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Management Units for cetaceans in UK waters (January 2015)

IAMMWG

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For further information please contact:

Joint Nature Conservation Committee
Monkstone House
City Road
Peterborough PE1 1JY

www.jncc.defra.gov.uk

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Joint Nature Conservation Committee, JNCC
Mark Tasker
Eunice Pinn
Kelly Macleod
Lindis Bergland
Catarina Aires

Natural England, NE
Fiona McNie

Natural Resources Wales, NRW
Tom Stringell
Kate Smith

Northern Ireland's Department of Environment, DoENI
Gary Burrows
Stephen Foster

Scottish Natural Heritage, SNH
John Baxter
Fiona Manson
Karen Hall

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1. This paper sets out the final agreed Management Units (MUs) for the seven most common cetacean species in UK waters. Details of each MU are provided, including boundaries and estimated abundance figures.

2. The MUs provide an indication of the spatial scales at which impacts of plans and projects alone, cumulatively and in-combination, need to be assessed for the key cetacean species in UK waters, with consistency across the UK.

3. Further detailed guidance will follow on how the Statutory Nature Conservation Bodies (SNCBs) will interpret the MUs. The guidance will include how MUs should be used to inform assessment processes for plans and projects with the potential to affect cetacean features of Special Areas of Conservation (SACs) and populations of European Protected Species under Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (otherwise known as the Habitats Directive).

4. The guidance will provide a pragmatic consideration of issues relating to the practical application of the MUs, including how decisions should be made about what proportion of animals within a MU might be affected by a proposed plan or project. Guiding principles will be developed on how 'local' impacts on this proportion might be placed in the context of, and balanced with, wider 'regional' implications. Other issues the guidance will consider include dealing with cross-border and cross-MU matters, and connectivity and rates of inter-change of species within and between MUs.

5. The MUs have been fully incorporated into the Population Consequences of Disturbance (PCoD) interim model for assessing the impacts of marine renewable energy developments on marine mammals, developed by the Sea Mammal Research Unit (SMRU) on behalf of The Crown Estate, the Department of Energy & Climate Change (DECC), Marine Scotland and the SNCBs. The interim PCoD model was published in February 2014 (see http://www.scotland.gov.uk/Publications/2014/02/8509).

6. The boundaries of the MUs detailed in this paper are final and will not change until they are formally reviewed, anticipated to occur in 2019, and every five years thereafter.

Contents

Glossary

Species is a specifically named taxonomic group of living organisms (e.g. animals and plants) of the same kind which are capable of producing fertile offspring but are predominantly reproductively isolated from other organisms.

Population is a collection of individuals all of the same species with a tendency to be found in the same area. Populations contain *genetic variation* within the population itself, and between other populations. Populations can exist in isolation, or can co-exist at least during a part of the year with other conspecific populations (i.e. other populations of the same species) in the same area.

Ecological Unit is the overall area frequented by a 'population' (see above) to reflect differences in spatial preferences of individuals with no consideration of managment (Evans & Teilmann 2009; Evans 2012).

Management Unit (MU) typically refers to a geographical area in which the animals of a particular species are found to which management of human activities is applied. An MU may be smaller than what is believed to be a 'population' or an 'ecological unit' to reflect spatial differences in human activities and their management. If MUs are defined at a smaller spatial scale than the population, it is important that management takes into account the rates of interchange of individuals between MUs; that is, the MUs should not be treated as if they were demographically independent.

Assessment Unit (AU) is a term developed by OSPAR for reporting purposes under the Marine Strategy Framework Directive. They reflect a geographical area occupied by a population and so are divisions based on biology/ecology rather than management. These areas vary by species, i.e. they are not the same within a regional sea for different species.

1 Background

The UK Statutory Nature Conservation Bodies (SNCBs) are increasingly receiving requests from Government, Regulators and developers for advice on the potential effects of construction and other offshore activities on marine mammals. This requires an understanding of the geographical range of populations and sub-populations, in order to provide advice on impacts at the most appropriate spatial scale. As part of the need to meet such requests, the Natural Resources Wales (formerly the Countryside Council for Wales [CCW]) commissioned work on defining Management Units (MUs) in Welsh waters (Evans 2012) and the Scottish Government commissioned similar work by the Sea Mammal Research Unit (SMRU) for Scottish waters (Northridge 2012). At the international level, the International Council for the Exploration of the Sea (ICES) Working Group on Marine Mammal Ecology (WGMME 2012, 2013, 2014) has assessed current knowledge of marine mammal populations and MUs as part of the further development of targets and indicators for determining 'Good Environmental Status' (GES) under the Marine Strategy Framework Directive (MSFD). Subsequently, ICES provided advice to the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) on appropriate assessment units for marine mammals (ICES 2014).

The Inter-Agency Marine Mammal Working Group (IAMMWG), comprising representatives of Natural England (NE), Scottish Natural Heritage (SNH), Natural Resources Wales (NRW) and Joint Nature Conservation Committee (JNCC) met at SNH Edinburgh on 28th June 2012. Expert scientific advice was also sought from SMRU. This paper derives from discussions at that meeting and subsequent correspondence. It was not possible for a representative of Northern Ireland's Department of Environment Marine Division (DoENI, formerly the Northern Ireland Environment Agency [NIEA]) to be present at the meeting. However, following the transfer of marine functions from NIEA to the DoENI Marine Division, there has been involvement from Northern Ireland representatives in the subsequent discussions and correspondence. A second meeting was held on 16th January 2013 at which the MUs were formally agreed by all bodies and sent for consideration by SNCBs' Chief Scientists Group (CSG) on 31st January 2013. Following recommendation from CSG and the further work undertaken by WGMME (2013, 2014) and ICES Advice (2014), the MUs proposed were updated. It is expected that the management units outlined in this document will be used during work undertaken to meet SNCB commitments to cetaceans, such as industry related casework and the identification of protected areas. It is expected that a second paper outlining seal MUs will be published in 2015.

2 Introduction

Almost all species of cetacean found in UK waters are part of larger biological populations whose range extends into the waters of other European States and/or the High Seas. Equally, the number of individuals present at any one time may be only a small proportion of those that make use of UK waters throughout the year. In order to obtain the best conservation outcomes for many species, it is necessary to consider the division of populations into smaller management units. Management Units (MUs) should be based on our best understanding of the structure of biological populations and any ecological differentiation within such populations (as outlined in the Appendix). However, the boundaries between MUs may be determined by either political boundaries (e.g. the boundary between Ireland and the UK) or the management of human activities (e.g. ICES divisions used for the collection of fisheries data and management of fisheries). As far as possible, the management units defined in this report have been based on the presence of known populations, with divisions proposed on the basis of ecological evidence and/or divisions used for the management of human activities. Therefore, whilst being consistent with the best biological understanding, an MU refers to the animals of a particular species in a geographical area to which management of human activities is also applied. As such, these MUs comprise partially artificial divisions of often slightly uncertain biological populations.

For example, harbour porpoises within the eastern North Atlantic are generally considered to behave as a 'continuous' biological population that extends from the French coasts of the Bay of Biscay northwards to the arctic waters of Norway and Iceland (Tolley & Rosel 2006; Fontaine *et al* 2007, 2014). However, for conservation and management purposes, it is sensible to divide this population into smaller units, now termed MUs. These smaller MUs reflect differences, to some extent, in the spatial preferences of individuals and also the spatial variation in human activities.

What was of importance in deciding the divisions between MUs, in the context of conservation and management, is whether human activities could impact individuals from one part of the population differentially if no structure were imposed by the MUs. For example, if fisheries bycatch (mortality from accidental capture or entanglement) of a particular species of cetacean were concentrated in an area to which individual animals had a preference to return over a period of their lifetime, this could lead to local depletion of the species in that area, justifying delineation of an MU. However, if individuals from the wider population replaced the removed animals quickly, there may be no local impact and no separate MU would be necessary. Where MUs are defined in this manner, it is important that the management takes into account the rates of interchange of individuals between the units. The MUs should not be treated as if they were demographically independent.

Examples of large-scale units include the OSPAR Regions; the division of European Seas under the EC Marine Strategy Framework Directive (2008/56/EC) (Figure 1); and the ICES fisheries management Subareas and Divisions (Figure 2). The International Whaling Commission considers population (stock) structure in the context of preparations to implement its Revised Management Procedure. The approach uses a hierarchical structure of geographical units in which so-called 'Medium Areas' delineate biological populations within an ocean basin within which catch limits are set by 'Small Areas', which are defined based on biological and operational information.

Figure 1. The Regional Sea divisions for MSFD assessments.

In 2012, the ICES Working Group on Marine Mammal Ecology (WGMME) undertook a review of current information on the population structure and management units of six cetacean species (harbour porpoise, common dolphin, bottlenose dolphin, white-beaked dolphin, white-sided dolphin and minke whale). One of the overarching recommendations was that the delineation of MUs for cetaceans should be, as far as is practical, aligned with the ICES Subareas and/or Divisions (Figure 2) that are used for the implementation of fisheries management measures. Since bycatch is considered globally to be the greatest human impact on cetaceans, such an approach would facilitate the calculation of robust bycatch estimates because both marine mammal and fisheries data would align spatially (similar to the approach adopted by the ICES Working Group on the Bycatch of Protected Species, WGBYC). ICES peer reviewed this work and provided advice to OSPAR in 2014 (ICES 2014). OSPAR has made no further decisions yet on the application of the proposed units.

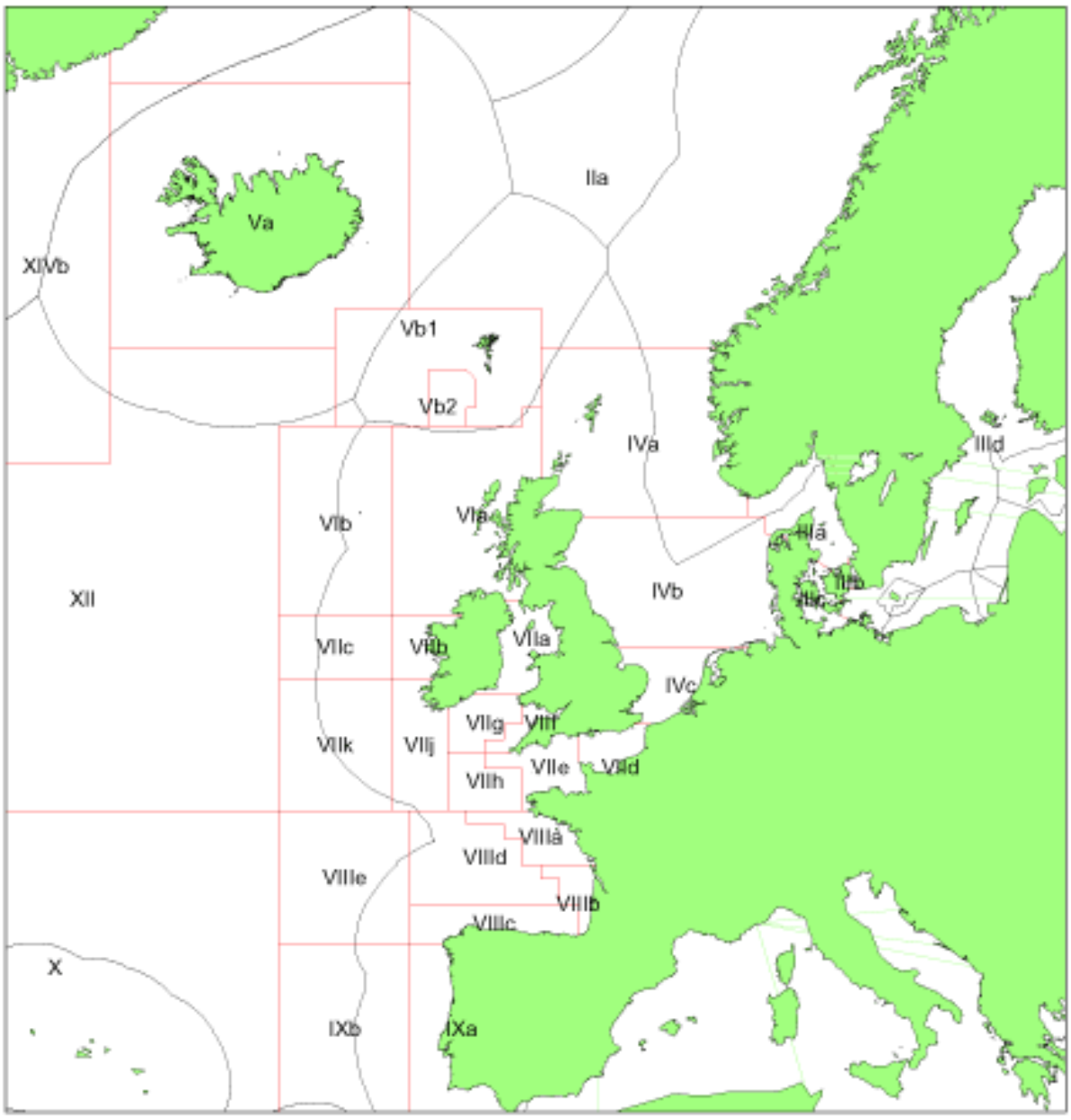

Figure 2. ICES Subareas and Divisions in the European North Atlantic.

For many cetaceans, the UK waters represent part of the range of a single continuous population. For some species, defining MUs at this scale is not appropriate or practical. As far as possible, the MUs defined in this report have been based on the presence of known populations, with divisions proposed on the basis of ecological evidence and/or divisions used for the management of human activities (see the Appendix for further details).

2.1 Anthropogenic threats to marine mammals

There has been a considerable volume of data collected on a global basis concerning the main anthropogenic pressures on cetaceans (e.g. Read *et al* 2006; Tyack 2008; Whitehead *et al* 2008; Elfes *et al* 2010; Mendez *et al* 2010; McQuinn *et al* 2011; Tyack *et al* 2011; Ayres *et al* 2012). Current anthropogenic pressures include:

- hunting and whaling (although not relevant in UK waters);
- fisheries and aquaculture interactions including mortality from accidental capture or entanglement (bycatch) and deliberate killing;
- pollution;
- habitat degradation or loss from coastal development;
- disturbance, usually caused by underwater sound;
- vessel strikes;
- depletion of food resources through competition with fisheries;
- anthropogenically mediated climate change.

Data derived from strandings can be used to give an indication of the occurrence of some of the pressures in coastal areas, but specific studies are required to quantify the impacts. There is relatively little quantitative or even qualitative information on pressures in offshore areas compared to our knowledge for inshore waters. Where specific information is available, it has been included within the MU descriptions outlined below.

It should be noted that the pressures on a particular species may vary between different MUs and also through time.

3 Species Management Units

3.1 Harbour porpoise (*Phocoena phocoena*)

The most important current anthropogenic pressure on harbour porpoises in NW European waters is bycatch. The harbour porpoise is the most commonly bycaught species recorded in independent monitoring of UK fisheries (e.g. Northridge *et al* 2012). Preliminary bycatch estimates for the whole UK gillnet fleet provide conservative (biased high) estimates of porpoise bycatch of around 1600-1900 porpoises per year, depending on whether acoustic pingers are being used correctly or at all (Northridge *et al* 2014). Bycatch accounted for 14.9% of stranded animal deaths between 2005-2010 (of 478 *post mortem* examinations) whilst 5.4% were the result of physical trauma (which potentially include deaths as a result of unidentified bottlenose dolphin attacks and vessel strikes) (Deaville & Jepson 2011). Given that the cause of death could not be identified in all cases, these are minimum estimates. Other anthropogenic activities that may affect harbour porpoises are renewable energy developments and the potential disturbance that associated construction noise can cause.

Three MUs (Figure 3) are appropriate for harbour porpoise (see Appendix). The MUs are defined as:

1. North Sea (NS) (comprising ICES area IV, VIId and part of Division IIIa [Skagerrak and northern Kattegat]). Noting that the northern and western boundary with Division VIa is arbitrary (but the shelf is relatively narrow here) and that there will be an interchange of animals here with the 'West Scotland' MU. The eastern boundary has been defined by the ASCOBANS North Sea Conservation Plan for the species. The northern peak of the EEZ is to be treated as part of the NS MU and has been included in abundance estimates (see below).

2. West Scotland (WS) (comprising ICES area VIa and b). Noting that the boundary with the North Sea MU is arbitrary and that there will be an interchange of animals here and also with the Irish Sea and Celtic Sea MUs. It should also be noted that harbour porpoise are generally rare in waters >200m depth.

3. Celtic and Irish Seas (CIS) (comprising ICES area VI and VII, except VIId).

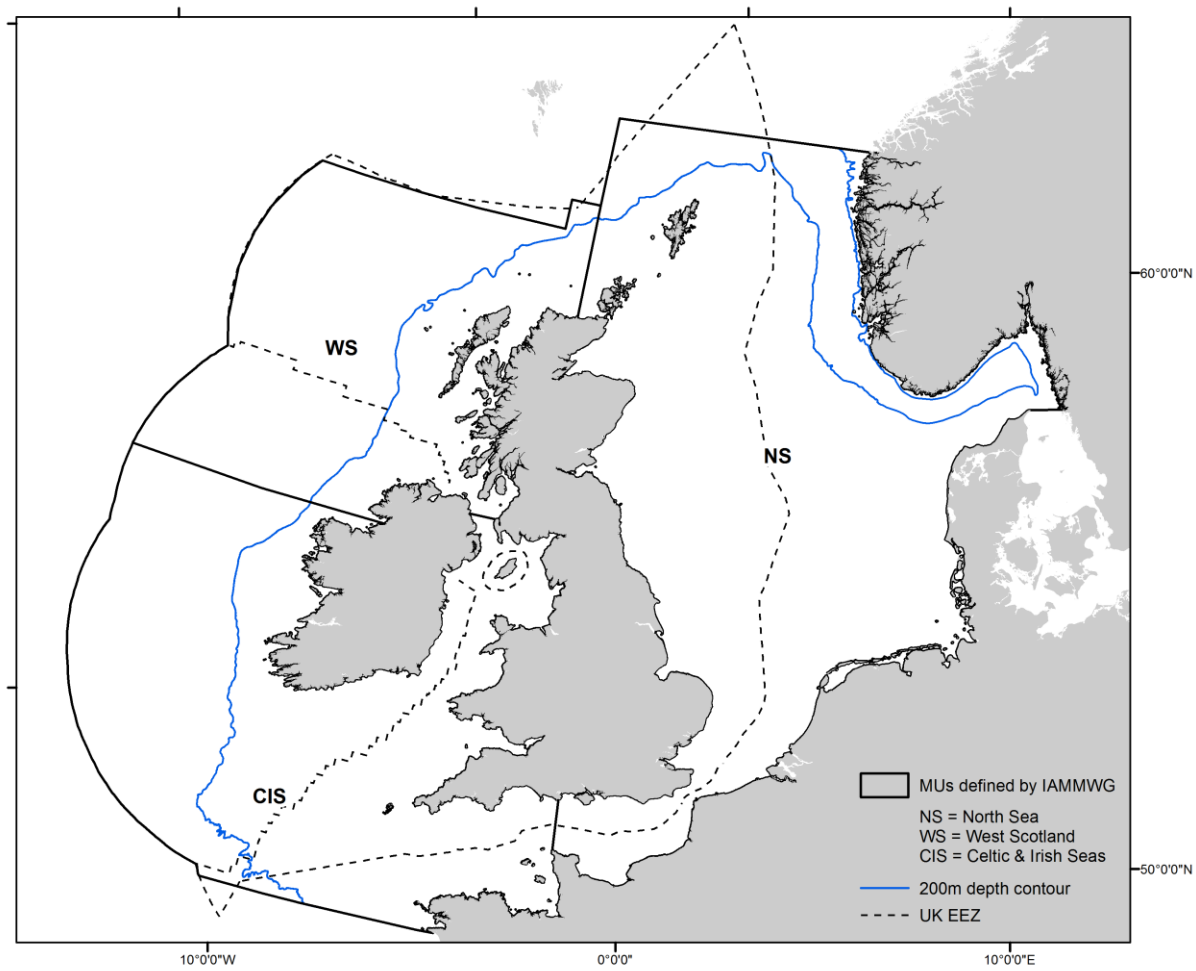

Figure 3. Harbour porpoise Management Units (MUs), noting that this species is largely confined to the continental shelf (i.e. waters <200m depth).

The abundance of harbour porpoise in these MUs is as seen in Table 1.

Table 1. Estimates of abundance of harbour porpoise in the defined Management Units (MUs).

MU	Abundance of animals in MU (CV)	95% Confidence interval for MU	Abundance of animals in the UK portion of MU (CV)	95% Confidence interval for UK portion of MU	Source
NS	227,298 (0.13)	176,360-292,948	110,433 (0.16)	80,866-150,811	Hammond *et al* 2013
WS	21,462 (0.42)	9,740-47,289	19,291 (0.49)	7,771-47,888	Hammond *et al* 2013; Macleod *et al* 2009
CIS	104,695 (0.32)	56,774-193,065	47,229 (0.32)	25,611-87,094	Hammond *et al* 2013; Macleod *et al* 2009

3.2 Common dolphin (*Delphinus delphis*)

Evidence from the UK's Stranding Scheme and the Bycatch Monitoring programme indicate that bycatch is the greatest anthropogenic pressure on this species. An estimated 322 (95% CI 172-1189) common dolphins were bycaught in UK gillnets in 2013 (Northridge *et al* 2014). Bycatch accounted for 35.7% of deaths of 129 stranded animals that received a *post mortem* between 2005 and 2010 (Deaville & Jepson 2011). This occurs almost entirely in the Celtic Sea, where the species is most common in UK waters. In addition to bycatch, 3.1% of deaths were the result of physical trauma, including vessel strike (Deaville & Jepson 2011).

Although the species has been recorded in the northern North Sea, it is uncommon there. Based on the information in the Appendix, a single MU is appropriate for this species comprising all UK waters and extending to the seaward boundary used by the European Commission for Habitats Directive reporting (area known as Marine Atlantic, termed MATL), with the eastern boundary determined by OSPAR's Regional Seas boundary (Figure 4).

The abundance of common dolphin in the Celtic and Greater North Seas (CGNS) management unit is 56,556 (CV=0.28; 95% CI=33,014-96,920). The UK component (abundance within the UK EEZ) is 13,607 (CV=0.23; 95% CI=8,720-21,234). These estimates were derived from SCANS-II (Hammond *et al* 2013) and CODA (Macleod *et al* 2009) and are likely to be biased low due to perception bias that could not be corrected for in the aerial surveys.

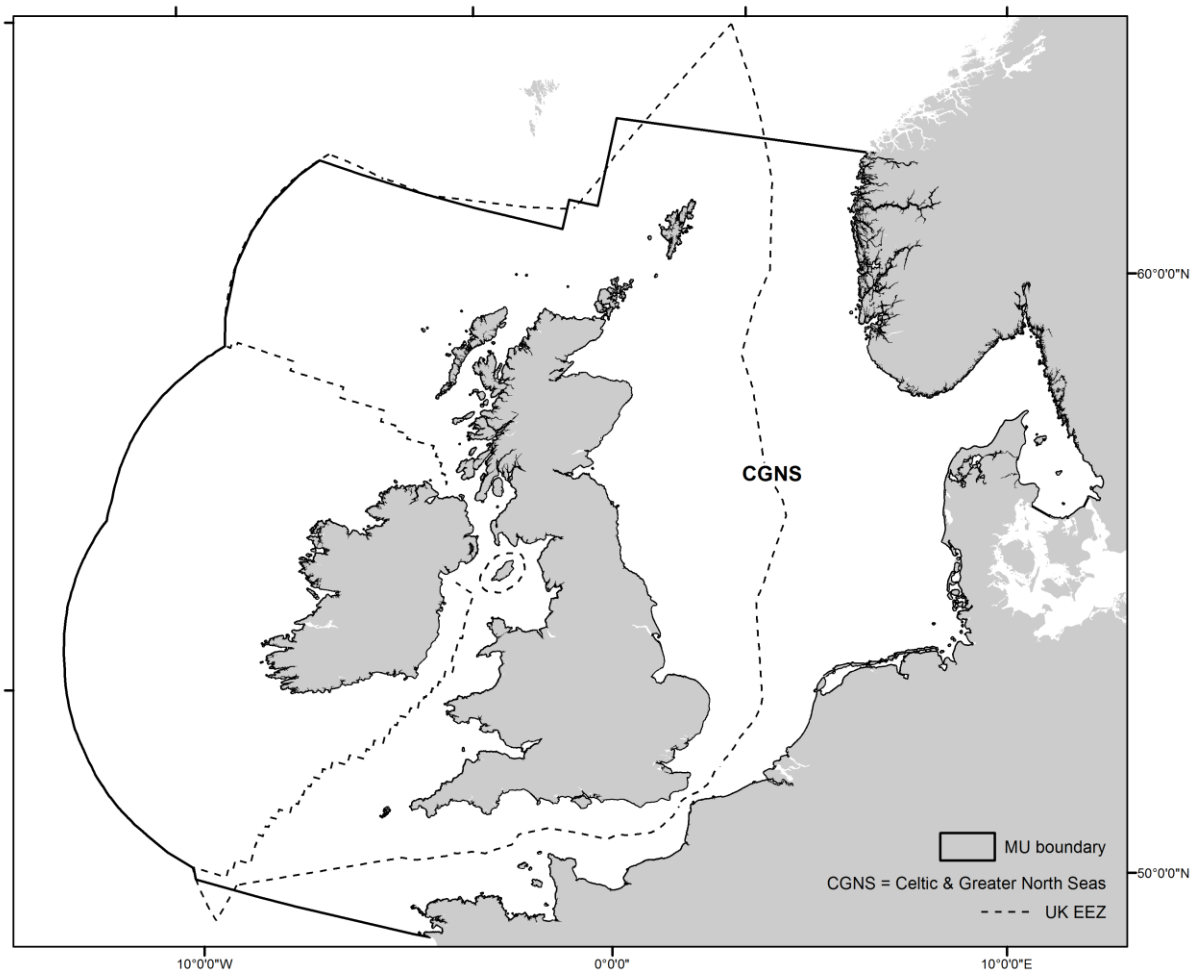

Figure 4. Common dolphin Management Unit (MU).

3.3 Bottlenose dolphin (*Tursiops truncatus)*

Between 2005 and 2010, 52 stranded bottlenose dolphins were reported, of which 18 were investigated at *post mortem*. Two of these were determined to be the result of bycatch, whilst the others were not directly linked to anthropogenic activity (Deaville & Jepson 2011). Since 2005 and the implementation of the UK's bycatch monitoring scheme, there have only been three bottlenose dolphins recorded as bycatch, most recently (2013) this occurred in demersal gillnets in the western English Channel (SMRU 2009; Northridge *et al* 2014).

A number of inshore groups have been identified in UK and Irish waters and there is limited interchange between them (see Appendix) (Robinson *et al* 2012; Cheney *et al*, 2013; ICES 2014). It is appropriate to recognise seven MUs at this time in UK waters (Figure 5):

1. Coastal West Scotland and the Hebrides (CWSH, to 12nm);

2. Coastal East Scotland (CES, to 12nm);

3. Greater North Sea (GNS, represented by ICES Area IV, excluding coastal east Scotland; and ICES area IIIa) It should be noted that very few bottlenose dolphin are seen in this area and, although there is no conclusive evidence, those seen are thought to belong to the Coastal Scottish group;

4. the Offshore Channel and SW England (OCSW) (ICES Divisions VIId to h);

5. Coastal West Channel (CWC, to 12nm);

6. Irish Sea (IS) (ICES Division VIIa);

7. Oceanic Waters (OW) (ICES Divisions VIa-b, VIIb, c, k and j, excluding coastal west Scotland).

It should be noted that there are two inshore groups of bottlenose dolphins in Irish waters, with separate MUs identified for the Shannon Estuary (SHE) and West Coast of Ireland (WCI) in the coastal region. It has been suggested that there may be an all Irish coastal population that is highly mobile, but has little interchange of animals with Welsh waters of the Irish Sea (O'Brien *et al* 2009). Table 2 provides estimates of bottlenose dolphin abundance for the seven UK MUs.

Table 2. Estimates of abundance of bottlenose dolphin in the defined Management Units (MUs).

MU	Abundance of animals in MU (CV)	95% Confidence Interval for MU	Abundance of animals in UK portion of MU (CV)	95% Confidence Interval for UK portion of MU	Source
CWSH	45	33-66	45	33-66	Cheney *et al* 2013
CES	195	162-253	195	162-253	Cheney *et al* 2013
GNS	0	0	0	0	
OCSW	4,856 (0.60)	1,638-14,398	3,014 (0.6)	1,017-8,936	Hammond *et al* 2013
CWC	100		100		Brereton *et al* 2014
IS	397 (0.23)	362-414	397 (0.23)	362-414	Evans 2012
OW	11,923 (0.21)	7,935-17,915	3,202 (0.28)	1,869-5,486	Hammond *et al* 2013; Macleod *et al* 2009

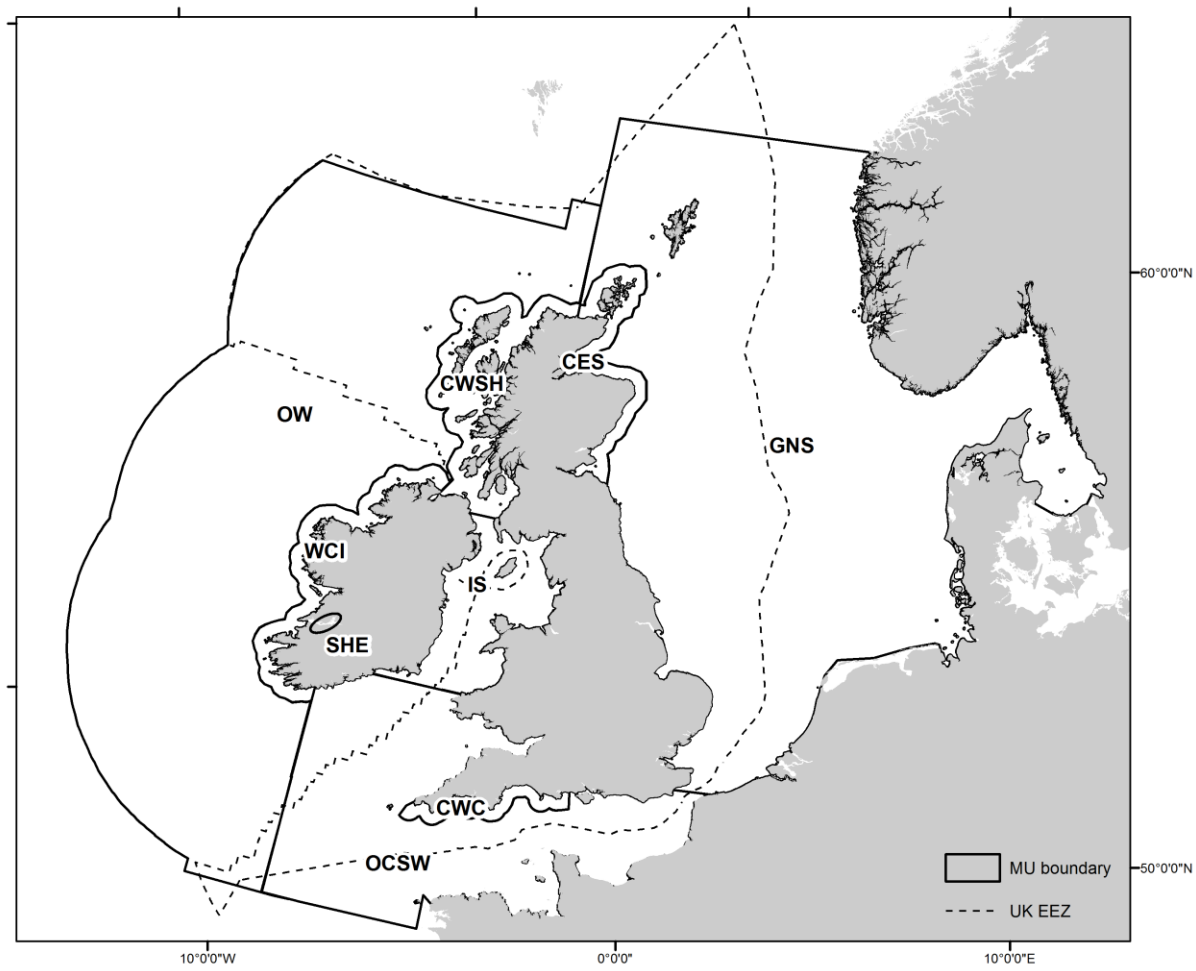

Figure 5. Bottlenose dolphin Management Units (MU). Note that for the Greater North Sea MU very few animals are seen in this area and, although there is no conclusive evidence, those seen are thought to belong to the Coastal Scottish group at this time.

3.4 White-beaked dolphin (*Lagenorhynchus albirostris*)

Between 2005 and 2010, 23 *post mortem* examinations were undertaken on white-beaked dolphins. The cause of death in about 9% of these was attributed to bycatch (Deaville & Jepson 2011). No other causes of death were obviously linked to anthropogenic activity, although about 48% were the result of live stranding (Deaville & Jepson 2011). Live strandings have been linked to anthropogenic activity in other species but there is no evidence for this in white-beaked dolphin. There has been a single record of bycatch recorded for this species (probable identification) in the UK's bycatch monitoring scheme from the northern North Sea (Northridge *et al* 2014). The main anthropogenic activity of concern for this species is likely to be acoustic disturbance. For example, the species has well-recognised negative reactions to seismic surveys, such as significant increases in fast swimming activity and declines in sightings rates during periods when airguns were firing (see Stone & Tasker 2006).

Based on the information in the Appendix, a single MU is appropriate for this species comprising all UK waters and extending to the seaward boundary used by the European Commission for Habitats Directive reporting (area known as Marine Atlantic, termed MATL) (Figure 6). However, it is worth noting that this species usually occurs on the continental shelf (i.e. in waters <200m depth) (Reid *et al* 2003).

The abundance of white-beaked dolphin in the Celtic and Greater North Seas (CGNS) management unit is 15,895 animals (CV=0.29; 95% CI=9,107-27,743). The abundance of animals in the UK EEZ is 11,694 (CV=0.30; 95% CI=6,578-20,790). The estimate was derived from the SCANS-II abundance estimates for continental shelf waters (Hammond *et al* 2013) which represent the core range for this species.

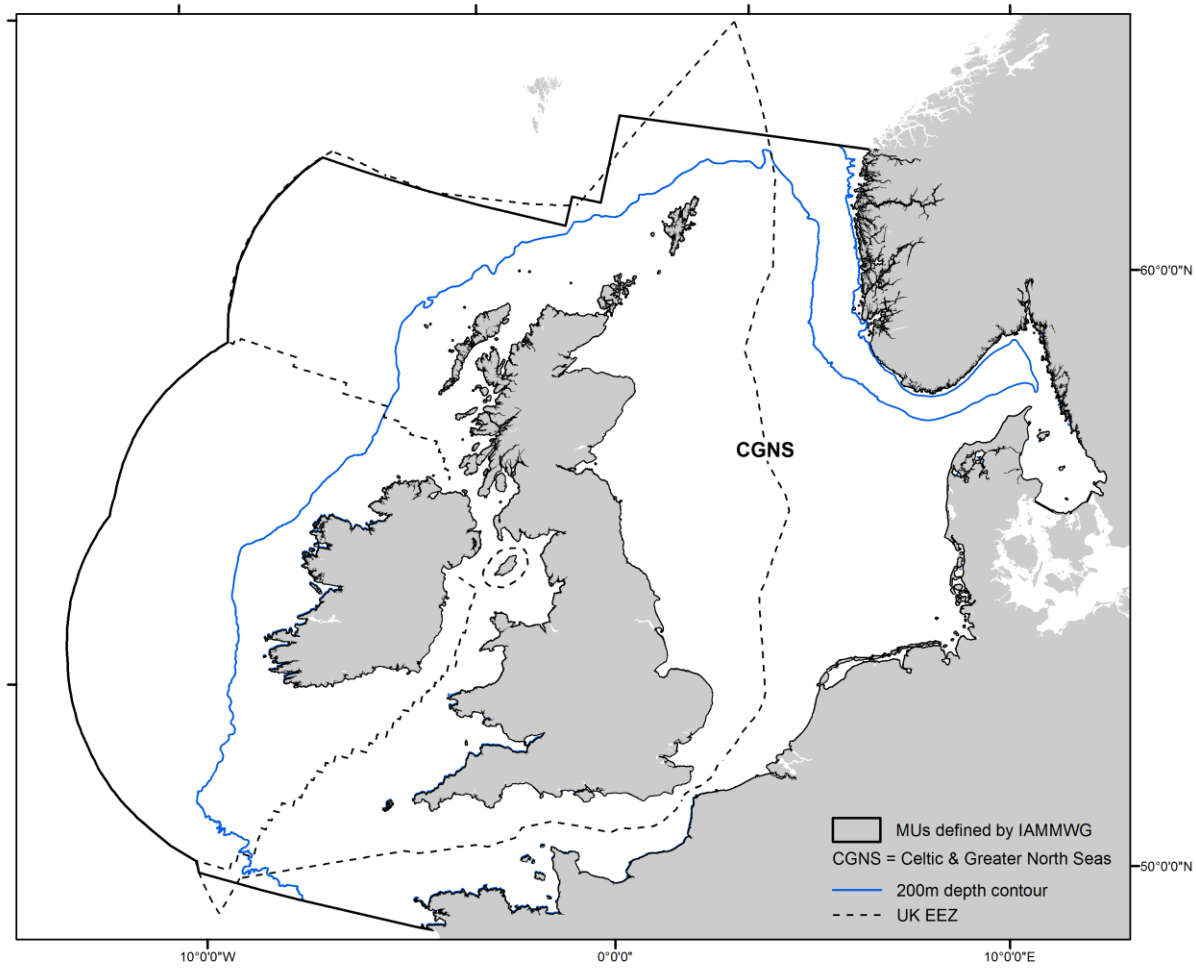

Figure 6. Management Unit (MU) for white-beaked dolphin.

3.5 White-sided dolphin (*Lagenorhynchus acutus*)

Between 2005 and 2010, 28 *post mortem* examinations were undertaken on white-sided dolphins. Although the cause of death was established in all of these, none were obviously directly linked to anthropogenic activity (Deaville & Jepson 2011). However, half the number of animals examined *post mortem* resulted from live strandings, which has been linked to some anthropogenic activities in other cetacean species, although there is no evidence for this in this species. There has been a single record of bycatch for this species (probable identification) in the UK's bycatch monitoring scheme from the northern North Sea (Northridge *et al* 2014). The main anthropogenic activity of concern for this species is likely to be acoustic disturbance, as evidenced by their negative reactions to seismic surveys, such as significant increases in fast swimming activity and declines in sightings rates during periods when airguns were firing (see Stone & Tasker 2006).

Based on the information in the Appendix, a single MU is appropriate for this species comprising all UK waters and extending to the seaward boundary used by the European Commission for Habitats Directive reporting (the area known as 'Marine Atlantic', termed MATL) (Figure 7).

The abundance of white-sided dolphins in the Celtic and Greater North Seas (CGNS) management unit is 69,293 animals (CV=0.37; 95% CI=34,339-139,828). The abundance of this species in the UK EEZ is estimated to be 46,249 (CV=0.28; 95% CI=26,993-79,243).

The estimate was derived from an analysis of SCANS-II (Hammond *et al* 2013), CODA (Macleod *et al* 2009) and T-NASS data (Hammond, SMRU, *pers. comm.*) which generated abundance of this species throughout the area covered by these surveys. The relevant areas to the MU where abundance was estimated were offshore and shelf waters west of Scotland together with the northern North Sea.

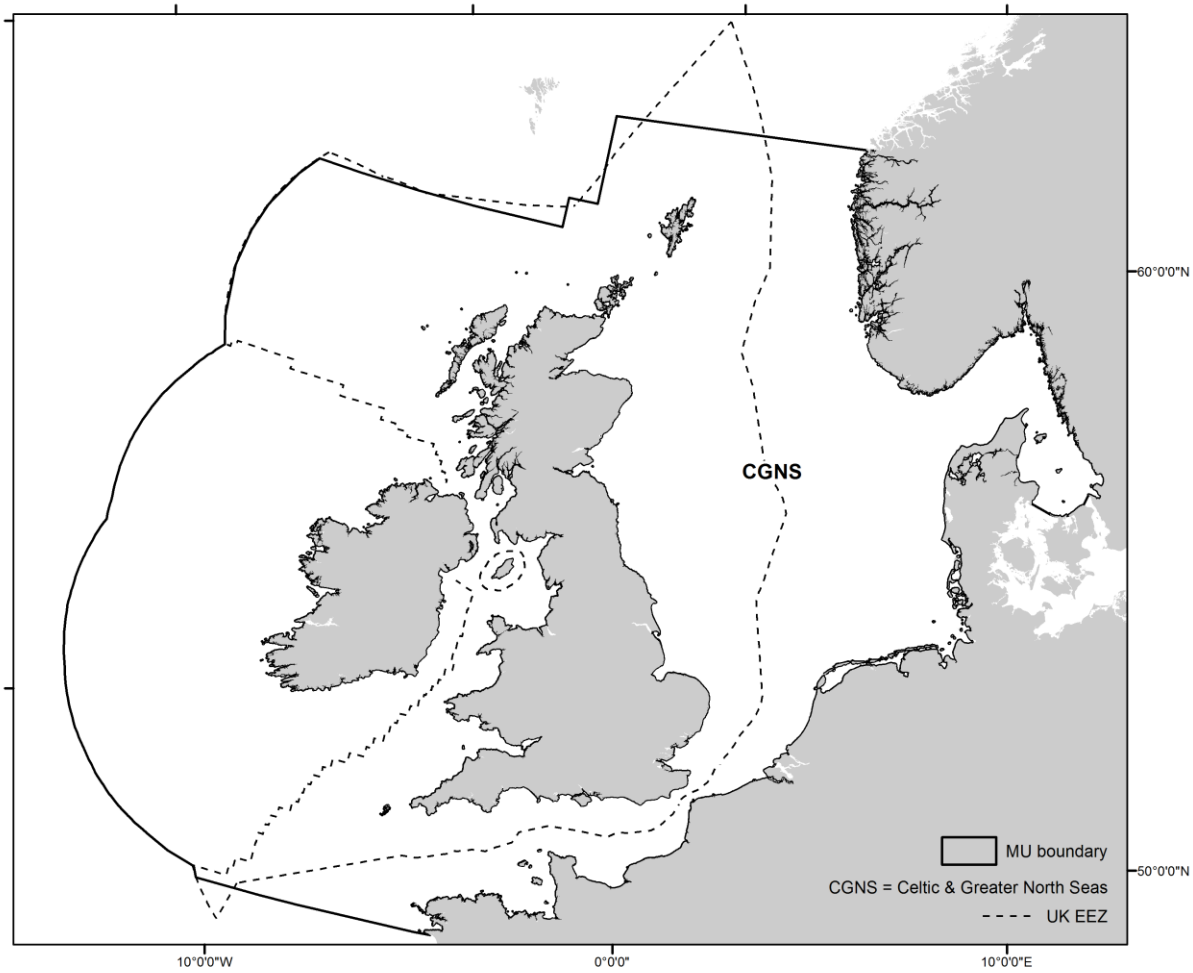

Figure 7. Management Unit (MU) for white-sided and Risso's dolphins.

3.6 Risso's dolphin (*Grampus griseus*)

Between 2005 and 2010, *post mortem* examinations were undertaken on nine of the 45 Risso's dolphins reported stranded. Of these, one was diagnosed as bycatch, three were the consequence of live-stranding and one died as a result of gas embolism (Deaville & Jepson 2011). The causes of gas embolism are generally thought to be related to sudden surfacing as a consequence of anthropogenic activities generating noise (Fernandez *et al* 2005; Jepson *et al* 2005). However, in this case, no direct link with anthropogenic activities was established. There have been no records of bycatch recorded for this species in the UK's bycatch monitoring scheme.

Risso's dolphins are most commonly sighted in the west, particularly around the Hebrides and also, seasonally, in the Celtic and Irish Seas. Based on the information in the Appendix, a single MU, comprising all UK waters and extending to the seaward boundary used by the European Commission for Habitats Directive reporting (the area known as 'Marine Atlantic', termed MATL) is appropriate at this time (Figure 7). There is no current abundance estimate available for this species.

3.7 Minke whale (*Balaenoptera acutorostrata*)

Limited *post mortem* data from the UK stranding scheme (11 conducted between 2005 and 2010) indicate that the greatest anthropogenic pressure on minke whales is entanglement in ropes/lines possibly associated with pot fisheries, accounting for three cases of deaths determined by *post mortem* examination (Northridge *et al* 2010; Deaville & Jepson 2011). Vessel strike was also recorded as the cause of death in about a tenth of the examinations (Deaville & Jepson 2011).

Based on the information in the Appendix, and with limited data on anthropogenic threats, a single MU is appropriate for minke whales in European waters at this time (Figure 8).

The abundance of minke whales in the Celtic and Greater North Seas (CGNS) management unit is 23,528 animals (CV=0.27; 95% CI=13,989-39,572). The abundance of minke whales in the UK EEZ is estimated to be 12,295 (CV=0.28; 95% CI=7,176-21,066). The estimate was derived from SCANS-II (Hammond *et al* 2013) and CODA (Macleod *et al* 2009) and is likely to be underestimated because the SCANS-II estimate was not corrected for perception bias in the aerial surveys and the CODA estimate was not corrected for perception or availability biases. It should be noted that the abundance of minke whales is highly seasonal, with abundance peaking during migration south into waters around the UK for summer.

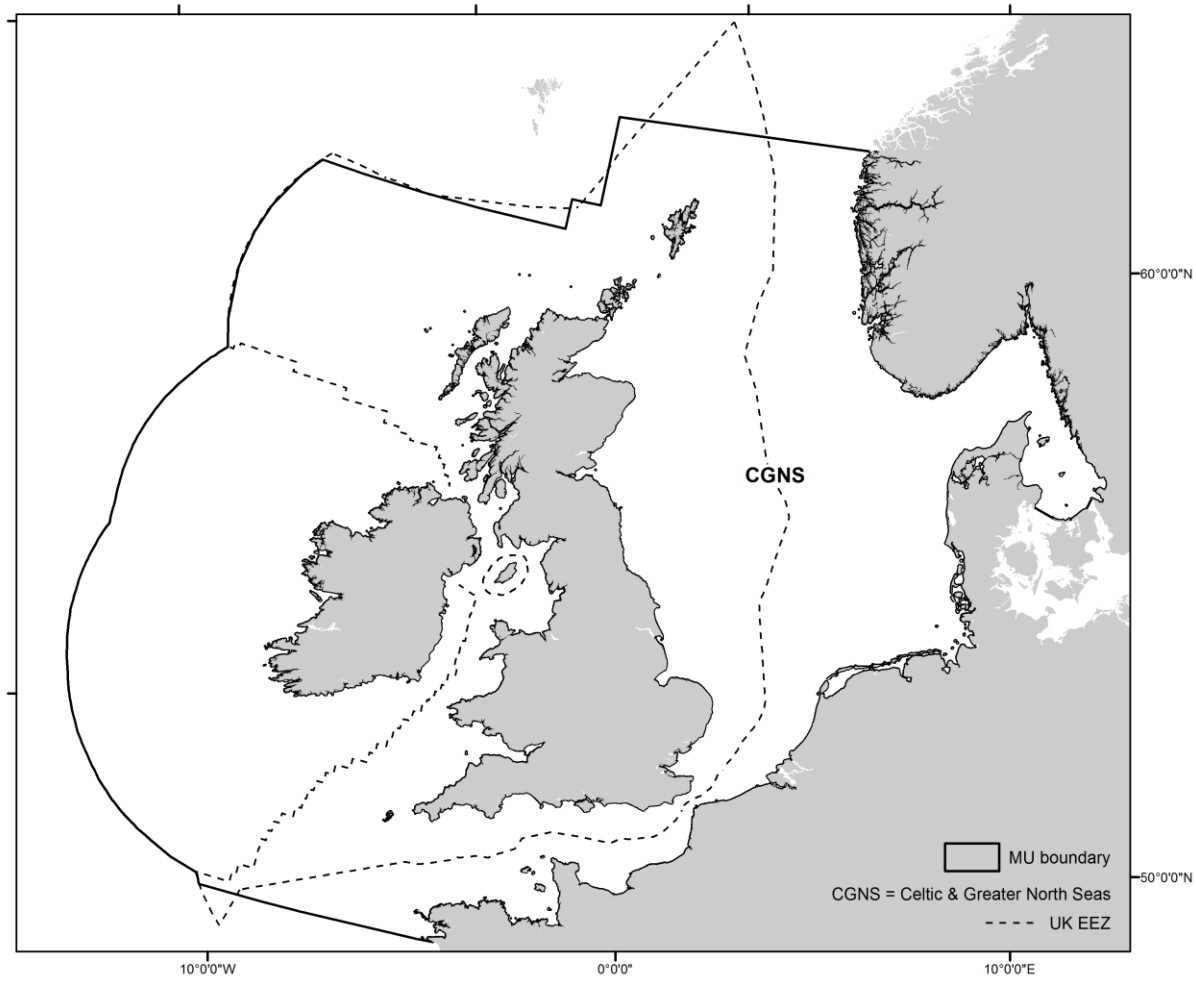

Figure 8. Management Unit (MU) for minke whale.

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Appendix: Review of available information in populations and subpopulations by species

Definitions

For the purposes of this review the following definitions were used:

A ***species*** is a specifically named taxonomic group of living organisms (e.g. animals and plants) of the same kind which are capable of producing fertile offspring but are predominantly reproductively isolated from other organisms.

A ***population*** is a collection of individuals all of the same species with a tendency to be found in the same area. Populations contain *genetic variation* within the population itself, and between other populations. Populations can exist in isolation, or can co-exist at least during a part of the year with other conspecific populations (i.e. other populations of the same species) in the same area.

A ***Management Unit*** (MU) typically refers to a geographical area in which the animals of a particular species are found to which management of human activities is applied. An MU may be smaller than what is believed to be the overall area frequented by a 'population' (see above) to reflect differences in spatial preferences of individuals (which constitutes an '***ecological unit***', see Evans & Teilmann 2009; Evans 2012) and/or spatial differences in human activities. However, what matters in the context of management is whether human activities could impact individuals from different populations differentially if no structure were imposed by MUs. For example, if fisheries bycatch of a particular species were concentrated in an area to which individual animals had a preference to return over a period of their lifetime, this may lead to local depletion in that area which could be justified as an MU. However, if other individuals of the species replaced the removed animals quickly, there may be no local impact and no separate MU would be necessary. If MUs are defined to be smaller than a population, it is important that management takes into account the rates of interchange of individuals between MUs; that is, the MUs should not be treated as if they were demographically independent.

Defining management units in practice

In 2007, ASCOBANS/HELCOM convened a workshop on small cetacean population structure for the ASCOBANS area (Evans & Teilmann 2009), the report of which provides a useful summary of how information on population structure can be used to determine ecological units (which they termed 'management units') and the multiple difficulties inherent in trying to achieve this. In specifying how the available information had been used to propose ecological units for small cetacean species, Evans and Teilmann (2009) stated:

> "*In general, the integration of both genetic and ecological markers is necessary to obtain the best possible indication of relevant stock structure. A major challenge that still needs fully addressing is how to integrate these rather different lines of evidence, and what time frame is most appropriate to consider here in the context of conservation management'.*

In 2012, 2013 and 2014, the ICES Working Group on Marine Mammal Ecology (WGMME) undertook reviews of current information on the population structure and management units of harbour porpoise, common dolphin, bottlenose dolphin, white-beaked dolphin, white-sided dolphin and minke whale in the ICES area. One of their overarching recommendations was that the delineation of management units for marine mammals should be aligned with the

ICES Subareas and/or Divisions (Figure 2) which are used for the implementation of fisheries management measures due to the significance of bycatch as the most important anthropogenic cause of death in the more common species. Subsequently, ICES provided advice to the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) on appropriate assessment units for cetaceans (ICES 2014).

Species Reviews

Harbour porpoise (*Phocoena phocoena*)

There has been much debate regarding the population structure of harbour porpoises in the eastern North Atlantic. Most studies to date indicate that the genetic variation is greater in females than males, suggesting that females are more philopatric than males. Although earlier work (Walton 1997; Tolley *et al* 1999; Andersen *et al* 2001) hinted at some differentiation, harbour porpoises within the eastern North Atlantic are generally considered to behave as a 'continuous' population that extends from the French coasts of the Bay of Biscay northwards to the arctic waters of Norway and Iceland (Tolley & Rosel 2006; Fontaine *et al* 2007, 2014). However, for conservation and management purposes, it is useful to divide this population into smaller units.

The ASCOBANS-HELCOM small cetacean population structure workshop proposed twelve ecological units in the central/eastern North Atlantic (Figure 1A) although the boundaries between these were not clearly defined. The workshop proposed the separation of the North Sea into two separate ecological units, but noted that the evidence was insufficient to define boundaries between any (sub-) populations at that time. Based on these and other findings, Murphy (2008) proposed that the UK should recognise two management units, namely an English North Sea and a western UK group comprised of the Irish Sea, Celtic Sea and western English Channel.

In 2012, WGMME reviewed these proposals and, with the exception of the splitting of North Sea into two regions, generally agreed with them. Regarding the two ecological units proposed for the North Sea, WGMME 2012 noted *'(a) the very strong difference in distribution of harbour porpoises in the North Sea observed in SCANS-II 2005 compared to SCANS in 1994; (b) the near continuous distribution of SCANS-II sightings across the southern and central North Sea and up the east coast of the UK (Figure* 2A*); and (c) the widespread movements of animals radio-tagged off northern Jutland across the central and northern North Sea (Figure* 3A*). Splitting the North Sea into two Management Units is therefore not supported by the data.*

There was also some discussion regarding the possible division of the Celtic Sea (plus SW Ireland, Irish Sea and western Channel) MU into Celtic and Irish Sea and some concern of the separation of the Northwest Ireland and West Scotland MU from the Celtic Sea.'

WGMME (2012) recommended that harbour porpoise MUs be proposed for the Iberian Peninsula, Bay of Biscay, Celtic Sea (including SW Ireland, Irish Sea and Western Channel) and NW Ireland/West Scotland and the North Sea.

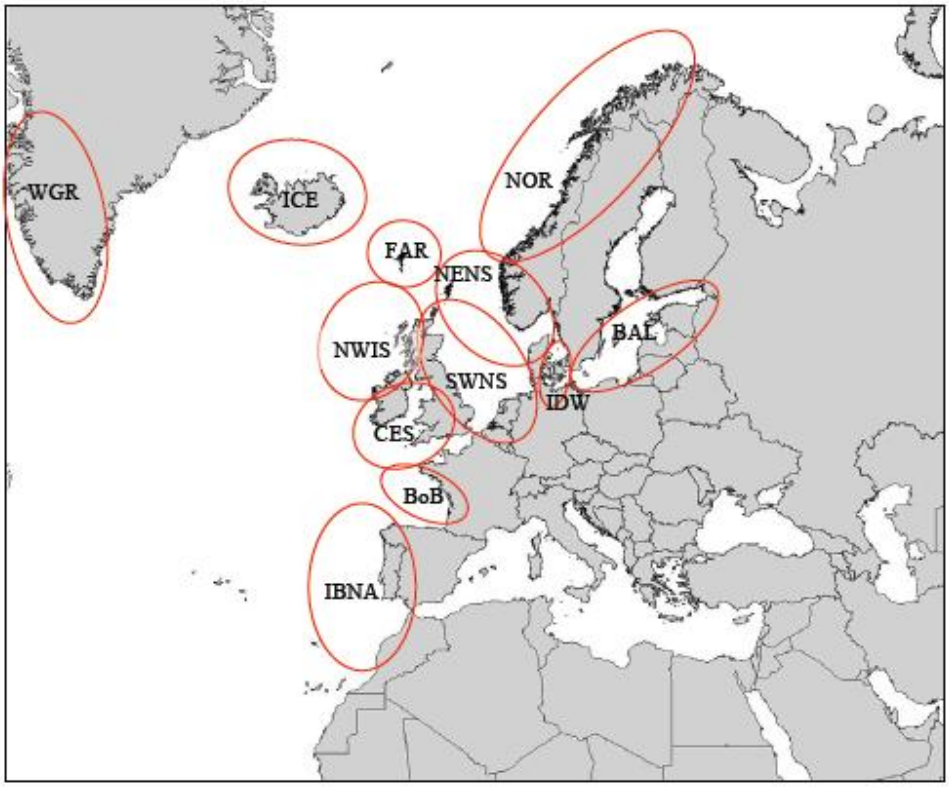

Figure A1. ASCOBANS proposed harbour porpoise ecological units (taken from Evans & Teilmann 2009). WGR–West Greenland, ICE–Iceland, FAR–Faroe Islands, NOR–North-west/Central Norway and Barents Sea, NENS–North-eastern North Sea and Skagerrak, SWNS–South-western North Sea and Eastern Channel, IDW–Inner Danish Waters, BAL–Baltic Sea, CES–Celtic Sea (plus SW Ireland, Irish Sea and western Channel), NWIS–Northwest Ireland and West Scotland, BoB–Bay of Biscay (west France), IBNA–Iberian Peninsula (NW Spain, Portugal and NW Africa).

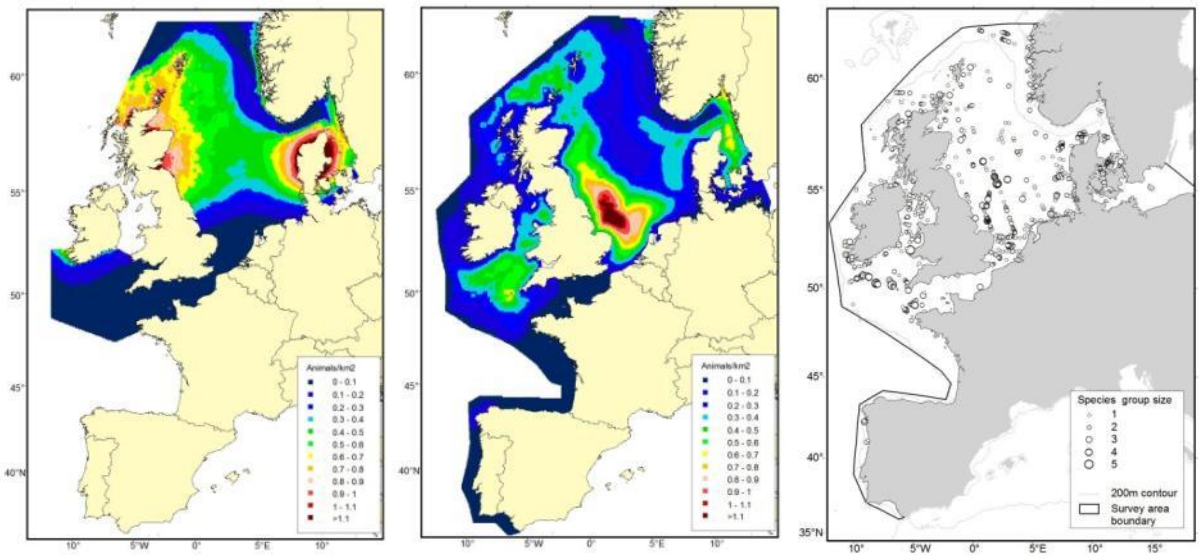

Figure A2. Modelled distribution of harbour porpoises in the European Atlantic from SCANS surveys in 1994 and SCANS-II surveys in 2005 and distribution of harbour porpoise sightings from SCANS-II (from Hammond *et al* 2013).

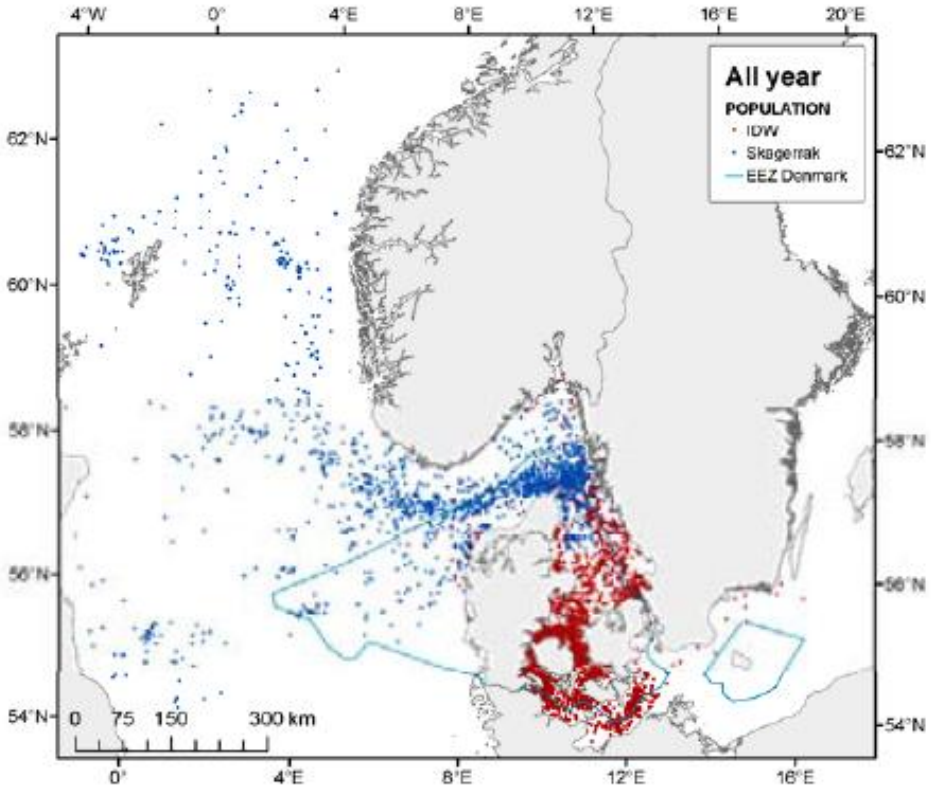

Figure A3. Locations (one per day) of 63 radio tagged porpoises. Porpoises tagged in the IDW are red and those tagged at the tip of Jutland are blue (N=63, n=4287 locations)(taken from Evans & Teilmann 2009).

Evans (2012) recommended that Welsh waters comprised a single ecological unit: Celtic Sea. This was considered broadly to equate to Irish Sea, Celtic Sea, Western English Channel and South-west Ireland, although boundaries have not been clearly determined. This was based on differentiation from other areas identified using mitochondrial DNA, micro-satellites, skeletal variation, tooth ultrastructure, as well as dietary and contaminant load differences (see Evans & Teilmann 2009 for further details). Subsequently, De Luna *et al* (2012) examined potential harbour porpoise stock structure, combining genetic analyses and morphological traits, and identified three subpopulations. These were the Inner Danish waters, Norwegian waters and British waters. Although slight differentiation was noted between animals to the west of the UK from those in the British North Sea, it was not found to be statistically significant.

Northridge (2012) presents a further assessment of harbour porpoise population structure for Scottish waters in particular. He notes that '*it is not helpful to think of managing porpoises in discrete populations. Management 'stocks' or units may help from a practical perspective, but degree of fluidity between groups suggests keeping large stock areas is most sensible. Nevertheless, most authors support a distinction between North Sea (including Northern Isles) and the west coast of Scotland*'. Northridge (2012) also supported WGMME's conclusions that the North Sea represented a single management unit.

WGMME (2013) revisited the issue of harbour porpoise management units focusing, in particular, on the area to the west of Britain and Ireland as well as wider European waters. It was concluded that the proposals put forward in 2012 did not need to be updated at that time. Following an OSPAR request to ICES for advice on suitable marine mammal assessment units for MSFD reporting, WGMME (2014) revisited the harbour porpoise management units. Slight amendments were made to the original proposals, aligning the North Sea MU boundary in the Skagerrak with that of the ASCOBANS North Sea

conservation plan for harbour porpoises[1] and aligning the boundary between the Iberian MU and the Celtic and Irish Seas MU with the national EEZ boundary. These proposals were issued as ICES advice to OSPAR (Figure 4A; ICES 2014) and underpin the UK MUs.

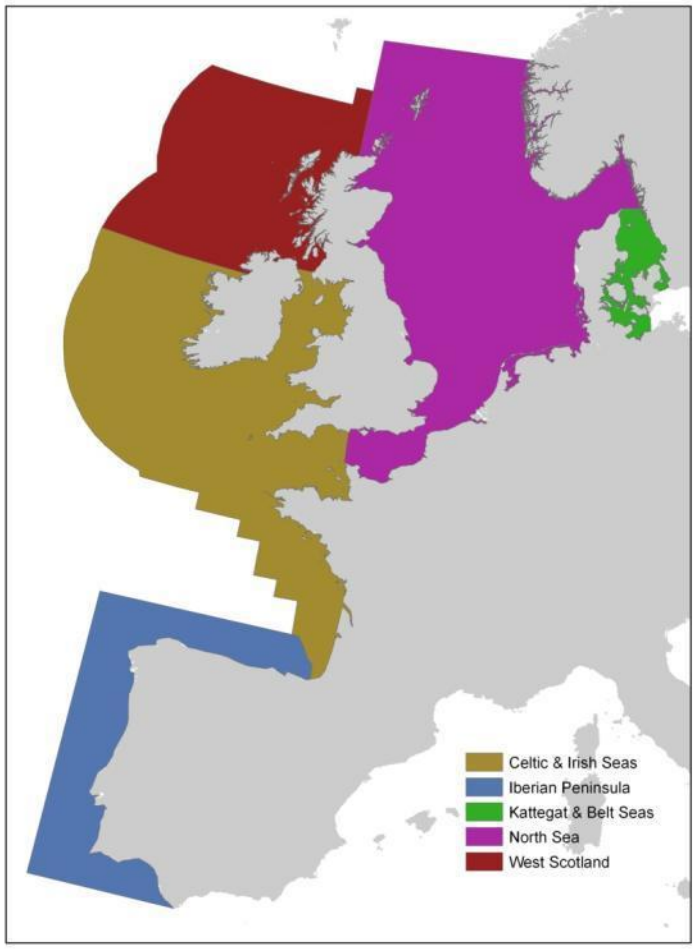

Figure A4. Management Units proposed for harbour porpoise (ICES 2014).

Common dolphin (*Delphinus delphis*)

The ASCOBANS-HELCOM workshop concluded that there was little evidence of genetic structuring in the North-east Atlantic, to enable the identification of potential sub-populations (Evans & Teilmann 2009). Rather, it indicated that there was a single population, ranging from waters off Scotland to Portugal, but with separate populations in the North-west Atlantic, and Mediterranean Sea (Figure 5A). It further proposed that, due to the low genetic differentiation in this species, common dolphins in the North-east Atlantic should be managed using an ecological unit approach. WGMME (2012) concluded that, although stable isotope and contaminant analyses suggest there may be some structuring of common dolphin populations within this region (see Caurant *et al* 2009), with the possible existence of neritic and oceanic ecological stocks, at present there are insufficient data to verify this or to designate separate ecological units. Based on the available information, WGMME (2012) concluded that the European North Atlantic common dolphins were considered to represent a single Management Unit. Moura *et al* (2013) also noted a lack of differentiation, so WGMME (2013) affirmed the proposed single MU for this species. Following an OSPAR request to ICES for advice on suitable marine mammal assessment units for MSFD reporting, WGMME (2014) revisited the common dolphin Management Unit and concluded

[1] See http://www.ascobans.org/sites/default/files/document/MOP6_7-02_NorthSeaConservationPlan_1.pdf

no changes were necessary. The proposal was issued as ICES advice to OSPAR (ICES 2014) and used to define the UK MU.

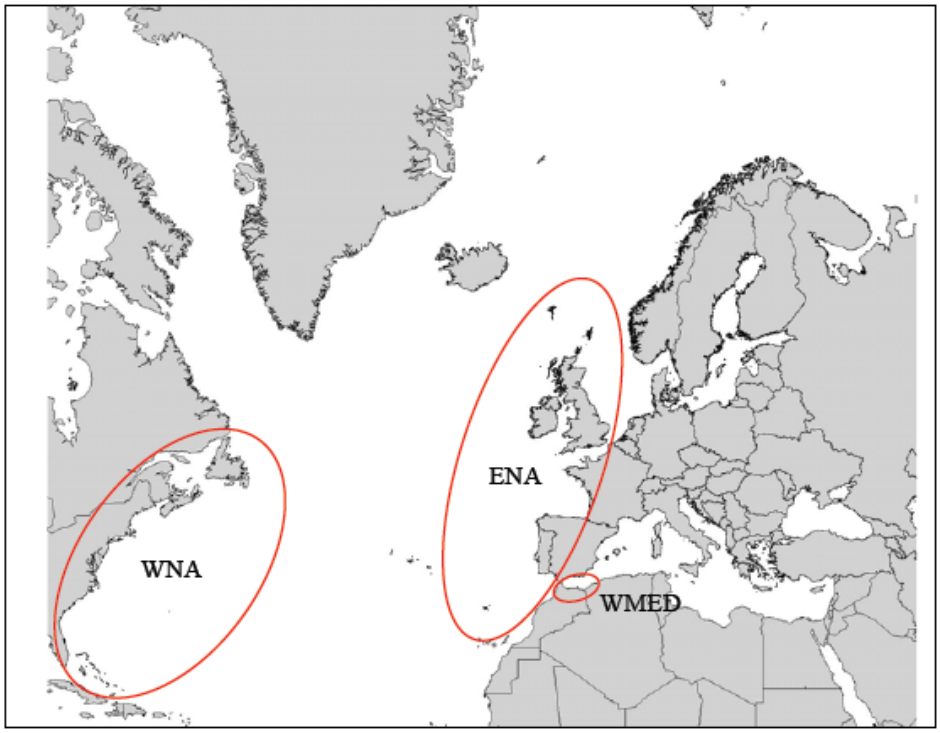

Figure A5. ASCOBANS recommended ecological units for common dolphin (taken from Evans & Teilmann 2009). WNA–Western North Atlantic, ENA–Eastern North Atlantic, WMED–western Mediterranean Sea.

Bottlenose dolphin (*Tursiops truncatus)*

Bottlenose dolphins are wide-spread and have recognised inshore populations as well as occurring offshore, particularly along the shelf edge (Reid *et al* 2003). This offshore population may enter near-shore waters on a seasonal basis (Reid *et al* 2003; Certain *et al* 2008). Divisions between populations have been difficult to clearly delineate. Parsons *et al* (2002) noted that the inshore Moray Firth population was more closely related to the inshore Welsh community than to its nearest neighbours in western Scotland, whereas Nichols *et al* (2007) noted that the individuals that used to reside in and around the Humber Estuary were a genetically distinct group separate from those in the Moray Firth.

The ASCOBANS-HELCOM small cetacean population structure workshop proposed 12 provisional ecological units based predominantly on photo-ID data (Figure 6A; Evans & Teilmann 2009). These units were the offshore Atlantic Europe, North Sea, Outer Hebrides, Inner Hebrides, Irish Sea, Southern England, Northern France/Channel Islands, Shannon Estuary (Ireland), Western Ireland, Brittany, South Galicia, and Sado Estuary (Portugal). Cheney *et al* (2013) proposed the presence of three parapatric populations of bottlenose dolphins in Scottish coastal waters, each of a different size and with marked contrasts in their ranging patterns. On the west coast, there are two small and socially segregated populations of dolphins, one of which includes approximately 15 individuals that have only been recorded in the waters of the Sound of Barra, whereas the other is double that size and ranges more widely throughout the Inner Hebrides and mainland coasts. On the east coast, there is a population of nearly 200 interacting dolphins between the Moray Firth, Fife and, recently, northern England. Analyses of photo-identification data from multiple studies have documented that some bottlenose dolphins make long-distance movements between the

east and west coasts of Scotland to Irish waters (Robinson *et al* 2012). Exchanges between the offshore and inshore animals, such as those noted in Ireland (Mirimim *et al* 2011a) have yet to be identified and/or quantified.

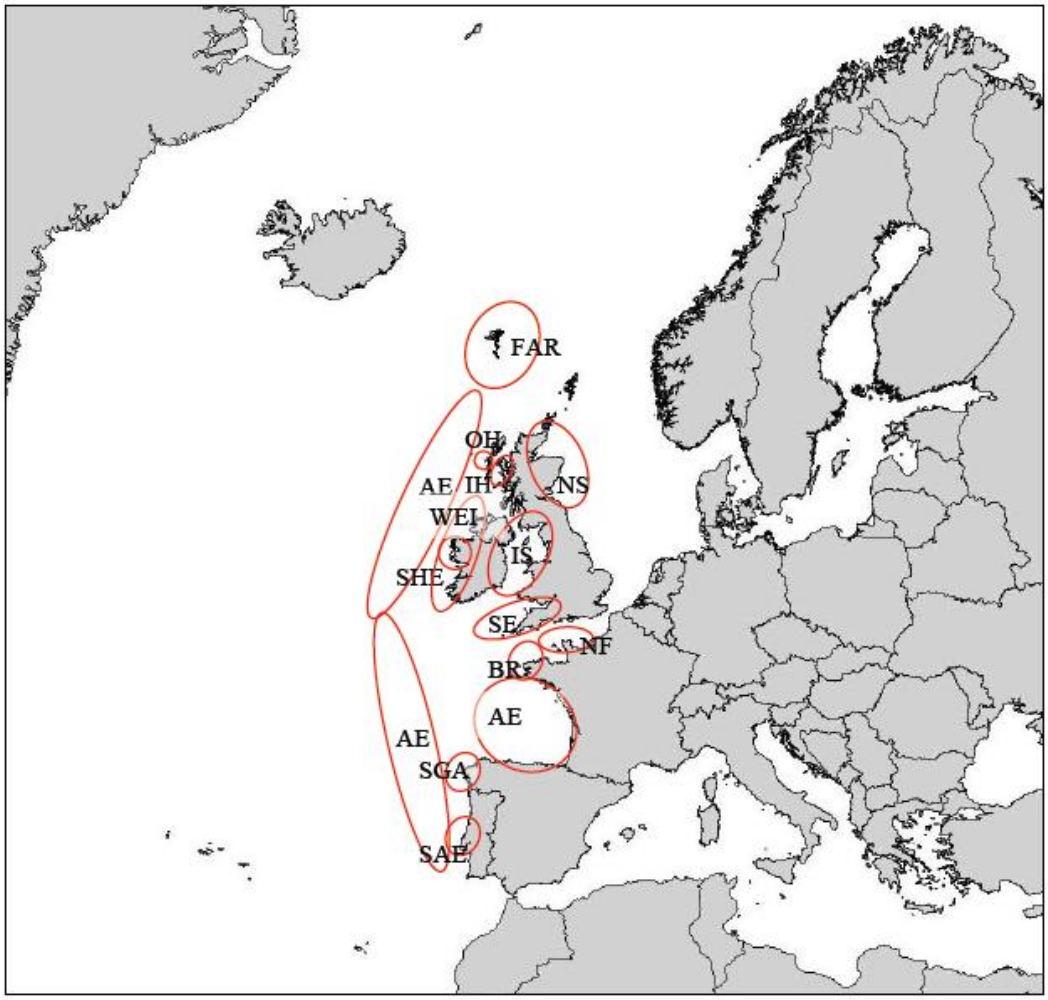

Figure A6. ASCOBANS recommended ecological units for bottlenose dolphin (taken from Evans & Teilmann 2009). AE–Atlantic Europe, NS–North Sea, OH–Outer Hebrides, IH–Inner Hebrides, IS–Irish Sea, SE Southern England, NF–Northern France/Channel Islands, SHE–Shannon Estuary (Ireland), WEI–Western Ireland, BR–Brittany, SGA–South Galicia, SAE–Sado Estuary (Portugal).

In Welsh waters, the inshore population is centred on Cardigan Bay, but recent studies have noted that a substantial portion of this population ranges during the winter over much wider areas, often moving into waters off North Wales and to the Isle of Man (Evans 2011). Evans (2012) concluded that the bottlenose dolphins in the Irish Sea should be considered to form a single ecological unit. However, it was noted that this may need to be further sub-division, reflecting different patterns of movement. Some individuals appear to be resident; others range seasonally over much wider areas; and a third grouping may not belong to Welsh waters but be transient visitors (Pesante *et al* 2008).

In Irish waters, evidence suggests that an all Irish coastal population may exist with little interchange of animals into Welsh waters (O'Brien *et al* 2009). The proposed MUs could be revised in the future in line with additional evidence.

Bottlenose dolphins are also regularly recorded off south-west England (Wood 1998; Doyle *et al* 2007; Brereton *et al* 2014), although numbers have fluctuated over the years with a complete absence of the species for several decades (Tregenza 1992; Wood 1998). Similar

to other parts of the UK, these animals are considered to be a combination of transients, occasional visitors and residents (Brereton *et al* 2014). Links between these animals and those in Wales and France have been recorded (Wood 1998; Brereton *et al* 2014).

Given the current understanding of bottlenose dolphin genetics and movements, WGMME (2012) proposed that the ecological units defined by Evans and Teilmann (2009) should be utilised. WGMME (2013) noted that defining MUs at an appropriate scale for this species was a significant challenge. Broadly, bottlenose dolphins can be divided into three types or groups related to their patterns of mobility and habitat use: resident, coastal and oceanic (Figure 7A). WGMME (2013) proposed that resident groups were Barra (Scotland; although for management purposes this group is included within the wider Scottish west coast group); Shannon Estuary (Ireland); Ile de Sein (France); Archipel de Molene (France); southern Galician Rias (NW Spain); Sado Estuary (Portugal). The coastal groups were identified as: west of coast Scotland (UK); east coast of Scotland (UK); Irish Sea (Ireland and UK); Connemara–Mayo (northern and western coasts of Ireland); the English Channel/Celtic Sea (Ireland, UK and France); northern coast of Spain; coast of Portugal (except for the Sado Estuary); the Azores (Portugal); Gulf of Cadiz (southern coast of Spain) and Strait of Gibraltar (southern coast of Spain). The oceanic waters comprised a single MU for all continental shelf/slopes/oceanic waters outside 12nm from the coast. It was noted however that although a separate MU was 'designated' for the North Sea (represented by ICES Area IV, excluding coastal east Scotland), very few bottlenose dolphin are seen in this area. Although there is no conclusive evidence, those seen were thought most likely to belong to the East Scottish coastal group.

Following an OSPAR request to ICES for advice on suitable marine mammal assessment units for MSFD reporting, WGMME (2014) revisited the bottlenose dolphin management units. ICES advice to OSPAR (ICES 2014) notes that within the Marine Atlantic biogeographic region, there was evidence to support 10 separate sub-populations (Figure 7A). ICES (2014) states that this was not a comprehensive list of coastal groups and that should further research reveal either changes in boundaries to the above units or additions to them, OSPAR should amend the list of assessment units. It was also noted that bottlenose dolphins occur in offshore waters and that an assessment unit could be added to reflect this, although current data indicate that these animals range beyond the boundaries of the MSFD assessment area. Whilst largely following this advice, the SNCBs decided that it was necessary to identify an MU for the offshore animals.

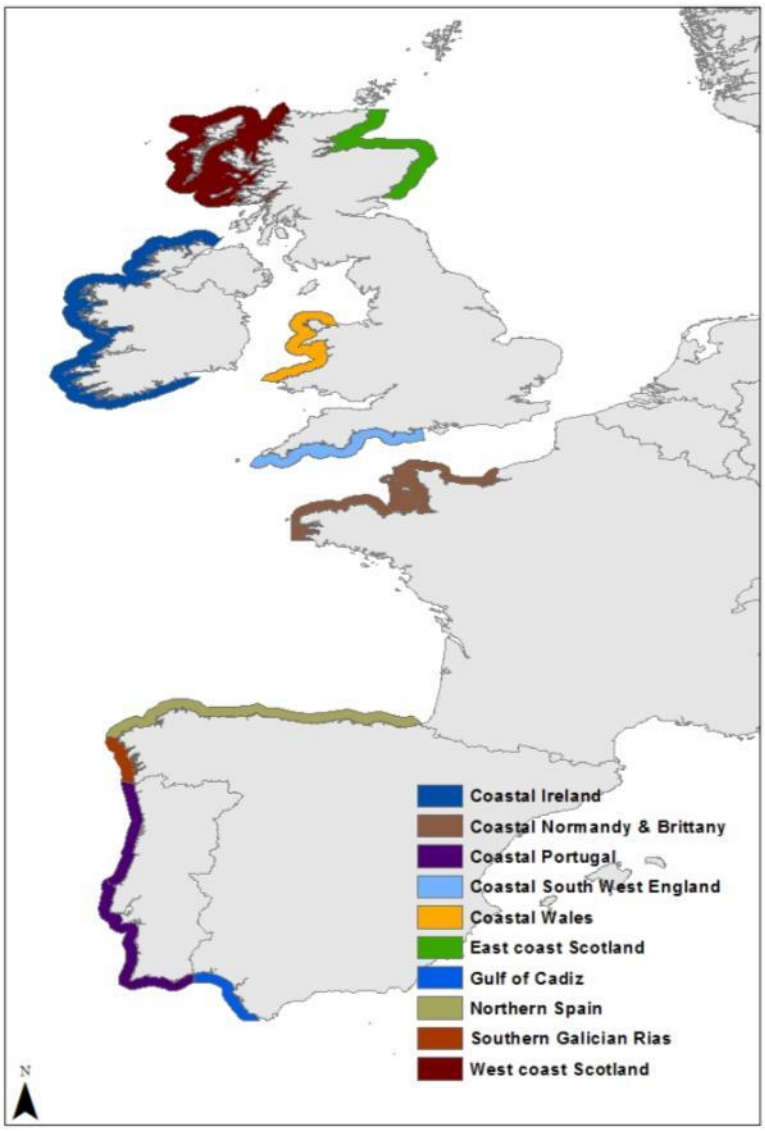

Figure A7. Bottlenose dolphin Management Units (ICES 2014).

White-beaked dolphin (*Lagenorhynchus albirostris*)

In the eastern North Atlantic, the ASCOBANS-HELCOM workshop (Evans & Teilmann 2009) found evidence for considering white-beaked dolphins from the northernmost part of Norway as a distinct ecological unit, but noted that individuals from all Norwegian coastal areas (north to south) appear to form a continuous and differentiated population that may be considered as a single separate unit, although more studies in the southern coastal areas of Norway is necessary to corroborate this (Figure 8A). Photo-identification had also revealed matches between Scottish waters and the Danish North Sea and Skagerrak (Kinze 2009).

WGMME (2012) proposed that there were three MUs for white-beaked dolphins in the eastern North Atlantic: a) northern Norwegian coast, b) waters around Britain and Ireland, and c) waters around Iceland. This was reaffirmed by WGMME (2013). Following an OSPAR request to ICES for advice on suitable marine mammal assessment units for MSFD reporting, WGMME (2014) revisited the white-beaked dolphin management unit and concluded no changes were necessary. The proposal was issued as ICES advice to OSPAR (ICES 2014) and underpins the UK MU.

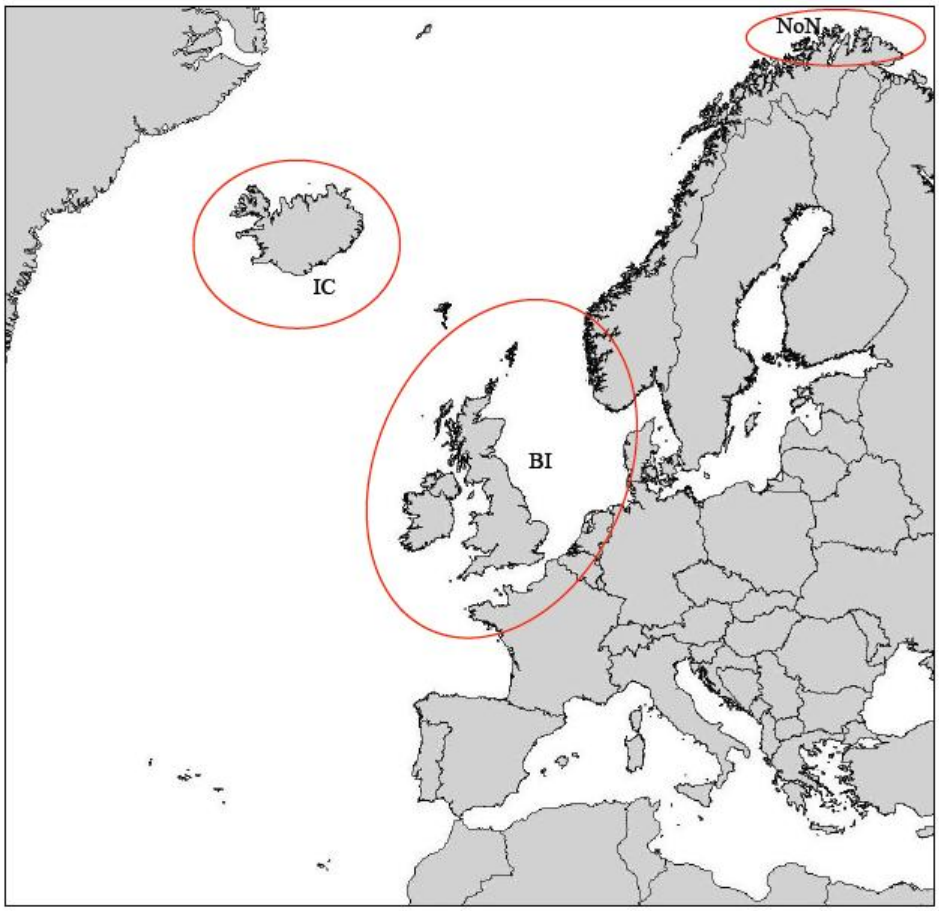

Figure A8. ASCOBANS recommended ecological units for white beaked dolphin (taken from Evans & Teilmann 2009). IC–Iceland, BI–British and Irish waters, NoN–northern Norway.

White-sided dolphin (*Lagenorhynchus acutus*)

The ASCOBANS-HELCOM workshop proposed at least four ecological units for the white-sided dolphin in the North Atlantic but noted that these may change if the number of sampling regions is increased (Figure 9A). The four ecological units proposed were: a) North-eastern North Atlantic including the northern North Sea; b) Central eastern North Atlantic including the Celtic Sea and Western English Channel; c) Gulf of Maine; and d) Cape Cod.

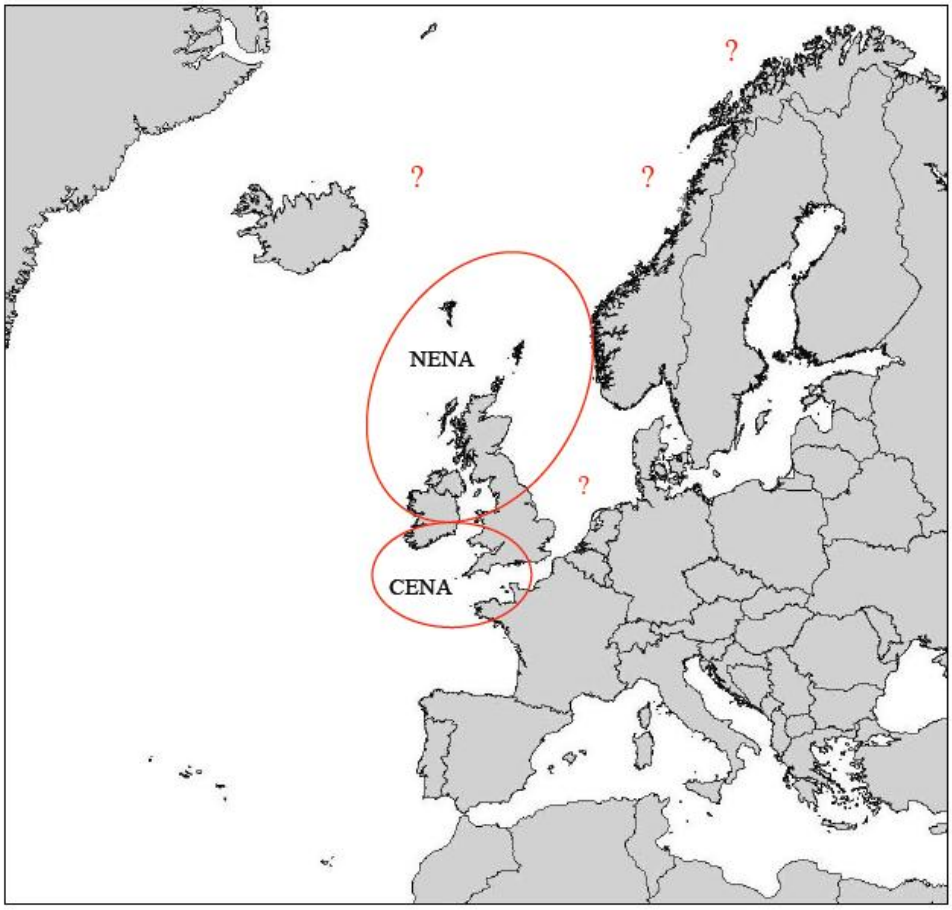

Figure A9. ASCOBANS recommended ecological units for white-sided dolphin (taken from Evans & Teilmann 2009). NENA–North-eastern North Atlantic including the northern North Sea; CENA-Central eastern North Atlantic including the Celtic Sea and Western English Channel.

Banguera-Hinestroza *et al* (2010) analysed genetic variation at the mitochondrial (mtDNA) control region for 344 white-sided dolphin samples in the North Atlantic. The analyses showed high haplotypic diversity (Hd) at mtDNA (0.927±0.007), but relatively low nucleotide diversity (0.00891±0.0003). These findings suggest a pattern of genetic diversity congruent with an ancient bottleneck followed by an expansion in range in most *L. acutus* populations that were analysed. Population structure analyses showed that samples from the western region of the eastern North Atlantic (West Ireland, Faroe Islands and north-west British Isles) were similar to samples from the western North Atlantic (USA coasts). However, samples from the North Sea and eastern Scotland did show some degree of differentiation from other populations, from both the eastern and the western North Atlantic.

Mirimin *et al* (2011b) investigated nuclear and mitochondrial genetic variability of 42 white-sided dolphins that stranded from 1990 to 2006 in County Mayo, Ireland. Results were consistent with the hypothesis of a large random-mating population of white-sided dolphins off the north-west coast of Ireland. In addition, the analyses of two live mass stranding events (19 and five individuals, respectively) revealed that dolphins within each group were mainly unrelated to each other, suggesting dispersal of both sexes from the natal group (i.e. no natal phylopatry).

WGMME (2012) concluded that the evidence for separation of the eastern North Atlantic into more than one management unit was weak and proposed that, at this stage, a single management unit is appropriate in the eastern North Atlantic. This was reaffirmed by WGMME (2013). Following an OSPAR request to ICES for advice on suitable marine mammal assessment units for MSFD reporting, WGMME (2014) revisited the white sided

dolphin management unit and concluded no changes were necessary. The proposal was issued as ICES advice to OSPAR (ICES 2014) and underpins the UK MU.

Risso's dolphin (*Grampus griseus)*

There is very little understanding of the population structure of Risso's dolphins. The main habitat of this species is the continental slope (Kruse *et al* 1999; Baird 2002). In UK and Irish waters, however, the species is found at a few coastal locations, with some well known populations having been recorded (Figure 8A) and 70-85 strandings over the last decade (Reid *et al* 2003; IWDG 2010; Deaville & Jepson 2011). The UK Risso's dolphin population is genetically differentiated from the Mediterranean population but there is limited genetic variability between the discrete groups in UK waters (Gaspari *et al* 2007). Evans (2012) noted that determining ecological units for this species on the basis of available survey data was impossible and that, at present, there was no evidence to suggest population sub-structuring within the North Atlantic. Evans (2012), therefore, recommended a single ecological unit encompassing the Celtic Sea area. For UK purposes, this was extended to encompass all UK waters.

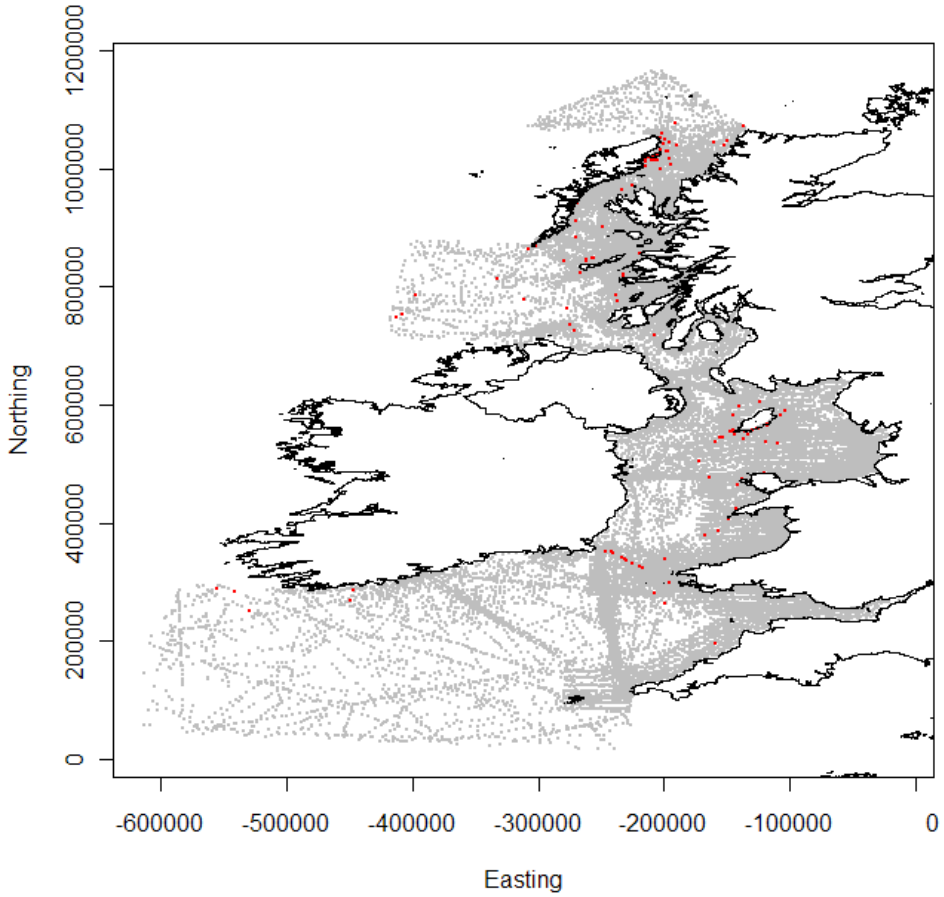

Figure A10. Realized effort (grey) 1982–2010 and sightings of Risso's dolphins for the west of Britain and Ireland (From Paxton *et al* 2011).

Minke whale (*Baleanoptera acutorostrata*)

The minke whale is widely distributed in the North Atlantic and occurs commonly off eastern Canada, Greenland, along Icelandic and Norwegian coasts, Jan Mayen and Svalbard Islands, around the UK, and as far south as Portuguese coasts. The population structure of minke whales in the North Atlantic has been investigated extensively as part of the process of developing the implementation of the International Whaling Commission's (IWC) Revised Management Procedure (RMP) for this species (see IWC (2009) for the most recent review). All information comes from animals in their summer feeding areas.

The IWC recognises three biological populations (referred to by the IWC as stocks) in the North Atlantic: Western population (including Canada and West Greenland), Central population (including East Greenland and Iceland) and Eastern population (including Norway). Within the areas representing these populations, known as 'Medium Areas', a number of 'Small Areas' have been defined for the purposes of setting catch limits. Small Areas may represent putative population sub-units among which animals may not mix completely from one year to the next. They may also be defined for operational reasons.

In the RMP, Small Areas are defined as areas small enough to contain whales from only one population, or to be such that if whales from more than one population were present catching operations would be unable to harvest them in proportions different to their relative abundance in the area. The way in which the RMP is implemented for each species/region is reviewed approximately every 5/6 years through Implementation Reviews.

At the 2003 Implementation Review (IWC 2004), new analyses continued to show that genetic differentiation was greater between the three putative populations (Eastern, Central, Western) than within them; data to assess structure within these populations were available only for the Eastern stock at the time. Genetic differentiation among Eastern sub-areas was generally low, but was statistically significant in several cases, including between the North Sea and the area immediately to the north, although counter-intuitively not between the North Sea and areas further north (Andersen *et al* 2003). Circumstantial evidence from pollutant levels, isotope ratios and fatty acid analysis was consistent with a distinction between the North Sea and other areas in terms of feeding (e.g. Born *et al* 2002, 2003). There was a significant genetic difference between the Barents Sea and areas to the west, which was maximised by a boundary at 28º E. No genetic evidence was found to support a distinction between the Vestfjorden area (EC Small Area) and surrounding areas. No significant genetic differences were found between the ES Small Area (East Svalbard) and areas to the south but there were operational considerations favouring retention of this area as a management area.

At the 2008 Implementation Review (IWC 2009), new genetic analyses found little evidence of population structure either between or within the Central and Eastern stock areas. Nevertheless, the same stock and sub-stock structure were maintained for the purposes of implementing the RMP.

In a recent study, Anderwald *et al* (2011) used microsatellite DNA and mtDNA markers to investigate minke whale population structure across the North Atlantic, assessing the possible impacts of migratory behaviour on stock structure. No evidence of geographic structure among putative populations was found in the IWC management areas indicating that the minke whales of the North Atlantic were likely to be a single genetic population. However, using individual genotypes and likelihood assignment methods, two putative cryptic populations were identified, which were independent of geographic location, i.e. they were distributed across the North Atlantic in similar proportions in different regions (Figure 11A). This supports the notion that individuals from different breeding populations form mixed assemblages at other times of the year. It was suggested that some differences found

in the proportional representation of these populations may explain some of the apparent differentiation among regions detected in previous studies.

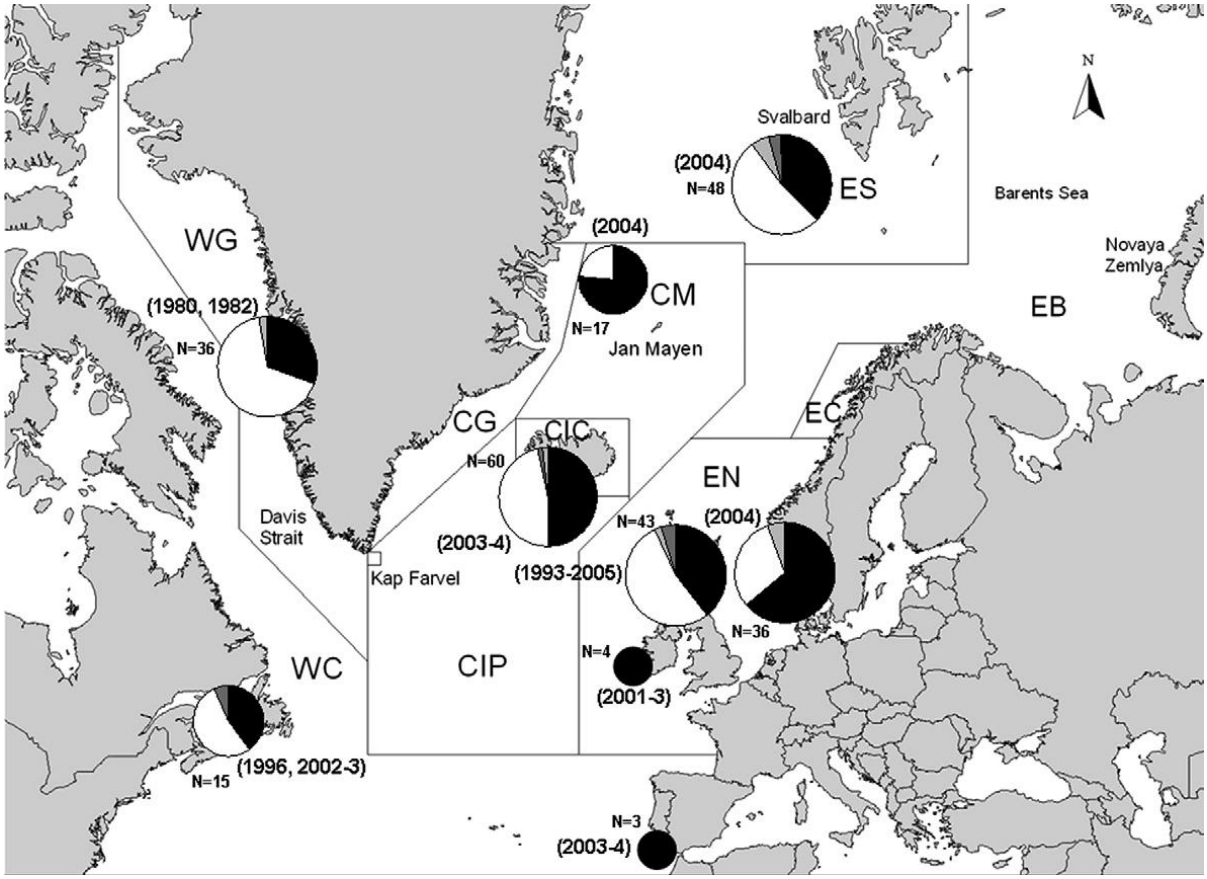

Figure A11. Sample sites in the North Atlantic within IWC management areas (West Greenland (WG), Central Eastern Greenland (CG), Central Jan Mayen (CM), East Svalbard (ES), East Barents Sea (EB), East Coastal Norway (EC), East North Sea (EN), Central Iceland Coastal (CIC), Central Iceland Pelagic (CIP) and West Canada (WC)). One sample site is included within a given management area, with the exception of EN, for which there were three sample sites: UK, Norway and Ireland. The geographic distribution of Population1 and Population2 in the North Atlantic according to GeneClass2 assignments of microsatellite genotypes is shown as pie charts: Black=Population1, white=Population2, light grey=putative Population1 individuals assigned to Population2, dark grey=putative Population2 individuals assigned to Population1. Sizes of pie charts indicate relative sample sizes for different areas. Sampling dates are given in parentheses (taken from Anderwald *et al* 2011).

Data from the SCANS-II survey indicated that during the summer individuals in a subsection of the East North Sea management area occurred in two areas of higher density, one in the North Sea and another off southern Ireland (Figure 12A). WGMME (2012, 2013) proposed that the Management Units proposed by the IWC for minke whales in the North Atlantic are retained at this time. The European North Atlantic group, therefore, comprises a single Management Unit. Following an OSPAR request to ICES for advice on suitable marine mammal assessment units for MSFD reporting, WGMME (2014) revisited the minke whale Management Unit and concluded no changes were necessary. The proposal was issued as ICES advice to OSPAR (ICES 2014) and underpins the UK MU.

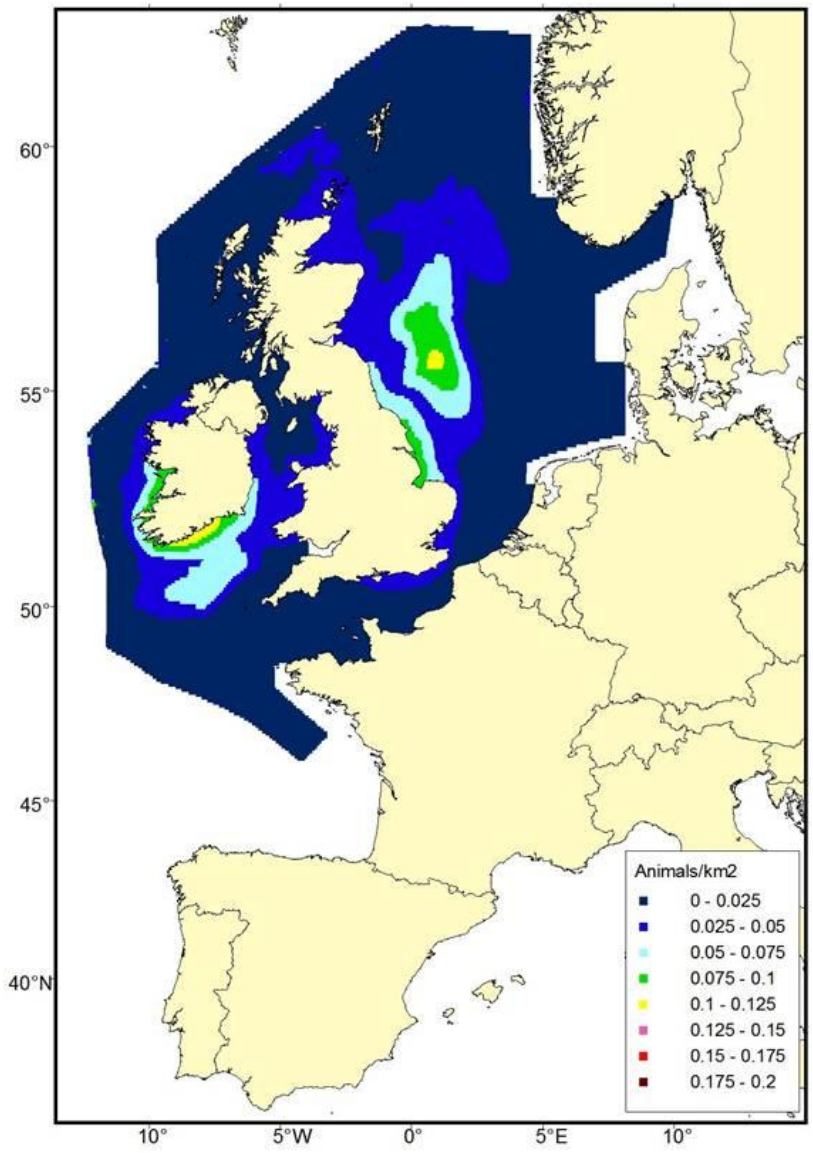

Figure A12. Minke whale density surface from SCANS II 2005 (Hammond *et al* 2013).

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