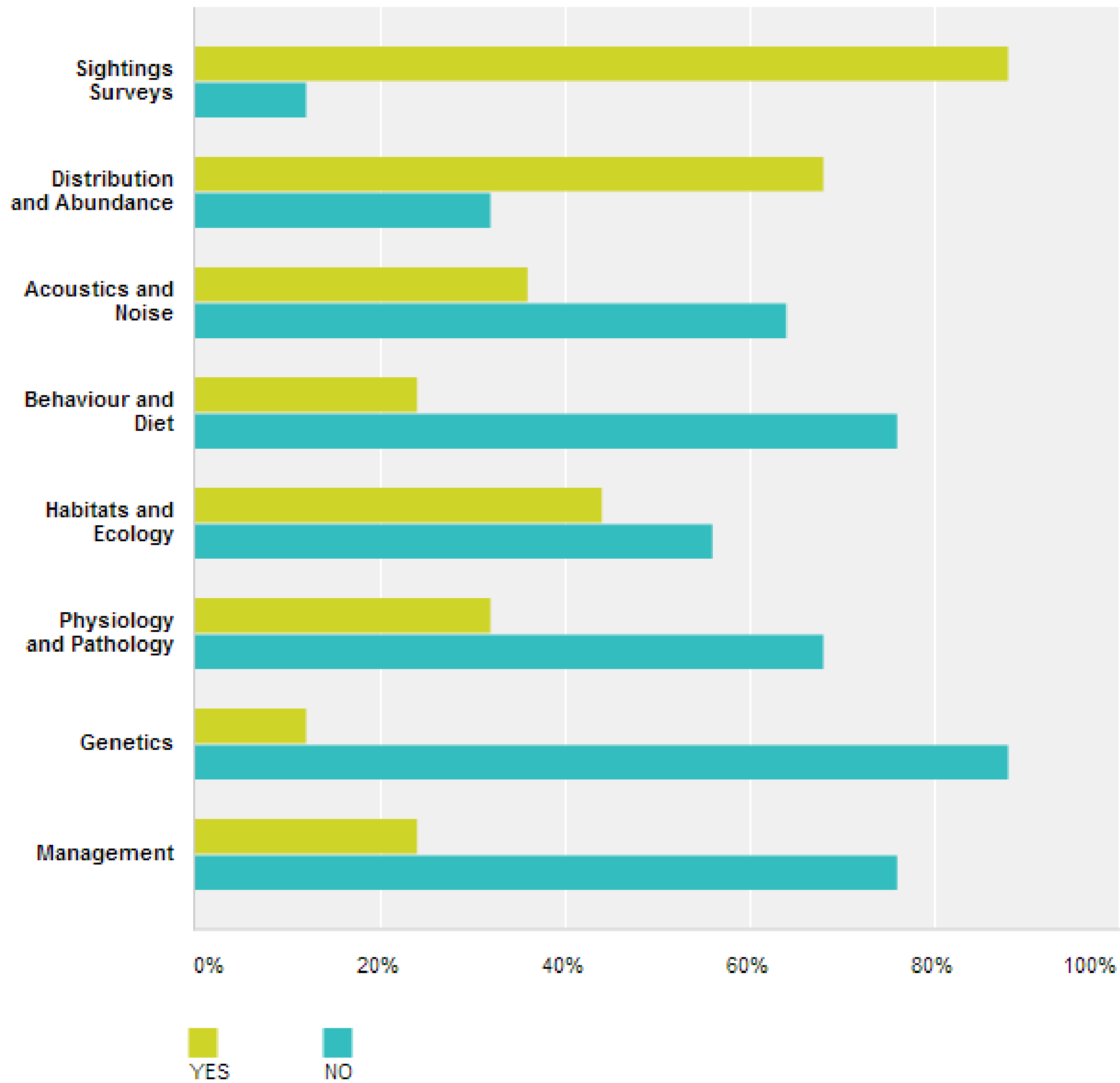
Results of SurveyMonkey

In total after the release on the survey it was successfully completed by 83 participants. The summary of answers to Questions 1-4 can be found below.

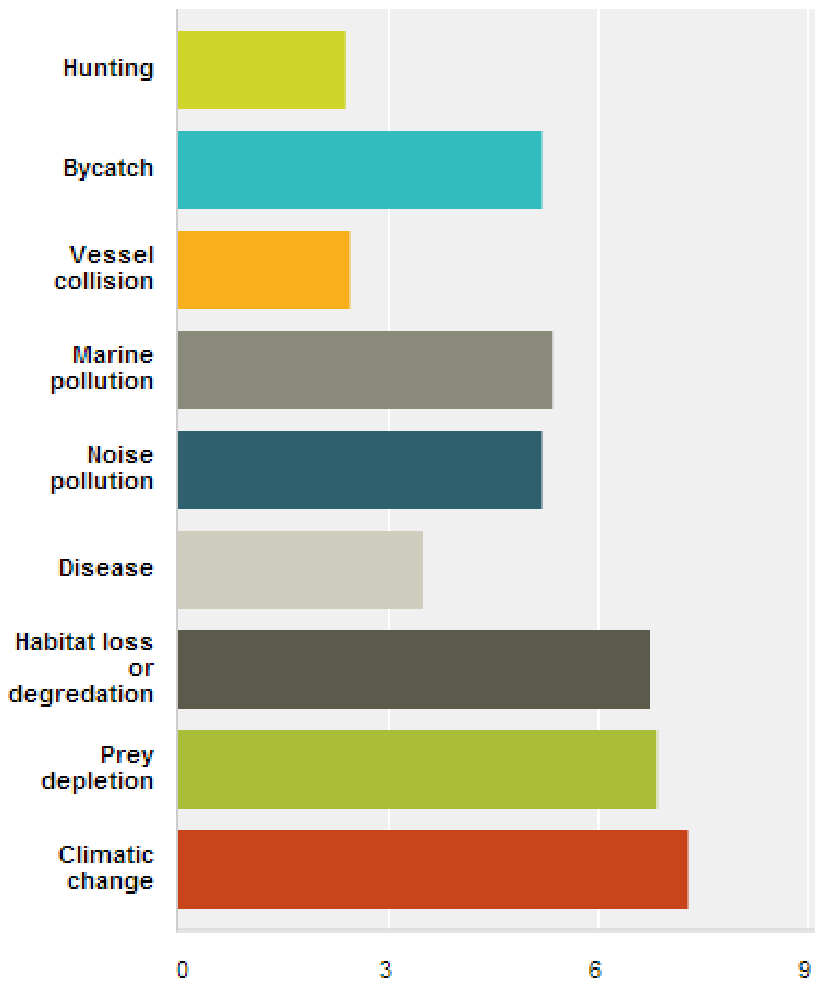
Q1. Have you observed white-beaked dolphins in the wild on any of the below platforms?



Q2. Have you previously or currently participate in activities listed below which have involved white-beaked dolphins?



Q3. Please rank using the boxes below the order in which you believe the current conservation status of white-beaked dolphins may be adversely affected by the named threats (1 is greatest - 9 is least). Only one answer can be given for each threat. All threats must be given an answer before proceeding further



Q4. Please provide information on your knowledge of sightings, research, or threats relating to white-beaked dolphins.

Of the 83 respondents to the white-beaked dolphin SurveyMonkey, approximately 30 participants provided additional information in Q4. These related to currently known information on the distribution and significant aggregations for the species in Scottish, Icelandic and Greenland waters. However new knowledge was gathered on additional sightings of the species in Irish, Canadian (Labrador & Newfoundland) and East Greenland waters. Furthermore besides the information gathered on threats to the species (climate change, noise pollution), additional observation of direct, and potentially under-reported, hunting of white-beaked dolphins in Greenland, Canada and the Faroe Islands.

Concluding Remarks

It is considered that the use of an online questionnaire, such as SurveyMonkey, could be a very useful means by which to collect additional information from the research and conservation community unable to attend ECS workshop events. It is accepted by authors that there are many flaws and issues with the reliability of using such a method including inabilities to monitor the true identities of respondents, truthfulness of evidence submitted or determine levels of expertise of those participating. However, this being assumed, overall the outcome of the findings of the SurveyMonkey showed that those surveyed agreed with many of the recommendations of outcomes of discussion held at the workshop. In particular with the outcomes of Q3. on the ranking of threats effecting *L.albirostris*. Therefore, it is considered that this means of collecting online evidence and consensus with the community unable to attend such expert workshops and events should be investigated and trialled further at future ECS conferences.

Annex 5. White-beaked dolphin bibliography

The following list comprises the known reference material available for white-beaked dolphin up to the date of the release of the workshop proceeding. It is intended to provide best available evidence for those compiling further reviews of the species in the Northeast Atlantic region and globally for the benefit of assessing conservation status.

Species Bibliography: white-beaked dolphin

Alling, A.K. and Whitehead, H.P. (1987) A preliminary study of the status of white-beaked dolphins, *Lagenorhynchus albirostris*, and other small cetaceans off the coast of Labrador. *Can. Field. Nat.,* 101: 131-135.

Andersen, S.H. and Rebsdorff, A. (1976) Polychlorinated hydrocarbons and heavy metals in harbour porpoise (Phocoena phocoena) and white-beaked dolphin (*Lagenorhynchus albirostris*) from Danish waters. *Aquatic Mammals*, 4: 14-20.

Atem, A.C.G., Rasmussen, M.H., Wahlberg, M., Petersen, H.C. and Miller, L.A. (2009) Changes in click source levels with distance to targets: studies of free-ranging white-beaked dolphins and captive harbour porpoises. *Bioacoustics* 19(1-2): 49-65.

Au, W.W.L. (2004) Echolocation signals of wild dolphins. *Acoustical Physics*, 50(4): 454-462

Banguera-Hinestroza, E., Bjørge, A., Reid, R.J., Jepson, P., Hoelzel, A.R. (2009) The influence of glacial epochs and habitat dependence on the diversity and phylogeography of a coastal dolphin species: *Lagenorhynchus albirostris*. *Cons. Genetics.,* 11: 1823-1836.

Barton, C.J.S. (2003) The effects of seismic activity on marine mammals in UK waters, 1998-2000. Report No. 323, Joint Nature Conservation Committee, Aberdeen.

Bertulli, C.G., Tetley, M.J., Magnusdottir, E. and Rasmussen, M.H. (Submitted) Observations of movement and site fidelity of white-beaked dolphins (Lagenorhynchus albirostris) in Icelandic coastal waters using photo-identification. *Journal of Cetacean Research and Management,* xx: xx-xx.

Brereton, T., Wynn, R., MacLeod, C., Bannon, S., Scott, B., Waram, J., Lewis, K., Phillips, J., Martin, C. and Covey, R. (2010) Status of Balearic Shearwater, White-beaked

Dolphin and other marine animals in Lyme Bay and surrounding waters. Report to Natural England, May 2010, 55pp.

Brereton, T., MacLeod, C., Kitching, M., Tait, A., Steel, D., Quigley, M. and Scott, C. (2010) Importance of the Farne Deeps and surrounding waters off the Northumberland coast for White-beaked Dolphin and other cetaceans and seabirds of Conservation Concern. Report to Natural England, July 2010, 109pp.

Buck, J.D. and Spotte, S. (1986), Microbiology of captive white-beaked dolphins (*Lagenorhynchus albirostris*) with comments on epizootics. *Zoo Biol.*, 5: 321–329.

Canning, S., Evans, P.G.H. and Pierce, G.J. (2005) Distribution of white-beaked dolphins along the South Grampian coastline. 110pp. In: Abstracts, 19th Annual Conference of the European Cetacean Society, La Rochelle, France, 2-7 April 2005. 2

Canning, S.J., Evans, P.G., Santos, M.B., Reid, R.J. and Pierce, G.J. (2005) Distribution of and habitat use of white-beaked dolphins (*Lagenorhynchus albirostris*) along the Aberdeenshire (UK) coastline, with new information on diet. Theme Session on Marine Mammals: Monitoring Techniques, Abundance Estimation, and Interactions with Fisheries (R). *ICES Council Meeting Documents. Copenhagen*. No. 2005.

Canning, S.J., Santos, M.B., Reid, R.J., Evans, P.G.H., Sabin, R.C., Bailey, N. and Pierce, G.J. (2008) Seasonal distribution of white-beaked dolphins (*Lagenorhynchus albirostris*) in UK waters with new information on diet and habitat use. *Journal of the Marine Biological Association of the United Kingdom,* 88: 1159-1166.

Carwardine, M. (1995) Whales, dolphins and porpoises. Dorling Kindersley, London, UK, 257 pp.

Collet, A. and Duguy, R. (1981) *Lagenorhynchus albirostris* (Cetacea, Odontoceti): espèce nouvelle pour la faune de France. *Mammalia,* 45(3), 387-8.

Das, K., Beans, C., Holsbeek, L., Mauger, G., Berrow, S.D., Rogan, E. and Bouquegneau, J.M. (2003) Marine mammals from Northeast Atlantic: relationship between their trophic status as determined by d13C and d15N measurements and their trace metal concentrations. *Mar. Environ. Res.*, 56(3): 349-365.

Das, K., Lepoint, G., Leroy, Y. and Bouquegneau, J. (2003) Marine mammals from the southern North Sea: feeding ecology data from delta C-13 and delta N-15 measurements. *Marine Ecology Progress Series,* 263: 0171-8630.

De Haan D.d., Dremiere, P.Y., Woodward, B., Kastellein, R., Amundin, M., and Hansen, K. (1998) Prevention of by-catch of small cetaceans in pelagic trawls by technical means. Third European Marine Science and Technology (Mast) Conference, Lisbon, 23 27 May 1998: Project Synopses Vol 5: Fisheries and Aquaculture, 262-266pp.

Dong, J.H., Lien, J., Nelson, D. and Curren, K. (1996) A contribution to the biology of the white-beaked dolphin, *Lagenorhynchus albirostris*, in waters off Newfoundland. *Canadian Field-Naturalist,* 110: 278-287.

Evans, P.G.H. (1980) Cetaceans in British waters. *Mammal Review,* 10(l): 1–51.

Evans, P.G.H. (2011) CETACEAN TREND ANALYSIS SUMMARY FOR THE ASCOBANS AGREEMENT AREA. 18th ASCOBANS Advisory Committee Meeting Report. AC18/Doc.6-05 (S), 12 pp.

Evans, P.G.H. and Teilmann, J. (2009) ASCOBANS/HELCOM Small Cetacean Population Structure Workshop. ASCOBANS; Bonn, Germany, 141 pp.

Fall, J. and Skern-Mauritzen, M. (in prep) White-beaked dolphin distributions and associations with prey in the Barents Sea. PLOS ONE, xx:xx-xx.

Galatius, A. (2006) Bilateral Directional Asymmetry of the Appendicular Skeleton of the White-Beaked Dolphin (*Lagenorhynchus albirostris*). *Aquatic Mammals,* 32(2):232-235.

Galatius, A., Jansen, O.E. and Kinze, C.C. (2012) Parameters of growth and reproduction of white-beaked dolphins (*Lagenorhynchus albirostris*) from the North Sea. *Marine Mammal Science*. doi: 10.1111/j.1748-7692.2012.00568.x 3

Galatius, A., Sonne, C., Kinze, C.C. Dietz, R. and Jensen, J.B. (2009) OCCURRENCE OF VERTEBRAL OSTEOPHYTOSIS IN A MUSEUM SAMPLE OF WHITE-BEAKED DOLPHINS (*LAGENORHYNCHUS ALBIROSTRIS*) FROM DANISH WATERS. *J.wildlife.dis*., 45(1):19-28.

Hammond, P.S. and Macleod, K. (2006) SCANS II - Report on Progress. Document Paper prepared for ASCOBANS 5th Meeting of the Parties, Netherlands, September, 2006. MOP5/Doc. 26.

Hammond, P.S., Berggren, P., Benke, H., Borchers, D.L., Collet, A., Heide-Jørgensen, M.P., Heimlich, S., Hiby, A.R., Leopold, M.F. and Øien, N. (2002) Abundance of harbour porpoise and other cetaceans in the North Sea and adjacent waters. *Journal of Applied Ecology,* 39: 361–376.

Hammond, P.S., Bearzi, G., Bjørge, A., Forney, K., Karczmarski, L., Kasuya, T., Perrin, W.F., Scott, M.D., Wang, J.Y., Wells, R.S. and Wilson, B. (2008). *Lagenorhynchus albirostris*. In: IUCN 2008. IUCN Red List of Threatened Species. Retrieved 24 March 2009.

Harlin-Cognato, A. D. and Honeycutt, R. L. (2006) Multi-locus phylogeny of dolphins in the subfamily Lissodelphininae: Character synergy improves phylogenetic resolution. *BMC Evolutionary Biology*, 6(1): 87-92.

Harries, O.R., Weir, C., Calderan, S., Van Geel, N., Shrimpton, J. and Gordon, J.C. (2012) The role of spatial modelling in the potential management of a priority Scottish cetacean species, the white-beaked dolphin (Lagenorhynchus albirostris). Proceedings of the European Cetacean Society Conference, Galway 2012.

Higdon, J.W. and Snow, D. (2008) First record of a collapsed dorsal fin in a White-beaked Dolphin, *Lagenorhynchus albirostris*, with a gunshot wound as a possible cause. *Canadian Field-Naturalist,* 122(3): 262–264.

Hummert, K., Vetter, W. and Luckas, B. (1995) Levels of alpha-HCH, lindane, and enantiomeric ratios of alpha-HCH in marine mammals from the northern hemisphere. *Chemosphere,* 31(6): 3489–3500.

ICES (2010) Report of the Working Group on Marine Mammal Ecology (WGMME), 12–15 April 2010, Horta, The Azores. ICES CM 2010/ACOM:24. 212 pp.

Jansen, O.E., Leopold, M.F., Meesters, E. and Smeenk, C. (2010) Are white-beaked dolphins *Lagenorhynchus albirostris* food specialists? Their diet in the southern North Sea. *Journal of the Marine Biological Association of the United Kingdom,* 90:1501-1508.

Jefferson, T.A., Leatherwood, S. and Webber, M.A. (1993) FAO Species identification guide. Marine mammals of the world. UNEP/FAO, Rome, 320 pp.

Joint Nature Conservation Committee (2007) Second Report by the UK under Article 17 on the implementation of the Habitats Directive from January 2001 to December 2006. Peterborough: JNCC. Available from: www.jncc.gov.uk/article17.

Kenney, R. D., Payne, P. M., Heinemann, D. W. and Winn, H. E. (1996) Shifts in northeast shelf cetacean distributions relative to trends in Gulf of Maine/Georges Bank finfish abundance. In: K. Sherman, N. A. Jaworski and T. J. Smayda (eds), The Northeast Shelf Ecosystem: Assessment, Sustainability, and Management, Blackwell Science, Cambridge, USA. 169-196pp.

Kingsley, M.C.S., Reeves, R.R. (1998) Aerial surveys of cetaceans in the Gulf of St. Lawrence in 1995 and 1996. *Can J Zool*, 76: 1529-1550.

Kinze, C.C. (2009) White-beaked dolphin *Lagenorhynchus albirostris*. In: Encyclopedia of marine mammals (Perrin, W.F., Würsig, B., Thewissen, J.G.M. eds.) Second Edition. Academic Press, Amsterdam, 1255-1258 pp.

Kinze, C.C. (2009) White-Beaked Dolphin: *Lagenorhynchus albirostris*. Encyclopaedia of Marine Mammals (Second Edition), 2009, 1255-1258pp.

Kinze, C.C., Addink, M., Smeenk, C., Hartmann, M.G., Richards, H.W., Sonntag, R.P. and Benke, H. (1997) The white-beaked dolphin (*Lagenorhynchus albirostris*) and the white-sided dolphin (*Lagenorhynchus acutus*) in the North and Baltic Seas: Review of available information. *Rep Int Whal Comm,* 47: 675-682.

Kirkwood, J. K., Bennett, P.M., Jepson, P.D., Kuiken, T., Simpson, V.R., and Baker, J.R. (1997) Entanglement in fishing gear and other causes of death in cetaceans stranded on the coasts of England and Wales. *Veterinary Record*, 141:94-98.

Kompanje, E.J.O. (1995) On the occurrence of spondylosis deformans in white-beaked dolphins *Lagenorhynchus albirostris* (Gray, 1846) stranded on the Dutch coast. *Zool. Med. Leiden*, 69(18): 231-250.

Law, R.J., Jones, B.R., Baker, J.R., Kennedy, S., Milne, R. and Morris, R.J. (1992) Trace metals in the livers of marine mammals from the Welsh coast and the Irish Sea. *Marine Pollution Bulletin*, 24(6): 296–304.

Leduc, R. G., Perrin, W. F. and Dizon, A. E. (1999) Phylogenetic relationships among the delphinid cetaceans based on full cytochrome b sequences. *Marine Mammal Science,* 15: 619-648.

Lien, J., Nelson, D. and Hai, D. J. (2001) Status of the White-beaked Dolphin, *Lagenorhynchus albirostris*, in Canada. *Canadian Field-Naturalist*, 115(1): 118-126.

MacLeod, C.D. Weir, C.R. Santos, M.B., Dunn, T.E. (2008) Temperature-based summer habitat partitioning between white-beaked and common dolphins around the United Kingdom and Republic of Ireland. Journal of the Marine Biological Association of the United Kingdom 88(6): 1193-1198.

MacLeod, C.D., Bannon, S.M., Pierce, G.J., Schweder, C., Learmonth, J.A., Herman, J.S. and Reid, R.J. (2005) Climate change and the cetacean community of north-west Scotland. *Biological Conservation*, 124:477-483.

MacLeod, C.D., Weir, C.R., Pierpoint, C. and Harland, E.J. (2007) The habitat preferences of marine mammals west of Scotland (UK). *Journal of the Marine Biological Association of the United Kingdom,* 87(01): 157-164.

Mikkelsen, A. M. and Lund, A. (1994) Intraspecific variation in the dolphins *Lagenorhynchus albirostris* and L. acutus (Mammalia: Cetacea) in metrical and non-metrical skull characters, with remarks on occurrence. *Journal of Zoology (London)*, 234: 289-299.

Mitson, R. and Morris, R. J. (1988) Evidence of High Frequency Acoustic Emissions From The White Beaked Dolphin. *Journal of the Acoustical Society of America*, 3: 2-9.

Mooney, T.A., Nachtigall, P.E., Taylor, K.A., Rasmussen, M.H., Miller, L.A., Katona, S.K., Rough, V. (2009) Auditory temporal resolution of a wild white-beaked dolphin (*Lagenorhynchus albirostris*). *Journal of Comparative Physiology*, 195(4): 375-384.

Muir, D.C.G., Wagemann, R., Grift, N.P., Norstrom, R. J., Simon, M. and Lien, J. (1988) Organochlorine chemical and heavy metal contaminants in white-beaked dolphins (*Lagenorhynchus albirostris*) and pilot whales (Globicephala melaena) from the coast of Newfoundland, Canada. *Archives of Environmental Contamination and Toxicology*, 17(5): 613-629.

Nachtigall, P. E., Mooney, T. A., Taylor, K. A., Miller, L. A. , Rasmussen, M. H., Akamatsu, T., Teilmann, J., Linnenschmidt, M. and Vikingsson, G.E. (2008) Shipboard measurements of the hearing of the white-beaked dolphin *Lagenorhynchus albirostris. J. Exp. Biol.*, 211: 642-647.

NAMMCO (2012) Report of the Nineteenth Meeting of the NAMMCO Scientific Committee. Tasiilaq, East Greenland, 19 – 22 April 2012, 226pp.

Northridge, S. and Thomas, L. (2003) Monitoring levels required in European Fisheries to assess cetacean bycatch, with particular reference to UK fisheries. Report to DEFRA.

Northridge, S., Tasker, M., Webb, A. and Camphuysen, K. (1997) White-beaked *Lagenorhynchus albirostris* and Atlantic white-sided dolphin L. acutus distributions in northwest European and US North Atlantic waters. *Rep. int. Whal. Commn* 1997.

Northridge, S.P., Tasker, M.L., Webb, A. and Williams, J.M. (1995) Distribution and relative abundance of harbour porpoises (*Phocoena phocoena* L.), white-beaked dolphins (*Lagenorhynchus albirostris* Gray), and minke whales (Balaenoptera acutorostrata Lacepède) around the British Isles. *ICES J. Mar. Sci.,* 52(1): 55-66.

Øien, N. (1996) *Lagenorhynchus* species in Norwegian waters as revealed from incidental observations and recent sighting surveys. International Whaling Commission, Cambridge, UK.

Osterhaus, A.D.M.E., Broeders, H.W.J., Teppema, J.S., Kuiken, T., House, J. A., Vos, H.W. and Visser, I.K.G. (1993) Isolation of a virus with rhabdovirus morphology from a white-beaked dolphin (*Lagenorhynchus albirostris*). *Arch. Virol,* 133(1-2): 189-193

Palka, D.L. and Hammond, P.S. (2011) Accounting for responsive movement in line transect estimates of abundance. *Canadian Journal of Fisheries and Aquatic Sciences*, 58(4): 777-787.

Pike, D.G., Paxton, C.G.M., Gunnlaugsson, T. and Víkingsson, G.E. (2009) Trends in the distribution and abundance of cetaceans from aerial surveys in Icelandic coastal waters, 1986-2001 Paper in NAMMCO Scientific Publication 7. Sc/59/48.

Pollock, C.M., Reid, J.B., Webb, A., and Tasker, M.L. (1997) The distribution of seabirds and cetaceans in the waters around Ireland. JNCC Report, No. 267.

Pollock, C.M., Mavor, R., Weir, C. R., Reid, A., White, R. W., Tasker, M. L., Webb, A., and Reid, J. B. (2000). The distribution of seabirds and marine mammals in the Atlantic Frontier, north and west of Scotland. Joint Nature Conservation Committee. Aberdeen. 92pp.

Rasmussen, M.H., Akamatsu, T., Teilmann, J., Víkingsson, G. and Miller, L.A. (2013) Biosonar, diving and movements of two tagged white-beaked dolphins in Icelandic waters. *Deep-Sea Research II*, 88-89 (2013): 97-105.

Rasmussen, M.H., Lammers, M., Beedholm, K. and Miller, L.A. (2006). Source levels and harmonic content of whistles in white-beaked dolphins (Lagenorhynchus albirostris). *The Journal of the Acoustical Society of America,* 120: 510-517.

Rasmussen, M.H., Wahlberg, M., Miller, L. (2004) Estimated transmission beam pattern of clicks recorded from free-ranging white-beaked dolphins (*Lagenorhynchus albirostris*). *The Journal of the Acoustical Society of America,* 116(3):1826-1831.

Rasmussen, M.H. and Miller, L.A. (2004) Echolocation and social signals from white-beaked dolphins, *Lagenorhynchus albirostris*, recorded in Icelandic waters. In: Echolocation in bats and dolphins chapter number .5.1. 0-53pp. (Editor: J. Thomas, C. Moss and M. Vater), University of Chicago press, Chicago.

Rasmussen, M. (2004) A study of communication and echolocation sounds recorded from free-ranging white-beaked dolphins (*Lagenorhynchus albirostris)* in Icelandic waters. Ph.D. Thesis. 109pp.

Rasmussen, M.H. and Jacobsen, T. (2003) Photo-identification of White-beaked dolphins in Icelandic waters. In: ECS-proceedings 2003, Las Palmas, Gran Canaria.

Rasmussen, M.H. and Miller, L.A. (2002) Whistles and clicks from white-beaked dolphins, *Lagenorhynchus albirostris* recorded in Faxaflói Bay. *Aquatic Mammals,* 28:78-89.

Rasmussen, M.H., Miller, L.A. and Au, W.W.L (2002) Source levels of clicks from free-ranging white beaked dolphins Lagenorhynchus albirostris Gray 1846) recorded in Icelandic waters. *J. Acous. Soc. Am*. 111: 1122-125.

Rasmussen, M.H. (2001) Behaviour of free-ranging white-beaked dolphins. In: ECS-proceedings 2001, Rome, Italy.

Rasmussen, M.H., Miller, L.A. and Au W.W.L. (2000) The sounds and calculated source levels from the white-beaked dolphin recorded in Icelandic waters. In: ECS-proceedings 1999, Valencia, Spain.

Reeves, R. R., Smeenk, C., Kinze, C. C., Brownell Jr., R. L. and Lien, J. (1999) White-beaked dolphin *Lagenorhynchus albirostris* Gray, 1846. In: S. H. Ridgway and R. Harrison (eds.), Handbook of marine mammals, Vol. 6: The second book of dolphins and the porpoises, Academic Press, 1-30pp.

Reid, J.C., Evans, P.G.H. and Northridge, S.P. (2003) Atlas of cetacean distribution in Northwest European waters. Joint Nature Conservation Committee, Peterborough, UK.

Rendell, L.E., Matthews, J. N., Gill, A., Gordon, J.C.D. and Macdonald, D.W. (1999) Quantitative analysis of tonal calls from five odontocete species, examining interspecific and intraspecific variation. *Journal of Zoology,* 249: 403–410.

Richardson, D.T. (1993) A field guide to whales, porpoises, and seals from Cape Cod to Newfoundland. Smithsonian Institution Press, Washington, DC, USA.

Santos Vázquez, M.B., Pierce, G.J., Ross, H.M. and Reid, R.J. (1994) Diets of small cetaceans from the Scottish coast. ICES Marine Mammal Committee C.M.1994/No. 11, 1-16.

Sergeant, D.E. and Fisher, H.D. (2011) The Smaller Cetacea of Eastern Canadian Waters Published on the web 13 April 2011. *Journal of the Fisheries Research Board of Canada*, 14(1): 83-115.

Siebert, U., Joiris, C., Holsbeek, L., Benke, H., Failing, K., Frese, K., and Petzinger, E. (1999) Potential relation between mercury concentrations and necropsy findings in cetaceans from German waters of the North and Baltic Seas. *Mar Poll Bull,* 38: 285-295.

Simard, P., Mann, D.A. and Gowans, S. (2008) Burst-Pulse Sounds Recorded from White-Beaked Dolphins (*Lagenorhynchus albirostris*). *Aquatic Mammals*, 34(4): 464-470.

Skern-Mauritzen, M. and Fall, J. (2010) Dolphin Densities and Distributions in the Barents Sea and Potential Influences by Recent Temperature Increases. Report to the International Whaling Commission, SC/N10/CC5.

Stone, C.J. and Tasker, M.L. (2006) The effects of seismic airguns on cetaceans in UK waters. *J Cetacean Res Manage,* 8: 255-263.

Van de Vijver, K.I., Hoff,P.T., Das, K., Van Dongen, W., Esmans, E.L., Jauniaux, T., Bouquegneau, J.M., Blust,R. and De Coen, W. (2003) Perfluorinated Chemicals Infiltrate Ocean Waters: Link between Exposure Levels and Stable Isotope Ratios in Marine Mammals. *Environmental Science & Technology*, 37(24): 5545-5550.

Waring, G.T., Josephson, E., Fairfield, C.P. and Maze-Foley, K. (2006) U.S. Atlantic and Gulf of Mexico marine mammal stock assessments - 2005. NOAA Technical Memorandum NMFS-NE, pp. 346 pp.

Waring, G.T., Quintal, J.M. and Swartz, S.L. (2000) U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments. NOAA Technical Memorandum NMFS-NE-162, 301pp.

Weir, C.R. and Stockin, K.R. (2001) The occurrence and distribution of bottlenose dolphins (Tursiops truncatus) and other cetacean species in the coastal waters of Aberdeenshire, Scotland. Report of the Sea Watch Foundation, 2001.

Weir, C.R., Pollock, C., Cronin, C., Taylor, S. (2001) The Marine Environment of the North East Atlantic Margin Cetaceans of the Atlantic Frontier, north and west of Scotland. *Continental Shelf Research*, 21(8–10): 1047–1071.

Weir, C.R., Stockin, K.A. and Pierce, G.J. (2007) Spatial and temporal trends in the distribution of harbour porpoises, white- beaked dolphins and minke whales off Aberdeenshire (UK), North-Western North Sea. *J Mar Biol Assoc UK,* 87: 327-338.

Weir, C.R. (2008) Occurrence of the white-beaked dolphin (*Lagenorhynchus albirostris*) and other cetacean species in the Minch, August 2007. Scottish Natural Heritage Commissioned Report No. 305 (ROAME No. F05AC701).

Weir, C.R., Calderan, S.V., Unwin, M., Pitman, R.L., Booth, C.G., Photopoulos, T. and Robinson, K.P. (2008) White-beaked dolphin (*Lagenorhynchus acutus*) occurrence in the Minch (Scotland, UK) during August 2007. Poster for 22nd Annual Conference of the European Cetacean Society, Egmont Aan Zee, The Netherlands 2008.

Weir, C.R., MacLeod, C.D., and Calderan, S.V. (2009) Fine-scale habitat selection by white-beaked and common dolphins in the Minch (Scotland, UK): evidence for interspecific competition or coexistence? *Journal of the Marine Biological Association of the United Kingdom,* 89 (5): 951-960.

Whitehead, H. and Glass, C. (1985) The significance of the Southeast Shoal of the Grand Bank to humpback whales and other cetacean species. *Canadian Journal of Zoology*, 63(11): 2617-2625.

Wohlsein, P., Puff, C., Kreutzer, M., Siebert, U. and Baumgärtner, M. (2007) Distemper in a Dolphin. *Emerg. Infect. Dis.*, 13(12): 1959–1961.

Annex 6. Abbreviations and Acronyms

ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic North East Atlantic, Irish and North Seas
AC	Advisory Committee
CBD	Convention on Biological Diversity
CMS	Convention on Migratory Species
COP	Conference of Parties
EC	European Commission
EEC	European Economic Community
EU	European Union
HELCOM	Helsinki Commission
HWDT	Hebridean Whale and Dolphin Trust
IMO	International Maritime Organization
IWC	International Whaling Commission
IUCN	International Union for the Conservation of Nature
MEAs	Multilateral Environmental Agreements
MOP	Member of Parties
MOU	Memorandum of Understanding
NAMMCO	The North Atlantic Marine Mammal Commission
NGOs	Non-Governmental Organizations
OSPAR	Oslo and Paris Commissions
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and cultural Organisation
WDC	Whale and Dolphin Conservation