

CEMP guideline

Common indicator: Abundance at the relevant temporal scale of cetacean species regularly present (M4) – Interim version

(OSPAR Agreement 2018-09)¹

This OSPAR biodiversity indicator is still in the early stages of implementation and as a result of iteration and learning, it is anticipated that there will be evolution of the methods, approaches and values documented in the CEMP guidelines. Version updates will be clearly indicated and be managed in a phased approach via ICG-COBAM through its expert groups and with the oversight and steer of BDC.

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1 Introduction

Cetaceans are widely distributed in a range of habitats and are overall abundant throughout the OSPAR Maritime Area. A total of 35 cetacean species have been recorded within OSPAR Regions II, III and IV, although only around a dozen occur commonly: In the Greater North Sea, Celtic Seas, Bay of Biscay and Iberian Coast, it is estimated that more than 1.5 million individuals occur, with their distribution extending beyond the OSPAR area.

Many of the less common species have their main ranges outside the above-mentioned OSPAR Regions and therefore are rarely seen in European Atlantic waters making them impossible to monitor systematically.

The M4 indicator for cetaceans has the potential to address two relevant criteria of the EU Commission Decision on GES (2017/848):

- D1C2 “The population abundance of the species is not adversely affected due to anthropogenic pressures, such that its long-term viability is ensured” (primary criterion).
- D1C4 “The species distributional range and, where relevant, pattern is in line with prevailing physiographic, geographic and climatic conditions” (primary criterion).

D1C3 (“The population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity, and survival rates) of the species are indicative of a healthy population which is not adversely affected due to anthropogenic pressures”, secondary criterion) and D1C5 (“The habitat for the species has the necessary extent and condition to support the different stages in the life history of the species”, primary criterion) are not considered to yield sufficiently relevant assessment information to warrant the assessment effort needed.

This CEMP guideline describes three assessment methods;

- M4-A Abundance and distribution of killer whales (pilot assessment)
- M4-A1 Abundance and distribution of coastal bottlenose dolphins
- M4-B Abundance and distribution of cetaceans other than killer whales and coastal bottlenose dolphins

Assessments are made at the relevant species-specific temporal and spatial scale.

2 Monitoring

2.1 Purpose

As top predators, cetaceans can indicate the state of the marine ecosystem. Their abundance and distribution would be expected to respond to changes in human activities, environmental change including climate change. Natural factors and factors due to anthropogenic activities including disease, competition with other species, resource depletion, pollution, disturbance, and fisheries interactions are likely to have an effect on distribution and abundance. Although no straightforward causal link has been demonstrated between cetacean abundance and distribution and human activities in the OSPAR Maritime Area, a number of human activities may, at least in part, be drivers of observed trends. Changes in distribution or declines in abundance of cetaceans assessed using this indicator would signal the need for further research and studies to establish a cause for the decline.

2.2 Quantitative Objectives

The geographical scope of the indicator is species dependent. With the exception of some coastal bottlenose dolphins (M4-A1), cetacean populations extend over large spatial scales beyond national boundaries and often beyond European North Atlantic waters.

Monitoring of cetaceans should be undertaken at the appropriate spatial and temporal scale per species. A good understanding of natural variability and patterns of movement is required prior to concluding that a decline or increase in population size has taken place, and further knowledge is needed prior to linking such changes to anthropogenic activities.

2.3 Monitoring Strategy

There is no structural spatially relevant internationally coordinated monitoring scheme for cetaceans.

Therefore, more localised (mostly national) monitoring programmes and a series of large scale international surveys such as SCANS (Small Cetaceans in European Atlantic waters and the North Sea) and CODA (Cetacean Offshore Distribution and Abundance in the European Atlantic) were used for the OSPAR Intermediate Assessment 2017 (<https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/>).

The international SCANS surveys were conducted in 1994, 2005 and 2016 (Hammond et al., 2002; Hammond et al., 2013; Hammond et al., 2017), and CODA in 2007 (CODA, 2009).

A structural international strategy on a relevant temporal (frequency to be decided) and spatial scale (dependent per species) should be developed in cooperation within OSPAR.

2.4 Sampling Strategy

Different sampling strategies are needed to assess different species. The objective of monitoring should be to detect trends. Frequencies of surveys should allow appropriate estimation of trends and ensure continuous adequate information for MSFD (and HD) reporting cycles.

Line transect (sightings) surveys, using ships and/or aircraft to cover the survey area representatively, are expected to be the most effective method for species that range widely over large areas. These design-based estimates can be supplemented with model-based estimates, especially where there is the potential to include more frequent but smaller scale surveys into a modelling framework.

Mark-recapture analysis of photo-identification data is more appropriate for small coastal populations of naturally well-marked species with a limited range, such as the bottlenose dolphin.

The data used to infer distribution and to estimate abundance has mostly been derived from large-scale aerial and shipboard surveys using a line transect methodology to generate robust estimates of abundance: SCANS (Small Cetacean Abundance in the European Atlantic and North Sea; Hammond et al., 2002), SCANS-II (Hammond et al., 2013), CODA (Cetacean Offshore Distribution and Abundance in the European Atlantic; CODA, 2009) and SCANS-III (Hammond et al., 2017). The results of other large-scale surveys using similar methods can also inform the process: North Atlantic Sightings Surveys (NASS) (www.nammco.no) and Norwegian Independent Line Transect Surveys (NILS) for minke whales (e.g. Solvang et al., 2015). Smaller-scale (mostly national) surveys have been conducted using the same or a similar methodology, such as in Belgium, Denmark, France, Germany, the Netherlands and Sweden (Scheidat et al., 2008; Viquerat et al., 2014; Gilles et al., 2016; Laran et al., 2017). The large-scale surveys provide information on distribution and abundance over a large area but are infrequent and only undertaken in summer. The smaller-scale surveys are undertaken more often and can reveal seasonal and sometimes annual trends at a local scale.

For the IA2017, data originating from the results of the following monitoring methods were used:

M4-A: To assess killer whale abundance and distribution, both line-transect and mark-recapture photo-identification methods were used. Photo-id surveys conducted over a period of time generate re-sightings of known individuals, and these data can be used to estimate population size using mark-recapture methods (Urian et al., 2017). It should be noted, however, that surveys to date have not encompassed the full range of North Atlantic killer whales.

M4-A1: In order to assess abundance and distribution of coastal bottlenose dolphins (with a limited geographical range), mark-recapture analysis of photo-identification data was used. Photo-id surveys conducted over a period of time generate re-sightings of known individuals and these data can be used to estimate population size using mark-recapture methods (Urian et al., 2017). For some coastal populations, study areas encompass only a limited part of the main range of the population.

M4-B: In order to assess abundance and distribution of wide-ranging cetaceans, line-transect surveys have been used. In European Atlantic waters, the most comprehensive line-transect surveys have been the SCANS surveys, with national surveys being conducted by individual countries. Data collection methods are described in Hammond et al., (2013), and summarised in Hammond et al., (2017). Efforts have been made to merge data from surveys undertaken by individual countries in the southern/central North Sea (Gilles et al., 2016).

2.5 Quality assurance/ Quality Control

Quality assurance of the data from large and smaller scale surveys was maintained following the SCANS protocols for data collection, validation and analysis. The data collected by photo ID followed the guidelines described in Urian et al., 2017. In an attempt to standardise data from smaller scale surveys and collate these, a Joint Cetacean Protocol has been established in the UK (Paxton et al., 2016).

2.6 Data reporting, handling and management

Each Contracting Party has its own data storage mechanism for national monitoring data. Within each assessment unit, indicator M4 is assessed using, where possible, available data from CPs. National data would need to be submitted to a central data custodian (to be decided) which is responsible for data analysis and dissemination of results.

Reporting formats should be developed. Central data management and data calls should be organized.

3 Assessment

The assessment method is described for all three assessments in **Annex 1**. This is based upon the Intermediate Assessment 2017:

Abundance and distribution of Killer whale (M4-A):

<https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/marine-mammals/abundance-distribution-cetaceans/pilot-assessment-abundance-and-distribution-killer-whales/>

Abundance and distribution of coastal bottlenose dolphins (M4-A1)

<https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/marine-mammals/abundance-distribution-cetaceans/abundance-and-distribution-coastal-bottlenose-dolphins/>

Abundance and distribution of cetaceans (M4-B)

<https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/marine-mammals/abundance-distribution-cetaceans/abundance-and-distribution-cetaceans/>

3.1 Assessment values and units

OSPAR ICG-COBAM has proposed an assessment value for cetacean abundance, to “*Maintain populations in a healthy state, with no decrease in population size with regard to the baseline (beyond natural variability) and restore populations, where deteriorated due to anthropogenic influences, to a healthy state*”. An index of relative abundance could be used to determine whether this assessment value was

being met or not, but where possible one should strive for measures of absolute abundance for assessing the impacts of human activities.

There is currently no quantitative evidence of *deterioration due to anthropogenic influence* among the 'regularly present' species within the OSPAR Maritime Area. However, assessment is contingent on the challenges to obtain robust population estimates across the range of the putative assessment unit and the lack of knowledge on baseline population sizes. Historical abundance is unknown. Consequently, a modern baseline has been utilized for the time being. It could be noted that the European Commission is currently reviewing Favourable Reference Populations (FRPs) under the Habitats Directive which could be considered in future development work.

The proposed long-term assessment values are measured by assessing short-term trends, which are defined as:

- Declining means a decreasing trend of $\geq 5\%$ over 10 years (*significance level $\alpha < 0.05$*)
- Increasing means an increasing trend of $\geq 5\%$ over 10 years (*significance level $\alpha < 0.05$*)
- Stable means population changes of $< 5\%$ over 10 years

It must be kept in mind that most cetaceans are long-lived, slowly reproducing species, implying that problems affecting reproduction as well as effects from sub-lethal anthropogenic pressures may show significant time lags before being detected.

The most useful abundance data for offshore cetacean species derives from the results of large-scale surveys, currently yielding the best overall abundance estimates for some species. To quantify changes, a trend analysis relative to the best baseline estimates should be performed. These should be kept under review as more information becomes available.

Table 1: Proposed assessment values and assessment units (AU). These assessment criteria are often based on limited data.

| Species | Present in OSPAR region | Population size baseline (abundance) ¹ | Additional information | Proposed assessment value | Proposed assessment unit(s) |
|---|--|---|--|---|---|
| M4-A | | | | | |
| Killer whale (<i>Orcinus orca</i>) | Largely beyond shelf edge but also inshore, in regions I, II, III, IV | Needs to be set | | n.a. (pilot indicator) | Yet to be fully determined although shelf population considered distinct from northern, more pelagic, population |
| M4-A1 | | | | | |
| Coastal bottlenose dolphins (<i>Tursiops truncatus</i>) | Inshore in regions II, III, IV | Needs to be set | Some interaction with offshore populations, more research needed into connectivity | For each assessment unit, maintain inshore bottlenose dolphin population sizes at or above baseline levels, with no decrease of $\geq 30\%$ over any ten-year period | a) West coast of Scotland; b) East coast of Scotland; c) Coastal Wales d) Coastal Ireland e) Southwest England; f) Normandy/Brittany; g) Northern Spain; h) Southern Galician Rias (Spain); i) Coast of Portugal; j) Gulf of Cadiz |
| M4-B | | | | | |
| Harbour porpoise (<i>Phocoena phocoena</i>) | II, III, and IV, likely part of population with distribution extending into region I | Needs to be set | More research needed into interactions with other regions Large-scale surveys at a frequency of 11 years are inadequate to monitor trends of a species with life expectancy much less than this | For each assessment unit, maintain harbour porpoise population size at or above baseline levels, with no decrease of $\geq 30\%$ over a three-generation period (36 or 22.5 years). | 1) North Sea: ICES Subarea IV, Division VIIId, and part of Division IIIa (Skagerrak); 2) Kattegat and Belt Seas: Part of ICES Division IIIa (Kattegat) and Baltic Areas 22 and 23; 3) Western Scotland and Northern Ireland: ICES Division VIa and Subdivision VIb2; 4) Celtic Sea and Irish seas: ICES Subarea VII with the exception of Division VIIId ² ; 5) Iberian Peninsula: ICES Divisions VIIIc and IXa. |
| Offshore bottlenose dolphins (<i>Tursiops truncatus</i>) | III, IV, likely part of population with distribution extending into region V | Needs to be set | Requires monitoring over relatively large area (including deeper Atlantic waters) at more regular intervals | Maintain the offshore NE Atlantic bottlenose dolphin population size at or above the baseline level, with no decrease of $\geq 30\%$ over a three-generation period (63 years). | No information as yet on AUs. For the time being assumed to form a single assessment unit. |
| White-beaked dolphins (<i>Lagenorhynchus albirostris</i>) | Region II and III with distribution extending into region I | Needs to be set | | Maintain the white-beaked dolphin population size at or above the baseline levels, with no decrease of $\geq 30\%$ over a three-generation period (54 years). | ICES advised a single assessment unit for OSPAR regions II and III for white-beaked dolphin. The species does not occur regularly in Region IV. |
| Minke whale (<i>Balaenoptera acutorostrata</i>) | Regions II and III with distribution extending into region I | Needs to be set | Hunted in region III in the past, depletion status unknown | Maintain the minke whale population size at or above the baseline levels, with no decrease of $\geq 30\%$ over a | ICES advised a single assessment unit for minke whale for OSPAR regions II, III, and IV. |

¹ Besides OSPAR intermediate assessment estimates (IA2017), SCANS or SCANS-II, SCANSIII, CODA and T-NASS estimates could be considered in future development work, noting that the estimate is based on the initial SCANS-II estimate and not the revised one (see Hammond et al. 2017). Baseline estimates will be discussed within the OSPAR Marine Mammal Expert Group.

| | | | | | |
|---|---|-----------------|---|---|--|
| a) | | | | three-generation period (66 years). | |
| Common dolphin (<i>Delphinus delphis</i>) | Regions II, III, and IV, part of a wider Northeast Atlantic assessment unit with distribution extending into region V | Needs to be set | Do not set value for subset. Requires monitoring over relatively large area (incl. deeper Atlantic waters) at more regular intervals (three to five years). | Maintain the Northeast Atlantic common dolphin population size at or above the baseline level, with no decrease of $\geq 30\%$ over a three-generation period (44 years). | ICES advised a single assessment unit for OSPAR regions II, III, and IV based upon an apparently wide-ranging population of short-beaked common dolphin in the Northeast Atlantic, from waters off North Scotland to Portugal. |

3.2 Spatial Analysis and / or trend analysis

Spatial analysis

Model-based density estimates have been used to predict the distribution and abundance of those species for which sufficient data are available from large-scale purpose-designed surveys. Such model-based results are not available for relatively rare species. Maps of observed sightings provide information on distribution based on recent data for which results from density surface models are not yet available. An analysis of changes in distribution for the most common species from collated survey datasets (1990-present) is currently underway.

Trend analysis

Abundance of animals per species has mostly been estimated using data collected from large-scale purpose-designed surveys using line-transect distance sampling methods (Buckland et al., 2001); these are known as design-based estimates (e.g. Hammond et al., 2013). Some abundance estimates come from models fitted to these data to generate a density surface from which abundance is derived; these are known as model-based estimates (e.g. Gilles et al., 2016). To assess trends, at least three abundance estimates are required over a relevant time scale. Robust assessments will require additional abundance estimates.

In any assessment of trend, it is important to consider the statistical power to detect a change in abundance of a given magnitude. Simple power analyses have been conducted to determine the annual rate of decline that could be detected with high (80%) power from the available estimates of abundance (see Annex 1 for further details).

3.3 Presentation of 2017 intermediate assessment results

Killer whales (M4-A) in the OSPAR Maritime Area are found predominantly in Arctic Waters and northern parts of the North Sea, Celtic Seas and Wider Atlantic. Further south there are distinct smaller groups occurring in coastal waters off west Scotland / north-west Ireland and in the Strait of Gibraltar. The abundance and distribution of killer whales may be indicative of specific aspects of the status of the marine environment, such as food web integrity and pollutant load. Owing to a lack of data, only a pilot assessment can be made at present.

Most populations of **coastal bottlenose dolphins** (M4-A1) in the areas assessed are relatively small (all <500 individuals). In many coastal areas of the North-East Atlantic Ocean, populations declined or disappeared completely during the 19th and 20th centuries. Where trends could be assessed, the remaining populations show little long-term change with the exception of the declining small population in the Sado Estuary in Portugal.

Other **Cetaceans** (M4-B) are widely distributed in a range of habitats and are overall abundant throughout the OSPAR Maritime Area. For most species, there are only three comparable estimates of abundance and a robust trend assessment is not possible. The longer time series of estimates for harbour porpoise, white-

beaked dolphin and minke whale in the North Sea, and harbour porpoise in the Kattegat / Belt Seas, show no evidence of any change in abundance since 1994. However, for harbour porpoise in the North Sea, a substantial southward shift in distribution occurred between 1994 and 2005 and was maintained in 2016 probably due to changes in prey availability.

There is a continued need for large-scale surveys, ideally undertaken more frequently than to date to increase the power to detect trends.

4 Change Management

Large scale surveys such as SCANS and CODA need to occur as a structural monitoring tool and at more frequent intervals to better assess cetacean abundance and trends. Additionally, some suggestions for future work are:

- A compilation of existing data on abundance
- An agreement on the delimitation of assessment units
- The development of a baseline for each species in each assessment unit
- The development of a standardized monitoring methodology, or alternatively a mechanism for standardizing data post collection. Although progress has been made, both effort-related monitoring of cetaceans and analytical procedures need further refinement and standardisation, both in methodology as well as frequency (at least every 6 years) and organisation.
- For small cetaceans, the development of an assessment tool and agreement on the body that makes the assessment

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Annex 1.

Description of the assessment method from the OSPAR Intermediate Assessment 2017

Killer whale (M4-A):

No assessment units (AUs) have been agreed for killer whale (*Orcinus orca*). However, there are distinctions between some groups based on photo-ID surveys, studies of well-known populations, genetic studies (biopsies and investigation of stranded animals), and on prey specialisation. Due to the lack of suitable data, it is not possible to assess trends in abundance.

Abundance and distribution of coastal bottlenose dolphins (M4-A1)

The trend assessments applied define 'stable' as population changes of <5% over ten years. This percentage (i.e. 5%) is derived from the International Union for the Conservation of Nature (IUCN) criterion to detect a 30% decline over three generations for a species, which equates to slightly less than 0.5% per year for odontocetes.

Assessment Units

Assessment units (AUs) for coastal bottlenose dolphin (*Tursiops truncatus*) have been determined on the basis of a combination of spatial separation, lack of photo-ID matches, and genetic differences (Evans and Teilmann, 2009; ICES, 2013) as outlined by ICES (2014).

Abundance

The abundance for coastal bottlenose dolphin populations has been calculated for each assessment unit where sufficient data exist. Abundance estimates were made largely using Photo-ID capture-recapture methods, and an indication is given about the trend in the population since the start of monitoring: stable, declining, increasing or unknown. At least four abundance estimates from different years should be available before the population trend can be assessed. On occasions, pooled estimates have been calculated from a period of years. Some small discrete populations of coastal bottlenose dolphin (e.g. in the Sado Estuary) have been assessed by a full census of individuals.

Distribution

Records of sightings and strandings have been used to identify where populations of coastal bottlenose dolphins existed historically.

Assessment Value

No assessment value has been applied in this assessment.

Definition of Trends

Declining is defined as a decreasing trend of $\geq 5\%$ over ten years (*significance level* $\alpha < 0.05$)

Increasing is defined as an increasing trend of $\geq 5\%$ over ten years (*significance level* $\alpha < 0.05$)

Stable is defined as population changes of <5% over ten years

Abundance and distribution of cetaceans (M4-B)

Methods

The data used to infer distribution and to estimate abundance mostly have derived from large-scale aerial and shipboard surveys that used line transect methodology to generate robust estimates of abundance: SCANS (Small Cetacean Abundance in the North Sea; Hammond et al., 2002), SCANS-II (Small Cetacean Abundance in the European Atlantic and North Sea; Hammond et al., 2013), CODA (Cetacean Offshore Distribution and Abundance in the European Atlantic; CODA, 2009) and SCANS-III (Hammond et al., 2017). The results of other large-scale surveys using similar methods have also been used: North Atlantic Sightings

Surveys (NASS) () and Norwegian Independent Line Transect Surveys (NILS) for minke whales (e.g. Solvang et al., 2015). Smaller-scale (mostly national) surveys have been conducted using the same or a similar methodology, such as in Belgium, Denmark, France, Germany, the Netherlands, and Sweden (Scheidat et al., 2008; Viquerat et al., 2014; Gilles et al., 2016; Laran et al., 2017). The large-scale surveys provide information on distribution and abundance over a large area but are infrequent, and only undertaken in summer. The smaller-scale surveys are undertaken more often and may reveal seasonal patterns at a local scale.

MSFD Criterion D1.1 – Species Distribution

Where possible, information on species distribution has been obtained from modelled density surfaces fitted to data collected during large-scale surveys (e.g. Gilles et al., 2016; Rogan et al., 2017). Where this was not possible, distribution was derived from the distribution of animals seen on these and other surveys.

MSFD Criterion D1.2 – Population Size

Abundance was estimated using line transect distance sampling methods (design-based estimates; Hammond et al., 2013). Shipboard survey methods have mostly used two observation teams on the same vessel so that animals missed on the transect line and any responsive movement could be accounted for in the analysis. However, for some species in some years, sufficient data were not available for such extended analytical methods to be used. Several aerial surveys used tandem aircraft or the circle-back procedure for harbour porpoises (*Phocoena phocoena*) to correct for animals missed on the transect line (Hiby and Lovell, 1998; Hiby, 1999); this was extended to dolphin species and minke whales (*Balaenoptera acutorostrata*) during SCANS-III in 2016. In other cases, conventional aerial survey methods were used, corrected for availability and observer bias where possible (Hammond et al., 2013).

Wide-scale surveys were conducted in France in 2011 and 2012 (see Laran et al., 2017). Irish data have been derived from the aerial surveys of cetaceans undertaken in 2015-2017 as part of the ObSERVE programme. While data were not available for this assessment, they should be available for future assessment.

Metrics

D1.1 – Species Distribution

Density surface models have been used to predict the distributions of those species for which sufficient data are available from large-scale purpose-designed surveys. For recent data for which results from density surface models are not yet available, maps of observed sightings provide information on distribution.

D1.2 – Population Size

Abundance of animals per species has mostly been estimated using data collected from large-scale purpose-designed aerial or shipboard surveys using line-transect distance sampling methods (Buckland et al., 2001); these are known as design-based estimates (e.g. Hammond et al., 2013). Some abundance estimates come from models fitted to these data to generate a density surface from which abundance is derived; these are known as model-based estimates (e.g. Gilles et al., 2016).

Baselines

Although the baseline should derive from historical data, these data are not available for any cetacean species. Historical abundance and distribution are therefore unknown. Even if numbers are suspected to have declined, they could probably not realistically be restored because today's marine environment is very different, in part due to climate change and human impact. Consequently, a recent baseline is proposed, which should then be assessed as a normal situation, or one that is already known to be degraded. The most useful baselines for wide-ranging cetacean species derive from the results of large-scale surveys (e.g. CODA, 2009; Hammond et al., 2002, 2013).

For most species, only two abundance estimates are currently available so a robust assessment of a trend involving change from a baseline is not possible. For harbour porpoise and white-beaked dolphin (*Lagenorhynchus albirostris*) in the Greater North Sea there are three estimates available (SCANS, SCANS-II and SCANS-III) so an assessment of sorts is possible. For minke whale, there are eight estimates available in the North Sea from SCANS and Norwegian surveys from 1989 to 2016 allowing a more robust assessment. For harbour porpoise in the Kattegat / Belt Seas, there are four estimates available.

Spatial Scope

Assessment Units (AUs) for assessing abundance and distribution have been defined for a number of species (ICES, 2014b) in separate regions, or in the OSPAR Maritime Area. For harbour porpoise, six AUs were defined. For bottlenose dolphin (*Tursiops truncatus*), ten AUs were defined for the relatively small coastal populations (covered in a separate section of the Intermediate Assessment) and a single offshore AU for the relatively large and wide-ranging population(s) of bottlenose dolphin living offshore. Currently, a single AU covering all European Atlantic waters has been defined for minke whale, white-beaked dolphin and short-beaked common dolphin (*Delphinus delphis*). No AUs have been defined for other species included in this document.

Assessment Value

No assessment value has been applied in this assessment.

Definition of Trends

Declining means a decreasing trend of $\geq 5\%$ over 10 years (*significance level* $\alpha < 0.05$).

Increasing means an increasing trend of $\geq 5\%$ over 10 years (*significance level* $\alpha < 0.05$).

Stable means population changes of $< 5\%$ over 10 years.

This percentage (i.e. 5%) is derived from the International Union for the Conservation of Nature (IUCN) criterion to detect a 30% decline over three generations for a species, which equates to slightly less than 0.5% per year for odontocetes.

Power Analysis

Power analyses were performed for species for which there are three or more comparable estimates of regional abundance from SCANS and other surveys, using previously estimated coefficients of variation (CV). The datasets comprised abundance estimates from three surveys over 22 years for harbour porpoise, three surveys over 22 years for white-beaked dolphin, and eight surveys over 27 years for minke whale. These data have 80% power (the conventional acceptable level) to detect an annual rate of change, at a significance level (α value) of 0.05, of 1.5% for harbour porpoise, 2.5% for white-beaked dolphin, and 0.5% for minke whale.

These annual rates of change decrease to $< 1\%$ for harbour porpoise and 2% for white-beaked dolphin, following an additional survey after six years.

The power to detect trends could be improved by increasing the frequency of the large-scale surveys.

Technical Explanation for the Reanalysis of Scans (1994) and Scans-II (2005) Data

SCANS-III surveyed the entire European continental shelf by aerial survey, except for the Kattegat and Belt Seas area, which were surveyed by ship. Most of these waters were surveyed by ship in SCANS and SCANS-II. Methodologies employed for ship (two-team 'tracker') and aerial survey (circle-back) should generate unbiased estimates of abundance for most species (harbour porpoise, dolphin species and minke whale) so estimates for these species from ship and aerial surveys are, therefore, comparable. However, there is a choice of two models to estimate detection probability when the two-team 'tracker' method has been employed on a ship survey. One method, called the point (or trackline) independence model, provides robust estimates of abundance incorporating estimates of the probability of detection of animals on the

transect line, so-called $g(0)$, which is assumed to be 1 in conventional line transect analysis. In this method a detection function is fitted to the primary team data to estimate average detection probability assuming $g(0) = 1$, and a second detection function is fitted to primary detections conditional on those detections being first seen by the tracker team to estimate $g(0)$. This is the preferred model for two-team 'tracker' data analysis.

The other method, called the full independence model, fits the second conditional detection function but does not fit the first conventional detection function. This model should be used to correct for bias introduced when there is movement of animals in response to the approaching survey ship. However, it is not a robust model and tends to underestimate abundance because of non-independence in tracker and primary sightings.

The full independence model was used to estimate abundance of all species from the ship surveys in SCANS in 1994 and SCANS-II in 2005. The point independence model had not yet been developed in 1994. In 2005, there was weak evidence of responsive movement for some species so a cautious approach was adopted at the time leading to estimates that were likely to be negatively biased. However, this creates a problem of comparison with estimates between SCANS, SCANS-II and SCANS-III in any assessment of trend. Aerial surveys are not subject to responsive movement and the circle-back methods used should be unbiased. In SCANS-III, there was no evidence of movement of animals in response to the survey ships so the more robust point independence detection function model was used for all species.

The solution implemented has been to reanalyse the SCANS and SCANS-II data using the more robust point independence model of detection probability so that estimates are comparable between 1994, 2005 and 2016.

In addition, the $g(0)$ estimates for dolphin species and for minke whale in the SCANS-III aerial survey have been used to correct estimates of abundance for white-beaked dolphin, common dolphin, bottlenose dolphin and minke whale from the SCANS-II aerial survey, in place of the corrections previously used for availability only, based on dive data from other studies.

The final result of the re-analysis of the SCANS and SCANS-II data is that estimates for 1994 and 2005 for most species are different (and generally larger) to those published by Hammond et al., 2002, 2013.

Annex 1 reference list

This annex reference list only contains sources not yet listed under chapter 5.

Hiby, A.R. and Lovell, P., 1998. Using aircraft in tandem formation to estimate abundance of harbour porpoise. *Biometrics* 54: 1280-1289.

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