

# Grey Seal Pup Production

## Common indicator assessment



# OSPAR

QUALITY STATUS REPORT 2023

2022

# Grey Seal Pup Production

## OSPAR Convention

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the “OSPAR Convention”) was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. The Contracting Parties are Belgium, Denmark, the European Union, Finland, France, Germany, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

## Convention OSPAR

La Convention pour la protection du milieu marin de l’Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d’Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. Les Parties contractantes sont l’Allemagne, la Belgique, le Danemark, l’Espagne, la Finlande, la France, l’Irlande, l’Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume- Uni de Grande Bretagne et d’Irlande du Nord, la Suède, la Suisse et l’Union européenne

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## Key Message

In Assessment Units across the Greater North Sea and Celtic Seas, grey seal pup production is largely increasing or stable. Within Arctic Waters, where Iceland was the single AU able to be assessed, grey seal pup production has declined since the baseline assessment year.

## Background (brief)

This indicator assesses trends in the number of grey seal pups born at breeding sites in Arctic Waters (Region I), Greater North Sea (Region II) and the Celtic Seas (Region III). Grey seals gather to breed at long-established colonies located on islands, sand banks and mainland coastlines around Europe.

As top predators, grey seals can be used as an indicator to reflect the state of the marine ecosystem. Grey seal pup production is influenced by, but not limited to, many factors such as disease, pollutants, competition with other species, changes in the distribution and abundance of prey, disturbance, or interactions with fisheries (via the removal of adults of a breeding age). Grey seals were hunted well into the 20th century, resulting in population depletions across OSPAR Regions. Protective legislation to reduce those anthropogenic threats has supported the recovery of colonies in recent years. However, the legal removal of seals to protect fisheries or for hunts is still carried out and the threat from by-catch remains present across many areas.

Several human activities may, at least in part, drive a change in pup production; however, it is often challenging to quantify the scale of the impact. The extent and history of both illegal and legal hunting means that it is not possible to know the undisturbed state, nor the current carrying capacity that could be attained alongside protection from illegal hunting and the large extent to which humans have expanded their activities at sea (such as shipping, mining, and wind farms). Exposure to persistent organochlorine and petroleum compounds are well established as an identifiable cause of substantial historic reproductive failure in the Baltic Sea sub-population of Atlantic grey seals and across the Greater North Sea (Jenssen, 1996; Sørmo et al., 2003; de Wit et al., 2020).

More recently, human disturbance of seal breeding sites from tourism is noted to be increasing across many areas (Bellman et al., 2019). The extent to which seals may be vulnerable and hence impact pup production is not yet clearly understood, though evidence of stress responses in breeding females are apparent (Twiss et al., 2020)

Pup production is only a partial indicator of the wider grey seal population condition. The outputs from this indicator are largely a secondary proxy for the grey seal element of the M3 indicator Seal Abundance and Distribution (<https://oap.ospar.org/en/ospar-assessments/quality-status-reports/qsr-2023/indicator-assessments/seal-abundance-and-distribution/>). Declines in pup production may signal that Assessment Units (AUs) are not in a healthy state. Further investigations into identifying the cause (natural or human-induced), assessing the relationship between such pressures and outcomes, may then be required to determine appropriate management measures.



Figure 1: Atlantic grey seal (*Halichoerus grypus*) pup and mother (courtesy of Megan Tierney, JNCC)

### Background (extended)

Grey seal pup production was assessed in the Greater North Sea in the 2010 OSPAR Quality Status Report (QSR) by means of an Ecological Quality Objective (EcoQO). The EcoQO for no decline of greater than 10% in grey seal pup production over a five-year running mean was assessed as met in all areas of the Greater North Sea with relevant local populations and where data were reported.

Grey seal pup production was then assessed again in the OSPAR Intermediate Assessment (IA) undertaken in 2017, which focused on the Greater North Sea and UK parts of the Celtic Seas. Using further developed threshold values (see **Assessment Methods**) based on those initial OSPAR EcoQO's, grey seal pup production increased over both the long term and short term, in all assessed areas where there were breeding sites and sufficient data to carry out the assessment.

While the methods between the IA 2017 and the QSR 2023 remain the same, the QSR 2023 expands upon those OSPAR Regions assessed within the IA 2017, now encompassing Region II, the whole of Region III, out to the Marine Strategy Framework Directive (MSFD) boundary, as well as the addition of Region I. The expansion into the Arctic Waters (Region I) may allow for more latitudinal variation in the examination of indicator trends, particularly concerning the effects of environmental change. The expansion is in line with the OSPAR NEAES 2030 **S5.04**: *By 2025 at the latest OSPAR will take appropriate actions to prevent or reduce pressures to enable the recovery of marine species and benthic and pelagic habitats in order to reach and maintain good environmental status as reflected in relevant OSPAR status assessments, with action by 2023 to halt the decline of marine birds.*

When linked and compared with suitable pressure indicators, assessments of pup production trends within and across OSPAR Regions can provide key insights into the drivers of observed changes and help inform appropriate management of those pressures especially where there is movement between Regions. However, it should also be noted that the already depleted state of grey seals across the North-East Atlantic at the start of this indicator's assessment baseline year (1992), the trends since this likely reflect already depleted colonies, recovering from low numbers.

Pup production is only a partial indicator of the wider grey seal population condition. The outputs from this indicator are largely a secondary proxy for the grey seal element of the M3: Seal Abundance and Distribution (<https://oap.ospar.org/en/ospar-assessments/quality-status-reports/qsr-2023/indicator-assessments/seal-abundance-and-distribution/>) indicator which assesses grey seal abundance on a single AU basis, spanning Regions I – III. It is suggested that the outputs of this indicator are used in conjunction with those from M3 to provide a more fine-scale, and temporally accurate, understanding of grey seal trends across the North-East Atlantic.

## Assessment Method

### Overview

Assessments of changes in abundance and distribution were made within discrete geographical areas of coastline, or 'Assessment Units' (AUs). Despite their ability to travel long distances, individual mature grey seals of both sexes are usually faithful to particular breeding sites and may return to within 10–100 m of individual breeding locations (Pomeroy et al., 2000). OSPAR Regions I, II and III were divided into 25 AUs (Figure a) to provide a description of changes in pup production at a 'local' scale where direct impacts on pup production, such as disturbance, persecution and food availability may be more detectable. The AUs do not necessarily represent demographically independent populations and survey coverage and monitoring effort is higher where breeding grey seals are most abundant. The AUs reflect a balance between population structure evidence and feasible monitoring sites for both harbour and grey seals within Contracting Parties. Monitoring of grey seal pups is conducted by the same organisations, and at a similar scale to that data provided for [M3: Seal Abundance and Distribution](#) and so match those AUs used for conducting assessments on harbour seals, and grey seal distribution within the M3 indicator. The AUs in the Greater North Sea are broadly similar to those previously defined as OSPAR EcoQO sub-units. See [M5 Coordinated Environmental Monitoring Programme \(CEMP\) Guideline](#) for further information on the development of these units.

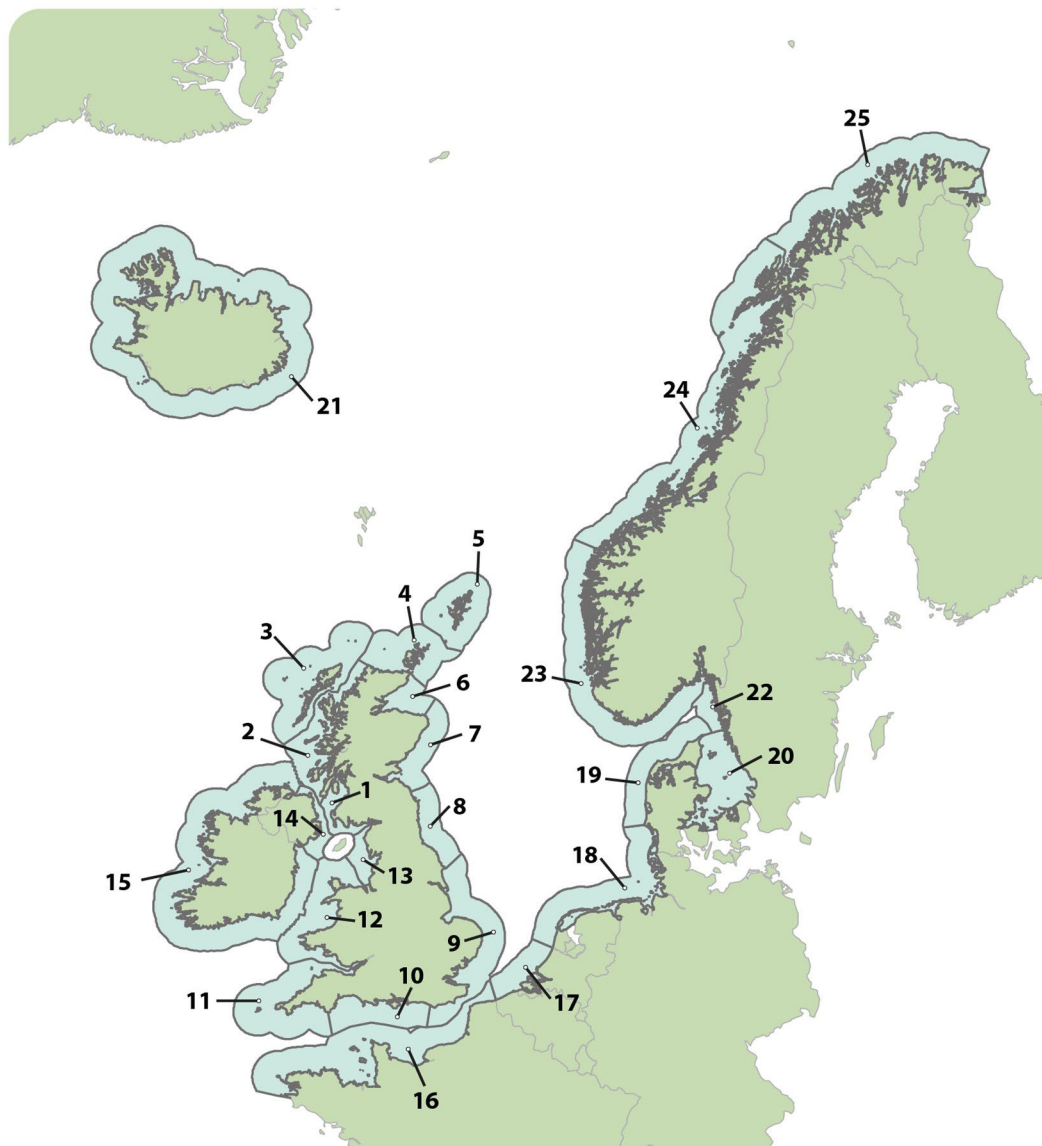


Figure a: Assessment units for grey seal pup production

Key: 1. South-West Scotland, 2. West Scotland, 3. Western Isles, 4. North Coast & Orkney, 5. Shetland, 6. Moray Firth, 7. East Scotland, 8. North-East England, 9. South-East England, 10. South England, 11. South-West England, 12. Wales, 13. North-West England, 14. Northern Ireland, 15. Ireland, 16. French North Sea & Channel Coast, 17. Belgium Coast and Dutch Delta, 18. Wadden Sea, 19. Limfjorden, 20. Kattegat, 21. Iceland, 22. Skagerrak, 23. Norway (Hvaler – Stad), 24. Norway (Stad – Vesterålen), 25. Norway (Troms – Finnmark)

#### Grey seal pup monitoring in the North-East Atlantic

Atlantic grey seals pup in the autumn or winter and moult in early spring. The frequency of surveys during these periods varies across OSPAR Contracting Parties due to differences in the total number of resident animals, funding, geography, and historical development of the monitoring programmes. Grey seal (*Halichoerus grypus*) pups are counted at major breeding sites ('colonies') usually using aerial photography survey methods (Figure b); where these are not possible, ground counts or boat-based counts may be used instead (e.g., Stringell et al., 2014). Multiple counts per colony are conducted, spread across the breeding season (August to February, depending on colony location).





Figure b: Aerial survey image of a grey seal colony (courtesy of Sea Mammal Research Unit)

For many colonies in Scotland (including all the major ones), pup counts are used to estimate total pup production, that is, the total number of pups produced over the season at each colony using an established statistical model that describes how the number of pups at the site vary over the season (Russell et al., 2019). Similarly, Ireland and Iceland also estimate pup production using multiple counts (Ó Cadhla et al., 2013; Granquist & Hauksson, 2019)

All other Contracting Parties count pups several times during the pupping season and provide peak count values as an index of pup production. The peak count gathered from monitoring will always under-estimate pup production because pups are born and leave the colony at different times and the breeding season is longer than any one pup stays on the colony. For some smaller colonies or stretches of coast where pups are born, often a single count is used as an index of pup production. Hereafter, both types of estimates are referred to collectively as a 'pup production index'.

Colony survey frequency varies by 'Assessment Unit' (AU) and ranges from annually to about five-yearly. In many AUs monitoring is undertaken in specific areas by local organisations and does not form part of synoptic surveys. Details of grey seal pup production monitoring programmes for each AU are given in Annex 2 of the M5 CEMP Guidelines.

#### Data Collation

Following a data call in February 2021, all Contracting Parties were asked to provide data on an AU-scale of peak grey seal pup count and/or total pup production estimates for the period 1992 (or earliest year) –2019 (or latest year). Data were received from the UK, Ireland, France, Belgium, Germany, the Netherlands, Denmark, Sweden, Norway, and Iceland.

Data received from Ireland and Norway were too sparse to conduct analysis on (<5 data points). Data submissions from these countries have been supplemented by descriptive evidence summaries to support the indicator.



Greenland noted that not enough annual counts have thus far been conducted in the country, and that seal presence is infrequent and limited. Similarly, for the Faroe Isles, only grey seals breed there and counts only commenced in 2018. Therefore, assessments were not able to be generated for these countries and instead, descriptive data have been provided to supply an overview of seal presence within these waters.

Although numbers from these noted countries are considered as marginal compared to those larger, frequently monitored haul-out sites and colonies in neighbouring countries, they are recorded in an OSPAR framework for completeness.

### Grey Seal Pup Production Threshold Values and Baselines

Two threshold values were used to assess grey seal pup production in each AU in relation to baselines described below. The use of the two threshold values aims to provide an indicator that would warn against both a slow but long-term steady decline and against a recovery followed by a subsequent decline (potentially missed with a fixed baseline set below reference conditions). The two threshold values together would be able to act as a trigger for investigation of any necessary management measures to promote recovery.

#### Threshold Value 1:

- No decline in seal abundance of >1% per year in the previous six-year period (this is approximately 6% over 6 years).

This uses a rolling baseline (Method 1; OSPAR, 2012) based on the most recent six-year period, seeking to identify if seal populations are maintained, with no decrease in population size with regard to the (short term) baseline (beyond natural variability (<1% per year)) and to identify if efforts are needed to restore populations, where they have deteriorated due to anthropogenic influences, to a healthy state.

To estimate the annual increase or decrease in the number of animals counted within the most recent six-year reporting round, the fitted trend abundance in 2014 was compared against that of 2019.

To avoid the problem of shifting baselines (See M5 CEMP Guidelines) when using the rolling baseline applied in Threshold Value 1, an assessment value relating to a fixed, historic baseline is also needed (Threshold Value 2).

#### Threshold Value 2:

- No decline in seal abundance of >25% since the fixed baseline in 1992 (or closest value).

The baseline chosen (1992) relates to that used by some Member States for reporting under the European Union Habitats Directive (Council Directive 92/43/EEC) (or if such data are not available, the start of the data series). Testing shows that there is sufficient monitoring to assess against this threshold value with confidence. It should however be noted that if data are not available from 1992, and a shorter timescale is assessed, the 25% decline since the baseline is not equivalent to those AUs where data do extend to 1992 (i.e., a 25% decline since 2003 would describe a more rapid contraction in the population than a 25% decline since 1992).

To estimate the annual increase or decrease in the number of animals counted within the long-term time period, the fitted trend abundance in 1992\* was compared against that of 2019.

\*Data as far back as 1992 were not available in all AUs; the first year of data thereafter was used. Indicator assessment values were set as a deviation from the baseline value (Method 3; OSPAR, 2012).

#### Appropriateness of Historic Baseline (1992)

The fixed 1992 (historical) baseline reflects a point in time when populations were already subject to anthropogenic pressures including culling or natural pressures, so this baseline year most likely represents a time when populations had not yet recovered from severe depletion.

Seals have been historically hunted both illegally and legally and it is not possible to know the undisturbed state, nor, for some areas, the current carrying capacity that could be attained alongside protection from

illegal hunting and absence of exposure to anthropogenic activities. Time series data for grey seal pup production do not provide an indication of a time when seal populations were not impacted and what it would look like in terms of abundance and distribution. It is therefore not possible to identify a baseline representing unimpacted conditions. This also leads to challenge in assessing the status of seals in relation to the concept of a “favourable conservation status”.

### Analysing Changes in Pup Production

As per the Intermediate Assessment 2017 (IA 2017), grey seal pup production was assessed based on either estimated pup production or peak counts using either generalised linear or additive models. It is deemed appropriate to use both types of pup data as the same method was consistently used at each site for the duration of the assessment period.

Generalised linear or additive models (GLMs, GAMs; Wood 2011) were fitted to count data on a log scale using negative binomial error (or a Poisson error distribution if necessary) as part of both threshold values of pup production. All analysis was conducted within R (R Core Team, 2021). Percentage change (mean and 80% confidence intervals) were estimated for each AU over the short- and long-term assessment periods; 80% confidence intervals were calculated to reflect the choice to set the significance level,  $\alpha$ , equal to 0,20 or 20% (Formula A). If the 80% confidence intervals encompassed the threshold, the assessment was classified as ‘inconclusive’.

$$\Delta_{\text{production}} = \frac{C - A}{A} * 100$$

Formula A: Calculation of long-term trend in production. Where A is the count fitted by the model in the baseline year and C is the count fitted by the model in the most recent survey year during an assessment of long-term shifts.

All assessments have included data that were available before (from 1984) and after (to 2020) the standard assessment window (1992-2019) to generate more robust population trends for analysis in the AUs. These data have been included to improve the robustness of the models and indicate more accurate trends. For AUs for which there were a limited number or temporal extent of counts for the AU, when possible, a more comprehensive time series from a subset of the AU (>75% of pups) was used as a proxy to allow robust trend fitting.

Quantitative assessments of trends in pup production were only completed for those AUs where more than four annual data points were available. For AUs for which there were a limited number or temporal extent of counts for the AU, when possible, a more comprehensive time series from a subset of the AU was used as a proxy to allow robust trend fitting.

### Results (brief)

All AUs with sufficient data to carry out an assessment within the Greater North Sea and Celtic Seas have achieved their threshold values both over the long- and short-term assessment periods (**Figure 2** and **Figure 3**). Long-term pup production increased between 1992 and 2019, ranging from high values of 1798% (80% CIs: 556, 5532) and 1667% (80% CIs: 1307, 2135) within the French North Sea & Channel Coast and Belgium Coast & Dutch Delta (AUs 16 and 17), respectively, to 12% (80% CIs: 1, 24) within Western Isles (AU 3). Short-term increases between 2014 and 2019 ranged from 119% (80% CIs: 104, 135) within the Wadden Sea (AU 18) to 1% (80% CIs: -6, 8) within North Coast & Orkney (AU 4) (**Table 1**).

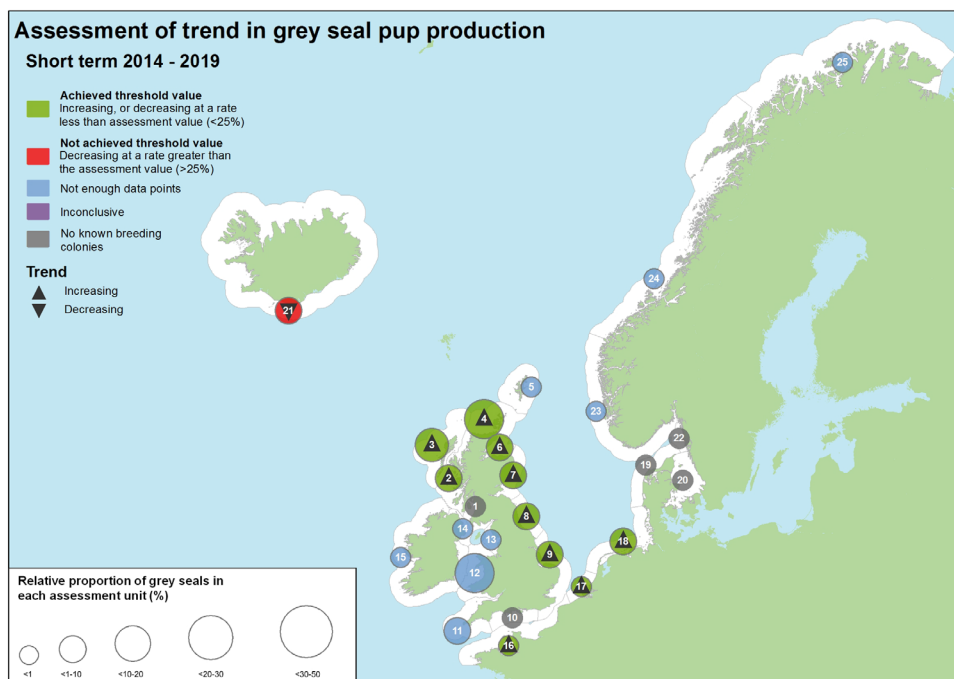


Figure 2 – Assessment of recent change in grey seal pup production (2014–2019)

The number in each circle refers to the Assessment Unit ID (see key). Relative proportion of grey seals is calculated using the combined total sum of the last count or count estimation in each AU.

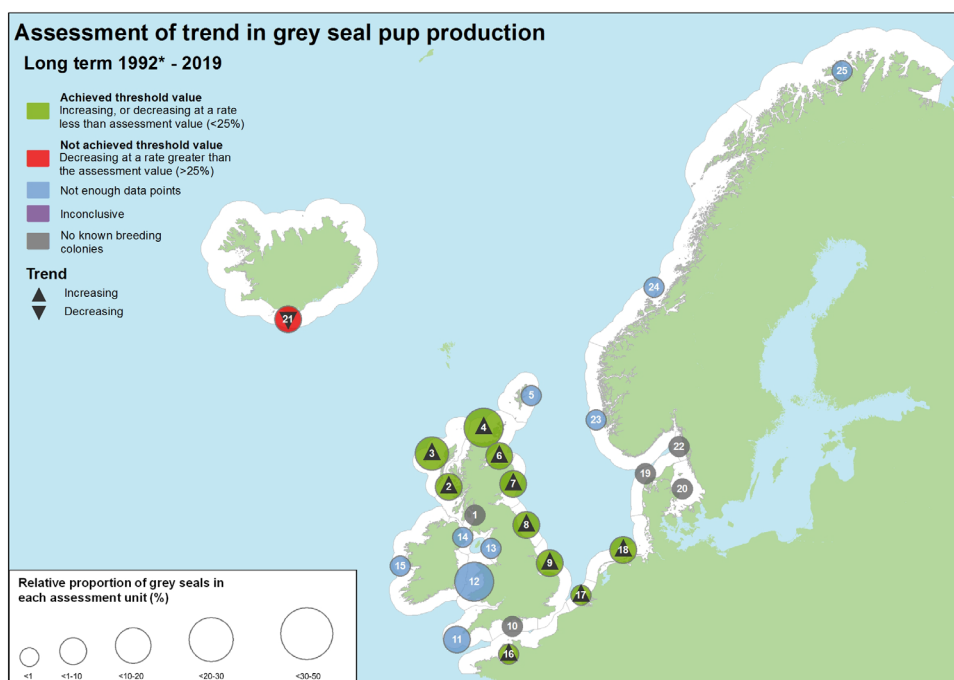


Figure 3 - Assessment of long-term change in grey seal pup production (1992\*–2019)

The number in each circle refers to the Assessment Unit ID (see key)

\*1992 was used as a baseline year, but in some Assessment Units a later year was used (see year in brackets in key). Relative proportion of grey seals is calculated using the combined total sum of the last count or count estimation in each AU.

### Assessment Unit (AU)Key

1. South-West Scotland, 2. West Scotland, 3. Western Isles, 4. North Coast & Orkney, 5. Shetland, 6. Moray Firth (1994), 7. East Scotland, 8. North-East England, 9. South-East England, 10. South England, 11. South-West England, 12. Wales, 13. North-West England, 14. Northern Ireland (2002), 15. Ireland (2003), 16. French North Sea & Channel Coast, 17. Belgium Coast and Dutch Delta (2003), 18. Wadden Sea, 19. Limfjorden, 20. Kattegat, 21. Iceland, 22. Skagerrak (2003), 23. MA1 (Norway) (2006), 24. MA2 (Norway) (2006), 25. MA3 (Norway) (2006)

Higher short-term percentage changes were detected within the French North Sea & Channel Coast (AU 16) and Belgium Coast & Dutch Delta (AU 17), where increases of 133% (80% CIs: 118, 149) and 962% (80% CIs: 455, 1898) were detected respectively. However, the much lower initial count of pups at these sites may distort the significance of these outputs.

Within Arctic Waters, Iceland (AU 21) was the only Contracting Party with sufficient data to conduct an assessment. As trends could only be fitted to AU data with more than four data points, Norwegian data from within this Region could not be assessed. Analysis outputs for Iceland demonstrate that the AU did not achieve the long- or short-term threshold value and was decreasing at a rate greater than 25% since the historical baseline (-43% (80% CIs: -52, -33)) and at a rate of greater than 6% between 2014 and 2019 (-10% (80% CIs: -13, -7)) (Table 1).

AU	Name	Metric	First Year	Last Year	N <sub>years</sub>	Latest Count/Estimate	Percentage Change (80% CIs)	
							Long-term	Short-term
1	Southwest Scotland	NA		2019		c. 0	No known breeding colonies	
2	West Scotland	production	1984	2019	30	4455 (87%)	35 (21, 50)	3 (-4, 10)
3	Western Isles	production	1984	2019	31	16083 (98%)	12 (1, 24)	5 (-1, 12)
4	North Coast & Orkney	production	1984	2019	31	22153 (96%)	90 (73, 112)	1 (-6, 8)
5	Shetland	peak		2018			NA	NA
6	Moray Firth	production	2006	2019	8	1865	32 (17, 50)	18 (9, 27)
7	East Scotland	production	1984	2019	32	7261 (>99%)	370 (328, 415)	28 (22, 35)
8	Northeast England	production		2019	36	2823 (>99%)	177 (157, 198)	53 (44, 62)
9	Southeast England	production	1984	2019	36	7902	4102 (3800, 4430)	75 (66, 86)
10	South England	production		2019		0	No known breeding colonies	
11	Southwest England	production		2019		c. 450 <sup>1</sup>	NA	NA
12	Wales	production		2019		c. 2250 <sup>1</sup>	NA	NA
13	Northwest England	production		2019		c. 10 <sup>1</sup>	NA	NA
14	Northern Ireland	production		2020		c. 500	NA	NA
15	Ireland	production		2005		1,574	NA	NA
15S	Ireland monitoring areas	production		2011		1,829	NA	NA
16	French North Sea & Channel Coast	peak count	2002	2020	16	75	1667 (1307, 2135)	133 (118, 149)

17	Belgium Coast & Dutch Delta	peak count	2003	2020	18	13	1798 (556, 5532)	962 (455, 1898)
18	Wadden Sea	peak count	2008	2020	13	1726	461 (381, 554)	119 (104, 135)
19	Limfjorden						No known breeding colonies	
20	Kattegat						No known breeding colonies	
21	Iceland	production	1982	2017	11	1452	-43 (-52, -33)	-10 (-13, -7)
22	Skagerrak						No known breeding colonies	
23	Norway (Hvaler - Stad)	peak count	2003	2020	3	35	NA	NA
24	Norway (Stad - Vesterålen)	peak count	2003	2020	4	404	NA	NA
25	Norway (Troms - Finnmark)	peak count	2008	2015	2	271	NA	NA

Table 1: Changes in grey seal pup production from surveys during the autumn breeding season in each Assessment Unit.

Nyears indicate the number of years for which data were available. For AUs for which a subset was considered, the approximate percentage of the AU total represented by that subset is shown in brackets after the last AU peak count/estimate.

Table colour key	
Achieved threshold value	
Not achieved threshold value	
Not enough data points	
Inconclusive	

#### Assessment output key

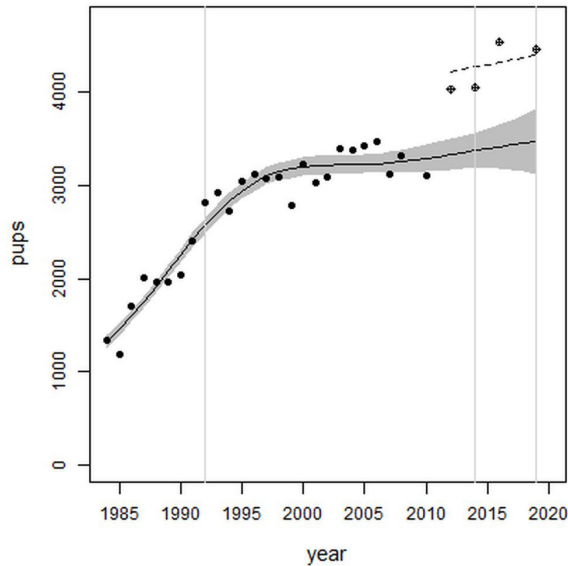
While grey seals do breed on Shetland (AU 5), South-West England (AU 11), Wales (AU 12), Northern Ireland (AU 14) and Ireland (AU 15), comprehensive time series data at the appropriate scale (i.e., AU) were not available within the data call to then be analysed as part of this indicator. No data at the scale of the AU were provided for Limfjorden (19), Kattegat (AU 20) or Skagerrak (AU 22) as pup production is zero to low in these regions.

Data points for Ireland were limited and so was not able to be analysed using the methods described above. Grey seal breeding surveys for the Republic of Ireland are focused on seven main breeding areas which encompassed c. 84% of production in 2005 (based on country-wide surveys; Ó Cadhla et al. 2007). Pup production was estimated to be 1 322 and 1 574 for the seven main areas and Republic of Ireland as a whole, respectively. These seven areas were surveyed again between 2009 and 2012 and pup production was estimated to be 1 829 (Ó Cadhla et al., 2013; **Figure 4**).

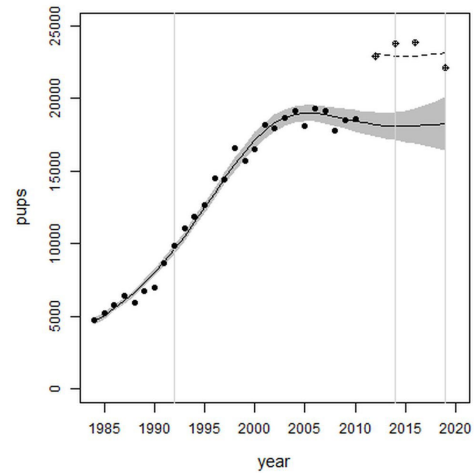
Further surveys have been conducted between 2015 and 2017 for four of the main breeding areas which encompassed 35% of production in 2005. Pup production has not yet been estimated from those data

collected between 2015 and 2017. Thus, in order to illustrate these data in a comparable manner, peak counts (summed across these four areas) were shown for 2005, 2009/2011 and 2015/2017. The relationship between peak counts and pup production will vary depending on the timing of both pupping and the survey flights. However, in 2005 across the seven areas, the peak count was 66% of pup production (range: 54 – 90%), suggesting an upward trend in the AU.

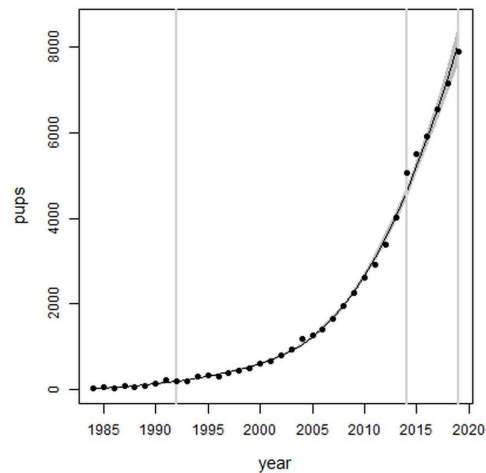
**2. West Scotland**



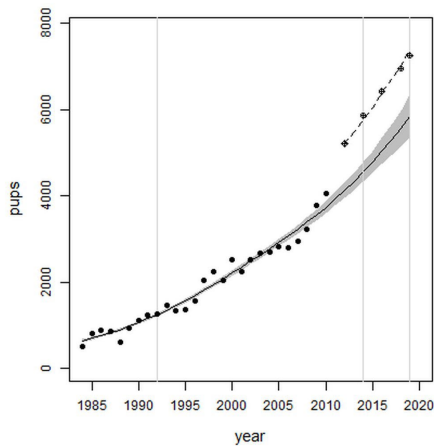
**4. North Coast & Orkney**



**9. Southeast England**

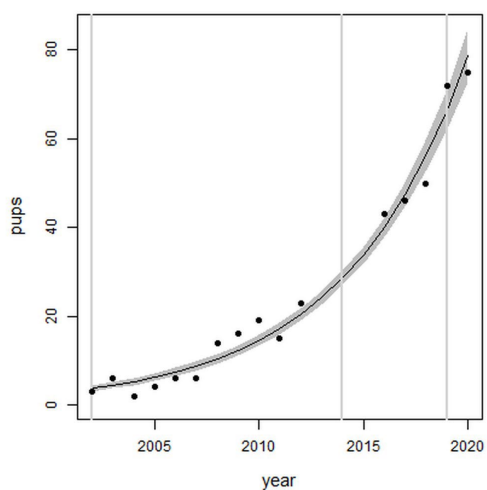


**7. East Scotland**

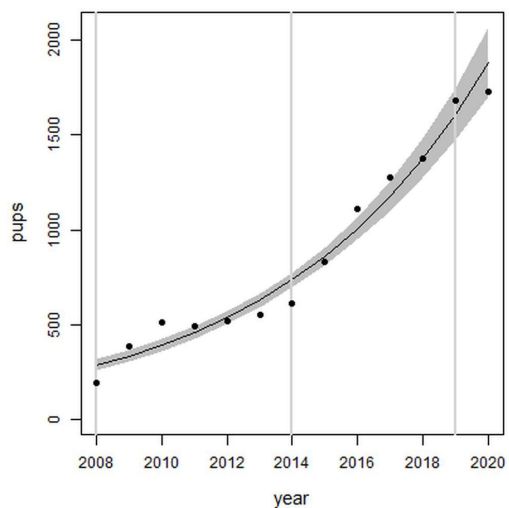




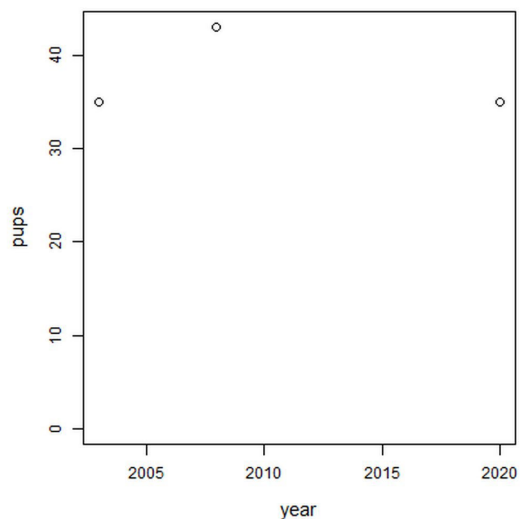
16. French North Sea and Channel coast



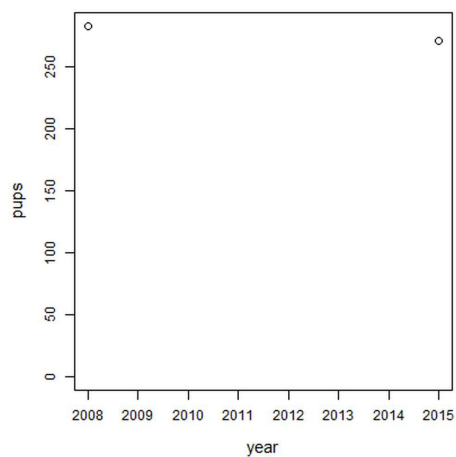
18. Wadden Sea



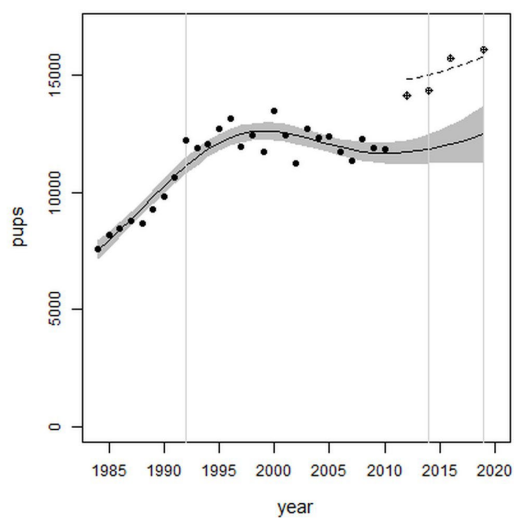
23. Norway MA1



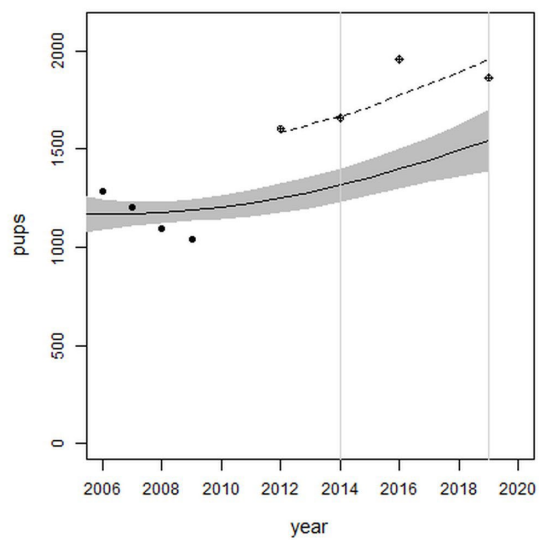
25. Norway MA3



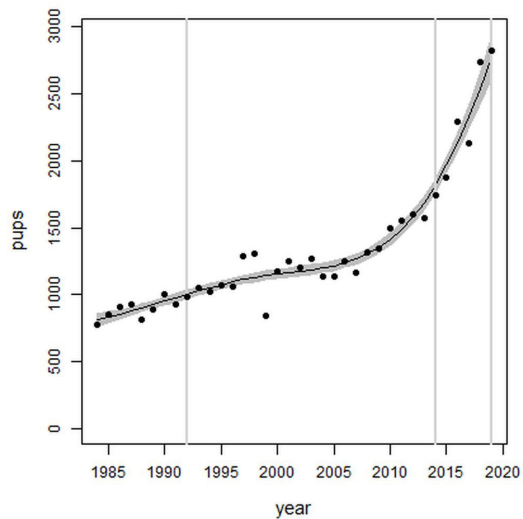
3. Western Isles



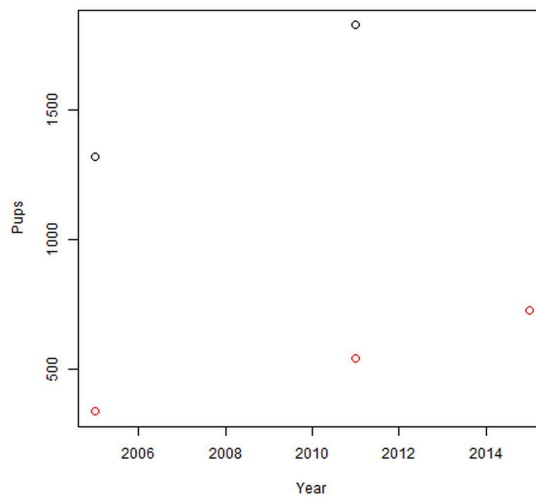
6. Moray Firth



8. Northeast England



15. Ireland



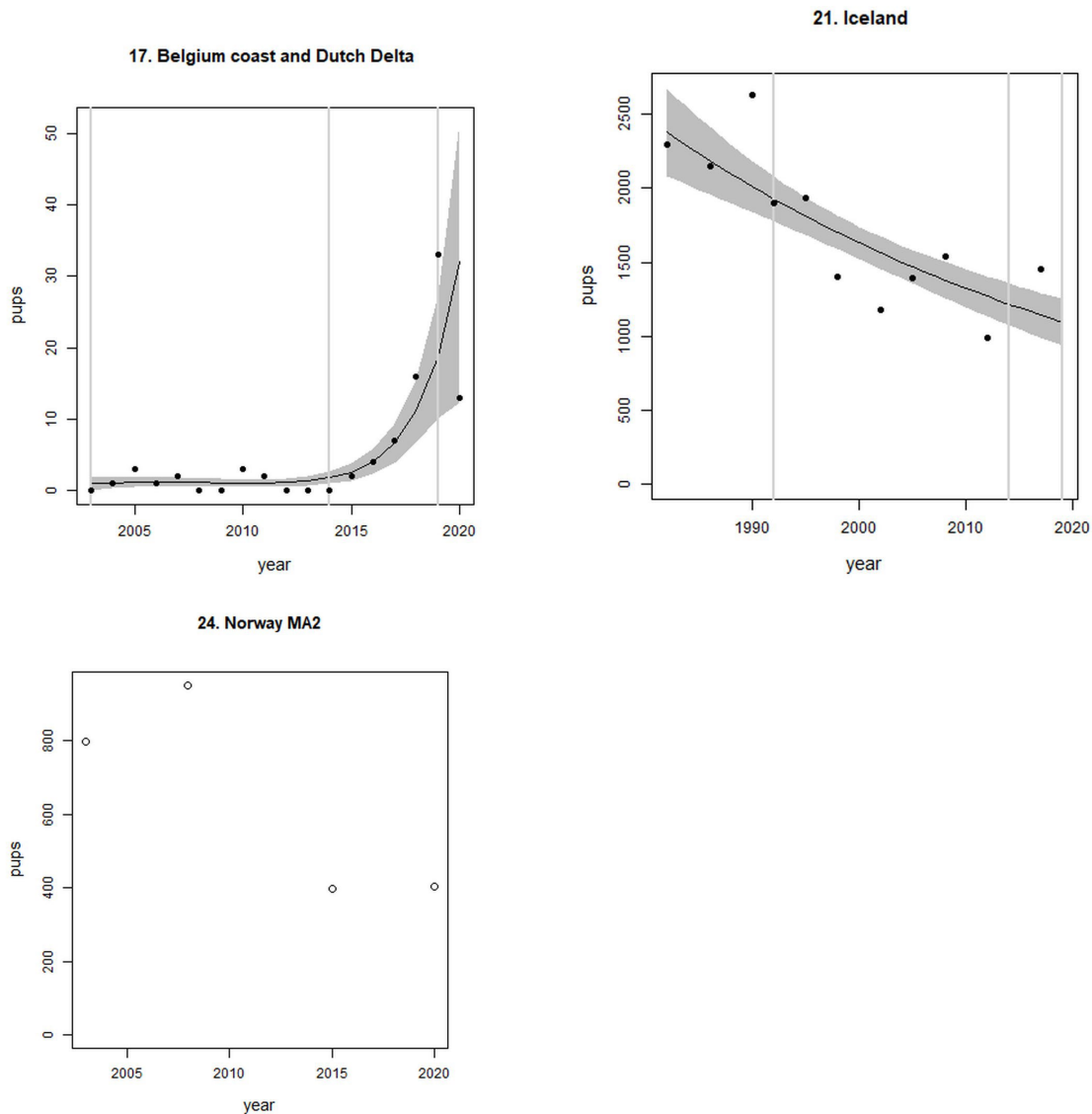


Figure 4: Trends in grey seal pup production from surveys during the breeding season (autumn)

Points denote observed numbers of seals. Grey vertical lines denote the years extracted as part of the long- and short-term assessments (baseline year, 2014 and 2019). 80% confidence intervals are illustrated in grey. For AUs 2-7, crossed points illustrate the change between film and digital survey methods (SCOS, 2012). For these AUs, a step increase in pup abundance was offered between the two years to account for the artificial increase in pups associated with the change in aerial survey method, allowing the assessment to be based on the trends excluding this jump. The plots for these AUs show the trends and surrounding CIs based on the original survey method (pup production estimates shown as filled dots). The crossed points show the estimates using the new method and the dashed line the trend line for those. The shape of this line matches the main trend line and is shown for illustration. For AU 15, the total estimated pup production for the seven monitoring areas is shown as open black circles (c. 84% of AU pup production in 2005). The total peak counts for the four monitoring areas (35% of AU pup production in 2005) referred to above are shown as red open circles.

## Results (extended)

As previously noted, grey seal pup production is continuing to increase rapidly in eastern England (AUs 6–9), including the Channel, Dutch Delta and Wadden Sea areas (AUs 16-18) both since the baseline year and short term, between 2014 and 2019 (**Figure 4**). The increase in pup production in these continental Europe AUs is, in part, driven by the immigration of animals from the large colonies to the north of the United Kingdom

(Brasseur et al., 2015). Continued increases within eastern England AUs is hypothesised to, in part, be driven by recruitment of females born elsewhere, from areas that have perhaps already reached carrying capacity in the north of the UK (Brasseur et al., 2015; Russell et al., 2019).

Pup production trend analysis within the northern region of the Celtic Seas AUs (2 – 4) and Orkney demonstrated rapid and sustained increases against the historical baseline year, but in more recent years there has been a declining rate of growth and levelling off in pup production. It is likely that these AUs have reached their carrying capacity for grey seals (Thomas et al., 2019).

Analysis outputs from Iceland demonstrate that the AU did not achieve the long- or short-term threshold value and grey seal pup production continues to decline. In 2019, a new regulation was enacted to support the recovery of both grey and harbour seals. This regulation bans hunting but does allow for exemptions to carry out “traditional hunt” – of which there are thought to be few. Prior to this, though it was acknowledged that seals were being removed for both subsistence and to reduce interactions with fisheries, no legislation on seal hunting was in place and no obligation to record removals was in place in Iceland. However even since the introduction of legislation it is considered that the risk from by-catch in Icelandic fisheries may pose a greater threat to the species’ recovery in the country (Granquist & Hauksson, 2019; Granquist, 2021).

Surveys and model-based assessments using Norwegian grey seal count data have historically indicated an increasing grey seal population in Norway. However, more recent surveys within AU 24 between 2014 and 2015 showed a decrease in grey seal pup production. Counts within AU 25 were either slightly reducing or stable in 2016 when compared to counts from 2006. Grey seal pup production in Norway (Stad – Vesterålen) (AU 24) was at the same low level in 2018. However, within this AU, pup production in Lofoten (Nordland) had almost doubled in 2020 compared to the low level in 2015 (NAMMCO, 2021).

### Confidence Assessment

Assessment methods largely follows those used in IA 2017, with some minor amendments as outlined in the [CEMP guideline](#). Confidence in the data availability is considered to be moderate as there was mostly sufficient spatial and temporal coverage to carry out assessments at the scale of the AUs, some gaps are still apparent. Using this method, the statistical power to detect a grey seal population rate of decline of 1% per year was low (around 20%) in some AUs, especially where monitoring occurs on a less than annual basis. There is consensus within the scientific community regarding this methodology, though some questions remain, therefore the confidence could be considered moderate. However, as the method has been developed specifically for this assessment and not been more widely used it could be considered more moderate / low.

### Conclusion (brief)

Grey seal pup production has increased over both the long term and short term in all assessed areas in Region II (except Shetland) and in Region III, where data was available to carry out an assessment. Within Region I, only data from Iceland was provided and able to be analysed. On both the long- and short-term scale, production is decreasing at a rate greater than the assessment values.

The results for pup production should be considered alongside those for the [M3 common indicator on Seal Abundance and Distribution](#). While both indicators show an improvement in the condition of the grey seal population in the North-East Atlantic, the population is likely to be recovering from a time when it was significantly depleted by human activity. Hunting, and potentially pollution and overfishing, reduced populations in the recent past and might still be having an influence. The natural carrying capacity for the number of grey seals in the North-East Atlantic is not known. Even without pressure from human activities it is clear that pup production cannot keep increasing indefinitely and will reduce as the natural carrying capacity is reached across AUs. Indeed, carrying capacity appears to have been reached in some AUs.

### Knowledge Gaps (brief)

In several assessment units there are either not enough data points to be able to carry out an assessment, or data is not collected using comparable methods for it to be analysed in a similar format to other AUs, leaving their outputs at 'Inconclusive' (Figure 2 and Figure 3).

Grey seals are capital breeders and there is limited information on the relationship between how the breeding resources that females require to produce pups may be impacted by human activity, and the locations where impacts on pup production would be realised (i.e., the AU in which trends are assessed). Indeed, adult grey seals do move amongst AUs between the foraging and breeding seasons, but the extent of their movement, and how this may influence local pup production values is at present poorly understood. Further multi-country collaborative studies on the movements of individual seals could help better understand this.

### Knowledge Gaps (extended)

It was not possible to make a quantitative assessment in all 25 Assessment Units (AUs) for several reasons. This may partially be due to the original delineation of the AUs being based largely around those appropriate for harbour seal monitoring by many Contracting Parties and so do not necessarily account for the spatial distribution of those areas used specifically for breeding by grey seals. This leaves several AUs as N/A simply due to there not being known breeding colonies in the region, or of sufficient size to conduct cost effective monitoring on them.

The remaining assessment gaps were due to a lack of sufficient annual and inter-annual data points to perform a quantitative assessment of the time series. Infrequent monitoring is often a result of funding dependency, but also may be because there are relatively few animals breeding in an area and / or may be related to difficulty in assessing breeding sites during the autumn and winter. Continued support for the long-term seal monitoring programmes in place within Contracting Parties will ensure that sufficient data are collected to provide quantitative assessments of grey seal pup production for those areas. The aggregation of data across national programmes in the North-East Atlantic provides a possibility for meta-analyses that place regional / national population trends into the wider regional context.

As noted in Background, pup production when used on its own is not a meaningful indicator of population condition. An ideal measure of population condition could include information on female fecundity and pup survival. However, demographic parameters are only available where long-term and detailed monitoring of colonies exists (e.g., Isle of May in Scotland), and have limited use at larger scales due to movement of both pups and adults between colonies. The potential development of formal analysis linking this indicator assessment and that of the [M3 common indicator on Seal Abundance and Distribution](#) could prove beneficial.

From the present data it is not possible to exclude human influence on pup production. Even without pressure from human activities, pup production cannot keep increasing indefinitely and will stabilise as carrying capacity is reached. Further demographic studies could help predict carrying capacity for the number of grey seals in the North-East Atlantic and provide an indication of likely future trends in pup production, with and without impacts from human pressures.

Grey seals exhibit increased site philopatry once they reach the breeding age, and some breeding sites themselves only exist for the season before individuals disperse across the North-East Atlantic (Brasseur et al., 2015; Russell et al., 2019). Recovery of grey seals throughout the North-East Atlantic is largely UK centric. As AUs in the UK begin to reach carrying capacity and as individuals reach breeding age they redistribute along coasts of continental Europe. Further research into the level and extent of exchange between UK and

continental Europe and Arctic countries would benefit understanding of potential spread of human impacts in areas.

Power to detect the growth rate specified in assessment value 1 (decline of >6% between 2014 and 2019) was retrospectively calculated using the formulae from Thomas (1997) where  $\lambda$  (the non-centrality parameter) is a function of the specified effect size (here, the assessment growth rate of -1% per year), the sum of squares and variance estimated from the fitted model. The total sample size was calculated as the product of the number of years of survey data and the typical number of replicate surveys performed in the Assessment Unit (AU). Using this method, the statistical power to detect a grey seal population rate of decline of 1% per year was low (around 20%) in some AUs, especially where monitoring occurs on a less than annual basis. This assessment value may need to be revised for future assessments and / or monitoring programmes improved to enhance the power to detect trends. In the present assessment, the confidence intervals provide a robust assessment of uncertainty in the magnitude of observed trends.

Seal colonies, particularly during the breeding season are experiencing increasing levels of human disturbance both on land and at sea from activities such as, but not limited to walkers, tour boats, paddle boats, jet-skis and recreational swimming activities (Strong & Morris, 2010; Andersen et al., 2012; Granquist & Sigurjonsdottir, 2014; Granquist & Nilsson, 2016; Bellman et al., 2019). Disturbance signs can range from increased alertness to complete 'flushes' of colonies into the water. The extent to which these activities impact pupping sites via stress responses and ultimately the success of breeding females is not clearly understood. The increasing frequency of reported disturbance events across the North-East Atlantic, and the unquantified impacts on population status warrants further research.

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## Assessment Metadata

Field	Data Type	
Assessment type	List	Indicator Assessment
Summary Results (template Addendum 1)	URL	<a href="https://odims.ospar.org/en/submissions/ospar_grey_seal_pup_msfd_2021_06/">https://odims.ospar.org/en/submissions/ospar_grey_seal_pup_msfd_2021_06/</a>
SDG Indicator	List	14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans
Thematic Activity	List	Biological Diversity and Ecosystems
Relevant OSPAR Documentation	Text	Agreement 2016-12 CEMP Guideline: Common Indicator - Grey seal pup production (M5)
Date of publication	Date	2022-06-30

Field	Data Type	
Conditions applying to access and use	URL	<a href="https://oap.ospar.org/en/data-policy/">https://oap.ospar.org/en/data-policy/</a>
Data Snapshot	URL	<a href="https://odims.ospar.org/en/submissions/ospar_grey_seal_pup_snaps_hot_2021_06/">https://odims.ospar.org/en/submissions/ospar_grey_seal_pup_snaps_hot_2021_06/</a>
Data Results	Zip File	<a href="https://odims.ospar.org/en/submissions/ospar_grey_seal_pup_prod_res_2021_06/">https://odims.ospar.org/en/submissions/ospar_grey_seal_pup_prod_res_2021_06/</a>



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**Our vision is a clean, healthy and biologically diverse North-East Atlantic Ocean, which is productive, used sustainably and resilient to climate change and ocean acidification.**

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