Zustand der deutschen Nordseegewässer 2018

Aktualisierung der Bewertung nach § 45c WHG, der Beschreibung des guten Umweltzustands nach § 45d WHG und der Festlegung von Umweltzielen nach § 45e WHG zur Umsetzung der Meeresstrategie-Rahmenrichtlinie

ENTWURF

Anlage 2

Kurzfassungen der OSPAR Indikatorbewertungen von Belastungen und Zustand im Überblick –

Auszüge aus dem →OSPAR Intermediate Assessment 2017

Stand Juni 2017

Inhalt

Trends in New Records of Non-Indigenous Species (NIS) Introduced by Human Activities

MSFD Descriptor: 2 - Non-indigenous species

MSFD Criterion: 2.1 - Abundance and state characterisation of non-indigenous species, in particular invasive species

OSPAR COMMISSION

Key Message Non-indigenous species are not only a major threat to marine biodiversity, but also have considerable socio-economic impacts. Newly recorded species have been encountered at a relatively constant rate in the areas assessed. Preventing the introduction of non-indigenous species is the most cost-effective approach to management

Background

Non-indigenous species (NIS) introduced by human activities are organisms moved into new areas outside their natural range by, for example, transfer of ships' ballast water, biofouling (accumulation of organisms on ships' hulls) and aquaculture. Species that naturally increase their range are not taken into consideration, however, NIS that spread to neighbouring areas by natural means following introduction (secondary dispersal), are still considered to be NIS.

The presence of NIS can exert pressures on the marine environment with possible social, economic or environmental impacts. Invasive NIS are one of the most significant threats to global biodiversity. Removing NIS subsequent to introduction is very difficult, which means preventing their introduction is the most cost-effective approach to management, thus avoiding costs and the need for eradication measures.

This assessment focuses on trends in new records of NIS introductions into the OSPAR Maritime Area, to determine the effectiveness of measures aimed at reducing NIS introductions.

This assessment is based on new records of NIS provided by OSPAR Countries, acknowledging limitations in these data, such as discrepancies between when the presence of a new NIS was recorded and when it was actually introduced. New political initiatives (for example, the European Union Invasive Alien Species Regulation and the Marine Strategy Framework Directive (MSFD)) mean that monitoring programmes focused on detecting introductions of new NIS, are starting to be developed. These will, in time, strengthen the data available and therefore the assessment of this indicator.

Image: The invasive sea squirt *Didemnum vexillum* covering a holding tank at an oyster rearing unit © Cefas

Results

The number of new non-indigenous species (NIS) recorded for the Greater North Sea, Celtic Seas and the Bay of Biscay and Iberian Coast over the period 2003–2014, varied by year and region (**Figure 1**), but showed no overall trend in the number of new NIS records over the assessment period.

The cumulative number of new NIS introductions (**Figure 1**) provides an indication of change in trends. In the Greater North Sea there was a relatively constant linear increase in the number of new NIS recorded over time, whereas the other two regions had particular years with relatively high numbers of new NIS records which meant a similar linear increase did not occur: Celtic Seas (2006, 2012) and Bay of Biscay and Iberian Coast (2004).

Data indicate that the numbers of NIS introduced into the Celtic Seas is lower than in the Greater North Sea, Bay of Biscay and Iberian Coast. It is difficult to speculate as to why this may be the case, given the nature of the data used.

For each of the three regions assessed, there were more new NIS records in reporting period 1 (2003–2008) then in reporting period 2 (2009–2014), as outlined in **Table 1**. There was considerably more in the case of the Greater North Sea and the Bay of Biscay and Iberian Coast, although this difference was not statistically different. In the Celtic Seas there is little difference between new NIS records between reporting periods 1 and 2, and no significant difference between the datasets.

There is moderate confidence in the method and low confidence in the data availability.

OSPAR Region	Mean number of new NIS records		Statistically significant difference between means (*p* value of 0.05)
	Reporting period 1 (2003–2008)	Reporting period 2 (2009–2014)	
Greater North Sea	10.17	7.67	No
Celtic Seas	3	2.83	No
Bay of Biscay and Iberian Coast	38.83	3.67	No

Table 1: Mean number of new NIS records in the Greater North Sea, Celtic Seas and the Bay of Biscay and Iberian Coast, and the results of a statistical comparison between the means for both periods, by OSPAR Region

Trends in New Records of Non-Indigenous Species (NIS) Introduced by Human Activities

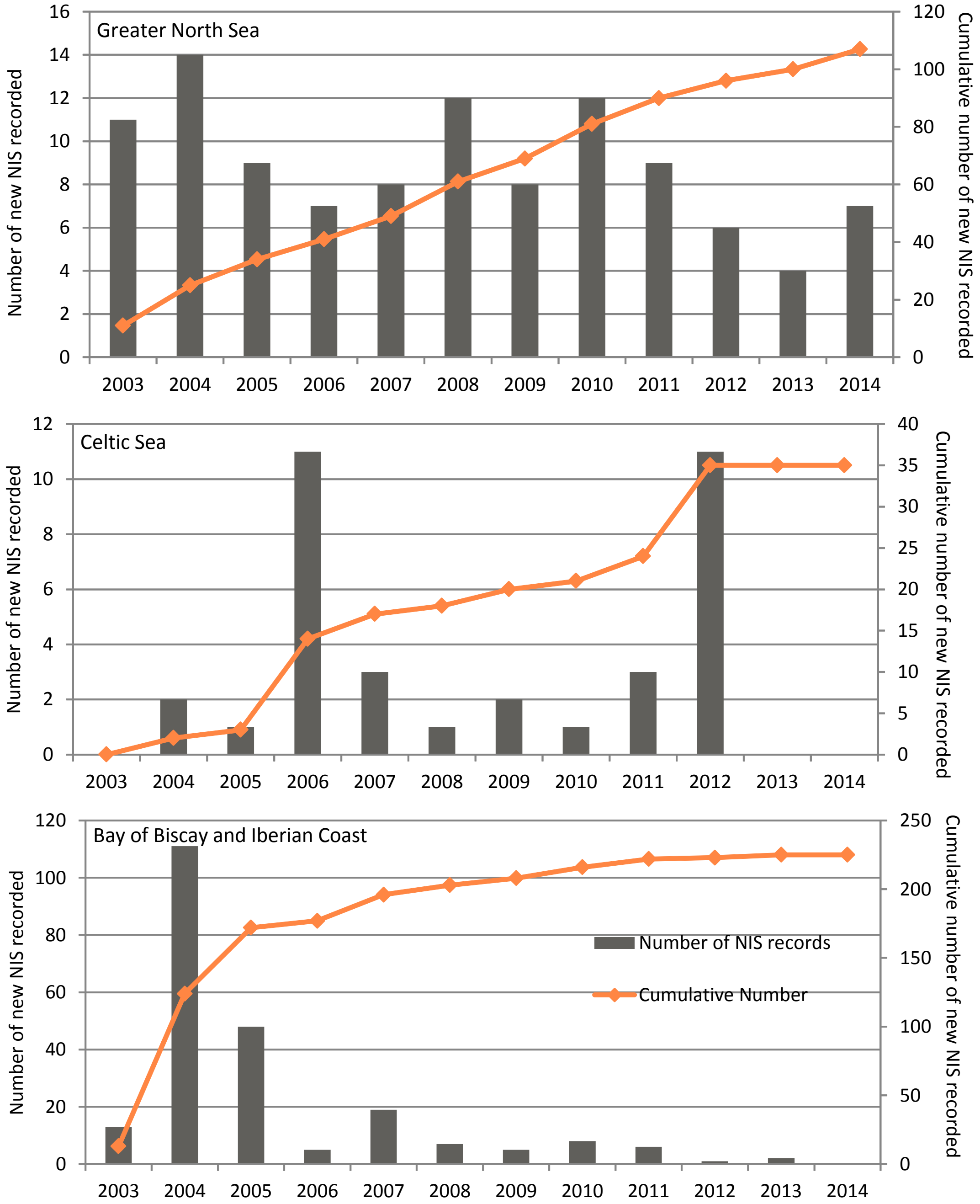

Figure 1: The number of new NIS records per year in each region assessed. Note the different scales used on each plot and on the two y-axes

Conclusion

Excluding a few years with high rates of non-indigenous species (NIS) introduction, new species have been encountered at a relatively constant rate for the three regions assessed. Therefore, more effort to reduce the current rate of introduction should be considered. Differences in the rates of introduction are relatively small between regions, and not statistically significant between the two six-year reporting periods (2003–2008 and 2009–2014).

There are a number of limitations identified with the data used. There is a lack of data with which it is possible to make an accurate and reliable assessment of introductions of new NIS in each of the regions assessed. Nevertheless, this assessment demonstrates the functionality of the method developed.

The main conclusion is, therefore, that development and implementation of coordinated and harmonised monitoring should be considered to provide accurate datasets for future assessments. In addition, to accurately determine whether the rate of introduction of new NIS is stable or changing, longer term datasets are required and hence more sustained monitoring. Emerging NIS are extremely difficult to detect thus the development of monitoring should take into account the risk based approach and a proportional application of management options for NIS once detected.

Continued implementation of the European Union MSFD, Invasive Alien Species Regulation, and Water Framework Directive, and the International Maritime Organization Ballast Water Management Convention, should ensure some of the identified gaps in monitoring are addressed.

Knowledge Gaps

Strengthening of non-indigenous species (NIS) monitoring would improve the assessment of this indicator. Efforts need to focus on a cost-effective approach to:

- Improve the baseline dataset, from available knowledge, for comparison against future assessment periods;
- Consider approaches and methodology used by other organisations and for other regulatory requirements;
- Coordinate and harmonise monitoring and response at the OSPAR regional level, in association with other Regional Seas Conventions;
- Improve data flow and management processes; and
- Investigate the development of additional methods to improve the speed and probability of early NIS detection.

Understanding of the contribution of different vectors to the introduction of NIS, would be improved through the development of complementary indicators.

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Third OSPAR Integrated Report on the Eutrophication Status of the OSPAR Maritime Area, 2006-2014

OSPAR Thematic Assessment

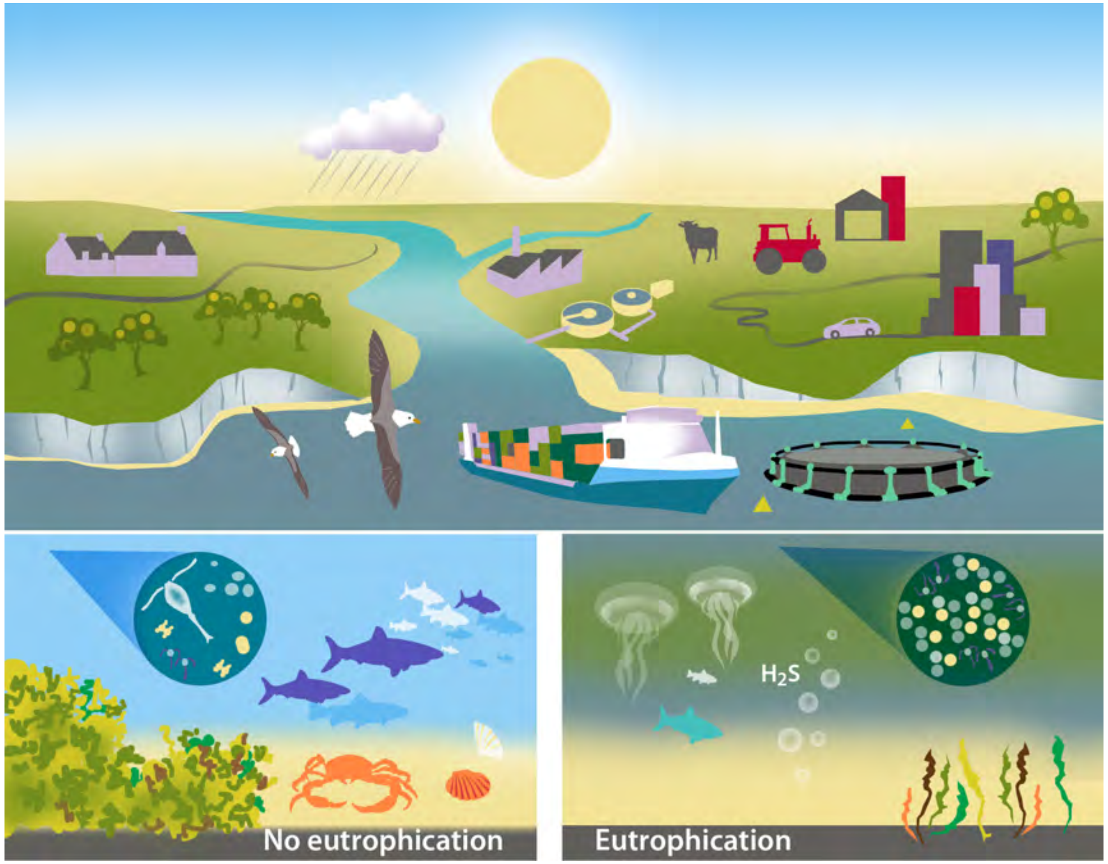
OSPAR COMMISSION

Key Message Eutrophication status in the OSPAR Maritime Area has improved since 1990, but eutrophication is still observed in 7% of the assessed area. The areas affected are mainly located in the south-eastern parts of the Greater North sea, and in some coastal waters of the Celtic Sea and Bay of Biscay

Background

OSPAR's strategic objective with regard to eutrophication is to combat eutrophication in the OSPAR Maritime Area, with the ultimate aim to achieve and maintain a healthy marine environment where anthropogenic eutrophication does not occur. OSPAR conducts periodic assessment of eutrophication status because excess nutrients in the marine environment can cause ecosystem problems.

Eutrophication is the result of excessive enrichment of water by nutrients. Excessive enrichment of marine water with nutrients may lead to algal (phytoplankton) blooms, with the possible consequence of undesirable disturbance to the balance of organisms in the marine ecosystem and overall water quality (**Figure 1**).



Identifying causal links between these disturbances (such as changes in habitats and biodiversity, blooms of nuisance algae or macroalgae, a decrease in water clarity, and behavioural changes or even death of fish and other species) and nutrient enrichment can be complicated by other pressures. Cumulative effects, including climate change, may have similar effects on biological communities and dissolved oxygen, further complicating efforts to demonstrate causal links.

Eutrophication is diagnosed using OSPAR's harmonised criteria of nutrient inputs, concentration and ratios, chlorophyll-a concentrations, phytoplankton indicator species, macrophytes, dissolved oxygen levels, incidence of fish kills and changes in zoobenthos. As there is no single indicator of disturbance caused by marine eutrophication, OSPAR applies a multi-step method using the harmonised criteria.

Eutrophication is considered to have occurred if there is evidence for nutrient enrichment causing direct and indirect effects **Figure 1**.

Figure 1: Simplified illustration of eutrophication

Results

The identification of the eutrophication status of the OSPAR Maritime Area was based on national assessments conducted by nine countries, using the OSPAR Common Procedure. Waters were classified as being problem areas, potential problem areas, and non-problem areas with regard to eutrophication.

In coastal areas, rivers are the main source of nutrients often creating problem areas with regard to eutrophication in connected estuaries, fjords and bights, and in areas affected by river plumes. Some of these areas are especially sensitive to nutrients, stimulating plant (including phytoplankton growth, measured as high concentrations of chlorophyll along many coasts of the North Sea and in the stratified Norwegian coastal current. Atmospheric deposition is also an important source of nitrogen, particularly in the Greater North Sea, although nitrogen deposition decreased by 31% between 1995 and 2014.

However, in some parts of the south-western North Sea, high nutrient inputs do not lead to eutrophication effects. This may be due to light limitation in turbid waters, or to vertical mixing of water.

Results cont...

The Norwegian Sea and Barents Sea (Arctic Waters) were classified as non-problem areas with regard to eutrophication. In the Greater North Sea, Celtic Seas, and Bay of Biscay more than 100 assessment areas in inshore and coastal waters were classified as problem areas with regard to eutrophication, with few large offshore waters classified as problem areas.

Problem areas or potential problem areas with regard to eutrophication were found in inshore waters and along the coasts of all countries that reported (**Figure 2**). The Greater North Sea had the largest surface area classified as a problem area (approximately 98 000 km²) or potential problem area (approximately 19 000 km²) with regard to eutrophication. Extensive problem areas were identified along the coast from Belgium to Denmark in the North Sea and in Danish and Swedish waters in the Kattegat and Sound. Smaller areas classified as problem areas (5–400 km²) or potential problem areas with regard to eutrophication in the Greater North Sea were found along the coast of France, the United Kingdom and Norway (**Figure 2**).

In the Celtic Seas, many small inland and coastal waters were classified as problem areas (approximately 500 km²) or potential problem areas (approximately 2 100 km²) with regard to eutrophication along the coasts of the United Kingdom and Ireland and on the French coast of Brittany. In the Bay of Biscay two areas were classified as problem areas (approximately 800 km2) and half of the areas classified as potential problem areas (approximately 3 900 km²) with regard to eutrophication. The results indicate high eutrophication pressure in parts of the Greater North Sea and Celtic Seas.

Nevertheless, atmospheric and riverine nutrient inputs to the OSPAR Maritime Area have declined since 1995. Compared to the second integrated eutrophication status assessment (2001–2005), the spatial extent of problem areas with regard to eutrophication has decreased in the waters of six countries and remained unchanged in two. Only one country observed a small increase in the spatial extent of problem areas.

Compared to the first eutrophication assessment (1990–2001), the spatial extent of problem areas in this third application of the Common Procedure has decreased for nearly all countries.

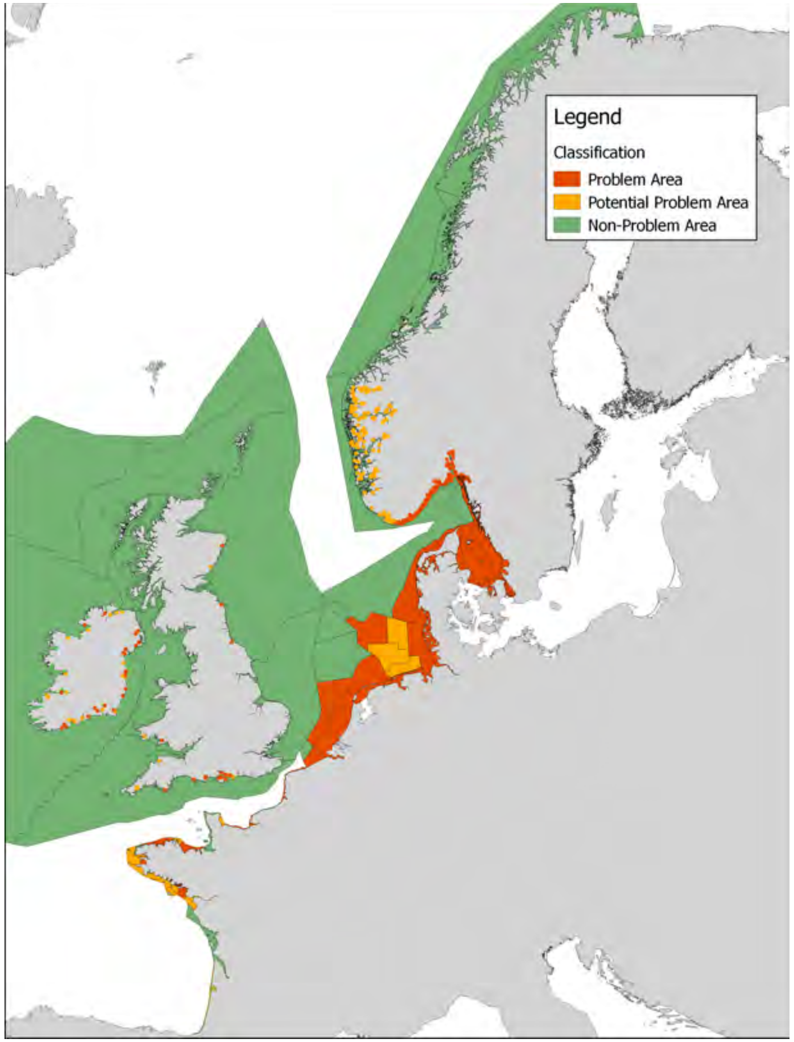


Figure 2: Eutrophication status in areas assessed in Arctic Waters, the Greater North Sea, Celtic Seas, and the Bay of Biscay, 2006–2014. Problem areas (red), potential problem areas (yellow) and non-problem areas (green) with regard to eutrophication. For Ireland, Norway and the United Kingdom's inshore and coastal waters the locations of problem areas and potential problem areas are illustrated with circles, because these assessed areas are too small to be seen if their actual area extent is mapped. White areas, not assessed

Conclusion

The results of the integrated eutrophication assessment for the period 2006–2014 show eutrophication still exists in the OSPAR Maritime Area, particularly in areas sensitive to nutrient inputs, such as estuaries, fjords and bights, and areas affected by river plumes. In particular, there is high eutrophication pressure on the Greater North Sea with some localised coastal problem areas in the Celtic Sea. Although the spatial extent of eutrophication has declined in the OSPAR Maritime Area since 1990, the concerns about atmospheric and riverine inputs of nutrients that were identified in the QSR2010 still remain.

Knowledge Gaps

There is need for scientifically robust, area-specific assessment levels of the harmonised criteria used in the application of the Common Procedure to identify eutrophication.

Improvements could be made to the assessment and area classification tools to achieve a common understanding of the way they are be applied and interpreted.

Data and information are lacking in some areas on some direct and indirect effects of the eutrophication.

At the present time the common indicators are assessed separately from the application of the Common Procedure. Integration of the indicator assessments into the Common Procedure assessment of eutrophication is desirable.

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The full assessment can be found at www.ospar.org/assessments

Nutrient Inputs to the Greater North Sea and the Bay of Biscay and Iberian Coast

OSPAR COMMISSION

MSFD Descriptor: 5 - Eutrophication
MSFD Criterion: 5.1 - Nutrient levels

Key Message Inputs of nitrogen to the Greater North Sea via water and air show a weak downward trend. Waterborne phosphorus inputs have reduced significantly. The decline slowed in the early 2000s but continues. Waterborne phosphorus inputs to the Bay of Biscay and Iberian Coast have decreased but nitrogen inputs have not

Background

OSPAR's strategic objective with regard to eutrophication is to combat eutrophication in the OSPAR Maritime Area, with the ultimate aim to achieve and maintain a healthy marine environment where anthropogenic eutrophication does not occur. The procedure to assess progress towards this objective takes into account the causes, and direct and indirect effects of eutrophication. Enriching the sea with nutrients can lead to eutrophication problems if this results in undesirable disturbances such as excessive growth of phytoplankton (algae), causing oxygen depletion in bottom waters leading to behavioural changes or even death of fish and other species. Elevated nutrient concentrations are thus an important indicator of where eutrophication might occur.

Nutrients, such as nitrogen and phosphorous, enter the marine environment from the atmosphere, rivers, land runoff, or by direct discharges into the sea. Human activities can result in large quantities of nutrients entering the sea (**Figures 1 and 2**). Data from long-term monitoring help scientists to quantify the effects of human activities and evaluate the success of measures taken to reduce nutrient inputs. One of main directions in the OSPAR Eutrophication Strategy is to cooperate to set appropriate nutrient reduction targets for problem areas with regard to eutrophication.

Nutrient emissions are regulated through OSPAR Recommendations and several EU Directives. Atmospheric emissions are also regulated through the UNECE Convention on Long range Transport of Atmospheric Pollution.

This assessment describes nutrient inputs of nitrogen and phosphorus to the Greater North Sea (waterborne and airborne) and the Bay of Biscay and Iberian Coast (waterborne).

Figure 1 (above): Exhaust emissions, including from shipping, are a significant source of atmospheric nitrogen deposition at sea ©Alfvan Beem

Figure 2 (left): Fish farming in Torskefjorden Norway. Open cage fish farms are a source of nutrients to the surrounding waters ©Ximonic/Simo Räsänen

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Nutrient Inputs to the Greater North Sea and the Bay of Biscay and Iberian Coast

Results

There has been a reduction in nitrogen inputs to the Greater North Sea since 1990, but the trend is weak. Nitrogen inputs to the Greater North Sea vary from about 1 400 to 2 000 kilotonnes per year (kt/y). Of this, approximately 500 kt/y is from atmospheric deposition (24–38% of the total). Particularly high nitrogen inputs occurred in 1994, 1995 and 2002, associated with central European flood events. Since 2003, total nitrogen inputs to the Greater North Sea have remained fairly constant at around 1 500 kt/y. Total nitrogen inputs to the Greater North Sea have decreased by about 500 kt/y over 24 years. Of this, approximately 150 kt/y is due to measures taken to reduce atmospheric nitrogen pollution.

Phosphorus inputs to the Greater North Sea have significantly decreased since 1990. Annual phosphorus inputs to this area have halved since 1990 to about 40 kt/y. Prior to 2003, phosphorus inputs varied from 70 to 90 kt/y. Highest inputs occurred in 1995 and lowest in 1996 and 2001. After 2002 phosphorus inputs of around 40 kt/y became typical. Since 2006, waterborne phosphorus inputs have decreased by about 1.5 kt/y. This compares to a rate of decrease of about 2 kt/y for the entire period 1990–2015.

Overall, waterborne nutrient inputs to the Bay of Biscay and Iberian Coast are considerably lower than those to the Greater North Sea, approximately half, and are more variable. Total nitrogen inputs are around 300 kt/y after 2000, although during 2000 they exceeded 500 kt. This is probably due to the extreme floods that occurred in autumn 2000. The minimum observed nitrogen input in 2005 (a year when Portugal did not report data) was approximately 137 kt. Nitrogen inputs are too variable to discern a temporal trend. Atmospheric nitrogen deposition to the Bay of Biscay and Iberian Coast was not assessed.

Phosphorus inputs to the Bay of Biscay and Iberian Coast have declined over the period since 1997. Highest phosphorus inputs occurred, as for total nitrogen, in 2000, and reached nearly 30 kt/y. Since 2004, inputs have been around 10 kt/y, although in the years when Portuguese data are available, this increases to about 12 kt.

Data reporting in the Bay of Biscay and Iberian Coast has been intermittent. The extreme variability in nutrient inputs in this OSPAR region makes a complete dataset important if trends and the impacts of measures are to be determined.

There is moderate confidence in the data used and moderate confidence in the methodology.

Image: Nutrients, such as nitrogen and phosphorous, enter the marine environment from the atmosphere, rivers, land runoff, or by direct discharges into the sea © Lucy Ritchie

Conclusion

Nutrient inputs to the Greater North Sea have decreased significantly since 1990. Total nitrogen inputs to the area are variable, but have decreased significantly. Reduced emissions of nitrogen to air have led to a reduction of about 150 kt/y in atmospheric nitrogen inputs. Changes in the proportion of nitrogen to phosphorus entering the Greater North Sea may affect algal community diversity.

Phosphorus inputs to the Greater North Sea are less variable than nitrogen and the significant reduction in input is particularly obvious. Since 2000, phosphorus inputs have roughly halved to about 40 kt/y. The greatest changes occurred between about 2000 and 2005, although further significant input reductions have occurred since 2006.

Riverine inputs to the Bay of Biscay and Iberian Coast are strongly affected by regional flood events. Furthermore, the time series of available data is shorter than for the Greater North Sea and recent reporting is less complete, making it difficult to draw conclusions on trends. However, phosphorus inputs between 1997 and 1999 were typically about 20 kt/y, while phosphorous inputs of about 13 kt/y are now found. Analyses show a statistically significant downward trend in phosphorus inputs to the Bay of Biscay and Iberian Coast, but not for nitrogen.

Knowledge Gaps

Nutrient input assessment is based on a combination of observations, statistical analyses and dynamic numerical models. Observations of river flow and chemical concentration could be improved by increasing measurement frequency, particularly under high flow conditions. Assessing nutrient inputs from unmonitored areas is dependent on high quality reporting from industry and agriculture and modelling tools adapted to local conditions. Atmospheric input estimates and pathways are sensitive to model resolution and could be improved, for example by data assimilation and more detailed emissions data. Atmospheric phosphorus deposition is effectively unknown, with no observations over the sea, few observations over land and no operational modelling.

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Winter Nutrient Concentrations in the Greater North Sea, Kattegat and Skagerrak

MSFD Descriptor: 5 - Eutrophication
MSFD Criterion: 5.1 - Nutrient levels

OSPAR COMMISSION

Key Message Since 1990, winter concentrations of dissolved inorganic nitrogen (DIN) and phosphorus (DIP) have decreased significantly in the southern North Sea and, for DIN, in the Kattegat, Sound and offshore areas of the Skagerrak. Since 2006, average winter concentrations of DIN and DIP in the area assessed have shown little change

Background

OSPAR's strategic objective with regard to eutrophication is to combat eutrophication in the OSPAR Maritime Area, with the ultimate aim to achieve and maintain a healthy marine environment where anthropogenic eutrophication does not occur. This indicator on winter nutrient concentrations is one of a suite of five eutrophication indicators. When assessed and considered together in the OSPAR Common Procedure in a multi-step method the suite of indicators can diagnose eutrophication.

Nutrients such as nitrogen, phosphorus and silicate enter the marine environment from the atmosphere, rivers, land runoff, or by direct discharges into the sea. Human activities can result in large quantities of nutrients entering the sea from sources that include agriculture, combustion processes (road traffic, shipping, power plants), municipal and industrial waste water treatment and aquaculture. Such nutrient discharges can lead to elevated nutrient concentrations in the marine environment, of which dissolved inorganic winter nutrient concentrations are a good indicator.

Dissolved inorganic nitrogen, phosphorus and silicate concentrations are measured in winter when biological activity and uptake of nutrients by phytoplankton is low. Waters with high nutrient concentrations are not necessarily considered eutrophic because it is the characteristics of these waters (e.g. currents, turbidity) that affect whether those concentrations lead to eutrophication and associated effects.

The present assessment is an intermediate step towards a regionally coherent assessment of winter nutrient concentrations at the level of subregions used in this eutrophication assessment.

Results

For the period 1990–2014, winter DIN and DIP concentrations decreased significantly in the southern North Sea and DIN concentrations decreased significantly in the Kattegat, the Sound and the offshore areas of the Skagerrak. For the shorter period 2006–2014, generally no trends could be detected, except for a limited, but significant increase in DIN concentrations in the coastal areas of the southern North Sea.

In the period 2006–2014, average offshore winter DIN concentrations in the northern North Sea are generally <8 µM except where the typically nutrient-rich inflow from the open Atlantic Ocean enters east of Shetland (**Figure 1**). Average winter DIN concentrations are generally <7 µM in the Sound and Kattegat, and <10 µM in the Skagerrak. The southern North Sea has the highest average DIN concentrations: exceeding 60 µM along the coasts in some eastern areas and 25 µM in some western areas. Concentrations in the central parts of the southern North Sea are 4–6 µM.

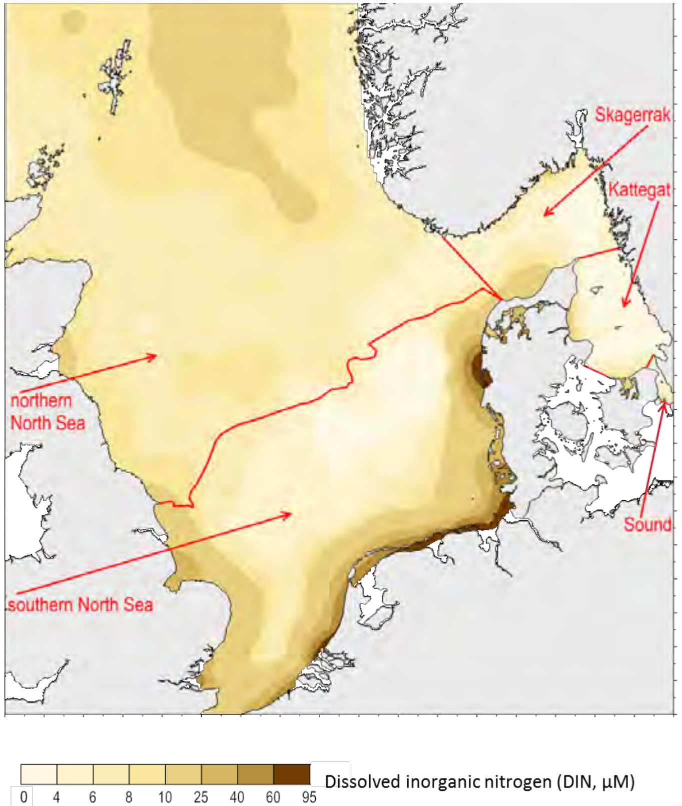

Figure 1: Distribution of average concentrations (2006–2014) of winter DIN (µM) in the northern North Sea, the southern North Sea, the Skagerrak, the Kattegat and the Sound. White areas (marine waters and estuaries) not part of this assessment, according to data availability. The accompanying table shows the results of the trend analysis for the periods 1990–2014 and 2006–2014. Downward arrows indicate a significant decreasing trend, upward arrows indicate a significant increasing trend, and horizontal arrows indicate no statistically significant trend

Area	Trend 1990-2014	Trend 2006-2014
Northern North Sea coastal (S18-30)	⟺	⟺
Northern North Sea offshore (S>30)	⟺	⟺
Southern North Sea coastal (S18-30)	⇩	⇧
Southern North Sea offshore (S>30)	⇩	⟺
Skagerrak coastal (S0-27)	⟺	⟺
Skagerrak offshore (S>27)	⇩	⟺
Kattegat	⇩	⟺
Sound	⇩	⟺

Winter Nutrient Concentrations in the Greater North Sea, Kattegat and Skagerrak

Results cont...

The distribution pattern for average winter DIP concentrations resembles that for DIN with highest concentrations along the southern North Sea coasts (**Figure 2**). Average annual winter concentrations are around 1.2 µM in coastal waters and around 0.8 µM in offshore waters of the southern North Sea. Average concentrations on the northern North Sea coasts are mostly <0.5 µM and increase up to 0.6 µM offshore, where nutrient-rich waters flow in from the Atlantic. For the Kattegat, Skagerrak and Sound, average concentrations are mostly <0.7 µM. In the east of the Skagerrak average concentrations are around 0.1 µM.

Data coverage varied widely between years, areas and salinity bands assessed. In the southern North Sea for example, the standard deviation of both DIN and DIP was between 40% and 80% across the time series in coastal areas (salinity 18–30) and offshore areas (salinity >30).

The ratio of nitrogen to phosphorus follows the distribution pattern of DIN with the lowest ratios in the offshore areas of the southern North Sea, the eastern Skagerrak, the Kattegat and the Sound. High ratios in coastal areas, namely in the southern North Sea, may link to greater success in reducing phosphorus inputs compared to nitrogen. Ratios have mostly remained stable since 1990 with clear, decreasing trends only in the Kattegat and Skagerrak and increasing trends in estuaries of the southern North Sea.

The distribution pattern of average winter silicate concentrations is similar to winter DIN and DIP concentrations in the areas assessed. Except for an increase in silicate concentrations in the Kattegat and a decrease in the estuaries of the southern North Sea, there are no statistically significant trends in winter silicate concentrations over the period 1990–2014.

Figure 2: Distribution of average concentrations (2006–2014) of winter DIP (µM) in the northern North Sea, the southern North Sea, the Skagerrak, the Kattegat and the Sound. White areas (marine waters and estuaries) not part of this assessment, according to data availability. The accompanying table shows the results of the trend analysis for the periods 1990–2014 and 2006–2014. Downward arrows indicate a significant decreasing trend, upward arrows indicate a significant increasing trend, and horizontal arrows indicate no statistically significant trend

Area	Trend 1990-2014	Trend 2006-2014
Northern North Sea coastal (S18-30)	⟺	⟺
Northern North Sea offshore (S>30)	⟺	⟺
Southern North Sea coastal (S18-30)	↓	⟺
Southern North Sea offshore (S>30)	↓	⟺
Skagerrak coastal (S0-27)	⟺	⟺
Skagerrak offshore (S>27)	⟺	⟺
Kattegat	⟺	⟺
Sound	⟺	⟺

Conclusion

Nutrient concentrations in coastal waters are higher than in offshore areas. Concentrations in estuaries and coastal areas in the southern North Sea relate to riverine inputs, which link to human activities such as agriculture, combustion processes and municipal and industrial waste water treatment. The influence of atmospheric nitrogen deposition on the Greater North Sea is not visible due to its more even spatial distribution.

Coastal nutrient concentrations in the southern North Sea and, for dissolved inorganic nitrogen (DIN) only, in offshore areas of the Skagerrak, and in the Kattegat and Sound have declined significantly since 1990. There were generally no statistically significant trends in the areas assessed over the short term (2006–2014); with the exception of a limited but increasing trend in the southern North Sea coastal waters (salinity 18–30). The lack of short term trends may be due to the minor changes in nutrient inputs (especially nitrogen) in the past decade (nutrient inputs indicator assessment) or to variability in the data.

Given that eutrophication is still evident in certain areas (see chlorophyll-a, *Phaeocystis* and oxygen indicator assessments) “a healthy marine environment where anthropogenic eutrophication does not occur” has not yet been achieved (Comprehensive Procedure integrated eutrophication report).

Knowledge Gaps

To obtain an assessment that is not only based on trends but also on the actual status of nutrient concentrations, regionally harmonised assessment values are required in all areas. These could be achieved by applying a common approach. For example, based on historical data, and modelling based on hind-casting in selected areas such as the Greater North Sea. Better informed models are required to estimate long-distance transports of nutrients and their regional effects. There is also a need to better understand the implications of data variability in trend assessment.

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The full assessment can be found at www.ospar.org/assessments

Concentrations of Chlorophyll-a in the Greater North Sea and Celtic Seas

MSFD Descriptors 5: Eutrophication

MSFD Commission Criteria: 5.2: Direct effects of nutrient enrichment

Key Message Decreasing (improving) trends in chlorophyll-a concentration are found in the Sound and Skagerrak (1990–2014), and in the offshore parts of the Greater North Sea (2006-2014). There is a small upward trend (low confidence) in the offshore Celtic Seas. Elevated concentrations are found in some coastal areas

Background

OSPAR's strategic objective with regard to eutrophication is to combat eutrophication in the OSPAR Maritime Area, with the ultimate aim to achieve and maintain a healthy marine environment where anthropogenic eutrophication does not occur. Chlorophyll-a is one of a suite of five eutrophication indicators. When assessed and considered together in the OSPAR Common Procedure (Agreement 2013-08) in a multi-step method, the suite can be used to diagnose eutrophication.

Elevated levels of phytoplankton biomass can be a direct effect of nutrient enrichment. Chlorophyll-a is measured as a proxy for the (carbon) biomass of phytoplankton. An image of the OSPAR Maritime Area based on satellite data shows the spatial distribution of chlorophyll-a on a day during the phytoplankton spring bloom (April) and a day in summer (July) (**Figure 1**). The highest chlorophyll-a concentrations are found in coastal waters.
In this assessment, chlorophyll-a concentrations in various sub-areas of the Greater North Sea and the Celtic Seas are described. Temporal trends have also been analysed.

The present assessment is an intermediate step towards coherent assessment of chlorophyll-a at the level of regions and sub-regions.

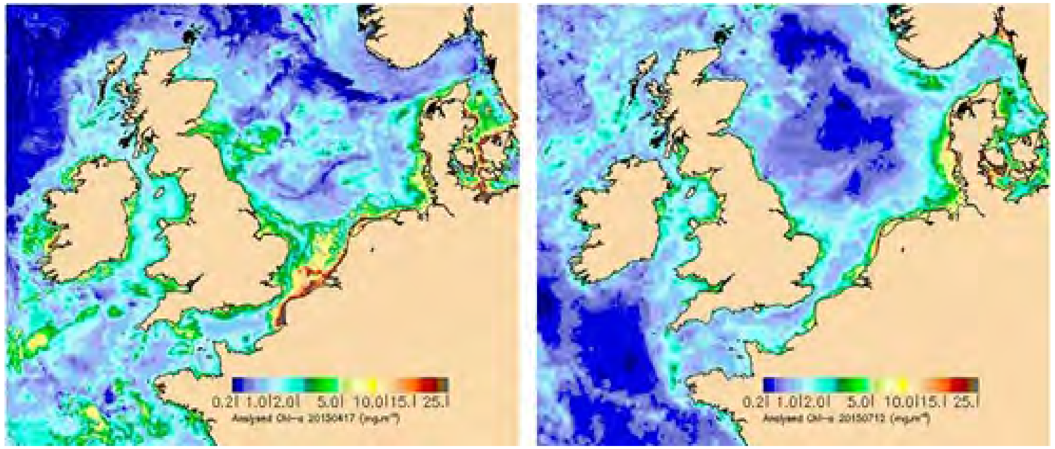


Figure 1: Satellite images of chlorophyll-a concentrations (left) on a day in April during the spring phytoplankton bloom in the North Sea and (right) on a day in July with lower summer concentrations of chlorophyll-a ©Francis Gohin, Ifremer, pers. comm.)

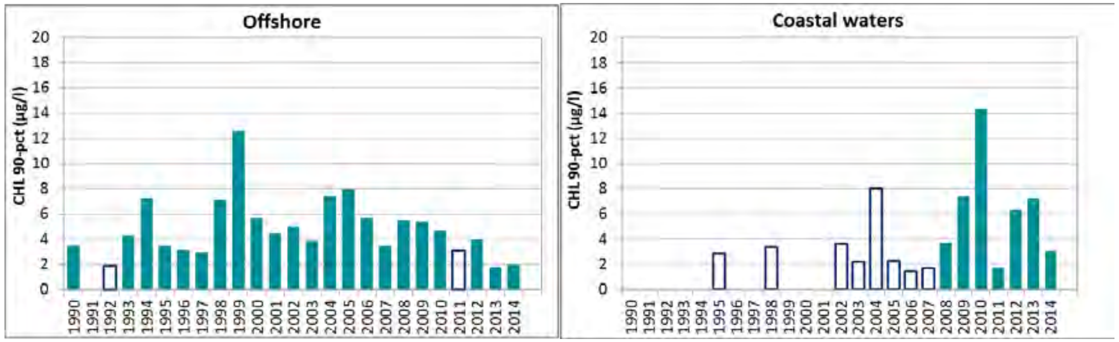
Results

In general, chlorophyll-a concentrations in coastal areas are higher than concentrations in offshore waters (**Figure 2**). Over the entire period of the assessment (1990–2014), statistically significant trends in the 90-percentile of chlorophyll-a during the growing season were downward in two areas, the Skagerrak offshore and the Sound. A statistically significant upward trend was observed in the offshore waters of the Celtic Seas, but the latter dataset contained a relatively high number of years with missing data. Also, this dataset contains data from different laboratories with different analytical methods, which may have led to a bias in the calculated 90-percentiles.

Chlorophyll-a was not assessed in the English Channel, Bay of Biscay and Iberian Coast, because data were too limited data for recent years (2004–2014).

There is high confidence in the methodology and high confidence in the data availability.

Northern North Sea



Southern North Sea

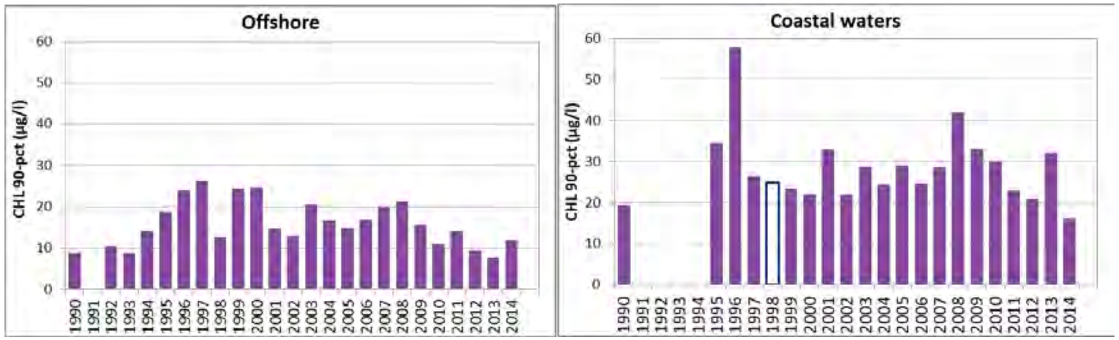
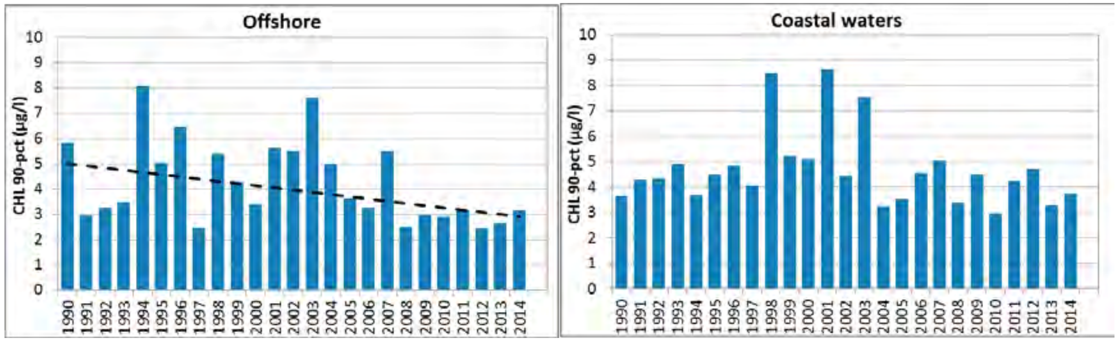


Figure 2: Continued overleaf

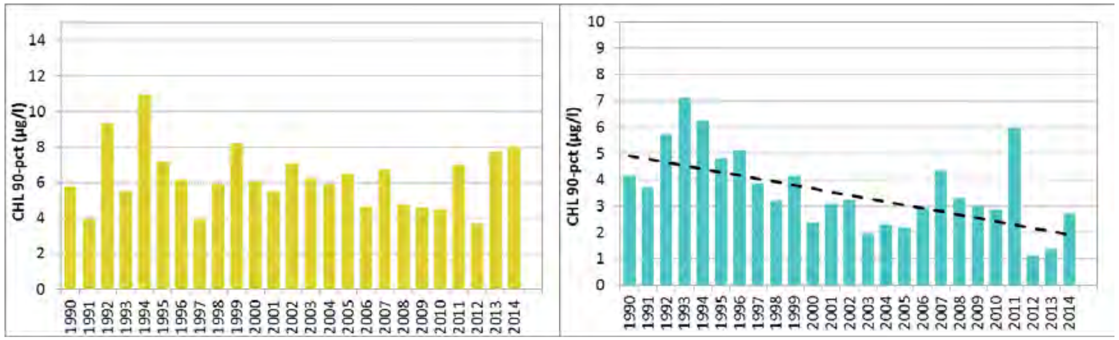
Concentrations of Chlorophyll-a in the Greater North Sea and Celtic Seas

Skagerrak



Kattegat

Sound



Celtic Seas

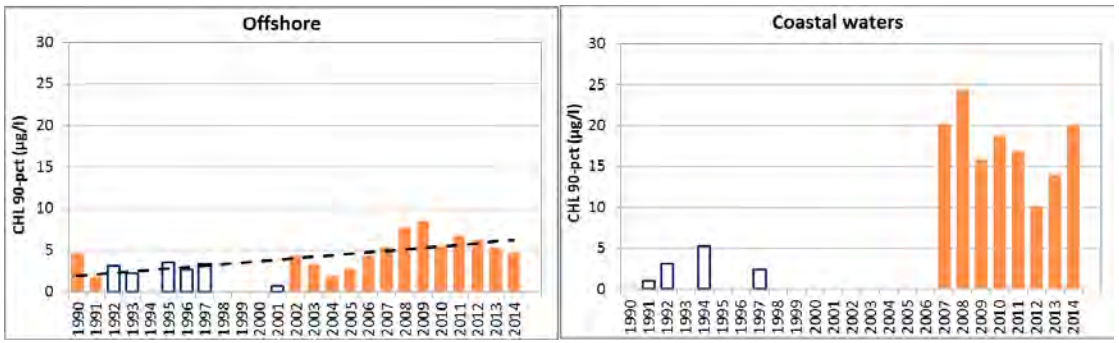


Figure 2: The 90-percentile growing season (March–September) chlorophyll-a concentrations in the OSPAR sub-areas assessed: northern and southern North Sea and Celtic Seas offshore (salinity ≥30) and the coastal salinity zone (salinity 18 to <30); Skagerrak offshore (salinity >27) and the coastal salinity zone (salinity ≤27); the Kattegat and the Sound. Coloured bars = years with at least five months of observations; white bars = years with three or four months of observations. The dashed line = statistically significant linear trend ($p<0.05$)

Conclusion

Chlorophyll-a concentrations are higher in coastal waters than in offshore waters. The highest concentrations are observed along the continental coast of the southern North Sea.
Over the assessment period (1990–2014), statistically significant trends in chlorophyll-a concentration during the growing season were downward in two areas, the Skagerrak and the Sound. A significant upward trend was observed in the offshore waters of the Celtic Seas, but there are years of missing data. In other areas, there were no significant trends over the years 1990–2014. Over the period 2006–2014, statistically significant downward trends were observed in the offshore parts of the southern and northern North Sea.

In coastal and marine systems a direct relation between nutrient inputs and concentrations on the one hand, and chlorophyll-a concentrations on the other, cannot always be observed. This is due to time lags and to factors other than nutrients that influence growth and loss of phytoplankton biomass (such as light conditions, grazing, shifts in species composition, and transport processes), and the often large spatial and interannual variability in growth conditions within the areas assessed.

Knowledge Gaps

Analytical methods for chlorophyll-a and monitoring design differ between countries, hampering comparability of the monitoring results.

Satellite remote sensing is another method for measuring chlorophyll-a across the entire OSPAR Maritime Area, because it provides a common data source and offers a solution for data scarcity in many areas. Work has commenced to investigate how this can be applied and organised in the North Sea, including in situ validation of satellite data and guidelines for harmonised sampling and analysis.

The current assessment uses large-scale assessment areas, where spatial heterogeneity hampers trend detection, highlighting the need for finer-scale spatial assessment.

This document was published as part of OSPAR's 2017 Intermediate Assessment.
The full assessment can be found at www.ospar.org/assessments

Trends in Blooms of the Nuisance Phytoplankton Species *Phaeocystis* in Belgian, Dutch and German Waters

MSFD Descriptor: 5 - Eutrophication

MSFD Criteria: 5.2 - Direct effects of nutrient enrichment

Key Message There are no observed temporal trends in the annual blooms of the nuisance phytoplankton species *Phaeocystis* along the Belgian, Dutch and German coast; nevertheless abundance is high

Background

OSPAR's strategic objective with regard to eutrophication is to combat eutrophication in the OSPAR Maritime Area, with the ultimate aim to achieve and maintain a healthy marine environment where anthropogenic eutrophication does not occur. Trends in blooms of nuisance phytoplankton species *Phaeocystis* is one of a suite of five eutrophication indicators. When assessed and considered together in the OSPAR Common Procedure in a multi-step method, the suite can diagnose eutrophication.

Excessive enrichment of marine water with nutrients may lead to algal (phytoplankton) blooms, with the possible consequence of undesirable disturbance to the balance of organisms in the marine ecosystem and overall water quality. Undesirable disturbance includes shifts in the composition and extent of flora and fauna and depletion of oxygen caused by decomposition of accumulated organic material produced by phytoplankton or seaweed communities during their growing seasons. *Phaeocystis* is a widespread marine phytoplankton. As it breaks down at the end of a bloom foam can form. It is used as an indicator of eutrophication because increased concentrations of more than 10^6 or 10^7 *Phaeocystis* cells per litre of seawater and increased duration of Phaeocystis blooms per year are an indication of nutrient enrichment.

Results

Three countries' *Phaeocystis* monitoring data are used in this assessment; Belgium (1990–2009), the Netherlands (1990–2014) and Germany (2001–2014).

Monitoring sites with available *Phaeocystis* data are located in coastal waters; these are mostly inshore and along some transects perpendicular to the coast (**Figure 1**).

Image (left): *Phaeocystis,* shown here on the beach of Spiekeroog, Germany ©Wera Leujak, Umweltbundesamt

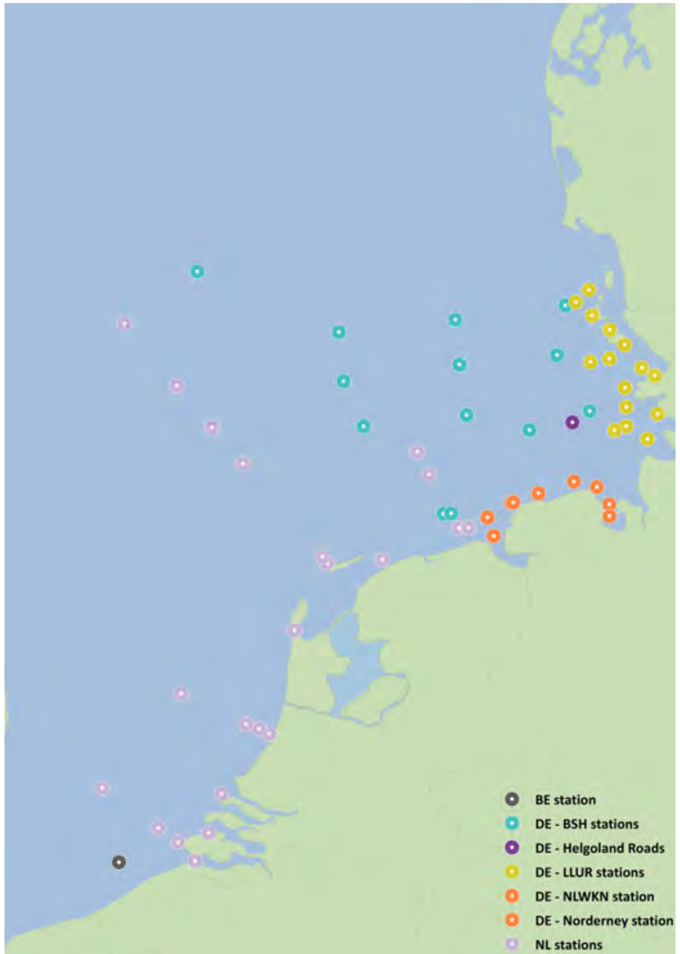


Figure 1 (right): Sites monitored for Phaeocystis by Belgium (BE), the Netherlands (NL) and Germany (DE) (2003–2012)

Trends in Blooms of the Nuisance Phytoplankton Species *Phaeocystis* in Belgian, Dutch and German Waters

OSPAR COMMISSION

Results cont...

At all Dutch (1990–2010) and Belgian (1988–2009) monitoring sites and at most German (2003–2012) monitoring sites, concentrations of *Phaeocystis* cells peak each year during the growing season, April–May. At the northern part of the German coast (**LLUR, Figure 1**) the peak is later, usually during June.

Since *Phaeocystis* species generally reach seasonal maxima during April and May, the focus for assessment was on spatial gradients of *Phaeocystis* abundance and temporal trends in this season. No statistically significant temporal trends were observed in the analysed data. The spatial distribution of maximum *Phaeocystis* concentrations sampled during spring and summer (April–August) 1990–2014 is shown in **Figure 2**. *Phaeocystis* abundance during this period was high along the Dutch and German south-east coast of the North Sea. Maximum abundances show regional ‘hot spots’ where locally *Phaeocystis* cell concentrations can exceed 100 million cells per litre.

The spatial pattern of *Phaeocystis* concentrations reflects the average salinity regime in the southern North Sea, which is influenced by river discharges within the residual coastal current. Similar spatial patterns in nutrient concentration have also been identified (see nutrient concentrations).

There is moderate confidence in the data availability and moderate confidence in the methodology.

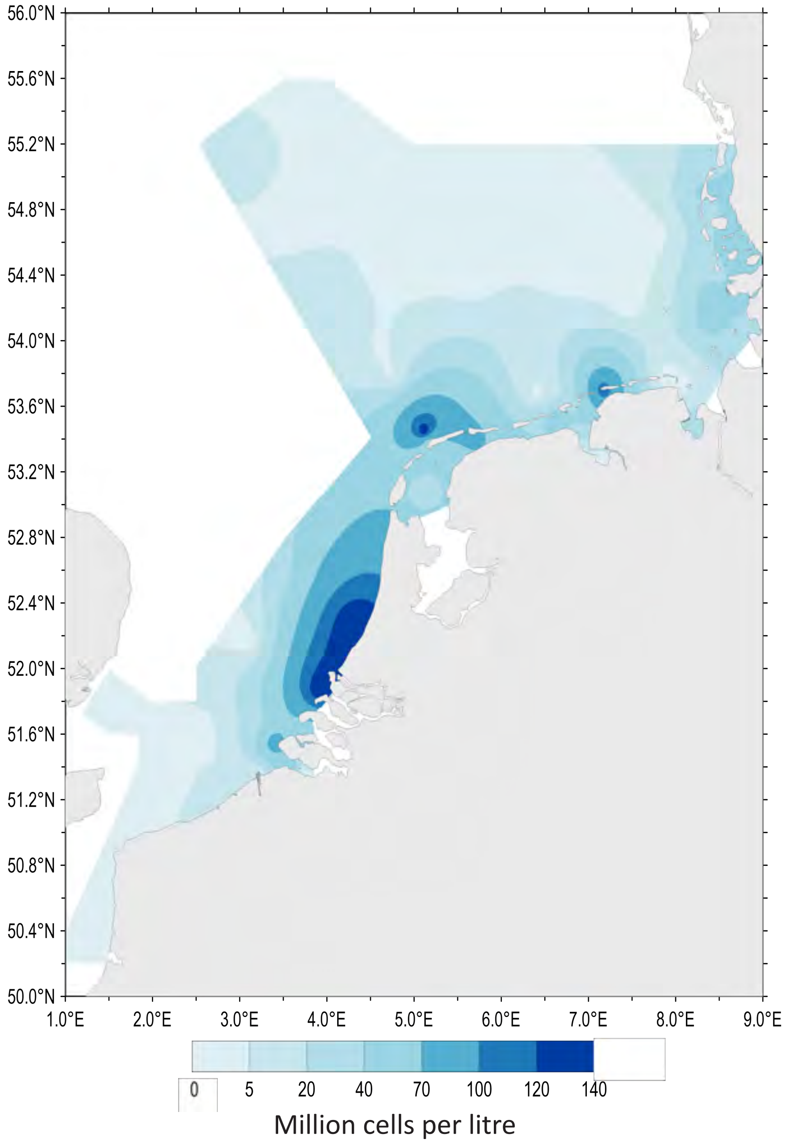


Figure 2: Gradients of maximum *Phaeocystis* concentrations (million cells per litre) in the period April–August (all available years and monitoring sites 1990–2014)

Conclusion

High concentrations of the nuisance marine phytoplankton *Phaeocystis* in coastal waters (often above one million cells per litre with peaks of up to 100 million cells per litre), with concentrations decreasing offshore, can occur in response to high nutrient concentrations, and may be indicative of eutrophication.

This assessment shows *Phaeocystis* blooms peak during the summer growing season (April–June) in the southern North Sea. The size of the blooms varies widely from year to year with seasonal average concentrations from near zero to over five million cells per litre. These fluctuations are probably affected by a combination of different factors, such as light, temperature, salinity, other hydrodynamic influences and nutrient availability. However, nutrient concentrations were more consistent and less variable than *Phaeocystis* concentrations in the southern North Sea (see nutrient concentrations assessment). Furthermore, no statistically significant temporal or spatial trends could be observed in the analysed data.

Knowledge Gaps

The availability of *Phaeocystis* data for the assessment was regionally restricted to the southern North Sea. The duration of blooms was difficult to determine owing to restricted sampling. Recent *Phaeocystis* data have yet to be fully reported and stored at the International Council for the Exploration of the Sea (ICES). The contributions of *Phaeocystis* to total phytoplankton biomass should be estimated to allow representative assessment in relation to chlorophyll-a concentrations.

Further research is needed to identify the reasons for the strong interannual variability in cell concentrations.

This document was published as part of OSPAR’s Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments

Concentrations of Dissolved Oxygen Near the Seafloor

MSFD Descriptor: 5 - Eutrophication
MSFD Criterion: 5.3 - Indirect effects of nutrient enrichment

OSPAR COMMISSION

Key Message Dissolved oxygen is necessary for healthy marine ecosystems. Overall, there is not a problem with dissolved oxygen concentrations near the seafloor in the areas assessed. However, there is oxygen depletion in some localised areas. Improvements in levels of dissolved oxygen concentrations have been observed in the Kattegat

Background

OSPAR's strategic objective with regard to eutrophication is to combat eutrophication in the OSPAR Maritime Area, with the ultimate aim to achieve and maintain a healthy marine environment where anthropogenic eutrophication does not occur. Dissolved oxygen is one of a suite of five eutrophication indicators. When assessed and considered together in the OSPAR Common Procedure in a multi-step method, the suite can be used to diagnose eutrophication.

Excessive enrichment of marine water with nutrients may lead to algal (phytoplankton) blooms, with the possible consequence of undesirable disturbance to the balance of organisms in the marine ecosystem and overall water quality. Undesirable disturbance includes shifts in the composition and extent of flora and fauna and depletion of oxygen caused by decomposition of accumulated organic material produced by phytoplankton or seaweed communities during their growing seasons. Oxygen depletion may result in behavioural changes or death of fish and other species. Although oxygen depletion can be an indirect effect of nutrient enrichment, other pressures often complicate the identification of causal links between disturbances and nutrient enrichment.

Figure 1: Water samples collected from the Celtic Seas during a *Karenia mikimotoi* bloom (July 2011). With reagents added, surface samples were darker (higher concentrations of dissolved oxygen) than near-bottom samples (lower dissolved oxygen). © Elisa Capuzzo, Cefas

Factors that influence oxygen concentrations include changes in water temperature and salinity and climate change. Seasonal oxygen depletion can be a natural localised process, particularly where the water column stratifies seasonally.

Oxygen concentrations above 6 mg/l are considered to support marine life with minimal problems, while concentrations less than 2 mg/l (hypoxia, i.e. oxygen deficiency) (**Figure 1**) are considered to cause severe problems.

Observations from the Baltic Sea show that when the oxygen content in the bottom water is very low, the only organisms that are able to thrive are the bacteria that live on and in the seafloor (**Figure 2**).

Figure 2: Low oxygen conditions in the Baltic Sea. The patches of white sulphur bacteria form a shroud © Peter Bondo Christensen

Results

Mean near-bed dissolved oxygen concentrations (2006–2014) assessed in large-scale regions of the northern North Sea, southern North Sea, English Channel, Celtic Seas, and Bay of Biscay and Iberian Coast were >6 mg/l. Mean near-bed oxygen concentrations were lower in the Skagerrak (5.25 mg/l), Kattegat (3.98 mg/l) and the Sound (2.80 mg/l). Oxygen concentrations in these three regions are strongly influenced by local eco-hydrodynamic conditions.

No statistically significant temporal trends were observed (1990–2014) in near-bed oxygen concentrations or percentage saturation in most of the large-scale regions (northern North Sea, southern North Sea, Skagerrak, Sound, English Channel, Celtic Seas, and Bay of Biscay and Iberian Coast). The Kattegat was the only exception, with significant upward trends observed in oxygen concentrations and percentage saturation.

Concentrations of Dissolved Oxygen Near the Seafloor

Results cont...

Within the large-scale regions, available data (1990–2014) were analysed at a smaller scale using ICES rectangles. Analyses showed that mean near-bed oxygen concentrations in the lowest quartile of the data during the summer stratification season were >6 mg/l in most ICES rectangles in each region, except in the southern North Sea and the Kattegat (**Figure 3**). For the southern North Sea, rectangles with mean values of <6 mg/l indicate localised areas with lower oxygen concentrations. These rectangles are mostly located in the eastern southern North Sea (outlined in bold in **Figure 3**), a region with a high degree of hydrodynamic variability. No temporal trends were identified in 12 of the 13 individual rectangles in the eastern southern North Sea (i.e. dissolved oxygen concentrations showed no change). A significant downward trend was observed in one rectangle (in the Skagerrak off the southeast coast of Norway). When all the data in these rectangles were aggregated (**Figure 3**) into one dataset, no statistically significant trend was found at the large scale.

In the Skagerrak and Kattegat, ICES rectangles also showed mean near-bed oxygen concentrations of <6 mg/l. However, the specific regional characteristics of this area mean that these levels are not considered to indicate oxygen deficiency. For the Kattegat, analyses of rectangles indicate areas with higher mean near-bed concentrations (4–6 mg/l) than those calculated using the large-scale regional analysis (2–4 mg/l).

In the Bay of Biscay and Iberian Coast, four rectangles showed lower oxygen concentrations (4–6 mg/l) but there were insufficient data for detailed analyses. One rectangle in the Celtic Seas showed a mean near-bed oxygen concentration (5.8 mg/l) towards the upper end of the 4–6 mg/l range, indicating a localised area with low oxygen. Overall, results indicate that oxygen concentrations, when analysed at larger scales, were not depleted during the shorter (2006–2014) and longer (1990–2014) assessment periods.

Confidence ratings in terms of data availability and methodology used are moderate.

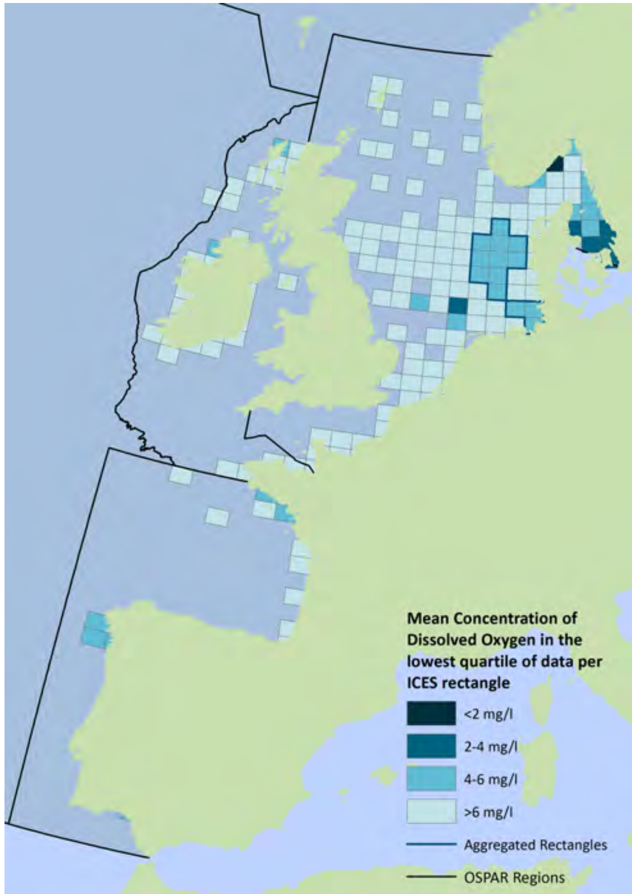


Figure 3: Mean concentration of dissolved oxygen in the lowest quartile of the data plotted by ICES rectangles for the period 1990–2014. Rectangles aggregated for analyses are outlined in bold. Data were filtered by season (stratification season 1 July–31 October), depth (within 10 m of the seafloor), and salinity (≥30). Results are shown for rectangles where there were five or more data points. Blank areas indicate where there were no data or insufficient data

Conclusion

Across large-scale assessment regions of the northern North Sea, southern North Sea, English Channel, Celtic Seas, and Iberian Coast and Bay of Biscay, there is no widespread oxygen deficiency. The Skagerrak, Kattegat and Sound have lower mean concentrations, but these are not considered to indicate oxygen deficiency owing to the regional-specific characteristics of this area.

Localised areas of oxygen deficiency are apparent, particularly in the eastern part of the southern North Sea. Oxygen concentrations and percentage saturation are improving in the Kattegat and deteriorating in a very localised area of the eastern southern North Sea.

Assessment outcomes are influenced by the size of the areas assessed and the availability of the data. Assessment at the scale of the southern North Sea, for example, shows a different outcome to assessments based on smaller areas, such as ICES rectangles. However, sufficient data are required to base assessments on smaller areas. In the case of dissolved oxygen, use of only near-bed data during the stratification season limits the amount of data that can be used in assessments.

Knowledge Gaps

Understanding of the relative importance of biological and physical processes (e.g. mixing and currents) in controlling near-bed oxygen dynamics, and the impacts of climate change on physical processes, oxygen deficiency and oxygen consumption is rather poor. This will need to be improved in order to better distinguish between the effects of nutrient enrichment and changes in seawater temperature as a result of climate change. Furthermore, robust assessments of oxygen deficiency require improved availability of suitable data. Since oxygen deficiency is localised and often short-lived, modelling can help in identifying hotspots.

This document was published as part of OSPAR's Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments

Inputs of Mercury, Cadmium and Lead via Water and Air to the Greater North Sea

MSFD Descriptor: 8 - Concentration of contaminants
MSFD Criterion: 8.1 - Concentration of contaminants

Key Message Total inputs of the heavy metals mercury, cadmium and lead to the Greater North Sea have reduced, since 1990. However, improved analytical procedures for mercury and cadmium since 1990 make it difficult to be certain what proportion of observed changes are due to reduced discharges and emissions

Background

OSPAR's strategic objective with regard to hazardous substances is to prevent pollution of the OSPAR Maritime Area by continuously reducing discharges, emissions and losses of hazardous substances, with the ultimate aim to achieve concentrations in the marine environment near background values for naturally occurring substances and close to zero for manmade synthetic substances. Heavy metals are hazardous because they can cause adverse biological effects on an organism's activity, growth, metabolism, reproduction or survival. Three of the most toxic heavy metals – mercury, cadmium and lead – are on OSPAR's List of Chemicals for Priority Action owing to their high toxicity and potential to cause harm to marine life.

Mercury, cadmium and lead are emitted through a range of natural, industrial and agricultural processes, for example fertiliser can be a source of cadmium (**Figure 1a**). Heavy metals are most often transported as, or tightly bound to, fine particles and the particles can be blown into the air from exposed soils and earth, and also from the surface of the sea. As a result, heavy metals are subsequently transported via the atmosphere. Unlike other heavy metals, mercury can also evaporate and be transported as a gas. In addition, mercury and cadmium can accumulate in the food chain (**Figure 2**), whereas lead does not.

Waterborne inputs of mercury, cadmium and lead are monitored by OSPAR countries. Atmospheric inputs are modelled by OSPAR countries (**Figure 1b**), based on annual emissions reported under European Union Emissions Directives and the United Nations Convention on Long-range Transboundary Air Pollution.

Figure 1: (a) Mineral fertiliser is a significant source of cadmium in many parts of Europe © Graham Horn; (b) An atmospheric monitoring station

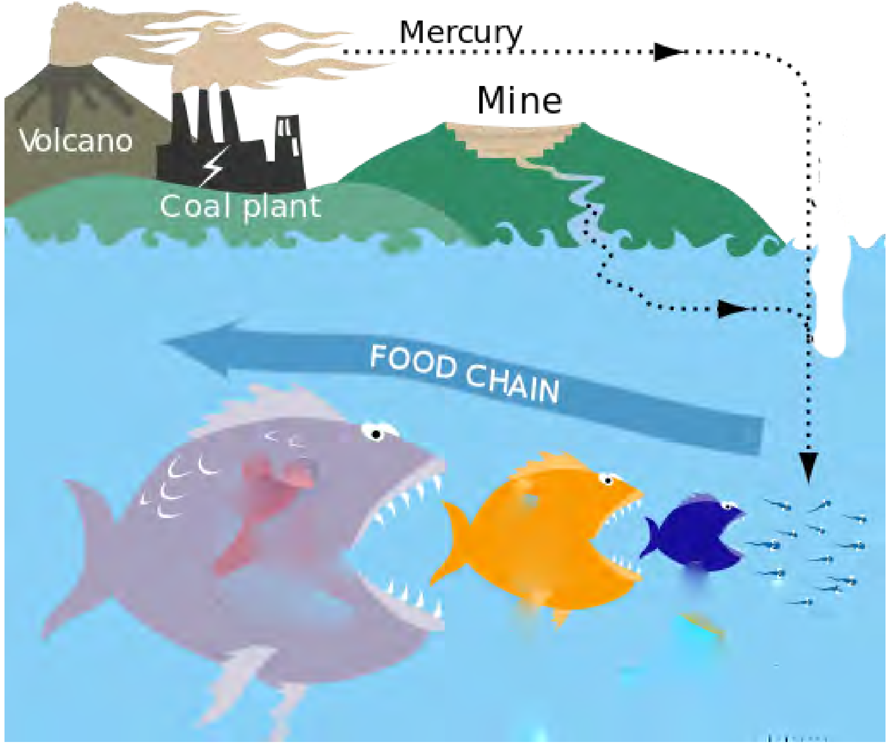


Figure 2 (right): Mercury from coal-fired power plants and other sources is transported through the atmosphere and water. Mercury, in the form of methylmercury, can bioaccumulate through the marine food web reaching high concentrations in top predators

Results

Although inputs of mercury, cadmium and lead to the Greater North Sea appear to have more than halved since the start of the 1990s (**Figure 3** overleaf), advances in analytical methods resulting in improved (lowered) detection limits mean that while there is a downward trend in inputs, the change is certainly overestimated. However, it is not possible to determine by how much. Overestimation occurred in the past because the limit of quantification for an analysis was higher than the actual concentration of the substance in the environment. Similarly, some countires have changed their metal analysis, for example from total metals to dissolved metals, since the introduction of the European Union Water Framework Directive in 2000. This has also resulted in an apparent input reduction. It is unclear whether similar issues affect the atmospheric deposition data, which are dependent on the quality of reported emissions, the accurate description of meteorological and chemical processes, and the quality of the validation data.

Inputs of Mercury, Cadmium and Lead via Water and Air to the Greater North Sea

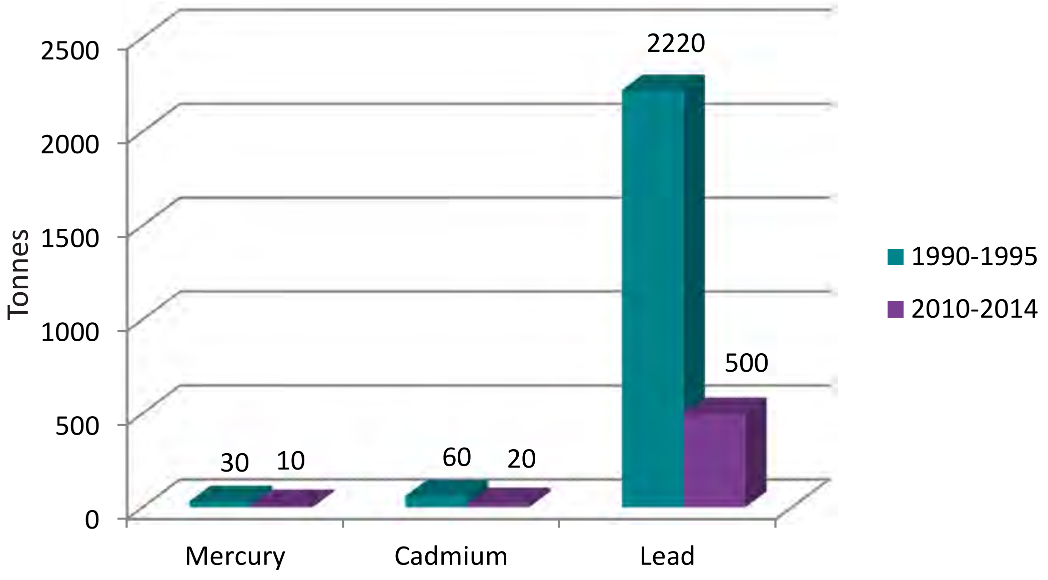


Figure 3: Estimated total inputs (riverine and atmospheric) of mercury, cadmium and lead to the Greater North Sea in 1990–1995 and 2010–2014. Values are in tonnes, rounded to the nearest 5 tonnes (100 tonnes in the case of lead)

Results cont...

Mercury inputs via water have approximately halved between 1990–1995 and 2010–2014 and air inputs have reduced by approximately one-third, noting a proportion of this is likely to be due to improved analytical techniques. Cadmium inputs via air and water have both reduced by two-thirds. Waterborne lead inputs have more than halved while airborne lead deposition is less than a third of the level it was in 1990.

All OSPAR countries have made substantial reductions in waterborne mercury inputs between 1990–1995 and 2010–2014. The Netherlands and Germany have made the greatest reductions in waterborne lead inputs, accounting for half the total waterborne reduction between them.

Airborne inputs of all three heavy metals have reduced significantly between 1990–1995 and 2010–2014. Mercury inputs due to countries' emissions are now significantly lower than inputs from 'non-OSPAR' countries. These non-OSPAR inputs come from outside the OSPAR Maritime Area as well as from re-suspended material; such as from exposed soils, and urban, arable and marine surfaces both within and outside the OSPAR Maritime Area.

There is moderate confidence in the methods and low confidence in the data used for this assessment.

Conclusion

OSPAR countries have made significant efforts to reduce emissions and losses of mercury, cadmium and lead to both air and water. These results appear to show significant progress towards the OSPAR objective to 'prevent pollution of the Maritime Area by continuously reducing discharges, emissions and losses of hazardous substances, with the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances'.

OSPAR countries have been most successful in reducing atmospheric lead inputs to the Greater North Sea. Secondary atmospheric pollution from re-suspended material and from sources outside the OSPAR Maritime Area are now the major sources of airborne pollution and there is a need for cooperation beyond OSPAR's boundaries to manage these in addition to the waterborne inputs.

Heavy metal input estimates are very uncertain, particularly for mercury and cadmium. Quantification limits vary between laboratories within countries, and as laboratories or methods change. This causes substantial changes in the estimated inputs. These uncertainties were greater at the beginning of the analysis period. Despite the methodological issues for mercury and cadmium, with measurement techniques that are close to detection limits, the monitoring data for the suite of heavy metals shows substantial input reductions.

Knowledge Gaps

Strict quality controls are needed in laboratories analysing heavy metal samples. High detection limits can lead to an overestimation of inputs and an inability to detect changes. The effect on quantification limits should be assessed whenever a change in analysis laboratory is considered.

There is a mismatch between the requirements of the European Union Water Framework Directive to measure metal concentrations in the dissolved fraction and the OSPAR Agreement to quantify total heavy metal inputs.

Knowledge gaps remain concerning the retention and export of heavy metals in estuaries, limiting knowledge of the proportion of metals that reach the marine environment.

There is limited knowledge of losses of heavy metals from harbours, shipping, historical dumping and other potential sources.

This document was published as part of OSPAR's Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments

Dumping and Placement of Dredged Material

OSPAR Thematic Assessment

OSPAR COMMISSION

Key Message No trends were identified in the amounts of dredged material dumped or placed within the OSPAR Maritime Area in the period 2008–2014, or in the average contaminant concentrations or contaminant loads associated with this material.

Background

Sediment is an integral and dynamic part of the ecosystem, and through various natural processes can build-up in estuaries and harbours. Sediments, although not in themselves polluting materials, are sinks for some contaminants bound to the sediment particles that end up in waterways, harbours, ports and seas mainly from anthropogenic sources such as sewage discharges, storm-water overflows, marine traffic, agricultural run-off, industrial wastewater and historically poor environmental management.

Ports and waterway authorities have a legal obligation to maintain navigation channels. This results in the need to dredge; referred to as maintenance or navigation dredging. Removal of sediment for new construction activities or deepening of navigation channels is referred to as capital dredging.
Most dredging activities result in the material being dumped or placed at designated sites within the marine environment. Adverse impacts from the dumping or placement of the dredged material can be physical (through smothering of habitats and organisms), chemical (through toxicity) and / or biological (though increased turbidity, and from bioaccumulation and biomagnification of contaminants through the food web). Dumping or placement of sediments on the seabed will bury benthos and can lead to damage to habitats and biological communities especially at newly designated sites. There is also potential for contaminants to be transferred and redistributed by re-suspension and uptake by biota.

Since 1986, the OSPAR Convention has encouraged Contracting Parties to minimise adverse impacts on the marine environment through its guidelines for management of dredged material and through actions addressing substances found in dredged material at source.

Results

In the period 2008–2014, over one thousand million tonnes of dredged material were deposited in the OSPAR Maritime Area. This value includes material from capital and maintenance dredging. The total amount disposed per country per year is given in **Figure 1**.

Average contaminant concentrations and total loads per country were calculated for cadmium, mercury, lead and tributyltin (TBT) for the period 2008–2014. Changes in total dredging quantities and total contaminant loads are dependent on external factors, including variation in sediment siltation rates due to storm events.

The calculated average concentrations, in mg/kg, dry weight (dw), for the trace metals are comparable to those described in the OSPAR Quality Status Report 2010. Although yearly fluctuations can be seen, there do not appear to be any meaningful increases or decreases across the entire assessment period. **Figure 2** shows the change in annual average calculated mercury concentration, per country for the period 2008–2014. Annual average mercury concentration varied between 0.17 and 0.23 mg/kg. These values are almost identical to those reported for mercury in the previous assessment period 2003–2007 (0.18–0.22 mg/kg).

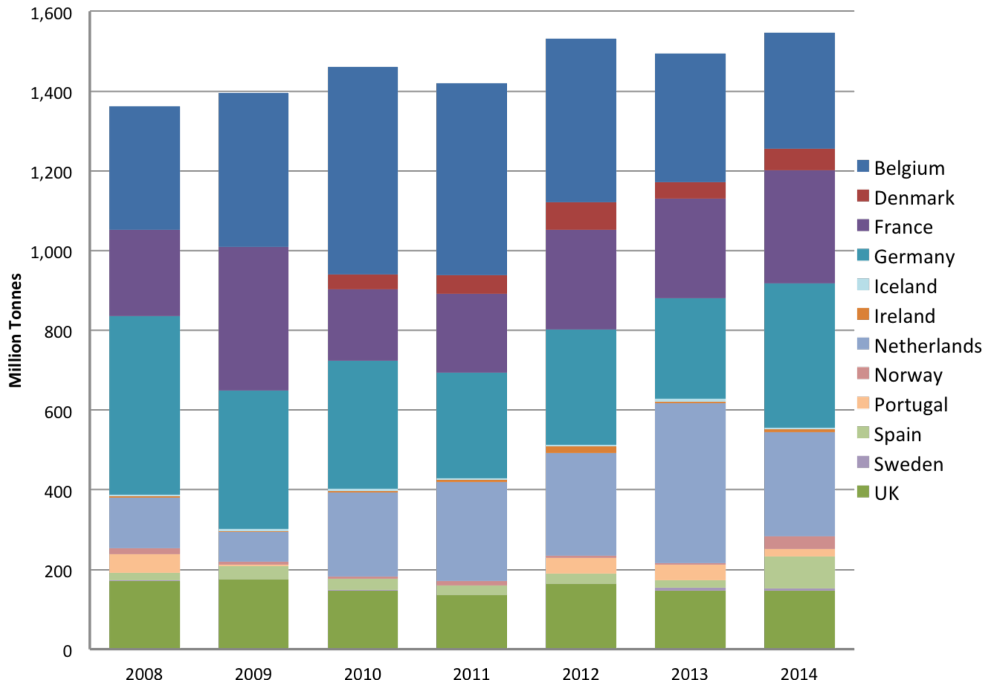


Figure 1: Total amounts, in million tonnes, of dredged material deposited in the OSPAR Maritime Area per country over the period 2008–2014

Results cont...

Figure 3 shows the total mercury load deposited in the OSPAR Maritime Area through the dumping or placement of dredged material by Contracting Party for the period 2008–2014. Trends cannot be accurately determined from these data owing to changes in the amount of material dredged each year; interannual variability is clearly apparent in the graphic. It must be noted that **Figure 3** shows the total amount of mercury deposited, which includes the naturally occurring background level as well as anthropogenically-derived mercury. The net amount of mercury from anthropogenic sources transported from the dredging location to the receiving sites is therefore less.

At present, there is no obligation under the OSPAR Convention for Contracting Parties to monitor the environmental impacts of dumping and placement operations, however many Contracting Parties undertake monitoring activities under national programmes. Beneficial use of dredged material (such as for beach nourishment and sediment recharge) has been monitored by OSPAR since 2013. This short period does not allow for trend analysis. The amounts for 2013 (28 million tonnes) and 2014 (37 million tonnes) are comparable; for both years beneficial use was implemented at approximately 80 sites. The most frequent reasons for beneficial use are beach nourishment and sediment recharge.

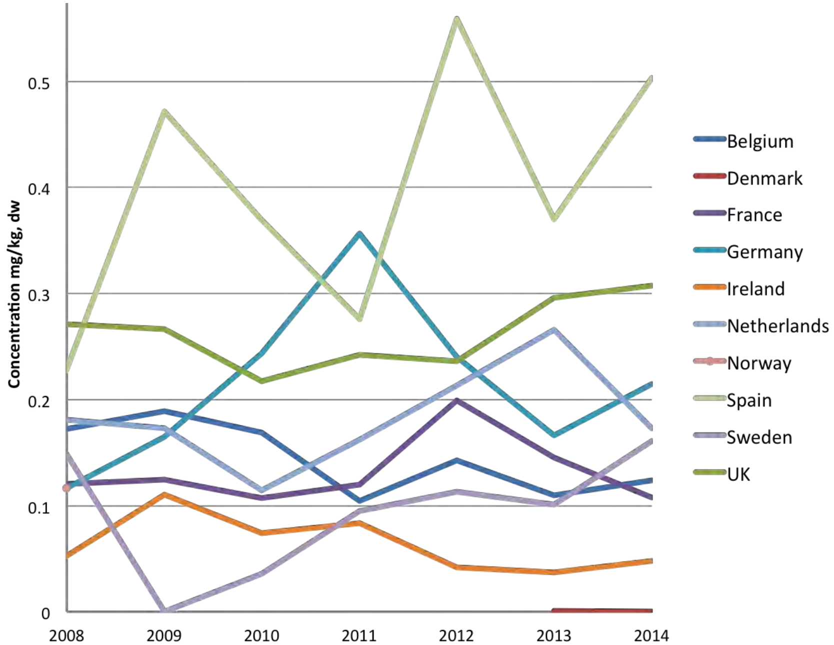


Figure 2: Annual average calculated mercury concentration (mg/kg, dw) in dredged material deposited in the OSPAR Maritime Area.

Conclusion

Dumping or placement of dredged material at sea is common practice within the OSPAR Maritime Area. No changes were detected for amounts of dredged material dumped or placed, for contaminant concentrations or for contaminant loads within the period 2008–2014. The range of concentrations for trace metals is consistent with the QSR 2010 assessment. Dumping and placement of dredged material is well regulated by OSPAR and the related regulations of the Contracting Parties. Together with European Union regulations, these have led to a reduction in pollution from dredged material in the past decades. However, there is a need to look further into the possibilities for harmonising assessment methodology and objectives, as well as for technical developments that would enable the detection of chemicals of emerging environmental concern, and thus reduce pollution further.

The 2014 data show that there are many cases where dredged material is being put to beneficial use. However not enough data have been collected on placement activities for a trend assessment to be undertaken.

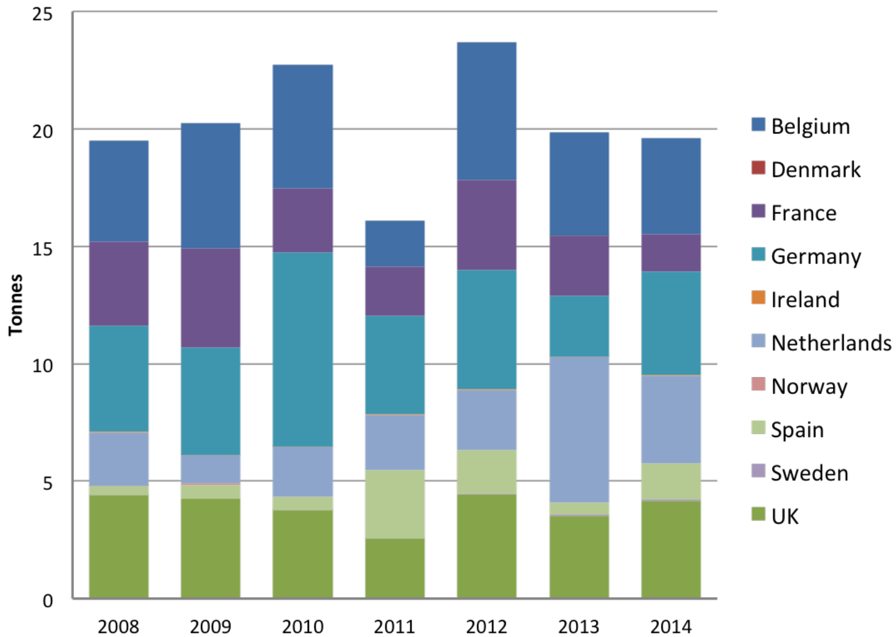


Figure 3: Total mercury load deposited in the OSPAR Maritime Area, in tonnes, through the dumping or placement of dredged material in the period 2008-2014 (data for Norway only available for 2008–2009 and for Denmark for 2013–2014).

Knowledge Gaps

While there has been research on the impacts of dumping and placement of dredged material on the marine environment there are emerging issues. These include the effects and amounts of microplastics and marine litter, in dredged material and the identification of new contaminants of concern. These require further investigation.

OSPAR collects data to support the management of dredged material, not for environmental monitoring purposes. As this is a limited data set, to improve the quality of future dredged material assessments, it would be beneficial to look into how data is collected and the analysis is undertaken. Concepts and methods for cumulative impact assessment could also be considered.

This document was published as part of OSPAR's Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments

Summary of Trends in Discharges, Spills and Emissions from Offshore Oil and Gas Installations

OSPAR Thematic Assessment

Key Message Hydrocarbons and offshore chemicals are routinely discharged to the marine environment during offshore oil and gas operations. Assessment of the discharges and spills show that OSPAR measures have led to decreases in the discharges of both hydrocarbons and the most harmful offshore chemicals

Background

Chemical inputs to the marine environment from the offshore oil and gas industry vary depending on the activity being carried out (**Figure 1**). Hydrocarbons are primarily discharged in produced water, which contains both naturally occurring substances and added chemicals, some of which are categorised as hazardous substances. Hydrocarbons and chemicals are also discharged during the exploration phase, in the course of drilling operations, although the more harmful chemicals are not used whenever this is possible and are frequently not discharged.

The least harmful substances used in the industry are considered to Pose Little Or No Risk (PLONOR) to the marine environment. The most harmful chemicals in terms of toxicity, bioaccumulation and biodegradation are considered as candidates for substitution.

The OSPAR Commission's strategic objective for offshore oil and gas activities is to prevent and eliminate pollution and take the necessary measures to protect the OSPAR Maritime Area against the adverse effects of offshore activities. This is achieved through setting environmental goals and improving management mechanisms.

Oil and chemicals also enter the marine environment through accidental spills.

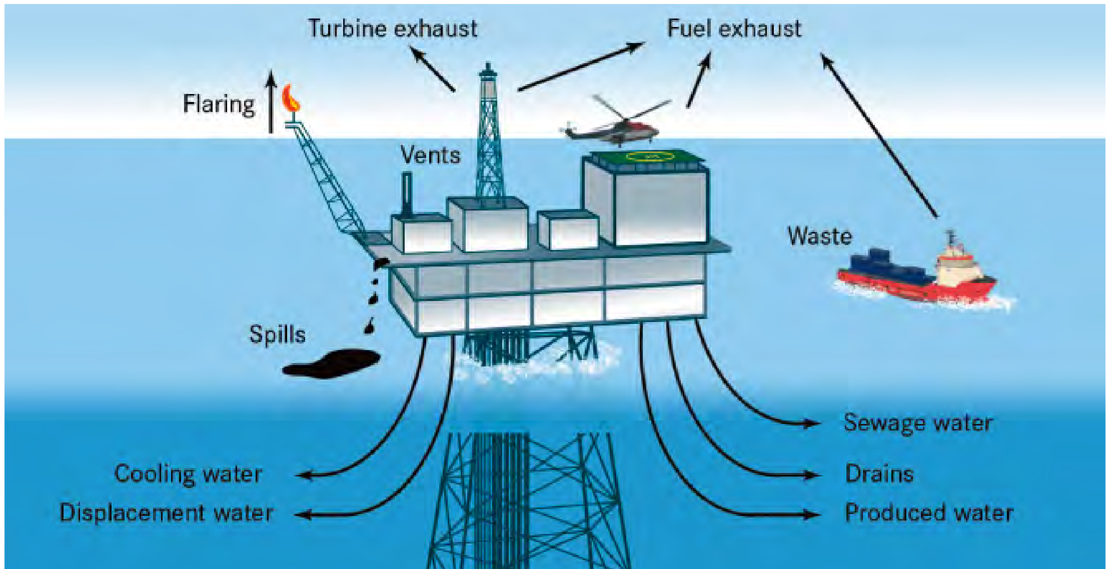


Figure 1: Sources of discharges and emissions from offshore installations

Oil and gas production in the OSPAR area

The OSPAR maritime area is a mature oil and gas production area. Total production has steadily declined over the period of the assessment. **Figure 2** shows the downward trend in production.

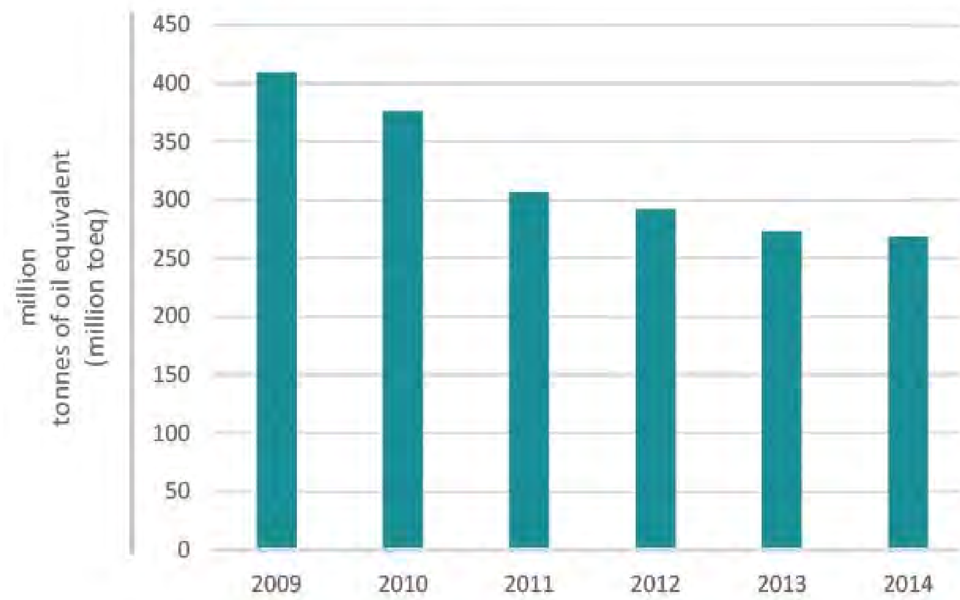


Figure 2: Total oil production in the OSPAR Maritime Area from 2009 to 2014

Summary of Trends in Discharges, Spills and Emissions from Offshore Oil and Gas Installations

OSPAR COMMISSION

Results

Results indicate a general downward trend for several indicators:

- The amount of dispersed oil discharged in produced water decreased by 18% between 2009 and 2014;
- The use of chemicals on OSPAR's List of Chemicals or Priority Action (LCPA) has reduced by over 90% since 2009, and in 2014 no LCPA chemicals were discharged;
- There has been a 30% decrease in the use of chemicals carrying substitution warnings, and a 40% decrease in their discharge.

Conclusion

Downward trends were observed in:

- Amount of dispersed oil discharged in produced water;
- Use and discharge of LCPA chemicals;
- Use and discharge of chemicals carrying substitution warnings.

The gradual reduction in dispersed oil discharged in produced water has been achieved through the application of standards set out in OSPAR Recommendation 2001/1 for the Management of Produced Water from Offshore Installations, as amended by OSPAR Recommendation 2006/4 and Recommendation 2011/8.

The phasing out of LCPAs was achieved through the application of OSPAR Recommendation 2005/2 on Environmental Goals for the Discharge by the Offshore Industry of Chemicals that Are, or Contain Added Substances, Listed in the OSPAR 2004 List of Chemicals for Priority Action.
Reductions in the use and discharge of substances carrying substitution warnings can be directly attributed to the implementation of OSPAR Recommendation 2006/3 on Environmental Goals for the Discharge by the Offshore Industry of Chemicals that Are, or Which Contain Substances Identified as Candidates for Substitution.

A decrease in the number of installations exceeding 30 mg l^{-1} oil for dispersed oil in produced water discharged to seawater was noted, though a clear trend is not apparent. Many of the downward trends have clearly been achieved as the direct result of measures adopted by OSPAR and their subsequent implementation by the offshore oil and gas industry.

Trends were not observed in:

- Quantities of chemicals spilled;
- Number of oil spills;
- Quantity of oil spilled.

It was not possible to determine any positive or negative trends in the number of oil and chemical spills, or in the quantity of oil and chemicals spilled, due to the unpredictable nature of such events.

Knowledge Gaps

In 2012, OSPAR adopted Recommendation 2012/5 for a Risk-Based Approach to the Management of Produced Water Discharges from Offshore Installations. However, the risk based approach has not been in operation long enough to indicate whether it is having an impact on the quality of the marine environment. This gap will be addressed as more information becomes available.

This document was published as part of OSPAR's Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments

Summary of Progress towards the Objective of the Radioactive Substances Strategy

OSPAR Thematic Assessment

Key Message OSPAR Contracting Parties have achieved substantial reductions in discharges from the nuclear sector in many cases and are continuing to make good progress in meeting the objectives of the OSPAR Radioactive Substances Strategy

Background

The OSPAR Commission's strategic objective regarding radioactive substances is to prevent pollution of the OSPAR Maritime Area through progressive and substantial reductions in discharges, emissions and losses of radioactive substances.

To achieve this objective, the OSPAR Radioactive Substances Committee carries out periodic evaluations of progress made in implementing the strategy. Three previous periodic assessments of progress towards the objective of the OSPAR Radioactive Substances Strategy have been published. The Fourth Periodic Evaluation focuses on progress made with regard to discharges from the nuclear and non-nuclear sectors.

Radioactive materials are an essential part of everyday life and have many applications, such as the generation of electricity and diagnostic and therapeutic uses in medicine. Radioactivity also occurs naturally. Exposure to natural background radiation results from naturally occurring radioactive materials in the ground, the air, food and cosmic rays from outer space. For most individuals, exposure to natural background radiation is the largest component of their total radiation exposure.

Use of radioactive materials and the disposal and discharge of radioactive waste is subject to stringent internationally agreed regulation. During the course of their use, quantities of radioactive substances may be discharged into the environment, subject to regulatory authorisation, from nuclear installations such as nuclear power stations, and from non-nuclear installations such as hospitals and oil and gas installations. These discharges can lead to additional radiation exposure for humans and other organisms.

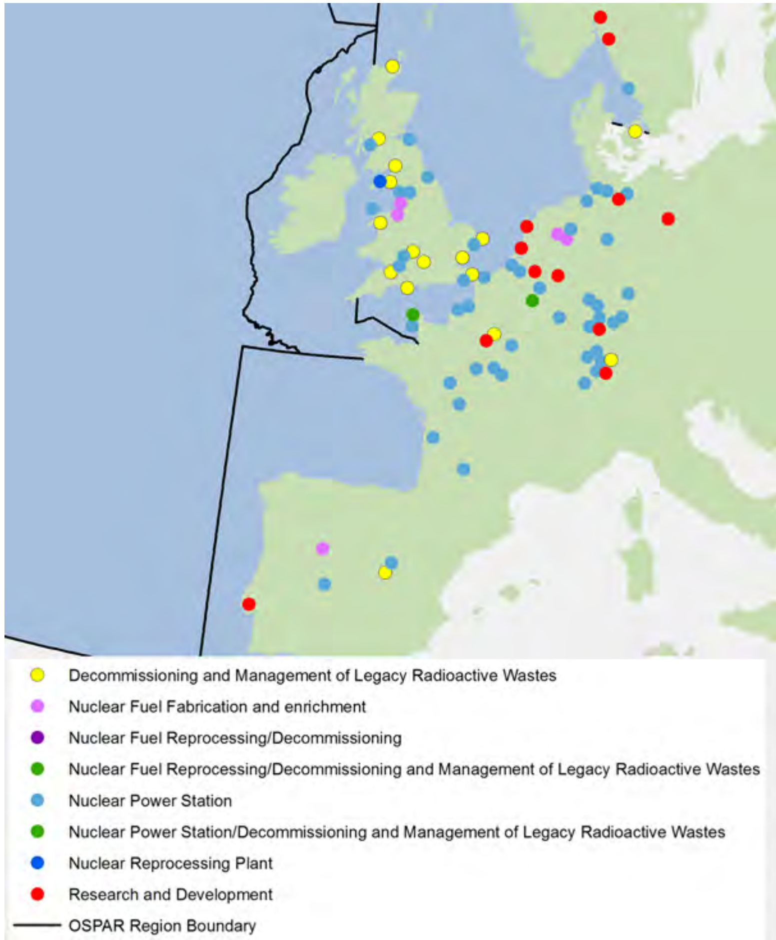


Figure 1: Location of nuclear facilities 2014

Results

OSPAR's Fourth Periodic Evaluation builds on the previous periodic evaluations to assess progress made by OSPAR Contracting Parties in reducing discharges of radioactive substances to the North-East Atlantic, in order to meet the objective of the OSPAR Radioactive Substances Strategy. For the nuclear sector, discharges from the latest assessment period (2007 – 2013) have been compared with data for the baseline period (1995 – 2001).

OSPAR collects discharge data for several radionuclides that, for evaluation purposes, are grouped into those that emit alpha radiation (total alpha) and those that emit beta radiation (total beta). Discharges of the beta-emitter tritium are not included in the assessment of total beta, but are collated separately. Discharges of the radionuclides Technetium-99 (Tc-99), Caesium-137 (Cs-137) and Plutonium-239,240 (Pu-239,240) are also assessed individually.

For the nuclear sector, in 35 out of 53 assessments across the four sub-sectors (nuclear fuel production and enrichment, nuclear power, nuclear fuel reprocessing, nuclear research and development), there is evidence that substantial reductions in discharges have been achieved compared to the baseline period. In another five assessments there is some evidence of a substantial reduction. None of the assessments show any evidence of an increase in discharges. Furthermore, results for the nuclear sector as a whole show clear evidence of reductions in the discharge of total alpha (**Figure 2** overleaf) and total beta (excluding tritium) (**Figure 3** overleaf), as well as for the individual radionuclides Tc-99 and Cs-137.

For the nuclear sector, the main contributors to the total activity discharged during the baseline period were the nuclear fuel reprocessing and nuclear fuel production and enrichment sub-sectors, however discharges from all the nuclear sub-sectors reduced. While discharges from the reprocessing sub-sector are much reduced, it remains the dominant source of discharges from the nuclear sector – contributing approximately 90% of the total alpha discharges and approximately 80% of the total beta (excluding tritium) discharges over the assessment period.

For the non-nuclear sector, the submission of discharge data began in 2005. In the case of the oil / gas sub-sector, enough data have been submitted to derive a baseline period (2005 to 2011). However, it will not be possible to identify trends in discharge without additional years of data.

The Fourth Periodic Evaluation of Progress towards the Objective of the Radioactive Substances Strategy

OSPAR COMMISSION

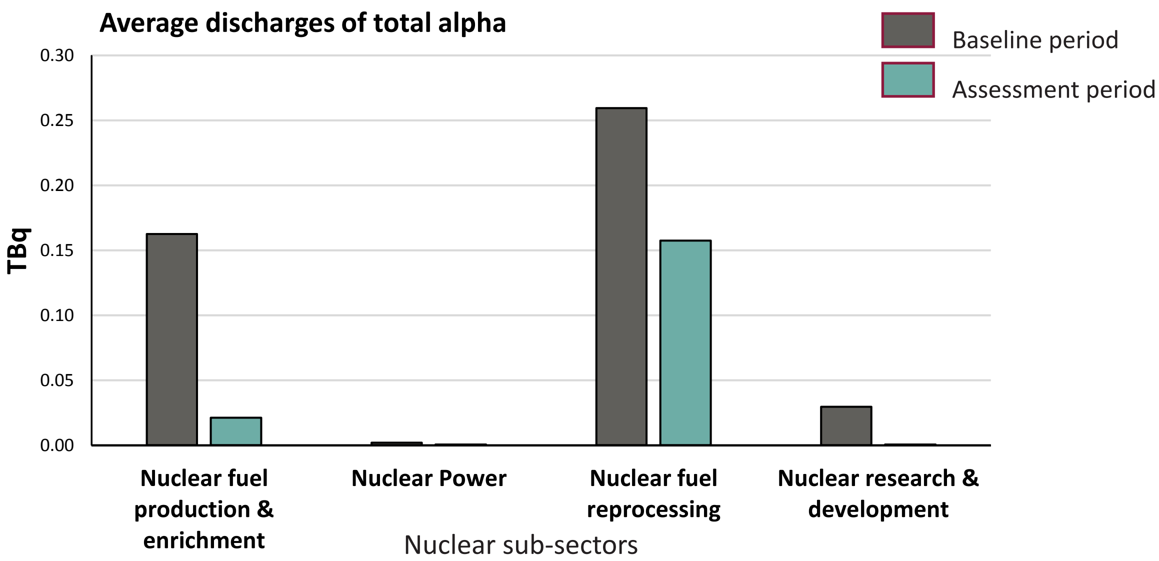


Figure 2: Average discharges of total alpha activity from the different nuclear sub-sectors in the period 2007 to 2013 (blue) relative to the baseline period 1995 to 2001 (grey)

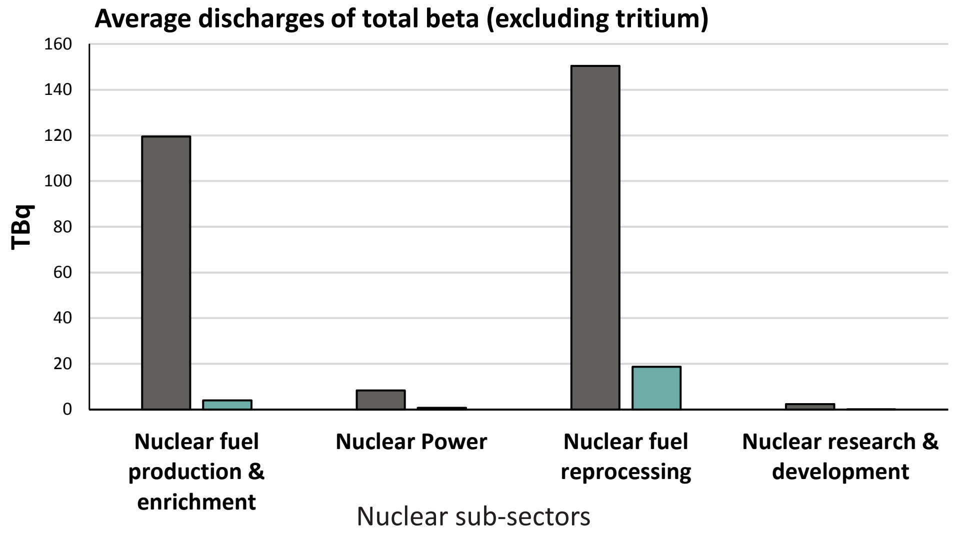


Figure 3: Average discharges of total beta activity (excl. tritium) from the different nuclear sub-sectors in the period 2007 to 2013 (blue) relative to the baseline period 1995 to 2001 (grey)

Conclusion

Overall, the Fourth Periodic Evaluation has confirmed that in relation to discharges from the nuclear sector:

- OSPAR Contracting Parties are continuing to make good progress in meeting the objectives of the OSPAR Radioactive Substances Strategy;
- OSPAR Contracting Parties have achieved substantial reductions in discharges in many cases, as required by the OSPAR Radioactive Substances Strategy.

In general terms, the situation for the nuclear sector has improved since the Third Periodic Evaluation. In particular:

- There has been a 2.5 fold reduction in discharges of total alpha since the baseline period (1995 – 2001);
- There has now been a 12-fold reduction in discharges of total beta (excluding tritium) since the baseline period (1995 – 2001);
- Discharges of Tc-99 have continued to decline with a reduction of 38 fold in the discharges since the baseline period.

Although the focus of the Fourth Periodic Assessment has been on discharges of radioactive substances from the nuclear and non-nuclear sectors, the radiological impacts on man and biota from these discharges are expected to be low, as previously concluded in the Third Periodic Evaluation..

Knowledge Gaps

As a long-established OSPAR Committee, the Radioactive Substances Committee has worked to turn knowledge gaps into work streams to support future evaluations. The Radioactive Substances Committee is currently working on, or is developing plans to:

- Periodically review the development of industrial abatement techniques for tritium in the liquid effluent of power and reprocessing plants;
- Determine additional activity concentrations in the marine environment resulting from discharges of naturally occurring radionuclides in produced water to the marine environment;
- Review the need to assess the discharges and indicators for the various sub-sectors of the nuclear and non-nuclear sectors;
- Determine a methodology for assessing whether additional concentrations in the marine environment above historic levels are close to zero.

This document was published as part of OSPAR's ntermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments

Status and Trends for Heavy Metals (Mercury, Cadmium and Lead) in Fish and Shellfish

MSFD Descriptor: 8 - Concentration of contaminants

MSFD Criterion: 8.1 - Concentration of contaminants

Key Message In most areas assessed (since 2009) concentrations of mercury, cadmium and lead in mussels and fish are above background levels. Nevertheless, all concentrations are below European Commission limits for foodstuffs. Concentrations are decreasing or show no significant change in all areas assessed; except for cadmium in a few North Sea and Irish Sea locations

Background

OSPAR's strategic objective is to prevent pollution of the OSPAR Maritime Area by continuously reducing discharges, emissions and losses of hazardous substances. Metals are ubiquitous hazardous substances in the environment, and are found in mussels and fish in all OSPAR regions. The most toxic metals to humans and animals are mercury, cadmium and lead, known as heavy metals, all of which naturally occur in the environment.

Mercury, cadmium and lead enter the marine environment from a number of natural, agricultural and industrial processes (see heavy metal inputs indicator assessments), via long-range transportation by air, riverine input or run-off from land. In some cases direct input occurs. For example, some metals used as antifouling chemicals (mainly copper) and corrosion anodes (mainly zinc) are deliberately placed in the marine environment, through their use on ships' hulls or marine installations, causing hot spots of metal concentrations in and around harbours.

Mercury is highly toxic. Mercury and cadmium accumulate in the food chain. Lead is not accumulated via the food chain.

Heavy metals do not disappear over time and can be trapped in deeper levels of sediment until mining, geological or biological processes release them, at which point they may affect biota. There are natural concentrations of heavy metals in all waters, sediments, mussels and fish, referred to as background concentrations. OSPAR uses the maximum concentration limits for heavy metals in fish and mussels set by the European Commission as proxy values for Environmental Assessment Criteria (EAC).

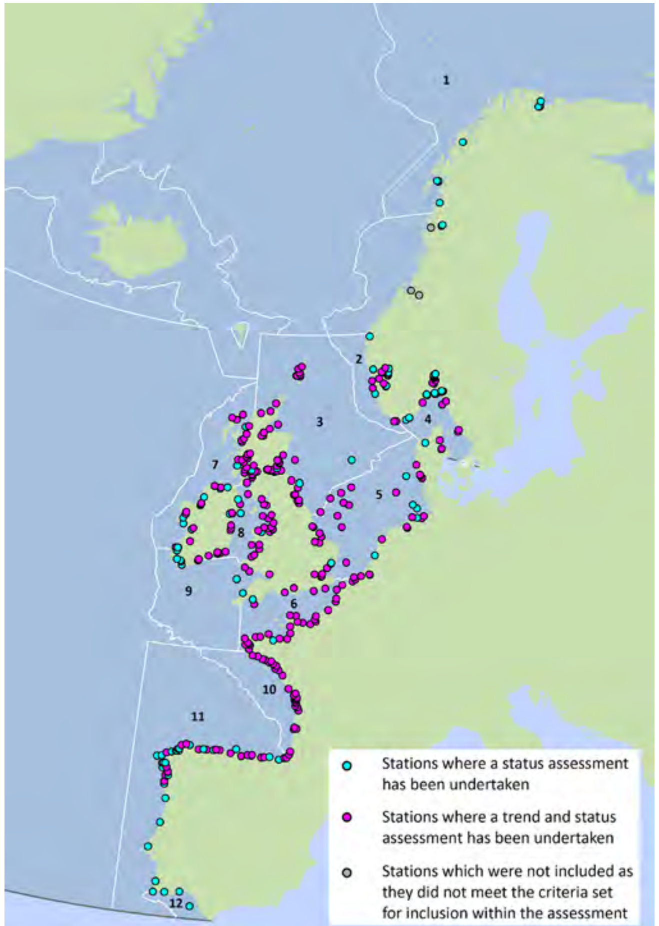


Figure 1: Monitoring sites used to assess heavy metal concentrations in fish and shellfish per OSPAR contaminants assessment area (white lines) determined by hydrogeographic principles and expert knowledge, not OSPAR internal boundaries.

Results

Different species of fish and shellfish are monitored for metal concentrations in the OSPAR Maritime Area. At coastal sites monitoring is mainly in blue mussels. Oysters are monitored in the Bay of Biscay and the Irish coast. At the remaining monitoring sites, mostly in open water, flatfish are monitored (**Figure 1**).

There are 22 monitoring sites in Arctic Waters not reported because they are not geographically representative of the region as a whole. This includes six to eight temporal trend monitoring sites in the Barents Sea, depending on the heavy metal monitored, and no heavy metals showed upward trends in concentration.

EC maximum levels for heavy metal concentrations in fish and shellfish are five times greater, or more, than background concentrations. In all OSPAR regions assessed since 2009 the average heavy metal concentrations are below EC maximum levels.

Images: Blue mussels (*Mytilus edulis*) © Mark A Wilson
Common dab (*Limanda limanda*) Wikimedia commons
Both species are routinely used for PCB monitoring in biota

Status and Trends for Heavy Metals (Mercury, Cadmium and Lead) in Fish and Shellfish

Results cont...

Mercury concentrations in biota are at or above background in all sub-regions (**Figure 2**). The highest concentrations are found in the Norwegian Trench, Northern North Sea, Southern North Sea and Irish Sea, at around twice the background concentration.

Cadmium concentrations in biota are above background in nine of the 12 OSPAR sub-regions; the exceptions are the English Channel, Northern Bay of Biscay and Iberian Sea. Concentrations in biota from the Barents Sea and Southern North Sea are at 2–5 times higher than the background level (**Figure 2**).

With the exception of the Irish and Scottish West Coast (**Figure 2**), lead concentrations in biota are above background. Mean concentrations in the Barents Sea, Skagerrak and Kattegat, and Northern Bay of Biscay are below the background level, but the upper confidence limits are above background. Lead concentrations in the Northern North Sea, Irish Sea, and Gulf of Cadiz all are at 2–5 times the background concentration.

There is high confidence in the assessment and sampling methodology and high confidence in the data used.

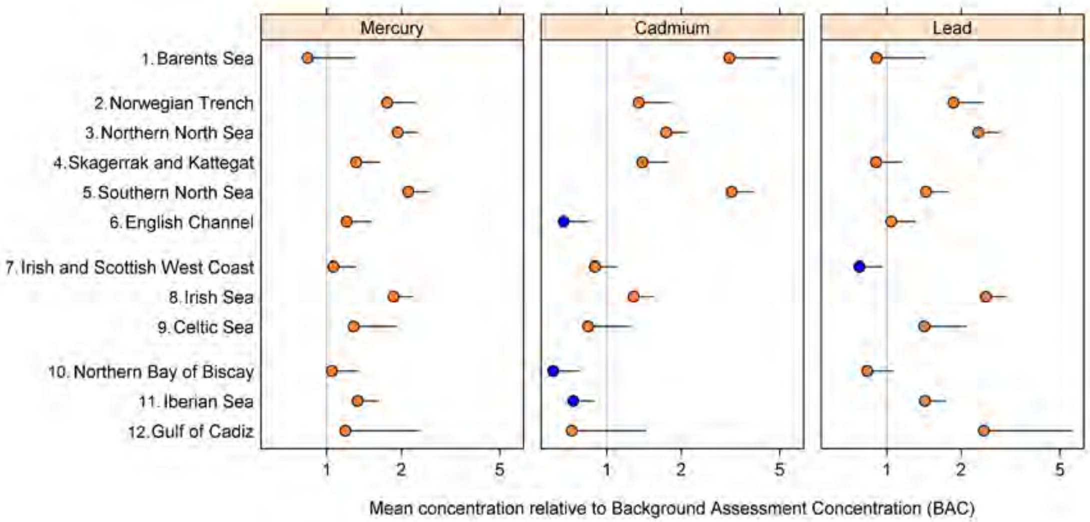


Figure 2: Mean concentrations of each heavy metals in biota in each OSPAR sub-region relative to Background Assessment Concentrations (BAC) (with 95% upper confidence limits), where value of 1 means that the mean concentration equals the BAC. Blue: mean concentration statistically significantly (p <0.05) below the Background Assessment Concentration (BAC) and the European Commission maximum levels for food, orange: mean concentration at (if confidence limit crosses 1), or above the BAC, but significantly below the EC maximum levels for food. The EC maximum levels are generally more than five times higher than the BAC and hence not shown

Results cont...

Mercury concentrations in biota show no statistically significant change in all sub-regions except for the Iberian Sea where there is a downward trend. In contrast, lead concentrations are declining in seven of the ten sub-regions and show no significant change at three.

The only sub-region where concentrations are increasing is the Southern North Sea, and for cadmium. Here, half of the monitoring sites show upward trends for cadmium, resulting in an annual increase in concentration of approximately 2%. Concentrations of lead and cadmium in mussels in the Northern North Sea (Shetlands) are low, but increasing.

There are 22 monitoring sites in Arctic Waters not reported because they are not geographically representative of the region as a whole. This includes six to eight temporal trend monitoring sites in the Barents Sea, depending on the heavy metal monitored, and no heavy metals showed upward trends in concentration.

There is high confidence in the assessment and sampling methodology and high confidence in the data used.

Conclusion

The ultimate aim of the OSPAR Hazardous Substances Strategy is for concentrations of heavy metals in biota to be at natural background levels. However, heavy metal concentrations in biota in most assessment areas are above natural background concentrations.

Average heavy metal concentrations in shellfish and fish are below European Commission maximum limits for foodstuffs in all OSPAR regions. Mercury concentrations show no significant change or show a downward trend in most sub-regions. The only sub-region showing an increasing trend in metal concentrations in biota is the Southern North Sea for cadmium.

Although mercury, cadmium and lead concentrations in shellfish and fish are below EC maximum levels in foodstuffs in all areas assessed, there is a potential to further reduce heavy metal levels in biota in order to reach natural background levels.

Knowledge Gaps

The assessment criteria are based on background concentrations and European Commission maximum levels in foodstuffs, rather than on environmental limits.

The European Commission has derived environmental quality criteria for fish only for mercury, which are lower than background concentrations, and should be re-examined. Environmental Assessment Criteria for all heavy metals in mussels and fish should be developed.

The reasons for the increasing concentrations of cadmium in the Southern North Sea need to be investigated to identify the sources.

This document was published as part of OSPAR's Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments

Status and Trends for Heavy Metals (Cadmium, Mercury and Lead) in Sediment

MSFD Descriptor: 8 - Concentration of contaminants

MSFD Criterion: 8.1 - Concentration of contaminants

OSPAR COMMISSION

Key Message Mean concentrations of mercury, cadmium and lead concentrations in marine sediments are decreasing or show no significant change in the majority of areas assessed. Nevertheless, concentrations in all areas are above natural background levels, and in four of the six areas assessed are above levels where adverse ecological effects cannot be ruled out

Background

OSPAR's strategic objective is to prevent pollution of the OSPAR Maritime Area by continuously reducing discharges, emissions and losses of hazardous substances. Metals are ubiquitous hazardous substances in the environment, found in marine sediments in all OSPAR regions. The most toxic metals to humans and animals are mercury, cadmium and lead, known as heavy metals, all of which naturally occur in the environment.

Mercury, cadmium and lead enter the marine environment from a number of natural, agricultural and industrial processes, such as emissions from coal-fired power stations, via long range transportation by air, riverine input or run-off from land (Heavy metal inputs Indicator Assessment). Some metals used as antifouling chemicals (mainly copper) and corrosion anodes (mainly zinc) are deliberately placed in the marine environment through their use on ships' hulls or marine installations, causing hot spots concentrations of these metals in and around harbours.

Mercury is highly toxic. Mercury and cadmium accumulate in the food chain, while lead is not accumulated via the food chain.

Heavy metals do not disappear over time and can be trapped in deeper levels of sediment until mining, geological or biological processes release them, at which point they may affect biota.

There are natural concentrations of heavy metals in all waters, sediments, and marine biota, referred to as the background concentrations. OSPAR uses the United States National Oceanic and Atmospheric Administration guidelines for assessing the ecological significance of contaminant concentrations in sediment (Effects Range-Low; ERL) as proxy for Environmental Assessment Criteria (EAC).

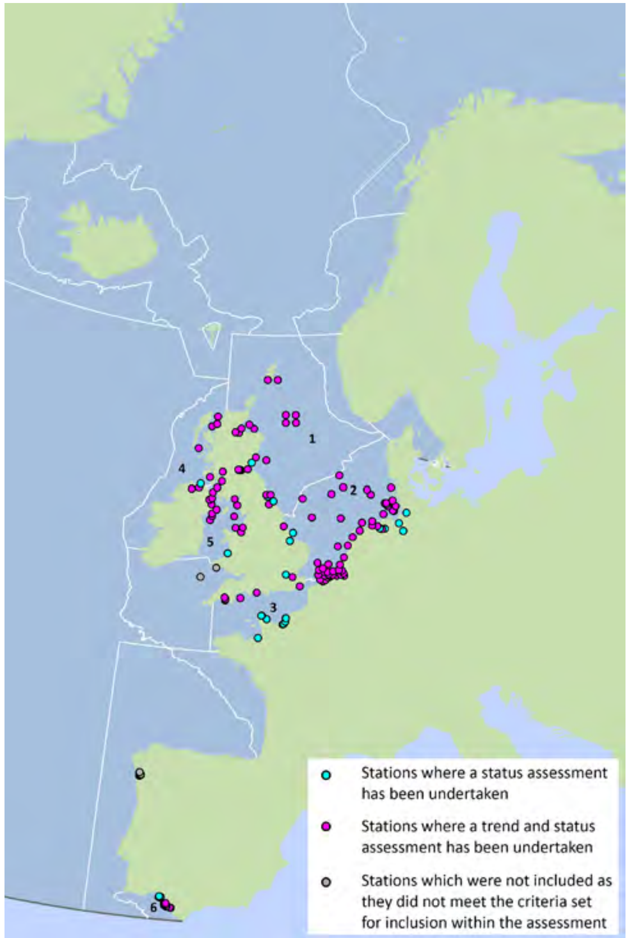


Figure 1: Monitoring sites used to assess heavy metal concentrations in sediment within OSPAR contaminants assessment areas (white lines) determined by hydrogeographic principles and expert knowledge, not OSPAR internal boundaries.

Results

Heavy metals in sediment are monitored on a regular basis as part of the OSPAR Co-ordinated Environmental Monitoring Programme (CEMP), at between 65 and 125 monitoring sites (**Figure 1**) depending on the heavy metal monitored. The assessment is based on monitoring sites that have been monitored at least since 2009; with some monitored since 1989. Temporal trends are assessed from the 10 years of monitoring data (i.e. 2005–2015), and the trend is determined from the last 5 years of data.

The concentrations of mercury, cadmium and lead were compared to Background Assessment Concentrations (BACs) and Effects Range-Low (ERL) values. Mercury and lead concentrations in sediment are at or above the BAC in all sub-regions. Mean concentrations of cadmium are below the BAC (**Figure 2**) in three of the six sub-regions assessed: Northern North Sea, Irish and Scottish West Coast and the Irish Sea.

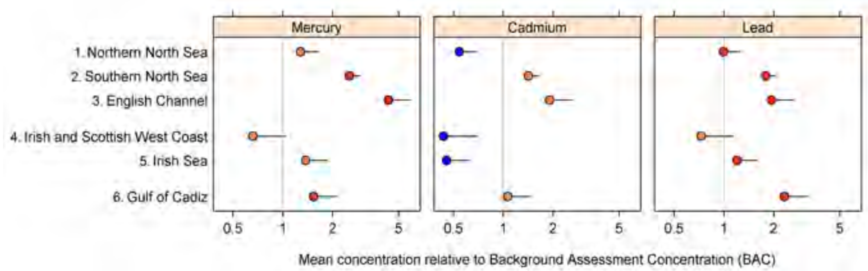


Figure 2: Mean concentrations of three heavy metals in sediment in OSPAR sub-regions relative to the Background Assessment Concentration (BAC) (with 95% upper confidence limits) where value of 1 means that the mean concentration equals the BAC. Blue: mean concentration statistically significantly ($p < 0.05$) below the BAC and the ERL, orange: mean concentrations at or above BAC but statistically significantly below the Effects Range-Low (ERL), red: mean concentration is above the BAC and at or above the ERL

Status and Trends for Heavy Metals (Cadmium,Mercury and Lead) in Sediment

Results cont...

Mercury concentrations in sediment are at or above ERL in three of the six sub-regions (**Figure 3**). Concentrations of cadmium in sediment are below the ERL in all OSPAR sub-regions. Lead concentrations are at or above the ERL in five of the six sub-regions, and below the ERL only in the Irish and Scottish West Coast sub-region.

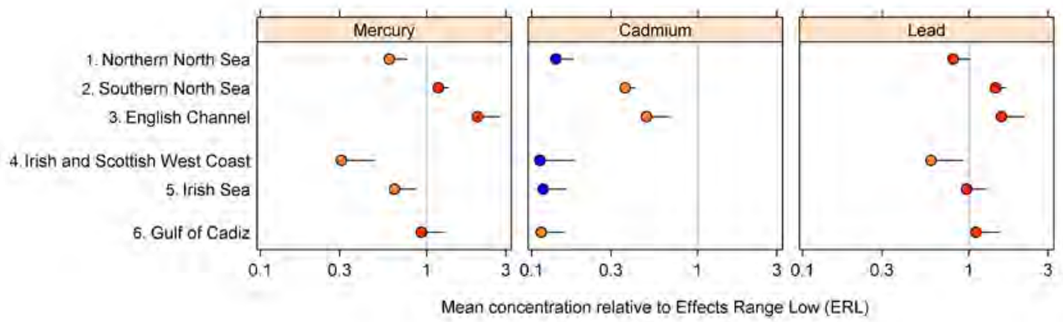


Figure 3: Mean concentrations of heavy metals in sediments relative to Effects Range-Low (ERL) concentration (with 95% upper confidence limits), where value of 1 means that the mean concentration equals the ERL. Blue: mean concentration is statistically significantly ($p < 0.05$) below the Background Assessment Concentration (BAC) and the ERL. Orange: mean concentration significantly below the ERL but at or above BAC. Red: mean concentration is above the BAC and at or above the ERL

Results cont...

The temporal trends in (overall mean) heavy metal concentrations in sediment (**Figure 4**) show decreasing levels of mercury in five of the six sub-regions and no statistically significant change in concentrations in the English Channel. Concentrations of cadmium show no statistically significant change in five sub-regions, but are decreasing in the Southern North Sea. Lead concentrations show no statistically significant change in four sub-regions and a downward trend in the Southern North Sea. In the Gulf of Cadiz there is an upward trend for lead.

This is a different pattern from that for biota, where most mercury concentrations show no statistically significant change and lead concentrations at most monitoring sites are decreasing (Common Indicator Heavy Metals in Biota). The response of sediments to measures taken to reduce heavy metal is expected to be slower than for biota, because the upper sediment layer (top few centimetres) sampled for analysis can represent several years of sedimentation and thus integrate heavy metal inputs over the corresponding period.

There is high confidence in the assessment and sampling methodology and high confidence in the data used.

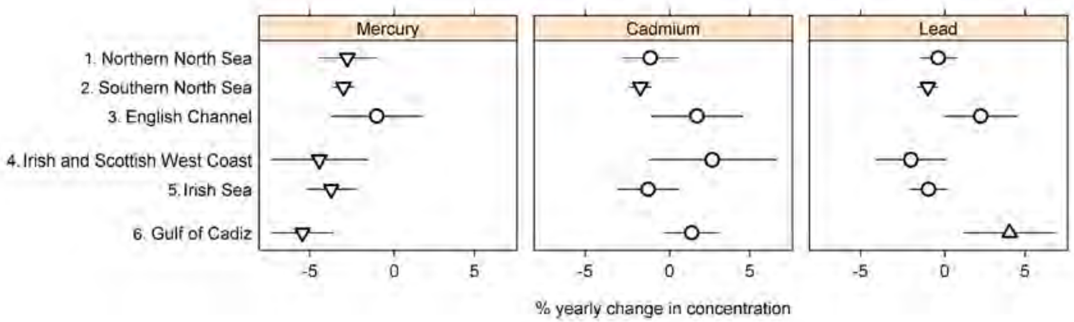


Figure 4: Percentage annual change in heavy metal concentrations in sediment in six OSPAR sub-regions. No statistically significant change in mean concentration (circle), mean concentration is significantly decreasing (downward triangle), mean concentration is significantly increasing (upward triangle), 95% confidence limits (lines)

Conclusion

The ultimate aim of the OSPAR Hazardous Substances Strategy is for concentrations of heavy metals in sediment to be at natural background levels. However, in most sub-regions heavy metal concentrations in sediment are above natural background concentrations. The highest concentrations in sediment of mercury and cadmium are found in the English Channel. Lead concentrations in sediment are highest in the Gulf of Cadiz. The lowest concentrations for all heavy metals are in the Irish and Scottish West Coast.

In half of the sub-regions mercury concentrations in sediment are above the ERL and in five of six monitoring sites lead concentrations are at or above the ERL. This means that in these sub-regions adverse ecological effects cannot be ruled out. In contrast cadmium concentrations are below the ERL in all six sub-regions.

The generally decreasing trends for mercury are not reflected in the concentrations of cadmium and lead; most cadmium and lead concentrations in sediment show no statistically significant change.

Knowledge Gaps

There is a lack of ecotoxicological data for developing new assessment criteria based on the European Union Water Framework Directive or OSPAR Environmental Assessment Criteria (EAC) principles, to replace the current Effects Range-Low (ERL) criteria. There are too few monitoring sites in Arctic Waters for a sub-regional assessment to be carried out.

This document was published as part of OSPAR's Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments

Trends in Concentrations of Polybrominated Diphenyl Ethers (PBDEs) in Fish and Shellfish

MSFD Descriptor: 8 - Concentration of contaminants

MSFD Criterion: 8.1 - Concentration of contaminants

Key Message Concentrations of polybrominated diphenyl ethers (PBDEs) detected in biota (fish, mussels, oysters) are declining in the majority of areas assessed. The exception is the Skagerrak and Kattegat where concentrations show no statistically significant change. The lack of assessment criteria means that the environmental significance of the concentrations cannot be assessed

Background

Polybrominated diphenyl ethers (PBDEs) are a group of congeners, mainly used as flame retardants in a variety of materials including plastics, textiles, electronic products, building materials, furnishings and vehicles. PBDEs may enter the environment through emissions from manufacturing processes, evaporation from products that contain PBDEs, recycling wastes and leachate from waste disposal sites (**Figure 1**). They are widespread and have been detected in air, sediments, surface waters, fish and other marine animals.

PBDEs are toxic, they take a long time to degrade and have the potential to accumulate in fish or shellfish (taken in either directly from the surrounding water or indirectly via food). As a result, some PBDEs were banned or restricted within the European Union starting in 2004. Production of some groups of PBDEs was banned in 2009 by 180 countries that are signatories to the Stockholm Convention.

The spatial distribution of PBDEs in the marine environment is variable. Some PBDE congeners tend to accumulate in fish and shellfish more than others. PBDE are known to have effects on the nervous, immune and endocrine systems of birds and mammals.

The OSPAR Hazardous Substances Strategy has the ultimate aim of achieving concentrations in the marine environment close to zero for man-made synthetic substances, and PBDEs are included in the group of brominated flame retardants on the OSPAR List of Chemicals for Priority Action. The status of PBDEs in biota is determined but not assessed because there are no OSPAR assessment values developed with which to assess status.

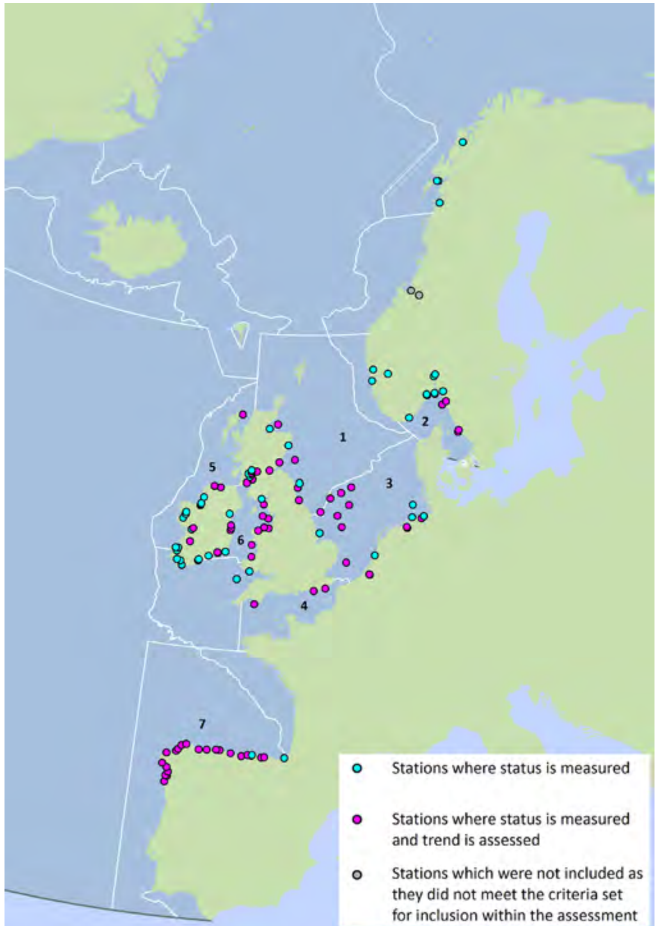


Figure 2: Monitoring sites used to assess PBDE concentrations in biota by OSPAR contaminants assessment area (white lines) determined by hydrogeographic principles and expert knowledge, not OSPAR internal boundaries.

Results

Polybrominated diphenyl ether (PBDE) concentrations are measured in biota (fish, mussels and oysters) taken annually (or every few years) from monitoring sites throughout much of the Greater North Sea, Celtic Seas, and Bay of Biscay and Iberian Coast. A few samples are also taken from Arctic Waters. Monitoring site locations are shown in **Figure 2**. Data recorded between 2010 and 2015 were used to investigate temporal trends in PBDE concentrations and to compare concentrations and patterns between OSPAR sub-regions. There were too few monitoring sites in Arctic Waters to give sufficient information for a trend assessment for that region.

Figure 1: Land-based waste dumping site with potential leakage of polybrominated diphenyl ethers (PBDEs) from products containing these flame-retardants

Trends in Concentrations of Polybrominated Diphenyl Ethers (PBDEs) in Fish and Shellfish

OSPAR COMMISSION

Results cont...

Temporal trends in mean PBDE concentrations were assessed in seven OSPAR sub-regions where there were more than five years of data. The results indicate that mean concentrations of PBDEs are decreasing in the majority of OSPAR sub-regions (**Figure 3**). The Skagerrak and Kattegat is the exception, where concentrations in biota show no statistically significant change.

Mean PBDE concentrations are <1 µg/kg wet weight in ten OSPAR sub-regions. The sub-regions showing the highest mean concentrations of PBDE in biota are the English Channel and Irish Sea. The lowest concentrations are found in the Iberian Sea. However, the species monitored differ between OSPAR sub-regions and this may be reflected in the results. In the Iberian Sea only mussels are analysed, which may explain the low mean concentrations of PBDEs, since mussels across the OSPAR sub-regions show lower concentrations than fish.

There is high confidence in the assessment and sampling methodology and high confidence in the data used.

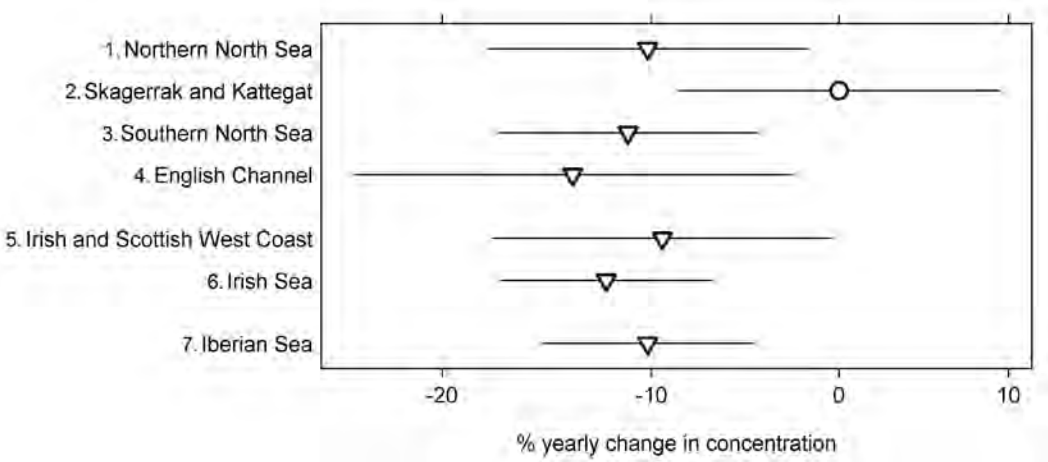


Figure 3: Percentage annual change in overall PBDE concentrations in each OSPAR sub-region. No statistically significant ($p < 0.05$) change in mean concentration (circle), mean concentration is significantly decreasing (downward triangle) 95% confidence limits (lines)

Conclusion

Since PBDEs were regulated, concentrations in fish and shellfish have decreased for the majority of the OSPAR sub-regions.

Temporal trends in polybrominated diphenyl ether (PBDE) concentrations in biota are declining by approximately 10% per year in six of the seven sub-regions assessed. In one sub-region, the Skagerrak and Kattegat, the trend shows no statistically significant change.

PBDE concentrations in biota vary between the OSPAR sub-regions assessed. The highest concentrations occur in the English Channel and the Irish Sea, with the lowest in the Iberian Sea. These differences could reflect the contamination load in the respective sub-regions but could also be influenced by differences in the species monitored. Because there are no assessment criteria available for PBDEs in biota, it is not possible to assess the environmental significance of the concentrations observed.

Knowledge Gaps

There is a lack of monitoring data, particularly in Arctic Waters. Cooperation between OSPAR and the Arctic Council's Arctic Monitoring and Assessment Programme (AMAP) will improve access to data for Arctic Waters.

Assessment values applicable to OSPAR monitoring data for temporal trends and the status of polybrominated diphenyl ethers (PBDEs) in biota need to be developed. A strategy is needed for making data from different monitoring species comparable.

The Environmental Quality Standard (EQS) derived within European Union to protect marine and freshwater ecosystems as well as humans from adverse effects of chemicals in the aquatic environments requires further investigation for use in the OSPAR Maritime Area.

This document was published as part of OSPAR's Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments

Trends in Concentrations of Polybrominated Diphenyl Ethers (PBDEs) in Sediment

MSFD Descriptor: 8 - Concentration of contaminants
MSFD Criteria: 8.1 - Concentration of contaminants

OSPAR COMMISSION

Key Message Concentrations of polybrominated diphenyl ethers (PBDEs) detected in sediment in the areas assessed either show no statistically significant change (Northern North Sea) or are declining (Irish Sea). The lack of assessment criteria means the environmental significance of the concentrations cannot be assessed

Background

Polybrominated diphenyl ethers (PBDEs) are a group of congeners, mainly used as flame retardants in a variety of materials including plastics, textiles, electronic products, building materials, furnishings and vehicles (**Figure 1**).

PBDEs may enter the environment through emissions from manufacturing processes, evaporation from products that contain PBDEs, recycling wastes and leachate from waste disposal sites. They are widespread and have been detected in air, sediments, surface waters, fish and other marine animals.

PBDEs are toxic, they take a long time to degrade and have the potential to accumulate in fish or shellfish (taken in either directly from the surrounding water or indirectly via food). As a result, some PBDEs were banned or restricted within the European Union starting in 2004. Production of some groups of PBDEs was banned in 2009 by 180 countries that are signatories to the Stockholm Convention.

The spatial distribution of PBDEs in marine sediments is variable. PBDEs do not dissolve in water and bind strongly to soil or sediment. As a result PBDEs in sediment are not very mobile.

The OSPAR Hazardous Substances Strategy has the ultimate aim of achieving concentrations in the marine environment close to zero for man-made synthetic substances, and PBDEs are included in the group of brominated flame retardants on the OSPAR List of Chemicals for Priority Action. The status of PBDE concentrations in sediment is calculated but not assessed because there are no OSPAR assessment values developed with which to assess status.

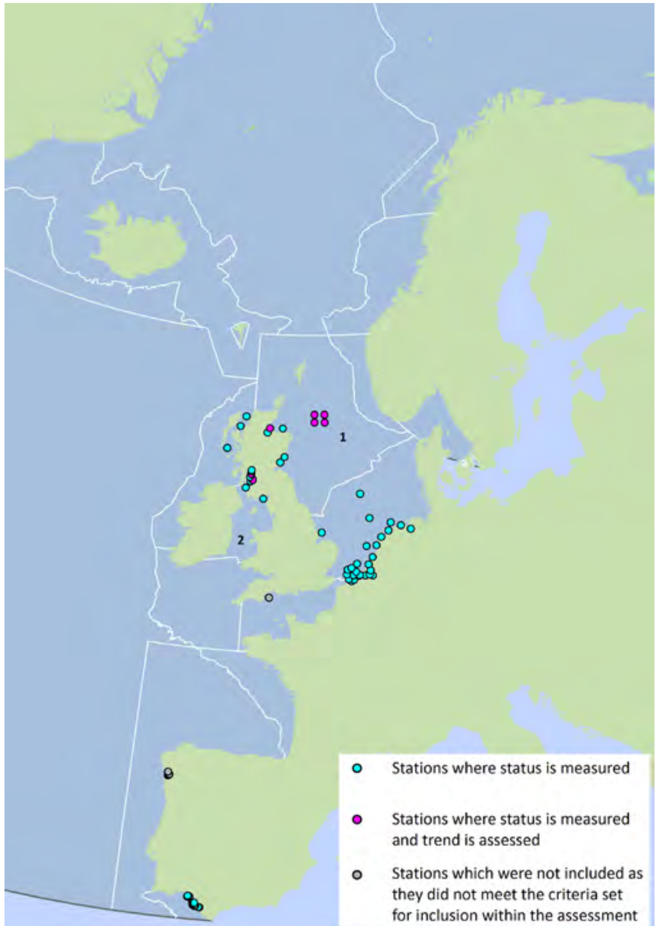


Figure 2: Monitoring sites used to assess PBDE concentrations in sediment by OSPAR contaminants assessment area (white lines) determined by hydrogeographic principles and expert knowledge, not OSPAR internal boundaries.

Results

Polybrominated diphenyl ether (PBDE) concentrations are measured in sediment samples taken annually (or every few years) from monitoring sites in the Greater North Sea, Celtic Seas, and Bay of Biscay and Iberian Coast. The locations of the PBDE monitoring sites are shown in **Figure 2**.

Figure 1: Polybrominated diphenyl ethers (PBDEs) are a group of compounds mainly used as flame retardants in a variety of materials, including electronic products (upper) and vehicles (lower)

Trends in Concentrations of Polybrominated Diphenyl Ethers (PBDEs) in Sediment

Results cont...

The number of time series used in each area assessed is very limited. Some of the PBDE in sediment data for the Greater North Sea, Celtic Seas, and Bay of Biscay and Iberian Coast could not be taken into account, either because some time series include data below concentration levels that can be accurately measured or because time series are too short for analysis. Furthermore, an OSPAR sub-region was only assessed if at least three monitoring sites had enough years of data and a representative geographic spread across a sub-region. It is expected that more monitoring sites can be included for future assessments.

Temporal trends in mean PBDE concentrations were assessed in two OSPAR sub-regions where there were at least five years of data (**Figure 3**). Mean PBDE concentrations in sediment show no statistically significant change in the Northern North Sea and decreasing in the Irish Sea.

The mean concentrations of PBDE in sediment were analysed for five sub-regions; Northern North Sea, Southern North Sea, Irish Sea, Irish and Scottish West Coasts and the Gulf of Cadiz. Concentrations in sediment are low (<1 µg/kg dry weight) and often below detection levels. The Gulf of Cadiz has the lowest concentrations of PBDE in any assessed area (<0.01 µg/kg dry weight), while the Irish Sea and Southern North Sea have the highest.

There is high confidence in the assessment and sampling methodology and high confidence in the data used.

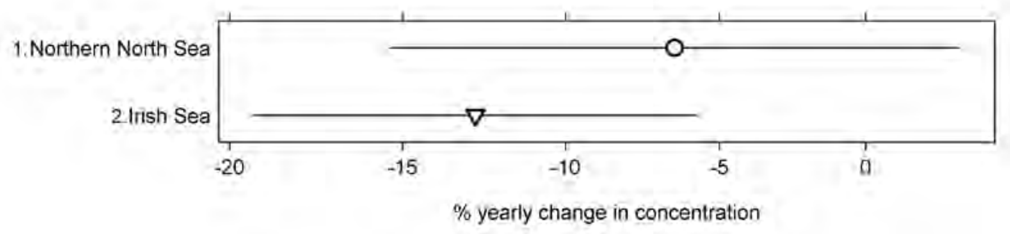


Figure 3: Percentage annual change in overall PBDE concentrations in each OSPAR sub-region. No statistically significant ($p < 0.05$) change in mean concentration (circle), mean concentration is significantly decreasing (downward triangle). 95% confidence limits (lines)

Conclusion

Polybrominated diphenyl ether (PBDE) concentrations in sediment are measured at very few monitoring sites in the Greater North Sea, Celtic Seas, and Bay of Biscay and Iberian Coast. As there are no assessment criteria available for PBDEs in sediment, it is not possible to assess the environmental significance of the concentrations observed.

There were enough years of data from some of the monitoring sites in the Northern North Sea and Irish Sea to carry out temporal trend analyses. PBDE concentrations are declining in Irish Sea and show no statistically significant change in the Northern North Sea.

The majority of measured concentrations of PBDE in sediment are low and often below detection levels. The Gulf of Cadiz has the lowest concentrations of PBDE in any assessed area, while the Greater North Sea has the highest.

Knowledge Gaps

There are few monitoring sites for the assessment temporal trends in polybrominated diphenyl ether (PBDE) concentrations in sediment in the OSPAR sub-regions which means the assessment cannot be considered representative for the OSPAR Maritime Area as a whole. Cooperation between OSPAR and the Arctic Monitoring and Assessment Programme (AMAP) will improve access to data for Arctic Waters.

Background Assessment Concentrations (BACs) and Environmental Assessment Criteria (EACs) need to be developed for PBDE concentrations in sediment in order to be able to assess the environmental significance of the concentrations observed.

This document was published as part of OSPAR's Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments

Status and Trends in the Concentrations of Polycyclic Aromatic Hydrocarbons (PAHs) in Shellfish

MSFD Descriptor: 8 - Concentration of contaminants

MSFD Criterion: 8.1 - Concentration of contaminants

OSPAR COMMISSION

Key Message Although mean concentrations of polycyclic aromatic hydrocarbons (PAHs) in shellfish in all ten assessed areas are above natural background concentrations, they are below levels likely to harm marine species. Mean concentrations are decreasing or show no statistically significant change in the areas assessed in the period 1995–2015

Background

Polycyclic aromatic hydrocarbons (PAHs) are natural components of coal and oil, and are also formed during the combustion of fossil fuels and organic material, for example during activities at an oil refinery. PAHs also occur as a result of natural processes such as forest fires.

PAHs enter the marine environment through atmospheric deposition, road run-off, industrial discharges and as a result of oil spills. PAHs in the marine environment often end up in marine sediment, where they can become trapped in lower layers unless the sediments are disturbed. PAHs also accumulate in shellfish, either absorbed directly from the marine environment or indirectly through food consumption. In contrast fish metabolise PAHs and therefore concentrations in fish are low. The problems caused by PAHs in the marine environment vary considerably from tainting the taste of fish and shellfish to potential carcinogenic effects on humans and animals.

The OSPAR Hazardous Substances Strategy has the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances. Due to their persistence in the marine environment, their potential to bioaccumulate and their toxicity, analyses of PAH concentrations in sediment and shellfish is reported in the OSPAR Coordinated Environment Monitoring Programme (CEMP). Monitoring PAHs in biota across the OSPAR Maritime Area began between 1995 and 1999.

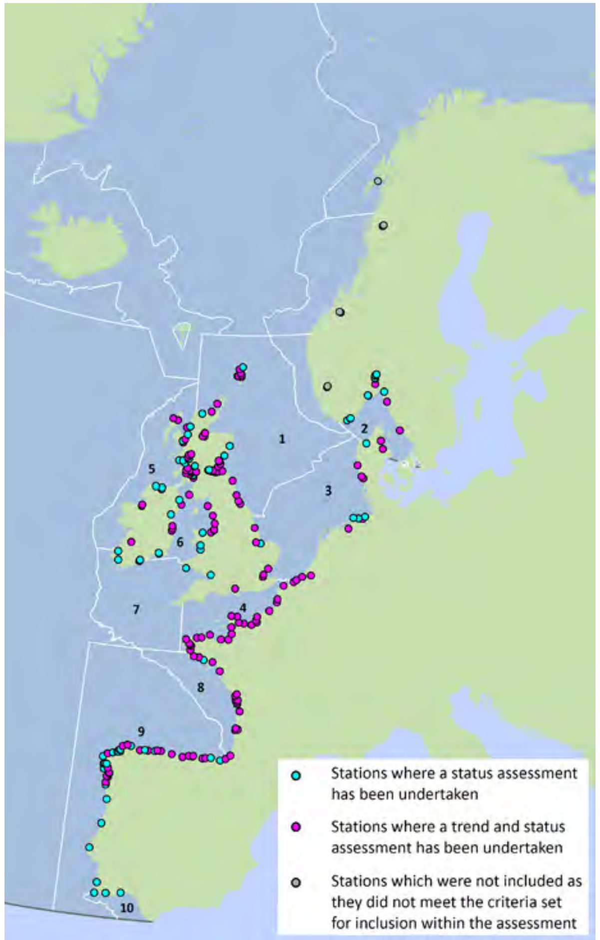


Figure 1: Monitoring sites used to assess PAH concentrations in shellfish by OSPAR contaminants assessment area (white lines) determined by hydrogeographic principles and expert knowledge, not OSPAR internal boundaries.

Results

PAH concentrations were measured in shellfish samples collected between 1995 and 2015 from 188 monitoring sites throughout much of the Greater North Sea, Celtic Seas, and Bay of Biscay and Iberian coast (**Figure 1**), at frequencies ranging from annually to every three years.

PAH concentrations were compared against two assessment criteria: the OSPAR Background Assessment Concentrations (BACs) and Environmental Assessment Criteria (EACs). Adverse effects on marine organisms are rarely observed when concentrations are below the EAC. BACs are used to assess whether concentrations are near background values for naturally occurring substances, such as PAHs; this is the ultimate aim of the OSPAR Hazardous Substances Strategy.

Mean PAH concentrations in shellfish for each OSPAR sub-region were compared to the EACs. PAH concentrations were below the EAC, but above the BAC in all 10 OSPAR sub-regions (**Figure 2**). As PAH concentrations in shellfish were below the EAC they are unlikely to cause any adverse effects.

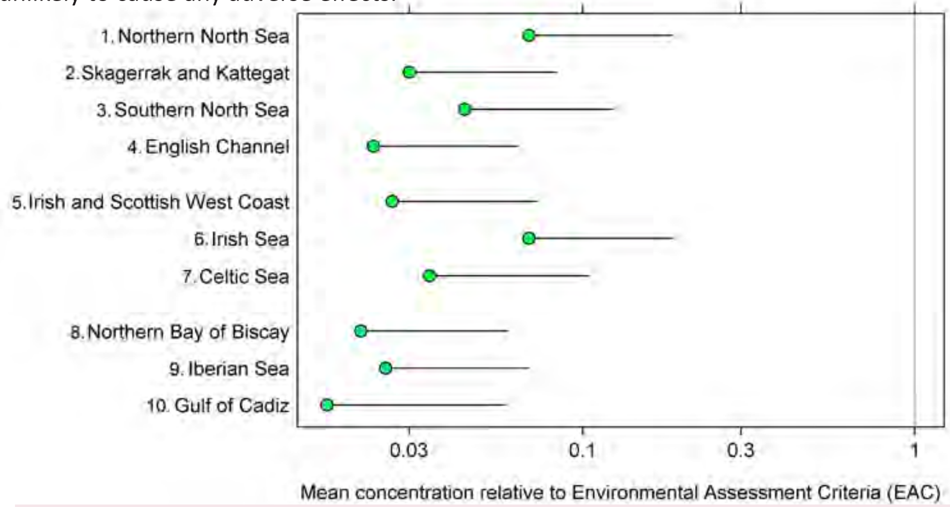


Figure 2: Mean PAH concentration in shellfish in each OSPAR sub-region, relative to the Environmental Assessment Criteria (EAC) (with 95% upper confidence limits), where value of 1 means that the mean concentration equals the EAC. Green: the mean concentration is statistically significantly ($p < 0.05$) below the EAC, but not statistically significantly below the Background Assessment Concentration (BAC)

Status and Trends in the Concentrations of Polycyclic Aromatic Hydrocarbons (PAHs) in Shellfish

Results cont...

Temporal trends in PAH concentration in shellfish were assessed in OSPAR sub-regions where at least five years of data were available (**Figure 3**). Four of the OSPAR sub-regions (Northern North Sea, Skagerrak and Kattegat, Irish Sea, Northern Bay of Biscay) show no statistically significant change in PAH concentrations. Declining PAH concentrations are observed in four OSPAR sub-regions (Southern North Sea, English Channel, Irish and Scottish West Coasts, and the Iberian Sea), with mean annual decreases in concentration of between 6.5% and 3.2%.

There is high confidence in the assessment and sampling methodology and high confidence in the data used.

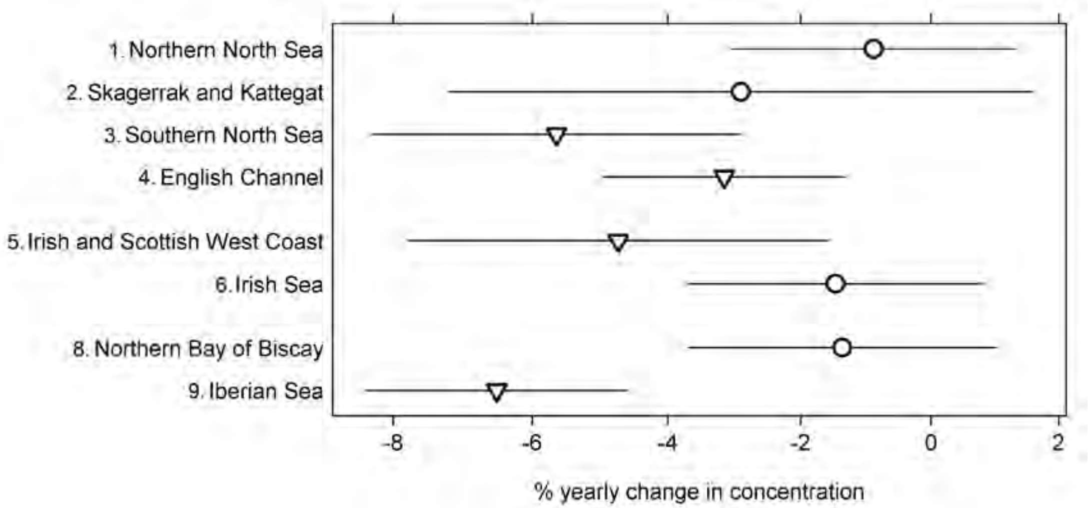


Figure 3: Percentage annual change in PAH concentration in shellfish in each OSPAR sub-region. No statistically significant ($p < 0.05$) change in mean concentration (circle), mean concentration is significantly decreasing (downward triangle). 95% confidence limits (lines)

Conclusion

Mean PAH concentrations in shellfish are above background concentrations in all assessed OSPAR sub-regions. However, concentrations in shellfish are below the Environmental Assessment Criteria (EAC) in all OSPAR sub-regions and therefore are unlikely to cause adverse effects. Temporal trends in PAH concentration in shellfish are either decreasing or show no statistically significant change in all OSPAR sub-regions assessed and no upwards trends are observed.

Whilst PAHs originate from natural sources and will always be present in the marine environment, better use of emission control technology in combustion processes could improve the situation further and reduce concentrations to natural levels.

Knowledge Gaps

There is a lack of monitoring data, particularly in Arctic waters, where there are insufficient monitoring sites with a good geographic spread for a sub-regional assessment of status and temporal trends.

Monitoring of PAH metabolites in fish bile could extend the biota monitoring programme to include open waters. Fish readily metabolise PAHs and so analysis of PAH metabolites in bile will indicate if fish have been exposed to PAH compounds.

Environmental Assessment Criteria (EACs) were used in the assessment of parent PAHs only; there are no assessment criteria for alkylated PAHs. There is a need for EACs to be developed for alkylated PAHs in shellfish. There are currently no data on PAHs in open waters, because shellfish are only found in the coastal zone. The limitations in using EACs and Background Assessment Concentrations (BACs) should be addressed with further research.

Image: Polycyclic aromatic hydrocarbons (PAHs) can accumulate in shellfish, either absorbed directly from the marine environment or indirectly through food consumption ©Jennifer McNew

This document was published as part of OSPAR's Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments

Status and Trends in the Concentrations of Polycyclic Aromatic Hydrocarbons (PAHs) in Sediment

MSFD Descriptor: 8 - Concentration of contaminants

MSFD Criteria: 8.1 - Concentration of contaminants

OSPAR COMMISSION

Key Message Mean concentrations of polycyclic aromatic hydrocarbons (PAHs) in sediment are below levels likely to harm marine species in the areas assessed, but are above natural background concentrations in four of the six areas assessed. Mean concentrations show no statistically significant change in four areas and are decreasing in two

Background

Polycyclic aromatic hydrocarbons (PAHs) are natural components of coal and oil, and are also formed during the combustion of fossil fuels and organic material. PAHs also occur as a result of natural processes such as forest fires. PAHs enter the marine environment through atmospheric deposition, road run-off, industrial discharges and oil spills. PAHs in the marine environment often end up in marine sediment, where they can become trapped in lower layers unless the sediments are disturbed. Associations have been demonstrated between the incidence of some diseases in flatfish and the concentrations of PAHs in the sediment over which they live and feed.

The OSPAR Hazardous Substances Strategy has the ultimate aim of achieving concentrations in the marine environment near natural background values for naturally occurring substances and close to zero for man-made synthetic substances. Due to their persistence in the marine environment, their potential to bioaccumulate and their toxicity, analyses of PAH concentrations in sediment and shellfish is reported in the OSPAR Coordinated Environmental Monitoring Programme (CEMP). Monitoring PAHs in sediment across the OSPAR Maritime Area began between 1995 and 1999.

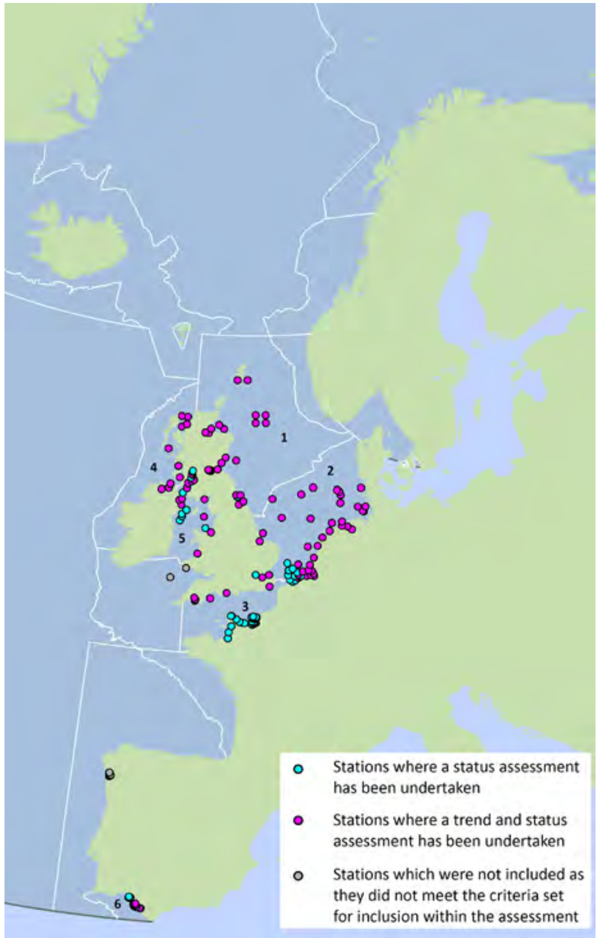


Figure 1: Monitoring sites used to assess PAH concentrations in sediment by OSPAR contaminants assessment area (white lines) determined by hydrogeographic principles and expert knowledge, not OSPAR internal boundaries.

Results

Polycyclic aromatic hydrocarbon (PAH) concentrations were measured in sediment samples collected between 1995 and 2015 from monitoring sites throughout much of the Greater North Sea, Celtic Seas, and Bay of Biscay and Iberian Coast (**Figure 1**), at frequencies ranging from annually to every five years.

The number of monitoring sites varied widely between OSPAR regions and sub-regions, with the Greater North Sea having the most. Only OSPAR sub-regions with at least three monitoring sites and a reasonable geographic spread were included in the sub-regional assessment of status and temporal trends.

PAH concentrations were compared against two assessment criteria: the OSPAR Background Assessment Concentration (BAC) and the United States Environmental Protection Agency's Effects-Range Low (ERL). Adverse effects on marine organisms are rarely observed when concentrations are below the ERL value.

Mean PAH concentrations in sediment are statistically significantly below the ERL in all OSPAR sub-regions (**Figure 2**). Therefore adverse biological effects in marine species are unlikely. Concentrations are lowest in the Gulf of Cadiz and in the Irish and Scottish West Coast sediments and are at background (i.e. statistically significantly below the BAC). In the other four sub-regions mean concentrations are below the ERL but not statistically significantly below the BAC (**Figure 2**).

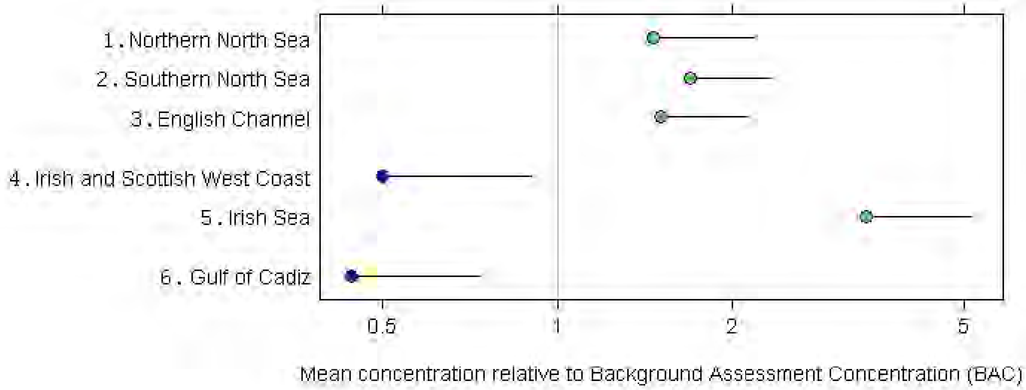


Figure 2: Mean PAH concentration in sediment in each OSPAR sub-region relative to the Effects Range-Low (ERL) (with 95% upper confidence limits), where value of 1 means that the mean concentration equals the ERL . Blue: the mean concentration is statistically significantly ($p < 0.05$) below the Background Assessment Concentration (BAC) and the ERL. Green: mean concentration is statistically significantly below the ERL but not statistically significantly below the BAC

Status and Trends in the Concentrations of Polycyclic Aromatic Hydrocarbons (PAHs) in Sediment

OSPAR COMMISSION

Results cont...

Temporal trends in the PAH concentrations in sediment were assessed for the period between the earliest monitoring date (1995 to 1999) and 2014. PAHs in sediment were assessed in six OSPAR sub-regions where there were at least five years of data (**Figure 3**). PAH concentrations are decreasing in the Gulf of Cadiz and the English Channel. In the other four assessed sub-regions concentrations show no statistically significant trend.

There is high confidence in the assessment and sampling methodology and high confidence in the data used.

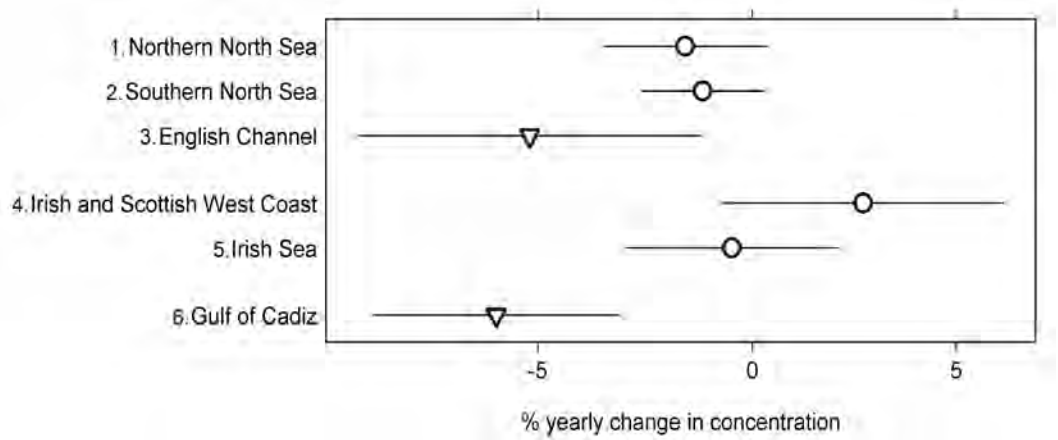


Figure 3: Percentage yearly change in PAH concentrations in each OSPAR sub-region. Statistically significant ($p < 0.05$) downward temporal trends (downward triangle), no statistically significant ($p < 0.05$) change (circle). 95% confidence limits (lines)

Conclusion

Mean polycyclic aromatic hydrocarbon (PAH) concentrations in sediment were at background levels in two of the six assessed OSPAR sub-regions. Mean PAH concentrations were below the Effects-Range Low (ERL) in all OSPAR sub-regions and therefore are unlikely to cause adverse effects in marine organisms.

However, PAH concentrations in sediment need to be kept under surveillance, because in four sub-regions concentrations are above background levels. Concentrations show no statistically significant trend in four areas, and are in decline only in the English Channel and Gulf of Cadiz.

Whilst PAHs originate from natural sources and so will always be present in the marine environment, better use of emission control technology in combustion processes could improve the situation further and reduce concentrations to natural levels.

Knowledge Gaps

There is a lack of monitoring data for polycyclic aromatic hydrocarbons (PAHs) in sediment, particularly for Arctic Waters and some parts of the Greater North Sea, Celtic Seas, and Bay of Biscay and Iberian Coast. Cooperation between OSPAR and the Arctic Monitoring and Assessment Programme (AMAP) would improve access to data for Arctic Waters.

The Effects-Range Low (ERL) developed by the United States Environmental Protection Agency was used in the assessment because there are no OSPAR Environmental Assessment Criteria (EACs) currently available. There is a need for EACs to be developed for both alkylated and parent PAH in sediment.

Image: Oil rig – Polycyclic aromatic hydrocarbons (PAHs) can enter the marine environment via industrial discharges and as a result of oil spills © Justin Gwynn
Inset: Sediment grab - Polycyclic aromatic hydrocarbons (PAHs) can accumulate in marine sediments © Marine Scotland Science

This document was published as part of OSPAR's Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments

Status and Trend of Polychlorinated Biphenyls (PCB) in Fish and Shellfish

MSFD Descriptor: 8 - Concentration of contaminants
MSFD Criterion: 8.1 - Concentration of contaminants

OSPAR COMMISSION

Key Message Polychlorinated biphenyls (PCBs) were banned in many countries in the mid-1980s. Since then, while local problems remain, PCB concentrations in shellfish and fish have decreased in most OSPAR sub-regions. With the exception of the most toxic congener (CB118), concentrations in biota are below the level at which they could present an unacceptable risk to the environment

Background

The OSPAR Hazardous Substances Strategy has the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for synthetic substances.

Polychlorinated biphenyls (PCBs) are man-made chemical compounds that were banned in the mid-1980s owing to concerns about their, toxicity, persistence, and potential to bioaccumulate in the environment. Since the 1980s, global action has resulted in big reductions in releases and remaining stocks have been phased out. However, despite European and global action, releases continue through diffuse emissions to air and water from building sites and industrial materials. Remaining sources include electrical and hydraulic equipment containing PCBs, waste disposal, redistribution of historically contaminated marine sediments and by-products of thermal and chemical industrial processes.

PCBs do not break down easily in the environment and are not readily metabolised by humans or animals. PCBs accumulate in marine animals, with greater concentrations found at higher trophic levels. PCB compounds are extremely toxic to animals and humans, causing reproductive and developmental problems, damage to the immune system, interference with hormones, and can also cause cancer. A sub-group of PCBs is 'dioxin-like', meaning they are more toxic than other PCB congeners.

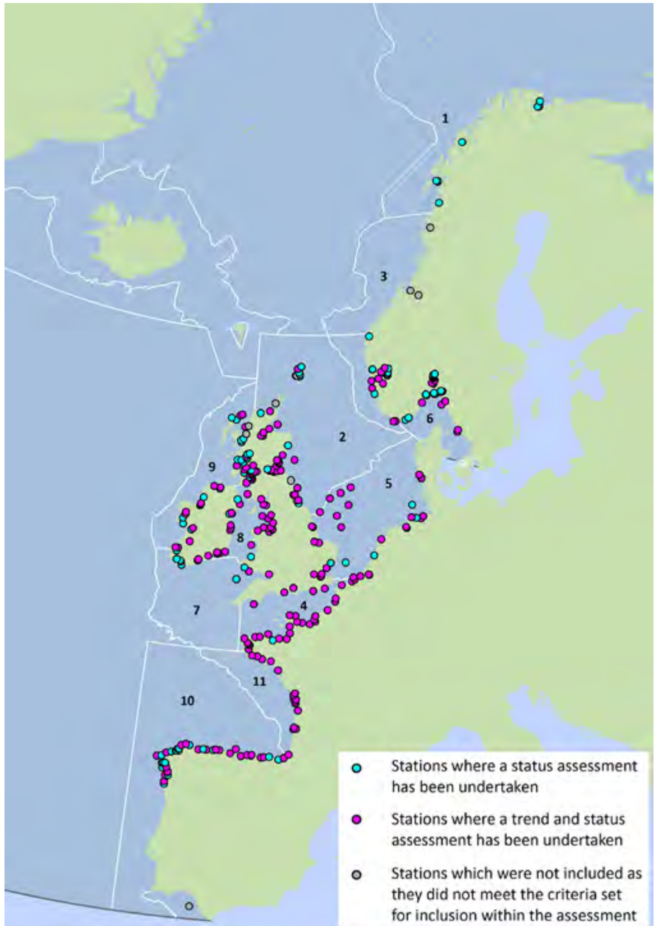


Figure 1: Monitoring sites used to assess PCB concentrations in biota by OSPAR contaminants assessment area (white lines) determined by hydrogeographic principles and expert knowledge, not OSPAR internal boundaries.

Results

Polychlorinated biphenyl (PCB) concentrations are measured in fish liver and shellfish. Samples are taken annually (or every few years) from sites mainly along the coast of the Greater North Sea, Celtic Seas, Iberian Coast and Bay of Biscay and at some coastal monitoring sites in Arctic Waters (**Figure 1**).

The time series used to inform this assessment started in 1995. The data are used to investigate trends in PCB concentration over the period 1995–2015 and to compare oncentrations against two sets of assessment values: Background Assessment Concentrations (BACs) and Environmental Assessment Criteria (EACs). Where concentrations are below the EAC they should not cause chronic effects in sensitive marine species and so should present no significant risk to the environment. BACs are used to assess whether concentrations are close to zero for man-made substances, the ultimate aim of the OSPAR Hazardous Substances Strategy.

Status Assessment

Concentrations in biota for six out of seven PCB congeners are below the EAC in all OSPAR sub-regions (**Figure 2**) within the period 1995–2015. However, there are differences between congeners, with concentrations in biota of one of the most toxic PCBs (CB118) close to or above the EAC in eight of the 11 OSPAR sub-regions (Northern North Sea, Norwegian Trench, English Channel, Southern North Sea, Skagerrak and Kattegat, Irish Sea, Iberian Sea and Northern Bay of Biscay), indicating possible adverse effects on marine life in these areas. In three sub-regions (the Celtic Sea, Irish and Scottish West Coast and Barents Sea) CB118 concentrations in biota are below the EAC.

PCBs in biota in most OSPAR sub-regions are still above the BAC. Mean concentrations of CB28 are below the BAC in the Irish and Scottish West Coast, Iberian Sea and Northern Bay of Biscay. Concentrations of other congeners that are below the BAC are CB52 (Irish and Scottish West Coast, and Iberian Sea) and CB180 (Irish and Scottish West Coast).

Trend Assessment

All OSPAR sub-regions assessed still have historical PCB contamination but concentrations in biota are reducing slowly (1995–2014) in nine out of ten, and show no statistically significant change in the other.

There is high confidence in the assessment and sampling methodology and high confidence in the data used.

Status and Trends of Polychlorinated biphenyls (PCB) in Fish and Shellfish

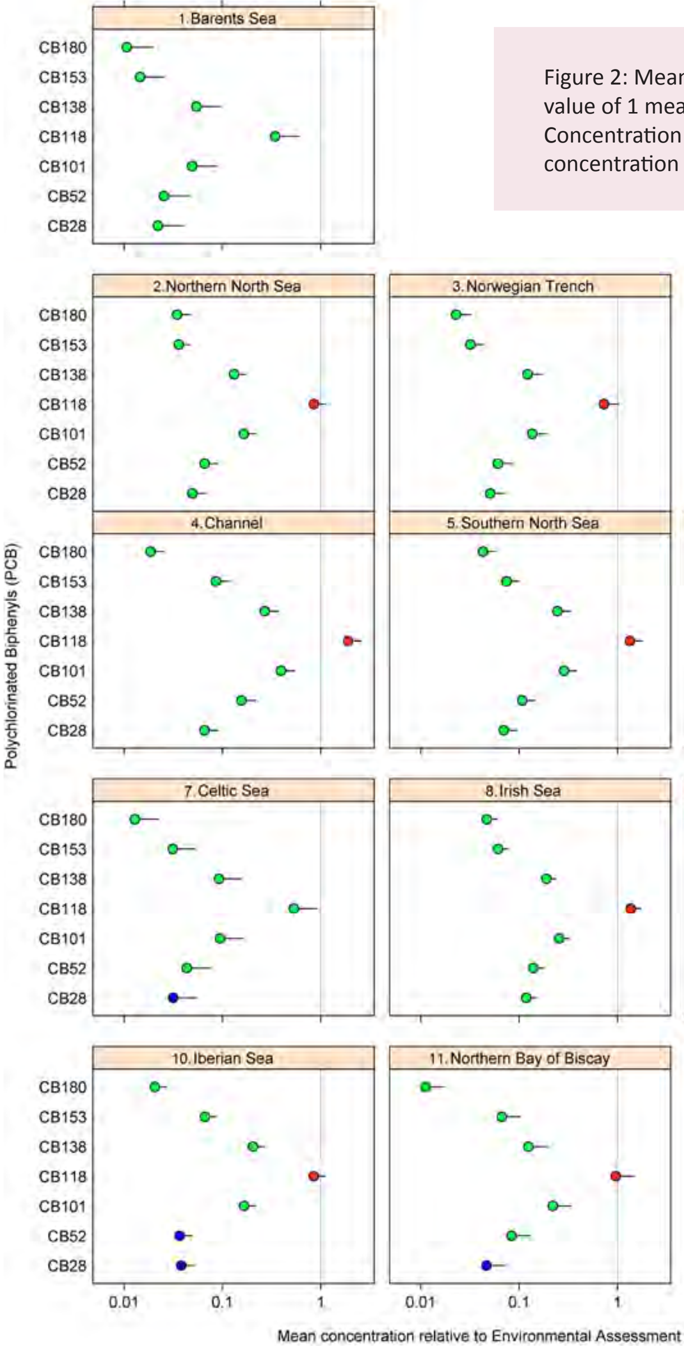
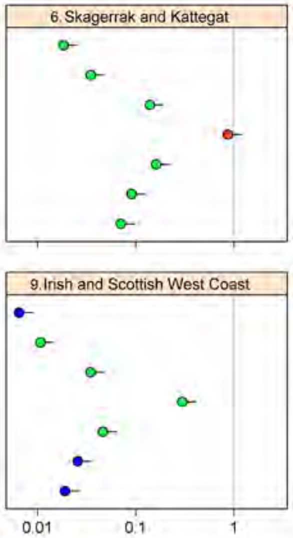



Figure 2: Mean PCB concentration in biota by congener (1995–2015) in each OSPAR sub-region, relative to the EAC (with 95% upper confidence limits) where value of 1 means that the mean concentration equals the EAC. Blue: mean concentration statistically significantly ($p < 0.05$) below the Background Assessment Concentration (BAC). Green: mean concentration statistically significantly above the BAC but below the Environmental Assessment Criteria (EAC). Red:mean concentration not statistically significantly below the EAC

Conclusion

More than 25 years after polychlorinated biphenyls (PCBs) were banned the majority of PCB concentrations in fish and shellfish have decreased to acceptable ecological concentrations in most OSPAR sub-regions. With the exception of the most toxic PCB congener (CB118), the concentrations of PCBs in fish and shellfish are below the level at which they could present an unacceptable risk to the environment. Mean concentrations of CB118 in biota are above this level in eight of the 11 areas assessed (**Figure 2**), and so adverse effects on marine organisms may still be possible in these areas.

PCBs remain in the sediment for long periods and have the potential to accumulate in biota and biomagnify up food chains. Due to past industrial uses and the persistence of PCBs in the environment, it will take several more decades before concentrations are close to zero, the ultimate aim of the OSPAR Hazardous Substances Strategy.

Knowledge Gaps

Even with discontinued use, it is likely that polychlorinated biphenyls (PCBs) are continuing to enter the environment through secondary sources such as leachate from waste disposal sites. Further research is required to define and quantify diffuse inputs from terrestrial sources. Although secondary poisoning was not considered in the development of the Environmental Assessment Criteria (EAC), because high PCB concentrations have been identified in cetaceans, OSPAR should consider developing EAC for the purpose of protection against secondary poisoning.

Images: Blue mussels (*Mytilus edulis*) © Mark A Wilson
Common dab (*Limanda limanda*) Wikimedia commons
Both species are routinely used for PCB monitoring in biota

This document was published as part of OSPAR's Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments

Status and Trends Polychlorinated Biphenyls (PCB) in Sediment

MSFD Descriptor: 8 - Concentration of contaminants
MSFD Criterion: 8.1 - Concentration of contaminants

Key Message Polychlorinated biphenyls (PCBs) were banned in many countries in the mid-1980s. Since then, while local problems remain, mean PCB concentrations in sediment have decreased in three of five OSPAR sub-regions. With the exception of the most toxic congener (CB118), concentrations in sediment are below the level at which they could present an unacceptable risk to the environment

Background

The OSPAR Hazardous Substances Strategy has the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for synthetic substances.

Polychlorinated biphenyls (PCBs) are man-made chemical compounds that were banned in the mid-1980s owing to concerns about their toxicity, persistence and potential to bioaccumulate in the environment. Since the 1980s, global action has resulted in big reductions in releases, and remaining stocks have been phased out. However, despite European and global action, releases continue through diffuse emissions to air and water from building sites and industrial materials. Remaining sources include electrical and hydraulic equipment containing PCBs, waste disposal, redistribution of historically contaminated marine sediments and by-products of thermal and chemical industrial processes.

PCBs do not break down easily in the environment and are not readily metabolised by humans or animals. They are extremely toxic to animals and humans. A sub-group of PCBs is 'dioxin-like', meaning they are more toxic than other PCB congeners.

Seven PCB congeners were selected as indicators of wider PCB contamination due to their relatively high concentrations and toxic effects.

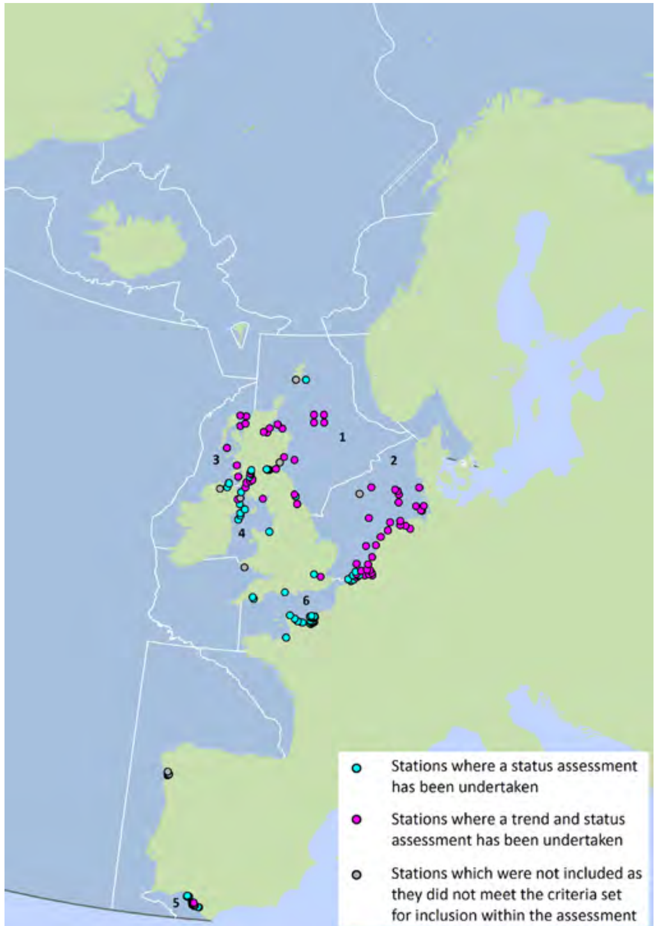


Figure 1: Monitoring sites used to assess PCB concentrations in sediment by OSPAR contaminants assessment area (white lines) determined by hydrogeographic principles and expert knowledge, not OSPAR internal boundaries.

Results

Polychlorinated biphenyl (PCB) concentrations are measured in sediment samples taken annually (or every few years) from monitoring sites throughout much of the Greater North Sea, Celtic Seas, Iberian Coast and Bay of Biscay (**Figure 1**).

The time series used to inform this assessment started in 1995. The data are used to investigate trends in PCB concentration over the period 1995–2015 and to compare concentrations against two sets of assessment values: Background Assessment Concentrations (BACs) and Environmental Assessment Criteria (EACs). Where concentrations are below the EAC they should not cause chronic effects in sensitive marine species and so should present no significant risk to the environment. BACs are used to assess whether concentrations are close to zero for man-made substances, the ultimate aim of the OSPAR Hazardous Substances Strategy.

Trend Assessment

PCB concentrations are decreasing in the Northern North Sea, Southern North Sea and Gulf of Cadiz. In contrast, concentrations show no statistically significant change in the Irish and Scottish West Coast and the Irish Sea (**Figure 2**).

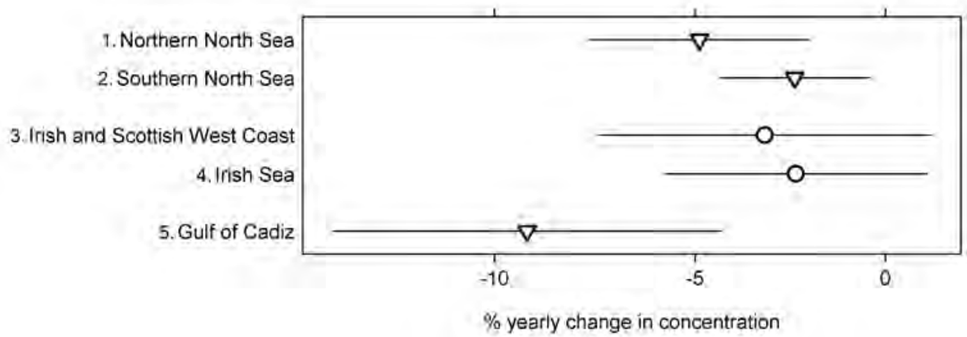
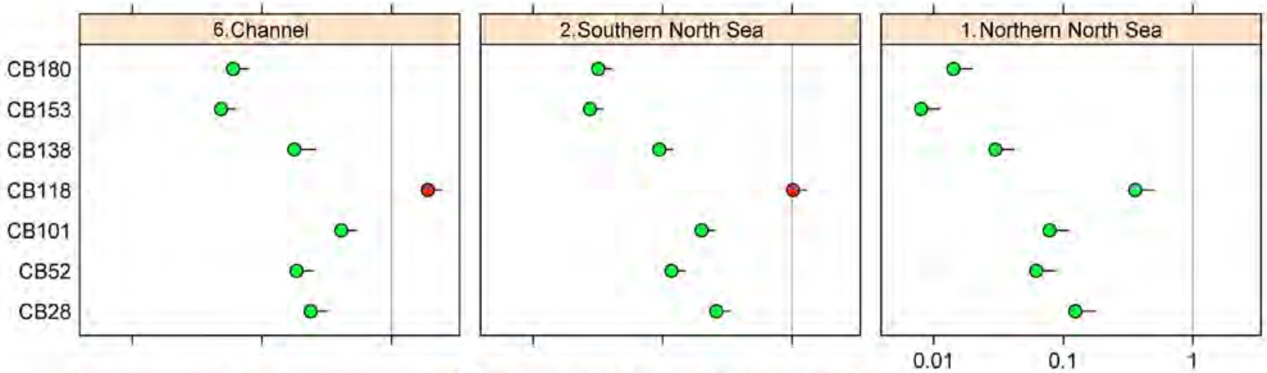
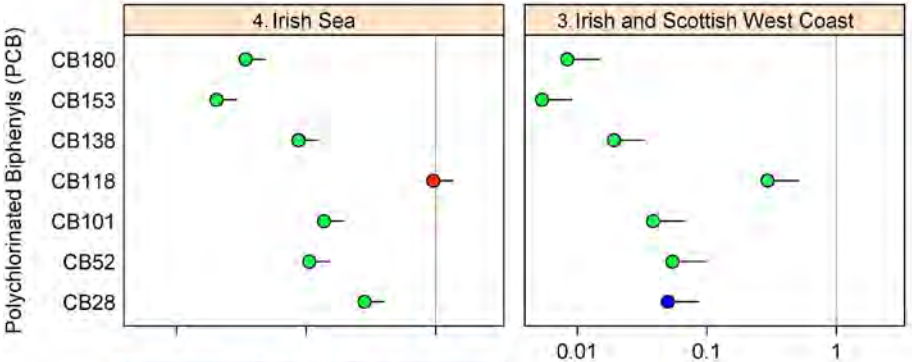
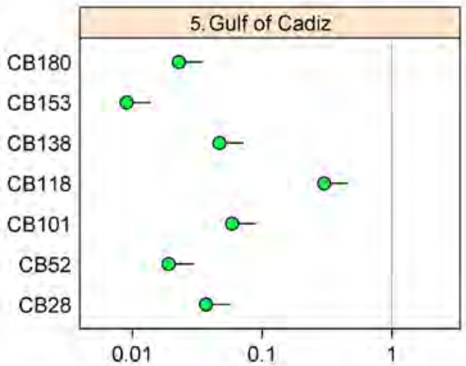


Figure 2: Percentage yearly change in PCB concentration in sediment (1995–2015) in each OSPAR sub-region. No statistically significant ($p < 0.05$) change in mean concentration (circle), mean concentration is significantly decreasing (downward triangle). Missing regions have too few monitoring sites for an assessment







Mean concentration relative to Environmental Assessment Criteria (EAC)

Results cont...

Status Assessment

Concentrations in sediment for six out of seven PCB congeners are below the EAC in all OSPAR sub-regions (**Figure 3**) within the period 1995–2015. However, there are differences between congeners, with concentrations in sediment for one of the most toxic PCBs (CB118) close to or above the EAC in three sub-regions (English Channel, Southern North Sea and Irish Sea), indicating possible adverse effects on marine life in these areas. In the Irish and Scottish West Coast, Northern North Sea and Gulf of Cadiz sub-regions, CB118 concentrations in sediment are below the EAC, but still above the BAC. CB28 in the Irish and Scottish West Coasts sub-region is the only measured concentration in sediment below the BAC.

There is high confidence in the assessment and sampling methodology and high confidence in the data used.

Conclusion

More than 25 years after polychlorinated biphenyls (PCBs) were banned they may still be causing adverse effects on marine life in some parts of the OSPAR Maritime Area.

PCBs are found in all marine sediments. While concentrations are decreasing in the Greater North Sea and Gulf of Cadiz, they show no statistically significant change in the Celtic Seas. With the exception of the most toxic congener (CB118), concentrations of all PCB congeners in sediment are below the level at which they could present an unacceptable risk to the environment. Mean concentrations of CB118 in sediment are at or above this level in three of the six sub-regions assessed.

PCBs remain in the sediment for long periods and have the potential to accumulate in biota and biomagnify up food chains. Due to past industrial uses and the persistence of PCBs in the environment it will take several more decades before concentrations are close to zero, the ultimate aim of the OSPAR Hazardous Substances Strategy.

Knowledge Gaps

There is a lack of monitoring data for some parts of the OSPAR Maritime Area, particularly in Arctic Waters, some parts of the Celtic Seas and the Iberian Coast and Bay of Biscay.

More research is needed to investigate how much of the reduction in polychlorinated biphenyl (PCB) concentrations in areas of former use is occurring at the expense of levels in areas where PCBs have not been commercially produced and used, such as Africa, which receive PCBs in the form of obsolete products and wastes.

Figure 3: Mean PCB concentrations in sediment by congener (1995–2015) in each OSPAR sub-region relative to the EAC (with 95% upper confidence limits) where value of 1 means that the mean concentration equals the EAC. Blue: mean concentration statistically significantly ($p < 0.05$) below the congener's Background Assessment Concentration (BAC). Green: mean concentration statistically significantly above the congener's BAC but below the Environmental Assessment Criteria (EAC). Red: mean concentration not statistically significantly below the EAC

Trends of Organotin in Sediments in the Southern North Sea

MSFD Descriptor: 8 - Concentration of contaminants
MSFD Criterion: 8.1 - Concentration of contaminants

Key Message Following bans on tributyltin, mean concentrations in sediment have measurably reduced in the Southern North Sea and are very low or undetectable elsewhere

Background

Tributyltin (TBT) and other organotin compounds are contaminants found globally, throughout the marine environment. Organotins have many applications, such as coatings, anti-odour/anti-fungal additives, pesticides, biocides in marine antifoulant paints, catalysts, wood treatments and preservatives. Extensive use in antifouling paints on watercraft (**Figure 1**) led to the widespread distribution of TBT in water, sediment and biota.

High concentrations of TBT in sediment are associated with commercial ports, harbours, shipyards, shipping lanes and marinas (**Figure 2**).

Organotins are toxic to many marine organisms even at very low concentrations. High concentrations can cause shell deformities in oysters and impair reproduction. For example, some female marine snails develop male sexual characteristics due to hormone disruption by TBT. This has led to widespread declines in some snail populations (Imposex Indicator Assessment). However, the situation is slowly improving following legislation banning the use of TBT in antifoulant paints. The OSPAR Hazardous Substances Strategy aims to achieve concentrations in the marine environment close to zero for man-made synthetic substances. TBT use was banned in the 1980s for vessels less than 25 m, and has been prohibited on all vessels and offshore installations since 2008. However, inputs of TBT to the aquatic environment are likely to continue, from countries not in compliance with the ban and from disused vessels or installations. Inputs of TBT may continue through the redistribution of already contaminated sediments. Wastewater treatment plants and landfills are another potential source of TBT to the marine environment, as organotin compounds are sometimes applied to consumer products.

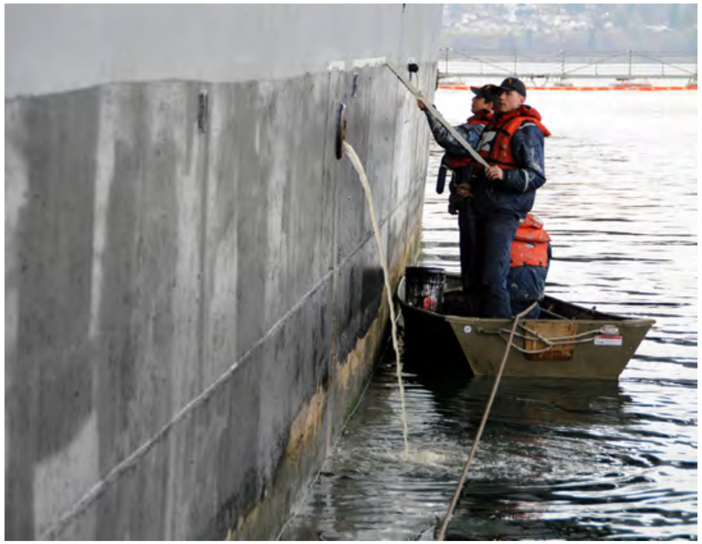


Figure 1: TBT has been used as an antifoulant in paint on ship hulls © US Navy

Figure 2: High concentrations of TBT in sediment are normally associated with commercial ports, harbours, shipyards, shipping lanes and marinas

Results

Most countries have stopped monitoring organotins in sediment, especially at offshore locations, because concentrations are now often so low that they are below the limit of detection. This means that a reliable assessment of organotin in sediment could only be carried out in the southern North Sea.

There are no environmental assessment values established for organotins in sediment. This means it is not possible to assess the environmental significance of the concentrations observed. In the Celtic Seas, data are only available for one monitoring site in the Irish Sea and one monitoring site in the Irish and Scottish West Coast OSPAR sub-regions. TBT concentrations at both monitoring sites are very low.

Results cont...

The Southern North Sea is the only OSPAR sub-region for which trend information is available for three organotin compounds (**Figure 3**): monobutyltin, dibutyltin and tributyltin. Trends in average sediment concentration for all three compounds in the Southern North Sea are decreasing, but still detectable. Annual average decreases are between 3.1% and 13.6%. These downward trends are also reflected in the reduction in biological effects associated with TBT exposure, which has been observed across the entire area assessed (Imposex Indicator Assessment). This indicates that the bans on the use of tributyltin are already having a positive effect on the marine environment.

There is high confidence in the assessment and sampling methodology and high confidence in the data used.

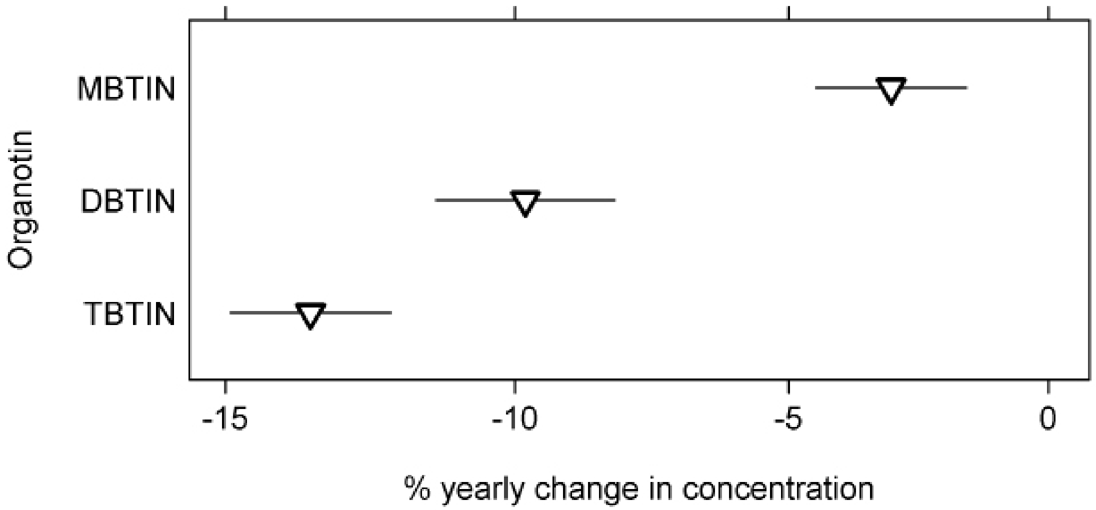


Figure 3: Percentage annual change in organotin concentrations in sediment by compound (with 95% confidence limits) in the Southern North Sea. Downward triangle: the mean concentration is statistically significantly ($p < 0.05$) decreasing, MBTIN: monobutyltin, DBTIN: dibutyltin, TBTIN: tributyltin

Conclusion

Almost a decade after the use of organotins was prohibited in antifouling paints on ships, concentrations detected in marine sediments have fallen considerably, and are often below the limit of detection. As a result, only a few countries continue to monitor organotin in sediment.

The Dutch part of the Southern North Sea is the only area with sufficient monitoring data for an assessment. Data for this area show a decreasing trend in organotin concentrations in sediment.

However, because there are no background concentrations or assessment criteria for organotin concentrations in sediment, the ecological effects of organotin in sediment have not been established. Most countries have opted to monitor the biological effects of organotin pollution, rather than tributyltin itself (Imposex Indicator Assessment).

Knowledge Gaps

Although direct inputs of TBT to the marine environment have been banned, non-pesticidal use of TBT is still ongoing in some countries and thus further monitoring of TBT concentrations in the marine environment is warranted.

As there are no background concentrations or assessment criteria for organotin concentrations in sediment, OSPAR experts should consider establishing these.

This document was published as part of OSPAR’s Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments

Status and Trend in the Levels of Imposex in Marine Gastropods (TBT in Shellfish)

MSFD Descriptors 8: Concentration of contaminants

MSFD Commission Criteria: 8.2: Effects of contaminants

OSPAR COMMISSION

Key Message Following bans on tributyltin in antifouling paints there has been a marked improvement in the reproductive condition of marine snails over the assessment period 2010–2015

Background

Antifouling paints are widely used on marine vessels to prevent the growth of marine organisms on the hull. In the 1980s, antifouling paint containing tributyltin (TBT) was used to prevent the attachment of algal slimes and other organisms. By the mid-1980s, the cause of poor growth in oyster stocks was identified as TBT in antifouling paints used on small craft operating in waters near the commercial shellfish beds.

TBT is toxic to many marine organisms at very low concentrations and is unequivocally linked to reduced reproductive performance in several mollusc species.

The OSPAR Hazardous Substances Strategy has the ultimate aim of achieving concentrations in the marine environment close to zero for man-made synthetic substances. Since the mid-1980s, a range of national and international measures has resulted in the phasing out of paints containing TBT in the OSPAR Maritime Area. In 2008, a global ban on TBT in antifouling systems on large vessels came into effect.

Following TBT exposure, some female marine snails (gastropods) develop male sexual characteristics. This is termed ‘imposex’. An OSPAR indicator has been developed to measure the extent of imposex within the OSPAR Maritime Area using the Vas Deferens Sequence (VDS). Although TBT ultimately affects many organisms, marine gastropods such as the dog whelk (**Figure 1**), are among the most sensitive, making this an ideal species for monitoring.

OSPAR’s Ecological Quality Objective for the North Sea is to reduce the level of occurrence of imposex in dog whelk and other marine gastropods.

Figure 1: Tributyltin affects many creatures, but marine gastropods, such as the dog whelk (*Nucella lapillus*) are among the most sensitive

Results

Imposex, measured as VDS, is currently monitored at more than 200 sites in the OSPAR Maritime Area, on up to three marine gastropod species. At the majority of sites monitored, imposex levels (VDS) are below the level at which harmful effects are first expected to occur. These levels are known as Environmental Assessment Criteria (EAC). In six of the ten OSPAR sub-regions, where there were sufficient data for assessment (over the period 2010–2015), levels of imposex in the three species monitored are significantly below the EACs for each species (**Figure 2**). In three sub-regions (Skagerrak and Kattegat, Celtic Sea and Northern Bay of Biscay) levels are at the EAC and in the Iberian Sea levels are more than five times in excess of the EAC.

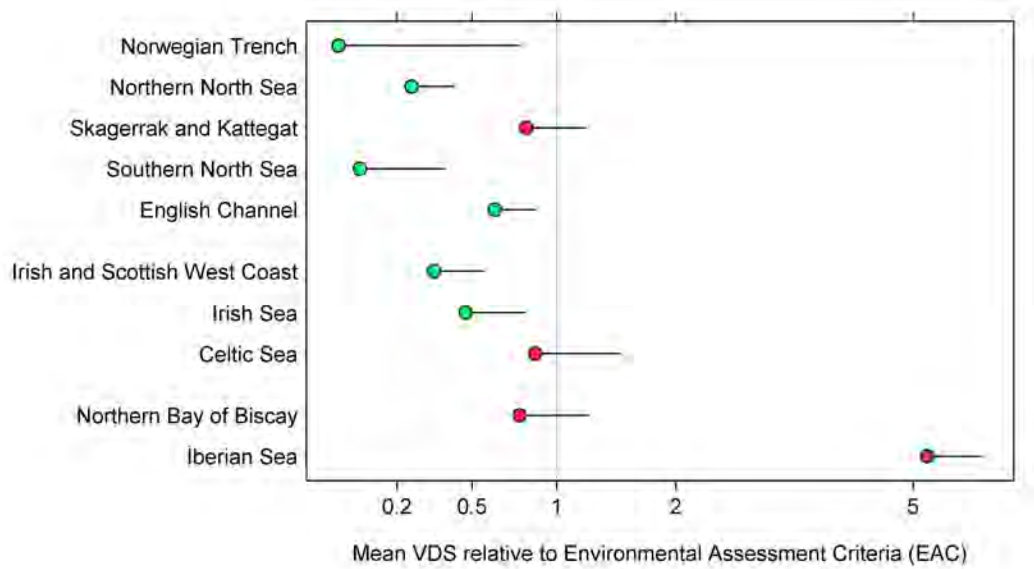


Figure 2: Mean Vas Deferens Sequence (VDS) (2010–2015) in three species of gastropods in each OSPAR sub-region relative to the Environmental Assessment Criteria (EAC) (with 95% upper confidence limits) where value of 1 means that the mean concentration equals the EAC. Green: Statistically significantly ($p < 0.05$) below the EAC. Red: Not statistically significantly below the EAC

Status and Trend in the Levels of Imposex in Marine Gastropods (TBT in Shellfish)

Results cont...

In none of the sub-regions was imposex at levels close to background, i.e. they were not significantly below the Background Assessment Criteria (BAC).

Temporal trends in imposex were analysed at 174 sites using the VDS. Improvement in imposex was detected at 48% of sites, worsening imposex at 0% of locations, and there was no statistically significant change in imposex at 52% of sites (2010–2015). The percentage of improvement in imposex was lowest in the Irish and Scottish West Coasts. Dog whelks are the most common monitoring species, and temporal trends in dog whelk imposex were assessed at 157 (of 174) sites and showed significant improvement at 74% of sites.

When assessed at an OSPAR sub-regional scale, overall improvement relative to the EAC is evident for the nine sub-regions assessed (**Figure 3**).

There is high confidence in the assessment and sampling methodology and high confidence in the data used.

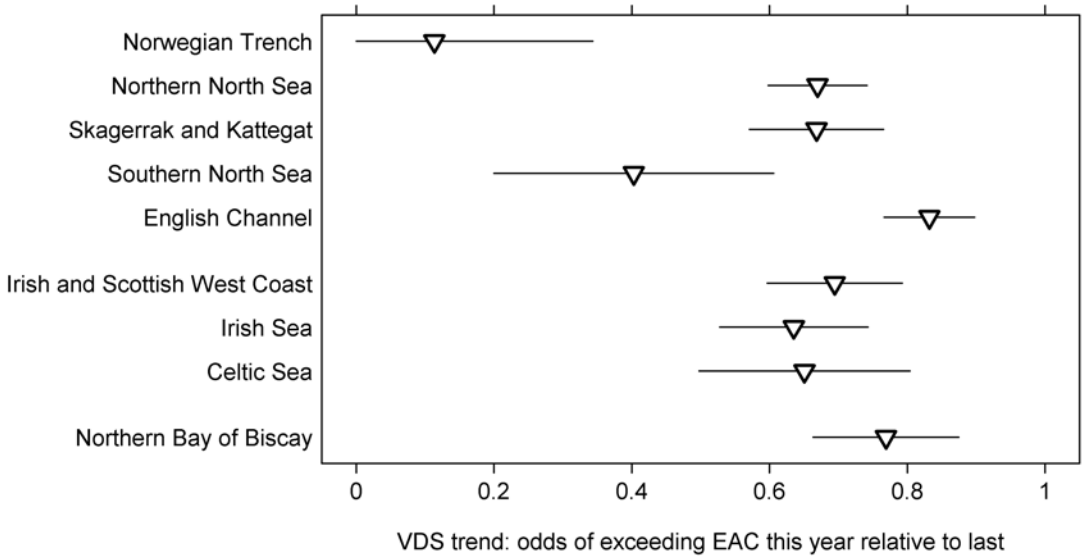


Figure 3: Temporal trends in imposex (Vas Deferens Sequence, VDS) in gastropods (2010–2015) in each OSPAR sub-region; mean concentration is statistically significant ($p < 0.05$) decreasing (downward triangle). 95% confidence limits (lines). The Barents Sea has too few monitoring sites for a regional assessment

Conclusion

Following actions taken to reduce, minimise or ban TBT use within individual countries, the European Union or globally, imposex is decreasing significantly. Compared to the QSR 2010, levels of imposex have markedly improved. In most OSPAR sub-regions, imposex induced by TBT is at or below the level at which harmful effects are first expected to occur and there is also evidence of significant downward temporal trends in the severity of imposex in all sub-regions assessed. Nevertheless, some areas are still subject to high imposex levels. Although levels of imposex are reducing, imposex is not yet at natural background levels in any of the areas assessed.

Ongoing measurement of imposex in marine gastropods is an effective tool for monitoring a contaminant-specific pollution effect. Imposex will continue to provide a good indicator for TBT pollution and will help in identifying illegal use of stocks of TBT-containing antifouling paints or losses of TBT from dockyards, marinas and vessel maintenance activities. Monitoring will identify whether there is any decrease in imposex at sites where imposex levels are not currently declining.

Knowledge Gaps

There could be concern about the potential for environmental harm associated with the substitute chemicals used to replace tributyltin (TBT) in antifouling paints.

The use of copper-based paints, in some cases with the addition of other chemicals, should be monitored to avoid adverse consequences of use of substitute chemicals, i.e. imposex measured as the Vas Deferens Sequence (VDS). TBT present in historically contaminated sediments could be remobilised and enter the water column, representing a potentially long-term issue. Impacts of illegal use of TBT should not be discounted.

This document was published as part of OSPAR's Intermediate Assessment 2017. The full assessment can be found at www.ospar.org/assessments

Beach Litter - Abundance, Composition and Trends

MSFD Descriptor: 10 - Beach litter
MSFD Criterion: 10.1 - Characteristics of litter in the marine and coastal environment

Key Message Litter is abundant on beaches in the OSPAR Maritime Area. Plastic fragments, fishing-related litter and packaging are the most common types of litter found. Plastics comprise over 90% of items in some areas. There are no overall trends in the number of beach litter items recorded in the period 2009–2014

Background

OSPAR has a stated aim to 'substantially reduce marine litter in the OSPAR Maritime Area to levels where the properties and quantities of marine litter do not cause harm to the coastal and marine environment'.

This indicator assessment describes the abundance and composition of beach litter in the OSPAR Maritime Area across 76 beaches in 2014/15, and trends in litter items that have been identified across 19 beaches in the period 2009–2014.

The abundance of marine litter in the OSPAR area provides information on the magnitude of litter pollution in adjacent waters and coastal areas, indicating spatial differences in litter pollution. The litter on a given beach may be generated locally at sea or on land, or may arrive from distant sources transported by rivers or ocean currents.

Beach litter composition gives an indication of the scale and magnitude of the problem, as well as the level of threat to the environment. Spatial differences in litter composition between survey sites indicate regional differences in sources.

Changes in composition and trends in the abundance of beach litter highlight where reduction measures are needed and, when implemented, the extent of their success.

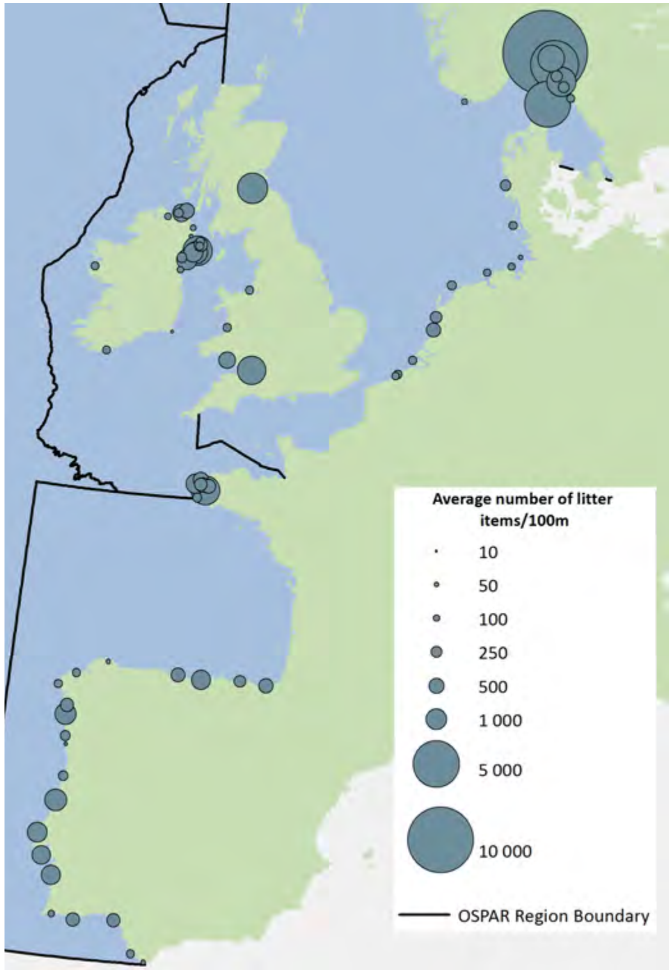


Figure 1: Average number of litter items per 100m for the period 2014-2015

Results

There are no overall trends in the abundance of beach litter items recorded in the OSPAR Maritime Area for the period 2009–2014. However significant decreasing trends, as well as increasing trends, could be identified for individual litter items on individual survey sites (such as on the north-western coast of Spain where the abundance of cotton bud sticks decreased by 12%).

The average total abundance of litter items per 100 m of coast varies widely in the OSPAR Maritime Area and within sub-regions. Values are presented for the period 2014–2015 (**Figure 1**), as longer data series were not available for the whole OSPAR Maritime Area. The averages were similar for survey sites in the southern North Sea (311), Celtic Seas (434) and Bay of Biscay / Iberian Coast (365), but an order of magnitude higher for the northern North Sea (mainly in the Skagerrak; 6090). However there was huge variation in abundance, both between sites and on individual sites, in the northern North Sea.

The majority of litter items were made of plastic or polystyrene (**Figure 2**). Across all OSPAR survey sites, plastic fragments are the most commonly found type of litter item, followed by packaging (food and drink), and fishing-related items (**Figure 3**). Packaging mainly consists of plastic items (including caps and lids, food containers, crisp / sweet packets / lolly sticks and plastic bags). Fishing-related items comprise nets and ropes and tangled nets / cord. Drinks bottles and containers are among the most recorded items at survey sites in all seas except the northern North Sea. All these items are considered harmful to the marine environment, due to their potential for entanglement, ingestion or injury.

Other items are also frequently recorded, especially on survey sites in the following regions:

- Cotton bud sticks in the Celtic Seas, Bay of Biscay / Iberian Coast and northern North Sea
- Cigarette butts in the Bay of Biscay / Iberian Coast
- Rubber balloons in the southern North Sea, northern North Sea, some survey sites in the Celtic Seas and one survey site on the Bay of Biscay / Iberian Coast
- Shotgun cartridges in the southern North Sea, northern North Sea and Celtic Seas

The abundance of these items indicates region-specific issues with wastewater outlets, smoking- and hunting-related litter, and public and private events where balloons are released.

There is moderate confidence in the methodology and data.

Beach Litter - Abundance, Composition and Trends

Marine litter composition by material

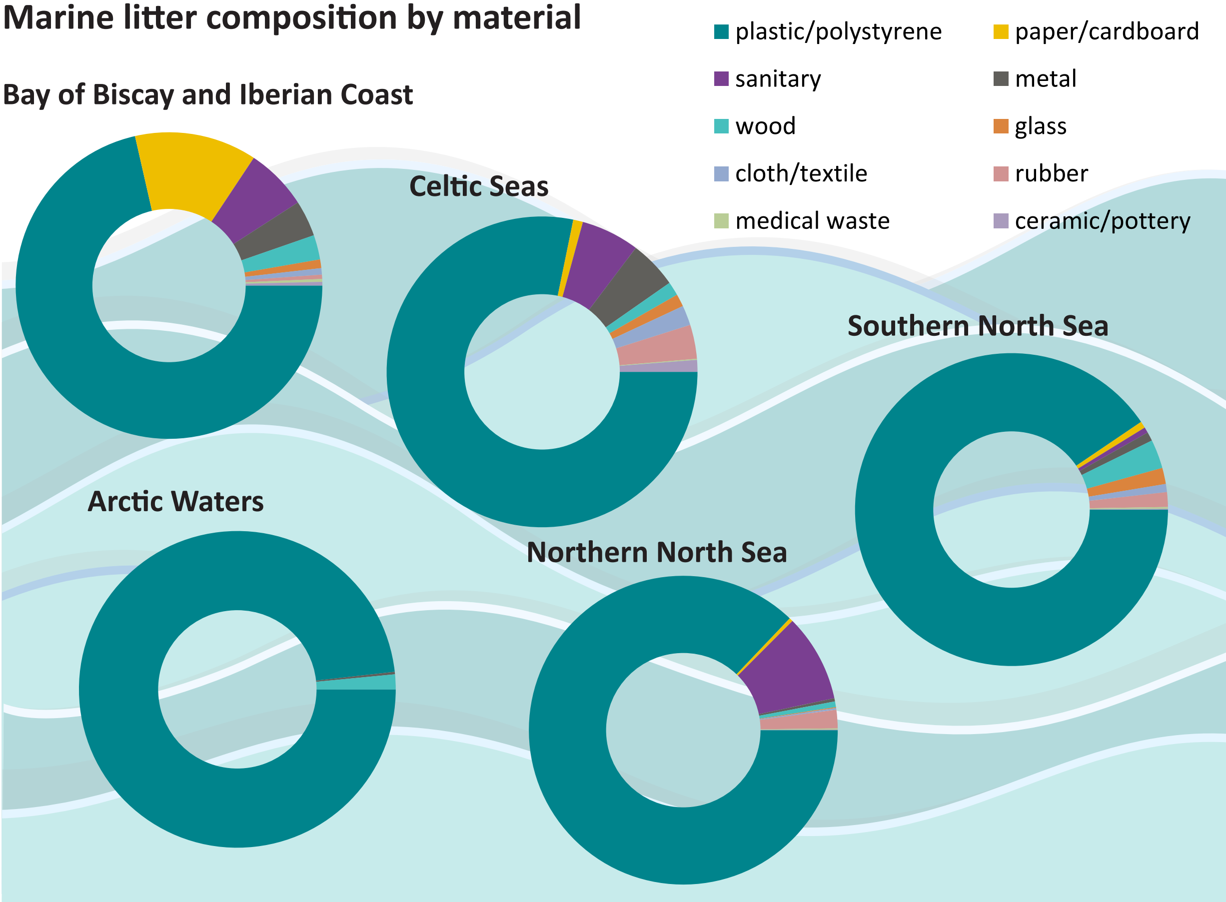


Figure 2: Composition of marine litter according to material / use categories for the period 2014–2015 in the OSPAR Maritime Area

Knowledge Gaps

Main sources of litter (e.g. fisheries) are apparent from the data; however a detailed identification of sources will require the allocation of the OSPAR items to sources at a regional level.

While it is well established that some types of litter can cause direct harm in the marine environment due to the threat of entanglement, ingestion or injury, there is still limited understanding of the harm caused by other types of litter which is the subject of ongoing studies and research.

Reference levels and baselines have not been defined for beach litter.

Conclusion

The amount of litter recorded on survey sites in the OSPAR area shows litter pollution is common on the coastlines of the North-East Atlantic. The main litter types recorded are plastic fragments, packaging, and nets and ropes. There have been some significant changes in the amount of litter recorded on survey sites in the period 2009–2014, but no general trends across all survey sites. This does not yet meet the commitment in the North-East Atlantic Environment Strategy to “substantially reduce marine litter in the OSPAR Maritime Area to levels where properties and quantities of marine litter do not cause harm to the coastal and marine environment”.

The large numbers of litter items considered harmful due to the potential threat of entanglement, ingestion or injury indicate that litter pollution is a problem for the marine environment in the OSPAR Maritime area. This is in addition to the socio-economic harm that all litter items cause through, among others, lost revenue and the costs of beach litter cleaning.

The OSPAR Regional Action Plan identifies actions to reduce marine litter and should consequently lead to a reduction in litter on beaches. The increasing number of survey sites and surveys undertaken over the past few years will also improve knowledge of marine
litter on the North-East Atlantic coast with regard to abundance, composition and especially future trends, if the monitoring effort is maintained.

Figure 3: Composition of marine litter according to main litter types for the period 2014–2015 in the OSPAR Maritime Area

Composition and Spatial Distribution of Litter on the Seafloor

MSFD Descriptor: 10 - Marine litter

MSFD Criterion: 10.1 - Characteristics of litter in the marine and coastal environment

OSPAR COMMISSION

Key Message Litter is widespread on the seafloor across the area assessed, with plastic the predominant material encountered. Higher amounts of litter are found in the Eastern Bay of Biscay, Southern Celtic Seas and English Channel than in the northern Greater North Sea and Celtic Seas

Background

Marine litter is a global problem, with increasing quantities of litter documented in recent decades. The abundance of seafloor litter is influenced by anthropogenic inputs, including litter transported by rivers and ocean currents, which can redistribute this material over long distances. Marine litter is therefore a transboundary problem.

Marine animals can ingest or become entangled in litter (e.g. discarded fishing gear, strapping bands) on or near the seafloor. This could result in death or injury, for example through suffocation or starvation. Plastic items are potential vectors for contaminants and can also scour or smother the seafloor. This can impact on fragile benthic habitats, reducing photosynthesis and preventing the movement of animals, gases and nutrients. Marine litter also acts as a vector for invasive species, transporting non-indigenous organisms into new areas where they can out compete or prey upon native organisms.

Litter on the seafloor has been studied in both coastal waters and the deep sea. The presence of large amounts of plastic litter has been reported on the European continental shelf. Benthic trawl surveys are a practical way to monitor seafloor litter (on the continental shelf), because they are already in use for fish stock assessments, cover a wide area of seafloor and collect a sufficient quantity of litter for analysis.

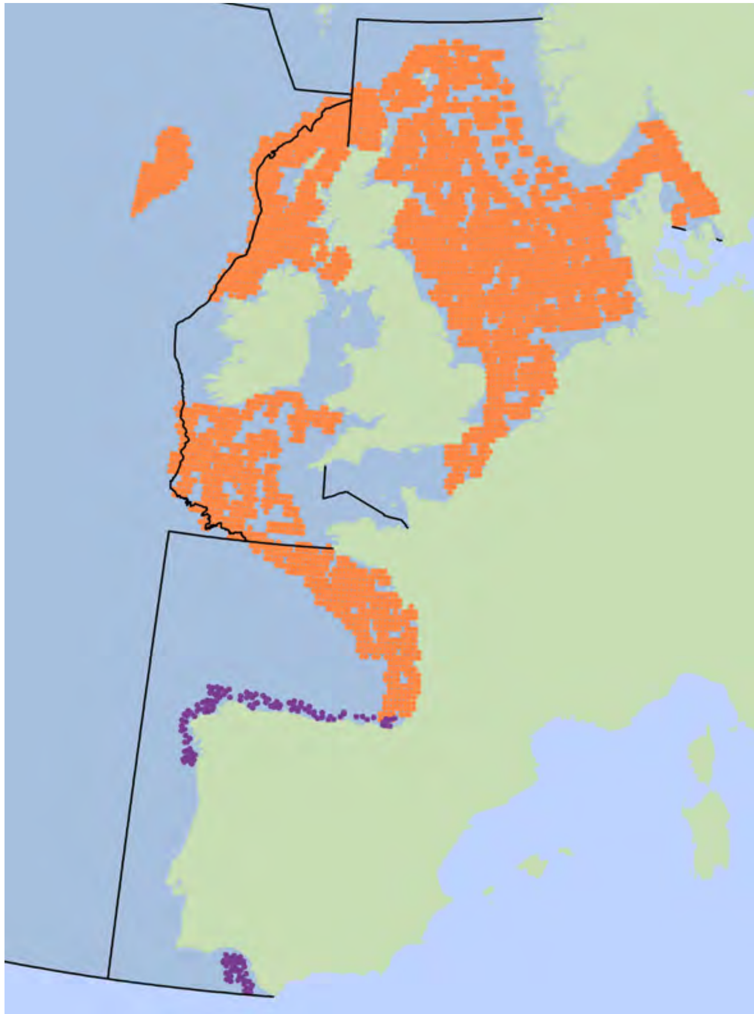


Figure 1: Stations used for assessing seafloor litter. Greater North Sea, Celtic Seas and the Eastern Bay of Biscay (GOV; orange) and the Iberian Coast and Gulf of Cadiz (BAK; purple) haul locations

Results

The distribution and abundance of marine litter on the seafloor in the OSPAR Maritime Area were investigated on the basis of data collected by trawl surveys from seven Contracting Parties (**Figure 1**). Benthic trawls are designed to capture marine biota on or near the seafloor over a range of different seafloor types. As a result, some trawl designs plough through the seafloor while others roll over the seafloor. The amount of litter captured during a survey is influenced by the type of interaction with the seafloor and the mesh size of the nets. Therefore, the sampled quantities are not absolute amounts, but 'relative' amounts. However, they still allow comparisons between regions sampled with similar gear. The number of stations monitored determines the confidence that can be applied to assessments and defines the time (number of years of data) needed to obtain an acceptable confidence level.

Widespread distribution of litter items, especially plastics, was discovered on the seafloor of the Greater North Sea, the Celtic Sea, the Bay of Biscay, the Iberian Coast and the Gulf of Cadiz. The assessment mostly focuses on the Greater North Sea, Celtic Seas and Eastern Bay of Biscay (excluding the Iberian Coast and the Gulf of Cadiz) which were sampled with a Grande Ouverture Verticale (GOV) trawl. For this area, the abundance of litter items (litter items per km^2) on the seafloor increases from north to south (**Figure 2**). In 2014, of all litter items recorded the percentage of plastic items was 68% for the Greater North Sea, 58% for the Celtic Sea and 98% for the Eastern Bay of Biscay. Nearly all trawls in the Eastern Bay of Biscay contained at least one plastic item; the area also has the highest levels of recorded litter within the assessment area.

It was not possible to directly compare the results for the Greater North Sea and Celtic Seas, which used a GOV trawl, with the results of the assessment of the Iberian Coast and Gulf of Cadiz, which were sampled with a BAK otter trawl (**Figure 2**). A map of relative abundance of litter items for the Iberian coast and Gulf of Cadiz, similar to **Figure 2** could not be created as the samples were clustered near the coast, due to the topography.

There is moderate confidence in the methodology and low to moderate confidence in the data.

Composition and Spatial Distribution of Litter on the Seafloor

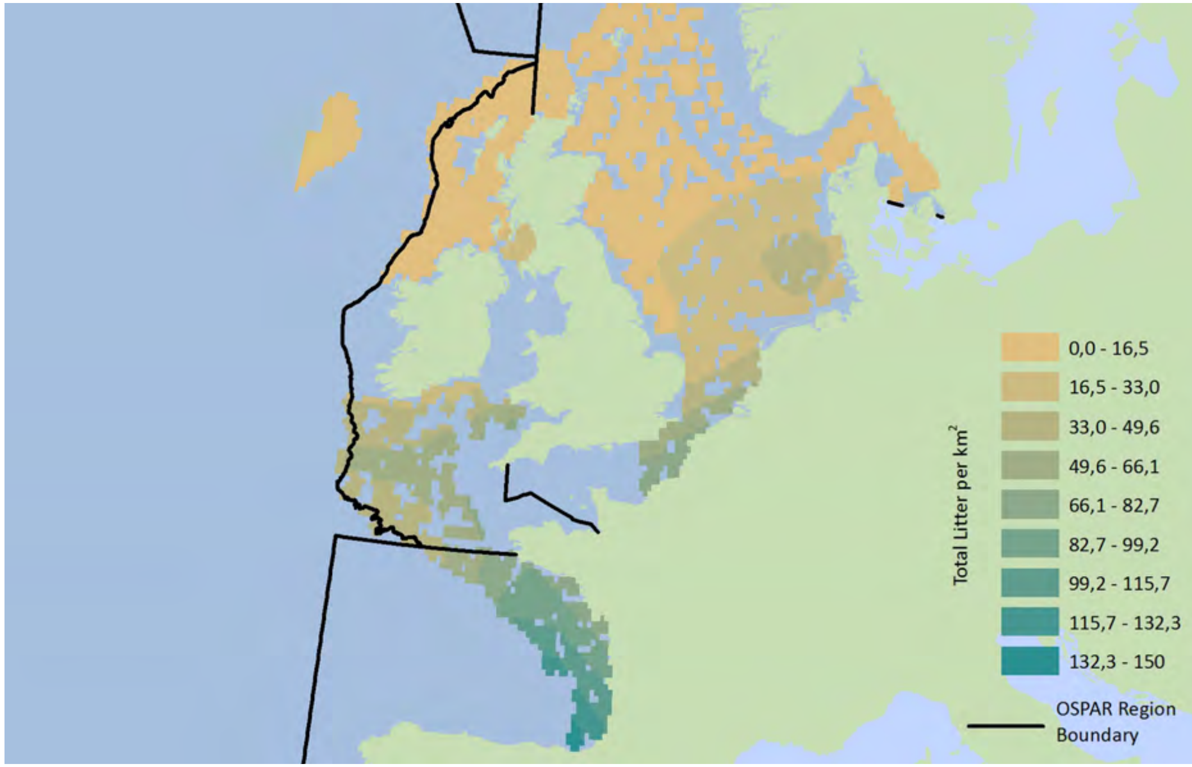


Figure 2: Relative number of litter items per km² seafloor across the Greater North Sea, Celtic Seas and the Eastern Bay of Biscay, based on the number of items caught as by-catch in fisheries trawls.

Conclusion

Litter is widespread on the seafloor across the areas assessed, with plastic the predominant material encountered. In the areas assessed, higher amounts of litter and plastic are found in the eastern Bay of Biscay, southern Celtic Sea and English Channel than in the northern Greater North Sea and Celtic Seas. This could be due to larger anthropogenic inputs, rivers, prevailing winds and / or currents. Previous studies have shown the Bay of Biscay to receive large amounts of litter from local rivers and transport that may result from large-scale circulation in the sub-region as a whole. Floating and sinking litter follow different pathways, and gather in different hotspots, which do not necessarily overlap. For example, the beach litter hotspot in the Skagerrak is not replicated in the seafloor litter. For most of the OSPAR regions, except the Greater North Sea, more survey stations or longer datasets are needed in order to detect a significant change in the abundance of seafloor litter. The OSPAR Regional Action Plan identifies actions to reduce marine litter and should lead to a reduction in seafloor litter.

Knowledge Gaps

There are a number of areas where further knowledge could improve the assessment. Information concerning seasonal influences, weather patterns and changes in currents, all of which could affect the distribution of litter, are not taken into account. Although only surveys using similar gear are used, the sampling design could also have an influence (fixed and random stratified sampling stations). Furthermore, there is a need to compare how different gear types capture litter (e.g. GOV and BAK trawls) if relative amounts of litter per km² are to be compared across the whole region in the future. Several data issues slowed down the assessment and these could be improved in following years.

Image: Marine litter by-catch on board the RV Endeavour © J. Thain

This document was published as part of OSPAR's Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments

Plastic Particles in Fulmar Stomachs in the North Sea

MSFD Descriptor: 10 - Marine litter
MSFD Criteria: 10.2 - Impacts of litter on marine life;
10.1 - Characteristics of litter in the marine and coastal environment

OSPAR COMMISSION

Key Message Currently 58% of beached North Sea fulmars have more than 0.1 g of plastic in their stomachs, exceeding OSPAR's long-term goal of 10%. This reflects the abundance of floating litter in their environment. There has been no significant change in the amount of plastic in fulmar stomachs over the past ten years

Background

Litter is widespread in the marine environment and is harmful to wildlife and the ecosystem. OSPAR aims to substantially reduce the amount marine litter in the OSPAR Maritime Area by 2020 to levels where properties and quantities do not cause harm to the marine environment. The quantity of plastics ingested by marine wildlife mainly reflects the abundance of floating litter in their environment.

OSPAR monitors and assesses plastics in the stomachs of northern fulmars as one of its indicators of environmental quality. Fulmars are abundant and widespread seabirds known to regularly ingest litter, with nearly all individuals having at least some plastic in their stomachs. Although fulmars forage near the water surface, their stomachs may also contain items from deeper water or items that may be indirectly ingested through their prey.

The fulmar Indicator Assessment approach is based on a previous OSPAR Ecological Quality Objective (EcoQO). The monitoring programme uses corpses of beached birds or individuals accidentally killed. OSPAR has a long-term goal of less than 10% of fulmars exceeding a level of 0.1 g of plastic in their stomachs. Research methods and results have been published in reports and peer-reviewed scientific literature as well as specific OSPAR Guidelines. This indicator is currently used only in the Greater North Sea. However it could be suitable for implementation in Arctic Waters and Celtic Seas and has already been used in fulmar studies outside the OSPAR Maritime Area, in the North Atlantic and North Pacific.

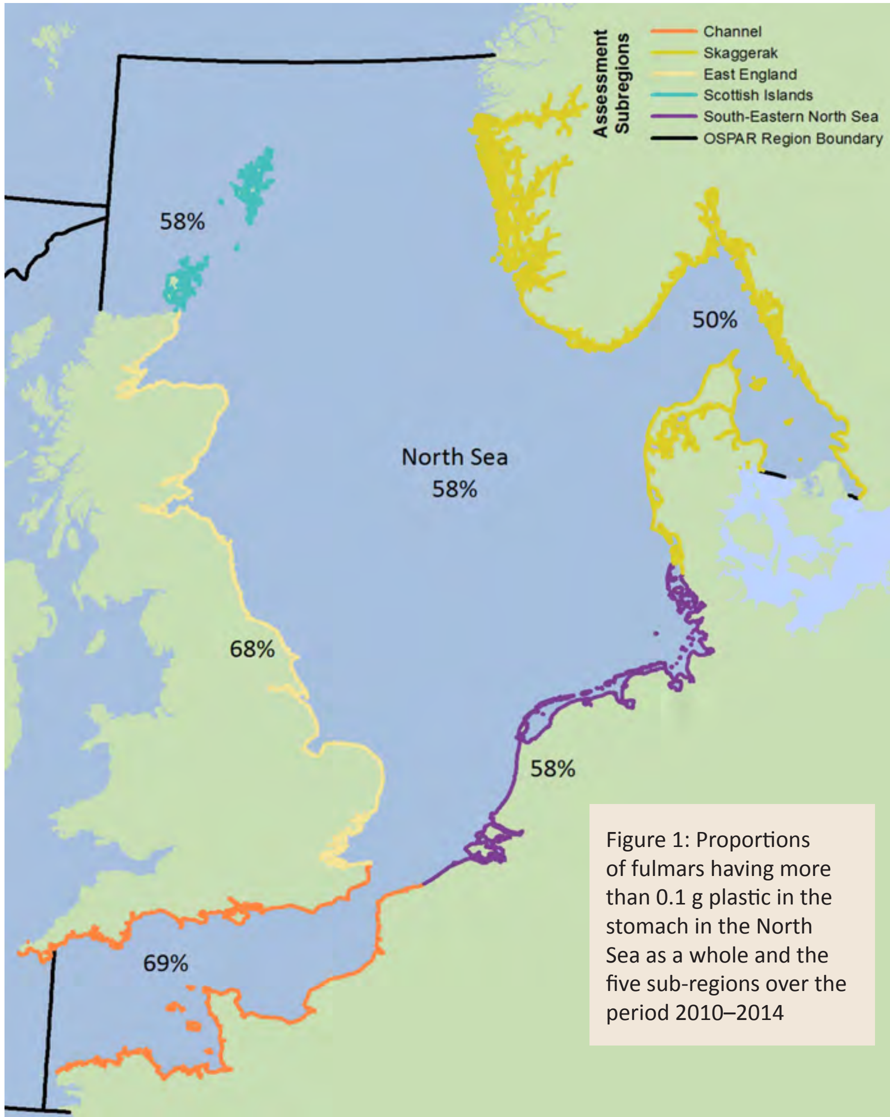


Figure 1: Proportions of fulmars having more than 0.1 g plastic in the stomach in the North Sea as a whole and the five sub-regions over the period 2010–2014

Results

Assessment 2010-2014

Over the five-year period 2010–2014 inclusive, OSPAR's long-term goal in terms of plastic litter ingestion by seabirds was not achieved anywhere in the North Sea. Among all 525 fulmar stomachs analysed over this period, 58% contained more than 0.1 g of plastic, whereas OSPAR's long-term goal is to reduce this to less than 10%. Of all birds analysed, 93% had some ingested plastic, and average values per bird were 33 particles and 0.31 g. Fulmars from the English Channel had the highest plastics load, slightly lower levels being observed further north. Over the last five-year period no significant increases or decreases in ingested plastic mass were observed in the North Sea as a whole or in any of the five sub-regions. **Figure 1** shows the sub-regional differences for the North Sea in relation the percentage of birds that have ingested more than 0.1 g. (This assessment uses the previous boundary between the North Sea and Celtic Seas, however this will be updated in the next assessment) Only in the far North-western Atlantic (the Canadian Arctic) do plastic ingestion levels approach the OSPAR long-term goal.

Trends 2005-2014

Trends are evaluated against the year of collection over the most recent ten-year period, in this assessment 2005–2014, inclusive. The current assessment for the five sub-regions (Figure 1) confirms that sub-regional levels have remained largely stable since the start of the data collection (Figure 2), with fairly constant sub-regional differences and levels clearly elevated relative to those observed in incidental studies further to the north in the OSPAR Maritime Area.

There is high confidence in both the methodology and data availability.

Plastic Particles in Fulmar Stomachs in the North Sea

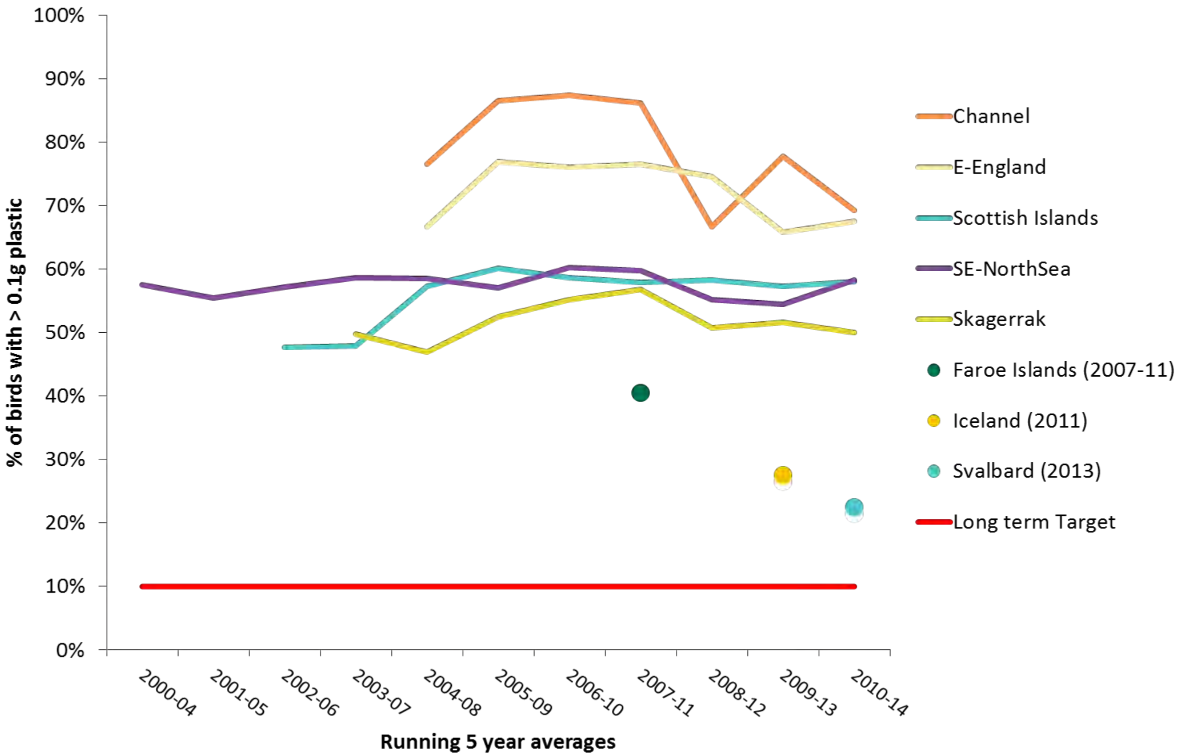


Figure 2: Running five-year averages for the percentage of fulmars having more than 0.1 g of plastic in their stomach since 2000 and/or the start of sub-regional participation in the monitoring programme. *Incidental data published for the Faroe Islands, Iceland and Svalbard are included to illustrate lower levels further north in the OSPAR Maritime Area, but nevertheless still well above the OSPAR long-term goal*

Conclusion

Since the early 2000s, levels of plastic ingestion by fulmars in the North Sea appear to have stabilised at around 60% of individuals exceeding the 0.1 g level of plastic ingestion specified in the OSPAR long-term goal definition. When considering the growth in marine activity and the increasing proportion of plastics in wastes, the observed stability in the indicator could be viewed positively. Even though the OSPAR long-term goal is still distant, it remains valid as a global assessment level.

Fulmar populations in the North Sea are currently in decline, as highlighted in the Marine Bird Abundance indicator assessment, but the causes of the decline are not well understood. Ingestion of plastic litter is recognised as a potential threat contributing to the status of fulmar populations, given that it is probable that sub-lethal effects of reduced body condition and health, affect a significant proportion of individuals in the population.

The OSPAR Regional Action Plan identifies actions to reduce marine litter and their implementation should lead to a reduction in the amount of litter ingested by fulmars.

Knowledge Gaps

The OSPAR Common Indicator on Plastic Particles in Fulmar Stomachs aims to reflect litter floating at the surface, and the potential harm from marine litter in the North Sea environment to pelagic (open sea) marine organisms. However, the fulmar monitoring effort does not give direct information on 'harm' or 'damage' but simply quantifies spatial and temporal patterns in abundance of plastics in fulmar stomachs as an indirect measure of harm. Dedicated experimental laboratory-based research into evidence of harm to fulmars from specified levels and types of plastics, as a specific example of harm, is urgently needed to strengthen the role of the OSPAR Common Indicator.

Image: Beached fulmar © JA van Franeker
Inset: Plastics from a fulmar stomach © JA van Franeker

This document was published as part of OSPAR's Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments

Distribution of Reported Impulsive Sounds

MSFD Descriptor 11 - Introduction of energy, including underwater noise
MSFD Criterion: 11.1 - Distribution in time and place of loud, low and mid frequency impulsive sounds

OSPAR COMMISSION

Key Message Impulsive sound data from 2015 are available for a limited number of countries and sound sources. The predominant sources are: seismic survey activity in the northern North Sea and eastern Atlantic; explosions and pile driving in the Southern North Sea; and naval sonar activity in the Celtic Seas and western English Channel. The amount of these activities varies substantially within these regions.

Background

OSPAR endeavours to keep the introduction of energy, including underwater noise, at levels that do not adversely affect the marine environment. Sound is a by-product of human activities in the marine environment (e.g. shipping or construction) or is produced intentionally for the purposes of surveying the seabed or water column. Sound is referred to here as 'noise' only when it has the potential to cause negative impacts on marine life. The introduction of anthropogenic sound became widespread with the advent of motorised shipping, and now has a wide range of sources. Anthropogenic sound sources are categorised as impulsive or continuous. This assessment addresses impulsive sound sources, which include percussive pile driving for inshore and offshore construction (**Figure 1**), seismic surveys (using airguns) to inspect subsea oil and gas deposits, explosions, and some sonar sources.

Impulsive sound sources have been observed to cause temporary displacement of small cetaceans (e.g. harbour porpoise), increased physiological stress in some fish species (e.g. European seabass), and developmental abnormalities in invertebrate larvae. While effects on individual animals have been shown for a number of species, there is uncertainty over whether and how the effects of sound on individuals are translated to the population or ecosystem scale. The purpose of this assessment is to assess the amount and distribution of impulsive sound sources across the OSPAR Maritime Area. This is the first such assessment of anthropogenic pressure from impulsive sound for the OSPAR Maritime Area, and these data will enable future assessment of the risk of impact to marine life.

Figure 1: Pile driving operation with bubble curtain.
© Trianel/Lang

Results

Data for 2015 were provided by Belgium, Denmark, Germany, the Netherlands, Sweden and the UK for four sound sources (seismic surveys, pile driving, explosions, and sonar and acoustic deterrents). The distribution of these impulsive sound sources is assessed in pulse block days, defined as the number of days in a calendar year in which impulsive sound activity occurred within a particular area (ICES statistical sub-rectangle). **Figure 2** (overleaf) illustrates the distribution of total pulse block days during 2015, based on the currently available data in the OSPAR Impulsive Noise Registry. This visualisation represents a partial assessment, since data were not available for all activities and Contracting Parties in this initial year of assessment. Impulsive sound sources were reported across the northern North Sea, to the Skagerrak, in the deep waters to the west of Scotland and to the south-west of England. Reported activity was sparser in the southern North Sea and Celtic Seas. In the northern North Sea there were areas where seismic surveys occurred on up to 227 days in 2015. In the southern North Sea explosions and piling for wind farms were more prevalent. Sonar was the predominant source type reported for the western English Channel.

In addition to recording the occurrence of specific types of sound generating activity, information on the intensity of the impulsive sources is also recorded where this information is available. Five intensity categories describe the relative intensity of sound sources (ranging from Very Low to Very High). This terminology relates to source intensity and not necessarily to impact. However all sources reported are above a specified intensity level considered to have the potential to impact marine organisms (including the Very Low category). **Figure 3** (overleaf) shows the proportion of activity corresponding to each intensity category for the Greater North Sea. There was only one occurrence of a Very High category sound source in the OSPAR Maritime Area – an explosion in the southern North Sea. However for 293 (29%) of occurrences no intensity information was provided. The use of standardised blocks (ICES statistical sub-rectangles) and information on the intensity of sources together enables an overview of where most reported impulsive sound occurred. It also allows the application of source mitigation measures to be included. Fluctuations in sound generating activity are anticipated from year to year. This initial assessment presents partial data for 2015, and it is expected that a more comprehensive dataset will be available for future assessments.

There is moderate confidence in the methodology used and low confidence in the data availability.

Distribution of Reported Impulsive Sounds

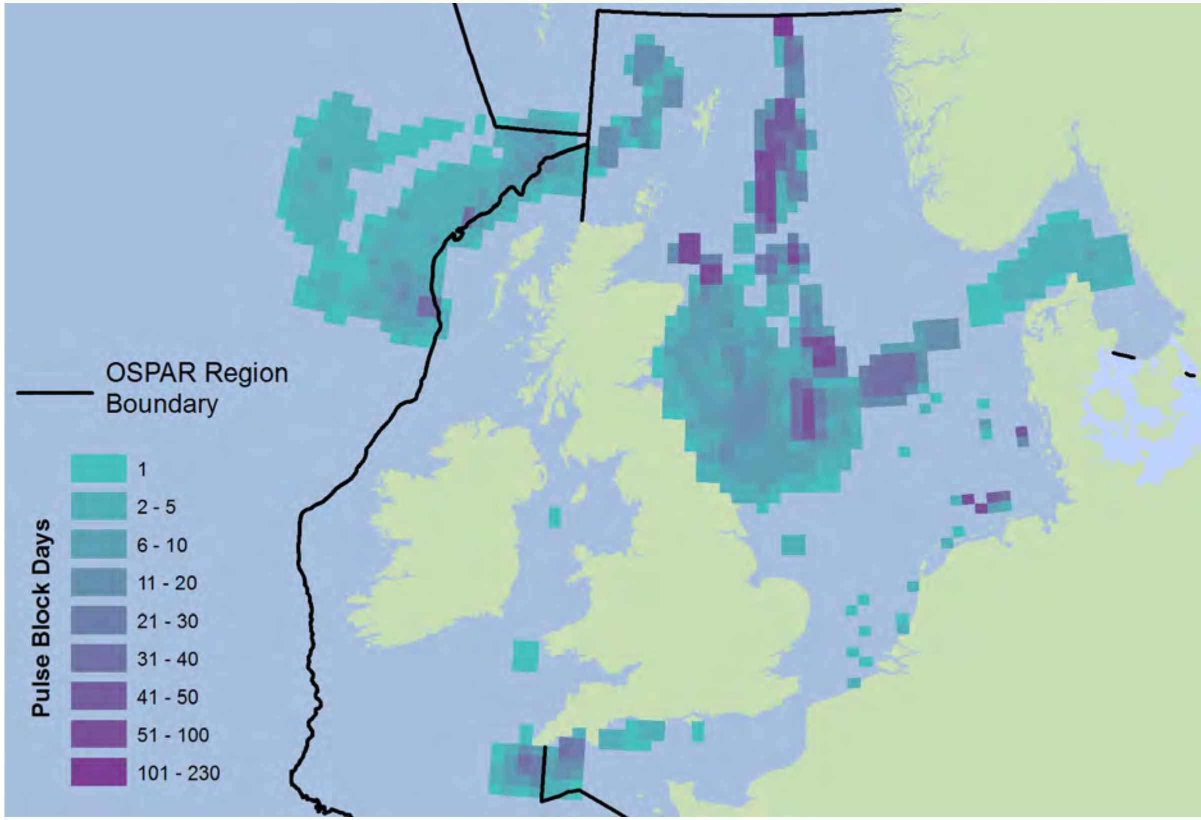


Figure 2: Total pulse block days reported for 2015

Knowledge Gaps

To ensure consistency across source types the definitions of the source intensity categories should be reconsidered, including how to include a reduction in source intensity from source mitigation technologies. Improved reporting in the future will also allow the assessment of cumulative effects.

Understanding of the effects of anthropogenic sound on particular species has advanced in recent years. Nevertheless, obtaining direct observations of the effects of anthropogenic sound on ecosystems or particular populations is challenging. As such, there is uncertainty as to whether and how these effects of sound on individuals are translated to the population or ecosystem scale.

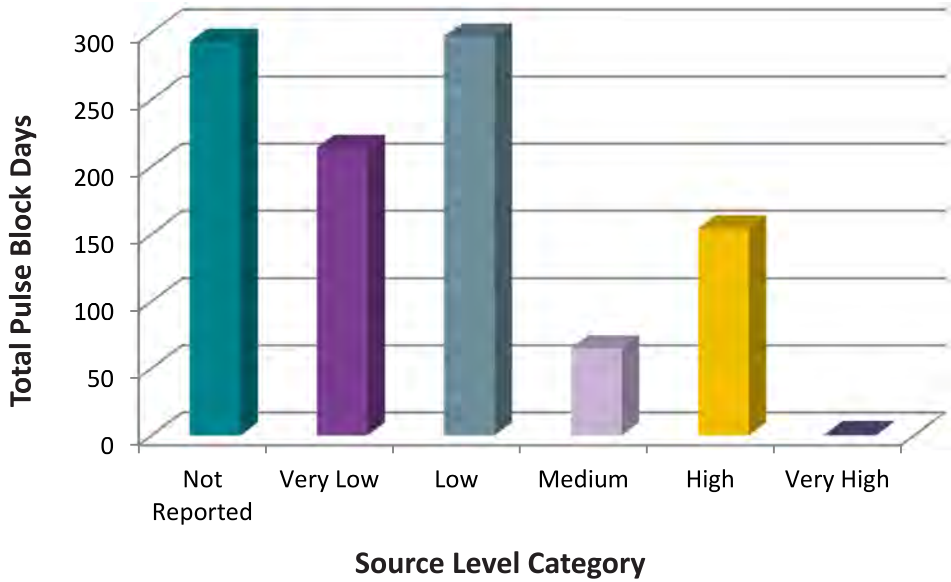


Figure 3: Pulse block days per source category for the Greater North Sea in 2015. The source categories describe the relative intensity of sound sources. Note that all sources included in the registry are above a specified intensity level considered to have the potential to impact marine organisms (including the Very Low category).

Conclusion

This first assessment of the OSPAR Impulsive Noise Indicator shows the distribution and intensity of reported activity in the OSPAR Maritime Area in 2015. The assessment provides the first detailed information on the distribution of reported impulsive sound sources at the regional scale. Reported activity was more prevalent in the northern and eastern North Sea, to the west of Scotland and in the Skagerrak, and was largely due to seismic survey activity. Sound sources categorised as Low or Very Low intensity were more common than higher intensity sources. This distribution is likely to vary year by year, depending upon the activities undertaken. More comprehensive reporting in future years should result in improved assessments of pressure from impulsive sound generation in the OSPAR Maritime Area. This assessment highlights the locations where marine animals, if present, may have been affected (in 2015), although the occurrence of effects would also depend on the distribution and susceptibility of the marine organisms to sound exposure. The likelihood and consequences of the effects of impulsive sounds are not assessed. However work to develop further Indicators to assess the risk of impact from these sources is planned.

This document was published as part of OSPAR's Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments

Marine Bird Abundance

MSFD Descriptor: 1 - Biological diversity
MSFD Criterion: 1.2 - Population size

OSPAR COMMISSION

Key Message Abundance of marine bird species assessed across the OSPAR Maritime Area has not been considered healthy since the mid-2000s. Species that use intertidal and inshore areas of the Greater North Sea during migration or over wintering are the exception, and have been present in healthy numbers since the early 1990s

Background

Marine birds rely on a range of food sources in the marine environment. They are sensitive to a variety of pressures, including fishing, predation by non-indigenous mammals (e.g. rats and American mink), loss of habitat and changes in water quality.

Abundance (numbers of adult birds or pairs at breeding colonies) is used as an indicator because it is practical to measure, good for assessing long-term changes in community structure and because it changes slowly under natural conditions. Rapid changes in number can indicate human-induced impacts and, supported by species-specific assessment values for the extent of decline, can serve as a prompt for management action. Historic changes include many species having benefitted from food provided by the fishing industry through discards.

For seabirds, this assessment is constructed mainly from data on 'breeding abundance'. For waterbirds (wildfowl and waders) this assessment is constructed mainly from data on 'non-breeding abundance' (numbers of birds using intertidal and inshore areas during migration or over winter). Annual estimates of breeding or non-breeding abundance of each are compared against assessment values that are designed to reflect the resilience of different species to population decline. It is desirable for the annual 'relative abundance' of a species to be above 0.8 (80% of the baseline) for species that lay one egg or 0.7 (70% of the baseline) for species that lay more than one egg. If 75% or more of species assessed exceed their individual assessment values, an assemblage of bird species is considered to be healthy.

Image: Northern gannet *Morus bassanus* ©Alan D Wilson

Results

The percentage of all species within each functional group exceeding assessment values for relative breeding abundance in 2014 and 2015, and for relative non-breeding abundance in 2015 in each OSPAR Region are shown in **Table 1**.

Table 1: Percentage of species assessed that had a relative abundance above the assessment values in each functional group in the Norwegian part of the Arctic Waters and Celtic Seas regions in 2015 and in . the Greater North Sea in 2014

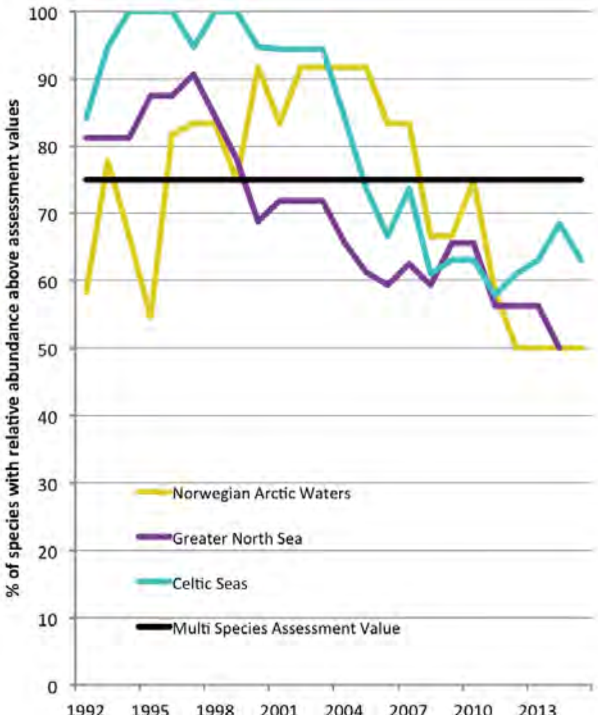
	Percentage of species above assessment values for relative abundance					
	Norwegian part of Arctic Waters		Greater North Sea		Celtic Seas	
Functional group	**Breeding**	**Non-breeding**	**Breeding**	**Non-breeding**	**Breeding**	**Non-breeding**
Wading feeders		0% (2)	40% (6)	82% (22)		47% (19)
Surface feeders	40% (5)	67% (3)	47% (15)	80% (5)	50% (12)	100% (1)
Water column feeders	57% (7)	14% (7)	75% (8)	100% (7)	86% (7)	50% (4)
Benthic feeders		60% (5)	100% (1)	56% (9)		50% (8)
Grazing feeders		50% (2)	0% (0)	80% (10)		62% (8)
Breeding/non-breeding total	50% (12)	47% (19)	50% (32)	77% (53)	63% (19)	53% (40)
All	48% (31)		67% (85)		55% (59)	

Results cont...

In all three OSPAR Regions assessed, less than 75% of all species assessed across the functional groups have met assessment values for relative breeding abundance (**Table 1**), indicating that the bird communities are not healthy. This was also the case for relative non-breeding abundance in the Norwegian part of the Arctic Waters and the Celtic Seas. In contrast, assessment values were met for non-breeding abundance in more than 75% of species in the Greater North Sea in 2014 (**Table 1**), which has occurred in every year since 1993, except in 2010 (**Figure 2**).

Changes in the annual percentage of species meeting assessment values since 1992 are shown in **Figure 1** (relative breeding abundance) and **Figure 2** (relative non-breeding abundance). There has been a decline in the proportion of species meeting assessment values since the mid-2000s or earlier in all OSPAR Regions assessed.

There was modearate confidence in both the methodology and the data used in this assessment.



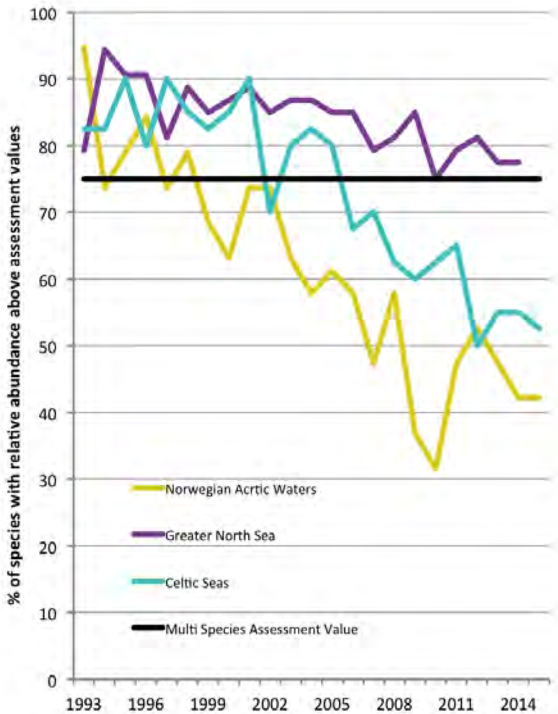


Figure 1: Change in the annual proportion of species exceeding assessment values for the relative breeding abundance of marine birds in the Norwegian part of the Arctic Waters (12 species) and Celtic Seas (19 species) regions during the period 1992–2015, and in the Greater North Sea region (32 species) during the period 1992–2014; The black line denotes the multi-species assessment value of 75%

Figure 2: Change in the annual proportion of species exceeding assessment values for relative non-breeding abundance of marine birds in the Norwegian part of the Arctic Waters (19 species) and Celtic Seas (41 species) regions during the period 1993–2015, and in the Greater North Sea region (53 species) during the period 1993–2014. The black line denotes the multi-species assessment value of 75%

Conclusion

Since the mid-2000s, the breeding abundance of more than a quarter of the marine bird species assessed in the OSPAR Maritime Area has been below the baseline set in 1992, indicating that the populations are not healthy. A similar pattern was found in the non-breeding abundance of species that visit the Arctic Waters and Celtic Seas during migration and / or during winter. In contrast, non-breeding populations in the Greater North Sea are doing much better, and with 75% or more of species meeting assessment values in every year since 1993 are considered healthy.

The majority of the breeding populations assessed were marine birds that forage offshore, mostly on fish. The species feeding on fish within the water column are faring better than those feeding at the surface. This suggests that the availability of small forage fish species at the surface is probably limiting the breeding success of some species. Drivers of food availability are likely to be ecosystem-specific changes, possibly initiated by past and present fisheries, in combination with climate change.

The non-breeding populations assessed are from all five marine bird functional groups, with the majority being wading feeders. The assessments of non-breeding abundance showed few differences between the functional groups.

Knowledge Gaps

This indicator assessment could also be applied to the Bay of Biscay and Iberian Coast and to the marine birds breeding on the Azores, if data were available from Contracting Parties. The assessment for Arctic Waters lacks data. This indicator assessment could also be expanded to include more data on seabirds and waterbirds collected at sea.

The baselines used in this indicator assessment were assigned to the first year of the data series being assessed. It would be more objective to set baselines that include ‘historical reference levels’, which reflect abundance at a point in the past long before the time series began, or ‘reference levels’, where anthropogenic impacts on population size are assumed to be negligible.

This document was published as part of OSPAR’s Intermediate Assessment 2017.

The full assessment can be found at www.ospar.org/assessments

Marine Bird Breeding Success / Failure

MSFD Descriptors: 1 - Biological diversity
MSFD Criterion: 1.3 - Population condition

OSPAR COMMISSION

Key Message Seabird species have experienced frequent and widespread breeding failure over the period assessed (2010 to 2015 inclusive) in Norwegian parts of Arctic Waters, the Greater North Sea and in the Celtic Seas. The surface feeding birds in the Greater North Sea and Celtic Seas frequently failed to raise young

Background

Breeding failure is the extreme event of almost no chicks being produced by a seabird colony in a single breeding season. This assessment describes changes in breeding failure rates in seabird colonies throughout the North-East Atlantic. The assessment is based on how many chicks are fledged (having wing feathers that are large enough for flight) annually, per pair, clutch or nest.

For tern species, widespread breeding failure occurs when the percentage of colonies failing per year exceeds the mean percentage for the preceding 15 years. For all other species, widespread breeding failure occurs when the percentage of colonies failing per year exceeds 5%. Frequent breeding failure is when breeding failure occurs for four years or more out of six (2010-2015 inclusive).

As long-lived species with delayed maturity, changes in the productivity (number of fledged young per nesting pair) of seabirds are expected to reflect changes in environmental conditions long before these are evident as changes in population size.
Breeding success or failure in marine birds can be a valuable indicator of population health, especially in areas where commercial fisheries and seabirds target the same prey. Therefore, results of this assessment should be viewed as an early warning of changes in the environment.

This Indicator Assessment has relevance to some of the seabird species included in the OSPAR List of Threatened and / or Declining Species and Habitats.

The seabirds in this assessment can be divided into two species groups based on how and where they feed at sea. Surface feeders forage on small fish, zooplankton and other invertebrates at or within the surface layer (the upper 1–2 m), whereas water column feeders dive below the surface to feed on fish and invertebrates (e.g. squid, zooplankton) at a broad range of depths or close to the seabed.

Species (Common Name)	Arctic Waters	Greater North Sea	Celtic Seas
Black-headed Gull	Insufficient data/ non breeding	Breeding failure in four or more years out of six	Breeding failure in four or more years out of six
Northern Fulmar	Breeding failure in four or more years out of six	Breeding failure in two years or less out of six	Breeding failure in two years or less out of six
Herring gull	Breeding failure in two years or less out of six	Breeding failure in two years or less out of six	Breeding failure in four or more years out of six
Common Gull	Insufficient data/ non breeding	Breeding failure in four or more years out of six	Breeding failure in four or more years out of six
Lesser black-backed gull	Breeding failure in four or more years out of six	Breeding failure in four or more years out of six	Breeding failure in four or more years out of six
Glaucous gull	Breeding failure in two years or less out of six	Insufficient data/ non breeding	Insufficient data/ non breeding
Great Black-backed Gull	Breeding failure in two years or less out of six	Breeding failure in four or more years out of six	Breeding failure in two years or less out of six
Manx Shearwater	Insufficient data/ non breeding	Insufficient data/ non breeding	Breeding failure in two years or less out of six
Black-legged kittiwake	Breeding failure in four or more years out of six	Breeding failure in four or more years out of six	Breeding failure in two years or less out of six
Arctic skua	Insufficient data/ non breeding	Breeding failure in four or more years out of six	Breeding failure in two years or less out of six
Great Skua	Breeding failure in two years or less out of six	Breeding failure in two years or less out of six	Breeding failure in two years or less out of six
Roseate tern	Insufficient data/ non breeding	Breeding failure in two years or less out of six	Insufficient data/ non breeding
Common tern	Insufficient data/ non breeding	Breeding failure in three years out of six	Breeding failure in four or more years out of six
Arctic tern	Insufficient data/ non breeding	Breeding failure in two years or less out of six	Breeding failure in two years or less out of six
Sandwich tern	Insufficient data/ non breeding	Breeding failure in four or more years out of six	Breeding failure in three years out of six
Little Tern	Insufficient data/ non breeding	Breeding failure in two years or less out of six	Breeding failure in two years or less out of six
Razorbill	Breeding failure in two years or less out of six	Breeding failure in three years out of six	Breeding failure in two years or less out of six
Little Auk	Breeding failure in two years or less out of six	Insufficient data/ non breeding	Insufficient data/ non breeding
Black Guillemot	Breeding failure in two years or less out of six	Insufficient data/ non breeding	Breeding failure in two years or less out of six
Puffin	Breeding failure in four or more years out of six	Breeding failure in two years or less out of six	Breeding failure in two years or less out of six
Northern gannet	Breeding failure in two years or less out of six	Breeding failure in two years or less out of six	Breeding failure in two years or less out of six
European shag	Breeding failure in four or more years out of six	Breeding failure in two years or less out of six	Breeding failure in two years or less out of six
Great Cormorant	Breeding failure in two years or less out of six	Breeding failure in two years or less out of six	Insufficient data/ non breeding
Common Guillemot	Breeding failure in four or more years out of six	Breeding failure in two years or less out of six	Breeding failure in two years or less out of six
Brünnich's guillemot	Breeding failure in four or more years out of six	Insufficient data/ non breeding	Insufficient data/ non breeding

Insufficient data/ non breeding	Breeding failure in three years out of six
Breeding failure in two years or less out of six	Breeding failure in four or more years out of six

Figure 1: Frequency of widespread breeding failure for seabird species in the North-east Atlantic area (2010–2015 inclusive).

Image (right): Kittiwake ©Parsons

Results

For the six year period (2010 to 2015 inclusive), widespread seabird breeding failures frequently occurred in 35% of species assessed in the Greater North Sea, 25% in the Celtic Seas and 44% in the Norwegian parts of the Arctic Waters (**Figure 1**).

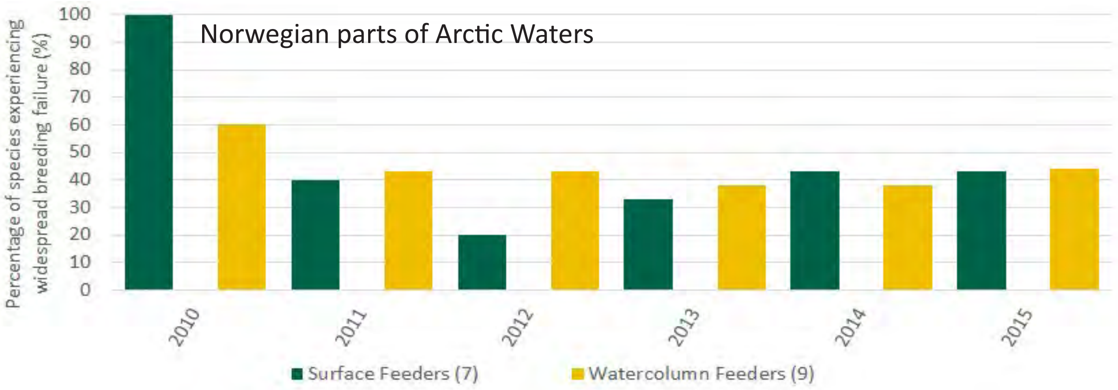
In the Celtic Seas and Greater North Sea, none of the six water column feeders showed frequent and widespread breeding failure during this period (**Figure 1**). In contrast, a third of surface feeders in the Celtic Seas and half the surface feeders in the Greater North Sea showed frequent and widespread breeding failure during the six year study period (**Figure 1**).

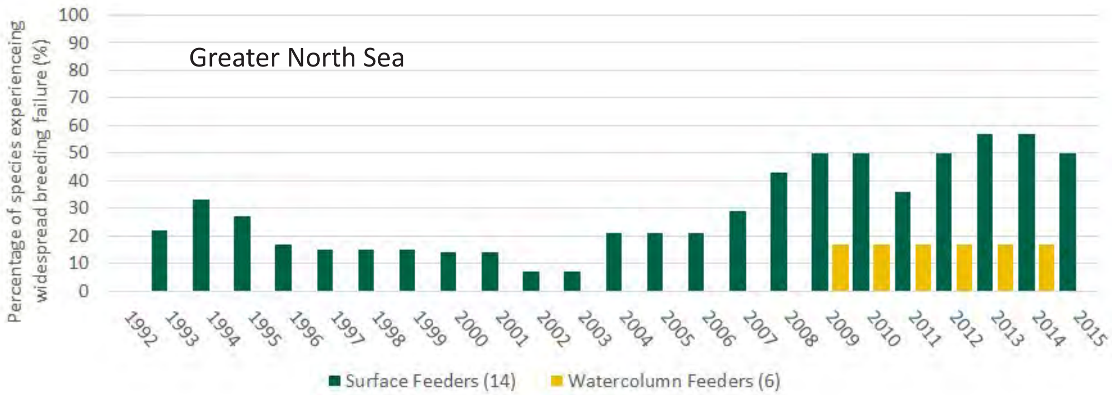
In the Norwegian parts of Arctic Waters, there was little difference between surface feeders and water column feeders, with up to 44% of species in each group showing frequent and widespread breeding failure during the six year study period (**Figure 1**).

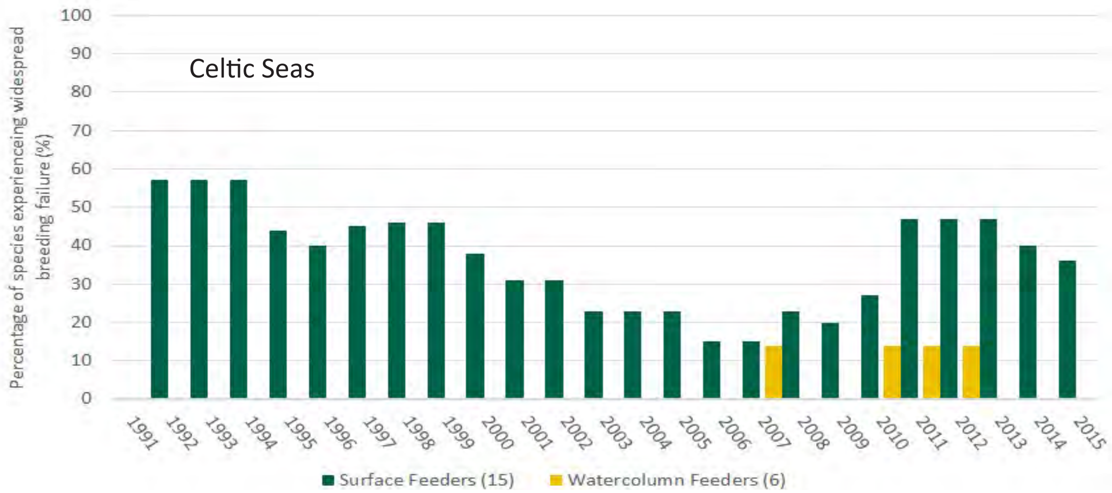
The proportion of surface feeders experiencing widespread breeding failure has exceeded 25% in every year since 2007 in the Greater North Sea (**Figure 3, overleaf**) and in every year since 2010 in the Celtic Seas (**Figure 4, overleaf**) and in the Norwegian parts of Arctic Waters (except for 2012) (**Figure 2, overleaf**).

There is moderate / low confidence in the methodology used and moderate confidence in the data.

Marine Bird Breeding Success / Failure







Conclusion

In the Greater North Sea and Celtic Seas, all seabird species that frequently failed to raise young feed on small fish in surface waters. Widespread breeding failure in seabird species feeding in deeper waters or at the seabed was far less frequent. This difference could be linked to the availability of small forage fish species at the surface (e.g. lesser sandeel and sprat) that are typical prey for various surface feeding species (e.g. black-legged kittiwake). In the Norwegian parts of the Arctic Waters, an equal proportion of surface feeders and water column feeders exhibited widespread breeding failure. This suggests the availability of prey fish may be low throughout the water column in some areas (from the surface to the seabed), for example sandeel and young herring. Prey availability is likely to be driven by ecosystem specific changes, possibly initiated by commercial fisheries (past and present) in combination with climate change.

In all regions, breeding failure (especially for ground nesting terns and gulls and cliff nesting guillemots on open ledges) will reflect the combined result of factors such as predation and disturbance from native and non-native mammalian predators and by other birds. Likewise, disturbance by humans may also have an impact.

Figures 2-4: Changes in the proportion of marine bird species assessed, which have experienced widespread annual colony failures in each year, in the Norwegian parts of Arctic Waters (top), Greater North Sea (centre) and Celtic Seas (bottom).

Maximum number of species included per year in each group shown in brackets in the figure legend. Number of species varied each year depending on data availability.

Knowledge Gaps

This indicator assessment does not include the Bay of Biscay and Iberian Coast or the Wider Atlantic, because data were not available for France, Spain and Portugal. The assessment for Arctic Waters was confined to Norwegian coasts (including High-Arctic islands) owing to a wider lack of data; other OSPAR Countries in the Arctic are encouraged to make data available for future assessments. In the Greater North Sea, areas outside the UK, Norway, the Netherlands and Belgium were not assessed due to lack of data. Data collected since 2012 in the Danish and German Wadden Sea were not available and these areas were therefore not included in the assessment.

This document was published as part of OSPAR's Intermediate Assessment 2017.

The full assessment can be found at www.ospar.org/assessments

Abundance and Distribution of Coastal Bottlenose Dolphins

MSFD Descriptor: 1 - Biological diversity

MSFD Criteria: 1.1 - Species distribution; 1.2 - Population size; 4.3 - Abundance/distribution of key trophic groups/species

OSPAR COMMISSION

Key Message Coastal bottlenose dolphin populations declined through the 19th and 20th century and have remained low, but stable, in the 21st century. However, the population in the Sado Estuary (Portugal) has declined since monitoring began (1980s). Abundance and distribution of bottlenose dolphins (as top predators) is indicative of environmental health

Background

Cetaceans are an important component of marine biodiversity. In European waters there is a large wide-ranging population of offshore bottlenose dolphin, as well as several much smaller coastal populations.
This assessment considers changes in abundance and distribution of coastal populations of bottlenose dolphin; offshore bottlenose dolphins are considered in the assessment of Abundance and Distribution of Cetaceans .

Coastal populations of bottlenose dolphins reside in relatively small areas, close to shore. They have the potential to be exposed to a greater level of human activity due to their proximity to humans and due to the small size of the area they inhabit.
Bottlenose dolphins are long-lived top predators and are highly susceptible to change in their environment. Changes in abundance and distribution provide important information on the state of the population. Several populations of coastal bottlenose dolphin have been monitored for several decades, whereas monitoring for most is relatively recent (last ten years) or consists only of anecdotal information.

Bottlenose dolphins are vulnerable to the accumulation of pollutants through the food chain and to local disturbance from shipping, tourism, industrial development, and incidental bycatch in fishing gear. Underwater noise can have long and short-term effects on cetaceans (such as hearing loss or displacement from an area), but it is unclear to what extent coastal bottlenose dolphins are affected. The conservation status of bottlenose dolphin is assessed under the European Union Habitats Directive (Council Directive 92/43/EEC).

Results

Coastal bottlenose dolphins are observed along the Atlantic coast of Europe from Scotland in the north to Spain in the south. The overall population size of coastal bottlenose dolphins in the Greater North Sea, Celtic Seas and Bay of Biscay and Iberian Coast regions is between 3000 and 4000 animals. Few locations have been monitored on an annual basis. The most extensive assessment was undertaken on the Sado Estuary population in Portugal (since 1986), and indicates that the population is in decline. Annual mark-recapture estimates for populations in East Coast Scotland (United Kingdom: observed since 1990), indicate that the population is stable and may be showing signs of increase. Estimates from the wider Cardigan Bay (United Kingdom: observed since 2002), the Gulf of St Malo including the Channel Islands (France, United Kingdom: observed since 2010), Ile de Sein (France: observed since 1992) and the Shannon Estuary (Ireland: observed since 1997) indicate broadly stable populations. However, in several of these locations the trend was assessed on fewer than four data points. A summary of available data and population trends is shown in **Table 1** overleaf.

Image: Bottlenose dolphin *Tursiops truncatus* mother and calf © Peter GH Evans

Assessment Unit (AU)	Monitoring Requirements Permitting an Assessment		Population Trend
	Length of time series ≥10 years	≥4 Abundance assessments	
West Coast Scotland	No	No	No assessment
East Coast Scotland	Yes	Yes	Possible increase / stable
Coastal Wales	Yes	Yes	Stable
Coastal Ireland	Yes	Yes	Stable
Coastal Southwest England	No	No	No assessment
Coastal Normandy and Brittany	No	Yes	Increase / stable (indicative)
Northern Spain	No	No	No assessment
Southern Galician Rias (Spain)	No	No	No assessment
Coastal Portugal	No	No	No assessment
Coastal Portugal (Sado Estuary)	Yes	Yes	Decline
Gulf of Cadiz	No	No	No assessment

Table 1: Summary of available data and population trend for each assessment unit (AU) where an assessment has been made

It should be noted that the Sado Estuary population is considered to be a separate AU to the Coastal Portugal AU. The length of time series indicates whether the monitoring requirements have been met. If the time series is less than ten years in length and has fewer than four years of abundance estimates, no assessment was undertaken. Population trend indicates the result of the assessment (if undertaken)

Conclusion

Most populations of coastal bottlenose dolphins in the areas assessed are relatively small. 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 population in the Sado Estuary in Portugal. The reasons for the decline in the Sado Estuary are unknown but could be related to estuarine pollution.

Bottlenose dolphins are vulnerable to the effects of persistent organic pollutants, with high levels occurring through bioaccumulation potentially inhibiting reproduction. Disturbance by recreational activities, such as whale watching, underwater noise , collision with ships and commercial fisheries are also identified as pressures for bottlenose dolphins.

Knowledge Gaps

Historical data on abundance and distribution of coastal bottlenose dolphins are either scarce or lacking. As a result, assessment was only possible for five populations of coastal bottlenose dolphin, with an indicative assessment provided for one other population. The time series of monitoring data was too short to undertake an assessment for the remaining populations. The connectivity between coastal bottlenose dolphins and wider-ranging offshore populations remains unclear. The impacts of human activities on these populations remain to be studied. Some coastal populations might be ephemeral.

This document was published as part of OSPAR's Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments

Abundance and Distribution of Cetaceans

MSFD Descriptor: 1 - Biological diversity
MSFD Criteria: 1.1 - Species distribution; 1.2 - Population size;
4.3 - Abundance/distribution of key trophic groups/species

OSPAR COMMISSION

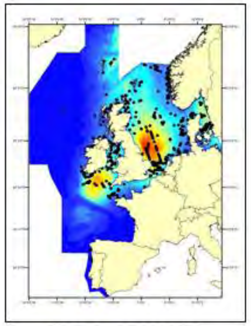
Key Message Cetaceans are widely distributed and abundant in the OSPAR Maritime Area. They are challenging to monitor. There is no evidence of changes in abundance for white-beaked dolphin, minke whale and harbour porpoise since 1994; there is insufficient evidence for other species. The distribution of harbour porpoise and minke whale has shifted southward in the Greater North Sea

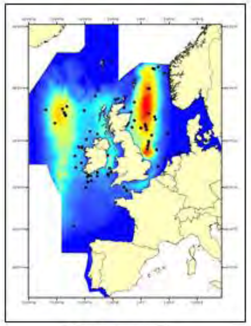
Background

Cetaceans are an important component of marine biodiversity in the North-East Atlantic Ocean. As apex predators, cetacean abundance and distribution are key indicators of environmental status, such as food web integrity. Thirty-six species of cetacean have been recorded in recent history within the Greater North Sea, Celtic Seas, and Bay of Biscay and Iberian coast. Many are widely dispersed oceanic species that are rarely seen and very difficult to monitor. As a result, this indicator is restricted to assessing species for which more robust data are available. The information originates primarily from a few dedicated large-scale surveys.

Some human activities affect the abundance and distribution of cetaceans. Historically, direct removal of individuals by hunting had severe effects on populations. Today, bycatch in fisheries is one of the major causes of mortality for small cetaceans. Other pressures such as chemical and noise pollution are known to affect individual animals, but the effects of these on populations are not yet well understood.

This assessment considers information on abundance and distribution and, where possible, assesses the status of the following species: harbour porpoise, offshore bottlenose dolphin, white-beaked dolphin, short-beaked common dolphin, striped dolphin, minke whale, fin whale, long-finned pilot whale, sperm whale and beaked whales (the latter as a combined species group). All of these species are also assessed under the European Union Habitats Directive. Coastal bottlenose dolphin and killer whale are considered separately within the Intermediate Assessment 2017.


Harbour porpoise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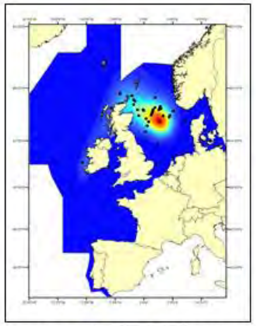
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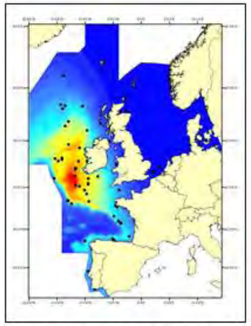
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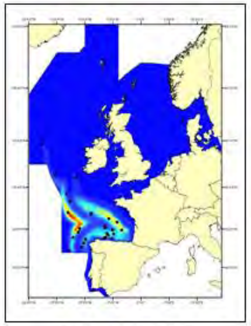
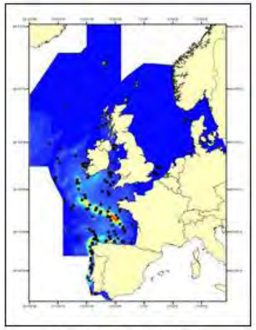

Striped dolphin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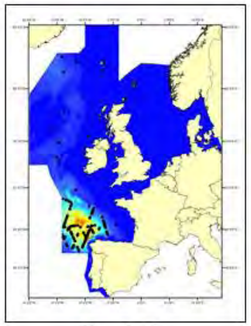
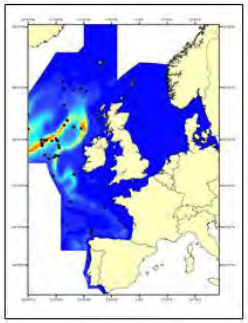
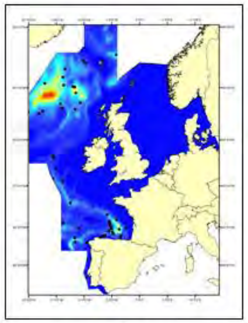

Fin whale


Pilot whale


Beaked whales

Results

Density distribution maps of cetaceans in the Greater North Sea, Celtic Seas, and Bay of Biscay and Iberian Coast indicate that cetaceans are distributed widely across the OSPAR Maritime Area (**Figure 1**). The relatively small amount of overlap in predicted high-use areas highlights how species use the marine area in different ways. Harbour porpoises are mostly restricted to continental shelf waters. Striped dolphin, and fin, sperm, beaked and pilot whales are primarily found in deep waters beyond the shelf edge. Bottlenose, white-beaked and common dolphins and minke whales are found in both shelf and deep waters. The most recent SCANS III survey in 2016 yielded population abundance estimates for harbour porpoise, common dolphin, striped dolphin, white-beaked dolphin, bottlenose dolphin, fin whale, minke whale, pilot whale, sperm whale and beaked whales (**Figure 2**). However, Irish and Icelandic waters were not covered by the SCANS III survey.

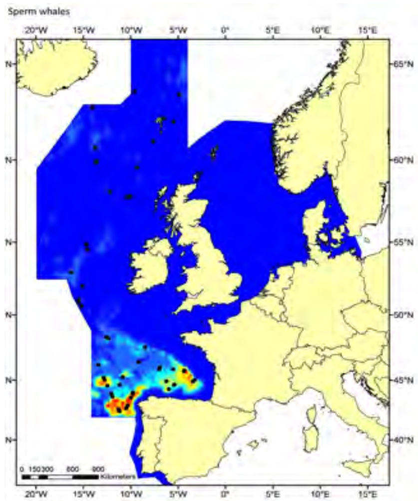

Sperm whales

Figure 1 (left and above): Maps of model-based density of various cetacean species from analyses of pooled SCANS-II, CODA and T-NASS data in summer 2005 and 2007 in the European Atlantic.
Cetaceans are distributed widely across the area and the relatively small amount of overlap in predicted high-use areas highlights how species utilise the environment in different ways. SCANS-II: Small Cetacean Abundance in the European Atlantic and North Sea). CODA: Cetacean Offshore Distribution and Abundance in the European Atlantic (CODA, 2009). T-NASS: Trans North Atlantic Sightings Survey

Results cont...

There is insufficient information to assess changes in distribution over time except for harbour porpoise in the Kattegat / Belt Seas (where there are comprehensive data from 1994, 2005, 2012 and 2016), and harbour porpoise, white-beaked dolphin and minke whale in the North Sea, where there are comprehensive data from 1994, 2005 and 2016, and additional years for minke whale. Between 1994 and 2005, the distribution of harbour porpoise in the North Sea shifted markedly from primarily in the north to primarily in the south; this shift was maintained in 2016 and more sightings were made throughout the English Channel in 2016 than in previous years. There is some evidence of a similar but weaker pattern for minke whale. White-beaked dolphin distribution did not appear to change between 1994 and 2016.

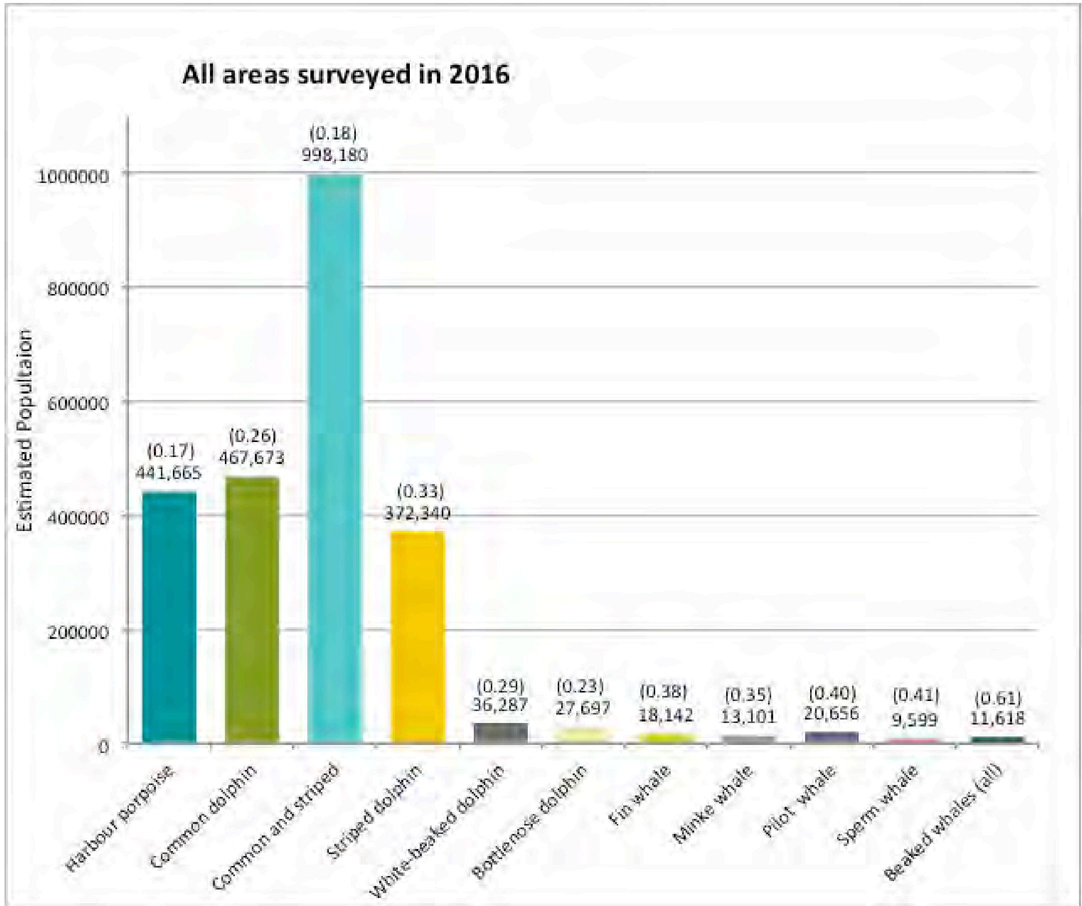


Figure 2: Population abundance estimates from the SCANS III survey in 2016, including the coefficient of variation (cv) values

Three or more comparable estimates of abundance are only available for harbour porpoise, white-beaked dolphin and minke whale in the North Sea, and harbour porpoise in the Skagerrak / Kattegat / Belt Seas. There is no evidence of any trend in abundance for these species in these regions. For other species, it is not possible to assess with any confidence whether populations are decreasing, stable or increasing. Nevertheless, the most recent estimates of abundance for 2016 are similar to or larger than earlier estimates for comparable areas.

There is moderate confidence in the methodology and low confidence in the data availability.

Conclusion

Cetaceans are widely distributed in a range of habitats and are overall abundant throughout the OSPAR Maritime Area. It is estimated that more than 1.5 million individual cetaceans live in the Greater North Sea, Celtic Seas, and Bay of Biscay and Iberian Coast. For most species there are only two 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 most likely 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.

Knowledge Gaps

Historical data on abundance and distribution of cetaceans are scarce or lacking, so for most species the data are insufficient to assess their status. Given the lack of data, it is not possible to identify whether there is a cause-effect relationship between human activities and cetacean population size and distribution. The power to detect trends could be improved by increasing the frequency of large-scale surveys. To date, large-scale surveys have been undertaken during summer, resulting in a lack of seasonal information at the large scale.

The availability of data from other large-scale surveys will help address knowledge gaps in the future.

This document was published as part of OSPAR's Intermediate Assessment 2017.

The full assessment can be found at www.ospar.org/assessments

Harbour Porpoise Bycatch

MSFD Descriptors: 1 - Biological diversity
MSFD Criterion: 1.3 - Population condition

Key Message Bycatch is recognised as a major cause of human-induced mortality of harbour porpoise. Nearly 4 000 harbour porpoises of a total population in excess of 490 000 are drowned in fishing nets annually in the areas assessed. However, there is low confidence in these bycatch estimates due to incomplete monitoring data

Background

The main human-induced cause of mortality of cetaceans in the OSPAR Maritime Area is being caught and entangled in fishing nets. Seals are also bycaught but there is insufficient knowledge to include them in this assessment.

Harbour porpoise has been included in the OSPAR List of Threatened and / or Declining Species and Habitats for the Greater North Sea and Celtic Seas owing to evidence of a decline in populations, their sensitivity and the threat of incidental capture and drowning in fishing nets. This assessment is taken solely from the latest advice on the numbers of cetaceans that are incidentally caught and killed by fishing, provided to the European Commission by the International Council for the Exploration of the Sea (ICES). No additional information has been provided by OSPAR Contracting Parties. ICES estimated the numbers of harbour porpoise caught in commercial nets (mainly set gillnets) in the ICES derived Assessment Units shown in **Figure 1**. The bycatch estimates are derived from estimates of annual fishing effort and counts of bycaught harbour porpoises made by observers or remote electronic monitoring on commercial fishing vessels.

Owing to uncertainly concerning the reliability of the fishing effort data and the potential for biases in the bycatch data, this assessment does not compare the ICES bycatch estimates with assessment values used by the OSPAR North Sea Ecological Quality Objective (EcoQO) for bycatch of harbour porpoise.

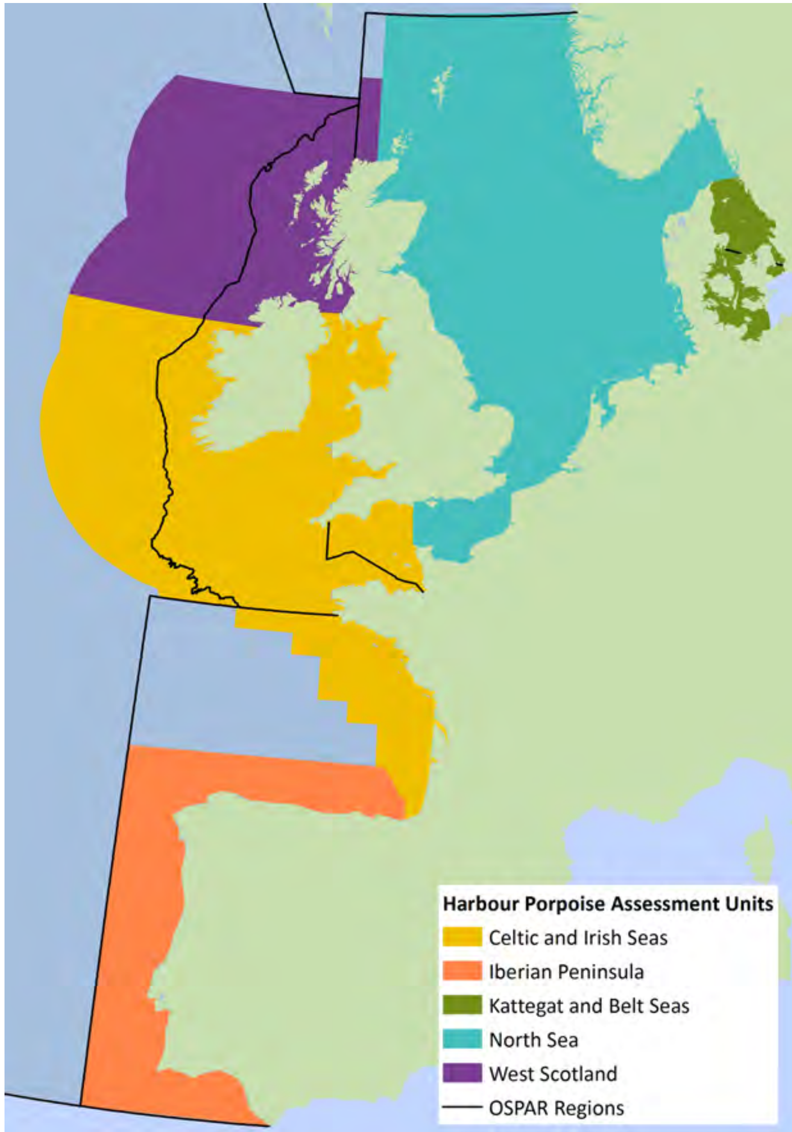


Figure 1: Harbour porpoise ICES Assessment Units (AUs) (as proposed by ICES, 2014) – note that these are ecologically derived and do not align with the OSPAR regions

Results

Bycatch mortality in harbour porpoise have been estimated by the International Council for the Exploration of the Sea (ICES) in three of their five assessment units (AUs): the Kattegat and Belt Seas, the North Sea, and the Celtic and Irish Seas. The results are shown in **Table 1** overleaf. Data on harbour porpoise bycatch from observers on fishing vessels were insufficient for the Iberian Peninsula AU and the risk of bycatch in the West of Scotland AU is very low. As a result these are not represented in this assessment.

Image: Dead harbour porpoise with marks from being caught in a fishing net ©Jan Haelters/RBINS

Results cont...

ICES expressed the estimated total harbour porpoise bycatch in the form of lower and upper 95% confidence limits rather than as a single estimate. The confidence intervals were used by ICES to better reflect uncertainty in the estimates of overall bycatch within each AU. ICES considers this uncertainty to result from the following factors:

- The data on fishing effort (in number of days at sea) are likely to be underestimated because effort from smaller commercial vessels (particularly <10 m in length), from recreational vessels, and from fisheries from the beach is not represented. This would lead to underestimates in bycatch;
- The bycatch rates may be overestimated because the majority of bycatch records were collected by observers on large vessels (>15 m) that use more gear than smaller vessels and may have higher likelihood of catching cetaceans;
- The data on fishing effort and the bycatch records from observers on vessels cover a wide range of vessel types and fishing gear types (i.e. trammel nets, set gillnets, driftnets). No account was taken of any spatial heterogeneity (i.e. patchiness) or of any differences in mesh size, net length or other important gear characteristics. ICES point out “there is an implicit assumption that the summarized observations are representative of the nature and diversity of the gillnet fisheries within each assessment region, and this is not likely to be true”.

ICES concluded that their approach to estimating bycatch “does not address several potential biases. An examination of these will require detail of the fleet structure and how the observations are stratified”.

Confidence is rated as moderate / low for the method of this assessment and low for data availability.

Table 1. Harbour porpoise bycatch mortality from fishing nets in each assessment unit (AU), compared against the best estimate of abundance. Data were insufficient for the Iberian Peninsula AU and the risk of bycatch in the West of Scotland AU is very low. These have not been included in the assessment

[a]2016 Data from preliminary analysis of the results from SCANS-III survey; [b]2005 data from SCANS-II survey because SCANS III estimates are not yet complete in the Celtic and Irish Seas AU (Source: ICES)

Note[1]: The data on fishing effort (in number of days at sea) are likely to be underestimated as effort from smaller commercial vessels (particularly <10 m in length), from recreational vessels and from fisheries from the beach is not represented. This would lead to underestimates in bycatch. Furthermore, variation in “Best abundance estimate” is not included in the calculation of annual bycatch rate

ASSESSMENT UNIT	Kattegat and Belt Seas	North Sea	Celtic and Irish Seas
Estimated total bycatch 95% Confidence Limits (CLs) (year)	165–263 (2014)	1235–1990 (2013)	1137–1472 (2013)
Best abundance estimate (year)	42 300 (23 368 – 76 658) (2016)[a]	345 400 (246 526 – 495 752) (2016)[a]	106 382 (57 689 – 196 176) (2005)[b]
Annual bycatch as a percentage of the best abundance[1] estimate	0.39–0.62%	0.36–0.58%	1.06–1.37%

Conclusion

In 2013 up to 2 000 harbour porpoise died as a result of entanglement in commercial nets in the ICES defined North Sea Assessment Unit (AU), out of a total abundance estimate of 345 400. In the same year, an estimated 1 500 individuals died in the Irish and Celtic Seas AU, out of a total abundance estimate of 107 300. In 2014, a further 260 harbour porpoise were estimated to have died in the Kattegat and Belt Seas AU, out of a total abundance estimate of 42 300.

Bycatch estimates provided by the International Council for the Exploration of the Sea (ICES) represent the best available estimates given the underlying data. More accurate bycatch rates could be obtained by observing bycatch on a sample of vessels that represents the wider fishing fleet in terms of fishing gear type, vessels size and distribution of fishing activity over space and time. The current bycatch estimates are derived from observing only 0.28% of the fishing effort for the fishing gear types classified as ‘nets’; a higher observer coverage in dedicated surveys would also improve the reliability of future estimates of bycatch rate.

Knowledge Gaps

This indicator assessment has not used an assessment value. The Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) recommends that ‘total anthropogenic removal’ of harbour porpoise should not exceed 1.7% of the best available estimate of abundance, with the precautionary objective of reducing bycatch to less than 1% and ultimately 0%.

The use of ‘Net meter per day’ could provide a more accurate record of fishing effort than ‘days at sea’, especially in the case of net types (e.g. set gillnets) that are more likely to catch harbour porpoise than mobile gear (e.g. trawls).

This document was published as part of OSPAR’s Intermediate Assessment 2017.

The full assessment can be found at www.ospar.org/assessments

Pilot Assessment of Abundance and Distribution of Killer Whales

MSFD Descriptor: 1 - Biological diversity

MSFD Criteria: 1.1 - Species distribution; 1.2 - Population size; 4.3 - Abundance/distribution of key trophic groups/species

OSPAR COMMISSION

Key Message Killer whales are long-lived, slow reproducing, top predators. Several populations exist, but data on abundance are scarce. Thus only a pilot assessment can be made. Killer whales are vulnerable to the effects of persistent organic pollutants accumulated through their diet, with high pollutant levels potentially impacting reproduction

Background

OSPAR's strategic objective with respect to biodiversity and ecosystems is to halt and prevent further loss in biodiversity, protect and conserve ecosystems and to restore, where practicable, ecosystems, which have been adversely impacted by human activities. This pilot assessment considers changes in abundance and distribution of populations of killer whales in the North-East Atlantic.

Some killer whales may seasonally reside in relatively small areas, close to shore. As a result, they have the potential to be exposed to a greater level of human activity than populations further offshore due to their proximity to human activities.

Although killer whales are widespread, they are not particularly numerous. Much of the information on population structure comes from photographic identification studies focused on particular groups occurring in coastal waters.

Killer whales are long-lived top predators and are susceptible to changes in their environment. Changes in abundance and distribution provide important information on the state of the population.

Killer whales are vulnerable to the accumulation of pollutants through the food chain, a key pressure identified for this species. Underwater noise can have long and short-term effects on cetaceans (for example, hearing loss or displacement from an area), but it is not known to what extent killer whales are affected.

Results

Within the OSPAR Maritime Area, several thousand killer whales occur in Arctic Waters and the northern parts of the Greater North Sea, Celtic Seas, and Wider Atlantic. These animals are mobile and feed predominantly on pelagic shoaling fish such as mackerel and herring. Some also feed on seals and birds. Further south, killer whales are most frequently sighted near the Strait of Gibraltar and along the Atlantic shelf edge, especially around the United Kingdom and Ireland, including the Northern North Sea. The abundance of these more southerly killer whales may not exceed 100 individuals.

There is a very small distinct group (10 to12 individuals) occurring around west Scotland and north-west Ireland. The killer whales that live near the Strait of Gibraltar are seasonally resident in the Gulf of Cadiz (spring) and Strait of Gibraltar (summer), following the Atlantic bluefin tuna, on which they feed extensively. They are considered genetically distinct from other killer whale populations.

High persistent organic pollutant loads in individuals leading to health problems and reproductive failure may have contributed to a decline in killer whale numbers and distribution, especially in industrialised areas.

The conservation status of killer whales has been assessed by the European Environment Agency as 'favourable' in terms of range and 'unknown' in terms of population under the European Union Habitats Directive (Council Directive 92/43/EEC).

Image: Killer Whales *Orcinus orca* © Christopher Michael

Conclusion

Killer whales 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.

Owing to a lack of data only a pilot assessment can be made at present.

Killer whales are vulnerable to the effects of accumulating persistent organic pollutants, with high pollutant levels potentially inhibiting reproduction. Mid-frequency military sonar may also negatively affect killer whales.

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.

Image: Killer Whales *Orcinus orca* © Christopher Michael

Image: Killer Whales *Orcinus orca* © Robert Pitman NOAA

Knowledge Gaps

Historical information on abundance and distribution of killer whales is either scarce or lacking. Due to this lack of information, no assessment of abundance can be undertaken, so only a pilot assessment of distribution is possible. There is no estimate for the size of killer whale populations within the Greater North Sea, Celtic Seas, and Bay of Biscay and Iberian Coast.

Human activities can affect killer whales. However, the relationship between human activities (e.g. disturbance, pollution, fishing, habitat alteration) and the impact of these activities on killer whale populations needs further study.

This document was published as part of OSPAR's Intermediate Assessment 2017.

The full assessment can be found at www.ospar.org/assessments

Seal Abundance and Distribution

MSFD Descriptor: 1 - Biological diversity
MSFD Criteria: 1.1 - Species distribution; 1.2 - Population size

OSPAR COMMISSION

Key Message Atlantic grey seals and harbour seals are resident in the Greater North Sea and Celtic Seas. Harbour seal abundance is stable or increasing in most of the Greater North Sea, but declining in a few areas. The reasons for this decline are unclear. Grey seal abundance is increasing and distribution is stable

Background

Atlantic grey seals and harbour seals are both regularly found in the Greater North Sea and Celtic Seas. As higher predators, seals can be used as an indicator to reflect the state of the marine ecosystem. This assessment of seal abundance and distribution aims to determine if populations of both species are in a healthy state, with no long-term decrease in population size, beyond natural variability. Historically, populations have declined due to anthropogenic influences. This assessment will help to determine trends in abundance.

Seal abundance and distribution are influenced by many factors, such as disease, competition with other species, changes in the distribution and abundance of prey, disturbance and interactions with fisheries. Seals were hunted into the 20th century, and as a result have disappeared entirely in some areas, but are now protected in most areas of Europe.

Future changes in distribution or declines in abundance may signal that populations are no longer in a healthy state. Further studies would then be needed to establish the cause of these changes and to determine whether management measures are required.

The conservation status of harbour seals and grey seals is also assessed under the European Union Habitats Directive (Council Directive 92/43/EEC).

Results

This indicator assessment uses estimates of seal numbers from monitoring programmes that count seals on land when they are moulting or breeding. Assessments of changes in abundance and distribution were made within discrete geographical areas of coastline, or ‘Assessment Units’ (AUs).

Grey seal abundance and distribution

Grey seal abundance in the Greater North Sea (excluding AUs in Norway) and in the United Kingdom part of the Celtic Seas has increased since 1992. In the Greater North Sea (excluding the United Kingdom, Sweden and Norway), where sufficient data were available, grey seal numbers during their moulting period in spring have increased substantially since 1992. The number of breeding colonies occupied between 2003–2008 and 2009–2014 generally increased or remained unchanged.

Harbour seal abundance and distribution

In the Greater North Sea, harbour seal abundance has increased over both the short term (2009–2014) and long term (1992–2014) in all AUs along the coast of continental Europe and along the east coast of England (Figure 1 and 2). In the Wadden Sea (AU17), which holds over 40% of harbour seals in the total area being assessed, numbers have trebled since 1992. Increases in abundance on the Belgian Coast and in the Dutch Delta (AU16) are likely to be due to immigration of seals from the Wadden Sea and possibly also from the South-East England (AU10) and French North Sea and English Channel Coast (AU15). Elsewhere in the Greater North Sea, short- and long-term declines in abundance exceeded the assessment values (declined >1% per year and decreased by >25% against baseline year, respectively) in East Scotland (AU8), North Coast and Orkney (AU5), and Shetland (AU6), but were inconclusive in the Moray Firth (AU7) (**Figure 1 and 2**). The causes of these declines are currently unknown and are the subject of a major research initiative in the United Kingdom.

Images: Atlantic Grey seal (*Halichoerus grypus*) ©John Weinberg (left); and Harbour seals (*Phoca vitulina*) © Silje-Kristin Jensen

Results cont...

In the United Kingdom part of the Celtic Seas there were insufficient data to conduct assessments in most AUs (**Figure 1**). In West Scotland (AU3), numbers have increased substantially since 1992 and the AU holds over 20% of harbour seals in the total assessed area of the Greater North Sea and Celtic Seas. In the Western Isles (AU4) and Northern Ireland (AU1) numbers have decreased since 1992, but had not conclusively exceeded assessment values. The presence of harbour seals at haul-out sites has either increased or remained the same in most AUs in the Greater North Sea and the United Kingdom part of the Celtic Seas. A notable exception is East Scotland (AU8), where abundance has declined dramatically since the mid-2000s. In this AU, the number of occupied areas has decreased from seven (out of a total of nine surveyed) in the period 2003–2008, to four (out of a total of six surveyed) in the period 2009–2014 (**Figure 2**).

There is a moderate / low confidence in the methodology used and moderate confidence in the availability of data.

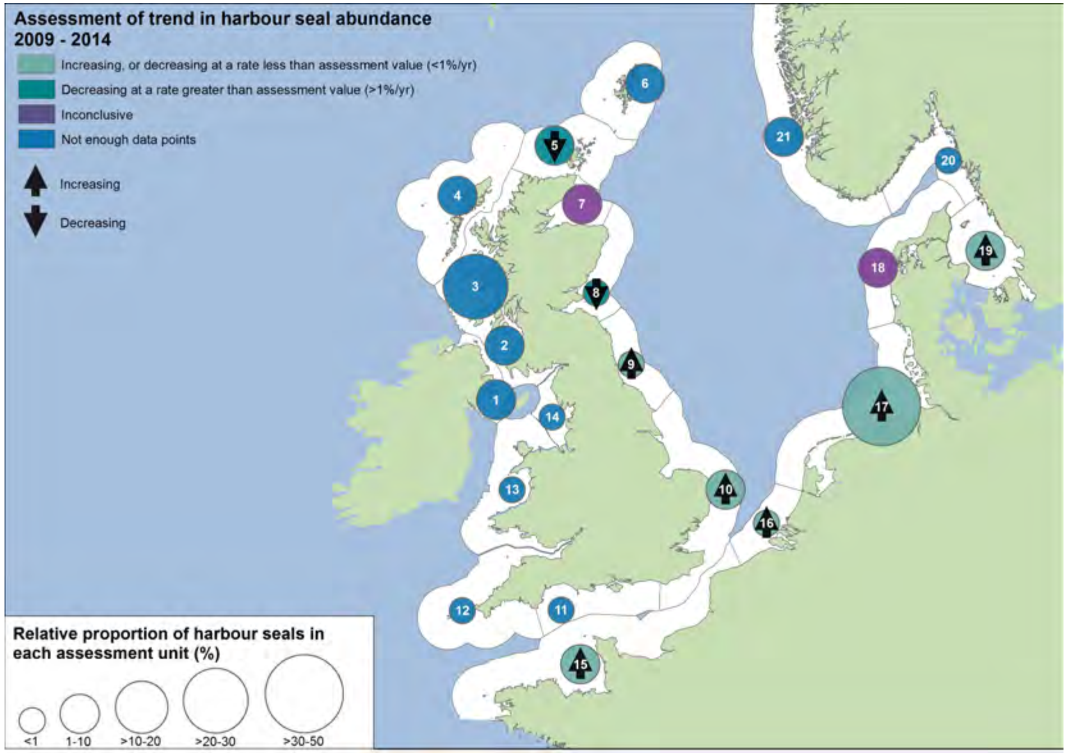


Figure 1: Assessment of recent change in harbour seal abundance (2009–2014). The numbers in each circle refer to the respective 'Assessment Unit' (mentioned in the text as AU).

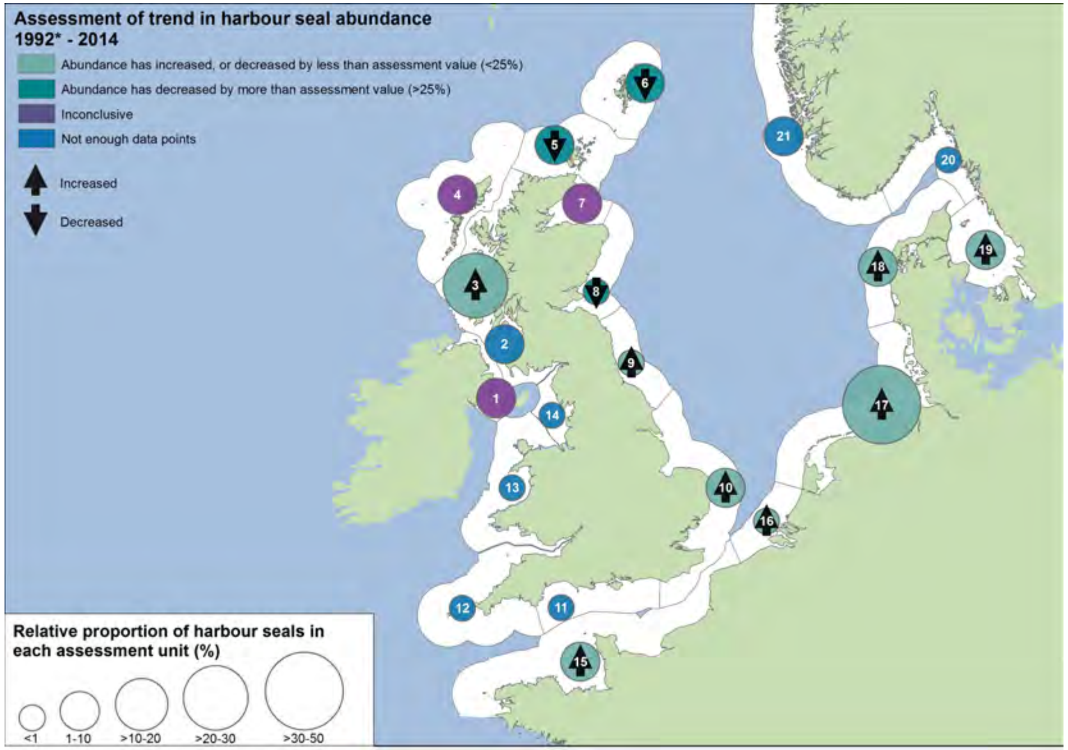


Figure 2: Assessment of long-term change in harbour seal abundance (1992*–2014). The numbers in each circle refer to the respective 'Assessment Unit' (mentioned in the text as AU). **Although 1992 was used as the baseline year, in some Assessment Units a later year was used due to data availability*

Conclusion

Grey seal numbers have increased throughout the areas assessed, as they recover from historical hunting pressure. Harbour seals are in decline in parts of the north-east of the United Kingdom, but are stable or increasing in most other regions. The reason(s) for the marked and prolonged declines detected in Orkney (AU5), Shetland (AU6), and East Scotland (AU8) are presently unclear but major research initiatives are already in place to investigate potential causes. One possibility is that the decline in harbour seal abundance has resulted naturally from increased competition with grey seals.

Knowledge Gaps

There are several knowledge gaps that need to be addressed to improve this assessment for it's next iteration. Data collection could be improved for some North Sea assessment units (AU) and the geographic scale could be increased. The frequency of monitoring could be improved to increase the power of the assessment. Further studies could be undertaken into the reasons for historic declines to help develop the understanding of pressures and impacts on the grey and harbour seal populations. Interactions between grey and harbour seal populations could also be investigated to develop understanding of how these impact each other.

This document was published as part of OSPAR's Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments

Grey Seal Pup Production

MSFD Descriptor: 1 - Biological diversity
MSFD Criterion: 1.3 - Population condition

Key Message In the Greater North Sea and in parts of the Celtic Seas, the number of grey seals born each year has increased substantially since 1992 and has continued to rise in recent years (2009–2014)

Background

This indicator assesses trends in the number of grey seal pups born at breeding sites in the Greater North Sea and in the United Kingdom part of the Celtic Seas. Grey seals gather to breed at long-established colonies located on islands, sand banks and mainland coastlines around Europe.

As higher predators, seals can be used as an indicator to reflect the state of the marine ecosystem. Grey seal pup production is influenced by many factors such as disease, competition with other species, changes in the distribution and abundance of prey, disturbance, and interactions with fisheries. Grey seals were hunted into the 20th Century, and as a result have disappeared entirely from some areas, but are now protected in most areas of Europe.

Seals have been hunted both illegally and legally for a long time and it is not possible to know the undisturbed state, nor the current carrying capacity that could be attained alongside protection from illegal hunting. Except for hunting, no straightforward link has yet been identified between pup production and human activity, although several human activities may, at least in part, drive change in pup production. If changes are detected, this signals the need to investigate the cause and to determine whether management measures are required.

Image: Atlantic grey seal pup (*Halichoerus grypus*) © Arran Bee

Results

In the Greater North Sea and parts of the Celtic Seas, grey seal pup production has 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 (**Figure 1 and Figure 2**). There is no decline in pup production in these areas, in line with both assessment values. Although the data available for Shetland (AU6) were not sufficient to allow an assessment, pup counts appear to indicate a long-term decline in pup production during the period 2004–2014.

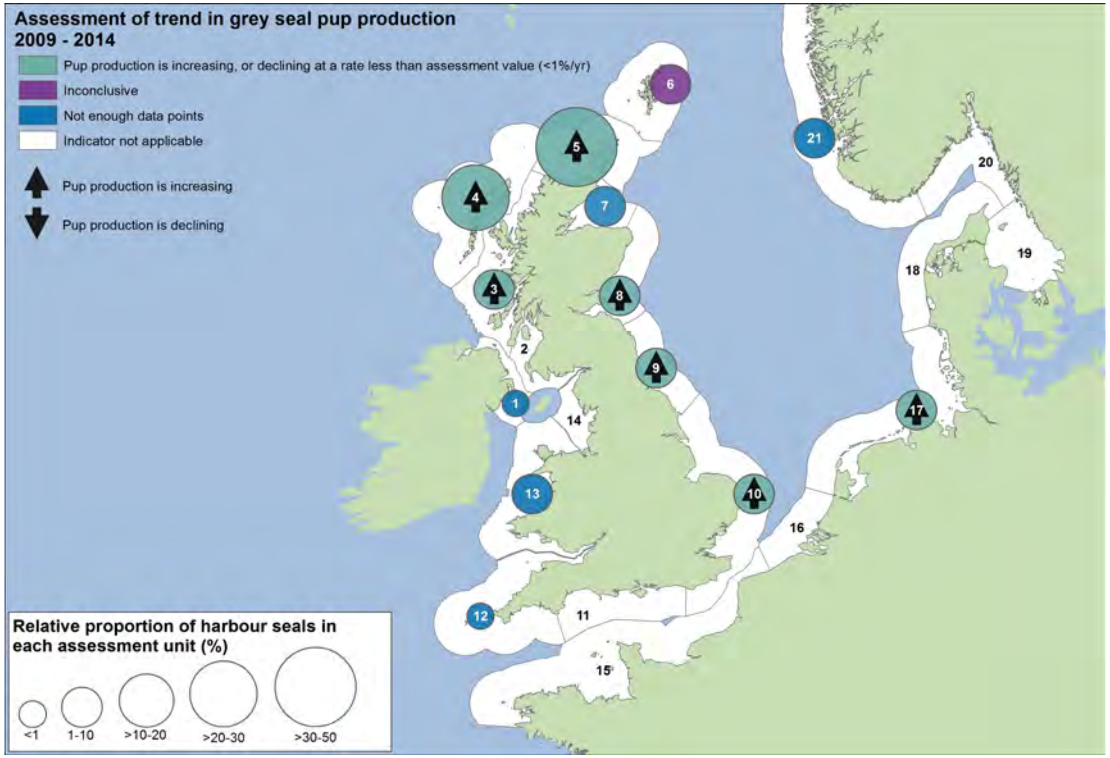


Figure 1: Change in grey seal pup production during the period 2009–2014, assessed against no decline greater than 1% per year. The numbers in each circle refer to the respective 'Assessment Unit' (mentioned in the text as AU).

Results cont...

Grey seal pup production increased rapidly in Greater North Sea Assessment Units (AUs) during the period 2009–2014. It is likely that the increase in pup production in the AUs in continental Europe (e.g. the Wadden Sea, AU17) is being driven by the immigration of animals from the large colonies to the north of the United Kingdom.

Growth rates in pup production were lower in West Scotland (AU3) and the Western Isles (AU4). This may be due to these areas approaching carrying capacity.

Changes in grey seal pup production were assessed up to 2014 in the Greater North Sea and in parts of the Celtic Seas within British waters. Grey seals breed along the coast of Ireland, but corresponding data are not available because the data density could not support an assessment.

Long-term change was assessed from a baseline year of 1992 (or later for some time series). Short-term change concerns the period 2009–2014. The analysis looked at the extent of long-term or short-term decline. No declines were detected.

The confidence rating for the methodology was considered to be moderate/low. The confidence rating for data availability was considered to be moderate.

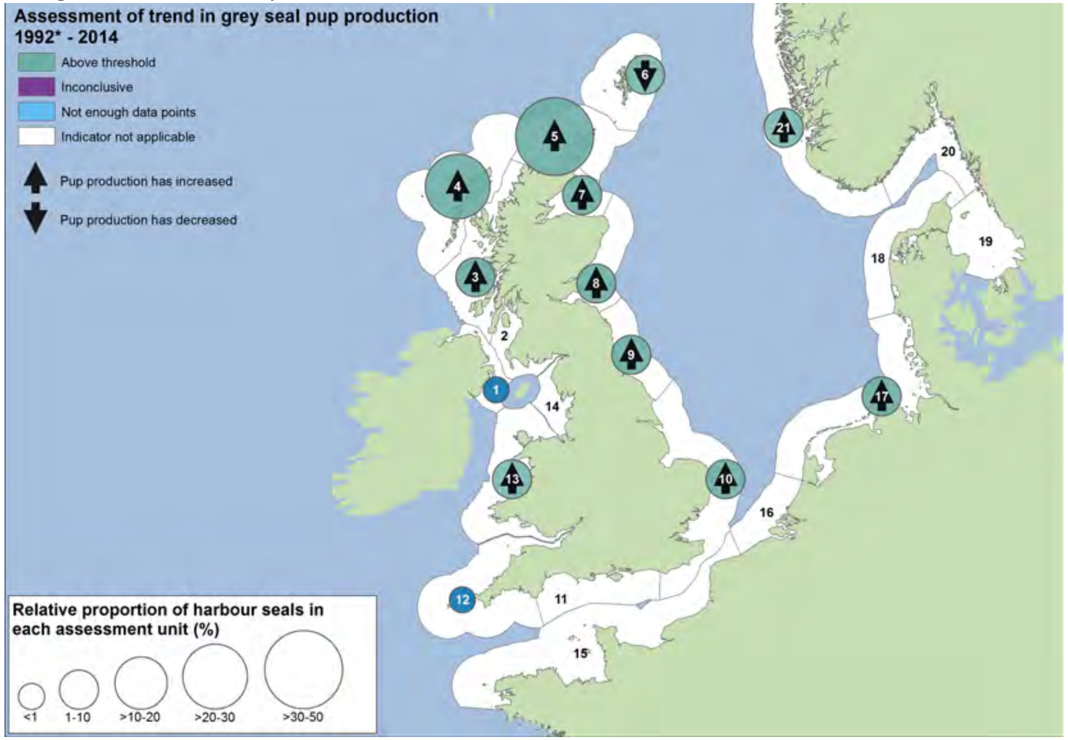


Figure 2: Change in grey seal pup production during the period 1992*–2014, assessed against no decline greater than 25%. The numbers in each circle refer to the respective 'Assessment Unit' (mentioned in the text as AU). *Although 1992 was used as the baseline year, in some Assessment Units a later year was used due to data availability*

Image: Aerial survey image of grey seal colony

Conclusion

Grey seal pup production has increased over both the long term and short term in all assessed areas in the Greater North Sea (except Shetland) and in the parts of the Celtic Seas covered by this assessment.

The results for pup production should be considered alongside those for the 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, pollution and overfishing are all likely to have 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.

Knowledge Gaps

There are several knowledge gaps that need to be addressed to improve this assessment for it's next iteration. There are currently insufficient data points in some of the Assessment Units (AUs) (**Figure 1**). Pup production is only a partial indicator of population condition, which is also affected by female fecundity, pup survival and body condition and this aspect of the indicator could be further developed. There is also a lack of information on human impacts on pup production and how adult grey seals move between AUs, including how this impacts populations.

This document was published as part of OSPAR's Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments

Summary Status of the OSPAR Network of Marine Protected Areas 2016

OSPAR Thematic Assessment

OSPAR COMMISSION

Key Message Since the 2010 Quality Status Report, OSPAR countries have nominated a further 289 marine protected areas to the Network, now comprising 448 protected areas, representing 5.9% of the OSPAR Maritime Area. Considerable progress has been made towards an ecologically coherent and well-managed network, particularly within the Greater North Sea and Celtic Seas. Nevertheless, further work is required

Background

In 2003, OSPAR set the goal to establish a network of marine protected areas (MPAs) across the North-East Atlantic and to ensure that it is ecologically coherent and well-managed. It is intended that the MPA network makes a significant contribution to the sustainable use, protection and conservation of marine biodiversity across the North-East Atlantic, including in Areas Beyond National Jurisdiction (ABNJ).

The assessment of ecological coherence was based on OSPAR's principles for an ecologically coherent network of MPAs. The following criteria were used:

- The geographic distribution of MPAs across the OSPAR Maritime Area to assess connectivity;
- The proportion of biogeographic provinces within MPAs to assess representativity; and
- The extent to which OSPAR listed habitat and species are protected within MPAs, to assess sufficiency of protecting features and their resilience.

The following questions were used to explore how well-managed the OSPAR MPA network is. These are based on the key stages in the implementation cycle of an MPA:

- Is MPA management documented?
- Are measures implemented?
- Is monitoring in place?
- Movement towards or achievement of conservation objectives?

With a better understanding of ecological coherence and management within the MPA network, OSPAR will be better able to identify gaps in the network and whether management measures need adjustment. Further details of both assessments are provided in the 2016 Status Report of the OSPAR MPA Network.

Results

Overall Status of the OSPAR MPA Network

On 1 October 2016, the OSPAR Network comprised 448 MPAs (**Figure 1**), including seven MPAs situated in ABNJ. The OSPAR MPA network covers 5.9% of the OSPAR Maritime Area and there is good coverage of coastal waters (16.7%). In the Exclusive Economic Zones (EEZs) of OSPAR countries, 2.3% of waters are covered and 8.9% are covered in areas beyond national EEZs.

The coverage of MPAs in the OSPAR Regions is shown in **Table 1**. In the Greater North Sea, the Convention on Biological Diversity target of 10% coverage by area-based measures has been exceeded.

Ecological Coherence of The OSPAR MPA Network

Despite good progress since 2010, the OSPAR MPA network cannot yet be considered ecologically coherent. Although the OSPAR MPA network is well distributed in the Greater North Sea and Celtic Seas, substantial gaps remain in Arctic Waters and the Wider Atlantic.

OSPAR Region	% coverage with MPA
Arctic Waters	1.9
Greater North Sea	14.7
Celtic Seas	7.6
Bay of Biscay and Iberian Coast	5.9
Wider Atlantic	8.3
OSPAR Maritime Area	5.9

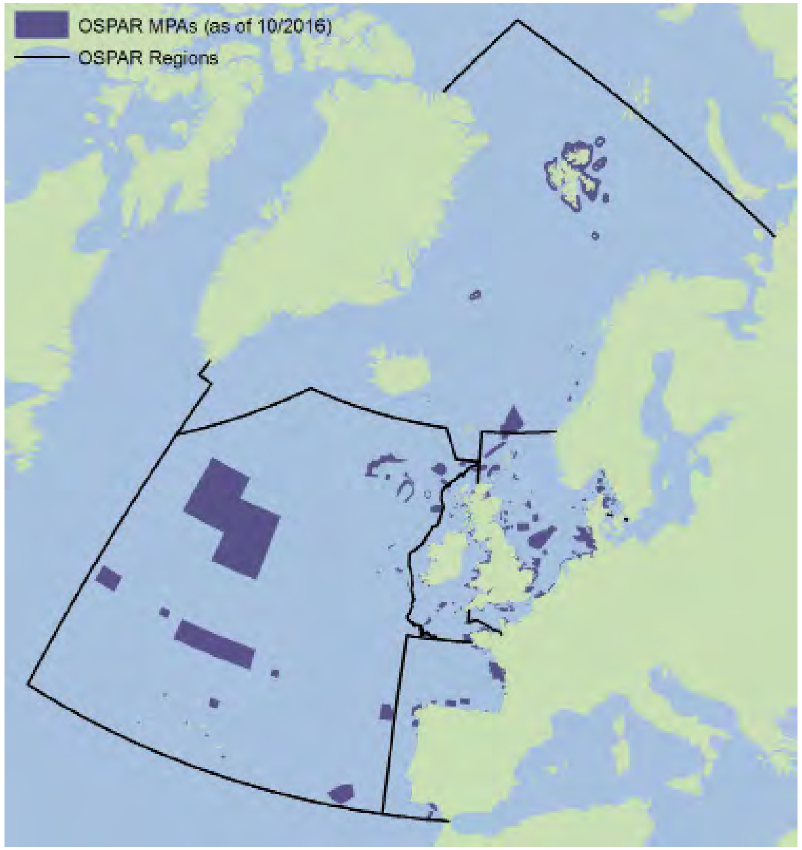


Table 1: Percentage (%) coverage of the five OSPAR Regions by OSPAR MPAs as of October 2016

Figure 1: OSPAR MPAs across OSPAR Regions (as of October 2016)

Results cont...

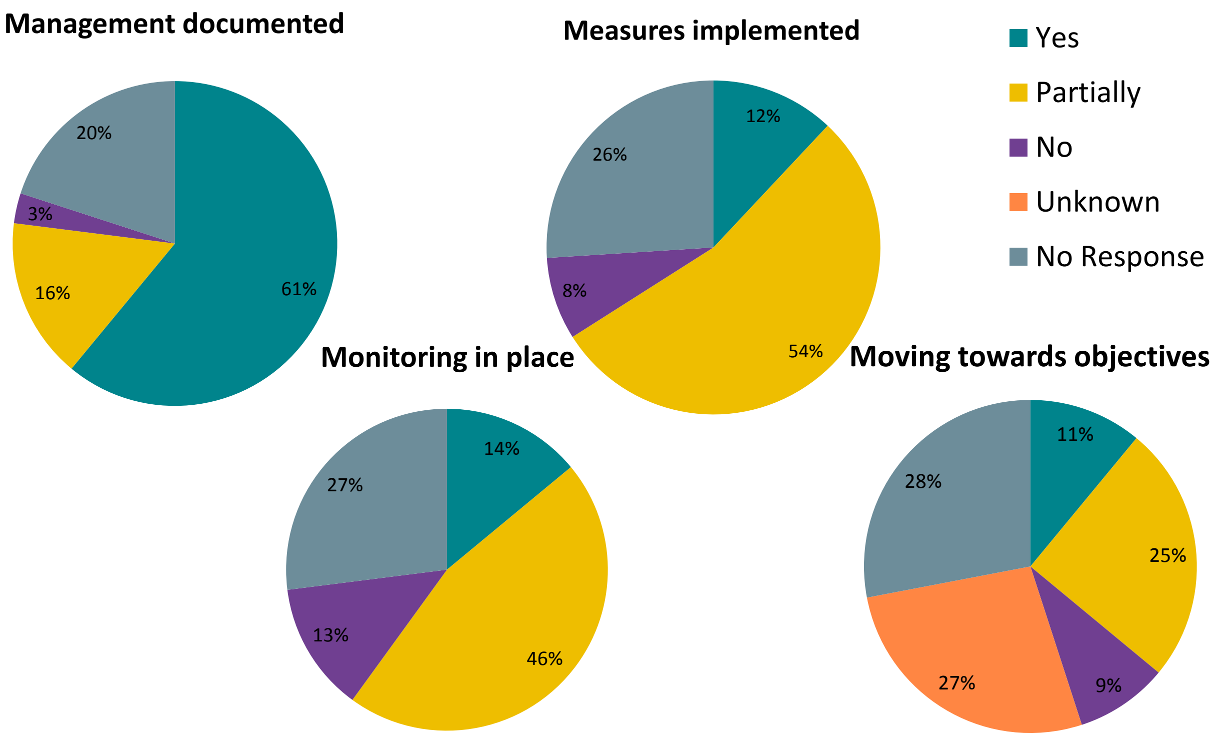
Nineteen of the 54 OSPAR listed features (i.e. species or habitats) are protected by more than one MPA in those parts of the North-East Atlantic where they are considered to be at risk. This includes all five listed invertebrates, three of the seven bird species, one of the two reptile species, one of the three marine mammal species, five of the 22 fish species and four of the 15 types of habitat.

Management of the OSPAR MPA network

MPA management information is publicly documented for 61% of OSPAR MPAs, with a further 16% partially documented (**Figure 2**). The latter is largely due to Contracting Parties updating conservation objectives or because work to identify potential management actions is ongoing.

Management measures have been implemented for 12% of OSPAR MPAs, with partial action for a further 54% (**Figure 2**). The situation is similar for site condition monitoring, where data have not yet been collected for all MPAs. As a result, only 11% of OSPAR MPAs are known to be moving towards or have achieved their conservation objectives.

Countries have started to implement management actions for OSPAR MPAs in ABNJ. Successful management, however, requires cooperation with international organisations with competence for the management of human activities, such as fishing, shipping and deep sea mining. A mechanism to help cooperation and communication between such organisations has been initiated in the North East Atlantic, referred to as 'the collective arrangement'.



Conclusion

Considerable progress has been made towards an ecologically-coherent and well-managed MPA network within the OSPAR Maritime Area, particularly within the Greater North Sea and Celtic Seas.

In the context of ecological coherence, efforts are needed to fill the perceived gaps in the MPA network. The Arctic Waters, Bay of Biscay and Iberian Coast and the Wider Atlantic could benefit from further MPA nominations. Further work is also required to ensure that habitats and species considered by OSPAR to be at risk, are adequately protected by MPAs where appropriate.

In the context of MPA management, additional efforts to implement management measures necessary to achieve the conservation objectives of the protected features of OSPAR MPAs should be considered. In parallel, long-term monitoring programmes could be broadened to evaluate with greater confidence whether the conservation objectives of OSPAR MPAs are being achieved.

For OSPAR MPAs in ABNJ, cooperation through dialogue and information sharing with relevant competent international organisations should be continued, in order to help the implementation of effective management measures for these MPAs.

Knowledge Gaps

The assessment methodologies for establishing ecological coherence and management effectiveness within Marine Protected Areas require development before the next OSPAR assessment, to ensure the results are robust.

To further develop these assessments the following information is required: Data and information to help support evaluation of the OSPAR conservation objectives, distribution, protection, and status of OSPAR listed features and habitats; knowledge of critical areas for wide-ranging species; and, improved information on the management status of all OSPAR MPAs.

Figure 2: OSPAR MPA Management. The pie charts represent each of the four questions used to assess MPA management as of October 2016

This document was published as part of OSPAR's Intermediate Assessment 2017.

The full assessment can be found at www.ospar.org/assessments

Changes in Phytoplankton Biomass and Zooplankton Abundance

MSFD Descriptors: 1 - Biological diversity; 4 - Marine food webs

MSFD Criteria: 1.6 - Habitat condition; 1.7 - Ecosystem structure; 4.1 - Productivity (production per unit biomass) of key species or trophic groups

Key Message Plankton form the base of the marine food web and respond rapidly to environmental changes. Local and large-scale changes in phytoplankton biomass and zooplankton abundance (beyond natural variation) were observed over the period 1958–2002, providing a possible early warning of a wider change in the marine environment

Background

Plankton organisms (both phytoplankton and zooplankton) form the base of the marine food web and are highly sensitive to physical and chemical factors, including nutrient concentration, salinity, and temperature. These factors are dependent on natural variation in climate and hydrography, as well as human-induced processes. Due to their short lifecycles, plankton communities respond rapidly (potentially more rapidly than other trophic levels) to these processes. Plankton-based indicators therefore have the potential to detect those changes at an early stage. Plankton is also essential for organisms higher up the food web, such as shellfish, fish and seabirds, and changes in the plankton community can thus impact on the whole marine ecosystem.

This indicator based on phytoplankton biomass and zooplankton abundance, provides a means to identify changes (anomalies) in key groups within the plankton community; changes which represent deviations from the assumed natural variability in the plankton time series. These are identified as small, important or extreme changes). This indicator can also help to understand changes in other parts of the marine food web. It has been assessed at two scales: large-scale (ecohydrodynamic regions) and small-scale (coastal stations). When combined with the two other pelagic indicators (that look at changes in plankton lifeform and changes in plankton diversity), it will enable a more sensitive detection of change at the plankton community level.

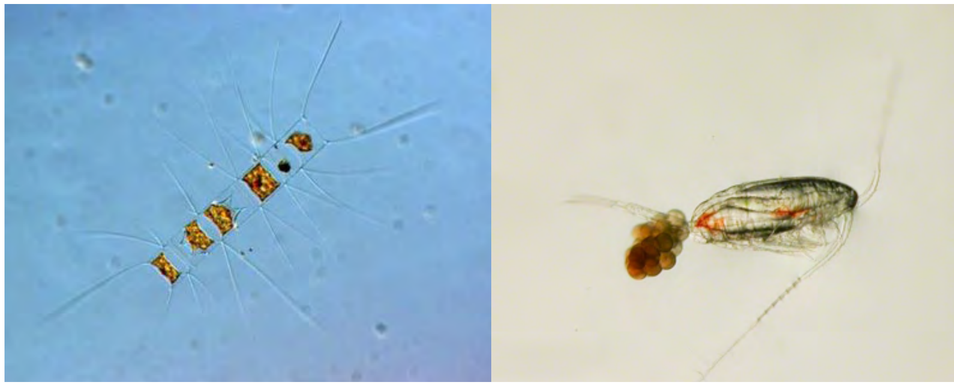


Image (left): Phytoplankton of the genus Chaetoceros and (right) A copepod, the most common type of zooplankton organism © Anais Aubert

Results

For phytoplankton, the time-series can be subdivided into four main periods (**Figure 1**). From the start of the time-series (1958) to around 1965, most anomalies are negative and qualified as important changes. The period 1965-1975 then appears relatively stable and characterised by small changes in phytoplankton biomass. From 1975, a decrease occurred with mostly negative anomalies, categorised as important changes in phytoplankton biomass. In fact, this period is recognised as marking a regime shift in the North Sea. The phytoplankton biomass after 1985 and up to 2012 mostly exhibits positive anomalies categorised as small and important scale change, with very few exceptions. The anomalies increase in strength, and are qualified as important, between 2010 and 2012.

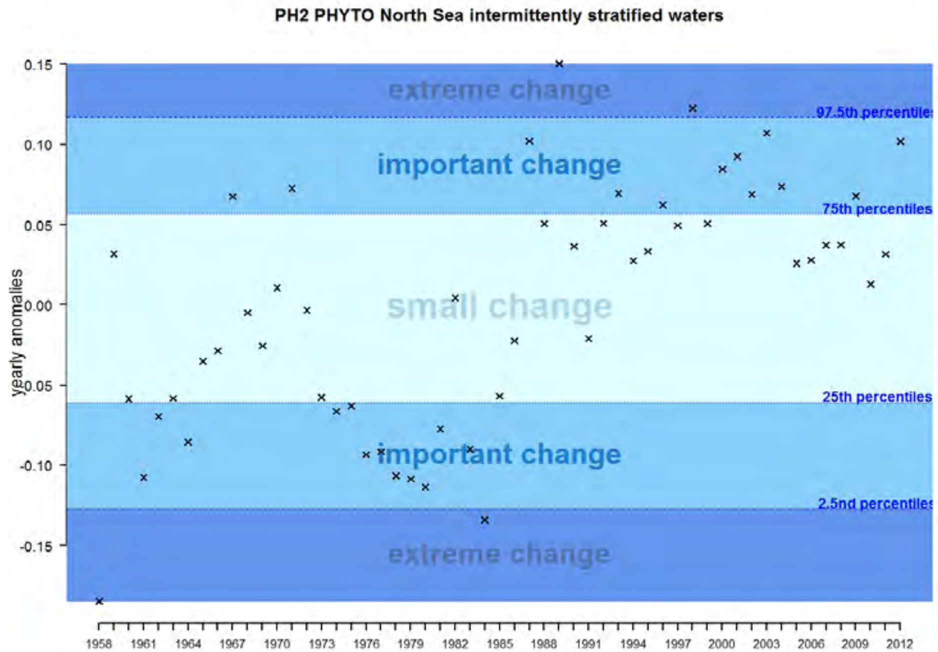


Figure 1: Annual anomalies for phytoplankton biomass for the Greater North Sea for intermittently stratified waters over the period 1958–2012

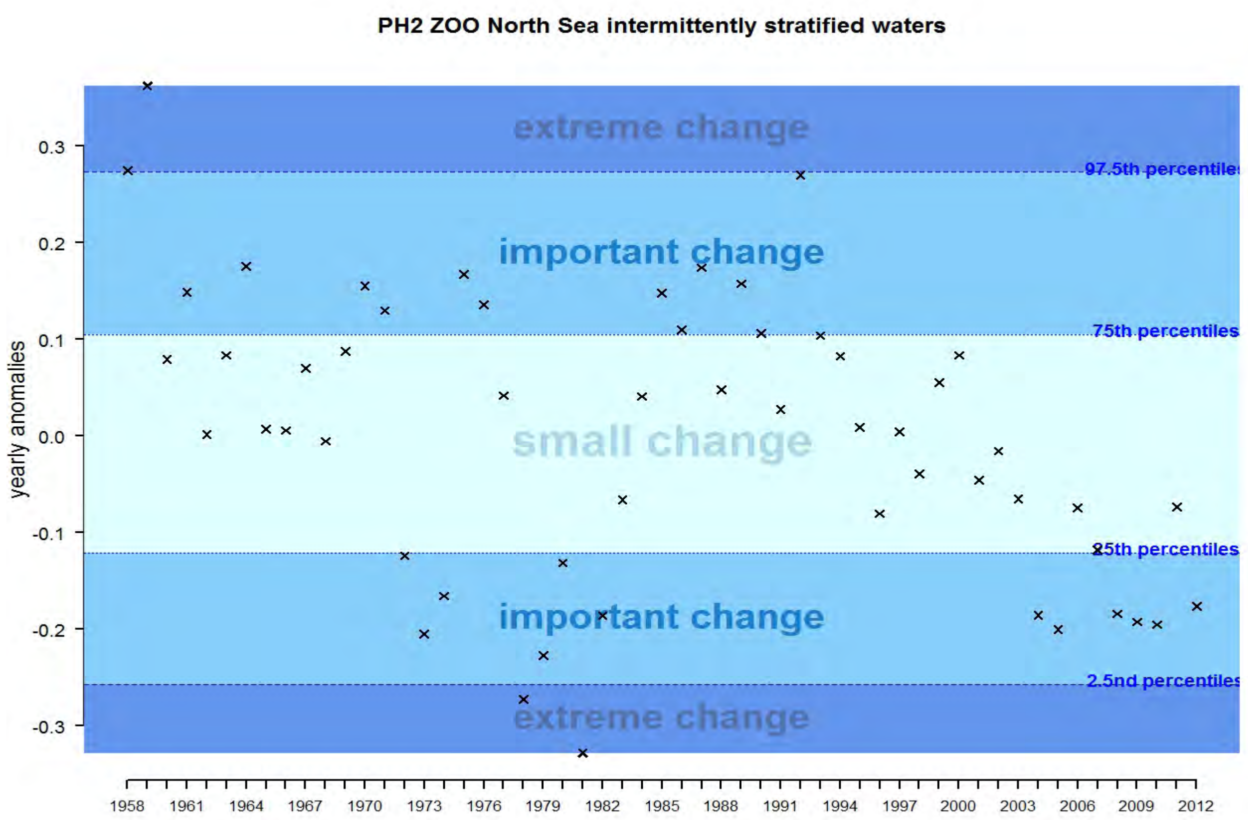
Changes in Phytoplankton Biomass and Zooplankton Abundance

OSPAR COMMISSION

Results cont...

For zooplankton, the time-series of annual anomalies shows five main periods between 1958 and 2012 (**Figure 2**). The time-series exhibits positive anomalies representing extreme change at the start (1958–1959) followed by a period with positive anomalies showing important and small change, between 1960–1972. After 1970, we see mostly negative anomalies and categorise these as important changes with some notable extreme negative anomalies around 1980. This shows a clear decrease in zooplankton abundance over this period. This period also corresponds to a well-known regime shift and fish stock decline in the North Sea. From 1982 to 2006, zooplankton abundance increased with mostly positive anomalies exhibited, and with some important changes, up to the mid-1990s. Subsequent anomalies are negative, and start to be for most of them, qualified as important changes from 2004 to 2012 showing a decrease in zooplankton abundance. The results tend to show that for this EHD zone (intermittently stratified waters) and for the known regime shift of the early 1980s, that zooplankton abundance exhibits stronger negative anomalies than phytoplankton biomass. For the most recent period after 2000, the results show two opposing tendencies: zooplankton abundance tending to decrease while phytoplankton biomass tended to increase. These results need to be related to knowledge about environmental variability and human pressures in order to fully interpret them.

The methods and data for this indicator are considered to be of moderate confidence.



Conclusion

This indicator shows the variation in phytoplankton biomass and zooplankton abundance for large geographic areas (ecohydrodynamic zones and entire OSPAR regions) and some small scale coastal stations. The indicator is based on the identification of changes calculated through time-series anomalies of phytoplankton biomass (chlorophyll-a and Plankton Colour Index) and zooplankton abundance (total copepod abundance).

The assessment is preliminary and shows that important scale changes occurred, acting as an early warning and flagging a potential issue for the wider marine ecosystem.

Knowledge Gaps

Further work recommendations are as follows: 1. Further interpretation of the results in detail, considering monthly anomalies and scientific knowledge expertise of the studied geographical assessment unit; 2. Link with environmental and anthropogenic pressure data to interpret the changes; and 3. Definition of reference periods related to GES (Good Environmental Status).

Figure 2 (left): Annual anomalies for zooplankton abundance for the Greater North Sea for intermittently stratified waters over the period 1958–2012

This document was published as part of OSPAR's Intermediate Assessment 2017.

The full assessment can be found at www.ospar.org/assessments

Changes in Phytoplankton and Zooplankton Communities

MSFD Descriptors: 1 - Biological diversity; 4 - Marine food webs

MSFD Criteria: 1.4 - Habitat distribution; 1.6 - Habitat condition; 4.3 - Abundance/distribution of key trophic groups/species

OSPAR COMMISSION

Key Message Plankton form the base of the marine food web and respond rapidly to environmental change, making them important indicators of ecosystem state. Between 2004-2014 Plankton communities experienced significant changes in relative abundance, indicating alterations to aspects of ecosystem functioning. The changes are widely accepted to be linked to prevailing conditions and may be driven by climate change, nutrient enrichment or other factors

Background

Plankton (microscopic algae and animals) form the base of the marine food web, making them important indicators for ecosystem state. Changes in plankton communities can affect higher food web levels, such as shellfish, fish and seabirds, since these organisms are supported either directly or indirectly by plankton. Indicators based on plankton lifeforms (i.e. organisms with the same functional traits; **Figure 1**) can be used to reveal plankton community responses to factors such as nutrient loading from human activities and climate-driven change. When examined in pairs with an ecologically-relevant relationship (**Figure 1**) changes in the relative abundance of two lifeforms together (called a lifeform pair) can indicate change in key aspects of ecosystem function, including links between pelagic and benthic communities, energy flows and path-ways, and food web interactions. For example, changes in the phytoplankton (algae plankton) lifeform can cause changes in the zooplankton (animal plankton) lifeform that feeds on them. At the North-East Atlantic regional scale, plankton community change is strongly linked to prevailing climatic conditions. Pelagic habitats, which are defined based on key water column features, are important to plankton community structure and dynamics (**Figure 2**).

Because this is a new Indicator Assessment in the first phase of development, no assessment value exists. Instead, the years 2004 to 2008 are used as compared to the last 6-year period (2009 to 2014) to examine changes in lifeform pairs.

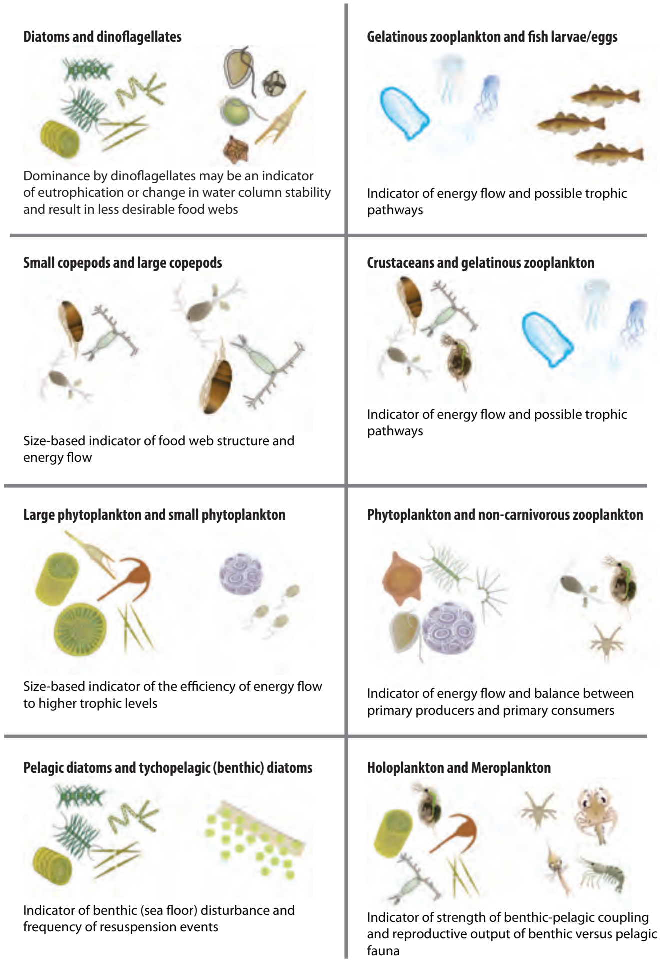


Figure 1: Plankton lifeform pairs and ecological rationale for their selection

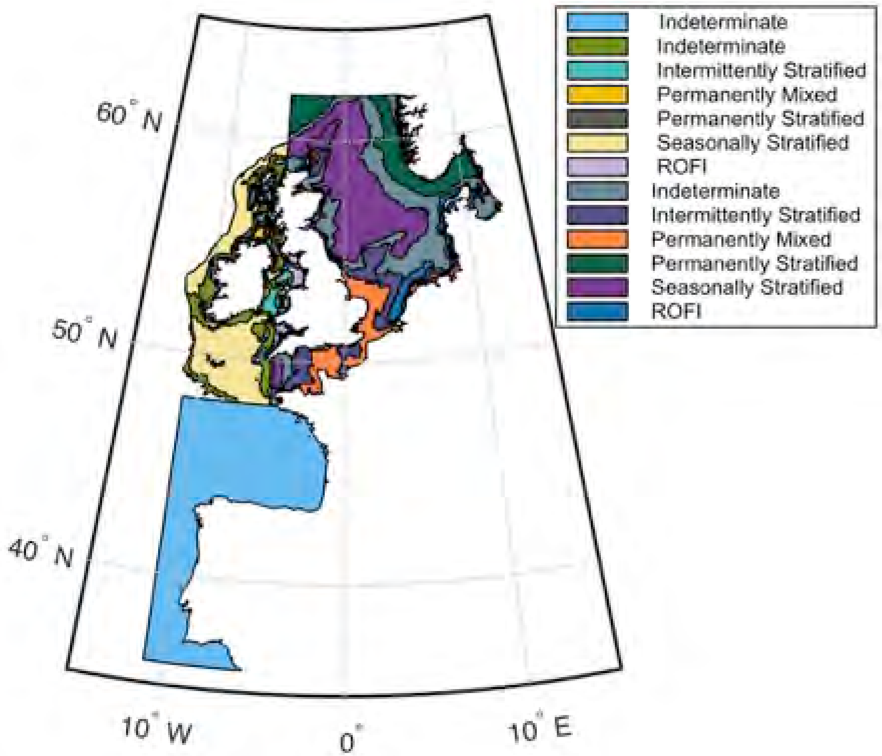


Figure 2: Ecohydrodynamic zones (EHDs) in the Greater North Sea, Celtic Seas, and Bay of Biscay and Iberian Coast

Ecohydrodynamic zones (EHDs) are constructed based on key water column features, which are important to plankton community structure and dynamics. Based on water column structure, there are six predominant EHD are types: permanently mixed throughout the year; permanently stratified throughout the year; regions of freshwater influence (ROFIs); seasonally stratified (for about half the year, including summer); intermittently stratified, and; indeterminate regions (inconsistently alternate between the above levels of stratification). Work is on-going to define echohydrodynamic zones in the Bay of Biscay and Iberian Coast

Changes in Phytoplankton and Zooplankton Communities

Results

This assessment reveals change in North-East Atlantic plankton communities between the periods 2004–2008 and 2009–2014. Although lifeform pairs exhibited significant change in some areas of the North-East Atlantic (**Figure 3**), this does not necessarily imply deterioration of environmental conditions.

The 'holoplankton and meroplankton' lifeform pair experienced significant change in most areas, suggesting changes in linkage between the benthic and pelagic components of the ecosystem. Changes have also occurred in the 'small copepod and large copepod' lifeform pair in many areas, which could indicate possible alterations to food web structure and energy flows. The 'pelagic and tychopelagic' (benthic) diatom lifeform pair only underwent significant change in a few areas, which could indicate no important changes in resuspension events in much of the North-East Atlantic.

It is not currently possible to link the changes in lifeform pairs to any particular human pressures, or to link these changes to other biodiversity Indicator Assessments.

The methods and data for this indicator are considered to be of moderate confidence.

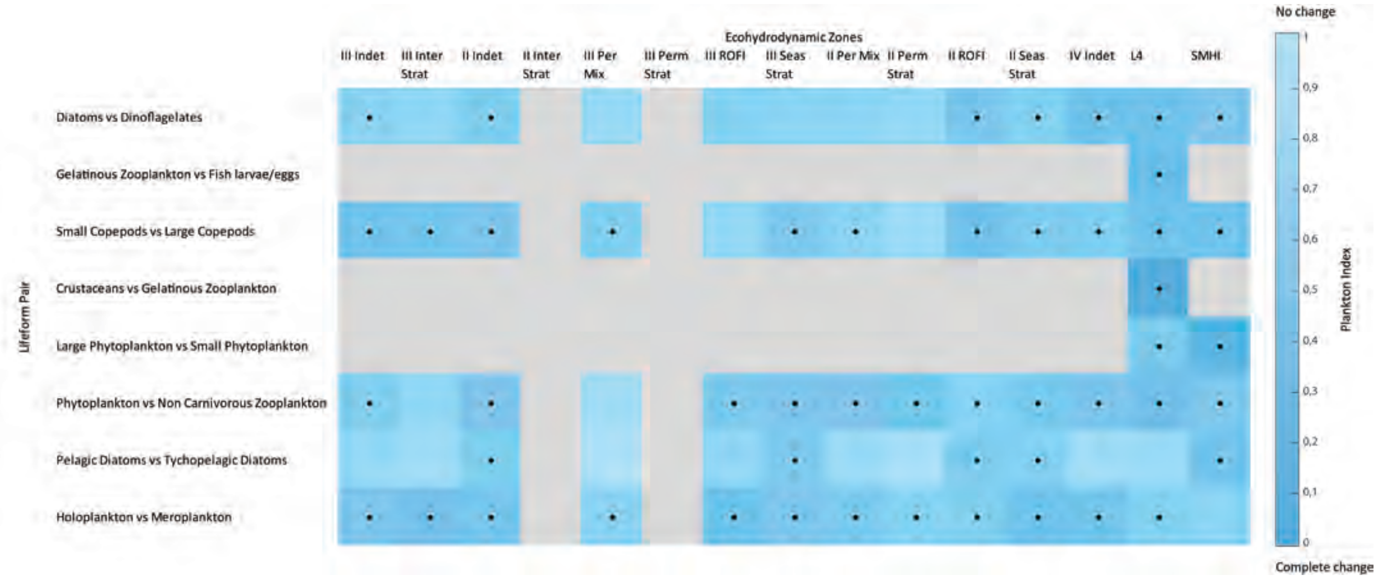


Figure 3: Change in Plankton Index between the periods 2004–2008 and 2009–2014 for each lifeform pair

Darker blue indicates a more pronounced change. Grey shading represents where there were not enough / well-represented data to determine a Plankton Index. Cells with dots indicate significant change (p<0.01) since the period 2004–2008. Changes in the Plankton Index do not necessarily indicate a deterioration of environmental conditions. They do, however, indicate change from starting conditions

Conclusion

This assessment indicates that there is variability in the plankton community for all lifeforms, which is in accordance with the published scientific literature on plankton dynamics.

While the indicator assessment shows there is change, further work is needed to draw conclusions on the magnitude, direction and the key pressures or environmental factors driving change in lifeform pairs. Interpretation of the results and further refinement of the methodology have still to take place. An extensive peer-reviewed research base, however, suggests that prevailing oceanographic and climatic conditions are the overall driver of plankton change in the North-East Atlantic.

Knowledge Gaps

Further scientific research is needed to examine the magnitude and direction of change in the Plankton Index with respect to each lifeform pair, as well as the ecological consequences of such change, for each lifeform pair in each ecohydrodynamic zone. It is also necessary to investigate links between change in lifeform pairs and human and climatic pressures. If changes due to prevailing conditions (such as natural variability and climate change) can be separated from those caused by human pressures in each region, this will help to inform management decision-making by allowing the application of regionally-targeted management measures only where needed.

This document was published as part of OSPAR's Intermediate Assessment 2017.

The full assessment can be found at www.ospar.org/assessments

Pilot Assessment of Production of Phytoplankton

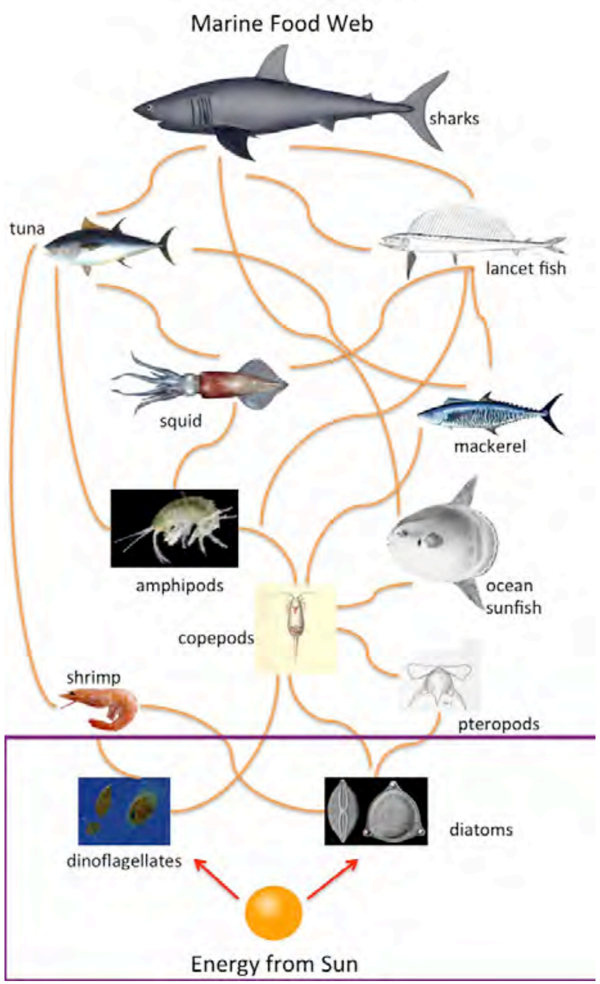
MSFD Descriptor: 4 - Marine food webs
MSFD Criterion: 4.1 - Productivity (production per unit biomass) of key species or trophic groups

OSPAR COMMISSION

Key Message This pilot assessment examines how the primary production of phytoplankton changes over time. The results show site-specific changes, but do not allow a generalised conclusion across OSPAR regions with the current dataset. In future this indicator could help understand effects of management measures and provide information on the dynamics of primary production, which is key to sustaining marine food webs

Background

Phytoplankton comprises photosynthetic plant-like microscopic organisms. The two major groups in coastal systems are diatoms and dinoflagellates. Phytoplankton primary production is fundamental to the marine ecosystem and represents the first available flow of energy through the ecosystem (**Figure 1**). Phytoplankton primary production (i.e. organic matter formation) can be measured in situ using oxygen and carbon dioxide tracers or various fluorometric techniques.



Phytoplankton primary production is affected by various pressures, including nutrient enrichment, light availability, grazing pressure, contaminants, hydrodynamics and climate change. Phytoplankton primary production is useful as an indicator of pressures on the marine food web. The ability of an ecosystem to recover from disturbance is a complex process; information on phytoplankton primary production, together with pelagic habitats indicators (e.g. plankton biomass, abundance and diversity) can help understanding of this process. There is currently no coordinated monitoring in the North-East Atlantic for phytoplankton primary production. This indicator is in development and the current assessment is a demonstration of how it could work, using available data.

Figure 1 (left): Representation of a marine food web (purple box represents phytoplankton primary production)

Figure 2 (right): Map showing the location of the study sites. OMEX: Ocean Margin Exchange (OMEX) project

Results

Measurements from several study sites (**Figure 2**) were analysed and used to support this pilot indicator assessment. For each one, the variations in annual primary production (APP) can be observed over time.

Results cont...

The results for the nine survey sites that were analysed in this pilot assessment are outlined below (**Table 1**).

The difference between the natural variability of a stable state and a change of state was investigated through statistical analysis. The link between the variation in trend, whether it is increasing or decreasing, and pressures on the ecosystem cannot be generalised across the sites included in this pilot assessment.

Study site		Results
North Sea		The ecohydrodynamic region UNC (unclassified for water column stratification) showed a decreasing trend in annual phytoplankton production from the start of the time series (1988-2013); it is not yet clear what is causing these changes.
Skaggerak Coast		Between 1985 and 2012, the long-term trend of primary production declined, however a tendency for increased rates from 1992 to 1996 can be observed.
Sylt-Rømø Bight (Germany, Denmark)		Over the period 1994-2014, no trend can be observed and pressure from human activity has little impact on primary production.
Central and Western English Channel	Portsmouth-Ouistreham transects	The annual estimations (coastal and offshore) show a decreasing gradient in primary production from the French coast to offshore, which could be induced by the coastal nutrient inputs from the Seine river.
	Baie des Veys	The annual estimations show a high coastal primary production linked to the estuarine nutrient inputs, which in turn support shellfish farming activity.
	Roscoff-Plymouth transects	Comparing the offshore annual estimations of both transects (Portsmouth-Ouistreham and Roscoff-Plymouth) shows an interannual offshore stability allowing characterisation of these offshore hydrodynamic zones (i.e. water masses).
Western English Channel Plymouth L4 Station		Over the period 2003-2010, no trend can be observed.
Celtic Sea Shelf Break		Annual estimation only available for 2001.
Liverpool Bay		Over the period 2003-2009, no trend can be observed.

Table 1: Summary of results concerning annual primary production for the various study sites. APP: Annual Primary Production (phytoplankton production)

Conclusion

This pilot assessment shows site-specific changes, however the current dataset does not allow a generalised conclusion across OSPAR regions. This assessment illustrates the potential for the indicator to show changes in phytoplankton primary production and provides key information on the dynamics of primary production. This pilot assessment also demonstrates interannual variability within study sites and variability between them. This indicates the importance of collecting enough years of data to understand the range in variability and the likely causes. Furthermore, phytoplankton primary production in coastal waters shows higher variability than in offshore areas and so needs monitoring at a higher frequency than in offshore areas in order to detect trends. Long-term monitoring in offshore zones should provide answers on more fundamental changes in ecosystems functioning because they are less subject to local variations (e.g. through nutrient inputs).

Based on the case studies presented, it appears that this indicator can contribute to a broader assessment. The first assessment carried out can also provide a baseline for further assessments. Different methods, sampling strategy and sampling design can support the further development of the assessment. This process allows flexibility for Contracting Parties to have differing monitoring programmes but still provide a coordinated assessment.

A more coordinated approach to spatial and temporal monitoring (sampling strategy) is necessary for a full assessment of this indicator. The European Union funded project EcApRHA resulted in a large amount of methodological development and scenarios to improve monitoring, enhancing the indicator’s development.

Knowledge Gaps

The relationship between pressures and phytoplankton primary production is not completely clear and should be evaluated in conjunction with other indicators and expert judgement.

The range in natural variations and assessment values for phytoplankton primary production require further study.

To define the assessment scales, hydrodynamic regions could be used, however this needs further validation for this phytoplankton primary production indicator.

The pilot allowed gaps to be addressed within what is planned under existing national monitoring in the near future without any further coordination. However, in order to progress to delivering a full assessment in the next cycle, there is a need for a consistent monitoring strategy to be developed taking into account the techniques available for phytoplankton primary production assessments. The EcApRHA project helped in proposing different scenarios for optimised monitoring.

This document was published as part of OSPAR’s Intermediate Assessment 2017.

The full assessment can be found at www.ospar.org/assessments

Pilot Assessment of Changes in Plankton Diversity

MSFD Descriptor: 1 - Biological diversity
MSFD Criteria: 1.6 - Habitat condition; 1.7 - Ecosystem structure

Key Message Phytoplankton form the base of marine food webs and respond rapidly to environmental change. Variations in plankton community composition affect other pelagic and benthic organisms. This pilot study shows that diversity indices detect trends and significant shifts in community composition. Integrating this indicator with other plankton indicators will improve future assessments

Background

Phytoplankton are plant-like microscopic organisms that occur in the sunlit layers of the ocean and freshwater systems (**Figure 1**). Monitoring phytoplankton can help inform our understanding of how sustained long-term and / or rapid changes in biodiversity can alter marine ecosystem functioning and impact the services they provide to humans. Phytoplankton are already being used as indicators for water quality assessments, such as in the European Union Water Framework Directive (WFD).

While plankton diversity has been adopted as an OSPAR common indicator for the Celtic Seas, this pilot assessment presents results for five sites in the Greater North Sea and Bay of Biscay and Iberian Coast since the only data available to test this indicator was from these regions (**Figure 2**).

Species composition and abundance are influenced by changes in physical and chemical environmental conditions. As a result, phytoplankton communities can fluctuate in space and time. Human-induced disturbances such as pollution and / or eutrophication (i.e. excessive nutrients) can drive marked changes in community composition because only some species can cope with the changed habitat conditions. Consequently, the dynamics of the phytoplankton community, and thus its structural attributes (e.g. diversity, dominance or size structure), will differ from those of natural (undisturbed) communities. To help assess dominance, an analysis of community variance is made over time. Low community variation characterises a site with average species composition over time (little change over time), whereas large community variance may indicate sites that have shifted to a species-poor state.

Figure 1: Five examples of phytoplankton groups. Phytoplankton are extremely diverse, varying from photosynthesising bacteria (cyanobacteria), to plant-like green micro-algae, silicon-armoured diatoms, dinoflagellates, plant-like green algae and calcite-plated coccolithophores (drawings not to scale). [adapted from Sally Bensusen, NASA Earth Observing System Project Science Office and NASA Earth Observatory]

Figure 2: Locations of the five time series. This assessment uses the previous boundary between the North Sea and Celtic Seas, however this will be updated in the next assessment

Results

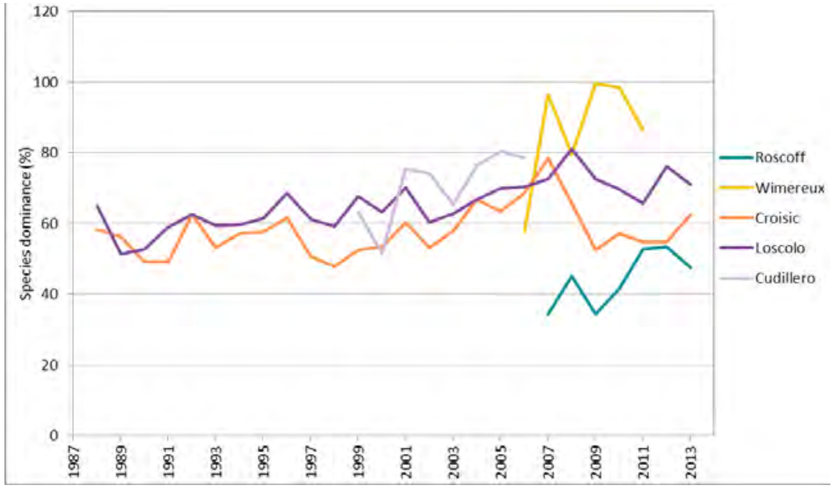
For this pilot assessment, which is a proof of concept, plankton diversity indices have been calculated to examine the seasonal and annual variability in phytoplankton community composition at five sites: four in French waters and one in Spanish waters. The amplitude of the variation in the phytoplankton community was also assessed to identify years where significant changes, or shifts in species composition, have taken place.

The results of this pilot assessment show that diversity indices are useful to describe the structure of the phytoplankton community and also variability of this structure.

Results cont...

Species dominance is highly variable between years and variations are site-specific (**Figure 3**). For the longer time-series (i.e. sites in the Bay of Biscay), a peak in dominance is shown in 2007–2008 but a long-term trend is difficult to identify. For the shorter time-series, i.e. sites in the Greater North Sea (Roscoff and Wimereux), there appears to be a tendency towards increased dominance from 2006 onwards, although care should be taken in trying to interpret trends for such a short period.

For Ouest Loscolo and Le Croisic in the Bay of Biscay (which both have a time series of 26 years), 2007 and 2008 were identified as years with a temporary shift to relatively high community variation (**Figure 4**). Inspection of the phytoplankton community composition, revealed unusually high abundance of *Leptocylindrus* spp. at Ouest Loscolo and a peak in abundance of *Lepidodinium* spp. at Le Croisic. However, the reasons for the high abundances of these species are still unclear.



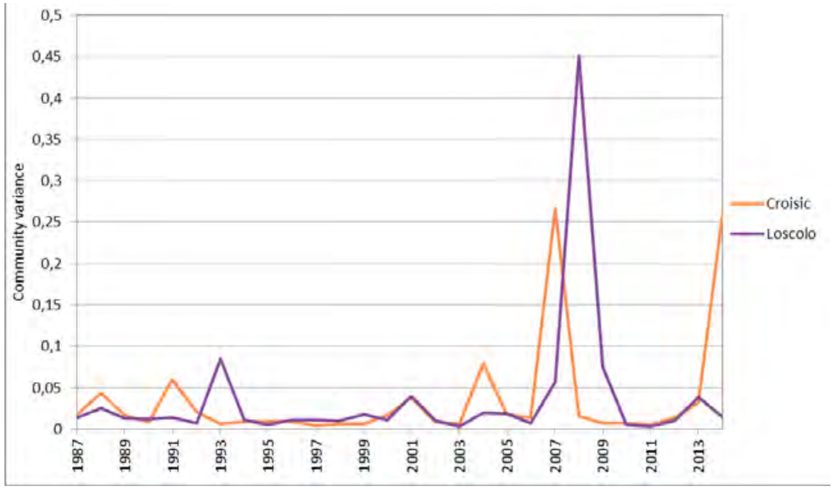


Figure 3 (top): Trends in percentage species dominance (annual averages) at Roscoff (2007–2013), Wimereux (2006–2012), Le Croisic (1988–2014), Ouest Loscolo (1988–2014) and Cudillero (1999–2006). Higher values indicate dominance by few species, whereas lower values indicate a more even balance among species

Figure 4 (bottom): Figure 4: Annual average phytoplankton community variance for Ouest Loscolo and Le Croisic

Conclusion

For the longer time series in this pilot study (Ouest Loscolo and Le Croisic, both Bay of Biscay), the diversity indices show 2007 to 2008 to be years with high dominance values. A corresponding shift in community composition was also identified. The community composition data showed these extreme events were marked by an unusually high abundance of one genus, namely *Leptocylindrus* spp. (a diatom - at Ouest Loscolo) and *Lepidodinium* spp. (a dinoflagellate - at Le Croisic).

As would be expected, the number of species is related to the dominance in the community. When one or a few species become extremely abundant (i.e. dominance increases), the overall number of species in the community (richness) decreases. Variations in the number of taxa and the dominance of phytoplankton species appear to be site-specific. This variation will be a reflection of the prevailing physiographic conditions and human pressures at the individual sites but could provide early warning of where there will be consequences for other pelagic and benthic organisms.

This pilot assessment shows that plankton diversity indices are a promising tool to assess plankton communities. However, for a more robust assessment of pelagic habitats, other measures such as total biomass / abundance of the community and information on functional groups should be included so that a multi-metric indicator could be developed.

The proof of concept presented here may be applicable to data in the Celtic Seas. It is also expected that it would also be suitable for application in other OSPAR regions, depending on data availability.

Knowledge Gaps

For a regional assessment, better acquisition of region-wide plankton data is required, including offshore stations. Appropriate training of taxonomists (to ensure comparable results) as well as the integration of semi-automated sampling techniques (to increase spatial coverage) are recommended for the implementation of monitoring programmes on a regional scale.

This indicator has been used as a proof of concept to assess the state of the phytoplankton community. For a more robust assessment of the pelagic habitat, information on the community structure of phytoplankton should be supplemented by other parameters, such as total community biomass / abundance and the dynamics of their functional groups.

Condition of Benthic Habitat Communities: The Common Conceptual Approach

MSFD Descriptors: 1 - Biological diversity; 5 - Eutrophication; 6 - Seafloor integrity

MSFD Criteria: 1.6 - Habitat condition; 5.3 - Indirect effects of nutrient enrichment; 6.2 - Condition of benthic habitat community

OSPAR COMMISSION

Key Message Benthic habitats are essential for marine life. Assessing their condition against all pressure types is a huge new challenge for science and management. Initial assessment results are available for two pressure types. Further development of this common approach will integrate assessment results and include additional habitat types and pressures

Background

Benthic habitats (**Figure 1**) are essential for marine life, because marine species rely directly or indirectly on the seafloor to feed, hide, rest or reproduce. Benthic habitats are characterised by animal and plant communities with no or slow mobility when compared to fish or marine mammals. The whole benthic community is therefore exposed when a pressure occurs. As a result, the condition (quality status) of benthic habitats is a reflection of the combined effects of all the pressures to which they are subject.

This study presents the concept for a common approach for evaluating the condition of benthic habitats and their communities. The application of this common approach has been endorsed by OSPAR for the Greater North Sea, Celtic Seas, and Bay of Biscay and Iberian Coast through the adoption of a Common Indicator. It has been recognised that to assess the impact of each human pressure on the condition of each benthic habitat type, along a pressure-impact gradient, requires specific assessment methodology and scales (**Table 1**). The aim is to inform management of human activities with as full an understanding as possible of the relative effects of different pressures on benthic habitats and their communities. For example, which habitats are affected, where, by how much and for how long?

OSPAR-wide assessments of benthic habitats are at an early stage of development and this concept will be further elaborated prior to the next OSPAR Quality Status Report and subsequent assessments.

Figure 1: Horse Mussel (*Modiolus modiolus*) beds
© Scottish Natural Heritage

Broad Habitat Type	Broad Pressure Type: Physical damage	Removal of species	Hydrological changes	Eutrophication (nutrients or organic matter)	Non-indigenous species	Contaminants	Litter	Energy, including underwater noise
Littoral rock and biogenic reef				A				
Littoral sediment				A				
Infralittoral rock and biogenic reef				A				
Infralittoral sediment	P			A				
Circalittoral rock and biogenic reef				A				
Circalittoral sediment	P			A				
Offshore circalittoral rock and biogenic reef								
Offshore circalittoral sediment	P			P		P		
Upper bathyal rock and biogenic reef								
Upper bathyal sediment								
Lower bathyal rock and biogenic reef								
Lower bathyal sediment								
Abyssal								

Table 1: Relationships between habitat and pressure types, and how / if the relationships are currently assessed or considered *Relationships based on the revised Marine Strategy Framework Directive (MSFD) - COMMISSION DECISION (EU) 2017/848) and OSPAR / MSFD pressure categories*

Key

A	Assessed and reported under the European Union Water Framework Directive (WFD)
	Considered under the European Union Marine Strategy Framework Directive (MSFD)
P	Partially assessed in the Intermediate Assessment 2017
	Main risks (potentially widespread across the OSPAR Maritime Area)
	Relationship identified but not currently assessed

Condition of Benthic Habitat Communities: The Common Conceptual Approach

Results

For the Intermediate Assessment (IA) 2017 only two condition versus pressure interactions have sufficiently developed methodologies and data availability to undertake assessments in the line with the common conceptual approach. These are coastal habitats in relation to nutrient and / or organic enrichment and species diversity in subtidal sediments in the Southern North Sea versus abrasion (by bottom trawling fisheries).

In the future, to have a better understanding of pressures on the seabed, the assessment of benthic habitats will include results from a range of assessments of specific pressures. Each set of results will differ depending on which pressure type (and thus, specific associated assessment scale) is considered. The cumulative effect of co-occurring pressures (different types of pressure at the same place and in the same time range) is not currently assessed. Further development will take place over the next assessment cycle (depending on progress in developing methods to integrate assessments and other indicators) to provide an overall understanding of the condition of benthic habitats in the North-East Atlantic. Progress on developing cumulative effects assessment is also addressed under Ecosystem Assessment Outlook.

Conclusion

Assessing the condition of benthic habitats against all pressure types within the OSPAR Maritime Area is a huge new challenge for science and management. In only a few years, experts involved in Regional Seas Conventions have developed common approaches to assess the effects of each pressure type.

Currently two habitat pressure interactions have been assessed in line with the common conceptual approach, however work to develop assessment of other habitat and pressure types is promising. Further work is needed to address knowledge gaps, monitoring and data flow needs to ensure sufficient and adequate data for an effective region wide assessment. The added value of a common approach to assessing the condition of benthic habitat communities will be realised through its application in combination with other benthic indicators. This will provide fuller understanding of the extent of the effects of pressures on benthic habitats: i.e. which habitat is affected, where, by how much and for how long has it been impacted? More extensive data and the development of methods for assessments of additional pressure-habitat interactions should, in the future, provide clearer signals and identify clearer trends to inform management needs.

Knowledge Gaps

Further methodological development is required to adapt, operationalise and implement coherently this common conceptual approach for all pressure and habitat types. Although promising, this indicator requires more development and testing to be fully operational for all OSPAR and MSFD purposes for the next assessment. An action plan to address some of these knowledge gaps has been adopted as a result of the OSPAR EcApRHA project.

Image: Biogenic reef *Sabellaria Spinulosa* © Rear Admiral Ron Jessop/Eastern IFCA

This document was published as part of OSPAR's Intermediate Assessment 2017.

The full assessment can be found at www.ospar.org/assessments

Extent of Physical Damage to Predominant and Special Habitats

MSFD Descriptors: 1 - Biological diversity; 6 - Seafloor integrity
MSFD Criteria: 1.6 - Habitat condition; 6.1 - Physical damage, having regard to substrate characteristics

OSPAR COMMISSION

Key Message Bottom contacting fishing physically disturbs seafloor habitats. 86% of the assessed areas in the Greater North Sea and the Celtic Seas have physical disturbance, of which 58% showed higher disturbance. 74% of all assessed areas experience consistent pressure year on year, which is very likely to affect the ability of habitats to recover

Background

Benthic habitats are formed of marine organisms living on or within the sediment and on rock. They undertake essential ecological processes and functions to support healthy ecosystems. They are a key component of the marine food web, including commercial fish and shellfish species, and provide a major food source for predators. The diversity of seafloor habitats is shaped by factors such as depth, light penetration, substrate type and their flora and fauna communities. These create a huge variety of habitat types, with communities showing different levels of sensitivity to physical damage. Some are very sensitive (e.g. fragile coral gardens), whereas others are more robust (e.g. mobile sands). Physical disturbance of the seafloor by human activities such as bottom contacting fishing, aggregate extraction or offshore construction can adversely affect benthic habitats, especially those with larger and fragile species and those with longer recovery time. This Indicator aims to help assess the current spatial extent and level of physical disturbance that human activities have caused to the seafloor.

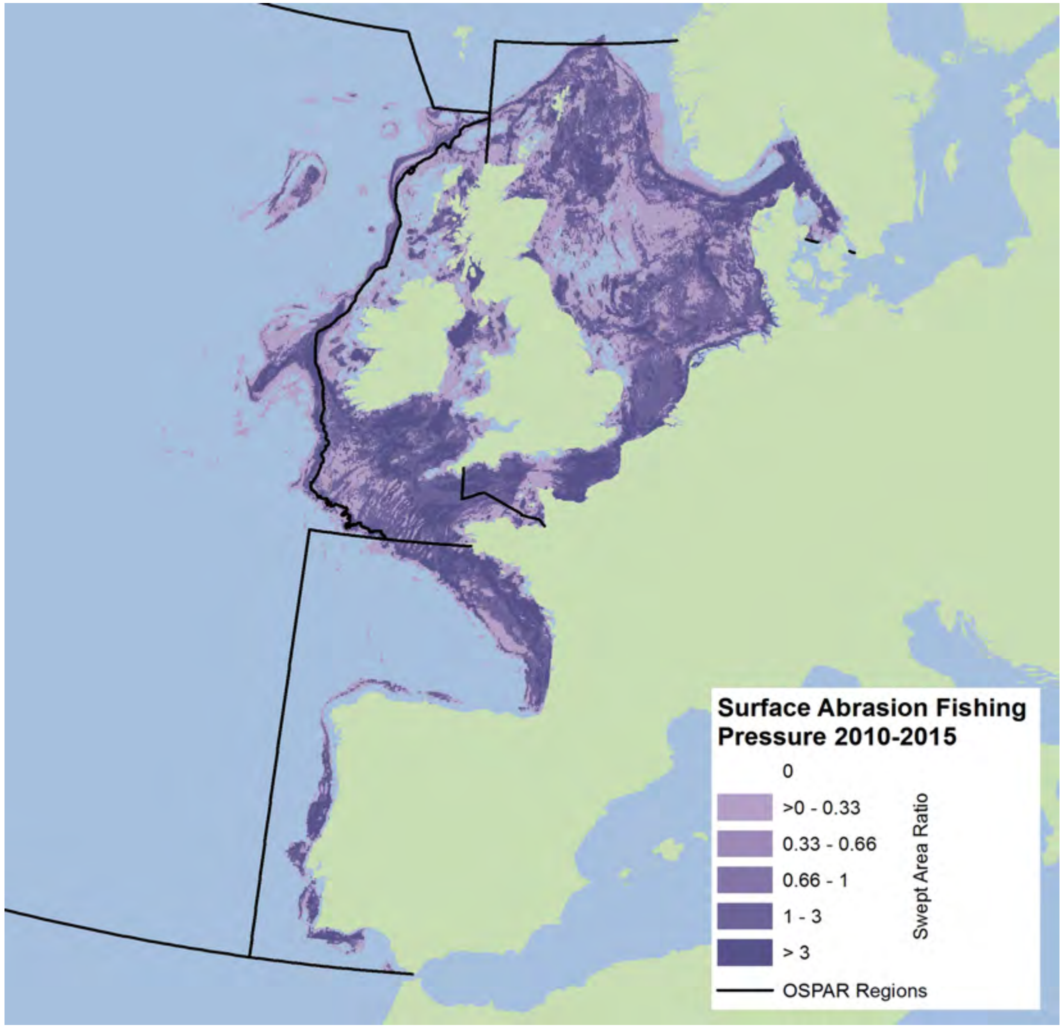


Figure 1: Aggregated surface abrasion pressure using the 2010–2015 data series. Pressure unit is swept area ratio (the proportion of grid cell swept by fishing gear)
The hatched area around the UK shows the areas where inshore fisheries activity from vessels <12 m in length is higher than those >12 m in length

Results

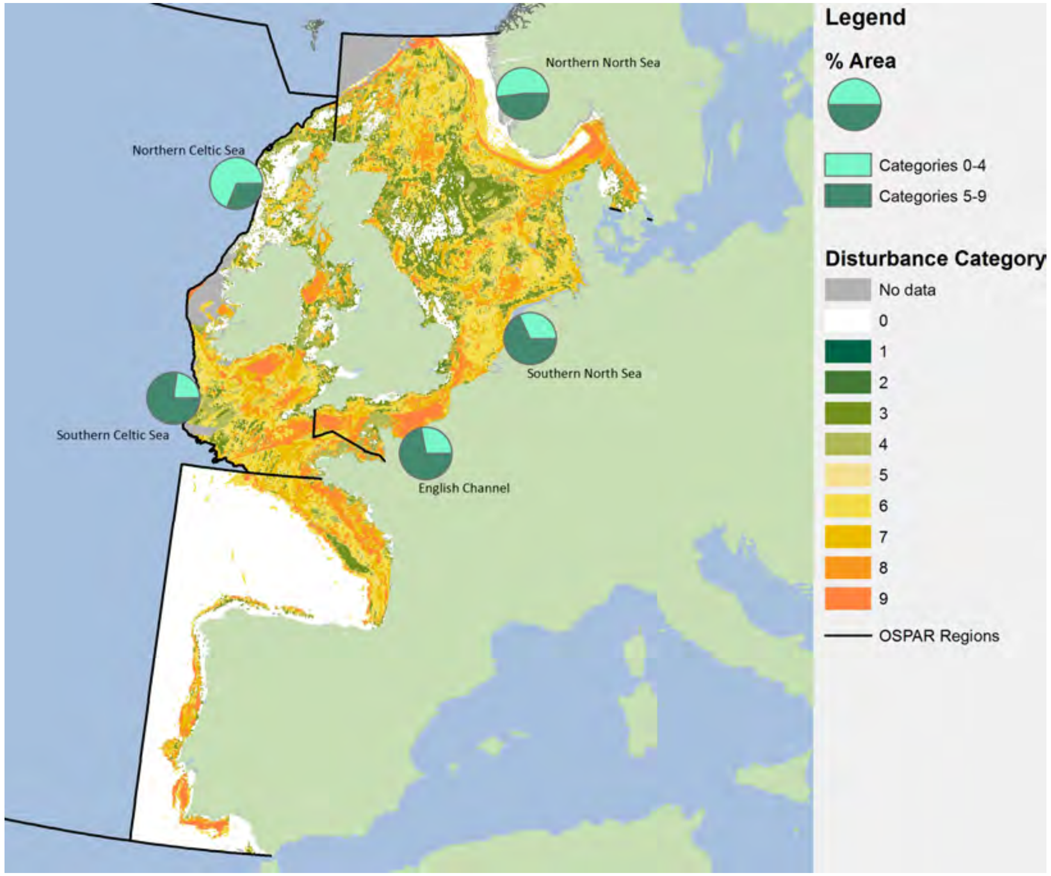
This initial assessment of the Indicator shows the distribution and intensity of pressure from bottom-contact fishing activity and the associated disturbance to the seafloor at the OSPAR regional scale. The approach uses a combination of semi-quantitative and categorical approaches of the pressure / impact relationship between habitats and fishing. A fully quantitative method is not possible at this stage as it would limit results to small-scale locations, or where long-term datasets are available.

Figure 1 shows the distribution of surface abrasion caused by vessels over 12 m in length fishing with bottom contacting gears, aggregated for the years 2010 to 2015. Areas with low levels of fishing-induced surface abrasion or none at all (e.g. north-west of Northern Ireland) are distinguished from those with higher levels of activity (e.g. the English Channel, Skagerrak and Kattegat). Overall, 74% of grid cells assessed experienced consistent pressure year on year, with the remaining 26% showing high levels of variability (a change of three categories or more on the fishing pressure in the same grid across years is considered to be highly variable). This is an important factor for subsequent analysis of disturbance, because how pressure varies over time will affect the ability of habitats to recover. This means that areas with high levels of variability will be at different stages of recoverability and impact.

Extent of Physical Damage to Predominant and Special Habitats

Results cont...

Figure 2 shows the aggregated values for surface and sub-surface seafloor disturbance for the period 2010–2015. The highest level of disturbance is found in the Southern Celtic Seas with 76% of this area subject to high disturbance (categories 5–9). The extent of disturbance in the English Channel and the Southern North Sea is slightly lower, 72% and 68% respectively. Within each assessment area there are grid cells showing no disturbance or low disturbance (categories 0–4), such as some central areas of the Northern North Sea.



This is the first OSPAR-wide assessment of physical damage to benthic habitats. As such, confidence in the methodology is low / moderate. Confidence in the data availability is low (but moderate to high in well surveyed areas).

Figure 2: Spatial distribution of aggregated disturbance using the 2010–2015 data series across OSPAR sub-regions

Disturbance categories 0–9, with 0= no disturbance and 9= highest disturbance. Plots show percentage area of OSPAR sub-regions in disturbance categories 0–4 (none or low disturbance) and 5–9 (high disturbance) across reporting cycle (2010–2015). The percentage was not included for the Bay of Biscay and Iberian Coast due to the lack of complete data

Conclusion

The assessment covers the period 2010–2015. It shows that up to 86% of the grid cells assessed in the Greater North Sea and Celtic Seas show evidence of some physical disturbance of the seafloor from bottom contacting fishing gears, of which 58% of areas show higher levels of disturbance. Areas assessed in the Celtic Seas and the English Channel have higher levels of disturbance than other regions. The amount of pressure across the six-year assessment period is not always consistent, with a quarter of the assessed grid cells showing high variability in pressure. This is particularly evident in the Greater North Sea. Surface pressure is evenly distributed across the assessed grid cells, whereas the highest level of sub-surface pressure is found along the southern and eastern coasts of the Southern North Sea from Northern France to the Kattegat.

Overall there are no clear trends across habitats or regions. The results do not take account of pre-2010 benthic fishing activity, which may have affected areas showing low disturbance or which are subject to pressures from other activities.

The spatial distribution of disturbance values could be used alongside the trend analysis to guide discussion on potential management.

Knowledge Gaps

During the next assessment cycle the aim is to move towards more quantitative approaches. Achieving this will require attention to the following points: availability and accessibility of habitat survey data; the lack of data from small fisheries and other activities causing physical damage (e.g. sand extraction and offshore construction); a review of the sensitivity method to strengthen Step 2; refinement of the disturbance matrix to strengthen Step 4; calculation of a final physical damage index per habitat type and sub-region to strengthen Step 5; and a better understanding of the impacts of different fishing gear types.

This document was published as part of OSPAR’s Intermediate Assessment 2017.

The full assessment can be found at www.ospar.org/assessments

Condition of Benthic Habitat Communities: Subtidal Habitats of the Southern North Sea

OSPAR COMMISSION

MSFD Descriptors: 1 - Biological diversity, 6 - Seafloor integrity
MSFD Criteria: 1.6 - Habitat condition, 6.2 - Condition of benthic community

Key Message Benthic habitat community quality has been sub-regionally assessed in terms of species richness in the southern North Sea. Community quality is generally lower in coastal areas than offshore areas and this is partly due to higher fishing pressure in coastal areas

Background

Benthic (seafloor) habitats are essential for marine life because marine species rely directly or indirectly on the seafloor to feed, hide, rest or reproduce. Benthic habitats are characterised by animal and plant communities with no or slow mobility compared to fish or marine mammals. The whole community is therefore exposed when a bottom pressure occurs. As a result, the condition (quality status) of benthic habitats is a reflection of the combined effect of all the pressures put upon it. The number of species corrected for their abundance, is often used to assess the impacts of different pressures (such as disturbance of the seafloor and extraction of species by fisheries, nutrient and organic enrichment, sedimentation and contaminants) on the benthic habitat and community condition.

Sub-regional-scale benthos assessments are a relatively new development. However, they build upon 15 years of international marine benthos experience within the framework of the European Union Water Framework Directive (WFD). The southern North Sea includes the waters of Belgium, Denmark, Germany, the Netherlands and the United Kingdom (**Figure 1**) and can be regarded as a coherent biogeographical zone of mainly subtidal soft sediments. Therefore the southern North Sea was selected for the first application of a common multi-metric index (MMI) for marine benthos. Several MMIs were tested and the single Margalef diversity index was selected because it is the most pressure sensitive.

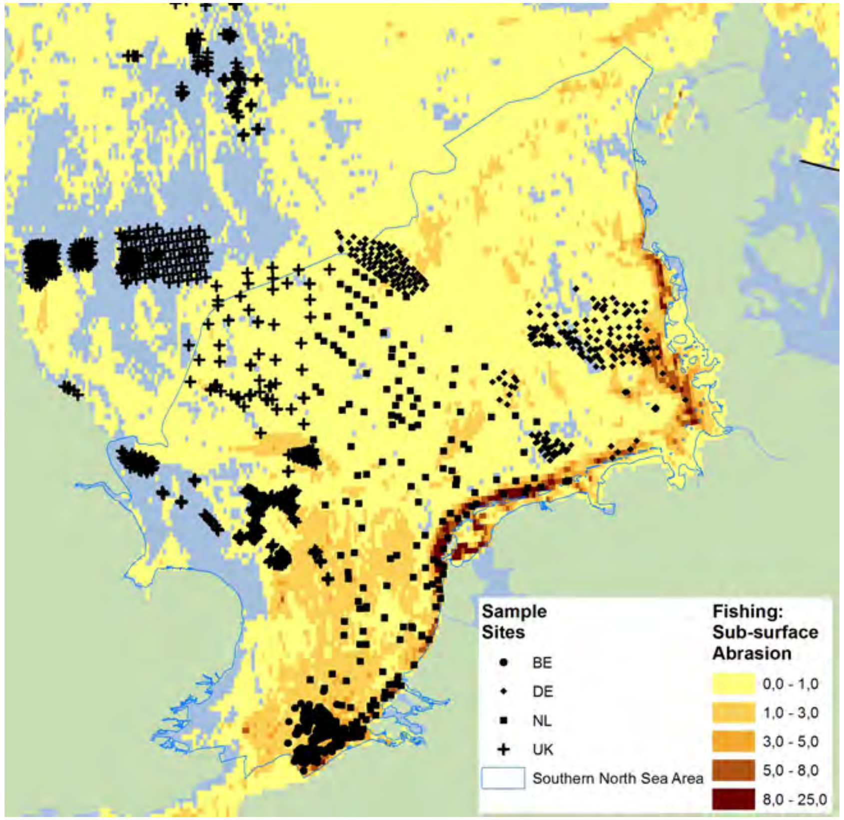


Figure 1: The southern North Sea encompasses the waters of the Belgium, Denmark, Germany, Netherlands, and United Kingdom
Black symbols indicate benthos monitoring samples (no benthos data from Denmark). Yellow/orange shading indicates bottom fishing abrasion in terms of swept area ratio

Results

The Margalef diversity index shows that in the shallow coastal areas of Belgium, Germany and the Netherlands a relatively lower benthic condition is generally observed compared to deeper offshore areas (**Figure 2**). The assessment result shows that, in spite of lower coastal reference values, the normalised Margalef diversity values (defined as sample index values divided by the reference value) in the Belgian, German and Dutch coastal areas are generally lower compared to the offshore areas (such as the German and Dutch Dogger Bank). The areas of the southern North Sea assessed (**Figure 2**) are based on the EUNIS 3 habitat classification system. Each habitat type has been assessed separately.

For the first time, the normalised Margalef diversity value (range 0–1) can be significantly related at a broad international scale to average fishing pressure in the assessment areas of the southern North Sea (**Figure 3**). In Figure 3, the curve shows an exponential decrease in the benthic habitat community condition in the fisheries activity range 0–2.3 subsurface sweeps / year, followed by a stabilisation of the community condition at higher fishing activities. This curve shows that at a fishing activity of >2.3 subsurface sweeps / year a resilient benthic community of lower quality has been induced, which remains at the same quality level under increasing fishing activity. Note that fishing activity has been averaged per assessment area-year to obtain an improved curve. The 90% confidence interval for each data point (assessment area-year) is shown. The relation is highly significant ($p < 0.0001$).

This fishing activity is generally relatively high in coastal areas (**Figure 1**) and relatively low in the Dogger Bank areas. The Dogger Bank extends from the eastern part of British waters to the northern Dutch and German waters. In summary, the normalised Margalef diversity index shows clear differences in benthic community quality between the assessment areas in the southern North Sea (**Figure 2**).

Condition of Benthic Habitat Communities: Subtidal Habitats of the Southern North Sea

OSPAR COMMISSION

Results cont...

The results of this assessment describe the impact of fisheries on benthic habitats. However, other human pressures in the coastal zone, such as nutrients and / or organic enrichment, dumping and sedimentation, coastal sand nourishment (at the shoreline), sand extraction and contaminants can also add to the coastal pressure mix on habitats, depending on the local conditions. Of these typically coastal pressures, only nutrients and / or organic enrichment may be present at a wider scale, while the other pressures generally act on a more local scale.

There is moderate confidence in the method for this assessment and high / moderate confidence for data availability.

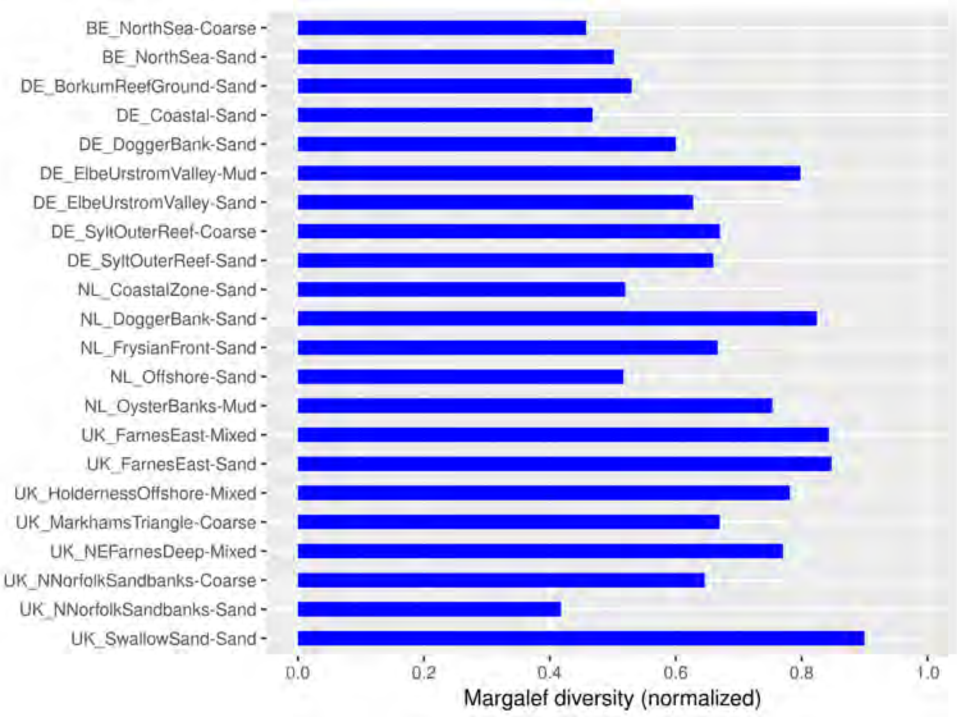


Figure 2: Assessment results for the southern North Sea assessment areas (habitat types) using the normalised Margalef diversity scores (range 0–1) averaged for the period 2010–2015 *Note that higher index scores indicate a higher benthic community quality*

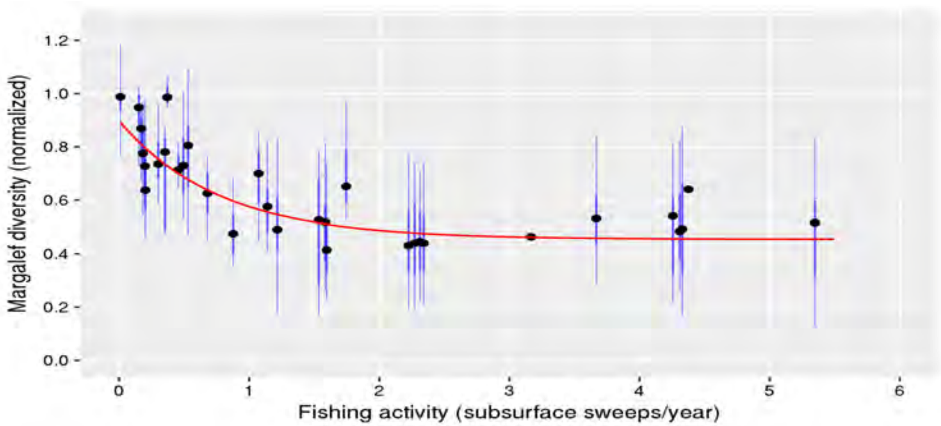


Figure 3: Relation between fishing activity (subsurface) and the normalised Margalef diversity value, as demonstrated for all benthos data from the Southern North Sea in the period 2009–2013 from assessment areas with sufficiently reliable reference values

Conclusion

This assessment has focused on the assessment of Condition of Benthic Habitat Communities - Subtidal Habitats of the Southern North Sea as one component of a more comprehensive indicator of the condition of benthic habitats defining communities (Condition of Benthic Habitat Communities).

The selected Margalef diversity index assessed the benthic community quality and shows clear differences between assessment areas. Coastal areas usually showed lower benthic quality (reduced Margalef diversity compared to reference values), partly due to relatively high fishing activity. Offshore areas, especially those with greater depth, had relatively higher or high Margalef diversity per sample compared to reference values.

This diversity index appears to be the most sensitive benthic index for indicating differences in impacts of fisheries pressures on benthic community condition in the areas assessed. This index was also the most sensitive benthic index to indicate anthropogenic nutrient and / or organic enrichment, sedimentation and heavy metal pressures in the areas assessed.

This is the first time that an international diversity index has been applied on such a broad geographic scale (across four countries). This method and the corresponding tailor-made software showed good results. This method could also be applicable to other OSPAR sub-regions in the next assessment cycle.

Knowledge Gaps

Margalef diversity reference values for assessment areas appeared to be well related to the important environmental variable depth. Depth is an important driver for a suite of habitat variables, including sediment composition. However, reference values may still be improved by explicitly incorporating sediment type within the model.

An assessment value for the Margalef diversity index score needs to be developed. It may also be useful to differentiate this assessment value for specific assessment areas. Further consideration of benthos data availability across the OSPAR Maritime Area is also needed for wider application of the indicator in the future.

This document was published as part of OSPAR's Intermediate Assessment 2017.

The full assessment can be found at www.ospar.org/assessments

Condition of Benthic Habitat Communities: Assessment of Coastal Habitats in relation to Nutrient and/or Organic Enrichment

OSPAR COMMISSION

MSFD Descriptors 1: Biological diversity, 5: Eutrophication

MSFD Commission Criteria: 1.6: Habitat condition, 5.3: Indirect effects of nutrient enrichment

Key Message This assessment indicated that 90% of the coastal water bodies in the OSPAR Maritime Area, for which European Union Water Framework Directive assessment data were provided, have benthic habitats in good status in relation to nutrient and / or organic enrichment. However, there were wide regional variations and some data gaps.

Background

Benthic habitats are essential for marine life, because many marine species rely directly or indirectly on the seafloor to feed, hide, rest or reproduce. Benthic habitats are characterised by animal and plant communities with no or slow mobility compared to fish or marine mammals (**Figure 1**). The whole benthic community is therefore exposed when a pressure occurs. As a result, the condition (quality status) of benthic habitats is a reflection of the combined effects of all the pressures to which they are subject.

OSPAR agreed that a common indicator for the condition of benthic habitat defining communities should be applied in the Greater North Sea, Celtic Seas and the Bay of Biscay and Iberian Coasts. It is recognised that the indicator should be based on a series of multimetric indices each assessing the impact of different pressures on different benthic community defining habitats. No single metric for benthic habitats can achieve this given the diversity and complexity of benthic habitats and their communities.

This assessment considers the impact of nutrient and / or organic enrichment on some benthic habitats in coastal waters, where land-based and riverine inputs mean these pressures can be most pronounced. This assessment takes advantage of progress made in assessing benthic invertebrates and macroalgae through the implementation of the European Union Water Framework Directive (WFD). Data on these elements of the WFD status classification have been compiled to present this assessment.

Figure 1 (left): Marine benthic invertebrates

Figure 2 (right):Status (condition) of benthic invertebrates in intertidal and subtidal sediments, in response to the (direct or indirect) effects of nutrient and / or organic enrichment

Results

Figure 2 and **Figure 3** present the status (condition) of benthic invertebrates, macroalgae and angiosperms in response to nutrient and / or organic enrichment in coastal habitats of the Greater North Sea, Celtic Seas, Bay of Biscay and Iberian Coast and Norwegian parts of Arctic Waters. The condition assessments are based on the European Union WFD data and classification information.

From a total of 2 932 WFD coastal water bodies in the Greater North Sea, Celtic Seas, Bay of Biscay and Iberian Coast, and Norwegian part of Arctic Waters, 776 (26.4%) have been classified for benthic invertebrates and 331 (11.3%) for macroalgae and angiosperms. Due to a mismatch between the identification of water bodies and assessment results, another 125 (4.3%) assessment results for invertebrates and 45 (1.5%) results for macroalgae and angiosperms could not be assigned to a water body and were not included in the assessment.

The status of benthic invertebrates is classified as good or high in most of the assessed areas (**Figure 2**). According to data provided, the WFD objectives of good or high status are achieved for benthic invertebrates in 95% or more of the assessed water bodies of France (95%), the United Kingdom (96%) and Spain (100%). In Sweden (3%) Denmark (5%) only a small proportion of the assessed water bodies in the OSPAR Maritime Area achieved a good or high status for benthic invertebrates.

Change in Mean Trophic Level of Marine Predators in the Bay of Biscay

OSPAR COMMISSION

MSFD Descriptor :4 - Marine food webs

MSFD Commission Criteria: 4.2 - Proportion of selected species at the top of food webs; 4.3 - Abundance/distribution of key trophic groups/species

Key Message The assessment of changes to Mean Trophic Level in the Bay of Biscay showed no apparent change in overall food web structure over recent decades. However there were some signs of increase in the biomass of marine predators

Background

Food webs are networks within which organisms are related by feeding relationships (i.e. predator-prey interactions). This is one of three food web indicators, which describes changes in the structure of the food web with respect to fish and invertebrates.

Trophic level, determined by diet studies, expresses the position of an organism in a food web. A low trophic level (TL) value (e.g. 1) is assigned to the primary producers at the base of the food web whereas a high TL value (e.g. 4 or more) is assigned to predators at the top. Mean Trophic Level (MTL) is calculated using species biomass data from different sources (e.g. scientific surveys and fisheries landings), and their assigned TL values. As the diet of species may vary among regions, it is important to use regionally-specific diet studies to determine regionally relevant TL values. These values are used to represent the feeding pathways / relationships in a given region, i.e. what-eats-what.

This indicator, currently based on invertebrates and fish, is mainly sensitive to fishing pressure. Fisheries usually target species at a high TL and thus drive a decrease in the availability of predators within the ecosystem. This in turn forces fisheries into targeting species at ever lower trophic levels and thus a decline in the MTL of fisheries landings. This is referred to as ‘fishing down marine food webs’ (**Figure 1**). If the phenomenon persists, the changes in food web structure could leave marine ecosystems increasingly vulnerable to natural and human-induced pressures.

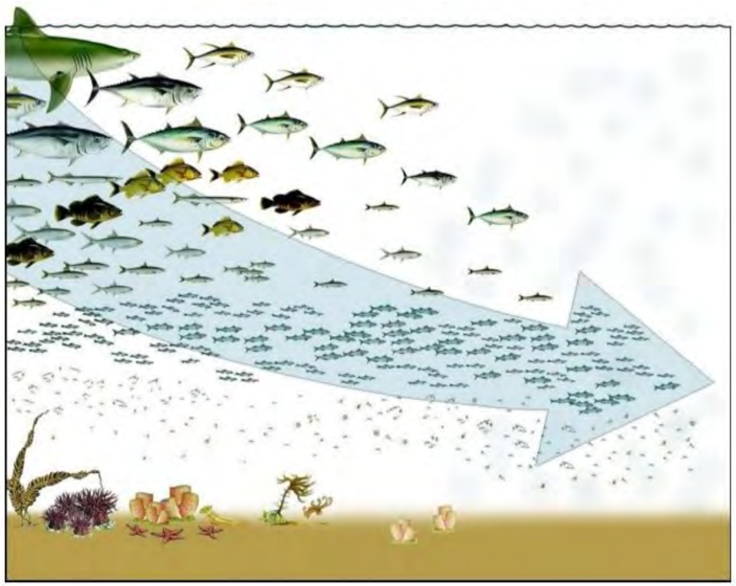


Figure 1: Representation of the ‘fishing down marine food webs’ concept

Results

The Mean Trophic Level (MTL) indicator was assessed over a period of 18 to 23 years for the northern and southern parts of the Bay of Biscay (**Figure 2**), using biomass survey data complemented by fisheries landings data and region-specific TL values for species concerned. Initially, the entire community was studied, followed by a focus on the bentho-demersal community (i.e. those species living on or close to the seabed) by excluding pelagic species (i.e. those living within the water column). Species above a certain TL value were selected in order to concentrate on the predator community.

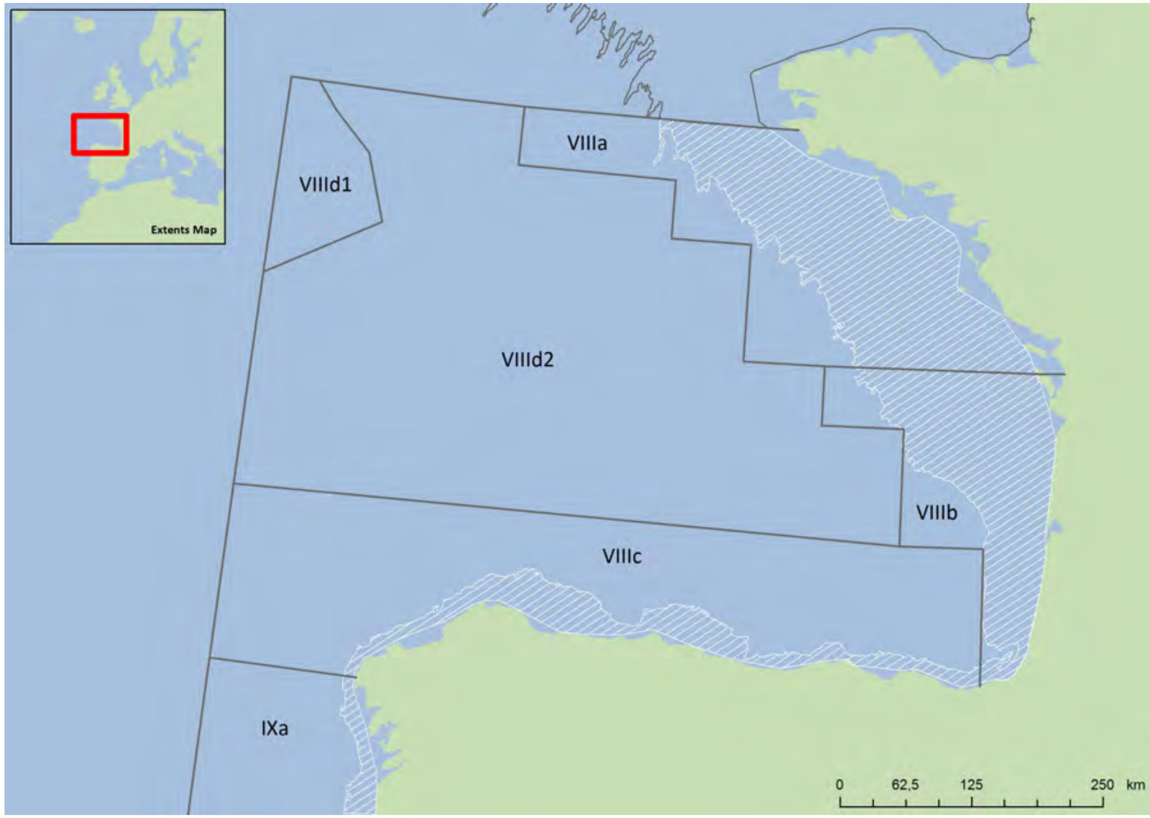


Figure 2: Bay of Biscay showing the regional subdivisions and the continental shelf (hatched area) of the northern and southern Bay of Biscay

Change in Mean Trophic Level of Marine Predators in the Bay of Biscay

OSPAR COMMISSION

Results cont...

In the Bay of Biscay (northern and southern parts), food webs indicate a general improvement from the unsustainable fishing pressure of previous decades, shown in this assessment by a significant increase in MTL. The biomass of predators has increased meaning that the structure of the food web is gaining stability and therefore resistance to perturbations.

To better reflect changes in the upper TLs of individual ecosystems, three MTL cut-off scenarios were used to assess trends in changes to MTL in the Bay of Biscay (**Table 1**): Above a TL of 2.0 (TL_2.0) includes all consumers; Above a TL of 3.25 (TL_3.25) includes higher trophic length fish; and Above a TL of 4 (TL_4.0) includes higher level predators.

This increase in MTL was detected in the northern part of the Bay of Biscay when assigning the MTL_3.25 and MTL_4.0 cut-offs to both survey and landings data and thus selecting predators for the assessment (**Table 1**). The increase was also identified in the southern Bay of Biscay, but only for survey data when excluding pelagic species and low trophic level species (MTL_3.25). The positive trends observed for this indicator reflect an increase in predator biomass in the northern part of the Bay of Biscay and to a lesser extent in the southern part. It conveys an apparent reduction in fishing pressure on high trophic level bentho-demersal predators, presumably allowing communities to begin recovery from past perturbations.

There is moderate / low confidence in the methodology used and high / moderate confidence in the availability of data.

Table 1: Trends in changes to MTL in the Bay of Biscay

*Analyses performed using landings and survey data over different Mean Trophic Level (MTL) cut-off scenarios. Statistically demonstrated increases in MTL are shown as green with up arrows and significance; where no increase is calculated, this is shown as green with a horizontal arrow. p-value for the statistical tests significance (linear model), *: p<0.05, **: p<0.01 ***: p<0.001. sp. : species*

	France (Northern Bay of Biscay)				Spain (Southern Bay of Biscay)			
	Surveys 1997 - 2015		Landings 1997 - 2014		Surveys 1992 - 2015		Landings 1989 - 2010	
	All sp.	Excluding pelagic sp.	All sp.	Excluding pelagic sp.	All sp.	Excluding pelagic sp.	All sp.	Excluding pelagic sp.
MTL_2.0	→	→	→	→	→	→	→	→
MTL_3.25	↗ *	↗ **	→	↗ **	→	↗ *	→	→
MTL_4.0	↗ ***	→	↗ ***	↗ **	→	→	→	→

Conclusion

The Mean Trophic Level (MTL) in the southern and northern Bay of Biscay showed no apparent change in the overall food web structure resulting from fishing pressure (MTL 2.0 in Table 1). However there were some signs of improvements when focusing in on the predator community (MTL 3.25 and 4.0 in **Table 1**).

Using the MTL indicator results from survey data complemented by those from landings data, reinforces the signal of food web state. In the same way, using regional trophic level values provides a better view of community structure within the study region and strengthens the accuracy of this assessment. Examining the community as a whole (both with and without pelagic species) as well as focusing specifically on predators, makes it possible to detect changes in food web structure.

Knowledge Gaps

Understanding the feeding relationships between species occurring in a specific region is essential to conduct a robust assessment of the food web, whether using the MTL indicator or any other Trophic Level based indicator. It is not currently possible to apply the MTL indicator anywhere other than the Bay of Biscay, owing to a lack of detailed information on feeding interactions and region-specific Trophic Level (TL) values. Repeated dietary studies implemented at the (sub)-regional scale and the computation of TL values would help fill this gap in knowledge.

To improve the assessment of the state of the food web, further work on the MTL indicator could include: incorporating additional datasets on biological compartments that are not currently included (e.g. benthos, mammals, or birds); investigating the influence of various anthropogenic pressures; exploring finer geographic scales; and further defining assessment values.

This document was published as part of OSPAR's Intermediate Assessment 2017.

The full assessment can be found at www.ospar.org/assessments

Recovery in the Population Abundance of Sensitive Fish Species

MSFD Descriptor: 1 - Biological diversity
MSFD Criterion: 1.2 -Population size

Key Message The decline in abundance of sensitive fish species has been halted in the Celtic Seas and Greater North Sea. However, significant recovery of populations is only apparent in the Celtic Seas

Background

OSPAR’s strategic objective with respect to biodiversity and ecosystems is to halt and prevent further loss in biodiversity, protect and conserve ecosystems and to restore, where practicable, ecosystems, which have been adversely impacted by human activities.

There are three fish indicators assessed in the Intermediate Assessment 2017. This indicator addresses the extent of population recovery among sensitive species. Fish species with life history traits such as large ultimate body size, slow growth rate, large length and late-age-at-maturity, are particularly sensitive to additional sources of mortality, for example fishing mortality. Populations of such species are known to have declined markedly in abundance through the 20th century, a period of marked expansion in fishing activity across the area assessed. Recovery in population abundance among a significant fraction of these species is therefore needed.

This assessment is calculated using catch data from scientific groundfish surveys. These are standardized monitoring programmes that occur each year in the same period taking representative samples according to specific guidelines.

Results

The abundance of sensitive fish species is assessed against two different sets of assessment values. The first assessment examines whether population recovery is underway and the secondary assessment examines whether population decline has been halted. For the purposes of the Intermediate Assessment (IA) 2017, the assessment year was the last year in each survey time series for which data were available. Both assessments use two sensitivity metrics to define suites of sensitive species (Average Life-history Trait (ALHT) and Proportion Failing to Spawn (PFS)). Both metrics rely on species’ life trait information. Generally consistent results using either metric demonstrate that assessment outcomes were robust to choice of metric. However, the principal assessment outcome should be based on the more recently developed PFS metric.

Results were integrated across surveys within OSPAR regions to determine if the assessment values for recovery or halting decline were met using both ‘averaging’ and ‘probabilistic’ integrating procedures. Choice of integration procedure had minimal effect on assessment outcomes.
Here results for the assessments based on the PFS metric using the ‘averaging’ integration method are presented. Population recovery among a significant number of sensitive fish species was evident in the Celtic Seas, but not in the North Sea (**Figure 1**).

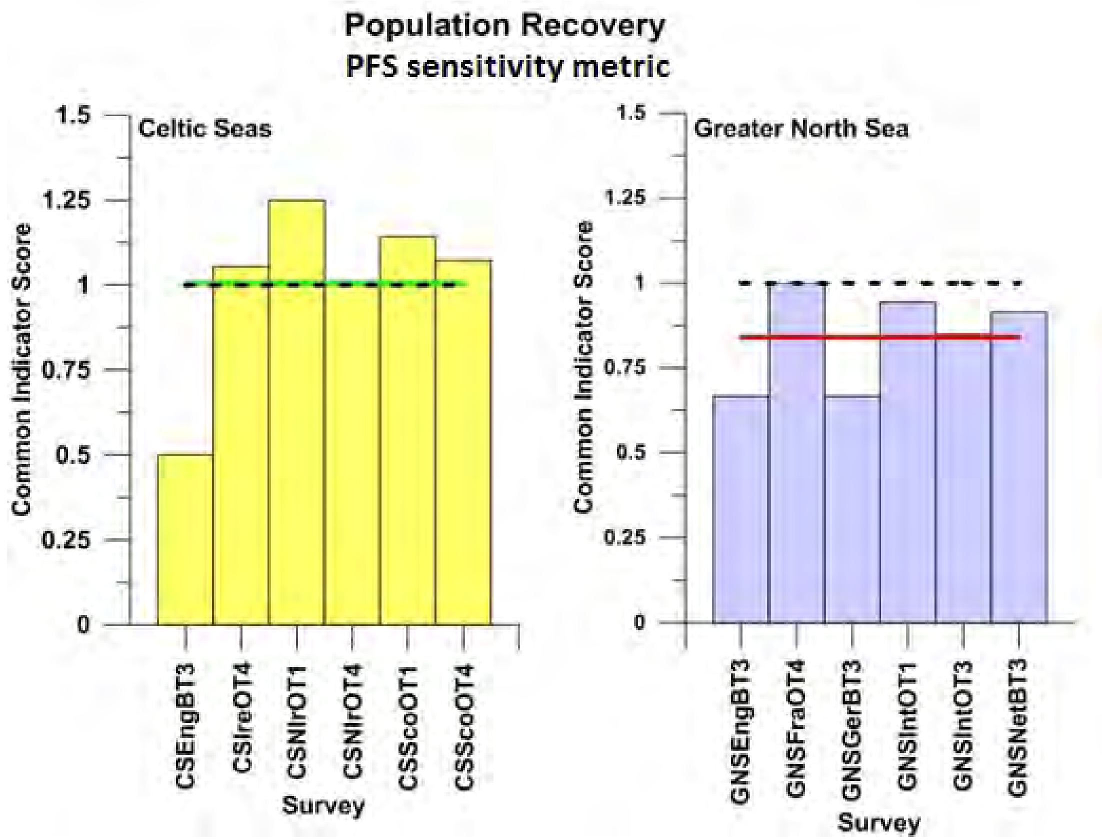


Figure 1: Outcomes against the ‘population recovery’ assessment for suites of sensitive species defined by the PFS sensitivity metric sampled by surveys carried out in the Celtic Seas and Greater North Sea

Outcomes for regional scale integrated assessments, using an “averaging” integration procedure are indicated by horizontal green (meets or exceeds assessment value, r epresented by black dashed line) or red (does not meet assessment value) horizontal lines. The Common Indicators Score is determined as indicator value / assessment value

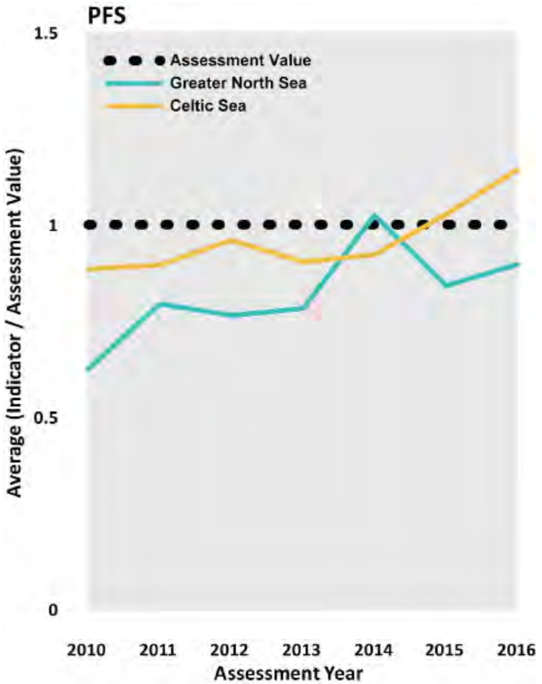
Recovery in the Population Abundance of Sensitive Fish Species

Results cont...

However in both regions, recent trends in the number of sensitive species increasing in abundance suggest an improving situation (**Figure 2**).

Further decline in the population abundance of sensitive fish species has been halted in both regions (**Figure 3**).

For this assessment the confidence in the methodology is moderate and the confidence in the data is high.



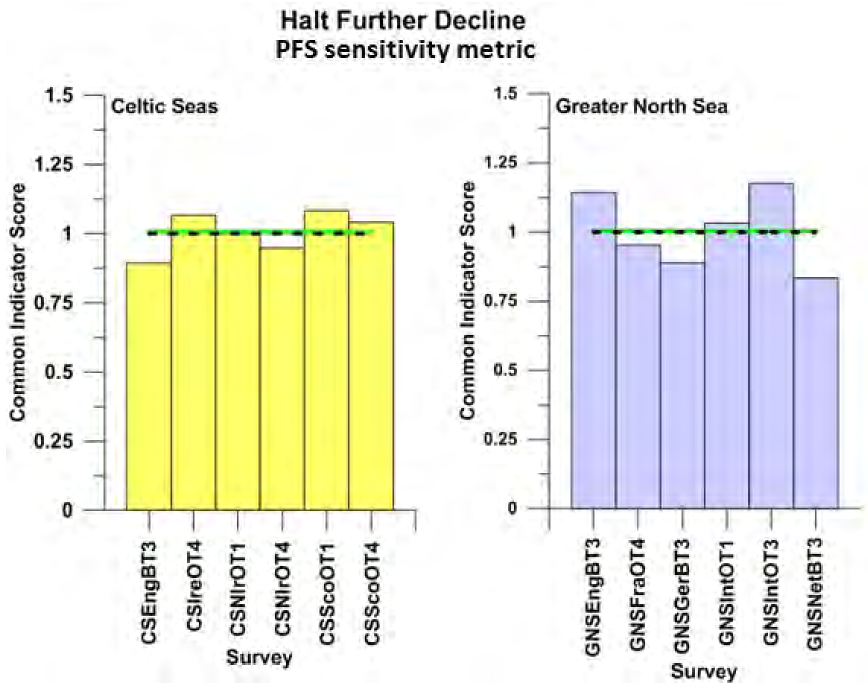


Figure 2 (left): Integrated assessment outcomes for population abundance recovery (where a value above 1 means the assessment value is being met or exceeded) derived using an averaging integration approach

Figure 3 (right): Outcomes against the ‘halt further population decline’ assessment for suites of sensitive species defined by the PFS sensitivity metric sampled by surveys carried out in the Celtic Seas and Greater North Sea.

Outcomes for regional scale integrated assessments, using an “averaging” integration procedure are indicated by horizontal green (meets or exceeds assessment value, represented by black dashed line) or red (does not meet assessment value) horizontal lines. The Common Indicators Score is determined as indicator value / assessment value

Conclusion

When considering OSPAR regions individually, evidence of recovery was compelling in the Celtic Seas, but in the Greater North Sea the number of sensitive species increasing in abundance was insufficient to meet the assessment value.

Evidence to support a halt in decline of the abundance of fish species sensitive to fishing mortality is clear. Assessment outcomes suggested that decline has been halted since 2010. These conclusions are robust regardless of which sensitivity metric is used to define suites of sensitive species and the choice of integration method.

When considering all areas assessed (the Greater North Sea and the Celtic Seas), evidence to support the case that significant recovery had been achieved in the population abundance of sensitive species, was unclear. The assessment outcomes were influenced by which sensitivity metric was used to identify the suites of sensitive species in each survey, and also by the type of integration method applied to derive integrated assessment outcomes from the individual survey assessments.

Knowledge Gaps

The key knowledge gaps for the assessment are: the availability of suitable population dynamics models to support the setting of absolute abundance targets for sensitive fish species, the effects of warming seas on the scope for population growth and potential for population recovery among large-bodied sensitive fish species.

This document was published as part of OSPAR’s Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments

Proportion of Large Fish (Large Fish Index)

MSFD Descriptor 4 - Marine food web
MSFD Criterion: 1.7 - Ecosystem structure

Key Message Recovery in the proportion of large fish in the demersal fish community is evident in the Greater North Sea. Assessment values indicating recovery are only met in the northern part of the Celtic Seas. In many individual survey-based assessments where assessment values are not currently met, recent recovery trends suggest they could be achieved by 2022, if current pressure levels are not increased

Background

Fishing mortality constrains the age structure of fish communities, reducing the proportion of larger / older individuals. Fishing is also size-selective, preferentially removing larger / older fish, and therefore affects fish community size composition. So far, three indicators relating to fish size have been developed to assess impacts of fishing on fish communities and the food web, considering parameters showing different responses in the ecosystem.

The Large Fish Index (LFI) has been developed to respond to fishing pressure on the proportion of large fish in demersal fish communities (species living on or near the seafloor). It was developed to support the Ecological Quality Objective for the North Sea demersal fish community. The North Sea LFI methodology has subsequently been adapted to derive LFIs for the Celtic Sea and Northern Iberian Shelf Sea.

The LFI uses estimates of fish abundance-at-length provided by international bottom trawl surveys. These are standardised monitoring programmes that occur each year in the same period taking representative samples according to specific guidelines. The assessment of each survey involves determining the suite of species constituting the demersal fish community and the length criteria defining large fish. The proportion of the demersal fish biomass that has a length exceeding the length criteria can then be calculated.

Specific assessment values are derived from the time series used for each regional assessment. The longest survey time series analysed started in 1983.

Results

Trends in the Large Fish Index (LFI) in each of the 13 groundfish surveys assessed are shown in **Figure 1**.

The assessment in the Greater North Sea relied primarily on two surveys (**Figure 1** - plots j and k), conducted at different times of the year, which both covered the greater part of the Region. Both surveys suggest that the proportion of large fish does not currently meet assessment values (**Figure 2** and **Figure 3**). However, both surveys show recovery and that size composition has recovered strongly from its most disturbed condition at the turn of the century. Extrapolation of current recovery trends in these two surveys suggests that LFI assessment values should be met before the next European Union (EU) Marine Strategy Framework Directive (MSFD) assessment in 2024. These results are generally supported by the other surveys.

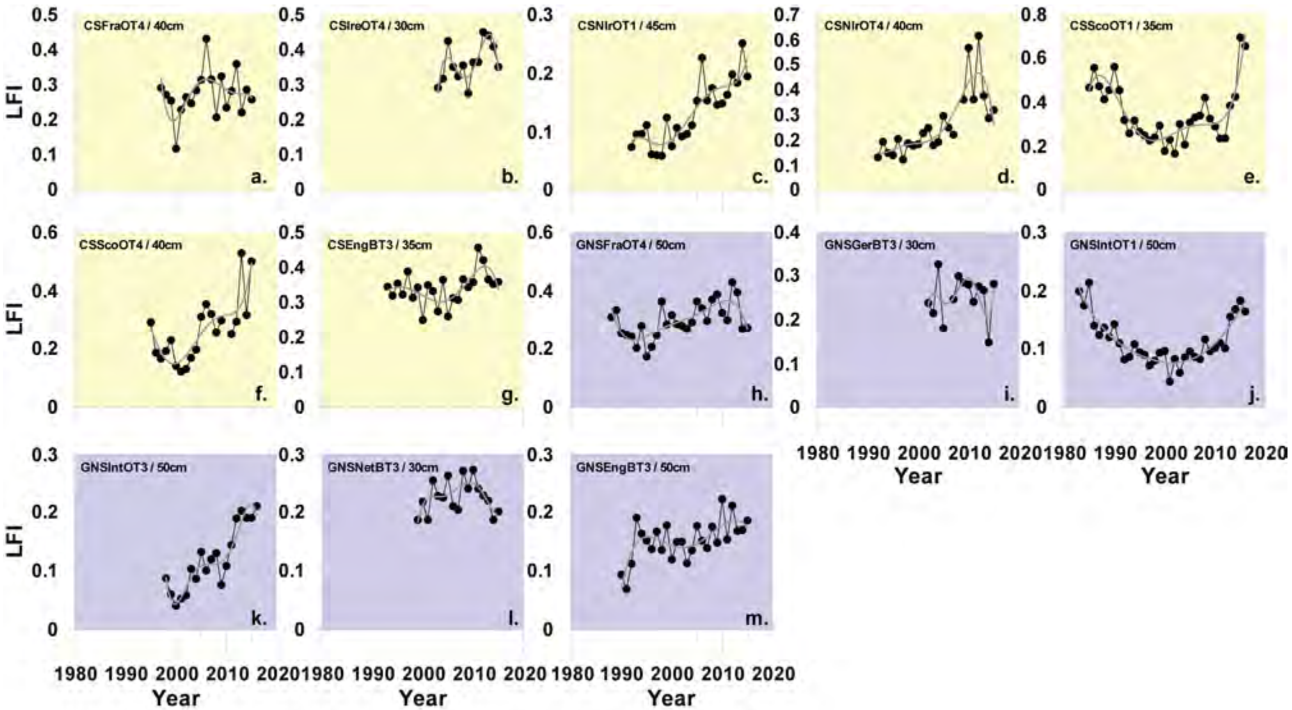


Figure 1: Trends in the large fish index (LFI) in 13 groundfish surveys in the Greater North Sea and Celtic Seas using the optimal length value (L_{LF}) determined to define 'large fish' for each survey

Plots are colour coded to reflect region (yellow: Celtic Seas; purple: Greater North Sea)

Results cont...

Surveys in the Celtic Seas only covered relatively small parts of that region. The assessment therefore relied on the compilation of individual survey-based assessment outcomes. The proportion of large demersal fish meets the assessment value in the northern half of the region (**Figure 1** - plots e and f). The LFI In other parts of the Celtic Seas region does not meet the assessment value. Recovery is evident in the Irish Sea and LFI assessment values could be achieved there by 2020 (**Figure 1** - plots c and d). In the south and west of this region, evidence of a recovery in LFI values is unclear (**Figure 1** - plots a, b and f), and at best suggests that it could take a decade or more before the assessment value is reached, unless current levels of pressure are reduced.

There is medium / high confidence in the assessment methodology and high confidence in the data availability.

Conclusion

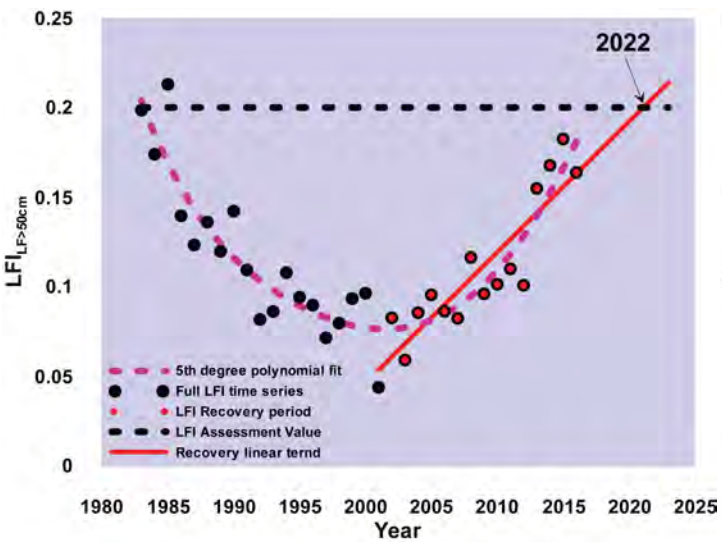
The recovery in the proportion of large fish in the demersal fish community reported in the Greater North Sea in Quality Status Report (QSR) 2010 has continued in the period to 2015. Recovery is also evident in a large part of the Celtic Seas region.

Assessment values are met only in the northern part of the Celtic Seas. Elsewhere assessment values could be achieved by 2022 if the current pressures levels are not increased. Exceptions were observed, notably in the south and west of the Celtic Seas region, where evidence of recovery is lacking, or the recovery rate was so low that it could take more than a decade before demersal fish size composition achieves the assessment value, unless current levels of pressure are reduced.

The time-lagged response of the Large Fish Index (LFI) to variation in fishing pressure means that where assessment values are met, or where they are not met but recovery is underway, measures necessary to restore demersal fish size composition are probably already in place. Additional measures may be required where assessment values are not met and evidence of recovery trends is either absent or weak. However, since LFI assessment values have generally yet to be achieved over most of the area assessed, any relaxation of management would be premature.

Knowledge Gaps

Knowledge gaps focus on: the lack of empirical data (including historical data) or appropriate models to inform Large Fish Index (LFI) assessment value setting; the lack of a single universal protocol to determine the optimal length value defining ‘large fish’ for all surveys; the effects of warming sea temperature on LFI assessment values and on demersal fish size composition recovery rates; and, a full understanding of relationships between all human pressures and their impact on the full demersal fish community, not just the commercial stocks. Future development of the indicator should explore the potential of spatial sub-divisional assessments..



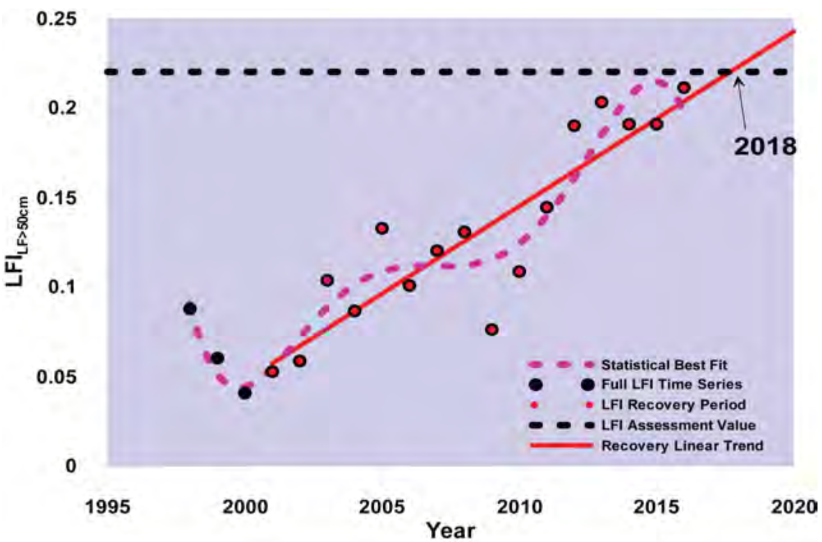


Figure 2 (far left): Large Fish Index (LFI) time series derived from the first quarter (January to March) international otter trawl survey in the Greater North Sea (Figure 1, plot j) showing annual data, data used to determine the recovery trend, linear trend fitted to the recovery period data, and the LFI assessment value

Figure 3 (left): Large Fish Index (LFI) time series derived from the third quarter (July to September) international otter trawl survey in the Greater North Sea (Figure 1, Plot k) showing annual data used to determine the recovery trend, linear trend fitted to the recovery period data, and the LFI assessment value

Pilot Assessment of Mean Maximum Length of Fish

MSFD Descriptor: 1 - Biological diversity
MSFD Criterion: 1.7 - Ecosystem structure

Key Message This pilot assessment measures the change in species composition as determined by the mean maximum length of each species, which is assumed to represent their vulnerability to additional (often fishing-related) mortality. There is no consistent pattern across the assessed regions but there are often distinct changes over time within regions

Background

Fishing mortality constrains the age structure of fish communities, reducing the proportion of larger / older individuals. Fishing is also size-selective, preferentially removing larger / older fish, and therefore affects fish community size composition. For the Intermediate Assessment 2017, three assessments relating to fish size have been developed to assess impacts of fishing on fish communities and the food web, considering parameters showing different responses in the ecosystem.

Maximum length (**Figure 1**) is one of the life-history characteristics that determine species vulnerability to additional mortality. This life-history characteristic is chosen because the assumption is that species known to grow to a large maximum length, also reproduce late and so are exposed for longer to pressures affecting the fish community compared to other fish species. Because they are exposed for longer such species are expected to be the first to decline if this pressure is high. This parameter was selected to represent vulnerability, as it is based on data that are widely available.

A decline in mean maximum length indicates that the abundance of the most vulnerable fish and elasmobranch species is decreasing, with a subsequent loss in species diversity.
The indicator is calculated using catch data from scientific surveys. These are standardised monitoring programmes that occur each year in the same period taking representative samples according to specific guidelines. Different components of the fish community are distinguished based on their feeding behaviour using habitat-based trophic guilds: namely, demersal communities (species living near the seafloor) and pelagic communities (species living only in the water column).

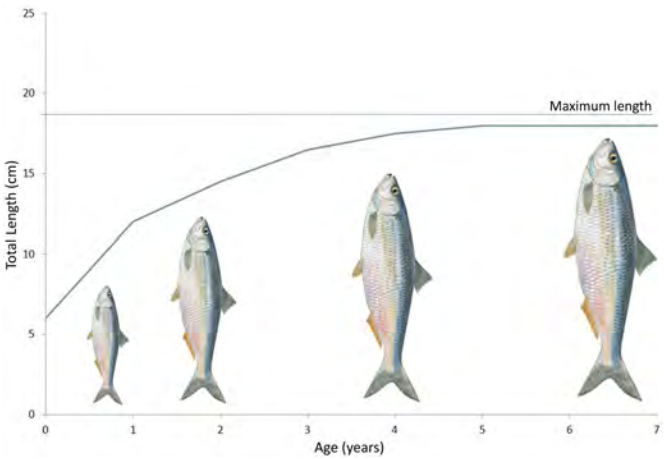


Figure 1: Maximum length based on the von Berthalanffy growth curve

Results

Greater North Sea
Within the Greater North Sea region there are some distinct differences between the sub-divisions, with mean maximum length declining in the southern and central sub-divisions and increasing in the northerly sub-divisions. This applies to demersal fish assemblages (**Figure 2**) and pelagic fish assemblages (**Figure 3**). Only in the Kattegat and Skagerrak is there a mixed signal from the indicator, with demersal fish still at a low level but showing the first signs of recovery, while pelagic fish show no change over time. In contrast to the declining trends in the southern Greater North Sea the mean maximum length of demersal fish assemblages in the English Channel appear to be increasing.

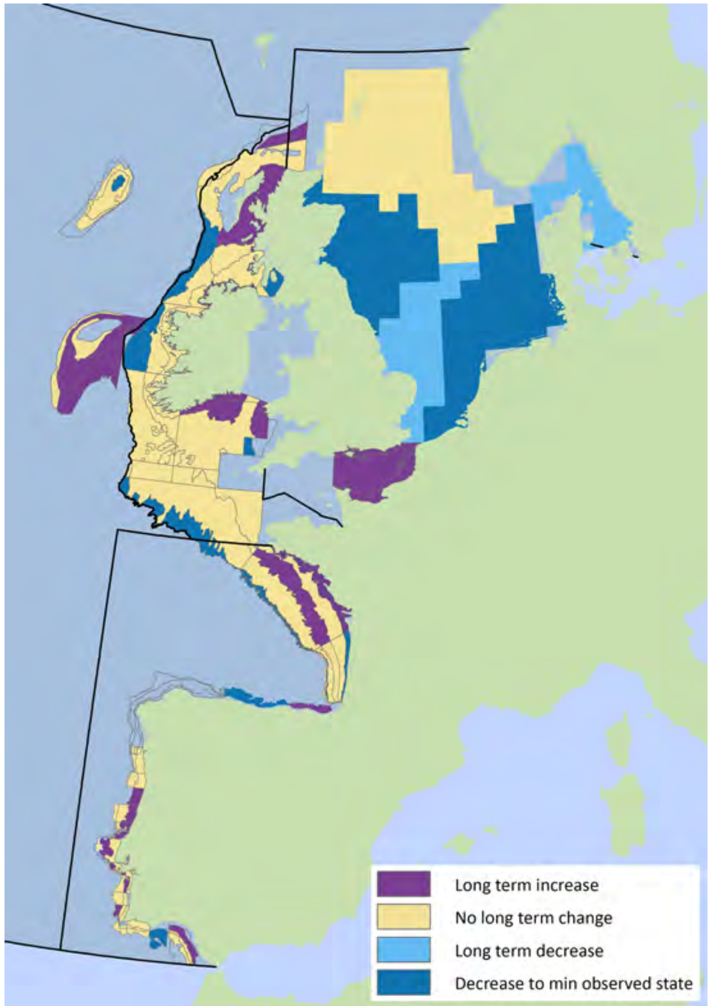


Figure 2: Spatial patterns in mean maximum length per sub-division for demersal fish assemblages

Pilot Assessment of Mean Maximum Length of Fish

Results cont...

Celtic Seas

Within the Celtic Seas region there are some distinct differences for mean maximum length between the sub-divisions with a mixed picture for demersal and pelagic fish assemblages. Demersal mean maximum length decreases along the shelf edge waters to the west, near the Irish coast of the Irish Sea and in the Clyde area, but increases to the south of Ireland, Isle of Man, Sea of the Hebrides and The Minch (**Figure 2**). For the pelagic fish community there are some more distinct sub-regional patterns with increases in the Irish Sea offshore, extending into the Celtic Sea but decreases in some northerly areas including the Sea of the Hebrides and west of Ireland (**Figure 3**).

Bay of Biscay and Iberian Coast

Within the Bay of Biscay and Iberian Coast region, there are some sub-divisional differences but no clear patterns. Decreases are observed for demersal fish assemblages in several sub-divisions along the shelf-edge in the Bay of Biscay as well as in the Sea of Cadiz (**Figure 2**). For demersal fish assemblages the main increases occur in the northern part of the Bay of Biscay closer to the shore and along the Portuguese coast. Few major sub-divisional changes over time are observed for pelagic fish (**Figure 3**).

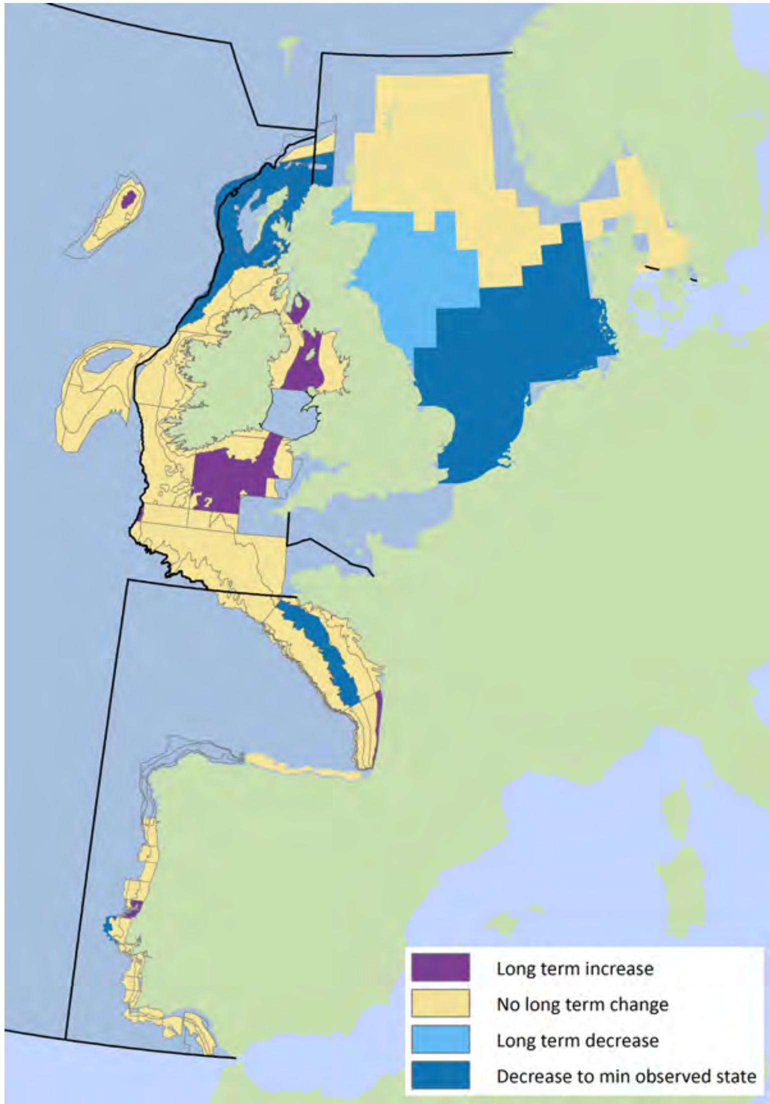


Figure 3:Spatial patterns in mean maximum length per sub-division for pelagic fish assemblages

Conclusion

The pilot indicator shows no consistent pattern in mean maximum length across regions but there are often distinct changes over time within each region. For example, in the Greater North Sea there is an overall decline in mean maximum length for both demersal and pelagic fish assemblages, which implies that the proportion of vulnerable species (i.e. large or slow-growing species with late maturity), is declining. However, in the English Channel demersal fish assemblages appear to be recovering. In the Celtic Seas, there is no overall trend but lots of variation over time, between surveys, and between sub-divisions, especially for demersal fish. In the Bay of Biscay and Iberian Coast, mean maximum length of demersal fish is clearly increasing. This is also the case for pelagic fish, except in the northerly part of the Bay of Biscay.

The observed patterns in mean maximum length suggest that fishing has impacted the fish community such that vulnerable species have declined, although it also appears that the recent reduction in fishing mortality has resulted in a recovery of the fish community, albeit often locally.

The results from this pilot assessment can help to strengthen OSPAR's fish community assessments in the future.

Knowledge Gaps

The main causes for the observed spatial and temporal patterns in the mean maximum length indicator are not yet known.

Reference levels representing a pristine or sustainably exploited state and that would allow a formal assessment, are not yet available.

This document was published as part of OSPAR's Intermediate Assessment 2017.

The full assessment can be found at www.ospar.org/assessments

Size Composition in Fish Communities

MSFD Descriptor: 4 - Marine food webs
MSFD Criterion: 4.2 - Proportion of selected species at the top of food webs

OSPAR COMMISSION

Key Message Typical Length measures the size-structure of fish and elasmobranch communities and it decreases under high fishing pressure. Although low compared to the 1980s, Typical Length for the assessed demersal fish has been recovering across the OSPAR Maritime Area since 2010. Pelagic fish generally show fluctuations but no trend. Locally, there are deviations from these patterns

Background

OSPAR's strategic objective with respect to biodiversity and ecosystems is to halt and prevent further loss in biodiversity, protect and conserve ecosystems and to restore, where practicable, ecosystems, which have been adversely impacted by human activities.

The Typical Length indicator is one of three food-web indicators currently used by OSPAR. It represents the average length of fish (bony fish and elasmobranchs) and provides information on the size composition within communities of fish. The indicator is calculated using catch data from species sampled by scientific surveys and given in units of centimetres. Communities are represented by habitat-based feeding assemblages (groups of fish): namely, demersal assemblages (i.e. species living on or near the sea floor) and pelagic assemblages (i.e. species living in the water column).

Fishing mortality constrains the age structure of fish populations, reducing the proportion of larger individuals (**Figure 1**). A gradual, steady decline in Typical Length is expected in response to high fishing pressure. This is because the size structure of the fish assemblage integrates the impacts of fishing pressure over long periods of time. Model simulations demonstrate that in food webs where predator-prey interactions dominate over other interactions, large species at high trophic levels (the position of the species within the food web) are highly sensitive to loss of diversity at lower trophic levels.

Figure 1: A large-bodied Atlantic Wolffish ©Jim Ellis

Results

The results of this assessment (**Figure 2**) apply at the community level and do not identify particular species.

Greater North Sea

The assessed demersal fish assemblage is recovering at the scale of the Greater North Sea as a whole due to recent increases in typical length indicator in some sub-divisions: Orkney / Shetland, Kattegat / Skagerrak and the United Kingdom coast in the English Channel. However, the current level is low relative to observed size structure in the early 1980s. Areas of concern, with long-term declines to lowest observed levels remain in the south-eastern and central-western North Sea. The pelagic fish assemblage generally shows fluctuations without trend, with the exception of a long-term decrease to a minimum level in the south-eastern North Sea.

Celtic Seas

Although the surveys showed mixed signals within the Celtic Seas for the typical length of the demersal fish assemblage, surveys in the north suggest some recovery from previous low states with increases to the west of Scotland. However, decreases are also apparent for shelf edge waters to the west. Elsewhere the picture is similarly mixed with decreases near the Irish coast of the Irish Sea and in the Clyde area, but increases to the south of Ireland, Isle of Man, Sea of the Hebrides, and The Minch. The pelagic fish assemblage generally shows no long-term change at the sub-regional level. However, increases are seen to the south of Ireland and decreases in some northerly areas including the Sea of the Hebrides and in coastal areas in the Irish Sea and to the west of Ireland.

Size Composition in Fish Communities

Results cont...

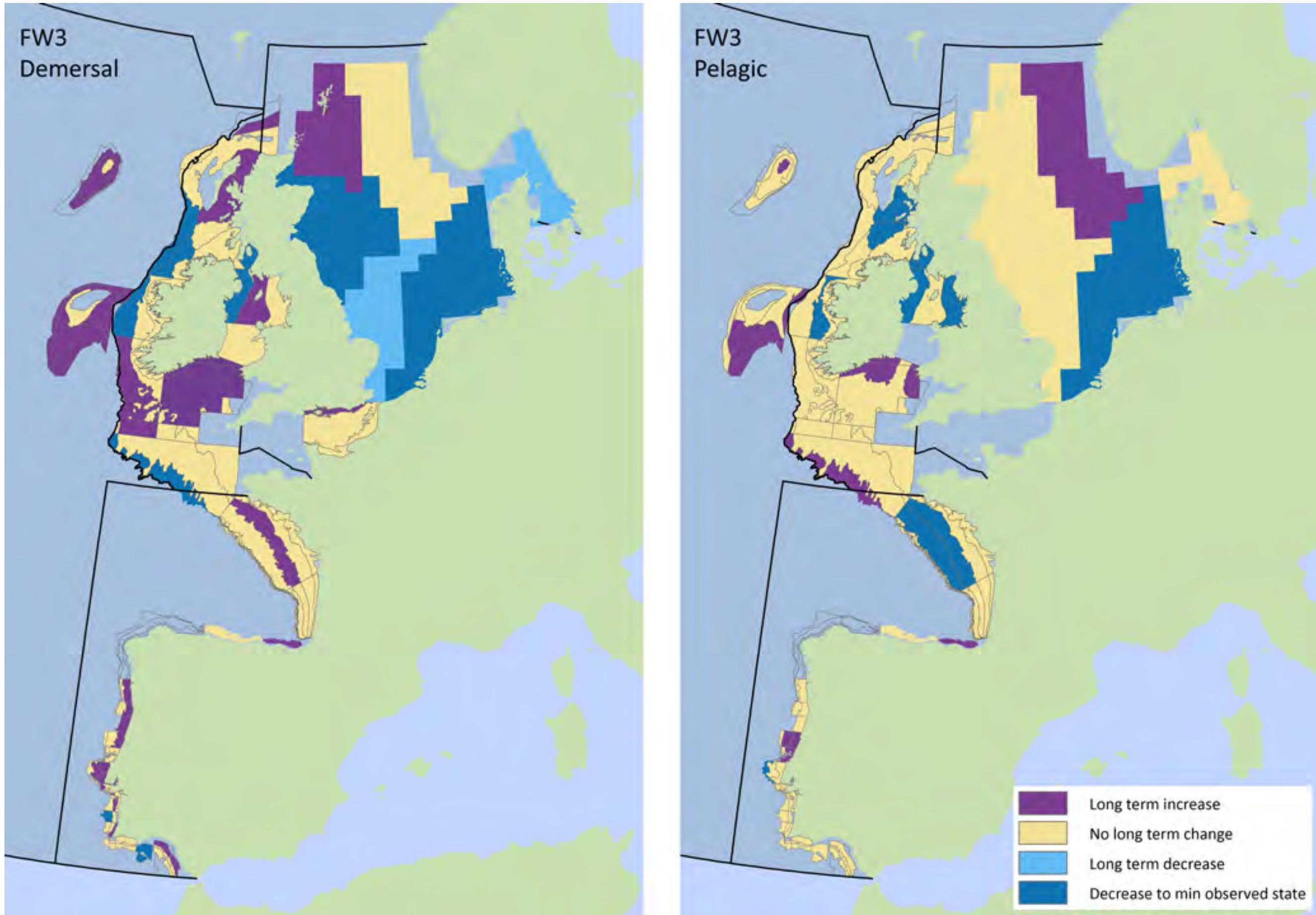
Bay of Biscay and Iberian Coast

The typical length of the demersal fish assemblage has increased in this region due to long-term increases in northerly sub-divisions in shelf waters to the west of France and in the coastal area of the Sea of Cadiz. Many sub-divisions to the west of Portugal have also shown increases, in contrast to decreases in some areas to the south. The pelagic fish assemblage generally showed no long-term change. However, decreases to a low state relative to previously observed size structure were identified in northerly sub-divisions in shelf waters to the west of France.

Wider Atlantic

The typical length of the demersal fish assemblage has increased at the Porcupine Bank and the Rockall Bank. While fluctuations without long-term change in size structure have been shown in the pelagic fish assemblages, in the recent period (last six years) a linear increase has been shown for the Porcupine Bank.

There is moderate / low confidence in the method for this assessment and high confidence for data availability.



Conclusion

Long-term decreases in Typical Length, between the 1980s and 2000s in the Greater North Sea and from the 1990s to 2005 in the Celtic Seas, imply that the size structure of fish communities deteriorated such that communities are now more dominated by small-bodied fish. In the Wider Atlantic and Bay of Biscay and Iberian Coast, an overall increase has been observed since 2010.

However, while the indicator in demersal fish assemblages is often still at a relatively low value, recovery since 2010 appears to be underway in the Typical Length of demersal fish and elasmobranchs in the Greater North Sea and Celtic Seas, overall or at least in some sub-divisions. The pelagic fish assemblage shows no long-term change in much of the OSPAR Maritime Area.

Knowledge Gaps

Further work is required to evaluate appropriate baselines and assessment values for this indicator. This is necessary because any historical baseline for the fish and elasmobranch community is likely to represent an impacted state. Assessment values should preferably be identified through multi-species modelling.

Figure 2: Spatial pattern of Typical Length indicator and time series for key surveys. Typical Length for fish and elasmobranchs is separated into demersal assemblages (left) and pelagic assemblages (right) for sub-divisions for key surveys, where data are available. The duration of the period for which long-term change is defined is dependent on the survey data available, all time periods considered are over ten years long

This document was published as part of OSPAR's Intermediate Assessment 2017.

The full assessment can be found at www.ospar.org/assessments